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International Conference on Integrated Fruit Production

editors:

F. Polesny, W. Müller & R.W. Olszak

IOBC wprs Bulletin
Bulletin OILB srop

Vol. 19(4) 1996

IOBC/WPRS and ISHS
Working Group
Integrated Plant Protection in Orchards

ISHS
Working Group
Integrated Fruit Production

OILB/SROP et SIHS
Groupe de Travail
Lutte Intégrée en Vergers

SIHS
Groupe de Travail
Production Intégrée des Fruits

INTERNATIONAL CONFERENCE ON INTEGRATED FRUIT PRODUCTION

Proceedings of the Meeting

at

Cedzyna, Poland
28 August - 2 September 1995

Edited by F. POLESNY (IOBC/WPRS)
W. MÜLLER (ISHS)
R.W. OLSZAK (Chairman Organizing Committee)

IOBC / wprs Bulletin
Bulletin OILB / srop Vol. 19(4)1996

The IOBC/WPRS Bulletin is published by the International Organization for Biological and Integrated Control of Noxious Animals and Plants, West Palaearctic Regional Section (IOBC/WPRS)

Le Bulletin OILB/SROP est publié par l'Organisation Internationale de Lutte Biologique et Intégrée contre les Animaux et les Plantes Nuisibles, section Régionale Ouest Paléarctique (OILB/SROP)

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ISBN 92-9067-078-9

This meeting was sponsored by

BASF, Ludwigshafen
Bayer AG
Carl Zeiss, Jena
Ciba-Geigy AG, Basel
Fa. G. Pessl, Weiz
Solvay Duphar B.V.
Sumitomo Chem.
Zeneca - Poland

Preface

Integrated Fruit Production (IFP) is a new system of producing fruit. It has been developed by scientists and by growers. IFP has been created in Europe and is now spreading continuously to all fruit growing regions of the world.

IFP is defined within the frame of Integrated Production as the economical production of high quality fruit, giving priority to ecologically saver methods, minimizing the undesirable side effects and use of agrochemicals, to enhance the safeguards to the environment and human health. All aspects of the system are under continuous review and need permanent improvement, based on latest research results and practical innovation.

To achieve common understanding of Integrated Fruit Production and to discuss new possibilities to improve the system, it is essential to organize meetings of experts in this field. The International Conference on Integrated Fruit Production in Cedzyna in Poland from 28th of August to 2nd of September 1995 was a resounding success in this sense. More than 150 paying participants from 26 countries attended the meeting. The contributions and discussions of the conference published in this proceeding volume are expected to bring outstanding improvements in IFP.

The conference was organized as a joint meeting of IOBC/WPRS (working group “Integrated Plant Protection in Orchards“ and working group “Stone Fruit“) and ISHS with the distinct aim of joining the experts in technical matters and the scientists. An efficient organizing committee was chaired by R.W.Olszak with the participation of secretary R.Z. Zajac and several members of the Research Institute of Pomology and Floriculture of Skierniewice. They did an excellent job! We would like to express our thanks to everybody who has helped in the organisation of the conference.

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Summarizing of presentations

PLENARY LECTURES

The current status of Integrated Pome Fruit Production in western Europe and its achievements.

Authors:- J.V. Cross, A. Bonauer, V. Bondio, J. Clemente, J. Denis, J. Grauslund, C. Huguet, E. Jörg, S. Koning, A. Kvale, C. Malavolta, R. Marcelle, I. Morandell, H. Oberhofer, M. Pontalti, F. Polesny, M. Rossini, A. Schenk, C. de Schaetzen, M. Vilajeliu.

A survey of integrated pome fruit production (IFP) in western Europe in 1994 was conducted by the IOBC/WPRS and ISHS Joint Group for Integrated Fruit Production. It showed that IFP and similar quality assurance (QA) schemes were operating in nearly all fruit producing countries in western Europe accounting for approximately 35% of the total area of pome fruit production (c 322,000 ha). The area has increased by 40% since the last survey was conducted in 1991. A total of 31 regional or national IFP or QA organisations were identified. The development of schemes in several other major fruit producing areas of the world including South Africa, eastern Europe, USA, New Zealand and Argentina is noted.

The regional/national guidelines of nearly all of the organisations did not comply in all respects with the IOBC/ISHS Euro-guidelines for IFP. There were important differences in 26 cases, including the permitting of the use of post-harvest treatment with an anti-oxidant for long term storage of superficial scald susceptible cultivars (5 cases), substantial permitted use of persistent residual herbicides (21 cases), permitted use of synthetic plant growth regulators (4 cases) and permitted use of chemical soil sterilisation for nematode control (1 case). However, in most regional or national guidelines requirements for some aspects of production were significantly higher than those of the IOBC/ISHS IFP Euro-guidelines.

Control procedures, usually by the IFP/QA organisation or by horticultural advisors, to ensure minimum requirements of the regional or national guidelines were upheld, varied substantially between regions (e.g. 0-100% of farms inspected) as did the proportion of growers excluded from IFP certification due to non-compliance with regional or national guidelines (range 0-47%).

Where IFP principles were adhered to strictly, a generally higher standard of horticultural practice resulted, including improved intrinsic and extrinsic fruit quality, though such benefits were difficult to quantify. A further important achievement was a higher standard of integrated plant protection, substantial (up to 30%) reduction in pesticide use, and use of less environmentally damaging pesticides.

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Growers were motivated by slightly improved marketing prospects for their fruit in a saturated market, though a price premium for IFP produced fruit was seldom sustained. Further important driving forces were the need for primary producers to reassure the food industry that they have been diligent in ensuring food safety and substantial EC grant awarded for IFP production in some regions (up to 900 ECU/ha/season). In regions where IFP is mature it is proving difficult to sustain the interest and commitment of all growers.

The need to define and research higher standards of IFP is highlighted and key elements of such standards are proposed.

Introduction

This paper presents the results of a survey of the status of Integrated Pome Fruit Production (IFP) and related quality assurance (QA) schemes in western European countries done in 1994 together with a brief note of developments in other fruit growing regions throughout the world. Attention is drawn to major differences between national or regional guidelines for IFP and the first edition of the IOBC/ISHS Euro-guidelines (Dickler and Schäfermeyer, 1991), and to the organisation of the procedures for checking compliance by the fruit grower with the guidelines. The achievements of IFP, its successes and difficulties, and the motivation of fruit growers are highlighted. Finally, conclusions are drawn and some recommendations for future research are given.

Survey

The survey was conducted by a postal questionnaire about Integrated Pome Fruit production in western Europe in 1994 completed by a representative from each fruit growing region. Where several fruit growing regions occurred in a given country, the completion of the questionnaires was co-ordinated by the national IFP representative on the IOBC/ISHS Joint Group for Integrated Fruit Production. The responses received are not strictly scientifically comparable as they are based on personal opinion, but they clearly reflect essential components.

Extent of implementation of IFP

Table 1 lists the main fruit producing countries of western Europe and their component IFP or QA organisations together with national and IFP or QA fruit production areas and numbers of growers. Whether or not each national or regional organisation claims to be IFP or a related form of quality assurance (QA), such as the "Environment Conscious" scheme in operation in the Netherlands, is identified.

Overall, a total of 31 IFP or QA organisations were identified. Approximately 35% of the area of pome fruit production in western Europe was grown according to IFP or related QA schemes. The results of the survey show large variations in the implementation of IFP or QA. In Germany and Italy 14 and 5 regional IFP organisations were identified respectively, each with substantial implementation of IFP. In contrast the large fruit producing area of France had only one IFP organisation, COVAPI, and IFP was implemented on only c 1% of the national fruit growing area.

Compliance of regional guidelines with Euro-guidelines.

The survey investigated how closely the guidelines of each regional or national IFP organisation complied with the first edition of the IFP Euro-guidelines (Dickler and Schäfermeyer, 1991) (see Table 2). Major differences occurred in relation to three important requirements of the Euro-guidelines. Firstly, five regional or national guidelines permitted post-harvest treatment of superficial scald susceptible apple cultivars scheduled for long term storage with an anti-oxidant (usually diphenylamine) a practice not permitted in the IFP Euro-guidelines. Secondly, 20 regional or national guidelines permitted extensive use of residual herbicides in established orchards. The Euro-guidelines specify that such herbicides should only be used in the first year after planting and that thereafter only contact-acting herbicides should be used. Thirdly, four guidelines permitted the use of synthetic plant growth regulators, including CCC on pears in the Netherlands and Belgium, and paclobutrazole on apples in Great Britain. The Netherlands QA scheme permits the use of pre-planting chemical soil sterilisation in specific localities where the soil is light and where root lesion nematodes (*Pratylenchus* sp) pose a significant threat. Soil sterilisation is generally considered to be unacceptable in IFP. However, despite these important failings most guidelines contained positive aspects which demanded a significantly higher standard for some aspects of production than the minimum requirements of the Euro-guidelines. For instance in the Netherlands the use of acaricides is prohibited in established orchards and the use of tunnel or transfer sprayers is mandatory.

Control procedures

The survey also showed that, apart from regions where IFP is in its infancy, control procedures (usually operated independently) have been implemented to ensure compliance with local guidelines (Table 3). However, the percentage of farms visited per annum varied substantially between regions. Regions with a larger number of smaller farms tended to have a lower proportion of farms inspected per annum. The minimum requirement specified by the Euro-guidelines is 10%. Almost all regions inspected annually the field notebooks containing records of all growers pesticide applications and justification for treatment. Of greater concern is the wide variation in the percentage growers failing due to non-compliance with local guidelines. The reasons for variation in failure rates could be due to differences in the standards of fruit growing, or of the rigour or otherwise of the local guidelines, but are more likely to be due to differences in the strictness with which control procedures are operated.

One of the most important aspects of the control procedures is the use of pesticide residue analysis of samples of fruit and/or of leaves taken pre- or post harvest to ensure only permitted pesticides have been used. Ultimately, this is practically the only effective check as to whether growers are falsifying their pesticide application records. The use of pesticide residue analysis as part of the control procedure varied dramatically between regions, between zero and 390 samples analysed per 1000 ha of pome fruit orchards. The number of active ingredients examined also varied from one to over 100 per analysis. The costs of IFP control procedures also varied greatly. In most cases the costs were borne by the grower but in some cases by the local or national government.

Financial benefits

The survey also investigated possible marketing and financial benefits to the grower as a result of IFP or QA. In some cases, IFP or QA attracted a price premium compared to fruit produced conventionally, notably the Netherlands (+ DF 0.05 per Kg), S. Tyrol, Italy (+ 15-50 Lira per Kg), Austria (AS 0.2 per Kg), Belgium (Walloon) (BF 0.5-1.0 per Kg), COVAPI, France (COVAPI) (+ 10%). However, such price premiums varied throughout the season and were often not sustained. Other regions did not receive any prime premium, but reported a market preference for IFP produced fruit. In several countries/regions growers received substantial government or EU grant for IFP; notably Germany (900 ECU/ha/season), Switzerland (SF400/ha/season in 1994, SF700 in 1995) and Emilia Romagna, Italy (450-800 ECU/ha/season).

Achievements of IFP

Finally, the survey investigated the achievements of IFP. Where IFP was strictly operated it was a valuable tool for introducing better horticultural practices. Growers achieved a generally higher standard of horticulture including orchard management and post-harvest fruit handling and storage. This was achieved partly through increased awareness and training of growers and partly by critical application of control procedures. These improvements could result in a higher standard of intrinsic fruit quality (external appearance and internal quality including taste, firmness and texture), though improvements were variable and difficult to quantify. One of the main driving forces for IFP was improving extrinsic fruit quality (see discussion) though no research has been done on improvements in consumer acceptance of IFP fruit.

A second important achievement of IFP was the implementation of higher standards of Integrated Plant Protection, including regular monitoring of pest, disease and weed levels in orchards, and use of safer, natural-enemy friendly pesticides. It was considered that IFP leads to up to a 30% reduction in pesticide use compared to conventional production and that IFP also has environmental benefits, though these are difficult to quantify.

The implementation of IFP is not confined to western Europe. The initiative is spreading to many other fruit producing regions throughout the world. Developments at varying stages of maturity can be found in eastern Europe (notably Poland and Hungary reported elsewhere in these proceedings), South Africa, USA (Massachusetts), New Zealand and Argentina.

Discussion

The survey clearly revealed a significant (c. 40%) increase in the extent of IFP and closely related QA schemes since the last survey in 1991 (Schäfermeyer and Dickler, 1991). However, there are large differences between regions, not only in the extent and maturity of IFP, but also in the strictness with which it was operated. Some variation is inevitable, but the wide variation that occurred undermines the integrity of IFP. An important question is how should the most glaring problems be ironed out? Endorsement procedures, now in operation by the IOBC, are intended to harmonise the guidelines, but the Euro-guidelines cannot be imposed forcibly. To date, the IOBC has received very few applications for endorsement of regional/national guidelines.

The second edition of the IOBC Euro-guidelines (Cross and Dickler, 1994) contained a small number of significant changes from the first edition, including allowance of post-harvest fungicide treatment under strict conditions. These changes have eased one or two of the problems, but some major difficulties remain. The survey indicates that the IOBC/ISHS Joint Group should give careful consideration to permitting the use of residual herbicides in IFP. With most regions ignoring the current prohibition of their use in established orchards it is clear some changes would be prudent. The option of permitting the use of moderately persistent, non-water polluting residual herbicides (e.g. pendimethalin, oxadiazon (see Cross *et al.*, 1992, 1993)) should be investigated carefully. Growers favour the triazines on account of their very low cost. However, because of herbicide resistance their use usually results in a change in the spectrum of weeds present. Frequent use of contact-acting herbicides may be just as damaging environmentally as routine use of residual herbicides. It is recommended that a scientific investigation of the feasibility of use of more environmentally-acceptable residual herbicides should be done in the major european fruit growing regions, including an assessment of environmental impact. The other important technical difficulty is the need for post harvest treatment with an anti-oxidant to prevent superficial scald on susceptible cultivars scheduled for long term storage. Investigation by medical and food scientists have concluded recently that anti-oxidants are highly beneficial to human health (Halliwell, 1994) by reducing the risk of cancer, providing they have no other undesirable health effects. No research on diphenylamine (the most widely used post-harvest anti-oxidant used on fruit) appears to have been done but the beneficial effects of ethoxyquin (also used widely) have been researched (Taimr, 1994). The alternative strategy for control of superficial scald recommended in IFP - the use of high quality controlled atmosphere storage often with ethylene scrubbing - is too costly, and makes growing of scald susceptible cultivars uneconomic. A further priority for research is to seek non-synthetic anti-oxidants. It is not feasible to debar much loved apple cultivars on account of the need for treatment with anti-oxidant post-harvest.

Good Agricultural Practice can be regarded as the pursuit of maximum short term profit by growers within legal constraints. It is characterised by the culture of high yielding cultivars of high external but often mediocre internal quality, intensive planting systems and heavy use and reliance on a wide range of agrochemicals with minimal regard for the environment or the development of resistance to pesticides. IFP and QA schemes provide an important means for pressuring growers to adopt more sustainable practices, but such practices are often less profitable and more difficult to manage and growers need financial compensation to motivate them. An aspect of IFP which requires critical examination, therefore, is the motivation of individual growers, co-operatives and fruit producing regions in adopting IFP or similar QA schemes. The strongest motivation, without doubt, is financial reward. Such rewards have to be great enough to offset any increased difficulties or costs as a result of adoption of IFP. Financial reward through a higher price for fruit or the award of government grant as shown by the survey, is pivotal. It is clear that even the smallest increase in fruit price ($<1\%$) is sufficient to motivate growers. Whilst some supermarkets in some countries have recognised the need for such incentives, most have not. The award of substantial grant to growers who achieve IFP standards in some regions is also a strong incentive. Unfortunately, such grants only distort the fruit market unless applied universally.

However, IFP and related QA schemes are adopted widely in many regions where no direct financial reward is immediately obvious though in many regions it is proving difficult to sustain the interest of all growers. A number of important motivating factors are in operation. The first is the desire by individual fruit growing regions to gain a competitive edge and secure market share in a market which is essentially saturated. However, a second factor playing an increasingly important part is the need for effective quality assurance schemes covering both intrinsic and extrinsic fruit quality (Cross and Berrie, 1995). Consumers today are better informed and conscious of environmental and food safety issues. Consumer perceived quality encompasses intrinsic and extrinsic factors. Intrinsic quality parameters are the physical - chemical properties of the fruit itself (texture, flavour, appearance etc) whereas extrinsic quality parameters are associated with the naturalness, environmental and ethical acceptability of production methods and type of packaging material. Fruit producers can gain a competitive edge by improving extrinsic quality and so impact on consumer acceptance of fruit. Quality assurance and hazard analysis procedures are applied universally in the food industry. There is a strong desire to apply such procedures to the primary product and its producers. The pressure for implementation of such procedures has increased significantly with the enactment of food safety legislation which requires all parts of the food industry, including growers, to show due diligence that food is safe. IFP and related QA schemes are liked by the supermarkets and food processors because they pass on the costs and responsibility for such procedures to the grower. Although financial reward has been a significant driving force in the adoption of IFP at least in the short term, these latter general pressures will ensure that it is sustained in the future.

Future directions

Whilst the heat of our enthusiasm in the initial development IFP may have cooled and the initial controversy surrounding IFP has died down, it has now become an accepted and routine part of growing practice in many areas. IFP will be further promoted if it is accepted officially by the European Union (in the same way as has been done for organic agriculture under Reg. 2092/91). We now need to ask where should we go next?

We as scientists and advisors should recognise IFP and related QA schemes as effective means of getting better techniques adopted in practice. A new initiative is needed to reverse the trend towards the declining standards to the lowest common denominator. One possibility is to define much higher, idealistic standards and to start experimental work and grower demonstrations to perfect and promote it. Key components of such a scheme we propose for apples could be as follows:-

1. Scab and mildew resistant cultivars of high intrinsic quality.

2. Single row, intensive planting systems with wide herb species-rich alleys.

3. Soil management using fertigation and organic mulch, or possibly non-competitive ground cover plants.

4. Minimal use of fungicides (a maximum 2 or 3 fungicide applications per annum), timed according to disease forecasting models, to preserve the resistance status of cultivars.

5. A maximum of one broad-spectrum organophosphate or carbamate insecticides of short persistence used per annum before petal fall. Other pests controlled using granulosis virus or highly selective IGRs.

6. Monitoring and control of intrinsic fruit quality.

7. Post-harvest storage in high quality conditions

8. Positive measures to conserve and improve wildlife and the environment in the orchard and its environs.

Such an R & D programme, though highly dependent on new cultivars, would provide a focus for revitalising our enthusiasm for IFP. Will supermarkets and consumers pay 1% more to ensure growers adopt it?

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Table 1. National areas of pome fruit production, regional or national organisations operating and areas and numbers of growers implementing IFP or related QA schemes in 1994.

Country	Total area of pome fruit (ha)	Total no. of pome fruit growers	IFP/QA organisation	Claimed IFP or QA?	Area of pome fruit production (ha)		No. of pome fruit growers	
					Total	IFP/QA	Total	IFP/QA
Austria	5,831	2,720	national	IFP	5,831	4,765	2,720	1,398
Belgium	20,000	1,600	Flanders	IFP	18,500	4,010	1,500	462
			GAWI (Walloon)	IFP	1,500	500	100	38
Denmark	3,444	625	national	IFP	3,444	962	625	104
France	75,000	14,104	Covapi	IFP	477	477	130	130
Germany	38,558	17,500	Baden-Württemberg	IFP	11,719	9,536	12,233	2,840
			Bayern	IFP	1,400	850	500	250
			Brandenburg	IFP	2,894	1,635	60	38
			Hessen	IFP	677	220	?	54
			Mecklenburg-Vorpommern	IFP	1,250	1,092	15	13
			Niederelbe	IFP	9,221	7,694	955	681
			Rheinland	IFP	2,200	1,900	200	140
			Rheinland-Pfalz	IFP	2,280	1,570	3,604	475
			Sachsen	IFP	3,035	2,824	57	49
			Sachsen-Anhalt	IFP	1,776	1,422	38	34
			Schleswig-Holstein	IFP	502	354	112	48
			Südoldenburg	IFP	150	130	20	18
			Thüringen	IFP	1,054	1,034	17	17
			Westfalen-Lippe	IFP	220	180	25	20
Great Britain	17,000	700	GRO-ACT	QA	13,000	13,000	550	540
Italy	71,237		Emilia-Romagna	IFP	27,700	7,750	15,500	1,900
			Valtellina (Lombardy)	IFP	1,400	850	2,800	920
			S.Tyrol	IFP	17,000	12,931	8,051	5,795
			Trentino	IFP	10,047	9,950	8,177	7,708
			Veneto	IFP	15,090	6,500	3,780	1,625
Netherlands	21,000	3,000	national	QA	21,000	14,800	3,000	1,700
Norway	2,300		national	QA	2,300	200	111	
Portugal	25,500	24,000	APAS	IFP	390	390	43	43
			AVAPI	IFP	710	710	87	87
Spain	56,000	11,200	Catalonia (1995)	IFP	319	319	40	40
Switzerland	6,080	4,500	MS/SOV	IFP	6,080	4,347	4,500	1,765
Total	321,950	79,949			183,166	112,902	69,550	28,932

Table 2. Main reasons for non-compliance of guidelines with IFP Euro-guidelines

Country	IFP/QA organisation	Non-Compliance of guidelines with Euro-guidelines			
		anti oxidant	residual herbicide	growth regulator	others
Austria	national				
Belgium	Flanders		✓	✓	
	GAWI (Walloon)		✓	✓	
Denmark	national				
France	Covapi				
Germany	Baden-Württemberg		✓		)
	Bayern		✓		)
	Brandenburg		✓		)
	Hessen		✓		)
	Mecklenburg-Vorpommern		✓		) a maximum of
	Niederelbe		✓		) 4 dithiocarbamate
	Rheinland		✓		) fungicide
	Rheinland-Pfalz		✓		) applications
	Sachsen		✓		) is permitted
	Sachsen-Anhalt		✓		)
	Schleswig-Holstein		✓		)
	Südoldenburg		✓		)
	Thüringen		✓		)
	Westfalen-Lippe		✓		)
Great Britain	GRO-ACT	✓	✓	✓	p.h. fungicide permitted
Italy	Emilia-Romagna	✓			) > 3 dithiocarbamate
	Valtellina (Lombardy)				) fungicide applications
	S.Tyrol				) permitted. Acaricides
	Trentino	✓			) permitted with resitrictions
	Veneto	✓			) S. Tyrol
Netherlands	MTB		✓	✓	soil sterilisation permitted
Norway	national		✓		
Portugal	APAS AVAPI				
Spain	Catalonia (1995)	✓			> 3 dithiocarbamate fungicide applications permitted
Switzerland	MS/SOV		✓ ✓		

Table 3. Control procedures in different IFP organisations

Country	IFP/QA organisation	% Farms controlled	% Fail
Austria	national	>10	4%
Belgium	Flanders†	0	0
	GAWI (Walloon)	100	0
Denmark	national (under development)	20	0
France	Covapi	100	0.8%
Germany	Baden-Württemberg	30	15%
	Bayern	100	0
	Brandenburg	25	7.9%
	Hessen	20	?
	Mecklenburg-Vorpommern	100	0
	Niederelbe	20	3.1%
	Rheinland	33	0
	Rheinland-Pfalz	25	10.1%
	Sachsen	100	6%
	Sachsen-Anhalt	100	2.9%
	Schleswig-Holstein	100	0
	Südoldenburg	20	5.5%
	Thüringen	100	0
	Westfalen-Lippe	100	0
Great Britain	GRO-ACT	20	0.2
Italy	Emilia-Romagna	5.5	21%
	Valtellina (Lombardy)	55	32%
	S. Tyrol	10	47%
	Trentino	10	<0.1%
	Veneto	20	0.6?
Netherlands	MTB	50	22%
Norway	national	0	0
Portugal	APAS	100	0†
	AVAPI	100	0†
Spain	Catalonia† (1995)	100	†
Switzerland	MS/SOV	30-40	<5%

† control systems under development

Tasks and position of the IOBC/WPRS IP-Commission; an evaluation of the role of IP Guidelines I-III

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Abstract

The IOBC/WPRS Commission on "Integrated Production" was established in 1977 and reactivated in 1990 with the task of formulating a basic document which defined Integrated Production/Integrated Farming, described the strategy to follow, described the standards for implementation and appraised the implementation procedure. This basis document has been published in the OIBC/WPRS Bulletin 16(1).

IOBC Guidelines are organized in a hierarchical way. Technical Guidelines I and II set the requirements for the IP-Organizations and their members (Guideline I) and the IOBC Guidelines valid for all farms (Guideline II). Guidelines III refer to specific crops. They are developed by the horizontal Working Groups and they are approved by the Commission. Guidelines I, II and III serve as the reference to evaluate the guidelines of national or regional IP-Organizations.

Any IP-Organization seeking the endorsement of the IOBC must send the requested documents (statutes, guidelines, inspection protocols ...). The documents are evaluated by members of the Commission and of the WG and the Organization is visited in place before a decision is made. The endorsed Organization is entitled to use the sentence *"Endorsed by IOBC"* in its logo. The endorsement is valid for 5 years.

The main aims of the Commission for the future are to encourage the production of more Guidelines III for specific crops, to maintain high IP standards and to close the links with the European Union.

Highlights of the history of the IOBC/WPRS IP-Commission

The Council of the International Organization for Biological and Integrated Control of Noxious Animals and Plants / West Paleartic Regional Section (IOBC/WPRS or, shortly, IOBC, thereafter) decided in the early 1970s to define the IOBC/WPRS position regarding the concept and implementation of Integrated Production (IP, thereafter). A Commission on "Integrated Production" was established in 1977 with the aim of producing an endorsement procedure for IP-Organizations in apple production. An international committee was set up in 1978 to supervise the use of the label by the regional and national IP-Organizations. GALTI (Switzerland) and COVAPI (France) got first a provisional permission to use the IOBC label (1979) and finally an official recognition of their guidelines in 1981.

In September 1990 the Council reactivated the Commission (renamed as "IP-Guidelines and Endorsement"), nominated three new members and gave it the task of formulating a basic document which defined Integrated Production/Integrated Farming, described the strategy to follow, described the standards for implementation and appraised the implementation procedure. As it was stated by Boller in 1993 in the Joint Meeting of the IOBC/WPRS and the International Society for Horticultural Science (ISHS, thereafter) for the approval of the Guidelines for Integrated Production of Pome Fruits in Europe, the following reasons urge the IOBC/WPRS to take action:

- *To stop the progressing erosion of IP concepts in more "advanced" countries and to repair the damage.*

  Some of the eroding factors were i) the lack of a clear IP-concept, which led to many national approaches, ii) the increasing importance of purely economic reasons due to the increasing concern by public opinion on the undesirable effects of conventional agricultural practices, which may led to lower standards, and iii) the creation of governmental IP-rules and guidelines by political and technocratic "experts" without proper scientific and conceptual basis.

- *To provide an uniform (European) basis for the definition of objectives and principles of Integrated Production/Integrated Farming.*

  There was not at that time any known international concept of IP. The IOBC had not developed further the IP concept since 1977, when the focus was put in Integrated Pest Management (IPM). So, a conceptual framework was needed to facilitate the coordination of the technical guidelines of different crops.

- *To stimulate the development of IP in "less advanced" countries by creating adequate technical guidelines.*

  One of the tasks of IOBC Working Groups, and of other organizations such as the ISHS, is to assist in the promotion and development of IP through technical assistance and recommendations to those interested in this support. The creation of high standard technical guidelines may help regional organizations to identify where more research and development are needed.

- *To reward good organizations by recognizing their achievements and by endorsing their products.*

  Some organizations whose members practice IP according to IOBC standards may be interested in letting it know to their clients, as IOBC is a scientific non-profit organization without any implication in the market.

The work of the Commission led to a draft document which was discussed in 1992 in a meeting with 14 representatives of the IOBC Working Groups and the Executive Committee. The final document was published in English, German and French in 1993 as IOBC/WPRS Bulletin 16(1) and in 1995 in Spanish and Italian as IOBC/WPRS Bulletin 18(1).

In 1993 the Executive Committee decided to enlarge the Commission and at present it has five members. The present tasks of the Commission are:

1. To publish the up-dated guidelines at the various levels defined in the IOBC/WPRS Bulletin 16 (1).

2. To evaluate the guidelines submitted by regional IP-Organizations for IOBC endorsement with respect to their conformity with IOBC principles and requirements.

IOBC/WPRS Technical Guidelines on Integrated Production

The basic documents of IOBC/WPRS dealing with IP are:

- Definition and Objectives of Integrated Production (Integrated Farming)
- Technical Guideline I: *General IOBC Requirements for Organizations and their Members practising Integrated Production*
- Technical Guideline II: *General IOBC Guidelines valid for all farms requesting IOBC endorsement*
- Technical Guidelines III: *Specific IOBC Guidelines defining minimum requirements in specific crops or farm sectors*

The first 3 documents are included in the IOBC/WPRS Bulletin Volume 16(1) and their main aim is to define IP and to set the standards that must be reached by the guidelines for specific crops. In order to allow for continuity, these documents will be revised at intervals nor shorter than 5 years, although IOBC reserves the right to make important additions in shorter intervals if necessary. For example, a section on Irrigation will be included in the second edition of Guideline II.

The Technical Guidelines III are developed by the Horizontal IOBC/WPRS Working Groups, either by the whole group or by a subgroup. They specify the standards that must be reached in specific crops and they serve as the reference to evaluate the guidelines of national or regional IP-Organizations. The final version of the guidelines is approved by the Commission.

At present, the Technical Guideline III for Pome Fruits has been approved and the Technical Guidelines III for Viticulture, Arable Crops and Stone Fruits are in preparation.

Endorsement Procedure

The Commission has prepared an Information Package that includes the Recommendations on how to proceed, the Tariffs, the Official Application and Contract Form, the IOBC/WPRS Bulletin 16(1), the Technical Guidelines III approved which are of interest for the organization (the OIBC/ISHS Guidelines for Integrated Production of Pome Fruits in Europe, at this moment) and the General Evaluation Scheme. The aim of this Information Package is to allow the IP-Organization to check whether their statutes, guidelines, inspection system and other relevant documents and procedures adjust to IOBC standards. The IP-Organization can then decide whether to apply for OIBC endorsement or not.

Figure 1 shows the scheme of the IOBC/WPRS endorsement procedure. Any association of growers seeking the endorsement of the IOBC must send an Application Form to the Secretariat of the IP Commission which acts as a contract between the organization and the IOBC. The IP-Organization declares that it submits the guidelines voluntarily and in full knowledge of the evaluation schemes applied by IOBC and that they will not challenge by legal action any decision taken by the Commission. The IOBC Commission declares that the results of the evaluation will be handle with appropriate discretion, that the name of the organization will be put in an annual list of endorsed organizations, and that the endorsed organization will be entitled to use the following text on its logo "Endorsed by IOBC/WPRS".

PROCEDURE FOR IOBC ENDORSEMENT

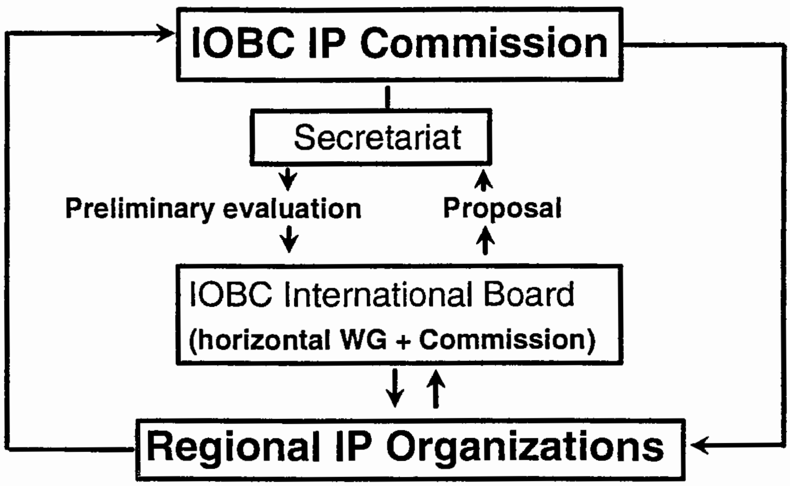

Figure 1. Scheme of the endorsement procedure

The following documents have to be submitted with the Application Form:

1. Completed general information about the applying organization.
2. Copy of the contract between the organization and the individual members.
3. The statutes (by laws) of the organization.
4. Most recent published guidelines.
5. Most recent published guidelines for labels (where available).
6. Most recent documents on inspection and evaluation procedures
7. Documents of introductory and current training course
8. Currently used checklists for
   - field inspections
   - farm records
   - handling and labeling of certified products.

The Secretariat of the Commission carries out a first evaluation of the documents to check that none is missing. The Commission also carries out an evaluation of the documents, checking whether they fulfill the requirements of Technical Guidelines I and II.

The guidelines that pass this first evaluation procedure are sent to the International Board, where members of the horizontal IOBC Working Groups and members of the Commission are involved. The International Board checks the adjustment of the guidelines of the organization to the Technical Guideline III and carries out an *in situ* visit to the organization.

The endorsement is valid for 5 years, but an annual re-evaluation is carried out. The organization must send every year the documents of the current year with clear indications of the changes made.

It is important to state that the IOBC/WPRS does not endorse individual farms nor certify products. The actual certification of products (labels) has to be carried out by the endorsed organization.

The endorsement procedure was opened in January 1995 and an announcement was published in many technical journals in several European countries. Several information packages have been requested to the Secretariat and some organizations are preparing the documents.

Some words about the future

The main aims of the Commission for the Future are:

1. To encourage the production of Guidelines III.
Although the final responsibility lies on the Horizontal Working Groups, we feel that Guidelines for all possible crops are needed, in order to wide the range of grower organizations that may be interested in IOBC endorsement.

2. To maintain high IP standards.
We are aware of the commercial implications that the words "Integrated Production" or "Integrated Farming" may have and we think that they may support the adoption of IP practices. But, the increase of the adoption of IP must not be done at the cost of lowering the standards.

3. To close the links with the European Union
Some Governmental bodies of the European Union are involved in supporting IP activities (we must remember here the 2078 Directive, for example). To close the links with EU is of the higher importance, as we think that IOBC has the expertise needed in IP. It would be desirable for Integrated Production that the EU would accept IOBC/WPRS Guidelines as the standards for IP.

Acknowledgments

I am specially grateful to Dr. Ernst Boller for the permission to reproduce part of the talk he presented in Bologna, 3 - 5 may 1993.

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An evaluation of plant protection practices according to IFP guidelines compared to current commercial practice

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Abstract

The publication of UK Guidelines for Integrated Fruit Production (IFP) in 1991 provoked considerable concern amongst UK growers, who felt that the standards were too difficult to achieve and would lead to unacceptable levels of pest and disease damage and increased costs. The main areas of concern were: (1) the concept of "treatment according to need", (2) restrictions to the use of only certain permitted pesticides; (3) no use of post-harvest treatments; (4) no use of residual herbicides. In 1991 a replicated trial was established on a commercial fruit farm with the objective of demonstrating the feasibility of producing fruit according to IFP Guidelines in the UK, in comparison with current farming practice. In particular, the concerns of growers as specified above were addressed. The study demonstrated over 4 years that scab and mildew control in IFP was as good as or better than that achieved by conventional production and often with reduced fungicide inputs and costs, particularly where the VENTEM™ scab warning system was used to assist in decisions on sprays. Similarly, control of *Adoxophyes orana*, the main pest identified, was improved in IFP compared to conventional production but with marginally increased insecticide use. Prediction of post-harvest rotting in store, based on pre-harvest assessment of rot risk in the orchard, indicated a low risk in each of the 4 years which was subsequently confirmed by mean losses of $<1\%$ in untreated stored fruit assessed in March. Weed control in IFP, using contact herbicides, was also commercially acceptable.

The study has demonstrated the feasibility of IFP, but has shown that increased management costs are usually required to operate it.

Introduction

Guidelines for Integrated Fruit Production (IFP) were first published in the UK in 1991 (Cross *et al*, 1991). Although well received by supermarkets, they provoked considerable concern and debate among UK growers, who felt that the standards were too difficult to achieve and would lead to unacceptable levels of pest and disease damage and increased costs.

There are 36 standards within the guidelines. Many of these are consistent with good agricultural practice and should therefore already be a part of current fruit production systems. The main areas of concern are as follows:

(1) The concept in IFP of treatment according to need requires that decisions for control of orchard pests and diseases must be based on risk assessment using information gained from orchard monitoring and weather. Many growers already practise orchard

monitoring for pests but decisions on treatment are more likely to be based on presence rather than a defined threshold. For diseases such as scab and mildew, the use of routine sprays from bud burst to harvest is however still very much the conventional approach. Any departure from this system is equated by growers with a guaranteed increase in damage due to disease, particularly scab. In addition, the requirement in IFP to carry out formal orchard assessments and maintain records is also considered too costly in management input.

(2) Pesticide use is restricted under IFP and only those products which are least toxic, least persistent, most selective and with minimal side effects on beneficial organisms, are permitted. Since the more selective pesticides tend to be more expensive these restrictions are perceived by growers to lead to increased costs.

(3) Under IFP, the use of post-harvest fungicide treatments for control of storage rots is not permitted. Since their introduction in the 1970s, post harvest fungicide treatments have been used routinely for control of rots in Cox regardless of need, and have provided a cheap and effective means of control (Berrie, 1989, 1992). Growers are reluctant to abandon such treatments, and fear a return to the losses in Cox experienced in the 1960s (Preece, 1967) before post harvest fungicide treatment was introduced.

(4) The use of residual herbicides is not permitted under IFP and in conventional systems simazine in combination with other residual herbicides is used in the autumn for weed control in the herbicide strip. Alternative control, using contact herbicide is thought to be less effective and more costly.

Although the UK guidelines were published, the feasibility of the production system, including integrated orchard protection, has not been demonstrated in commercial practice. The purpose of the trial described here was to demonstrate the feasibility of the system in the UK and in particular to address the concerns of growers outlined above.

Materials and Methods

In 1991 a trial site was established in a commercial apple orchard of cv Cox on MM106 rootstock, in Kent in South East England. At the site, crop protection according to UK IFP guidelines was compared with current commercial practice in large plots (5 rows of 70-72 trees), each treatment being replicated three times and fully randomised (randomised complete block design). Untreated plots were included to indicate pest and disease incidence and were not part of the experimental design. All pesticide sprays were applied by farm staff using a tractor-trailed axial fan orchard air blast sprayer (mist blower), at 100-150 litres/ha. Herbicide treatments were applied using a tractor mounted sprayer.

Decisions on chemical treatment (choice of product and rate) in the IFP plots were based on the results of regular plot assessments. The centre row in each plot was assessed for pests, diseases and weeds every two weeks from green cluster to harvest, according to the assessment schedule in the IFP guidelines (Cross *et al*, 1991, Cross and Berrie, 1994). Secondary mildew was assessed on extension growth according to the method of Butt and Barlow (1979). In 1991 and 1992 decisions on scab control were based on crop growth stage, disease incidence and local scab warnings (Smith periods) and weather information obtained from the nearest Meteorological Office Station at RAF Manston (approximately 10 miles away). In 1992 a METOS automatic weather station (Gottfied Pessl, Weiz, Austria) was installed in the orchard. In 1993 and 1994 decisions on scab sprays were based on information derived from the PC-based VENTEM™ scab warning system (Xu *et al*, 1993), using the key stage strategy (Butt *et al*, 1994). The timing of insecticide sprays for *Archips podana* and *Cydia pomonella* were based on threshold pheromone trap catches and for *Adoxophyes orana* on egg hatch sums from the first significant (> 10 moths/trap) pheromone trap catch. In July and September the plots were assessed for storage rot risk (Berrie, 1993) to determine the need for pre-harvest sprays for control of storage rots.

All treatments on the conventional plots were applied according to the growers conventional farm practice and were based on crop growth stage, experience and a brief orchard walk to determine pest presence. Fungicide sprays were applied routinely on a 14 day schedule.

At harvest 1000 fruits were picked per plot and assessed for pest and disease damage. Fruit from the centre row in each plot were harvested into bins and either drenched (conventional) with a fungicide pre-storage or left undrenched (IFP). The fruit was stored commercially in a controlled atmosphere store at 3.5-4°C and 2% oxygen until the following March. After storage 1000 fruits from each plot were assessed for rots.

Results

Orchard Monitoring

Assessments of pest, disease and weeds in IFP plots to determine treatment need took approximately 30 minutes to complete on 25 trees. Ten such assessments were made per season. In addition weekly visits were made to monitor pheromone traps and in 1993-94 to download the METOS weather station. Therefore around six hours per 25 trees per season was spent monitoring; compared to around two hours per 25 trees per season for conventional plots.

Pests

The pest species recorded in the orchard are shown in Table 1. *Adoxophyes orana* was the most damaging pest recorded in each of the four years (Table 1). Overwintered caterpillars caused damage to blossom and young fruitlets with up to 46.7% of blossoms infested in untreated plots (1992) (Table 2) followed by two generations per season. First generation caterpillars in June and July initially fed on leaf rolls in shoots (up to nearly 50% shoot infestation) and then on fruit whereas the second generation caterpillars, which usually arose from eggs laid directly on fruit, caused damage just prior to harvest. High numbers of moths were recorded in traps ranging from 40-309 in June to 85-241 in August. Most of the insecticide applied post blossom (Table 3) was directed at control of *A. orana*. Use of chlorpyrifos gave some control but was not completely effective and required multiple applications. The least damage to fruits and shoots was consistently recorded in IFP plots (Table 2) where application of chlorpyrifos was timed according to egg hatch sums. The use of carbaryl in conventional plots in 1991 proved completely ineffective, and resultant shoot and fruit damage was similar to that in untreated plots. Results with *Bacillus thuringiensis* (Biobit) were inconsistent.

Table 1. Pest species recorded and number of times in 4 years that pesticide action was needed in IFP/conventional comparison trial Wingham, Kent, UK. 1991-94.

Pest	Number of times action needed
Aculus schlechtendali	0
Panonychus ulmi	0
Adoxophyes orana	12
Archips podana	3
Cydia pomonella	3
Operophtera brumata	0
Orthosia incerta	0
Phyllonorycta blancardella	0
Hoplocampa testudinea	0
Dysaphis plantaginea	3
Rhopalosiphum insertum	3
Aphis pomi	0

Table 2. Assessment of infestation of *Adoxophyes orana* in blossoms and shoots and fruit damage at harvest, Wingham, Kent, UK. 1991-94.

Assessment stage	Treatment	Year			
		1991	1992	1993	1994
Pink bud	IFP	10.7	27.3	3.0	8.0
% infested	Conventional	8.0	18.0	3.7	10.8
rosettes	Untreated†	7.5	46.7	15.0	6.7
% infested	IFP	15.0	19.2	17.8	13.9
shoots	Conventional	38.3	25.7	30.6	27.5
summer	Untreated†	42.0	49.3	40.0	25.0
% fruit	IFP	1.8	1.1	2.0	3.0
damage	Conventional	3.1	1.4	2.3	6.3
harvest	Untreated†	2.5	3.4	3.1	9.2

† unreplicated indicator plots

Pre-blossom insecticide sprays were mainly targeted at aphids (*Dysaphis plantaginea* and *Rhopalosiphum insertum*). Adequate control was achieved by use of either chlorpyrifos or pirimicarb.

Phytophagous mites were adequately controlled by *Typhlodromus pyri* and intervention with an acaricide was not required in any year.

Insecticides (Table 3) were applied at reduced dose in IFP, but despite this, actual usage was greater than in conventional plots, mainly due to increased use of chlorpyrifos for control of *A. orana*. This however did result in consistently better control of this pest in IFP. Insecticide costs in IFP were consequently greater (Table 3), due also in part to the use of more expensive selective insecticides pirimicarb and diflubenzuron.

Table 3. **Pesticide use shown as total number of applications and dose equivalents, and annual costs (£/acre) in IFP/Conventional comparison trial, Wingham, Kent, UK. 1991-94.**

Year	Insecticide				Fungicide			
	IFP		Conventional		IFP		Conventional	
	No. applications (dose equiv.)	cost	No. applications (dose equiv.)	cost	No. applications (dose equiv.)	cost	No. applications (dose equiv.)	cost
1991	6 (4.7)	39	5 (3.3)	24	19 (11.7)	101	18 (9.7)	83
1991	7 (5.4)	39	5 (3.9)	35	17 (9.2)	80	12 (5.7)	56
1993	4 (3.5)	31	5 (3.0)	26	13 (9.2)	93	16 (6.8)	80
1994	6 (4.1)	43	5 (3.8)	35	12 (5.8)	68	19 (9.5)	106

Diseases

In 1991 scab risk (Table 4) was low in March - May. No scab was recorded on rosettes in treated or untreated plots (Table 5). Consequently scab sprays (dithianon, penconazole) were terminated at the end of June in IFP plots and one month earlier in conventional plots. Favourable weather in June resulted in scab infection on shoots which increased to 30% in untreated plots. Scab levels on fruit at harvest were negligible. Scab levels in 1992 were also negligible on fruit and shoots in the sprayed plots, but rose to 15% scabbed fruit in untreated plots with 93% of leaves showing late scab infection in October. In both years fungicides were applied at reduced dose in IFP plots (Table 3), but despite this, fungicide use and consequently costs were greater on IFP plots than conventional (Table 3). In 1993 and 1994 VENTEM scab warnings (Table 4) were used to assist spray decisions. In 1993 scab risk in March - May was again low and no scab was recorded in IFP or conventional plots but reached 86.7% of shoots and 26.7% of fruit infected on untreated plots. VENTEM scab warnings were used practically in a key stage strategy. This resulted in fewer applications than in conventional but despite using fungicides (dithianon, captan, penconazole) at reduced dose, the overall use was greater in IFP than conventional where lower doses had been applied (Table 3). In 1994 the scab risk was high with 11 periods recorded in May. Negligible levels of scab were recorded on sprayed plots but over 80% of shoots and fruit were infected in unsprayed plots. VENTEM scab warnings were used in a modified key-stage strategy, being applied routinely at the key stages of bud burst and petal fall, and at other times according to the scab risk but taking into account other requirements for pest and nutrient sprays. The decisions followed are shown in Table 6. The new strategy resulted in fewer sprays and reduced fungicide use and costs compared to conventional (Table 3).

Table 4. Record of apple scab periods, Wingham, Kent 1991-94

	1 Smith periods		2 VENTEM™	
Month	1991	1992	1993	1994
March	0	0	0	0
April	3	2	2	3
May	1	2	4	11
June	13	3	4	3
July	8	8	9	5
August	2	8	5	8
September	7	5	11	13
October	-	-	18	20

1. Smith periods recorded at Manston, Kent (Smith periods are Mills periods based on relative humidity rather than leaf wetness).
2. VENTEM™ periods recorded at Wingham, Kent

Levels of primary mildew were low (<1%) in sprayed plots in all years, but rose in untreated plots to 3.7% in 1994 (Table 7). Levels of secondary mildew were low and similar on both IFP and conventional plots, but were achieved with lower fungicide (penconazole, bupirimate, nitrothal-isopropyl) use in IFP plots. Secondary mildew levels on untreated plots were high, rising to 80% of leaves infected.

Table 5. Assessment of apple scab on rosettes, shoots, fruits and leaves Wingham, Kent, UK. 1991-94.

Assessment stage	Treatment	Year			
		1991	1992	1993	1994
% infected	IFP	0	0	0	0
rosettes	conventional	0	0	0	0
May	untreated†	0	0	0	56.7
% infected	IFP	2.0	0	0	0
shoots	conventional	6.8	0	0	0
summer	untreated†	30.0	10.0	56.7	85.0
	IFP	0	0.03	0	0.2
% infected	conventional	0	0.1	0.03	0.3
fruit-harvest	untreated†	0.07	15.5	26.7	80.3
% infected	IFP	4.5	2.2	0.9	4.8
leaves (late scab)	conventional	8.7	0.7	2.0	3.8
October/November	untreated†	22.8	93.0	92.8	96.5

† unreplicated indicator plots

Table 6. Factors taken into account when making scab spray decisions, Wingham, UK. Kent 1994.

Timing	VENTEM™ scab risk	Other factors requirements	Decision (% recommended dose) on treatment
16/3 (bud burst)	key stage	none	dithianon (75)
31/3	nil	rain forecast Easter (holiday)	dithianon (33)
11/4	nil	pest above threshold + urea spray	dithianon (25)
26/4	very low risk	mildew + urea spray	penconazole + dithianon (36)
11/5 (petal fall)	key stage/risk	aphids above threshold + mildew	penconazole + dithianon (75)
30/5	mod risk	none	captan (67)
7/6	low risk	rain forecast	captan (33)

Table 7. Assessment of primary (% mildewed blossom) and secondary (% mildewed leaves), Wingham, Kent, UK. 1991-94.

Assessment stage	Treatment	Year			
		1991	1992	1993	1994
Primary blossom	IFP	0.5	0.3	0	0.7
mildew-April	conventional	0.4	0.2	0	0.6
% mildewed blossoms	untreated†	0.3	1.7	2.8	5.7
*Secondary mildew	IFP	0	0	0	0
*May	conventional	0	0.7	0.1	0
	untreated†	7.0	13.3	27.0	2.5
*Secondary mildew	IFP	2.5	1.9	2.2	0.5
*early June	conventional	1.3	0.3	1.3	1.2
	untreated†	38.0	25.3	36.0	38.0
*Secondary mildew	IFP	6.5	2.4	2.3	1.7
*late June	conventional	3.5	2.1	0.4	0
	untreated†	38.0	2.0	22.0	38.0
*Secondary mildew	IFP	2.8	0.5	3.5	1.7
*early July	conventional	1.7	1.7	3.8	2.2
	untreated†	26.0	4.0	49.0	80.0
*Secondary mildew	IFP	1.2	0.7	7.0	3.2
*late July	conventional	1.3	0.7	6.8	5.0
	untreated†	4.0	10.7	41.0	80.0
*Secondary mildew	IFP	6.3	-	5.2	3.7
*August	conventional	6.0	-	4.0	7.3
	untreated†	16.0	-	80.0	67.0

† unreplicated indicator plot
* % mildewed leaves

Storage rots

In 1991 a potential risk of *Monilinia fructigena* and *Phytophthora syringae* was identified and a 3 spray programme (2 x captan and 1 x thiophanate-methyl) applied in July and August. In subsequent years one or two sprays of captan were applied pre-harvest, but in general the orchard assessment indicated a low risk of rotting in each of the years. Conventional plots received a post-harvest drench of metalaxyl + carbendazim. In each of the years losses due to rots in IFP plots (Table 8) were <2% and similar to conventional. In 1991 losses due to rots in conventional plots were nearly twice that in IFP.

Table 8. Percent losses due to storage rots in IFP/conventional comparison trial, Wingham, UK 1991-94, assessed in February after controlled atmosphere storage at 3.5°C and 2% oxygen

Year	% loss IFP	% loss Conventional
1991	1.6	3.3
1992	1.4	1.5
1993	0.7	0.7
1994	0.8	0.7

Weeds

The main weed problems were caused by grass species (*Poa annua*, *Poa trivialis*) and thistles (*Cirsium arvense*). Other weeds present included *Sonchus* spp, *Solanum nigrum*, *Polygonum* sp, *Senecio vulgaris*, *Gallium aparine* and *Chenopodium album*. In IFP, weed control was centred around the use of amitrole in the autumn and pre blossom, and glufosinate post blossom. Codacide oil was also added occasionally to enhance control. Mowing off weeds was occasionally necessary prior to herbicide application. Weed control was adequate in IFP but did not maintain a weed-free strip as in conventional plots. In the latter, weed control was achieved by the use of residual and contact herbicides, mainly simazine, in the autumn and glufosinate post-blossom.

Sedum acre was established in some plots to evaluate its potential as a ground cover species. The plant, once established, prevented any weed growth apart from thistles, and proved resistant to all herbicides applied.

Discussion

The pest and disease control achieved in IFP was of a high standard and similar to that achieved using conventional production methods. The term conventional refers to current commercial practice, however, in the UK there is considerable variation in current orchard practice. Most growers now practise Integrated Pest Management (IPM) which is centred around the conservation of the predatory mite *Typhlodromus pyri*. This system has developed as a matter of necessity to control phytophagous mites - *Panonychus ulmi* and *Aculus schlectendali*. The use of routine sprays for control of apple scab and powdery mildew is normal practice, although most growers apply fungicides at reduced dose in order to save costs. This is also true for certain insecticides.

Overall insecticide use was greater and therefore cost more in IFP despite a reduction in total dose applied compared to the full product label recommendation. This was due in part to the use of more expensive selective pesticides (pirimicarb and diflubenzuron) and also due to the use of more applications at higher dose of chlorpyrifos for the control of *A. orana*. Other related preliminary studies had shown that populations of *A. orana* at the site were becoming less sensitive to chlorpyrifos (Cross pers. comm). This spray regime consistently gave good control of *A. orana*, but such intensive use of a broad spectrum OP, particularly near harvest, is unacceptable in IFP. Current research is evaluating alternative strategies for control of *A. orana* including the use of granulosis virus and the juvenile hormone analogue insect growth regulator fenoxycarb for use in the UK. Reduction in the use of OPs is unlikely to occur until these alternative methods of control become available.

At the trial site, the grower usually sprayed for scab and mildew control on a 14 day schedule. These sprays were generally applied at doses lower than recommended to save costs. Consequently the differences in fungicide rates used between conventional and IFP were very small, despite the reduced doses used in IFP plots. By monitoring powdery mildew levels it was possible to achieve a lower fungicide use at the end of the season. However with apple scab, where the attendant risks of fruit damage are much greater, dose reductions in IFP were more difficult to achieve in 1991-92 based solely on available weather data and orchard scab assessments. The grower with his greater experience of the orchard was able to make with confidence further reductions in dose in the conventional plots. In 1993-94 decisions on scab treatment were assisted by information on scab risk from VENTEM™. In 1993, three fewer sprays were applied in IFP, but this still resulted in greater fungicide use compared to conventional, since higher doses were applied overall. In 1994 a different strategy was adopted in which the use of VENTEM™ warnings were combined with requirements for pest and nutrient sprays. This more rational approach achieved considerable savings in fungicide and costs, even in a year of exceptionally high scab risk. This study has demonstrated how use can be made of scab warnings to improve disease control and minimise fungicide use.

The use of rot risk assessments successfully predicted a low rot potential for the trial orchard. Rot risk analysis can be used to determine the need for pre-harvest sprays, but lends itself much better to the use of post-harvest treatments, where a decision on treatment can be delayed until all the facts are known. Current UK guidelines (1992) do not permit the use of fungicides post-harvest, although their use is allowed in European standards. They will be included in the next revision of the UK guidelines.

Weed control was adequate in IFP, although there was a need to tolerate a higher incidence of weeds, than in conventional production. The main problems encountered were higher costs and timeliness of treatment. In general the use of amitrole in the autumn maintained good weed control until the following spring, usually just prior to blossom. Further treatments of either amitrole or glufosinate were planned but could not often be applied at the ideal weed growth stage because weather (wind) or the orchard growth stage (blossom) were unsuitable. Use of certain types of residual herbicide may therefore have advantages both for crop husbandry and environmentally, and their use in IFP should be reassessed.

One of the principle aims of IFP is a reduction in the use of pesticides. However balanced against this is an increase in management costs arising from the need to make orchard assessments and keep accurate records. The average size of fruit farms in the UK is around 20-30 hectares, and the time spent at orchard monitoring can therefore be considerable. However, once experience in monitoring is gained the full procedures are not usually needed. Properly designed forms and/or use of computer systems can also minimise paperwork.

The results presented here demonstrate the feasibility of the IFP system under commercial conditions. The long term use of selective pesticides is likely to result in the build-up of new pest problems, which only a long term study can identify. The potential for reducing fungicide inputs by disease monitoring and use of scab warning systems has been clearly demonstrated. However such reductions on susceptible cultivars such as Cox and Bramley can only be limited and depend on weather conditions. Greater reductions in fungicide use can only be achieved by the use of scab/mildew resistant apple cultivars. This approach is currently being investigated in a new trial at HRI - East Malling.

Acknowledgements

The authors wish to thank The Ministry of Agriculture, Fisheries and Food for supporting the research described in this paper. Particular thanks are due to Mr. Ian Chandler of Chandler and Dunn Ltd for providing the trial orchard and for his help and that of his staff in conducting the trial.

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Activities of the subgroup : "Integrated control of pome fruit diseases"

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In 1985 a meeting of phytopathologists was suggested at the symposium "Integrated Plant Protection in Orchards" held in Wageningen, the Netherlands.
The need for such a meeting grew from the idea that to attain the goal of fully integrated crop protection the Working Group would have to address pathogens as well as pests. In that time the emphasis of the parent Working Group was on pests and its meetings were attended mainly by entomologists.
It has been considered necessary that in the future the control of the most important fungal diseases on apples and pears should be included to a larger extent in the concept of the integrated pest management.
A subgroup was formed to deal with diseases and it was proposed to hold the first meeting in August 1987 in Lana, Italy.

1. Lana (Italy)

The meeting has taken the form of a Workshop confined to scab, powdery mildew, canker and storage diseases and the programme covered the following topics :

1. Biology and epidemiology of the fungus :
   Determination of infection conditions and infection periods.
2. Disease assessment : damage thresholds, action thresholds and economic injury levels.
3. Chemical control : products, timing of treatments forecasting, warning systems and spray schedules.
4. Effects and side-effects of fungicides on target and non-target organisms, resistance, toxicity to men and environment, side effects on vegetative growth and cropping, phytotoxicity (e.g. reduced pollen germination, increased leaf fall and fruit skin russeting).
5. Non chemical or alternative control methods : antagonism of organisms on leaf surfaces, resistant varieties of apple and pear, urea sprays, dormant kill by surfactant sprays in winter, pruning, etc...

Dr. Dennis Butt was asked to coordinate the initiative.
Dr. Oberhofer should be the local organizer.

MacHardy (Research needs for improving apple scab warning systems, Department of Botany and Plant Pathology, University of New Hampshire, Durham 03824, USA) made a critical analysis of published lab and orchard studies of Apple Scab Warning Systems and suggests that one method for determining the length of leaf witness (based on the daily periodicity of ascospore discharge); one "infection curve" for predicting primary infection periods (modified from Mills curve for light infection and also based on the daily periodicity of ascospore discharge) and one "infection curve" for predicting secondary infection periods should be reliable in most, if not all, localities.

Two variables that may dictate an adjustment of the infection curves are inoculum potential and cultivar susceptibility to scab.
This work leads to the implementation of new factors in the meteorological recording and warning instruments and to the introduction of the Mills/a-3 infection curve for predicting primary infection periods.

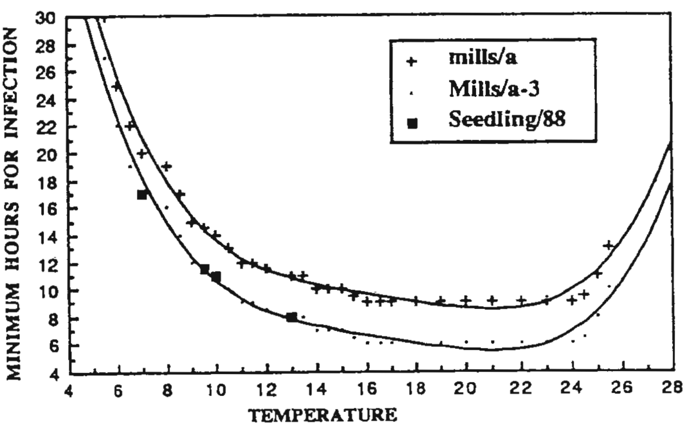

Fig. 1 : The relationship between the hours of leaf wetting, temperature, and leaf infection by ascospores of *Venturia inaequalis*. The "Mills/a" curve was derived from Mills. The "Mills/a-3" curve lowers the "Mills/a" curve 3 hours to compensate for the daily periodicity of ascospore discharge. Seedling/88 (solid blocks) refers to four instances in 1988 when foliar scab lesions occurred on potted McIntosh seedlings placed in an orchard during a rainy period and kept wet for the number of hours indicated.

In Lana also new strategies for chemical control of scab were presented.
The introduction of different sterol-inhibiting fungicides allows us to realize the treatments at the right time after an infection with a sufficiently long safety margin.
The application of the curative control method involves a smaller amount of spray applications because each application is well-considered and only realized when all conditions for infection have been fulfilled.
As an anti-resistance-strategy combinations of SBI-fungicides and classic protectants were proposed (Creemers, New strategies for control of scab on apple and pear, Opzoekingsstation van Gorsem, Sint-Truiden, Belgium).
The participants at Lana recommended that the parent Working Group should form a subgroup "Orchard Diseases" and stated the following objectives :

1. To reduce the usage of fungicides before and after harvest
2. To search for biological control agents
3. To promote the breeding and introduction of varieties with durable resistance against multiple diseases

4. To make chemical and non chemical control methods compatible
5. To avoid harmful side-effects of fungicides on the environment, the crop and beneficial organisms used in IPM programmes
6. To develop and implement disease forecasting and infection warning systems
7. To develop and use pathogen and disease assessment methods
8. To determine disease damage thresholds and adopt action thresholds
9. To facilitate the exchange and dissemination of information, collaborative studies and standardisation of methods.

2. Brissago (Switzerland)

The second workshop on integrated control of pome fruit diseases was held at Brissago, Switzerland.
The agenda was again limited to apple and pear but broadened to include bacterial pathogens.
The programme concentrated on techniques for the better timing of interventions by growers and on the production and testing of cultivars with stable resistance to pathogens.
Papers were also included on side effects of fungicides and on the integration of pest and pathogen control.
As at Lana a session was allocated to storage diseases and the complexity of the orchard system had been exposed.
At that meeting Solomon (The conflict between pest and disease control in orchards, AFRC, Institute of Horticultural Research East Malling Maidstone, Kent, ME19 6BJ England) reported about the conflict between pest and disease control in orchards.
The fungicides used in apple and pear pathogen management programmes can influence the phytophagous pests and predatory and parasitic insects and mites present on the tree. Whilst any toxicity of fungicides to pest species is usually welcomed, the same effect on natural enemies of pests is potentially damaging to integrated pest management (IPM) programmes. An understanding of these possible side effects of fungicides is necessary if an undesirable conflict between phytopathological and entomological requirements is to be avoided.
There is a high possibility of fungicides having an impact on pests, beneficials, and on the strategy for managing them. The fungicide programme may indirectly influence pest management philosophy, increasing the likelihood of a decision to apply an insecticide or acaricide. More likely to cause problems for pest management, however, are the toxic side effects of fungicides on predators. Some of these effects are not acute, and are, therefore, difficult to detect. Nevertheless, they influence pest management; an understanding of these effects is necessary if conflicting requirements in the management of pathogens and pests in orchards are to be avoided.

In Brissago the most important recommendations for future work were focused on.

1. Disease assessment :
In general we need better understanding of principles of disease measurement, assessment must be quantitative and qualitative, the method must be adapted to particular disease and purpose and standardization must be strongly encouraged.
We need more use of damage, action and economic thresholds.

More specific the subgroup recommends :

1. Assessment of effective PAD of scab (the potential ascospore dose defined as the seasonal production of ascospores per m² orchard floor in the amount of ascosporic primary inoculum)
2. To determine incidence/severity relationship
3. To determine the economically tolerable level of disease on fruit.

2. Epidemiology and forecasting :
In general we need more knowledge of biology and epidemiology of pathogens and diseases.
We have to quantify parameters of an epidemic (latent period length, sporulation quantity, infection period length, extension of lesions, etc.) on different cultivars (not only scab resistant cultivars).
We need modeling of epidemics to evaluate the effect of changing the value of certain parameters through breeding and/or cultivation methods.

More specific :

1. The qualification of infection periods and the importance of conidia in primary inoculum
2. Weather monitoring instrumentation must be reprogrammable and data storage and interactive units are desirable.
   High resolution 48 hour weather forecasts would be very useful.
3. We need information on degradation of chemicals.

3. Genetics of hosts and pathogens :
The most important thing is the stability of resistance.
Specific for genetics of host : the genetics of resistance in apple to scab and mildew must be understood.

1. Minor genes of additive effect in commercial cultivars must be considered as well as in resistance sources.
2. We need to determine the mechanisms of resistance of different resistance genes at ultrastructural and biochemical levels.
3. We have to study and use V-genes other than Vf and new genes.

In genetics of pathogens the genetic systems and life cycles of different pathogens must be considered.
We must determine :

1. The variation for virulence and fitness in populations of races of the pathogens
2. The epidemiology of different races of pathogens
3. The distribution of races (geographic and frequency in the population).

4. Cultivar development :

1. In general we have to establish clear priority of quality requirements and relative priority among diseases and pests in relation to the country and prospective markets.

2. International coordination is essential to avoid duplication as much as possible but essential work should be repeated independently.
3. Testing of disease/pest resistant cultivars is critical and storage disorders are critical criteria. We need rapid submission of information and pathogen isolates to originating breeding team.

5. Integration of pest and disease management

Effects of fungicides on predatory mites :

1. It is clear that small effects, or effects on only one stage in the life cycle are not serious if a fungicide is applied only once. Such effects may be difficult to detect in single-application tests. The problem is that fungicides are applied many times during a season. While not offering a subsitute for field experiments, models can show clearly the importance of a small effect of a frequently applied fungicide; it disrupts the predator/prey relationship, leading to an outbreak of spider mite.
2. In fungicide trials there may be a great deal of potential information on effects of fungicides on predatory mites. There is a valuable opportunity for collaboration between the pathologist and the entomologist. If we avoid the use of acaricides and acaricidal insecticides in those trials, then mites can be sampled so acaricidal effects of fungicides can be detected.
3. Effect of sulphur on phytoseiid mites is an example.

6. Storage diseases

The objectives are :

- Reduce use of fungicides before and after harvest.
- Avoid harmful side effects of fungicides on beneficial organisms and the environment.

1. Breeding: must do effective early selection for resistance to fruit storage diseases to obtain new cultivars that combine high quality, disease resistance and good storage potential.
2. Cultural measures: a) Reduction of infection pressure by: (i) Proper picking time, (ii) Avoidance of bruises and other injuries, (iii) Elimination and control of cankers
   b) Increased natural resistance by influencing the mineral composition (Ca).
3. Technical measures: Cool fruit promptly at the lowest temperature in controlled atmospheres.
4. Chemical measures:
   There are two questions :
   a) How to avoid or to inhibit resistance?
   b) How to control fungal diseases already resistant?
   Possible solutions are :
   1. New compounds
   2. Post harvest treatments : dipping, drenching, fogging.

In order to minimize the use of fungicide sprays shortly before harvest for control of storage diseases, post harvest fungicide treatment of fruit is recently permitted in the second edition of Guidelines for Integrated Production of Pome Fruits.

1. Only on cultivars with a moderate to high susceptibility to storage rots.
2. Only fruit with a significant risk of storage rots but which is otherwise suitable and intended for long term storage.
3. Residues must not be greater than for pre-harvest treatment.

3. Lofthus (Norway)

The third Workshop on Integrated Control of Pome Fruit Diseases organised by the subgroup "Orchard Diseases" of the IOBC/WPRS Working Group "Intergrated Plant Protection in orchards" was held in 1993 at Lofthus, Norway..
As before, the agenda was limited to diseases of apple and pear.
Session topics covered integrated fruit production, fungicides, computer-aided disease management, molecular biology, apple scab, storage rots, cankers and fireblight.
During this workshop Parisi clearly demonstrates that the Vf resistance present in recently released cultivars and selections is overcome by the Ahrensburg inoculum of ***Venturia** inaequalis.*
These results emphasize an urgency for defining new breeding strategies.
A second thing pointed out is the increasing computer application in the management of diseases.
Xu (Computer applications in the management of diseases in horticultural crops, Plant Pathology and Weed Science Department, Horticulture Research International, East Malling, West Malling, Kent, United Kingdom) Fruit production is becoming more complicated as the principles of integrated fruit production (IFP) are adopted by growers. This complexity is accompanied by an increase in the quality and quantity of information for decision-making.

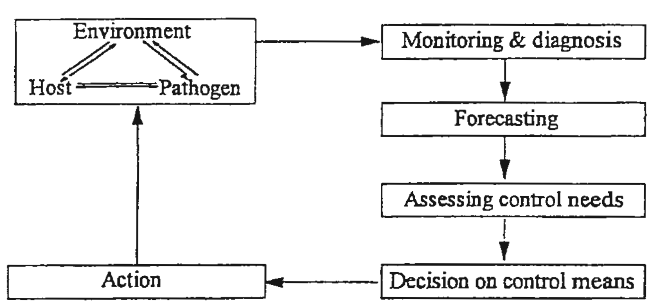

Fig. 2 : Diagram of rational management

Computers can be used to store, retrieve, organise and interpret information. This information, taken from sources such as technical reports, computer simulations and experts, can be in forms of text, graphics, video images and sound.
In the last twenty years, computers have begun to play an increasingly important role in plant disease epidemiology and control. The impact has been on areas such as environment

monitoring, automated instrumentation, data capture, data analysis and simulation modelling. The understanding of pathosystem dynamics has been considerably advanced by simulation studies. The accelerated research and development of integrated fruit production (IFP) in the past decade has led to a sudden expansion of knowledge about fruit disease management.

It is important for the integrity of IFP that it is scientifically sound and logical and that it is not based on emotive decisions. Pressure will come from growers to adjust the guidelines to make them as easy as possible. Each country has different problems due to climate, varieties grown, methods of culture, pest and disease, flora and fauna, etc.

Caution must be exercised in accepting a solution which is merely the lowest common denominator, easy for every grower in every country. At the same time, the standards must not be set too high or unfairly, so that one country could use them as a means of preventing fruit imports. These factors can only be kept in balance by maintaining ruthless scientific impartiality.

Conclusion

IFP has expanded rapidly with overall beneficial effects. The linking of higher standards in fruit growing to the market place is an important achievement. Though IFP fruit seldom attracts a premium price, it is often favoured relative to conventionally produced crops: if this does not occur growers will lose interest and IFP will decline. There is always a danger that media or pressure groups will react adversely to IFP, pointing out that the degree of chemical use is only marginally reduced compared to conventional production. We must therefore work to achieve greater benefits and find ways of measuring them. To realise the aims of IFP we must strive in research to find alternatives to chemicals for the control of pests and diseases.

PROSPECTS OF INTEGRATED FRUIT PRODUCTION IN SOFT FRUITS IN POLAND

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1. Abstract

Poland produces great quantity of soft fruits. In 1995 it will amount to 100.000 t of currants, 45.000 t of gooseberries 30.000 t of raspberries and 200.000 t of strawberries. Most of those fruits are used for freezing and processing. In recent years, however, production of fruits for fresh consumption is also systematically increasing. It refers especially to strawberries and raspberries. During several years new groups of consumers arise who are looking for fruits that can be considered as a "healthy food". To meet demands of such consumers the Research Institute of Pomology and Floriculture at Skierniewice has undertaken the initiative of elaboration and implementation of guidelines for the integrated fruit production (IFP) to produce healthy fruits for fresh market as well as to some branches of the processing industry. It is anticipated that soft fruits will be produced by modern means with the minimum application of chemical compounds. We decided to begin with strawberries and raspberries.

The basic limitation of IFP for these species in Poland is a small area of plantations - their average size usually does not exceed several hundreds square meters. Production of such fruits is also strongly influenced by changing market trends. It is the reason why very often this production is carried out by growers without sufficient experience and technical equipment. For that reason we are trying to organize growers into small groups that, would be able to produce fruits of high quality by applying modern methods entirely safe for the man's health and for the environment. Production will be under control of the state-employed advisers. Growers following the IFP guidelines will obtain a certificate stating that fruits offered for sale meet the requirements for the "healthy food". It will give growers the right to mark their fruit with a special label. Till now only IFP guidelines for strawberry have been worked out.

2. Introduction

Modern methods of small fruit production aim not only at the yield increase but also at substantial reduction of chemicals use which contaminate environment and are hazardous to human health. Integrated Fruit Production (IFP) may meet these requirement and bring a profit to the farmer. Experiments conducted in Poland on integrated apple production (Niemczyk 1995) show, that similar methods could be applied also in production of dessert small fruits.

3. Small fruit production in Poland

Poland is a world leader in small fruit production, mainly: currants, raspberries, gooseberries and strawberries. In 1995 estimated yields amounted to:

raspberries	30 000 t
gooseberries	45 000 t
currants	100 000 t
strawberries	200 000 t

Most of small fruits is destined for processing or freezing. Therefore mainly cultivars suitable for the purpose are grown. In the case of raspberries: Malling Promise, Malling Seedling, Norna and Veten (80%), gooseberries: White Smith (90%), black currants: Ojebyn (70%) and strawberries: Senga Sengana (85%).

The intensity of production is strongly diversified. Raspberries, gooseberries and strawberries are being produced traditionally at low effectiveness. Small family plantings, not larger than several hundred square meters, mostly bringing farmers additional income. Small area enables fruit harvest by only family members but does not allow to introduce modern equipment in plant management and protection. It results in low yields, at an average amounting to: 5 t of black currants, 5 t of gooseberries, 2 t of raspberries and 6 t of strawberries per hectare.

However, in recent years positive changes in small fruit production are being observed. There are farms growing strawberries on large areas. Even earlier big currant plantations were established. It was possible after introduction of mechanized fruit harvest. At present most of black currants comes from big, modern plantings. It is very likely that this tendency will develop also in other small fruit species.

4. Background of IFP in small fruit

The idea of producing small fruits according to IFP methods was born in Poland few years ago. It was founded mainly on major social and political changes switching Polish economy towards free market economy. However, these changes engendered new problems also in small fruit production. Processing and freezing industry being a monopolist on the fruit market was not able to sell the fruit, which resulted in considerable price reduction and limited purchase. It caused a drastic reduction in profitability making it sometimes unmanageable. In this situation many farmers reduced the area of plantings or liquidated them evoking substantial decrease of production. However, some growers decided to switch towards production of dessert quality fruit instead. They are being sold easily for fairly good price, also abroad and are not subject to altering conjuncture of the production. abroad.

The idea of IFP in small fruits appeared at the time of increased demand of the market for fresh high quality fruit, with special attention to strawberries and raspberries. The consumers have become aware of chemical residues hazard and they have required fruit free of them.

In promotion of IFP idea very important role has been played by orchard extension service, paying much attention in their everyday contacts with farmers to modernization of production and adapting it to changing market demands. They have convinced many growers to increase fruit quality for fresh market with the aid of IFP methods. The results of the experiments in apple production performed in Poland have shown worthiness of this idea. The method has developed for few years and gains popularity (Niemczyk 1995). Also, the experiments have proven that IFP could be engaged in production of other fruit species.

5. Perspectives of IFP development for small fruits

The IFP system in small fruit branch is new not only in Poland but worldwide. The rules for strawberry production elaborated in the USA (Hollingsworth et al. 1992) can be applied in Poland only to a small extent because of many differences in production intensity and aerial structure. To supply our farmers with the knowledge of new technology the Research Institute of Pomology and Floriculture has elaborated principles of IFP for small fruit growers in Poland. It has been assumed that they will allow to undertake profitable production of gooseberries, currants, raspberries and strawberries with minimal use of chemicals. Fruits should be destined for fresh consumption and processing, first of all for children food. It is expected they could be sold abroad as a fresh or preserved fruit.

The employment of IFP will assure customers that fruits and preserves are safe and healthy. The presented IFP rules concern all small fruit species grown in Poland. Strawberries and raspberries will probably gain the largest attention as the most favorable to be eaten fresh by children and adults. Strawberries are the most important among small fruits, right after apple, when volume of production is considered. Detail instructions for IFP method are already in print and soon will be extended among growers and advisory services.

6. Integrated production of strawberry

6.1. Formation of strawberry groups and IFP structure

Honesty and certain knowledge about strawberry production principles are expected from these who want to practice IFP. First step is to join producers into collectives of few to several growers. In Poland it is especially important because plantings are small and only in groups the growers can get full technical and advisory support from state services. It includes 2-3 days courses on the principles of integrated production which should precede the introduction of IFP tactics. Staff of the Research Institute of Pomology and Floriculture takes active part in these courses. Practical trainings are being held during the vegetation season. They aim at teaching farmers the evaluation of plant condition and to recognize main pests and diseases which could be troublesome. Group structure allows to supervise and monitor following IFP rules. The growers are obliged to keep record of all management practices which facilitate the supervision.

It is assumed that such groups would be organized in each village, where at least few growers intend to join IFP programme. The Local Committees will give advice and supervision. They will be subordinated to Regional IFP Boards - part of the section of Association of Polish Fruit Growers.

6.2. Planning and management of IFP plantings

The Research Institute of Pomology and Floriculture has already prepared instruction concerning strawberry production according to integrated methods (Integrated strawberry production, in press).

This publication contains detail information how to establish and maintain profitable strawberry plantation with reduced chemical use. Special attention is paid to the most important stages of production process. First of all site selection and soil preparation are considered. The chosen site should be free of perennial weeds and soil born pests, and enriched with nutritional elements. Manure and cover crops are recommended; mineral fertilizers are allowed only on very poor soils. When rich soils are regarded soil analyses should precede fertilizing.

Root feeding pests, such as: white grubs (*Melolontha melolontha* L), wireworms (*Agriotes* spp.) and strawberry root weevil (*Otiorhynchus* spp.) are common in Poland. In the case of serious infestation or pest population exceeding economical threshold it is advisable to control them before establishing the planting. When Verticillium wilt (*Verticillium dahlie* Kleb.) is likely to cause problems cultivars resistant to the disease should be chosen. Planting material must descend from certified mother plantation, which guarantees its healthiness.

During vegetation period use of pesticides is allowed to a limited extent, i.e. to control grey mold (*Botrytis cinerea* (Pers.) Berk), strawberry blossom weevil (*Anthonomus rubi* Hbst.), mites (*Tetranychus urticae* Koch) and weeds. Only selective pesticides are allowed for preventive use against grey mold, such as Euparen (dichlofluanid), Rovral (iprodione), Ronilan (vinclozolin) or Sumilex (procymidon). The control of other diseases and pests is recommended only when economic threshold is surpassed exclusively with use of selective pesticides. Weeds could be controlled with such leaf herbicides as Betanal 160 EC (fenmedifam) and Betanal Progress AM 180 EC (fenmedifam + desmedifam + etofumesat) and runners with Basta 150 SL or Basta 180 EC (glifosynate) after fruit harvest. The instruction contains recommendations concerning management practices, fruit harvest and preparation for sale.

6.3. Certification

The certificate will be an official proof that certain lot of strawberry fruit was produced according to IFP rules. It expires with the end of fruit harvest. The certificate will contain the following information: 1. the fruit lot does not contain undesirable chemicals or their residues are lower than acceptable norm, 2. chemicals were used only when necessary, respecting preharvest intervals, 3. all management practices were performed in accordance with IFP rules. Certificate could be granted only to the growers who declare to produce strawberry with IFP methods, join IFP group and follow the principles.

The grower applies for certificate. It will be issued by Regional Administration of IFP, taking into account the opinion of Local Committee supervising the group and the results fruit analyses checking the residues of nitrates and heavy metals. It is predicted that in the future fruits will be checked for presence of pesticide residues.

Strawberries are more delicate than apples, with short period of ripening and shelf-life. Then, it is impossible to base certificate issue on fruit currently picked because results of analyses will be known after fruit harvest. These results will serve for the next year certificate. They will also be a proof of farmer's honesty in realization of IFP principles. It is assumed that IFP certificates for strawberry growers will be granted after 2 years of farmers practice.

Certificate will allow to label fruit with special tag carrying information: "Integrated Fruit Production - State Supervision - Ministry of Agriculture and Food Administration". The tag could be placed on the top of fruit wrapping. For customers it will be a sign that it is a "safe food" which does not contain harmful chemicals.

7. Recent experiences with integrated production of strawberries

First trials with integrated strawberry production begun in 1993 in the vicinity of Warsaw, a large strawberry region producing great part of fruit for Warsaw market. It was initiated by local extension service. Integrated apple production served as a pattern to organize farmers in groups interested in strawberry production according to this method. The farmers took part in a few courses on the subject with emphasis to establishing and managing plantings (_urawicz 1994).

In 1994, at time of fruit harvest, samples of fruit were taken to establish the amount of nitrates and heavy metals presence. The tests were repeated in 1945. Some of group members, for the first time labeled their fruit not only with names of the grower but also with information that fruit are free of hazardous chemicals. They learnt that this attracted customers and fruit were sold fast for a good price.

These experiences show that consumers are interested in buying "healthy food". It has encouraged producers to continue and extend strawberry area conducted with IFP system. It is assumed that first certificates will be granted in 1996, then the producers could officially promote their fruit.

Now we can say that first experiences with integrated methods in Poland are promising. IFP attracts attention of advisory service and strawberry growers in other regions of the country. We hope that these production methods will gain popularity and be extended.

8. Conclusions

1. In spite of high production of strawberries for processing in Poland the requirement for good quality of dessert fruitis increasing.

2. Fruit quality can be increased when integrated methods of production are engaged.

3. First experiences with selling strawberries produced with integrated methods gave evidence that there is demand for them and production is profitable.

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IFP: A Dynamic System

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Abstract

Since 40 years the system of Integrated Production is in discussion and gradually in realisation. In the first period people had to define the system as a new way beside the already known organic farming. In the second period scientists worked out guidelines and exact instructions for farmers and growers. Finally, the marketing of this new production line had to be established including the creation of control measurements and labels. So far, the system works for each crop separately. Also the guidelines are written separately for each species. The term Integrated Fruit Production (IFP) stands now for all commercially grown fruit species in the temperate zones.

After the definition of IFP, the system has to be improved gradually. Within a few years we have to start to adopt our guidelines to new requirements. Scientists have to work out new solutions. In addition IFP has no geografical borders. The problem is worldwide. Enlargement of integrated thinking is more necessary than ever.

1. Evolution of IFP

After the second World War the society made great efforts in getting enough food. We are greatful to the industry, primarily to the chemical industry, helping to raise the efficiency of the agricultural production. At that time we had already some circles to promote the organic farming (Müller Grosshöchstetten, Rudolf Steiner). The two pressures - on one side more industrialized production and on the other side the more "natural" production - created a new thinking.

Some scientists from Germany and Switzerland - primarily entomologists - were aware of this situation. They pointed out that we have to find a way in between these two extremes. The most important aim was to work out a possibility to reduce the use of pesticides. They included several disciplines in finding a solution in the control of insect pests. They called the new system: Integrated Pest Management (IPM). IPM was first tested out by horticultural entomologists. The names of Steiner (D), Baggiolini (CH), De Fleuter (NL) and Wildbolz (CH) are clearly linked with the development of IPM.

In the 1970ies the first groups for promoting integrated systems were founded. In 1972 the largest food retailer in Switzerland, Migros, started with a new system called Migros-Sano or M-Sano. Migros engaged a group of people to build up an agricultural production system under a "natural" scheme. By the way, the M-Sano-Organisation improved gradually and is nowadays officially accepted as an IP-group. In 1977 Baggiolini from the Federal Research Station of Changins (CH) founded a group with growers in the area of the Lake Geneva, called GALTI (Groupement des Arboriculteurs Lémaniques). The group GALTI started with the control of pests with less pesticides, but they continued with more emphasis on all aspects of the growing tree. COVAPI (Comité Français pour la Valorisation de la Production Fruitière Intégrée) followed the example of GALTI in 1979.

With the foundation of SAIO (Swiss Working Group of Integrated Production in Fruit-Growing) in 1978 and AGRIOS (Arbeitsgruppe für Integrierten Obstbau in Südtirol) the situation changed dramatically in 1988. The Integrated Fruit Production (IFP) was definitively accepted by growers. Until 1989 14 IFP-guidelines for pome fruit production were drawn up in 9 European countries.

At the first International ISHS-Symposium for Integrated Fruit Production, held in Wädenswil (CH) in 1989, the start was given for a fast spreading of IFP. The IOBC/WPRS Working Group "Integrated Plant Protection in Orchards" got the mandate to coordinate the regional and national guidelines in Europe.

To get the acceptance of the consumers for the IFP-products at the end of the 1980ies and the beginning of the 1990ies many labels were brought out. It gave a certain confidence in all IFP-products. The IFP-lables are an answer to the labels of the organic farming groups.

2. Present situation

Around 1985 we had a big change in agricultural production. The consumer started to be more conscious of the quality of the products, at least in the industrialized countries. Moreover, the environmental aspects in food production became much more important. Even the society changed their attitude to food.

The fruit growers answered with differenciation of the production systems into:

- Extensively grown (high stem field trees)
- Organic farming
- Integrated Fruit Production
- Conventional Production
- "High Tech"-Production (up to 20'000 trees / ha)

These different production systems are nowadays more pronounced, more distinct separable from each other than 10 years ago. Looking all over, the IFP is still the most accepted system with a very high potential for the future.

At the present situation the general aims of IFP, as they are defined by both organisations ISHS and IOBC, have not to be changed. We still need the three principal aims:

1. High product quality
2. None / low environmental stress
3. Low production costs

In the last few years a great emphasis was made to improve fruit quality in general. Big effort was made to harmonize shoot growth and the number of fruits. The use of growth regulators and nitrogen-fertilizer could be reduced.

The research for reducing the environmental stress has not yet advanced enough. Organically grown products are very much favored above the other products. In consequence the second large food retailer of Switzerland, Coop-Switzerland, decided in 1994 to start with a new food-line, called "Naturaplan". Coop did a big step with Naturaplan towards a more ecological production. Coop is accepting IFP- and Bio- (organically grown) products for Naturaplan until the end of 1996. Thereafter only Bio-products are accepted. On the Swiss market only about 3 % are Bio-products. Coop is making big effort to raise the sell of Naturaplan-products which means Bio-products up to 20 % within a few years. These figures stand for all food stuff. Big effort is made for fruits and vegetables. Therefore, there is high pressure on the fruit-growers to change the IFP-system into the Bio-system.

With the advancement of IFP there is already a differenciation between IFP-fruits. The influence of the market can not be neglected by producing only IFP-fruits. The economical factors are becoming more important than ever.

According to the Swiss Minister of Agriculture Switzerland should produce over 90 % of all plant food in integrated or biological ways by the year 2'000. In 1995 we reached about 40 % of the total plant production.

Concerning fruits we are optimistic to reach the given figures by the Ministery of Agriculture.

IFP in Switzerland

	1994 accepted	**1995** applied for
Apples	73 %	85 %
Pears	61 %	75 %
Plums	51 %	68 %
Cherries	40 %	63 %
Apricots	18 %	30 %
Strawberries	55 %	67 %
Raspberries	34 %	43 %

The Bio-production of Swiss fruits is only between 2 to 3 %. But there is great interest from many growers to start with.

3. Future tasks in IFP

According to today's understanding the IFP-system has to be improved step by step. Scientists are asked to promote the system by investigating all aspects. There is no way back.

Breeding: "More competitive...."

In the near future much work has to be done by breeding new varieties. With the new generation of varieties we should get:

- More resistance or tolerance to apple scab, apple mildew, fireblight, monilia, botrytis, insect pests, cracking of sweet cherries, etc.
- Better fruit quality in respect of the appearance and flesh properties
- Good and regular yield

Special attention has to be payed to the fruit quality. Until now the quality assessment was made on the actual fruit on a certain given time. The modern consumer likes to know more about the production method: Bio, IFP or conventional. He likes to be informed about the health effects by eating an apple or some plums, etc. The scientist should give him an answer.

Production system: "Easier and faster yield...."

The grower needs a production system which is very easy to handle:

- Slow growing trees with very little pruning requirements: Super spindle, V-system
- No growth regulators
- Little fruit thinning
- Excellent ratio from leaves to fruits
- Low fertilizer requirements

For the evaluation of the production system we need more data about the effect of sunlight, temperature and humidity.

Plant protection: "Less chemicals - more nature..."

Some examples for next steps in plant protection:

- The use of fungal antagonists
- Better knowledge of predators
- Improvement of pheromones
- Better strategies in disease forcasting
- Recycling techniques for the use of plant protection material
- Improved balancing of the inputs and outputs of energy and chemical ingredients in the orchard
- Mechanical and biological control of weeds

Promotion: "IFP can be practised everywhere..."

The nucleus of IFP lays somewhere in the region of Southern Germany - Switzerland - South Tyrol. IFP should spread out in all regions of Europe and in all countries of the world. IFP should grow to a normal practice.

Most countries started the IFP in apples and pears. But there is no reason to hold it back from other fruits. We need groups who are dealing with the guidelines of all fruits.

Scientific performance and IFP guidelines

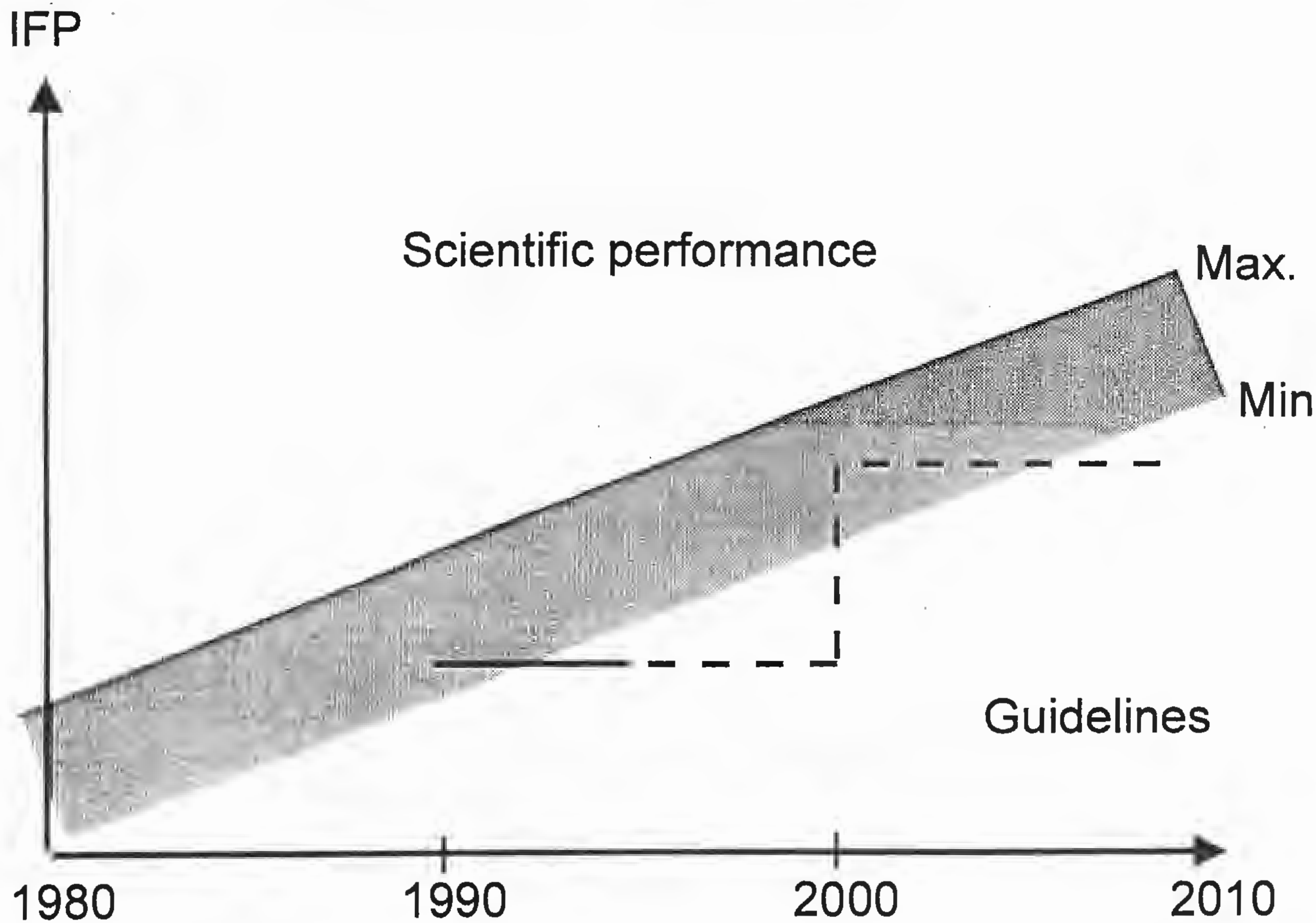
The scientific performance has always to go ahead of the evolution. The research worker has always to test new possibilities to reach a certain given aim.

We need guidelines for the grower and labels for the consumer. The labels are connected with the guidelines. This means we have to adopt the guidelines to the latest findings in research and development.

In about 1990 we started with guidelines. In the meantime we know more about the effectivity of the guidelines. In respect of the full system between the growers and consumers we should keep the actual guidelines another 5 years before adapting them to the new situation. We should first improve the IFP-system in small blocks before renewing the guidelines.

Figure 1:
The IFP is improving progressively. The guidelines should not be revised before a real need. They should not change too often.

IFP: Science and guidelines



SPECIAL CHALLENGES FOR IFP IN STONE AND SOFT FRUIT

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ABSTRACT- Many studies on the application of Integrated Stone Fruit Production have been carried out during recent years. The greatest amount of experience was achieved on peach, which is a very important culture in Europe. Nevertheless our knowledge in some fields is still poor, and this is a limitation when it comes to making further progress.

Problems like the resistance of *Myzus persicae* (Sulz.) to insecticides, the response of *Anarsia lineatella* (Zeller) to pheromones and the need for the availability of stocks resistant to nematodes and insects carrying viruses are briefly discussed. Some of the topics are common to apricot and almond. In plum orchards the monitoring of *Cydia funebrana* (Treitschke) is still difficult. In cherries Monilia disease may be damaging and needs further research. A very important problem is the characteristics of the Integrated Fruit Production programmes that have been established in several regions of Europe. Among them many unjustified differences may be observed. This points out the need for an effort of harmonisation according to general, common criteria.

In soft fruit production the situation is worse. Only a few biological/biotechnical control methods have been developed, and most of them will not be accepted by the fruit growers for economical reasons. Severe problems in soft fruit production may be caused by fungal root rots (e.g. in strawberries and raspberries), root nematodes, Botrytis and several pests. Appropriate plant protection products for an integrated control of most pests and diseases are hard to find. The registered pesticides mostly are quite toxic and broad-spectrum. Often they do not fulfil the requirements laid down in the IOBC-Guidelines for IFP in pome fruits. Breeding programmes resulted in some cultivars less susceptible to root rot. But these new cultivars mostly either do not meet the quality standards demanded by the market or have a low yield. A further critical point is the supply of healthy planting material. Under these circumstances it seems difficult to establish comprehensive IFP-systems for soft fruits. Breeding activities, efforts to promote biological control and registration of selective compounds may improve this situation.

INTRODUCTION

Stone and Soft Fruit are cultures spread differently over Europe. Among stone fruits, the almond ist typical of the Mediterranean areas, while the area where the peach and apricot are grown extends further into the continent. Cherry and plum are also grown in northern countries.

The situation is the opposite for soft fruits, which are important in northern and central Europe, but in the south, with the exception of strawberry, are restricted to mountain areas.

The large number of species that make up these two groups and the different climates in which each crop can be grown makes an overall examination of the phytosanitary situations impossible. We believe it would be more productive to point out certain aspects where sufficient research has not yet been done or which have emerged only recently. We will supply problems to consider and starting points for future coordinated action which we hope may be discussed and agreed on in the IOBC Working Groups.

PEACH

Among stone fruits the peach is certainly the culture with the greatest economic importance, and into which the greatest amount of research in the field of IFP has been carried out. The biggest production is in Italy, Greece, Spain and France, but the high number of cultivars means that cultivation is possible from northern Africa to central Europe.

One of the first points to underline is connected to the high number of cultivars, chosen to respond to agronomic and commercial necessities, but with little consideration for their resistance to pests or diseases.

The research in course to select cultivars resistant to the aphids that carry the Sarka virus is of particular interest (Massonie *et al.*, 1992; Avinent *et al.*, 1991). Effective treatments against bacteria, viruses and MLOs do not exist, and so it is essential to select strains which are resistant in different ways.

Another example of this need is the difficulty of replanting peach orchards because of the presence of nematodes. The ban on the use of methyl bromide, a method of land disinfestation not permitted in many guidelines, makes all the more topical the search for cross-breeds that resist nematodes and also have good yields.

One of the key species for the peach is the Aphid *Myzus persicae* (Sulz.), which carries diseases and also directly causes serious damage.

Although numerous studies have been carried out on this aphid, there are still certain gaps in our knowledge. Resistance to insecticides and the role of natural enemies are particulary relevant.

Important results have been obtained in basic studies on populations on herbaceous secondary hosts in central and northern European countries. Results of particular importance were obtained in research on the biochemical basis of resistance to insecticides carried out in Rothamsted in England and at other centres in Europe (Devonshire & Moores, 1992; Field *et al.*, 1988).

But if we consider the area where the peach is grown, it is clear that very little has been done on this subject. Studies are needed on this topic because the peach is the primary host on which the sexuales mate and fertilized eggs are laid. The sexual part of the life cycle is responsible for the increase of variability in Aphid populations.

The changes which occur from year in areas where the series of interventions with insecticide on the peach and on the secondary host are different deserve closer investigation (Cravedi & Cervato, 1994).

In the absence of knowledge about the composition of *M. persicae* populations on the peach as far as resistance to insecticides in the various peach-cultivation areas is concerned, the problem is constantly underlined and empirical solutions put forward.

The choice of insecticides based only on their immediate efficacy, and the random alternation of various substances lead to no lasting result.

Another dangerous species fo the peach throughout the world is the oriental fruit moth, *Cydia molesta* (Busck). The later cultivars are particularly at risk and their defence requires numerous insecticide interventions.

In *C. molesta* control significant progress has been made with the use of pheromones. Besides monitoring traps, pheromones are now widely used for mating disruption. Italy and France are two European countries where this method has met with the approval both of technicians and farmers, and it is used in many places (Audemard, 1984; Molinari & Cravedi, 1992). In the Mediterranean area interest is less because of the presence of *Ceratitis capitata* (Wied) which however calls for insecticide intervention. Protecting the fruit of late ripening cultivars with paper bags as resorted to in some parts of Spain and southern Italy is worthy of a mention, but it is certainly not a solution which can be suggested on a large scale.

The success obtained with pheromones against *C. molesta* has, however, shown up the difficulties in *Anarsia lineatella* (Zeller) control. This species, which is not as evenly widespread as *C. molesta*, in some areas causes serious risks for the peach, the apricot and the almond (Audemard, 1987; Barnett & Hendricks, 1992; Zalom, 1994).

At present dispensers are also available for the disruption method for *A. lineatella* and one widely used model contains pheromones for both species. However, the results obtained against *A. lineatella* leave many uncertainties. In several situations the failures of the disruption method depend on the fact that *A. lineatella* is not completely inhibited from mating. The behaviour of *A. lineatella* is unpredictable even with pheromone traps, and so the captures made with these are hardly useful for estimating future larval infestations.

Research on the reproductive behaviour of *A. lineatella* is something to which it will be necessary to turn our attention in the next few years.

It might also be quite important to evaluate the efficacy of biological products against fruit-eating moths. *Bacillus thuringiensis* has already provided good results against *C. molesta*, but further experience would be useful. We have less information, on the other hand, about the action of *B. thuringiensis* on *A. lineatella* larvae (Pari et al., 1993).

The application of the IFP criteria has brought with it positive aspects like the reduction in the harmfulness of Tetranychid mites. The fact that in some places regular defence interventions against mites are still required shows that an in-depth analysis is needed into the environmental causes, the presence of beneficial organisms and the strategies that are adopted locally.

However, in many cases the reduction of chemical interventions against the key species has brought with it an increase in harmfulness of generally less important pests.

On the peach in many areas infestations of the scale insects *Pseudaulacaspis pentagona* (Targ.) and *Quadraspidiotus perniciosus* (Comst.) are increasing. This is more worrying where the use of pheromones for mating disruption of *C. molesta* removes the effect on scale insects of the insecticides which would otherwise be used.

In order to be able to clarify the terms of the problem it is important that a study is begun of the natural enemies of scale insects. It is not yet clear what action the various species of parasitoids and predators take to keep down numbers of scale insects nor which species are the most important in different areas. The identification of which entomophagous species are most important for defence and the study of their biology will make it possible to plan strategies of defence which will probably vary according to climatic conditions, considering that the peach is grown between the 30th and 50th parallel.

Another important subject is the evaluation of the effects that treatments needed to control other phytophagous species have on the useful insect population.

The present tendency is to make plant protection part of overall strategies of integrated production, but we still need firm and reliable data about the influence that the control of fertilization, irrigation and soil management have on the development of many phytophagous insects and diseases.

Some leafhoppers seem to be influenced by the growing conditions of the orchard, the presence of weeds, the crops grown in neighbouring fields and the presence of uncultivated areas. Some studies have been carried out to investigate into what lays the peach open to infestations of Miridae. In recent years, first of all only in southern Italy but now also in the north, it has become much more common to find infestations of *Empoasca decedens* Paoli and other Cicadellidae.

Direct damage is serious only in young orchards, but these reports increase our interest in leafhoppers, which carry viral diseases on the peach, apricot, plum and almond (Llacer & Medina, 1988; Poggi Pollini *et al.*, 1993).

The progressive spread in Spain, France and Italy of the thrips *Frankliniella occidentalis* (Pergande), which is harmful for the fruit of the nectarine, but also for plums and cherries, requires us to pay attention to perfecting agronomic methods of prevention and identifying the role that natural enemies can play (Grassely & Lacasa, 1994; Guarino & Tocci, 1994; Nicolas, 1995).

In recent years in northern Italy infestations of leafminers have been reported on all stone fruits. *Phyllonorycter cerasicolella* (H.S.) and *Ph. pomonella* (Zeller) have infested some orchards severely, causing early defoliation, particularly in plum and peach. The group of parasitic microhymenoptera, the connection between various cultures and the side effects of defence interventions are all important topics of research.

We have dealt with the topic of plant pathology only marginally because there is a lot of research and experiment about the main diseases like peach leaf curl, gum spot, powdery mildew, branch cancer and prunus blossom blight. We know a lot about this topic and at the moment there are no particular crises.

APRICOT

The troubles with the apricot are fewer in number than those of the peach and do not lead to serious difficulties. The aphid *Hyalopterus pruni* (Geoff.) is more to be feared as a carrier of Sarka than for any direct damage it causes. Among Lepidoptera only *Anarsia* is of any importance and in different countries the number of different treatments is limited; these are mostly for prunus blossom blight, a disease which can be destructive. In the Peloponnese there are very common infestations of the Tetranychid mite *Tetranychus urticae* Koch.

In the areas where similar situations occur it is certainly a good idea to look for the causes, which are probably greatly influenced by the microclimate established according to the shape of the foliage, the watering and other causes in those particular climatic situations.

One species which has caused serious damage recently in various parts of central Italy on peach but particularly on apricot is the earwig *Forficula auricularia* L.

Reports of such damage have been coming in frequently for some years now. In order to establish correct defence strategies, an improvement of our knowledge of the biology of *F. auricularia* in orchards and surrounding areas would appear to be important (Santini, 1994).

PLUM

Our knowledge about the most important phytophagous species, the moth *Cydia funebrana* (Treitschke), is still incomplete. An improvement in the monitoring of adults with pheromone traps and the preparation of other reliable methods of sample-taking are greatly needed (Molinari, 1994).

Other damages are caused by sawflies, aphids and MLOs-Carrying leaf-hoppers. Sawflies are a group of species the distribution of which in the various regions is still unknown. Aphids cause more damage in northern climates; it would be useful to have further information about their natural enemies and about methods of sampling.

The symptoms of leaf-hopper-transmitted MLOs found on apricot, plum and peach are extremely serious. The situation is particularly worrying on plum and apricot and a study of vectors is essential.

CHERRY

The cherry does not present particularly serious problems, at least in Mediterranean areas.

However, *Rhagoletis cerasi* L. control is in many cases carried out with being sure of the risk or the most opportune moment.

The relationships between growing techniques and the insect population in orchards could be investigated. In particular soil predators can be important.

ALMOND

At present interest in the almond is on the increase, but it is definitely the crop that least work has been done on in Europe as far as the application of integrated production methods is concerned. Ample information is available about the main troubles (Liotta & Maniglia, 1994). The agricultural crisis in many southern regions and competition from countries where production costs are low have, however, made the almond less profitable. The adoption of appropriate growing techniques seems to be the most effective remedy to the attacks of Buprestidae, especially of *Capnodis tenebrionis* (L.), against which there are no other effective, non-contaminating means of defence. The study of viral diseases is equally important: these constitute one of the major factors limiting cultivation.

Closer attention to the bug *Monosteira unicostata* M.R. would make an important contribution towards the rationalization of defence (Moleas & Addante, 1989; Savino, 1989).

SOFT FRUITS

Compared to pome and stone fruit our knowledge on the entomological and phytopathological problems of soft fruit crops in western Europe is quite poor. For a lot of soft fruit pests important informations on their biology are missing. This may be due to the fact that the soft fruit area is much smaller and the economic importance is far less than the one of pome and stone fruits. IFP-systems for the latter crops are far more advanced. For soft fruit crops several important „tools“ to warrant an integrated fruit production still are not available.

In the following the most important problems of strawberries, raspberries and currants/ gooseberries are highlighted-challenges to both, scientists and extensionists. Problems of elder, blueberries, sea buckthorn and other crops of minor importance are not dealt with.

Strawberries

In plant protection schemes of strawberries fungal diseases play the most important role. Grey mould *Botrytis cinerea, Verticillium*-wilt, Red stele rot *Phytophthora fragariae* var.*fragariae*, Rhizome rot *Phytophthora cactorum* and powdery mildew *Sphaerotheca macularis* require numerous control efforts. Blossom weevil *Anthonomus rubi*, two spotted spider mite *T. urticae* aphid species, strawberry mite *Tarsonemus pallida fragariae* and root nematodes *Pratylenchus spp.*, are considered as the most serious pests.

Especially *Verticillium* - wilt and the root rots are an existential threat to strawberry production in several areas. Chemical control - if available - requires high application dosages and gives unsatisfactory results. Non-chemical control offers good prospect. Resistance breeding provided us with cultivars resistant resp. tolerant to *Verticillium spp.* (Dathe, 1994; Simpson & Blanke, 1994) and *Phytophthora fragariae* var. *fragariae* (Dathe, 1993). Resistance to *P. fragariae* var. *fragariae* obviously is race-specific. Two points need further research, the determination of races in the growing areas and the accumulation of resistances to several races.

As comprehensive cultivar testing programmes indicate, some cultivars combine low susceptibilities to several diseases *Verticillium* spp., *Mycosphaerella fragariae*, *Sphaerotheca macularis* and spider mites (Krüger, 1994). But more breeding efforts are demanded in combining these properties with better yields and qualitites. Nevertheless by now it seems possible to introduce „healthy“ cultivars into practice in some branches of strawberry growing (self marketers, industrial production) thus replacing highly susceptible cultivars which dominate in many regions.

In controlling strawberry root rots, *Verticillium* - wilt and root nematodes crop rotation has to be taken into consideration. From several arable crops it is known that they either are increasing or decreasing the diseases resp. nematodes (Krüger, 1995). But a systematic investigation on the influence of the whole crop roation (sequence of crops) on the root disease-nematode complex is still missing.

Infected resp. infested planting material was and still is the cause for the rapid spread of several diseases and pests, *P. fragariae* var. *fragariae*, *Colletotrichum* spp., *Xanthomonas fragariae* and *Tarsonemus pallidus fragariae* (Billen, 1995; Fried 1994; Jung & Heupel, 1995). Farmers' practice of producing their own planting material but also bad qualities of commercial planting material are the main reasons. There is a strong need to set up minimum standards for the qualitiy of planting material and to install routine testings for the main noxious agents.

Biological control of root nematodes by growing certain *Tagetes* species is very effective (Fried & Lung, 1994). It is a challenge for extension officers to promote this control measure.

Further biological control measures that have been investigated were the use of predatory mites (Epp & Galli, 1991) and the use of anthocorids against *Thrips tabaci* in protected production (Jung, 1994). The latter measure proved to be successful, the first one partly. But by now there will be no chance for acceptance in practice because of economical reasons. A more economic (cheaper) production of beneficial organisms or different application methods are needed to enhance practice-acceptance of biological pest control.

The blossom weevil *Anthonomus rubi* occurs in most growing regions. Little is known on the biology, on crop losses and on a method to forecast population dynamics. But by now the greatest obstacle to a control based on sound decision-making is the lack of a selective compound (not toxic to bees) with a short harvest interval.

Raspberries

In raspberries fungal diseases are of vital interest, e.g. raspberry root rot *Phytophthora fragariae* var. *rubi* or cane blight (several fungus species), or they require numerous fungicide applications for sufficient control (e.g. grey mould, *Botrytis cinerea*) in all growing areas. The importance of pests varies between the growing regions. Raspberry cane midge *Thomasiniana theobaldi*, several spider mite species, raspberry beetle *Byturus tomentosus*, raspberry gall midge *Lasioptera rubi*, aphid species and the blossom weevil are considered as serious pests.

Resistance breeding also offers good prospect for the control of raspberry root rot. Cultivars resistant to *P. fragariae* var. *rubi* have been developped (Laun, 1992), and some (late ripening) varieties by now are introduced into practice. But still there is a need to improve yielding and quality properties of resistant varieties. Some raspberry varieties also combine resistance or low susceptibility to root rot with aphid-resistance (vectors of Raspberry Common Mosaic-complex) but fruit size is unsatisfactory and susceptibility to *Botrytis cinerea* is high (Röser, 1995).

The provision with healthy planting material is insufficient because of the same reasons as in strawberries (Scherer & Riedel, 1990). In addition to the contamination with *Phytophthora*- root rot infections with RCM-complex create problems. These viruses are hard to assess visually on young plants. An indicator-plant test to detect the viral agents is available, but there is a strong need for a rapid diagnosis method (Lankes, 1994) to speed up virus-elimination and production of virus-free planting material.

Of local importance, but if it occurs of existential importance is Rubus stunt, (e.g. in Germany) a disease caused by a MLO and transmitted by leafhoppers (Van der Meer, 1987). Little is known on the distribution of the vector in raspberry orchards in Europe (with the exception of The Netherlands).

Information on the biology and key natural enemies of almost all the pests of raspberries, currants and gooseberries are incomplete. Systematic investigations on, e.g. predatory mites of these crops have, as far as we know, not been carried out. Studies on the side-effects of pesticides, fungicides etc. concentrate on beneficial organisms of pome fruit orchards or „unspecific" antagonists, e.g. *Chrysoperla carnea* (see e.g.the results presented in Vogt, 1994).

In the field of biological control in soft fruit crops (with the exception of strawberries) first of all an inventory has to be taken and afterwards the methods already applied successfully in pome and stone fruits have to be evaluated in soft fruits.

In general the pest situation differs between pome and stone fruits on the one and the soft fruit crops on the other side. Whereas in the first ones Tortricids often play a key role in the latter ones noxious beetles and gall mites are the main pests. Biological spider mite control may be adopted for perennial soft fruit crops.

Currants and Gooseberries

Reversion of black currant causes severe yield losses in western Europe (Adams & Thresh, 1987). This viral/MLO ? - disease is transmitted by the black currant gall mite. A detection method is available (Krczal *et al.*, 1985) but it is lengthy. In addition to that thermotherapy and meristem culture in black currant is problematic. Virus-elimination by now is not possible (Lankes, 1994), and so the provision with virus-free planting material is insufficient. More research is needed on the causal agent of the disease, a rapid diagnosis method and the progapation of healthy planting material.

Among the quite few pests of economic importance in black currant (aphids and mites) the black currant gall mite is difficult to control. Resistance genes to control the mite have been transferred to black currant (Herr, 1991) and so the introduction of resistant cultivars (which often combine mite and powdery mildew resistance) is the task for the extension officers during the next years.

In protected production of red currants (protected from rain to postpone harvest) an increase of scales has been observed (Meesters, 1995). The same may happen if broad-spectrum insecticides are replaced by selective compounds.

Chemical Plant Protection

The first step away from routine pesticide schemes is supervised control. The presence of pest is registered via assessment or traps. For a few soft fruit pests several coloured sticky traps are available, e.g. to monitor raspberry beetle, blossom weevil and cane gall midge (Höhn, 1991; Epp et.al., 1992). But with the last two pests uncertainties with a clear diagnosis surely will occur in practice. So, simple diagnosis methods and more tools for pest monitoring have to be evolved.

A recent survey on the basis of decision-making in soft fruit crops gave a shattering result. Almost no threshold values are used in practice. For most of the pests they have not been elaborated. The few thresholds proposed, e.g. for blossom weevil of strawberries (Bosch, 1977) or currant and gooseberry pests, (Institut für Pflanzenschutzforschung, 1988), up to now have not been evaluated by applied research. The same holds for forecasting models. Elaboration of thresholds must be a central point in order to establish IFP systems in soft fruits.

The number of plant protection agents permitted for the use in soft fruits varies strongly within the European countries. In Switzerland or the Netherlands many active ingredients are registered whereas e.g. in Germany extremely few are permitted (BML, 1993; Schweizerischer Obstbauverband, 1994). Most of the pesticides are broad-spectrum and some are toxic or very persistent. They do not fulfill the requirements for pesticides to be used in integrated fruit production as laid down in the IOBC-Guideline for IFP in pome fruits (Cross & Dickler, 1994).

As long as selective compounds, not being harmful to key beneficials, are not available, successful biological control measures (e.g. spider mite control by predatory mites) are not applicable in soft fruit crops.

Having listed a series of studies and experiments we believe to be necessary, it is worthwhile remembering that a fundamental role in the realization of integrated production programmes is played by the service technicians. They have to choose the means of control according to common criteria. Comparing the choices made shows up very clear differences among the strategies suggested. In some cases methods very close to those of organic farming are favoured, while in others solutions using a large quantitiy of chemicals are chosen.

There are excessive differences also among the chemical insecticides to use. In order to iron out differences which are not justified by particular local situations it is essential to follow common principles more closely and to work on internationally recognised guidelines.

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DEVELOPMENT OF AN INTEGRATED AND BIOLOGICAL FRUIT GROWING SYSTEM FOR SCAB RESISTANT APPLE CULTIVARS.

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Abstract

In order to find ways to reduce pesticide use, research was started in 1989 by the Research Station for Fruit Growing to develop a system for integrated fruit growing. The aim of this research was to develop an integrated fruit growing system as it is described by the IOBC definition (Cross and Dickler, 1994) i.e. an economical production of high quality fruit that safeguards the environment and human health. Through this research it became clear that a substantial reduction of pesticide use can only be achieved with a reduction of fungicide use. Reducing fungicide use causes big economical losses because of high incidence of apple scab. Several methods have been experimented to deal with the scab problem but until now no good solution has been found. A way to reduce fungicide use without high scab infestation is the breeding and growing of scab resistant apple cultivars. As a growing system with only resistant cultivars is treated with little fungicide, it is completely different from the current growing system. It is therefore necessary to develop a growing system for it. The Research Station for Fruit Growing initiated a new research project in 1993, in which an integrated and biological fruit growing system for scab resistant apple cultivars will be developed. Three fields (each of about one hectare) were planted with resistant cultivars. In one field, an integrated growing system for resistant cultivars and in another field, a biological system will be developed, according to the european guidelines for biological fruit growing. In the third field detailed research will be done on specific problems that may occur like "new" diseases that can appear in a system with very low level of fungicide use. Description of this research and preliminary results are described.

1. Introduction

In 1989, the Research Station for Fruit Growing started the development of an integrated fruit growing system (Schenk and Wertheim, 1992). The aim of this experiment was the development of a fruit growing system that was economically sound and that was safeguarding the environment and human health by minimizing the use of agrochemicals and giving priority to biological control. Three systems of apple growing with varying input of chemicals were laid out on a semi-practical scale on two sites in the Netherlands. In each system 8 apple cultivars were planted: 6 current cultivars and 2 scab resistant cultivars. In order to measure the impact on the environment of each system the environmental yardstick for pesticides was used (Reus, 1993).

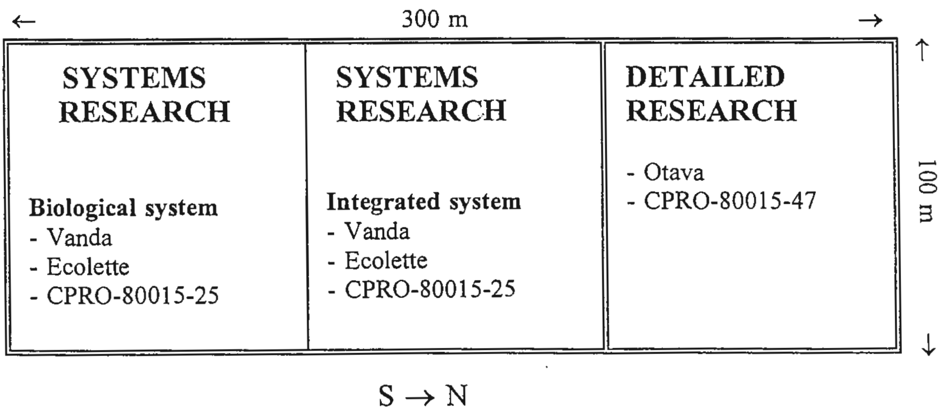
The Dutch Multi-Year Crop Protection Plan (Anonymus, 1991) defines that Dutch fruit growing should reduce pesticide use in 2000 with 44% compared to 1986.

In this first trial it became clear that the reduction of insecticide and herbicide use is possible, using new application techniques and biological control methods. However, it was very difficult to reduce fungicide use: on the current cultivars a little reduction in fungicide use leads to high levels of infection of apple scab (*Venturia inaequalis*), the key problem in Dutch apple orchards. This scab infection caused unacceptable economic losses. With the scab resistant cultivars in this experiment a very high reduction of pesticide use could be achieved without economic losses because of the sprays omission of scab control. A way to reduce fungicide use without unacceptable economic losses can be the breeding and growing of scab resistant cultivars. Shaffer (1994) could reduce the fungicide applications by 64% by using scab resistant cultivars.
Therefore a new trial was set up in 1993, while the old trial is partly being continued. The goal is to develop an integrated and biological growing system for resistant apple cultivars.

2. Material and methods

The total area of the trial is 3 hectares. Trees are planted in a single row of 2.75 m by 1 m (3636 trees per hectare) in a North-South orientation. Two hectares are used for systems research: on one hectare a biological system will be developed and on one hectare an integrated system will be developed (Fig. 1). In the systems research three cultivars are planted: Vanda (Jolana x Lord Lambourne, Czechoslovakia), Ecolette (Elstar x Prima, the Netherlands) and CPRO-80015-25 ((Elstar x D3) x Priscilla, the Netherlands). The third part of the experiment is a field where detailed research will be undertaken like the control of "new" pests or diseases that might occur in a system with low fungicide use. In the area for detailed research two cultivars are planted: CPRO-80015-47 ((Elstar x D3) x Priscilla, the Netherlands) and Otava (Sampion x Jolana, Czechoslovakia). The resistance source for scab in all cultivars is Vf-resistance, derived from *Malus floribunda* 821. This resistance is controlled by the so-called Vf-gene, probably in combination with minor genes. All cultivars have rootstock M.9 and were grafted at 25 cm height in order to reduce growth. The trees are planted rather high "on" the soil which is also a method of retarding growth vigour.

Figure 1. Outline of the experiment.



2.1. Systems research

In systems research a fruit growing system is built up in semi-practical way. For this type of research, a large area is required for creating "the system". At least half of an hectare is needed. In this experiment one hectare per system is used. Five percent of the trees, 210 per system, are observation trees, which are randomly divided throughout the field. On these trees all observations are conducted such as observations on growth, leaf analyses, insects and mites, diseases and weeds.
The systems research is carried out in two: the "biological" and the "integrated" field. In each field a system is being developed for respectively biological and integrated fruit growing of resistant cultivars. In the "biological" field the national guidelines for biological fruit growing are being followed: this means no use of chemically formulated pesticides and growth regulators or chemical fertilizers is allowed. In the "integrated" field the national guidelines for integrated fruit growing (MBT: environmentally conscious production) are followed. The guidelines for integrated fruit growing emphasize biological mite control and use of those pesticides that are least harmfull to the environment. Biological mite control is achieved in the Netherlands by the introduction of the predatory mite *Typhlodromus pyri* during the year of planting. The guidelines for integrated fruit growing limit the use of acaricides (two years after introduction of predatory mites no acaricides are allowed anymore), organophosphates, most carbamates and they forbid the use of pyrethroids, all being too harmfull to the predatory mite. In integrated fruit growing the use of benzimidazole fungicides is also limited because of their harmfullness to earthworms. Details of "MBT" are described by Koning (1995).

2.2. Detailed research

The field for detailed research is to be a field where experiments can be done having the conditions of low fungicide use and resistant cultivars. It is known that the potential for other diseases than scab exists when scab control is omitted. Travis (1994) observed more fruit rot in some resistant cultivars though were significant differences between the cultivars.
In this field research is carried out on weed management, wind breaks, support material and nitrogen-management in biological fruit growing.

3. Results

3.1. Results; systems research

In 1994 and 1995 several treatments were applied to both fields. They are described in table 1.

Table 1. Treatments in the integrated and biological field in 1994 and 1995.

	Integrated field	Biological field	
Fertilization			
1994	60 kg K_2O / 180 kg P_2O_5		
	fertigation/tree	manure/ha	
	9 g N	30 tons =	129 kg N
	3 g P		63 kg P
	3 g P		288 kg K
1995	10 g P	20 tons =	86 kg N
	3 g P		42 kg P
	3 g P		192 kg K
Growth retarding			
1995	root pruning	root pruning	
Crop protection			
1994	azocyclotin	-	
	predatory mites July	predatory mites May	
	mating disruption	mating disruption	
1995	azocyclotin	sulphur	
	hexythiazox	sulphur	
	tolylfluanide	-	
	predatory mites July	-	
	pirimicarb	pyrethrum	
	pirimicarb	earwigs	
	propoxur	-	
	vamidothion	-	
	mating disruption	mating disruption	
Weed management			
1994	glyphosate	rotor hoe	
	glufosinate	manual weeding	
	MCPA		
	simazine		
1995	glyphosate	rotor hoe	
	MCPA / 2,4-D	manual weeding	
	simazine		
	diuron		

Fertilization

Fertilizer is applied in the integrated field through fertigation with Kristalon Lila (19-6-6) and in the biological field through organic manure. The biological field was irrigated in summer.

Leaf analyses indicate that nitrogen level is significantly lower and that potassium level is significantly higher in the biological field for all cultivars (Table 2). There is no difference between the phosphorus levels. There was no significant interaction between cultivar and system. This observation is confirmed by the leaf colour observation. For the leaf colour observation a score is given for leaf colour ranging from 1 (yellow) to 9 (dark green). The leaf colour score was significantly higher for the integrated field. There was no interaction between cultivar and system, which means that each cultivar reacts the same to the way of fertilization.

Table 2. Observations on leaves in the integrated and biological field in 1994

	Integrated field	Biological field
Leaf analyses (ppm) July 1994		
N	2.65[a]	2.22[b]
P	0.19[a]	0.20[a]
K	1.98[a]	2.37[b]
Leaf colour (1-9) July 1994		
	7.976[a]	6.752[b]

Data with no letters in common are statistically different at a significance value of ≤ 0.05

Pest control

In May 1994 0.5 kg Peropal (a.i. 25% azocyclotin) was sprayed against the red spider mite. Predatory mites were introduced in July 1994. Monitoring in 1995 no predatory mites could be found and the number of red spider mite *Panonychus ulmi* was too high. Therefore 1.5 kg Eupareen (a.i. 50% tolylfluanide), 1 kg Peropal and 0.4 kg Nissorun (a.i. 25% hexythiazox) were sprayed in July 1995, and afterwards predatory mites were introduced again. In biological fruit growing the use of chemical acaricides is forbidden and therefore predatory mites were introduced very early in 1994. In July 1995 one predatory mite per leaf could be found but there was a rather severe infection of apple rust mite, *Aculus schlechtendali*. Therefore sulphur was sprayed twice at 3 and 2.5 kg per hectare. Aphids, especially *Dysaphis plantaginea*, had to be controlled with 1 treatment of 0.3 kg Pirimor (a.i. 50% pirimicarb) in 1994 and in 1995 with one treatment of 0.3 kg Pirimor and one treatment with 0.6 l Kilval (a.i. 40% vamidothion). In the biological field one treatment with 1 l Spruzit (a.i. 20% pyrethrum) was applied against aphids. Earwigs were introduced in the biological field and hiding places for them were created in the trees. The common green capsid *Lygus pabulinus* is treated in the integrated field with 1 kg Undeen (a.i. 50% propoxur). Leafrollers and codling moth are successfully controlled using mating disruption.

Disease control

Until 1995 no disease control was carried out in order to get an idea of the disease incidence that will occur. In 1995 it became clear that fruit tree canker *Nectria galligena* has to be treated.

Infection of fruit tree canker has been recorded and the results are given in table 3.

Cultivar CPRO-80015-25 showed highest incidence of fruit tree canker in spring 1995 and the incidence of fruit tree canker infection was higher in the biological field for all cultivars. Since in both the biological and the integrated field no treatments were applied, there must be another reason for this difference. The fertilization practice in both fields was different and also the period of leaf drop. It is possible that in one period the conditions for an infection were better than in the other period. This can also be the reason for the differences between the cultivars although it is possible that there is also a difference in susceptibility between the cultivars.

Scab has been observed on Ecolette: once on a cluster with fruits in June 1995 and on one shoot in July 1995. Since these cultivars are not fully resistant against powdery mildew (*Podosphaera leucotricha*), it is normal that powdery mildew will occur when no fungicides are sprayed. On cv. Ecolette 5% of the leaves had one spot or more of powdery mildew, on cv. Vanda and cv. CPRO-80015-25 powdery mildew occurred on 15% of the leaves in June 1995. No other diseases were noted until then.

Table 3. Infection of fruit tree canker in spring 1995 (percentage of trees)

Cultivar	Integrated field	Biological field
cv. CPRO-80015-25	0.7	2.8
cv.Vanda	0.5	1.8
cv.Ecolette	0.1	0.6

Weed control

In May 1994 1 l Simazin (a.i. 50% simazin) and 5 l Roundup (a.i. 37% glyphosate)were used in the integrated field, in July 1994 4 l Finale (a.i. 20% glufosinate) and 0.8 l MCPA (a.i. 50% MCPA) were applied to control weeds. In the biological field weeds were four times mechanically removed by the rotor hoe, once by hand.

In 1995 the integrated field was kept weed-free with a spring treatment with 3 l Roundup, 1 kg Diuron (a.i. 80% diuron) and 1 l Simazin. MCPA and 2,4-D were sprayed to control broadleaf weeds.

Growth

In order to measure the growth of all cultivars in both systems, the number of shoots, length of shoots and increase in stem diameter is recorded on each observation tree.

The number of shoots was measured in February 1995 before winter pruning. The number of shoots per tree was significantly higher for all cultivars in the integrated field (Table 4). There was a significant interaction between cultivar and system. The smallest difference of number of shoots was observed on Vanda (1.33), the biggest difference on Ecolette. This indicates that Ecolette has the clearest reaction to the system in which it is grown.

Table 4. Number of shoots per tree in February 1995

Cultivar	Integrated field	Biological field
CPRO-80015-25	10.82[a]	9.29[b]
Vanda	16.63[a]	15.30[b]
Ecolette	15.76[a]	11.71[b]

L.S.D.$_{0.05}$ = 1.243
Data with no letters in common are statistically different at a significance value of ≤0.05

The length of shoots was measured in February 1995 (Table 5). Trees in the biological system have a significantly reduced shoot length compared to trees in the integrated field. These data show a significant interaction between cultivar and system. The smallest difference in shoot length between the two field was observed on cv. CPRO-80015-25 (209.7), the biggest on cv. Ecolette (380.3).

Table 5. Shoot length (in cm per tree) in February 1995

Cultivar	Integrated field	Biological field
CPRO-80015-25	540.7[a]	331.0[b]
Vanda	727.4[a]	423.4[b]
Ecolette	905.4[a]	525.1[b]

L.S.D.$_{0.05}$ = 57.62
Data with no letters in common are statistically different at a significance value of ≤0.05

The stem diameter was measured in spring 1994 and 1995. To measure growth the increase in stem diameter is calculated (Table 6). For all cultivars the increase in stem diameter is higher in the integrated system. As regards increase in stem diameter there is a significant interaction between cultivar and system. The biggest difference is observed on cv. Ecolette (0.859), the smallest on cv. CPRO-80015-25 (0.492).

Table 6. Increase of stem diameter from 1994 to 1995

Cultivar	Integrated field	Biological field
CPRO-80015-25	1.951[a]	1.459[b]
Vanda	2.399[a]	1.773[b]
Ecolette	3.206[a]	2.347[b]

L.S.D.$_{0.05}$ = 0.129
Data with no letters in common are statistically different at a significance value of ≤0.05

3.2. Results on the detailed research

Orchard floor management

Research is conducted on weed management by using covering crops. In earlier research van Hartingsveldt (1994) concluded that white clover is a good cover crop for trees, 4 years and older. Until now it is not known what the effect is of white clover on newly planted trees, in combination with fertigation. Therefore a new experiment was set up in 1993. White clover was sown immediately after planting, one year and two years after planting, and compared with bare soil treated with herbicides. Tree growth was observed after one year and it was clear that the growth of trees in the field with clover sown immediately after planting was far less than the growth of the trees on the bare soil.
Several grass types for the alleyways are observed, in order to find a grass type that has good qualities as alleyway and doesn't pose too much competition to the trees. No results are yet available. Some of the grass types appear to be very sensitive for disease (rust).

Tree support material

Since rootstock M.9 is a rather weak rootstock, it is necessary to give the trees some support material like wooden poles. These wooden poles however, are of pine-wood and treated with creosotic oil or wolman-salt, which is a mixture of heavy metals. Alternative support material is tested in this field. The possibilities of poles made of concrete, Robinia-wood and pine-wood treated according to the Plato process are considered.
Concrete poles can be used for more than one generation of trees and the concrete can be re-used easily. A disadvantage is the difficulty in handling and the price, until now. It is a very common supporting material in Italy. In this country concrete poles are up to 50% cheaper than wooden poles (Torggler, 1994).
Robinia-wood (grown in Hungary) would be a good alternative but until now there is few experience with it. It is expensive and until now not available for Dutch growers.
Another alternative seems to be the Plato process (van Zuylen, 1995). The Plato (Proving Lasting Advanced Timber Option) process is a process in which normal pine-wood, rather soft, is turned into very hard pine-wood by a treatment with high temperature (200° C) and high pressure (14 atm.). Without chemical products it is possible to make a pine-wood pole last for twenty years. This research is still in a premature stage and there are no large amounts of poles treated according to the Plato process available. 30 poles will be placed and tested in the field for detailed research.

Wind breaks

Besides their utility as protection against the wind, wind breaks can have other functions (Gauthier, 1994). They are the hiding place for several natural enemies, and can provide pollen to bees or other insects, like lacewings. Six different wind breaks are tested and observed: *Alnus glutinosa, Alnus cordata, Alnus incana, Salix viminalis, Salix caprea* and *Cupressocyparis Leylandii*. Six trees of each species are planted in two replications. Several times per year the entomofauna is monitored using beating tray samples. Until now only preliminary results are available and it appears that *Alnus cordata* contains very few insects and *Alnus glutinosa* the most. The *Cupressocyparis Leylandii* is observed because it can give hiding place to overwintering adults, whereas the willows are observed because of their early flowering.

Optimalisation of the nitrogen management in biological fruit growing
The mineralisation of organic manure starts rather late in the season when the temperature is sufficiently high. Nitrogen is very important for fruit growing in spring when trees are flowering and buds are initiated for next year. In summer a high nitrogen level can lead to fruit colouring problems and late growth. In order to find a solution for this problem cover crops are sown on the weed-free strip in summer. Crops that are used are described by Butijn (1951) as being probably suitable for this purpose. The experiment is carried out on two cultivars, cv. CPRO-80015-25 and cv. Ecolette in six replications. Cover crops that are sown are *Phacelia tanacaetifolia, Brassica rapa, Trifolium repens* and *Brassica napus.*

Discussion

In a system with resistant cultivars and without fungicide use, until now no specific problems in a system with resistant cultivars and without fungicide use are observed. It is, however, too soon to conclude that this will be a system without problems in the future. Since the most commonly used scab resistance is controlled by just one gene *i.e.* the Vf-gene, there's a reasonable possibility that scab resistance will be overcome by a new race of scab, because few mutations in the scab species are needed. The Vf-gene for resistance to scab has been used successfully for 50 years in apple breeding programs. This might indicate that the Vf-gene in combination with minor genes is responsible for the resistance. In 1993 Parisi *et al.* (Parisi *et al.*, 1993) published the discovery of a new race of scab (race 6) that was virulent to apples with resistance due to the Vf-gene. In their experiment severe scab problems occurred on several scab resistant cultivars like Prima and Coop 9.
In our experiment with resistant cultivars scab was always found but in very low numbers since 1989. It never became a severe infestation and it was never treated. Until now our rare observations of scab on resistant cultivars are considered as a moment o high sensibility of the cultivar. When scab resistance really breaks down in the future, it is very likely that this scab isolate has a lower evolutionary fitness than the "common" scab and a treatment scheme will be adapted. The overcome of scab resistance emphasizes however the urgency diversifying the sources of resistance. This change in breeding program has no influence on the usefulness of the results of the system development. The aim of the system development was to develop a growing system for scab resistant cultivars undependently from their source of resistance.
In the systems research it became also clear by measurement of growth that all cultivars show a different reaction to the growing system. Possibly one cultivar is more suitable for a specific system than another cultivar.

Acknowledgements

I owe many thanks to my assistant H. Veijer for carrying out all observations and sharing a constructive critical view on the experiment. I thank E. van Remortel for the statistical analyses and J. de Schipper for organizing the practical work in the orchard.

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ECOLOGICAL STUDIES AND PROPSECTS FOR CLASSICAL BIOLOGICAL CONTROL OF APPLE PESTS IN EUROPE AND ELSEWHERE

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Abstract

Although IPM strategies have been developed in many apple growing regions of the world, in several areas the pesticide load is still heavy, IPM relies largely on reducing the excessive application of broad-spectrum pesticides and their replacement with more specific ones, the use of IGRs where permitted, and in some instances pheromones. IOBC/WPRS working groups were instrumental in developing protocols to test the side effects of pesticides on non-target and beneficial organisms and guidelines for integrated production of pome fruits in Europe.

Some major natural control agents such as predatory mites and anthocorids received due consideration, and some biological control agents were deliberately used to alleviate specific pest problems (e.g. *Aphelinus mali* against apple woolly aphid and *Prospaltella perniciosi* against San José scale). In spite of all past efforts, the effect of natural control and the use of classical biological control agents has been largely disregarded, a heritage from the days when a zero percent tolerance level was advocated and accepted as a standard that was prohibitive to the use of biocontrol agents. However, problems from increasing resistance to a decreasing number of registered pesticides warrant a novel approach. We now need to better understand and compare the ecology of natural control agents. Key issues would be investigations on the diversity and abundance of natural enemies in different regions and in relation to orchard management, varieties etc. in order to enhance opportunities for biological control.

The likely area of origin of apple and some major pests such as codling moth is in central and eastern Asia where natural enemy complexes are known to be different from those in western Europe. As the evolutionary centres of pests are known to have the greatest diversity of co-evolved natural enemies, these must not be ignored as potential sources of biocontrol agents to be used elsewhere.

Apple Pests

Only a handful of a countless number of phytophagous arthropods have got out of hand and have become more or less serious pests of our most important commodities, agricultural crops. They have been favoured by all sorts of agricultural practices, particularly by growing crops as monocultures producing unlimited food resources and at the same time impoverishing the fauna and flora. The use of pesticides enhanced the development of

secondary pests whose natural enemies were more susceptible than the phytophages themselves.

Particularly concealed living leafminers were considered as pesticide-induced secondary pests of which some erupted to previously unknown levels. With current IPM methods, these have been brought under control, but others resurge because they attain resistant to pesticides, and new species attain pest status. Thus, in Switzerland, the tortricid *Grapholita prunivorana*, for unknown reasons, became locally a pest that damaged up to 30% of the fruits in the 1980s. The use of diflubenzuron against codling moth did not kill *G. prunivorana*. At the same time also some "old" pests such as scale insects including San José scale built up to pest proportions (Wildbolz, 1988). Similar situations can be expected in the future and anywhere.

Some pests are suspected to have appeared as a consequence of heavy fertilization. For instance, the apple leaf-curling midge, *Dasineura mali* found ideal conditions to complete up to three generations when virtually continuous leaf growth into the late autumn provided them with an unlimited food resource. At the same time a new gallmidge, *Macrolabis* sp. was recorded for the first time fom apple (Carl, 1980).

Today the most important pests in European apple orchards are tortricids, aphids and mites, and there are pests of secondary importance such as shoot- and wood-boring Lepidoptera, the apple sawfly and the apple blossom weevil (Blommers, 1994). Elsewhere in the world the pest complexes and problems are basically similar.

The key pest worldwide is codling moth. As it is a direct pest attacking the fruit, in the golden days of chemical control a zero percent tolerance level was set and achieved, at the expense of an excessive amount of chemicals applied. At that time is was argued that not only did the consumers want fruit unblemished by codling moth, but also it was unreasonable to expect producers to go into the process of sorting out attacked fruit. Both were happy, but only for some time, until the pitfalls of chemical plant protection became apparent.

Today this has fortunately changed. It has become true that many consumers warmly greet the worm in the apple as a sign of untreated fruits, and many producers have put up with it and follow the IPM recommendations that they are given. The tolerance level, now set at about 2% is still unneccessarily low, also from an economic standpoint in view of overproduction; I believe with several others that 5% or even more would be tolerable, and would enhance the chances for biological control.

Conservation of natural control agents

Our general belief is that we have done enough for the conservation of natural enemies if we adhere to the use of selective pesticides, we do not overdose them, we do not kill off predatory mites or introduce them where they are absent, and we provide nesting sites for birds. Is this really all we can do?

How can we improve the action of say the braconid *Ascogaster rufonotatus*, one of the most important parasitoids of codling moth in Europe if we do not know under which environmental conditions it thrives? From a brief study in the 1960s we have indications that this species is more abundant in neglected apple orchards with a rich flora in and around them than in others without a diverse plant association. While this is some circumstantial evidence for the need of food sources other than are available on apple trees e.g. honey dew of aphids, it does not answer any question as to how to improve the situation.

In the Soviet Union, nectar and pollen-producing plants as ground cover were recommended as a food source for parasitoid adults of the codling moth and San José scale (DeBach & Rosen, 1991). No information is available on the species of natural enemies that should benefit from this measure. In China, *Ageratum conyzoides* was grown in orchards to provide pollen as food for phytoseiid predators. At the same time it lowers the temperature by an average of 5 °C and raises humidity which is conducive to the survival of predators and parasitoids (Knutson & Gordon, 1982). Again this is only circumstantial evidence that requires much more detailed ecological studies to draw conclusions.

Van Lenteren (1987) has reviewed the environmental manipulations that are advantageous to natural enemies of pests. Remarkable progress has been made in greenhouses, but the review also shows the general paucity of our knowledge in this field of research outside glasshouses.

Biological control

Biological control is part of natural control which is a combination of all factors of environmental resistance and constraints that act on a species and prevent it from making use of its inherent unlimited exponential growth. Tortricids for instance, probably the most important single pest group on apple, have a reproductive capacity of about 50-200 per generation. These would be increasing in numbers at an enormous rate unless they suffer heavy mortality prior to reaching the reproductive adult stage. In principle, natural control comprises not only biotic mortality factors, parasitoids, predators and pathogens, or limitations of food resources, but also abiotic, physical factors such as climate and weather, and shelter. All factors together normally keep phytophagous arthropods at an equilibrium level. As abiotic factors are mostly density-independent, they do not regulate populations: a heavy thunderstorm washes away 50% of a population, regardless of its size. And as we cannot usually influence them, we restrict the term **natural control** to biotic agents limiting and regulating population size of pest.

Many natural enemies are known to act in a density-dependent manner, and hence they can regulate populations: their impact becomes greater as populations increase and dimishes on low populations. Beneficials with these characteristics are the most interesting and promising as potential biological control agents. If they are naturally associated with a host they are sometimes called natural biological control agents

We speak of **classical biological control** if exotic natural enemies are deliberately introduced, established and left on their own to reduce host populations. The advantages of this control strategy cannot be overemphasized: There will be permanent control with no side-effects on the environment, rarely affecting other, non-target organisms depending on the host specificity of the agent used. The economic benefits are far greater than with non-biological control techniques, or with other biological control techniques which follow below. To quote an example from the orchard scene, Tisdell (1990) has estimated the benefit/cost ratio for biological control of the orchard mite at 24.4:1, whereas the ratio for non-biological control is at 2.5:1. There exist similar estimates for a wide range of biological control programmes with similar results.

There are other means of biological control like **inoculation** that plays a certain role in apple orchards, for instance when you are asked to introduce phytoseiid predators into your plantation for the contol of spider mites. biological control by **augmentation** tries to increase entomophages within defined areas where control should be achieved. While this has some of the advantages of classical biological control, there are recurrent costs for the release of the agent; therefore this should be only a second choice, and it plays no role in apple orchards. This has recently been reviewed by King et al. (1985). There is finally the **inundation** technique that requires very large numbers of agents to be released. Usually this method is restricted to the use of Trichogrammatidae, not because these egg parasitoids are the best choice but for the simple reason that they can be produced in immense numbers at very low cost. They have sometimes been tried in apple orchards, strangely against codling moth, the species among all the orchard pests worldwide with the lowest tolerance level.

Biological control as central part of IPM in apple orchards?

IPM, also in apple orchards, started out by reducing the application of broad-spectrum pesticides from a calendar base (8-10 sprays per season) to the actually required level to keep pests under a certain tolerable level. The achievements were impressive. Often more than 50% of the costs of pesticides and labour in their application could be saved, and the environmental impact of toxic materials was greatly reduced, however this was not good enough.

Since the appearance of selective pesticides, more progress has been made. The West Palaearctic Regional Section of IOBC was leading in the development of protocols for testing the side effects of pesticides on non-target and beneficial organisms and guidelines for integrated Production of pome fruits in Europe (Cross & Dickler, 1994). "Populations of key natural enemies (e.g. phytoseiid mites on apple or anthocorid predators on pear) must be preserved. ... This means that plant protection products toxic to them may not be used."

These are the right steps in the right direction, and biological control for instance of spider mites was a full success. However they concern only two groups of natural enemies, both predators. What do we know about this almost countless number of parasitoids that attack leafollers, leafminers, aphids and other orchard pests in different parts of the world? We assume that they play an important role as mortality factors, for instance when we see all these mummified aphids. Natural factors are limiting aphid and leafroller populations to some degree (Wildbolz, 1988). This is about the present state of our knowledge but we need to know more about their population ecology and effect on their hosts under optimum conditions in order to enhance their effectiveness by manipulating the environment in their favour.

Classical biological control has been tried in but a few cases, mainly because for a long time the high input of agrochmicals precluded its application. The present situation is more conducive to biological control as the example of spider mites demonstrates. IIBC has been carrying out some research on leafrollers in the past (see the following Section), and is currently working on the biological control of apple ermine moth and the apple sawfly both of which are of European origin, on behalf of the Government of Canada. These studies will be dealt with elsewhere in this conference.

Our domestic apples *Malus domestica* probably all derive from *M. pumila* found at the boundary of Europe and Asia, or from *M. sieversii* occurring in central Asia (Jones & Aldwinckle, 1990). If this is so, one should seek for control agents primarily in these original areas as the evolutionary centres of pests are known to have the greatest potential for useful co-evolved natural enemies. We know already that the complex of natural enemies e.g. in Kazakhstan, in the area of Alma Ata (literally translated "father of the apple") is different qualitatively and quantitatively from that in western Europe. The ichneumonids *Mastrus ridibundus* and *Liotryphon* sp. play a prominent role as well as the braconid *Microdus rufipes*. At the moment there is too little information to be of help in making proposals or decisions. However, it is suggestive that in this area or in western China new parasitoids or better adapted strains can be found that could be useful elsewhere. Detailed ecological studies are required before any conclusion can be drawn. It will be only through cooperation with these countries that the required information can be obtained.

In addition to introduced pests, either with the plant or later, crops are plagued by native pests. These will be the subject of the following paragraphs.

Biological control of native pests

In the beginning there were more or less fortuitious examples of successful classical biological control of native pests by exotic natural enemies, mostly parasitoids. These were later summarized and used as an argument to include also native species as targets for introduced exotic natural enemies. Obviously this would widen the scope for biological control enormously. Virtually any pest species could be considered as target. While there is some disagreement that native pests are even more promising targets than introduced pests (Hokkanen and Pimentel, 1984, 1989), there is unanimity that there is sufficient evidence that they are suitable targets (e.g. Carl, 1982; Waage & Greathead, 1988).

In apple orchard pests this means that that particularly tortricids and aphids should be considered as potential targets for the introduction of natural enemies from other areas.

In the 1960s IIBC was requested by Agriculture Canada to search for natural enemies of the red-banded leafroller, *Argyrotaenia velutinana*. A study was carried out on the nearest relative in Europe, *Adoxophyes orana*, which was later complemented by investigations on *Argyrotaenia pulchellana* which at that time in upper Italy and southern France simultaneously decided to spread from a large number of herbaceous plant species (over 60) to acquire trees, *Morus, Platanus* and apple as new host plants.

From the 20 parasitoid species that were recorded from *A. orana* from Germany, Switzerland and Italy (Carl, 1974), the eulophid *Colpoclypeus florus*, common to both host species, was selected as the most promising agent for introduction into Canada because it was well synchronized with the host, without the need for alternate hosts, and with more than one generation developing on the same host generation. Following its release in Ontario, Canada in the 1960s, it was only recorded from *Spilonota ocellana* and *Choristoneura rosaceana* in the 1990s, after almost 30 years (Hagley & Barber, 1991)! Even more spectacular is the fact that the parasitoid turned up rather unexpectedly in Washington State at the Pacific coast about two years ago where it attacks *Pandemis* sp. and *C. rosaceana* and parasitism has reached as high as 80%. Further studies are under way to evaluate the degree of control exerted on these hosts (Mills, personal communication).

This seems to turn into a good example to demonstrate that classical biological control does work also against native pests and that sometimes it may take a long time for a parasitoid to adapt to a new environment.

Discussion

Integrated pest management in apple orchards over the past decades has made considerable progress by reducing the input of plant protection products, but with a few exceptions it has made little use of the potential that biological control has to offer.

Some natural enemies such as predaceous mites have been put under protection, and plant protection materials developed that are harmless to these and other beneficial species. Unfortunately we must admit that very little is known about the population ecology and impact of most of the almost countless number of natural enemies occurring in the apple orchard system, particularly parasitoids.

While it is clear that the protection of hymenopterous parasitoids has alleviated the problems with some leafminers, the role of beneficial species on other pests has been largeley ignored. It appears to be an absolute necessity to learn more about the basic needs of the more important natural control agents and even change agricultural practices in their support where this is indicated, to enhance natural control.

A much larger field of biological control, largely untapped, is the use of agents against introduced pests which apple pests are in most parts of the world as well as against native pests.

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LECTURES

Section: IFP General Problems

COMPARISON OF INTEGRATED AND CONVENTIONAL PRODUCTION OF APPLES

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Abstract
The aim of the experiment was to show the practical possibilities in an integrated apple production system. One plot containing 30 trees of each of eight cultivars were treated according to principles for Integrated Fruit Production, while a similar plot were treated conventionally. 'Prima' and 'Priam' proved their scab-resistance (not sprayed against scab). The remaining cultivars were sprayed according to Mill's infection table. In the conventional plot 10-17 fungicide treatments were applied per year, while the integrated plot received 3-16 treatments depending on cultivar and year. However, the integrated plot was not treated against storage diseases in order to evaluate the risk of omitting these sprays. In the conventional plot fruits were mostly free of scab at harvest. In the integrated plot incidence was mainly between 0 and 1 per cent, with a few cases of 2-5 per cent scab. Gloeosporium-rot and storage scab gave rise to considerable losses during storage, particularly in 'Aroma'. Sufficient control of insect pests was difficult with the few selective insecticides available. Capsids and apple sawflies caused a considerable damage, while totrix moths was controlled by diflubenzuron.

1. Introduction

Research on Integrated Production (IP) of apples in Denmark began in 1985, when the present experiment was planted. Results up to 1992 was reported at the last symposium (Grauslund et al. 1993). The main difficulty in practising the IP-system was control of tortrix moths, for which no acceptable insecticide was available at that time. Also scab control according to a warning system proved difficult. Mite control without any treatment was very good. - This paper summarizes the main results until 1995.

2. Material and methods

Sixty trees of eight cultivars were planted in 1985-87 (Grauslund et al. 1993). The orchard is divided into two blocks with 30 trees per cultivar in each block. From 1987 one block is treated 'conventional' with a normal pesticide programme. The other block is treated 'integrated', that is scab control according to warning (KMS-P using Mill's table) and pest control using selective pesticides after pest monitoring. The pesticides used are shown in table 1. From 1992 the cultivars were divided into three groups with respect to scab treatment in the integrated plot. Group 1: 'Prima' and 'Priam' (not treated). Group 2: 'Discovery', 'Ananas', 'Aroma', 'Ingrid Marie' and 'Filippa' (treated at severe warning). Group 3: 'Belle de Boskoop' (treated at light warning). Fungicides were applied at normal rates in both plots from 1992. A treatment against fruit tree canker (captan) were applied at green tip and at leaf fall and one against calyx rot (thiophanatmethyl) during bloom in all cases. Sprays against storage diseases were not applied in the integrated plot in order to evaluate the risk of omitting these sprays (1-2 x captan). From 1991 15 trees in each block of 'Aroma' were pruned in August while the remaining 15 trees continued with normal winter-pruning.

3. Results

Table 1 shows the use of pesticides in the years 1990-94. Despite the reduction in number of fungicide treatments in the integrated plot only very few fruits had scab at harvest, Table 3. However, in 1991 which was a difficult year for scab control due to heavy infection treatments were not reduced and 1-5 % fruits had scab. It was more difficult to control scab in 'Belle de Boskoop' than cultivars in group 2 (more leaf symptoms). Omitting sprays against storage diseases (storage scab and Gloeosporium) was not justified, and even 1-2 captan-sprays used in the conventional plot was not enough. 'Aroma' was clearly most sensitive to Gloeosporium. Table 2 shows that infections were less severe in August-pruned trees, probably due to better drying conditions (more open trees) or to a slightly reduced fruit size. The two scab-resistant cultivars 'Prima' and 'Priam' received very few fungicide treatments and no scab was found. However, the reduced treatment resulted in more infections with fruit tree canker ('Prima': 7 and 27 % ,'Priam': 0 and 23 % infected trees in conventional and integrated plots respectively).

Table 4 shows per cent fruits with damage of various pest insects as main effects of year and cultivar in the two treatments. Tortrix moths which was a problem during the first years have succesfully been controlled with diflubenzuron. A number of species have been identified as being responsible for this damage (Grauslund et al.1993, Ravn et al. 1993). Considerable variation in damage occur from year to year with no clear difference between cultivars, Figure 2. Capsids have recently given rise to serious problems in practical IFP (Hesjedal & Bertelsen 1995, Ravn et al. 1995) because no routine petal fall sprays are used. No treatment was applied in the integrated plot, but 'Ananas', 'Aroma' and 'Filippa' are more susceptible to this pest, Figure 1. Mite control in the integrated plot was very good without any treatment as in the first years (Grauslund et al. 1993).

4. Discussion

The experiment shows that it is possible to reduce the total pesticide input in an integrated production system. But when no routine sprays are used some pests (i.e.capsids, tortrix moths, apple sawfly) may become damaging and require new means of control. Cultivars with resistance or low susceptibility to scab need none or only few scab treatments, but reduction in fungicide use may result in increased infection with other diseases like fruit tree canker and storage rots. In strong growing trees August-pruning may reduce Gloeosporium-rot, but this must be confirmed.

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Table 1. Pesticides used and number of treatments 1990-94. Cultivars grouped for scabcontrol in the integrated plot since 1992. Group 1: Prima, Priam. Group 2: Discovery, Ananas, Aroma, Ingrid Marie, Filippa. Group 3: Boskoop.

	Conventional					Integrated				
Year FUNGICIDES	90	91	92	93	94	90	91 Groups:	92 1,2,3	93 1,2,3	94 1,2,3
Captan	5	6	8	6	12	1	2	3,3,3	2,4,4	2,5,8
Thiophanatmethyl	1	1	1	1	1		1	1,1,1	1,1,1	1,1,1
Tolylfluanid	1		4	3		2	2		0,1,1	0,0,1
Sulphur	2	1		1	1					
Bitertanol		1		2	1	2	5	0,0,1	0,3,3	0,2,4
Dithianon		1		1	1					
Fenarimol	1						1	0,2,2		0,1,2
Triadimefon	3				1					
No. of treatments	13	10	13	14	17	5	11	4,6,7	3,9,9	3,9,16
INSECTICIDES	Conventional					Integrated				
Pyrethroids		2	2	1	1					
Clofentezin	1	1								
Hexythiazox					1					
Fenitrothion	1									
Pirimicarb	1									
Amitraz			1	1						
Carbaryl (*thinning)	*1	*1	1							
Dicofol			1							
Fenbutatinoxyd				2						
Bac. thuringiensis						2	1			
Diflubenzuron							1	1	2	
Phosalone										1
No. of treatments	4	4	5	4	2	2	2	1	2	1

Table 2. Per cent fruits with Gloeosporium in Aroma after storage in relation to treatment with fungicide against rot and pruning-method.

Year	Fungicides	Winter-pruning	August-pruning
1992	+ (Con.)	5.7	3.2
1992	- (Int.)	17.7	4.4
1993	+ (Con.)	6.0	1.2
1993	- (Int.)	11.6	7.6
	LSD (pruning)= 3.6	Average: 9.4	Average: 4.1

Table 3. Per cent fruits with scab at harvest (Sh), storage scab (Ss), and Gloeosporium rot (Gl) during five years of conventional (C) and integrated (I) growing.

CULTIVARS		1990 C	1990 I	1991 C	1991 I	1992 C	1992 I	1993 C	1993 I	1994 C	1994 I
Discovery	Sh	0	0	0	1	0	2	0	0	0	0
Ananas	Sh	0	1	0	1	0	0	0	1	0	0
Prima	Sh	0	0	0	0	0	0	0	0	0	0
Priam	Sh	0	0	0	0	0	0	0	0	0	0
Aroma	Sh	0	0	0	2	0	0	0	0	0	0
	Ss	0	0	0	1	0	0	0	1	0	1
	Gl	5	12	12	13	5	9	4	10	*19	*56
Ingrid	Sh	0	1	2	5	0	0	0	0	0	1
Marie	Ss	0	0	0	0	0	0	0	4	0	3
	Gl	0	4	6	5	4	2	1	13	*30	*54
Boskoop	Sh	0	1	0	3	0	3	0	0	0	0
	Ss	0	0	0	4	0	2	1	18	0	3
	Gl	0	0	0	0	1	2	0	0	2	2
Filippa	Sh	0	1	0	1	0	0	0	0	0	0
	Ss	0	0	0	0	0	1	0	0	0	3
	Gl	0	0	0	1	1	2	0	0	3	9

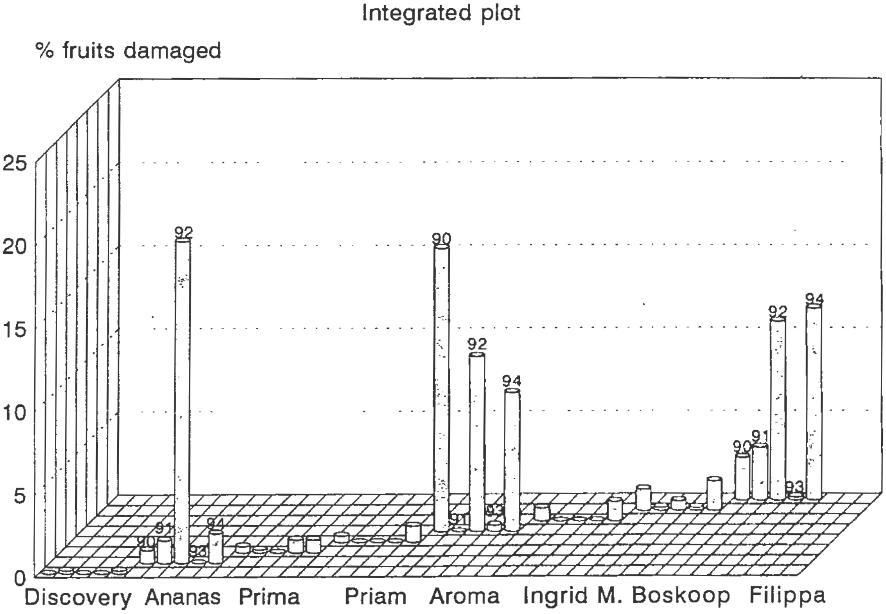
* :Too late assesment in the 1994-season.

Table 4. Per cent of harvested fruits with damage of various pests.

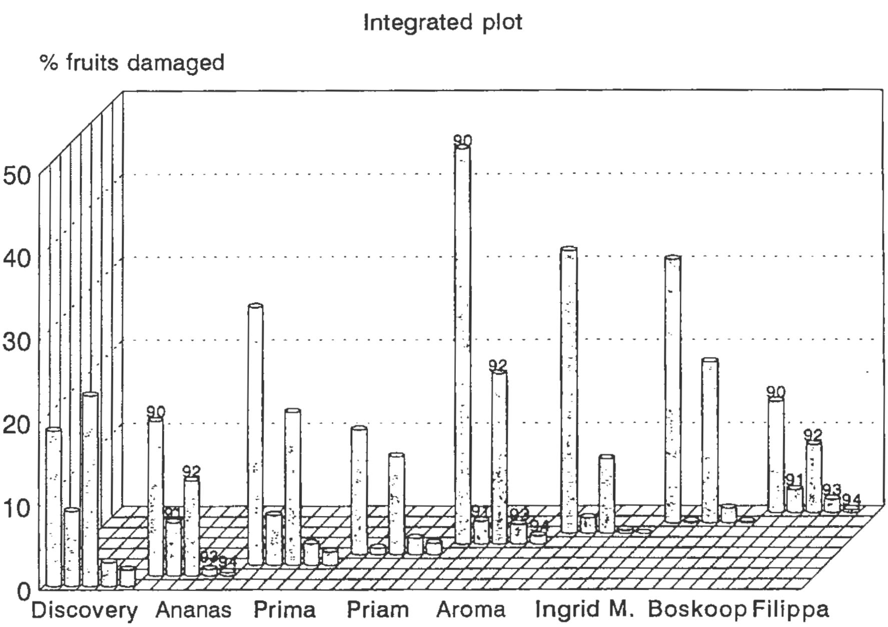
YEAR	Apple sawfly C	Apple sawfly I	Capsids C	Capsids I	Tortricids Early C *	Tortricids Early I	Tortricids Late C	Tortricids Late I
1990	2	1	0	3	-	-	6	26
1991	3	3	0	1	0	2	0	4
1992	6	4	0	5	2	3	0	15
1993	3	6	0	0	0	2	0	2
1994	3	4	2	3	0	0	0	1
CULTIVAR	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**
Dicovery	8	7	0	0	1	2	2	11
Ananas	2	2	0	5	1	2	1	8
Prima	2	4	0	0	0	1	1	12
Priam	4	5	0	0	0	1	1	6
Aroma	2	3	2	7	0	1	3	13
I. Marie	0	1	1	0	0	1	2	9
Boskoop	3	4	0	1	2	3	1	11
Filippa	4	4	0	6	1	2	1	5

* In 1990 tortricid damage was not separated in early and late.

Figur 1. Damage caused by capsids 1990-1994



Figur 2. Damage caused by tortrix moths in late summer 1990-94



IFP - MORE THAN THE PRESERVATION OF PREDATORY MITES

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ABSTRACT

In the South Tyrol, as in many other fruit growing regions, guidelines for the integrated production of pip fruit were laid down first in 1989.

Regarding pest control they require, among other things, a drastic reduction of the number of allowed pesticides. The paper deals with the positive and the negative effects of this programme.
Possible solutions how to overcome pest resistance without turning back to broad-spectrum insecticides will be pointed out.
The problems which arise when the action threshold is below the economic injury level will also be discussed. Furthermore, a valid IFP-programme should observe not only the principles of IPM, but it should also include all aspects of orchard management.

INTRODUCTION

In this presentation I will first explain how the resistance of spider mites to traditional miticides led us to a modified pest management programme and a new approach to fruit production. Then I will point out the benefits of IFP from the point of view of pest management and show some problems that arose in connection with our IFP programme and their solutions. Finally I will deal with the terms "economic injury level" and "action threshold" and their implications for the growers.

1. The resistance of spider mites - the impetus to a modification of our pest management programme and to a new philosophy of fruit production.

The South Tyrol is one of the most intensively cultivated apple growing regions in the world. An about 17,600 ha large continuous orchard area belongs to about 8,000 owners. The South Tyrol is a very mountainous country, therefore good orchard land is scarce and apple trees are planted on each suitable square metre. Under these circumstances the danger of pest and disease resistance is quite high. Over the years we have had several cases of resistance (cf. table 1).

Table 1. **Cases of pest resistance in pip fruit orchards in the South Tyrol, Italy.**

Year	Pest	Resistance to
1964	red spider mite	OPs
1969	leaf miner	DDT and other organochlorines
1973	pear psylla	OPs
1982	red spider mite	cyhexatin (Plictran)
1988	leaf miner	CSIs (Dimilin etc.)
1990	codling moth	CSIs
1995	rosy apple aphid	pirimicarb and other carbamates?

In 1982 red spider mites became resistant to cyhexatin (Plictran). The consequences were higher control costs per ha, severe damage to the trees and bad prospects for a successful chemical control in the future. In this situation the growers could quite easily be convinced to change their control tactics. Our main suggestions were:

a) Avoid any superfluous chemical treatment
b) Exclude all products that are toxic to natural enemies
c) Raise the tolerance level for pests that do not attack fruit

Ad a): **Avoid unnecessary treatments:**
This is possible with pests which do not damage the fruits, for example with the green apple aphid (*Aphis pomi*) and the leaf hopper (*Empoasca vitis*). We also succeeded in reducing the use of pesticides against other pests, provided there is a certain lapse of time between their first appearance and the beginning of their feeding, for example with some leaf roller species.

Ad b): **Exclude products toxic to predators:**
Our most important source for evaluating the side-effects of pesticides on natural enemies are the various IOBC-publications. In the light of this the Advisory Service has drastically reduced the number of recommended pesticides in contrast to those allowed by the law (cf. table 2).

Table 2. **Pesticides recommended by the Advisory Service for apples compared to those allowed by the law (1995)**

	Advisory Service	Legally allowed
fungicides	25	44
insecticides	22	71
acaricides	4	21
herbicides	4	21

Ad c): **Higher tolerance levels**
The toleration of higher levels of spider mites was based on the one hand on various publications (Zwick et al., 1976; Pasqualini et al. 1982), on the other hand the growers had no choice because from the beginning of the 1980s they could no longer rely on the effectiveness of the available acaricides.

With the registration of clofentezine (Apollo) and hexythiazox (Matacar) in 1988, however, some growers became less willing to tolerate more spider mites per leaf. At present the effectiveness of both these pesticides is already declining. The new miticides pyridaben (Nexter) and phenpyroximate (Miro) provide protection only for a short time. Therefore the conservation of mite predators is gaining importance again.

2. The benefits of IFP from the point of view of pest management

Even today most consumers do not exactly understand what IFP means. Nevertheless, the term and the label evoke positive associations with the product.
However, I will pass over the influence of IFP on the marketing and concentrate on the consequences of IFP regarding various pests, beneficial insects and mites and the use of pesticides.
The most important result of this new attitude towards pest management was that quite a number of chemicals which were recognized as highly toxic to people and the environment were banned.
Whereas acaricides were sprayed 3-4 times each season before 1983, nowadays no acaricides are necessary in about 70 % of all orchards in the South Tyrol. Furthermore, since then the woolly apple aphid (*Eriosoma lanigerum*) has been kept under control by its natural enemies, mainly *Aphelinus mali*.
In carefully managed orchards various parasites, such as *Apanteles sp.*, *Holcothorax testaceipes* and *Cirrospilus sp.* are able to parasitize leaf miners like *Phyllonorycta blancardella* to such an extent that chemical control is no longer necessary.

In orchards managed according to our IFP-guidelines sprays against the green apple aphid are an exception. As a rule, green lacewings (*Chrysoperla carnea*), some syrphid species and ladybirds (*Coccinellidae*) are able to control the aphids so well that the fruits are not soiled with honey dew.
Artificial nests are used in the orchards to attract titmice (*Parus caeruleus*) and other birds which feed on caterpillars, mainly noctuids and geometrids, so that specific sprays often become superfluous.

3. Problems in connection with the IFP-programme and their solutions.

Codling moth (*Cydia pomonella*)
As early as in the year 1990 we noticed, at first only in a few places, that codling moth populations were increasing in orchards treated with diflubenzuron. Up to that time one treatment with 100 g a.i./ha per generation had been sufficient. In 1991 10-40 % damaged fruits in spite of 3-5 sprays with CSIs were not unusual in these areas. In 1992 H. Riedl, Oregon, and R. Zelger, Laimburg (Riedl et al., 1994), proved that some codling moth strains had developed a strong resistance to chitin synthesis inhibitors. The resistance appeared after about 25 CSI applications.
From 1992 onwards we were forced to warn against the use of CSIs on larger and larger areas. After having thus lost an important component of our pesticide list there was a danger that we would not be able to make an IFP-programme that would come up to international standards.
Phosalone (Zolone), which had an acceptable degree of effectiveness north of the Alps, failed under our conditions. Fenitrothion (Fenitrocap) and quinalphos (Ekalux), which are about as effective as azinphos (Gusathion) but less acutely toxic, are throwbacks in comparison with CSIs. To my mind, 3-5 treatments with OPs against codling moth per season are incompatible with a plausible IFP-programme. Furthermore, such a control strategy would once more severely harm the fauna in our orchards.
Therefore we are energetically trying to introduce the mating disruption technique on a large scale. After some field tests on smaller plots by the Laimburg and the Advisory Service between 1988 and 1990 RAK 3+4 was used on 110 ha in 1991. Unfortunately BASF did not sell this dispenser again in the following year.
In 1993 we made a new start with Isomate-C dispensers on 232 ha. This technique, combined with a supplemental treatment with an insecticide, reduced the average codling moth damage considerably (cf. table 3.).

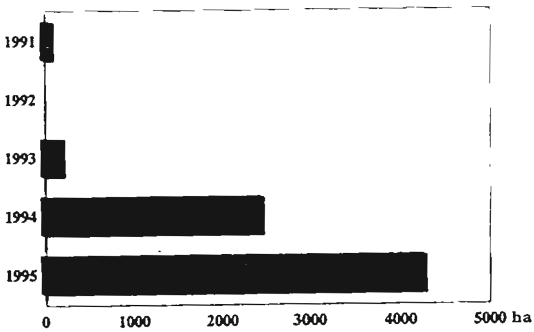
Table 3. **Fruit damage caused by codling moth in disrupted orchards, 1992-1994.**

location	checked orchards	Ø fruit damage 1992	1993	1994
Leifers	80	6.6 %	0.9 %	0.2 % *
Bozen	52	5.2 %	1.2 %	-
South Tyrol	913	-	-	0.4 %

* only 20 apple orchards

In 1994 the disrupted area expanded to 2,500 ha. The data collected in 913 disrupted orchards at harvest showed an average codling moth damage of 0.4 %. In comparison with non-disrupted orchards, the number of additional treatments was reduced by two thirds.
In the Leifers area we recorded the damage caused by codling moth over a period of two years. The results show that there was significantly less fruit injury after two years of mating disruption (cf. table 3).

Graph 1. **Development of mating disruption in the South Tyrol 1991-1995**



This year 4,400 ha apple orchards are furnished with dispensers (cf. graph 1), 2,500 ha of which with combined dispensers against codling moth and leafroller (1,500 ha Isomate-C-Special, 1,000 ha RAK 3+4, 20 ha Ecopom Combi).
On the basis of the checks at the beginning of August we can predict that codling moth damage will be below 1 % this year in most cases if it was below 1 % at harvest in the previous year and if the disrupted area is larger than 3 ha.
Supplemental treatments were necessary where the damage at harvest exceeded 1 % last year and in border rows near buildings, untreated nut trees and stacks of wood.
At present our action threshold is at 0.5 % fruits with recent entries.
We think that at least 3 fruit checks à 1,000 fruits should be made each season to ensure adequate monitoring.
With regard to leafroller the results of mating disruption are still so contradictory that we did not recommend it this year and will not recommend it for next year, either. We hope that the researchers and scientists will be able to improve the mating disruption technique for leafrollers, before they will have developed a resistance against fenoxycarb (Insegar), tebufenozide (Mimic) and flufenoxuron (Cascade).

Rosy apple aphid (*Dysaphis plantaginea*)
We also restricted the pesticides recommended against aphids to the carbamates pirimicarb (Pirimor) and ethiofencarb (Croneton). Since 1990 we have noticed that their effectiveness has been diminishing. Today we hope to maintain the same high degree of control by a more accurate timing of the treatments. Following the suggestions made by C. de Gendt (Gendt de, 1993) we used Pirimor selectively against the stem mothers in pre-bloom. Even so, we had to recommend a further treatment with vamidothion (Kilval) on 70 % of the total orchard area after bloom in order to prevent fruit damage.
While we see in the mating disruption technique a possible way of overcoming the resistance of codling moth, concerning the control of aphids we have fallen back to the 1980s.

4. Economic injury levels and action thresholds

The term "economic injury level" is already well-defined. In practice, however, we often have to make treatment decisions before a certain damage is caused. With indirect pests it is easier to work with action thresholds. In table 4 some examples are shown.

Table 4. **Some examples of action thresholds**

Pest	**Action threshold**
Phyllonorycta blancardella	1 mine/leaf/June
Phyllonorycta corylifoliella	3-4 mines/leaf/June
Panonychus ulmi	15 adults/leaf/August
Aphis pomi	15 shoots with colonies out of 100/summer

With direct pests it may be problematical to work with action thresholds, as will be shown in the following two examples:

Rosy apple aphid (*Dysaphis plantaginea*)
The IOBC-guidelines suggest applying an aphicide when the first colonies are found in the orchards. Nevertheless, two publications (Hull et al., 1983; Gendt de, 1993) show that the degree of effectiveness is highest if the stem mothers are controlled by a selective spray. A degree day model developed by B.Graf (Graf et al., 1985) has proved very valuable for determining the best date for such a treatment. The disadvantage is that treatments at such an early stage eliminate at the same time also the harmless apple-grass aphid (*Rhopalosiphum insertum*) and prevent thus the population build-up of important predatory insects and parasites. However, since there is rarely an orchard which does not have to be treated against this pest, I would recommend choosing the earlier date, because then a smaller amount of pesticide input is sufficient.

Codling moth (*Cydia pomonella*)
Also with this direct pest the control measures with classical pesticides have to be taken before a certain economic injury level is reached. One has to keep in mind, however, that all predictive models tend to lead to rather more sprays than actually necessary because the weather, which has a decisive influence on the development of this pest, can be predicted only for a period of four or five days.

A big obstacle to the implementation of IFP-ideas is still the growers' underestimation of the importance of careful monitoring. In the following years it will be one of our main targets to convince as many growers as possible that accurate checks at certain key times (e.g. leafroller density after bloom) are absolutely indispensable.

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The development of integrated fruit management programs in Michigan, USA

by

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Abstract

Chemical inputs for apple, peach and cherry production in Michigan, and in the central and eastern regions of the U.S.A. have risen steadily since the turn of the century. Under these conditions, growers use between 1 and 8 different fungicides; and 2-10 insecticides applied at 7-10 day intervals throughout the season, depending on the crop. Growers have typically made as high as 15 (apple) and as low as 5 (cherry) chemical spray applications in a growing season in Michigan. In recent years growers have become more aware of integrated pest management techniques and have actually reduced the amounts and number of applications since the early 1980's. Research projects for peach (Southwest Michigan Research and Extension Center, Benton Harbor) and apple (Clarksville Hort. Exper. Station) were initiated in 1990 and 1994, respectively, at two research stations in Michigan to compare the effectiveness of Conventional, Low Chemical and Moderate Chemical levels of management techniques. Chemicals in the soil water is also being monitored in these plots. Preliminary data for both trials will be reported in this paper. Scientists in the Michigan Agricultural Experiment Station comprise research teams from various disciplines to test new approaches in reducing chemical dependency and impact on the environment. Additionally, a report will be given on the various programs currently underway in Michigan to reduce pesticide usage by commercial fruit producers.

Peach Integrated Pest Management Project

In 1990 J. Flore, J. Johnson, M. Whalon, G. Bird, E. Hanson, A. Jones and W. Shane established six 0.3 ha plots of peach, *Prunus persica* L. cv. Newhaven, with two replicates per pest management treatment at the Southwest Michigan Research and Extension Center, Benton Harbor, Michigan, USA. The trees were spaced at 5 X 7 m and plots located at least 200 m apart. Three pest management strategies for Michigan peach production were compared starting in 1993 for effects on fruit quality and yield, and pesticide residues on fruit and in the soil. The first treatment protocol followed Conventional Pest Management techniques (MSU Fruit Spraying Calendar, E-154), with full cover insecticide applications on a two week basis.The second treatment protocol followed a Standard Integrated Pest Management strategy, relying on monitoring pest populations and timing insecticide sprays with treatment thresholds. The third treatment protocol was a Low Chemical Input strategy, that employed oriental fruit moth mating

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disruption, endophytic rye groundcover (SR 4100, Seed Research of Oregon, USA), timed mowing, biological nematode control, selective thinning and perimeter insecticide sprays. Full cover insecticide applications were used only when other control techniques had been exhausted. The 1993 season ended with a total of 7 full cover insecticide sprays in the Conventional plots, 4 in the standard IPM plots, and 2 in the Low-chemical input plots. 1993 insect damage evaluations showed no significant differences between any of the treatment strategies for the control of oriental fruit moth *Grapholita molesta* Busck and plum curculio *Conotrachelus nenuphar* (Herbst). Harvest evaluations showed 99.5 % insect clean fruit in the Conventional plots, 93.5 % clean in the Low-Input plots and 89.5 % clean in the standard IPM plots. All of the damage in the Low-chemical Input and Standard IPM plots were a result of rose chafer *Macrodactylus subspinosus* (fabricius) and Japanese beetle *Popillia japonica* (Newman).

Apple Integrated Pest Management

Production methods for apple rely heavily on pesticides and ground applications of nitrogen, herbicides and other nutrients. Production systems have changed substantially in the last 10 years. Trees are smaller, there are more per acre, and management is more intense. This results in high production and high quality, but leaves little margin for error. These intense practices contribute to the potential for ground water contamination from pesticides, herbicides and nitrates. Fruit growers are concerned that a high use of agrichemicals compromises their ability to sustain the production system, protect the ground and surface water, and maintain their market share given consumer perceptions related to food safety and pesticide use. Further, concerns about worker safety and economic pressures coupled with the possible loss of registration for several minor use pesticides present compelling reasons for apple growers to reduce chemical input and consider adapting alternative pest control strategies.

The apple industry, and the MSU Experiment Station and MUSE Extension are fully aware of the potential loss of current control measures, and are actively pursuing alternatives to conventional control. They have demonstrated success to reduce chemical input in peach (LISA/ACE final report, 1994), and through a special federal grant "Safeguarding the Supply of Fruit for Consumers" have initiated work on Blueberry, and Apple. It was through that grant that this project was conceived and initiated. The main objectives were: 1) to compare conventional versus low chemical input strategies on modern high density apple plantings, and to provide a basic set of experimental plots for research and demonstration tin the future, 2) to give visibility to IPM in modern apple planting systems, and 3) to be used as a resource to compare chemical residues in the soil, water and fruit from whole orchard systems (no data collection other than yield and fruit quality). Until this point however, no provision had been made for monitoring of the chemical residues in the ground water, in the soil, or in the fruit.

Materials and Methods

Eight plots were established at the Clarksville Horticultural Experiment Station, Clarksville, Michigan in June 1994 with 300 trees planted in each plot at a spacing of 1.5 x 4.5 m at 1428 trees per ha. Four rows, 24 trees in length, are grouped together, for each of three varieties (adjacent to each other) in a North/South direction. Varieties / rootstocks under test are; Empire / M.9 EMLA (fresh harvest), Liberty / Mark (disease resistant, processing) and Idared / Mark (dual, fresh & processing).Trees at planting were of small caliper and largely lacking feathers, and, therefore, pruned to a single stem. Trees are being trained to the slender spindle system with a target height of 2.5-2.9m. Trees are being supported by 2.5 m metal tubes for individual trees and one strand of high tensile wire at 2.2 m height. Trees are being irrigation by a trickle system. First harvestable crop is expected in fall 1996.

Lysemiters were constructed and installed in July 1995 in each of the eight plots to assist in collecting soil chemicals for analysis (Brown, 1974, Cameron, 1992, Klocke, 1993). The lysimeters are round with dimensions of 1.8 m in diameter and 1.8 m in depth (4.81 cu. m.). Soil for each lysimeter was collected on a site adjacent to one of the eight plots and represented by the Kalamazoo Sandy Loam soil series which is found in five of the eight plots. This was done to provide uniform soil reactions and percolation. In an effort to reduce the potential disturbance of the soil macropore space, metal cylinders 1.8 m wide were driven into the soil with a vibrating hammer to a depth of 1.8 m. After the attachment of metal sheets to serve as a false bottom, the cylinders and soil was lifted and stainless steel bottoms welded. The lysimeters were then transported to each of the eight plots, where they were inserted into the ground. A tube was connected to the bottoms and attached to a 163 liter stainless steel storage tank. One tree will be planted in each lysimeter in fall 1995. Samples will be drawn from the storage tank weekly and analyzed for NO_3 and triazene levels. Soil moisture will also be monitored. A water balance sheet will be constructed from the weekly data. In 1996 N^{15} will be applied in the lysemiters at two different rates (conventional and low N) and uptake and leaching will be monitored. Timing will be one of the main components.

Pest Management Treatments

A vegetation barrier consisting of hybrid poplar *Populus deltoides* Bartr. X *Populus nigra* L. cv. Imperial Carolina dn 34, white pine *Pinus strobus* L.and Italian alder *Alnus cordata* L was established on the perimeter of four of the eight plots. These same plots have the alley-ways planted with endophytic rye groundcover (SR 4100, Seed Research of Oregon, USA). Rye grasses containing the fungal endophyte, *Acremonium lolii*, have been shown to have both toxic and feeding deterrent effects on insect herbivores). Garcia-Salazar and Whalon (1990) found that numbers of X-disaease leafhoppers, *Paraphlepsius irroratus* (Say), *Scaphytopius acutus* (Say), and *Norvellina seminuda*, and catfacing bugs, *Lygus lineolaris* (Patisot de Bequvois) and *Lygus hesperus* in Michigan peaches, could be reduced by replacing traditional orchard groundcover with endophytic rye grass. The function of the barriers will be to test their effectiveness in confining or restricting mating disruption pheromones within the individual plots. The endophytic rye will be tested to determine its effectiveness in suppressing insect populations. The remaining four plots were established without perimeter barriers and standard kentucky blue / fescue grass for the sodded alley-ways.

Disease Control Treatments.

Four of eight plots will be sanitized annually; leaves vacuumed at the conclusion of fall season and a Lime / Sulfur application sprayed on canopies in late winter and spring. All eight plots will receive 3 disease control strategies, seven trees in each of 12 rows for each variety will have one of the following treatments applied: 1) Conventional spray calendar (10 sprays / yr.), 2) Spray sterol inhibitors (4 times / yr.), 3) Chemically Impregnated netting (draped over trees).

Entomological Monitoring.

The following insects and mites will be monitored beginning in the 1996 growing season:

- Mites
- Codling Moth
- Red-Banded Leaf Roller
- Plum Curculio
- Aphids
- Tarnish Plant Bug
- Apple Maggot
- White Apple Leaf Hopper
- Spotted Tentaform Leaf Minor

Orchard floor and Nitrogen Management Study in a Commercial Tart Cherry Orchard

C.E. Edson, et. al., initiated a study in 1995 in a commercial mature Montmorency tart cherry orchard in northern Michigan. The treatments will encompass the interactive effects of selected orchard floor and nitrogen management systems on : 1) the presence of herbicide and nitrogen leaching; 2) soil and plant nutrition; 3) tree growth, yield, and cold hardiness; 4) the phytophagous/entomophagus arthropod complex (emphasis on mites); 5) the presence and density of herbivore, carnivore, and microvore nematode species; 6) the presence of beneficial soil fungi and their relationship to nematode population dynamics; 7) the diversity of plant species in the system; 8) total pesticide use in the system; 9) efficacy of target pest control; and 10) production economics. The research plot will serve as a demonstration for the alternative management systems in an effort to reduce chemical input.

The renewed interest in reducing chemical inputs in fruit orchards in Michigan has been initiated by public and private concerns over food safety. Michigan State University and the state Department of Agriculture has made this topic a high priority funding the above new projects. Our fruit industries hope to gain economic benefit from information developed in these projects.

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Extending the Concepts of IFP to Other Crops: an IPM Certification Program in Massachusetts, USA

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ABSTRACT An IPM certification program in Massachusetts certifies IPM-grown sweet corn, strawberries, potatoes, cole crops and tomatoes. Survey information from consumers, the food industry and farmers in the northeastern United States showed support for the concept of certifying and marketing crops grown using environmentally-responsible techniques, especially integrated pest management. The program, *Partners with Nature*, is administered as a collaboration of state and federal agencies. Certification is based on the use of best management practices including nutrient management, disease management, insect management, weed management, pesticide application and education. A point system weights management practices based on their importance to management and their difficulty. Growers who complete 70% of the possible IPM practice points are certified. Farmers who enroll in the certification program are provided with educational materials and qualified growers are given documentation of their certification and marketing assistance, including posters and brochures, and marketing assistance. The program is also associated with a federal government IPM cost-sharing program: growers who meet certification requirements are eligible for cost-share funds. Because of the mutual support of these state and federal programs, grower participation in both of the programs has grown in each year.

Massachusetts is a small, agriculturally diverse commonwealth in the northeastern United States. Numerous small farms, increasing urbanization and an environmentally-concerned population have contributed to strong state government support of an IPM research and education program. The relationship between farmers and their urbanized and concerned neighbors also set the stage for the development of an IPM certification program. In 1984, growers participating in Massachusetts IPM demonstration projects requested signs to demonstrate to their neighbors that they were environmentally-conscientious farmers, who use pesticides only when needed (Hollingsworth, 1994). University of Massachusetts Extension produced a sign to identify each farm as an "IPM Cooperating Grower." The signs were readily adopted by growers who displayed them in their fields, farms and farmstands. Over time it became evident that while many growers were part of demonstration projects, many of them did not follow the University recommendations. Further, the signs implied that the University was certifying all growers in the program as "IPM Growers." We replaced the sign with one headed by the slogan, "We Support IPM." The concept of IPM-grower identification persisted as a number of growers developed marketing programs around their use of IPM and other growers asked UMass Extension to explore the idea of IPM certification.

In 1990, a mail survey of the food marketing industry was conducted to determine whether a potential market existed for produce labelled "IPM-Grown" (Paschall et al., 1992, Hollingsworth et al., 1993). Consumers, retailers, wholesalers, processors and farmstand owners in the six New England states were contacted. Seventy-seven percent the consumers returning the questionnaire had not heard of IPM, however, after a brief explanation of IPM was given, 84% supported the idea of labels for IPM-grown labels, as did 67% of retailers and wholesalers, 69% of processors and 57% of farmstand owners. A majority of respondents in all groups felt that their state Department of Agriculture should be responsible for certifying IPM-grown produce.

To determine the attitudes of Massachusetts farmers toward IPM certification, questionnaires were mailed to 1000 Massachusetts certified pesticide applicators (Hollingsworth et al., 1992a). Seventy-five percent of growers returning questionnaires (68% response) indicated that they would enroll in an IPM certification program (Table 1). Most farmers agreed that certification should be based on specific growing practices. Thirty-nine percent of the respondents felt that the Massachusetts Department of Food and Agriculture should certify IPM-growers, and 39% (especially cranberry growers) felt that farmers' organizations should be the certifying agencies.

Table 1. Survey of Massachusetts certified pesticide applicators (from Hollingsworth et al., 1992a).

Would you enroll in an IPM certification and marketing program?

	YES (%)	NO (%)	Undecided (%)
Apple	81	13	6
Small Fruit	83	13	6
Cranberry	72	22	6
Vegetable	71	17	12
TOTAL	75	17	8

On the basis of these survey results, we concluded that there was sufficient market potential and grower interest to develop an IPM certification program. The purposes of the program were to: recognize growers who reduce pesticide use; assure consumers of the safety of the food supply; meet marketing challenges from other states; encourage adoption of IPM; and improve structure and delivery of IPM in the Commonwealth of Massachusetts.

As we began to structure the IPM certification program, we were approached by the Massachusetts office of the USDA Consolidated Farm Services Agency (then known as the Agricultural Stabilization and Conservation Service) to help develop standards for a federal cost-share program, providing funds to growers who practice "Integrated Crop Management." A coalition consisting of University of Massachusetts Extension, Massachusetts Department of Food & Agriculture (MDFA) and the USDA Consolidated Farm Services Agency (CFSA) formed to develop the Massachusetts IPM certification program. Components in developing the program included developing crop-specific IPM standards, developing a process to certify growers, and developing an educational and marketing program.

Crop-specific IPM guidelines were developed for apple, cranberry, strawberry, sweet corn and potato because Massachusetts has had active extension IPM research and demonstration programs for these crops. Guidelines were developed with the cooperation of extension specialists, University of Massachusetts faculty, growers and USDA personnel, and were tested through the CFSA ICM cost-share program.

IPM guidelines are based on a point system, in which the more important IPM practices are given greater weight. For example, in sweet corn IPM, pheromone trapping of corn earworm, *Helicoverpa zea*, is considered to be a key component, thus trapping for *H. zea* and using appropriate treatment thresholds are assigned more points than other insect management practices (see Table 2). Growers must accumulate 70% of the total points possible to be certified. Practices must be documented with written records where practical and partial credit can be earned for a given practice by completing a percentage of the appropriate practice. Practices are divided into the following categories: cultural practices and soil and nutrient management; pesticides application and records; insect management; weed management; disease management; and education. In most cases, growers need to acquire points from each category. Standards for apple and strawberry were published in a Massachusetts extension publication (Hollingsworth et al., 1992b, 1992c).

Table 2. Insect management section from Massachusetts Sweet Corn IPM Standards.

1. Pheromone trapping for corn earworm (CEW), as specified in state sweet corn IPM publication, is conducted weekly.	**25 pts**
2. Pheromone trapping and/or field monitoring for European corn borer (ECB), as specified in state sweet corn IPM publication, is conducted weekly.	**15 pts**
3. Pheromone trapping for fall armyworm, as specified in state sweet corn IPM publication, is conducted weekly.	**15 pts**
4. Application of insecticides for ECB correspond to thresholds specified in state sweet corn IPM publication.	**15 pts**
5. Application of insecticides for CEW correspond to thresholds specified in state sweet corn IPM publication.	**15 pts**
6. Application of insecticides for fall armyworm correspond to thresholds specified in state sweet corn IPM publication.	**15 pts**
7. Occasional pests for which thresholds are not available, are treated only after scouting.	**5 pts**
8. Insect pests are kept below economic injury level using non-chemical means such as biological insecticides (eg. *B.t.*'s) or beneficial insects.	bonus: **10 pts**

The point system has a number of advantages. It lists all of the best management practices available to the grower. Growers are given the flexibility to design the most appropriate IPM system for a particular farm. The use of the most desirable practices is encouraged by weighting specific practices. Allowing partial credit encourages growers to try new techniques.

The certification process has three elements: preseason enrollment; a midseason progress review; and the submission of records at the end of the season. When growers enroll in the program they receive a notebook to assist with them through the certification process. The notebook includes fact sheets relating to IPM practices, record keeping forms, lists of additional resources, and information about the certification procedures. Growers or their consultants are interviewed at mid-season. Conditional certification is usually granted at midseason, so that qualified growers can receive marketing materials before harvest and sale of their crops. Growers submit required records and documentation at the end of the season to complete the certification process.

The purpose of the educational component is to increase what growers and the public know about IPM. A marketing committee of extension specialists, growers, and CFSA and MDFA personnel created a program name (*Partners with Nature*) and helped to design an appropriate logo (Figure 1).

Figure 1. *Partners with Nature* program logo.

Educating growers in IPM techniques continues to use the traditional methods, such as grower meetings and publications, but the IPM guidelines themselves have also become an important teaching tool. The *Partners with Nature* notebook has been especially useful for entry-level growers. A marketing packet, including suggestions for advertising and talking to the news media, was also distributed to growers. Marketing surveys and conferences play an important part in improving the delivery of IPM education (Hollingsworth et al., 1995). Public education has taken the form of posters, brochures, leaflets which explain the components of IPM and the purpose of the *Partners with Nature* program. Press releases, press events and radio public service announcements have also been developed.

In 1993, the *Partners with Nature* pilot project was initiated, intending to certify apples, strawberries and sweet corn. Among apple growers, the topic of IPM certification became controversial. A motion was passed by the Board of Directors of the Massachusetts Fruit Growers Association requesting that apples not be included in the *Partners with Nature* certification program and this request was honored. The program certified sweet corn and strawberries in 1993, adding potatoes and cole crops in 1994, and field-grown tomatoes in 1995 (Table 3). While the *Partners with Nature* program shows consistent grower interest and the program is growing, the importance of the CFSA ICM cost-share program to *Partners with Nature* is evidenced by a decrease in sweet corn participation in 1994, when a number of sweet corn growers completed their three-year eligibility in the CFSA program (Table 4). Participation in the CFSA ICM cost-share program also continues to grow, and in 1994, 25 apple growers completed the CFSA ICM standards. This provides a strong indicator that apples may be included in the *Partners with Nature* program in the future.

Table 3. Number of crops certified by Massachusetts' *Partners with Nature* program.

	1993	1994	1995
Sweet Corn	27	23	31
Strawberry	15	16	18
Cole Crops	-	1	3
Potatoes	-	0	4
Tomatoes	-	-	12
Total Crops	42	40	68
Number of Farms	40	28	37

Table 4. Number of farms in Massachusetts CFSA ICM Cost-Share Program, by crop.

Year	Apple	Sweet Corn	Cran-berry	Straw-berry	Potato	Cole Crops	Field Corn	Forage
1990	4	11	4	7	6	0	14	8
1991	5	12	2	9	3	3	14	0
1992	11	15	6	9	8	2	9	6
1993	11	39	10	8	2	5	10	14
1994	25	35	26	12	4	7	1	0

Our program is small, but it is young. We are encouraged by its growth and by the enthusiastic comments of our growers. Massachusetts is small, but we are cooperating with other states and organizations to extend the impacts of our project.

Acknowledgements

The *Partners with Nature* program is a true collaboration of state and federal agencies. I thank my colleagues of University of Massachusetts Extension, Bill Coli and Vicki Van Zee for their ideas and efforts in developing the program, Commissioner Jonathan Healy and Iliana Rivas for the support of the Massachusetts Department of Food and Agriculture, and Paul Fischer and Dick McIntire for the valuable contributions of the USDA Consolidated Farm Services Agency in promoting and conducting the program.

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EIGHT YEARS' EXPERIENCES OF IPM IN HUNGARIAN APPLE ORCHARDS

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Abstract

In Hungary eight years' experiences are available in implementing IPM.

In order to make logical decisions about the necessity of treatments and to choose the most suitable selective preparations - taking into consideration also the interest of parasitoids and predators - the most important investigation or monitoring methods used are: systematic plant surveying, monitoring the population dynamics of the main pests, operating pheromone traps in order to observe important lepidopteran spp., monitoring the occurence of predators and parasitoids, registering the occurence of secondary pests.

In the recommendation of the program, the insecticides Pirimor (pirimicarb), Dimilin 25 WP (diflubenzuron), Insegar (fenoxycarb), Match (lufenuron), Dipel (Bt), Zolone (phosalone), Nevikén (sulphur+vaselinoil) were applied. As acaricides Mitac (amitraz) and Torque 55 (fenbutin oxide) were used. Only those fungicides were applied, which did not endanger predatory mites.

Using IPM technology, we succeed in: keeping the density of leaf miners below the level of economic loss; retarding the build-up of populations of leaf rollers, mainly of *Adoxophyes orana* by using two treatments per year. The population density of *Zetzellia mali* and *Phytoseiidae* species increase and they are able to regulate the population dynamics of tetranychid mites. The parasitoids the leaf rollers and leaf miners can immigrate in the IPM plot, and in the orchard their population density increase.

The population density of aphids (*Dysaphis devecta, D. plantaginea, Aphis pomi*) is regularly high in the IPM orchards, therefore we have to use every year pirimicarb against them. From the secondary pests *Anthonomus pomorum* and *Stephanitis pyri* multiplied in the orchard.

Introduction

The ecological bases of integrated pest management in apple orchards have been studied by a research team of the zoological Department of the Plant Protection Institute in Hungary for 15 years. The arthropod communities were investigated in the different types of the apple orchards (Mészáros *et al.* 1984, Jenser *et al.* 1992. During these investigations many significant data about the pest and beneficial insects, their occurence, population density, distribution, migration as well as their effectiveness have been obtained (Balázs 1989, 1992a, Jenser and Balázs 1993).

By reason of these experiences we had the opportunity to carry a comparative experiment on IPM in apple orchard. This technology has been applied since 1987 in Kecskemét-Szarkás at the Experimental Station of Research Institute for Fruit Growing and Ornamentals.

Material and Methods

The experiment were carried out in an apple plantation of 5 ha, to which in 1992 an additional territory of 4 ha was attached in connection with a USDA project. This circumstance provided an excellent opportunity to compare the effects of IPM technology used for various time periods.

From the 4 ha IPM plot 2 ha was sown with flowering plants, with Compositae (*Calendula officinalis, Taraxacum officinale, Centaurea cyanus*), Fabaceae (*Coronilla varia, Onobrychis viciifolia, Lotus corniculatus*), Umbelliferae (*Anethum graveolens, Coriander sativum, Falcaria vulgaris, Carum carvi, Daucus carota ssp. sativa, Pastinaca* *sativa*) etc. The aim of sowing these plants was to investigate the effect of flowering plants on the occurrence of predators and parasitoids.

To the IPM orchard was attached a conventional orchard in each case.

Five to seven insecticide and acaricide sprayings were applied a year, depending on the occurrence of pests. The IPM orchard was sprayed with the following selective insecticides: Pirimor (pirimicarb), Dimilin 25 WP (diflubenzuron), Insegar (fenoxycarb), Match (lufenuron), Dipel (Bt), Zolone (phosalone), Nevikén (sulphur+vaselinoil). As acaricides Mitac (amitraz) and Torque 55 (fenbutin oxide) were used. Only those fungicides were applied, which did not endanger predatory mites.

Eleven sex pheromones (CSALOMON, Plant. Prot. Inst. HAS) were used for monitoring the following Lepidoptera species: *Adoxophyes orana* (F.v.R.), *Archips rosana* (L.), *Pandemis heparana* (Den. et Schiff.), *P. ceresana* (Hbn.) *Grapholita lobarzewskii* (Now.) *Cydia pomonella* (L.), *Leucoptera malifoliella* (Costa), *Phyllonorycter blancardella* (Fabr.) *Ph. corylifoliella* (Haw.), *Nepticula malella* (St.), *Synanthedon myopaeformis* (Bork.).

To establish the percentage of the leaves infested by the caterpillar of leaf rollers and leaf miners were taken each in every plot before blooming ten shoots from 20 trees, and after blooming 10x100 leaves. Parasitoids were reared continuously from Microlepidoptera species in the laboratory.

Leaves of 5 shoots were taken from 10 trees each in every plot, and the phytophagous and zoophagous mites were selected under a stereoscopic microscope. The aphids were investigated on 10 shoots from 9 trees from each plot, as well as by yellow traps. Limb beating was performed on one branch of 30 trees in each plot.

The samples were taken, and traps were emptied or controlled weekly from the middle of April until the middle of October.

Fruit evaluation was carried out on two occasions yearly: 4x5 fallen fruits at the end of August, and 4x200 fruit at harvesting were investigated in each plot.

Results, Conclusions

The applied insecticides and acaricides were selected by the regular monitoring of the pests, their parasitoids and predators. According to the population density of the pests, their predators and parasitoids as well as their proportions were decided:

- the necessity of the spraying,
- its point of time,
- the applicable insecticides.

When in spring the larvae of *Adoxophyes orana* were observed as dominant species on the leaves, the chemical control was based on the use of fenoxycarb (Insegar) or lufenuron (Match). When in the dry and warm wether the population density of leaf miners (*Phyllonorycter corylifoliella, Ph. blancardella, Leucoptera malifoliella*) increased, the chemical control was based on the use of diflubenzuron (Dimilin) or lufenuron (Match). The leaf miners became dominant pests in the conventional plot, while the parasitoids were able to keep their population level under the economic threshold in the IPM plots.

The density of codling moth was high, especially in summer, in this years. In compliance with circumstance diflubenzuron, lufenoron and *Bacillus thuringiensis* (Dipel) were applied in the IPM plots.

The changes in the abundance of leaf miner as well of leaf roller species are summarized in the Fig. 1. In 1992 in IPM plots the infestation of leaf rollers, while in the conventional plot of leaf miners prevailed. In 1993 leaf miners dominated in each plot, however, their amount was especially high in the conventional one. In 1994 the infestation of leaf rollers and leaf miners was much higher in the conventional plot than in the IPM ones.

The population density of leaf rollers changed depending on the insecticides used in the plots, of the effectiveness of their parasitoids, on climatic factors and on surrourdings (Balázs 1991, 1992b). From 16 parasitoids of leaf rollers *Macrocentrus linearis* the most important species. This parasitoid decreased the population density of *A. orana* in the 2nd generation in IPM plot to the economic threshold (Balázs 1995).

From 48 parasitoids of leaf miners the most important parasitoid species were: *Sympiesis sericeicornis* Nees, *S. gordius* Walk., *Pnigalio pectinicornis* L., *P. soemius* Walk., *Pediobius pyrgo* Walk., *Holcothorax testaceipes* Ratz., *Chrysocharis pentheus* Walk., *Pediobius pyrgo* Walk., *Tetrastichus ecus* Walk., *Achrysocharoides atys* Walk., Neochrysocharis chlorogaster Erd. and *Pholetesor bicolor* Nees (Balázs 1995). At the time of colonization and multiplication of pests only 1-2 parasitoids are important. At the outbreaks not only the individual number of parasitoids increases but their species diversity as well.

It has been established that a 1-3 % leaf infestation of leaf miners is at least necessary for the parasitoids to exert their activity. There is an invert ratio between leaf damage and parasitization rate (Fig. 2). In case of IPM orchards the beneficial effect of parasitoids becomes very soon noticeable and within 1-3 years any control measures become unnecessary (Fig. 3). It was proved, that the problem of leaf miners charracterized the conventional treated orchard (Fig. 4).

In the conventional apple orchards where broad-spectrum insecticides, like organophosphorous and pyretroid preparations, as well as artificial fertilizer are regularly and intesively used the populations of fruit red spider mite (*Panonychus ulmi* Koch), two spotted spider mite (*Tetranychus urticae* Koch) and sometimes hawthorn spider mite (*T. viennensis* Zacher) occur in alternating population densities, their population can increase to an high density in a short period, and cause severe damage.

Some 30 species of predacious mite have been collected in different biotopes on decidious trees. Howewer only a few specimens have been found in treated orchards. Their populations are practically absent or their specimens occur seldom and sporadically in low number in the conventional orchards (Jenser *et al.* 1992). The introduce of *Typhlodromus pyri* was unsuccessful. Therefore they cannot regulate the population of phytophagous mite species (Kuenen 1949, Vrie and Boersma 1970, Jenser 1990).

After the use of selective insecticides the population density of *Zetzellia mali*, a Stigmaeid predacious mite, increase rapidly. Its populations proved to be an effective regulating factor of tetranychid mites (Komlowsky and Jenser 1992). The presence of phytoseiid mites was observed only two, three, sometimes six year after the regular use of selective insecticides. When the populations of Phytoseiidae species increase, the density of *Z. mali* decrease and it become one of the regulating species of the phytophagous mites in the orchard.

Owing to the cessation of the application of broad-spectrum insecticides in the IPM orchards such a population community could develop which involve phytophagous and zoophagous species in low density as well as the alternative food sources of the zoophagous species. In this community the population density of tetranychid mites is low, their population dynamic is well balanced, the density of phytophagous species does not increase to a high peak in a short time (Fig.5).

At the beginning of the experiment *Aphis pomi* (de Geer), *Dysaphys plantaginea* (Pass.) *D. devecta* (Walk.) and *Rhopalosiphum insertum* Walk. were present in the orchard. After the cessation of the use of broad-spectrum insecticides, *A. pomi* became significant pests in the IPM plot. Its colonies were present on the growing shoots and occasionally also damaged the fruits. From the *Dysaphis* species, the population density of *D. devecta* increased in the IPM plot, at the same time the individual number of *D. plantaginea* was higher in the IPM plot than in the conventional one, in every year (Haltrich and Markó 1996).

From the secondary pests *Anthonomus pomorum* L. and *Stephanitis pyri* Fabr. multiplied in the orchard (Markó *et al.* 1996, Rácz and Balázs 1996).

At the fruit evaluation it was found that in years 1993 and 1994 the damage caused by codling moth was 2.0-3.5 percent in IPM and 5.5-15.1 percent in conventional, that caused by leaf rollers 5.0-10.5 percent in the IPM and 9.5-16.6 percent in the conventional orchard (Fig. 6). San Jose scale were present in 1.0 percent (IPM) and 0.3 percent (conventional). Significant difference was established in both years between the percentages of the damaged fruits in the IPM and conventional orchards.

Acknowledgements

The authors thank for Gyöngyi *Nyíri*, Krisztina *Mihályi* and László *Kazinczy* for the technical assistance. This research was supported by the Hungarian Scientific Foundation OTKA (agrement number 017719) and by USDA (agrement number 58-319R-3-022).

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FIGURES

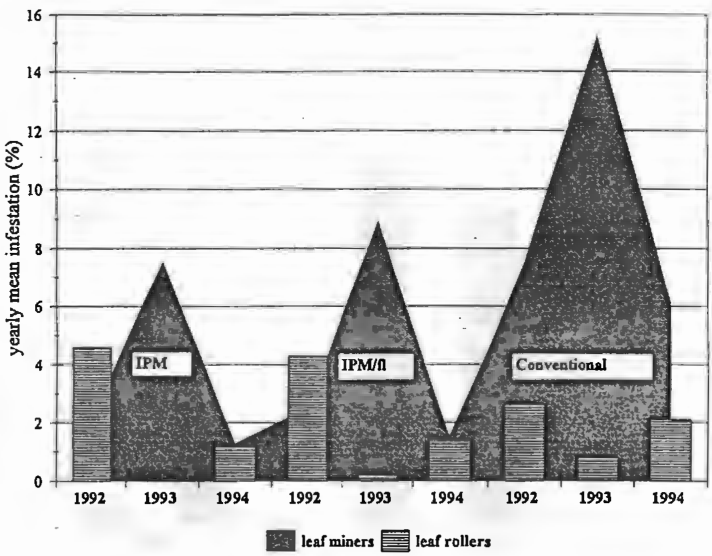

Fig. 1. Leaf infestation in the IPM and in the conventional orchard
(Kecskemét-Szarkás, 1992-1994)

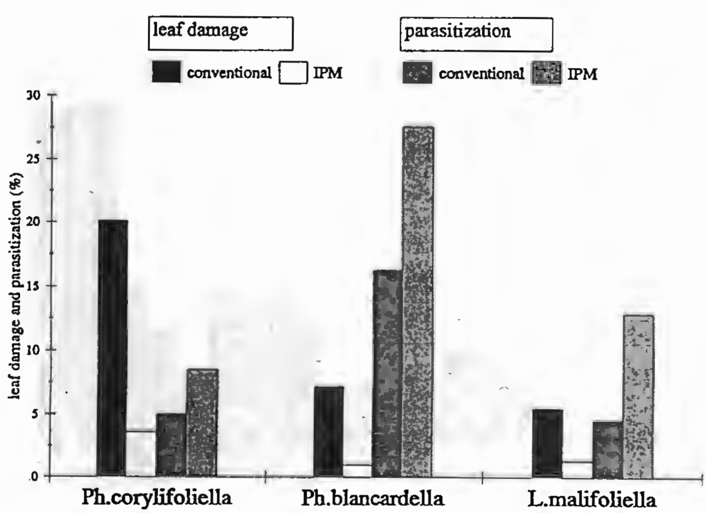

Fig. 2. Interdependence of leaf damage and parazitization rate in apple orchard
(Kecskemét-Szarkás, 1993)

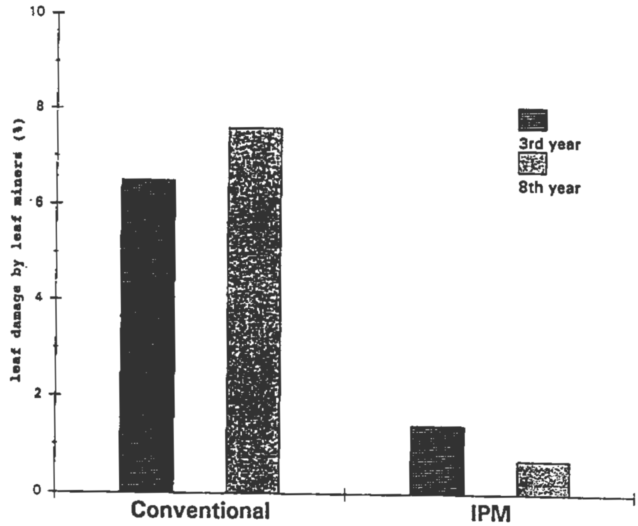

Fig. 3. Effect of IPM technology, used for 3, 8 years, respectively
(Kecskemét-Szarkás, 1994)

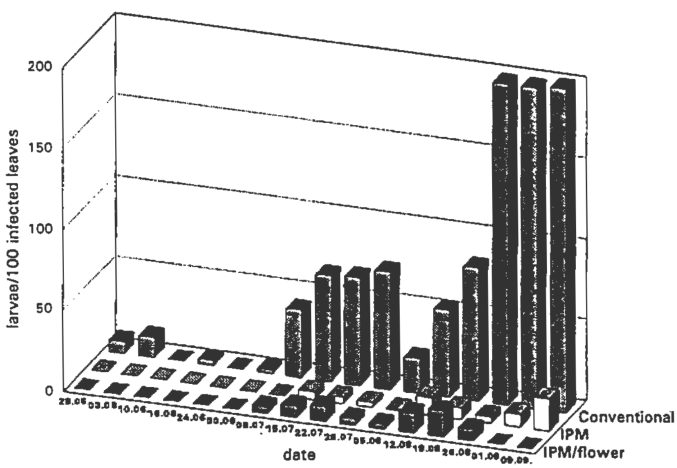

Fig. 4. The population density of *Phyllonorycter corylifoliella*
(Kecskemét-Szarkás, 1993)

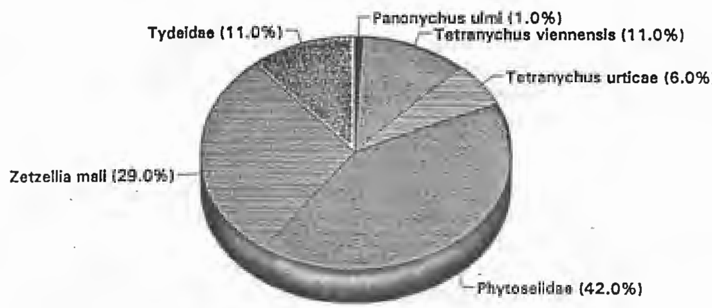

Fig. 5. Percentage of phytophagous and zoophagous mites in IPM orchard (Kecskemét-Szarkás, 1994)

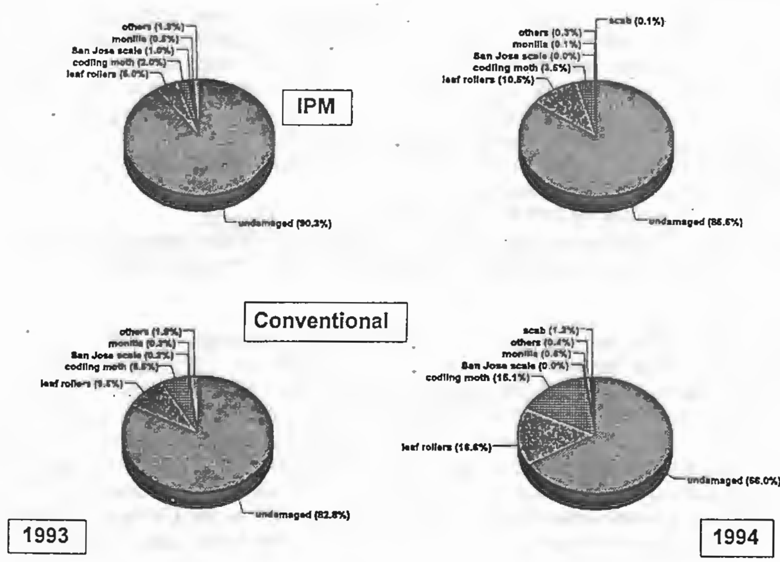

Fig. 6. Fruit infestation (Kecskemét-Szarkás, 1993-1994)

Experiences with integrated pest management in apple orchard during the initial phase of a long term study

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Abstract
The possibility of application of integrated fruit production has been tested in a pilot farm of 15 ha at the Research Station, Ujfehértó for three years (1992-1994). The following tendencies have been observed in the IPM orchard:
Due to the accurate observations on the swarming of dominant species of **insects** also the well-oriented spraying and the use of specific insecticides (chitin synthesis inhibitors, juvenile hormones) the amount of pesticides applied and the number of applications were decreased. The dominant populations (codling moth, summer fruit tortrix, red spider mites, aphids, leaf miners) are more balanced resulting a decrease of damage by the major pest species. The higher populations of predators and parasites help to control the main pests. No or fewer treatments were needed to control the *Phyllonorychter spp.*, the leaf rollers and the red spider mites. The Mountain - ash bentwing required special spraying (for one year). Two or three treatments in one year were applied to control the aphids, the May bug and the codling moth. Among the beneficial organisms *Aphelius mali, Zetzellia mali, Stethorus punctillum*, the parasites of leaf miners and leaf rollers, *Coccinellidaes* also *Crysopa spp.* were observed.
Number of treatments in controlling the **diseases** apple scab and apple powdery mildew were mainly influenced by the frequency and lengths of infectious periods.
Foliar herbicides glyphosate and glufosinate were applied under the trees and partial mechanical tillage was carried out on the between-rows field to control the **weeds.**
Neither the pesticide usage nor the number of plant protection problems decreased in the orchard applying **conventional pest control** techniques.
The cumulated **toxicity index** (T_c) has been introduced to calculate the pesticide load of the applicator and that of environment:

$$T_c = \text{Sum of } [1000 \times \text{pesticide}_{(i)} \text{ rate} / LD_{50(i)}]$$

The conventional plant protection results in higher load of environment comparing to the integrated one, specially in the case of insecticides (e.g., 46 times higher in 1994)

Introduction

The possibility of the application of integrated apple production is tested in a 15 ha pilot farm of the Research Station for Fruit Growing (Ujfehértó). This farm has been treated according to the principles of integrated fruit production for three years since 1992. Plant protection is supervised by the Plant Health and Soil Conservation Station (Nyiregyháza). Its plant protection specialists have been working on the development of less dangerous plant protection programmes for over 15 years (Molnár 1975; Molnár and Sántha, 1983; Molnár and Somogyi, 1983; Lantos et al. 1992). This work is supported by the Plant Health and Soil Conservation Station of Budapest as well as the Cornell University (Ithaca, US) based on the joint project of the Hungarian-US Joint Fund (project No. JNFO-296-305).
The pilot farm is composed of the clones of Jonathan, Red Delicious and Golden Delicious grafted on rootstocks EM-4, EM-9, EM-26 and EM-27. The row and plant spacing are 5x2 meter.
This paper wants to report the findings of the plant protection and the trends concluded.

General requirement

The following criteria has been set up for the use of chemicals in the pilot farm:

- chemicals should be used only as the very last means (i.e. above the economic threshold limit) and these chemicals should fulfil the requirements listed below:
- pesticides possessing specific action are preferred;
- no risk to the pesticide applicator and to the consumer (low LD_{50}, rapid degradation);
- no harm to the beneficials (e.g. lady birds, predatory mites, *Orius spp.*,);
- no pollution of the environment (soil biology, ground water, quality of soil, etc.), rapid degradation in the environment.

The basic condition for this practice is to have thorough knowledge not only on the pests but on the beneficial organisms as well. This knowledge helps to control the pests at the most optimal time and mode and to protect the beneficials as well. Among the materials available there should be equipment and instruments adequate to trace the growth stage of pests e.g., sexual attractant traps, coloured plates, microscopes, hand lens, and to record any changes in the weather conditions such as Metos or Paar-KMSP.

Plant protection practice

The three years period has been used to establish the IPM system. During the first year of this study, the pyrethroids, and a significant part of organo-phosphate insecticides have been replaced. Fungicides dinocap and mancozeb being harmful to the predatory mites have been eliminated or used at much less extent. All the soil-herbicides have been replaced by foliar products.

Control of pests

Besides the acaricides with ovicidal action (Apolló, Nissorun 10 SP) the use of chitin synthesis inhibitors (Andalin DC 25, Cascade 5 EC) were allowed to apply. Control of aphids was mainly based on Pirimor 50 DP. One - one treatment - with the contribution of parasites - was sufficient to control the codling moth and leaf miners. The chitin synthesis inhibitors (Dimilin 25 WP, Alsystin 25 WP, Nomolt 15 SC) and the juvenile hormone Insegar were preferred for that purpose. The maybeetle attacking in the eastern part of Hungary at flowering was controlled by the organophosphorous insecticide Zolone 35 EC being not harmful to the bees. Because of the moderate insecticide usage in the first two years, fewer insecticide treatments were needed in the 3.rd year of the programme. Three applications with chitin synthesis inhibitors and two with special aphicide were sufficient. Acaricide had to be applied only at the row neighbouring to the traditional plant protection. These technological changes are shown on Table 1. in comparison with the traditional plant protection practice.

The results of assessment of damaged fruits (Table 2.) indicates, that by applying specific products it is possible to produce crop free of damage. The environmentally tolerant products give opportunity to build up the populations of the species of beneficials, when the other conditions are advantageous for them. Our growing region is relatively rich in these organisms (*Aphellius mali, Zetzellia mali, Stethorus punctillum, Coccinnellidaes*, *Crisopa spp.*).

Although the situation of main pests became better balanced, the population of some pests e.g., *Stephanitis pyri, Cicada spp.* having been earlier of secondary importance has increased.

Neither the pesticide usage nor the number of plant protection problems decreased in the orchard applying **conventional pest control** techniques. E.g., after the oppression of leaf rollers and leaf miners, the attacks of codling moth, aphids, woolly aphids and San Jose Scale have increased. The green apple aphid was present in high density every year.

Table 1

Frequency of insecticide applications

Pesticide	Active ingredient	Conventional			IPM		
		1992	1993	1994	1992	1993	1994
Alsystin 25	Triflumuron	-	-	-	-	1	1
Agrol Plusz	oil	-	-	-	-	1	-
Cascade 5EC	Flufenoxuron	-	-	-	1*	-	-
Dimilin 25WP	Diflubenzuron	1	-	1	1	1	2
Insegar	Fenoxicarb	-	-	-	1	-	-
Nissorun	Hexythiazox	1	-	-	1	-	-
Omite 57E	Propargite	-	1	-	1*	2	1*
Oxotin F600	Fenbutatin oxide	-	-	1			
Pirimor	Pirimicarb	-	-	-	1	1	1
Reldan	Chlorpyrifos-m	-	-	-	1	-	-
Torque 55SC	Fenbutatin oxide	1	-	-	1*	-	-
Zolone 35EC	Phosalone	1	-	1	1	1	-
Dimecron 50	Phosphamidon	1	3	-	-	-	-
Fendona 10EC	Alphamethrin	2	3	-	-	-	-
Filitox 50EC	Methamidophos	2	1	-	-	-	-
Metil Cotnion	Azinphos methyl	-	-	1	-	-	-
Neoron	Bromopropilate	-	-	1			
Trebon 30EC	Ethofenprox	-	-	2	-	-	-
Ultracid 40WP	Methidathion	2	2	3	-	-	-
Unifosz 50EC	Dichlorvos	-	-	1	-	-	-

Note: *=applied at some part of the orchard

Table 2

Results of assessment of damages

Year	% Damage of fruits					
	Codling moth		Leaf rollers		San Hose Scale	
	harvested	dropped	harvested	dropped	harvested	dropped
1992	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.07	0.0	0.0
1994	0.0	1.59	0.001	0.79	0.03	0.0

Control of diseases

Because of the dominance of cultivar Jonathan, the control of powdery mildew (*Podosphaera leucotricha*) and apple scab (*Venturia inaequalis*) is of outstanding importance. No need for treatment of cultivars belonging to the delicious group of varieties with powdery-mildew killing products. The intensive stage of shoot growth (in May and June) was critical for the development of both diseases because the young plant parts are the most sensitive and the pathogenicity is the strongest at that time. The synthetic EBI formulations (e.g., Systhane 12 E, Punch 40 EC) are efficient against both diseases. The control philosophy was to assure continuous protection by applying systemic and herein after contact (Nimrod 25 EC, Captan) products.

Weed control was at a minimum and restricted to the application of foliar herbicides. Between - row fields were covered with regularly cut natural plant population. Two or three applications of glyphosat or glufosinate were sprayed to the strip of 50 cm in the rows of trees. A sideharrow is used to increase the weed-free band by 80 cm.

In the conventionally cultivated orchard the between-rows fields were treated 4-5 times by mechanic tillage and, the strips in the rows of trees were sprayed by soil and leaf herbicides with two applications (Dual 960 + Maloran 50 WP, then in summer Hungazin DT + Glialka).

Load of pesticide applicator and that of environment
The toxicity index (T_i) has been introduced in 1990, to measure the load of the pesticide applicator and that of the environment (Lantos et al. 1992):

$$T_i = 1000 \text{ x } (\text{pesticide}_{(i)} \text{ rate} / LD_{50(i)})$$

This index is based on the quotient of the application rate and the oral LD_{50} of the pesticide. Although T_i does not exactly show the pesticide load of the environment, however it indicates the ratio of relative toxicity of various products. It is thought that the highly toxic formulations cause great injury in the lower living organisms and they also

Table 3

Comparison of amount pesticides used (kg/ha)

Year	Conventional	IPM
1992	45.3	39.1
1993	39.7	59.8*
1994	58.9	38.5
1992-1994	143.9	137.4*

* including oil treatment in spring

Table 4

Comparison of toxicity indexes of plant protection technologies

Year	Type	Toxicity index		
		Conventional	IPM	Ratio
1994	Fungicide	14.8	8	1.9
	Insecticide	352	7.6	46.2
	Herbicide	1.6	2.4	0.7
	All	368	18	26
1992-1994	Fungicide	21.4	20.3	1.04
	Insecticide	649	30.7	21
	Herbicide	3.3	5.5	0.6
	All	674	56.5	11.9

cause increased risk to men entering the food chain or to the living water. The cumulated toxicity index (T_c) is used to evaluate the overall load of the pesticide applicator and that of the environment:

$$T_c = \text{Sum of } \{T_i\}$$

Comparing the effect of integrated and conventional pest management technology made in 1994, the following statements can be made. (Table 3 and 4.)
In 1994 the volume of pesticides applied to the farm area (expressed in kg/ha) is only ~1.5 times higher than that used in the integrated area, but the corresponding T_c is 26 times higher in the conventional area than under integrated conditions. Both the natural volume and the T_c rate of herbicides are almost the same in the two areas, while the fungicide consumption is higher by 16 % in the conventional farm area. There is a great difference in the use of insecticides between the two areas: under conventional pest management two and a half times higher volumes of insecticides and acaricides were used than in the integrated pest management area while the toxicity index is 46 times higher with the conventional pest control schedule than with IPM.

Comparing results of 1992-1994 years investigations, a more comprehensive picture is obtained. It is found that in the years of the transition from conventional to integrated pest management, there is no difference of magnitude in the natural volumes between the conventional and the integrated pest management. Nevertheless the IPM as a long term technology results in a decreased pesticide usage either in volume and in toxicity indexes. E.g., the cumulated toxicity index of insecticide treatments is 21 times and 12 times higher in the conventional plant protection than in the integrated one respectively.
The use of organophosphates results in the highest toxicity index. Though both the LD_{50} and consequently the T_i of the pyrethroids are much lower, they should be used carefully, because they may greatly harm the beneficial organisms. The T_i of other selective new types of insecticides is extremely low, their application is, therefore greatly recommended. They are selective products, i.e. they kill certain pest groups with high efficiency. Their advantages are, on the other hand, that they are safe to the beneficial organisms and mean smaller load to the environment.

Conclusions
Based on the three years observations, the following trends can be concluded.
Due to the accurate observations on the swarming of dominant species of **insects** also the well-oriented spraying and the use of selective insecticides the amount of pesticides applied and the number of applications were decreased. It is possible to apply less poisonous pesticides. The dominant populations (codling moth, summer fruit tortrix, red spider mites, aphids, leaf miners) are more balanced, there is a decrease in damage by the major pest species. It is obvious, that the higher populations of predators and parasites help to keep the pests species at a certain level.

The total cost of integrated plant protection was about 20% more expensive in three years period, mostly because of the increased application of expensive new insecticides, i.e. Insegar and Dimilin during the first two years. The long term results: healthier plantations, higher population of predators and parasites, fruits containing less residues, lower load of the pesticide applicator and that of environment will counterbalance the higher costs.

This pilot farm can be used to demonstrate the applicability of IPM method in large scale; the plant protection specialist can identify the possible problems encountering due to the application of IPM programmes and accomplish out environmentally sound protection methods in due time. It is thought that the further development of technology is necessary in the near future. Authors wishes to continue the technological development of IPM because the number of new products and the plantations applicable for IPM increase. Many well qualified plant protection engineers and farmers are ready to use the principles of IPM provided the market will recognise the healthier fruits in the production price.

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Modified summer programme using border sprays for managing the codling moth, *Cydia pomonella* (L.) and the apple maggot, *Rhagoletis pomonella* (Walsh) in Ontario apple orchards

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The efficacy of two insecticide control programmes for managing the codling moth, *Cydia pomonella* , and the apple maggot, *Rhagoletis pomonella* , was compared in commercial apple orchards in Norfolk County, Ontario, Canada, during the 1993 and 1994 growing seasons. In the cover spray programme, sprays of organophosphorous (OP) insecticide for codling moth and apple maggot control were applied to the entire orchard following Ontario integrated pest management guidelines for apple. In the border spray programme, an initial cover spray of OP insecticide was applied to eradicate any codling moths that had colonized the orchard during the previous growing season and subsequent sprays were applied to a ca four-tree-wide (i.e. ca 20 m) zone around the perimeter of the orchard. The border sprays were applied to control codling moths or apple maggots that invaded the orchard since application of the initial cover spray. Three orchards received the cover spray programme and three orchards received the border spray programme. The relative efficacy of the two programmes was compared by banding 50 trees in each orchard with strips of corrugated cardboard to trap second-generation codling moth larvae and by collecting samples of apples at harvest and inspecting them for apple maggot and codling moth injury as well as for injury caused by other orchard insect pests. During 1993, an average of 3.3 cover sprays were applied in the cover spray orchards whereas one cover spray and an average of 2.7 border sprays were applied in the border spray orchards. During 1994, an average of 2.7 cover sprays were applied in the cover spray orchards whereas one cover spray and an average of 2.3 border sprays were applied in the border spray orchards. Seventeen codling moth larvae were recovered from two of the three border spray orchards during the 1993 growing season. Fifteen of these larvae were recovered from one orchard. One larva was recovered from the three cover spray orchards . Two larvae were recovered from one of the three border spray orchards during the 1994 growing season. Larvae were not recovered from the cover spray orchards. The mean percentage of apples infested by the codling moth and the apple maggot was similar in the border spray and the cover spray orchards during both the 1993 and 1994 growing seasons. Infestation by the codling moth did not exceed 0.17 %, viz. 17 in every 10,000 apples, at any of the six test orchards. During the 1993 growing season, no apple maggot infested apples were found at any of the six test orchards. However, during the 1994 growing season, 0.19 % of the apples inspected at one of the three border spray orchards were infested with this pest. In a square, 10 ha orchard, one spray applied to the border zone would require only one-quarter as much insecticide as a spray applied to the entire orchard. During a typical season when 3 - 4 sprays were applied in this orchard to control the codling moth and the apple maggot, the border spray programme would require the use of one-half as much insecticide as the cover spray programme.

THE APPLICATION OF INTEGRATED PRODUCTION ON PLUM AND APRICOT IN EMILIA-ROMAGNA (ITALY)

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ABSTRACT
The "Regional project 1986-1990 for the diffusion of integrated pest management in orchards and vineyards", and the Regional Crop Advisory Service created on the base of this first experience, involves, in 1995, approximately, a total area of 17,900 hectares of fruit orchards (700 hectares of plum and 600 of apricot fruit orchards, more or less 17% of the total regional surface) covering over 7,300 farms.
The project aims to involve approximately 50% of the fruit growing farms in Emilia-Romagna by improving technicians activity and applying a quality trade-mark to promote the produce of farms practicing integrated production methods.
The text provides details of methods used for integrated pest management and other agronomic methods applied in plum and apricot fruit orchards and some of the results obtained.
An analysis of the emerging problems and research and experimentation status is given.

THE REGIONAL CROP ADVISORY SERVICE

The Regione Emilia-Romagna (RER) is one of the leading areas for fruit cultivation in Italy. The productive surface under fruit crops is of 87,800 hectars, mainly peaches, apples and pears (34, 14 and 25,000 hectars respectively).

In order to apply the methods of integrated pest management and integrated production, the regional Government organizes the "Regional Crop Advisory Service" ("Servizio Assistenza tecnica alle coltivazioni"). The techniques applied are defined following the principles of integrated production (IP) (IOBC, 1993).

This service involved, in 1995, approximately, a total area of 17,800 hectares of fruit orchards (8,900 of stone fruits, of which 700 hectares of plum and 600 of apricot fruit orchards, more or less 17% of the total regional surface) covering over 7,300 farms.

At present (1994), IP is practiced on all the main fruit crops (stone fruit, pome fruit, kiwi and kaki), grapevines and also on the main arable and vegetables crops (protected and open field).

The farms involved in the service are assisted by 150 technicians employed, through contributions from RER, by producers' associations. The contribution from RER is about 40% of the costs. These technicians are responsible for the application of regional guidelines for integrated production in the assisted farms, and for running training activities aimed to make them as self-sufficient as possible in integrated production (pest management, fertilization, irrigation and the other main agronomy techniques).

12 other technicians work as coordinators and are responsible for training activities of newly employed technicians and for drawing up weekly bulletins which are recorded on telephone answering machines and publicized in the local TV network, newspaper and by videotex.

The farms are visited once a week or once every two weeks, according to their degree of autonomy and all the data about the methods applied are noted. On pilot farms (about 1,300 fruit orchards, of which 200 of plum and apricot) the methods applied and the sampling results are also noted on appropriate forms and data are then collected and processed by means of a computer network. The same network distributes meteorological and weather forecasting data collected and processed by the Regional Meteorological Service (40 automatic stations). A specific software permits these data to be processed by forecasting models.

Scientific support is provided by regional bodies (Regional plant protection service, Regional Meteorological Service, etc.) and university and ministery institutes.

The representatives of these bodies, and also of producer's organizations, are divided into commissions to define the Regional integrated production guidelines. ERSO (Regional body for research, experimentation, extension in horti-flower- and seed- culture) is responsible for the coordination of this activity. The regional Agricultural development service takes care of scientific and technical coordination of the service as a whole.

A specific applied experimental support is undertaken directly by the regional bodies by 30 further technicians.

INTEGRATED PRODUCTION IN PLUM AND APRICOT ORCHARDS

Complete information about the integrated production methods adopted on stone fruits is available in the Regional integrated production guidelines (Disciplinari di produzione integrata) published by Regione Emilia-Romagna (ERSO, 1995).

IPM techniques

The guidelines for sampling methods and economic thresholds for the principal stone fruit pests and diseases were initially suggested on peaches by ACTA (1979) . After several years of experimentation and adaptation, (also of the most suitable chemical product) a clearer, more standardized and practical frame of reference has emerged and can facilitate the diffusion of IPM in plum and apricot cultivation, and also of the other main stone fruits, even if the growers concerned know very little about this sector (Domenichini & Cravedi, 1985; Domenichini *et al.*, 1986; Malavolta *et al.*, 1988, Malavolta *et al.*, 1995). Some of the most important IPM techniques applied on apricot and plum orchard in RER have been recently published (Malavolta *et al.*, 1995).

Samplings are carried out weekly on shoots, leaves and fruit (100/ha plus 25 for each hectar after the first), which are randomly chosen on 20 plants/ha (plus 5 for each hectar after the first); sex (Agrimont or Zoecon) and chromotropic (Rebell) traps, 1, 2 or more according to the size of the orchard and of the species monitored, are also used.

The justification of treatments, by means of sampling for pests (application of economic thresholds) or of climatic conditions favourable for diseases (when possible by means of forecasting models), is always required. Timing of treatments is also based on forecasting models when available.

Biological and biotechnological methods are generally advised when available. Concerning pesticide choice, a list of advised active ingredients is given: it normally permits the optimal application of integrated control. In particular emergency conditions the use of partially selective active ingredients is also admitted due to technical and/or economical problems.

Fertilization

Fertilization is also managed by technicians. In this case a standardized soil analysis is required every 5 years in order to apply a balanced program calculated according to technical guidelines, annually revised on the basis of experimental results. This program relates soil content to fruit quality, pest management and environmental protection. Both organic and synthetic fertilizers are permitted. Where available maps of soil contents are used instead of soil analysis.

The maximum quantity of nutrient permitted is reported in table 1. If more than 60 kg are needed, nitrogen fertilizers have to be split in two or more applications in order to increase the nitrogen use efficency (NUE) and reduce leaching. It is forbidden to apply mineral nitrogen before blossom because tree uptake is very low and apply more than 40 kg of N after the middle of October, particularly on very wet soils.

Phosphorous and potassium must be supplied on the basis of soil analysis and inputs must not exceed the amounts taken up by trees (about 50 kg/ha of P_2O_5 and 150 Kg/ha of K_2O.

Table 1. Maximum nutrient input (Kg/ha/year) permitted on apricot and plum fruit orchards.

CROP	N			P	K
tree vigour	high	medium	low	(P_2O_5)	(K_2O)
Apricot	110	90	60	50	150
Plum	110	90	60	50	150

Weed management

Mechanical weed control is advised. The use of glyphosate (and also of gluphosinate-ammonium and gluphosinate-trimesio) is permitted only on the row, not on alleyways. During the first two years after planting the use of trifluralin and oxifluorfen is also permitted.

Agronomy techniques

Concerning the other agronomy techniques (i.e. irrigation, cultivar choice, planting system, etc.) a list of rational practice is also advised. For irrigation an interactive videotex system based on orchard precipitation data is employed.

RESULTS OBTAINED

IPM techniques

The introduction of IPM techniques in stone fruit cultivation has led to an average reduction of about 30% (20-45) in the number of treatments, quantities of pesticides used and overall pest control costs, compared with farms practicing traditional pest management (see table 2).

Main pest and diseases treated and active ingrediens employed on average per year are listed in Table 3.

Table 2. Results obtained in IPM compared with traditional pest management (1994)

CROP	Number of treatments (nr. comm. products)		Quantity of pesticides (kg comm. products)		Costs ITL (x1000 distr.excl.)	
	IP	reduct.%	IP	reduct.%	IP	reduct.%
Apricot	6.7	-40.7%	24.4	-71.7%	143	-70.8%
Plum	7.4	-47.1%	47.2	-45.6%	389	-42.4%

Table 3. Main pest and diseases treated and active ingrediens employied (1994)

PEST and DISEASES	nr. comm. products*	
	Apricot	Plum
Prunus blossom blight	0.7	1.3
Gum spot	1.2	0.5
Plum rust		0.3
Powdery mildew	2.9	
Bacterial canker of stone fruits	0.1	1.3
Plum fruit moth		1.4
Oriental fruit moth		0.3
Peach twig borer	0.7	
San Josè scale		0.3
Black plum sawfly		0.3
Green plum aphids		1.0
Brown plum aphid		0.2
Leaf rollers		0.1
European red spider mite	0.0	0.0
other	1.1	0.5
TOTAL	6.7	7.4

ACTIVE INGREDIENTS	nr. comm. products*	
	Apricot	Plum
acephate	0.1	1.0
azinphos-methyl	0.5	1.2
Bacillus thuringiensis	0.1	0.4
benomyl	0.3	0.3
bitertanol	0.2	0.1
carbaryl	0.1	0.2
carbendazim	0.2	0.3
calcium polysulphur		0.2
copper	1.0	1.9
diazinone	0.1	
ethiofencarb		0.2
phosalone		0.2
pirimicarb		0.1
sulphur	2.9	
thiophanate-methyle	0.2	0.1
thiram	0.4	
triforine	0.3	0.6
ziram	0.3	0.2

* number commercial product applied / year

Furthermore, this initiative has had some influence on the type of protection methods recomended by other agricultural technicians in RER, thus contributing to a rationalization of pest control strategies on a much larger scale than is directly affected by the service. At present, in fact, the weekly bulletins produced are a permanent reference point for all technicians working in this sector.

Fertilization

During 1994 , average N supply in apricot orchards was 40-50 Kg/ha, mainly supplied after fruit set. In plum orchards, due to the fact that trees often shows a low fruit set, nitrogen fertilization has been based on expected yields. Nitrogen was distributed in spring (at blossom) and, if fruit set was high, during fruit development too, (early May); by each application, an average of 40-50 Kg/ha was supplied; late cultivars also needed post-harvest N-supply.

Nitrogen was mainly supplied in a mineral form (ammonium sulphate, ammonium nitrate and urea).

During 1994, 40% of apricot and 18% of plum orchards did not apply any soil fertilizers.

Weed management

About 80% of plum and 90% of apricot orchards apply only mechanical weed control. Glyphosate, gluphosinate-ammonium and gluphosinate-trimesio are the only herbicides applied.

COMMERCIAL PROMOTION AND PERSPECTIVES

In any case, the final aim of the project is to involve, by 1990, approximately 50% of the land given over to fruit and grapevine cultivation in Emilia-Romagna and also to include other cultivation (e.g. protected and open field crops).

For this purpose the improving of technicians' activity is already in progress (by using information systems and the group/area approach instead of single farm approach).

A quality trade-mark to promote the produce of farms practising integrated production has bee set up. This trade mark "QC" (qualità controllata, that is checked quality)is available for producers' associations or single farms that agree to apply the official regional IP guidelines (also for post-harvest, storage, handling, quality standards, etc.) and to observe specific obligations, controls and sanctions. During 1994 about 10% of the total regional fruit production will be commercialized under this label.

The programme includes the financing of a laboratory for the rearing of beneficial organisms. This laboratory , built at the Centrale Ortofrutticola alla Produzione in Cesena, aims to establish methods for mass-rearing of beneficial organisms and to research the possibilities for their use in biological pest control programmes for open field and protected crops.

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LECTURES

Section: Insect Problems

OPTIMIZING THE RISK ASSESSMENT FOR THE APPLE SAWFLY *HOPLOCAMPA TESTUDINEA* KLUG (HYMENOPTERA, TENTHREDINIDAE)

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ABSTRACT

Computer simulation and field experiments were run to optimize the risk assessment for the apple sawfly *Hoplocampa testudinea* within the scope of IFP in Switzerland. A soil temperature driven phenology model proved to be a useful tool to determine the optimal time for the installation of white sticky traps. Based on mark-release-recapture experiments the optimal number of traps for a reliable population monitoring was found to be three per variety. Due to the limited range of action of the traps and the low mobility and heterogeneous distribution of the sawflies a maximum distance of 50m between traps is suggested. The relationship between trap catches and infestation level varies between the different cultivars, and hence specific economic injury levels have to be established.

INTRODUCTION

The apple sawfly *Hoplocampa testudinea* KLUG is a common pest in Swiss apple orchards, causing occasionally severe damage. The risk of unacceptable yield losses is particularly high in years or locations with moderate or low fruit load. In recent years population increases were reported especially from the eastern part of Switzerland. For instance in 1993 the economic injury level was exceeded in 53% of the supervised orchards (Graf *et al.*, 1994). In the past numerous studies investigated the biology of the apple sawfly with the objective to develop effective control measures (Miles, 1932; Velbinger, 1939; Kuenen & van de Vrie, 1951; Böhm, 1952; Chaboussou, 1961; Gottwald, 1982). It has been shown that exact timing is crucial for a successful control (Höhn *et al.*, 1993). Among various monitoring methods (Wildbolz & Staub, 1984) white sticky traps have found wide acceptance and are used in many IPM programs (Owens & Prokopy, 1978; Coli *et al.*, 1985; Wildbolz & Staub, 1986; Galli *et al.*, 1993). Nevertheless, experiences in commercial apple orchards in Switzerland revealed the need for further improvement of sawfly prognosis.

In the present study we tried to develop an enhanced forecasting system in order to improve the risk assessment and to facilitate the timing of control measures. Both the phenology of spring emergence (time prognosis) and the density dependent infestation level (infestation prognosis) were addressed.

MATERIALS AND METHODS

Prognosis of spring emergence: In Swiss apple orchards the risk assessment for sawfly attack is mainly based on white sticky traps of the type Rebell® bianco. The economic injury level was established empirically at 20 to 30 sawflies per trap (Höhn *et al.*, 1993). Traps have to be installed in due time. When exposed too early they attract many other insects such as honeybees or Diptera, and lose their attractiveness beforehand. When set up too late they miss the first sawflies. A soil temperature driven phenology model (Graf *et al.*, 1996) was used to predict the flight and to determine the optimal time for the installation of the traps. The model is based on a time-varying distributed delay (Manetsch, 1976), and uses parameters which were estimated from experiments on the effect of temperature on the post-diapause development (Graf *et al.*, 1996). The model was validated comparing wasp catches on white sticky traps with predicted sawfly emergence in 1993, 1994 and 1995.

Prognosis of the infestation level: Various factors influence the effectiveness of the traps and hence the reliability of the population estimates. Mark-release-recapture experiments were run to study the flight activity of the sawflies and the range of action of the white sticky traps respectively. In 1993 a total of 240 newly emerged adults were marked with a fluorescent aerosol paint-spray (Remund & Boller, 1975). The marked sawflies were released in groups of 40 at six different dates in the centre of an experimental apple orchard where 18 sticky traps were arranged in three concentric circles (radius 4m, 12m and 25m) around the point of release. In 1994 and 1995 a total of 400 adults were marked 100 at a time with a different colour and released at three different dates (phenological stages 61, 63 and 71 according to Meier *et al.*, 1994) at four different distances (5m, 10m, 20m and 40m) from a single white sticky trap. In both experimental series the traps were inspected twice a day and the recapture rates recorded.

Since the spatial distribution of sawfly activity in an orchard is very heterogeneous population estimates have to be based on more than one trap. In 1994 and 1995 field experiments were run in 11 commercial orchards in Central and Eastern Switzerland with the objective to determine the optimal number of white sticky traps for a reliable sawfly monitoring. At each site an Idared and a Golden Delicious plot were equipped with five equally distributed traps. During the flight period the traps were inspected weekly and the sawflies were counted. In the second half of May the infestation level was established on 1000 untreated fruits per site and variety. The relationship between trap catches (population density) and infestation level was studied by means of linear regression. Step by step 1, 2, 3, 4 or all 5 traps were included for the population estimates, the regressions each time recalculated, and the coefficients of determination (r^2) compared. For both Idared and Golden Delicious regressions were computed separately to expose varietal differences.

RESULTS AND DISCUSSION

Prognosis of spring emergence: The temperature dependence of post-diapause development and the phenology model are discussed in detail in Graf *et al.* (1996). The main results are briefly summarised here. The thermal threshold for the post-diapause development of the apple sawfly was found to be 4.5°C for both females and males. The thermal constants, however, differed slightly, females taking on average 205 and males 220 day-degrees to reach the adult stage. Since the model was not expected to discriminate between females and males the overall thermal constant of 210 day-degrees was used. Model predictions on sawfly emergence in three consecutive years are compared to corresponding trap catches in Fig. 1. The model reproduced the overall flight pattern in an excellent manner even under varying weather conditions. In 1993 and 1995 the model predicted the emergence of the first sawfly just one and two days too late respectively. In 1994 the predicted beginning of the flight was 5 days too early. Despite these deviations from field observations the model seemed to be more reliable than tree phenology in predicting sawfly emergence. The model is considered to be a useful tool to determine the optimal time for trap installation under Swiss conditions.

Prognosis of the infestation level: The mark-release-recapture experiments demonstrated a confined flight activity of the sawflies and a limited range of action of the white sticky traps respectively. In the first experiment (Fig. 2) where sawflies were released in the centre of a grid of 18 traps on average 47% were recaptured. 77% were caught within a range of 4m and 97% within 12m. No preference was observed for a particular direction; sawflies seemed to disperse as easily across as along the tree rows. In the second experiment (Fig. 3) where sawflies were released at increasing distances from a single trap recapture rates decreased exponentially from 56% at 5m to 3% at 40m. In both experiments more than 95% were recaptured within the first 24 hours after release. This indicates that experienced sawflies are not likely to be caught and that most catches on white sticky traps are newly emerged adults. Furthermore the traps appeared to be more attractive before and after blossom than during full bloom (phenological stages 61-65 according to Meier *et al.*, 1994)) since flowers divert from the traps.

The field experiments in commercial apple orchards demonstrated clearly that the reliability of sawfly monitoring can be improved by increasing the number of white sticky traps (Fig. 4). The coefficient of determination (r^2) of the regression between trap catches and infestation level was enhanced by more than 15% when the population estimates were based on five instead of only one trap. Three traps were concluded to be the optimal number since they contributed the most to the improvement (13%). The regressions were computed for Idared and Golden Delicious separately (Fig. 5). The slopes were significantly different, confirming the higher attractiveness of Idared. At the same flight intensity the corresponding infestation level was roughly twice as high on Idared as on Golden Delicious. 30 sawflies per trap corresponded to 4.5% primary infestation on Idared but only 2% on Golden Delicious. Moreover, in Golden Delicious barely half as many sawflies were caught as in Idared. These findings strongly suggest that the risk assessment of the apple sawfly should take varietal differences into account.

CONCLUSIONS

The risk assessment for the apple sawfly can be improved with respect to timing and population monitoring. The phenology model described by Graf *et al.* (1996) allows determination of the optimal time for the installation of white sticky traps in a fast and simple manner. When setting up the traps it has to be considered that sawfly populations are heterogeneously distributed and most individuals remain within a range of 25m from the site of emergence. Traps should not be more than 50m apart. Three traps per variety enable reliable population estimates. Variety specific relationships between trap catches and infestation level have to be identified in order to take differences in flight intensity and attractiveness into account. Based on the nature of these relationships specific economic injury levels have to be established for the more important cultivars or groups of cultivars.

ACKNOWLEDGEMENTS

We would like to thank K. Carl and his team from IIBC in Delémont for the help in sawfly collections.

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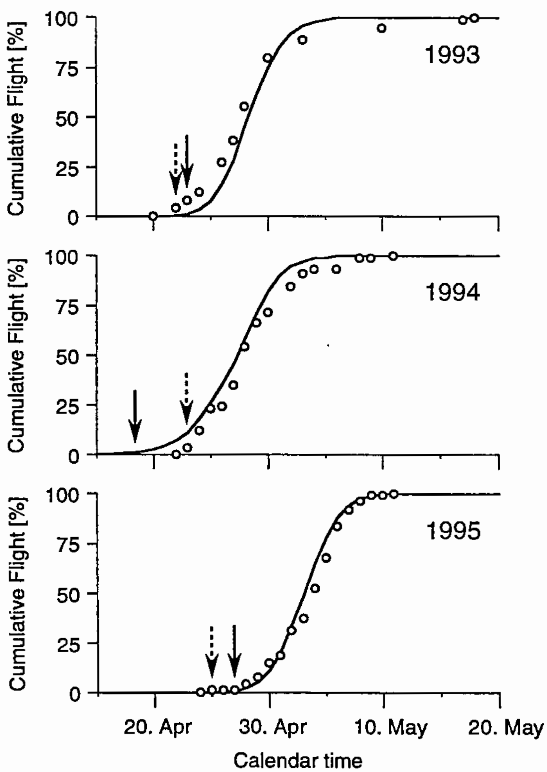
Fig 1: Model predictions and field observations on spring emergence of the apple sawfly (*H. testudinea*) in 1993, 1994, and 1995.



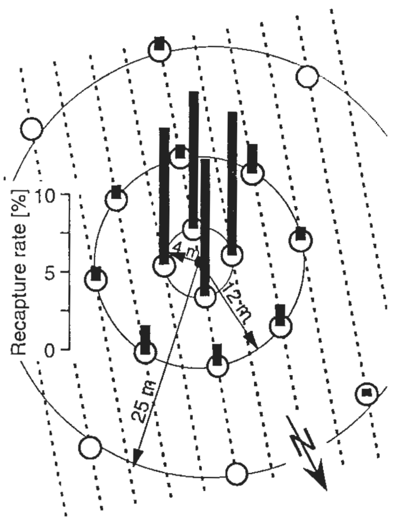


Fig. 2: Recapture rates of marked sawflies within a grid of 18 sticky traps arranged in three concentric circles (radius 4, 12 and 25 m) around the point of release.

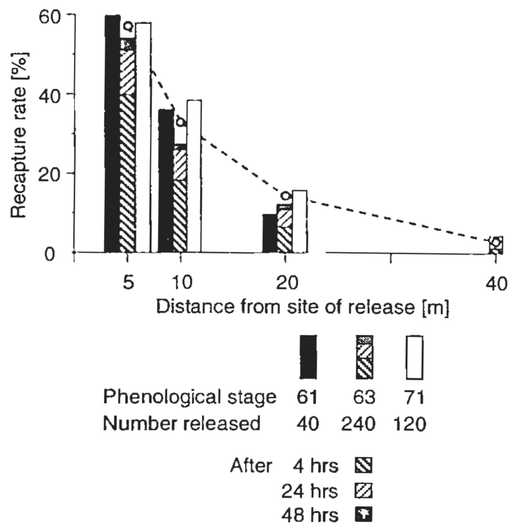


Fig. 3: Recapture rates of marked sawflies released 5, 10, 20 and 40 m from a single white sticky trap at three different phenological stages (61: 10% open blossom; 63: 30% open blossom; 71: end of petal fall).

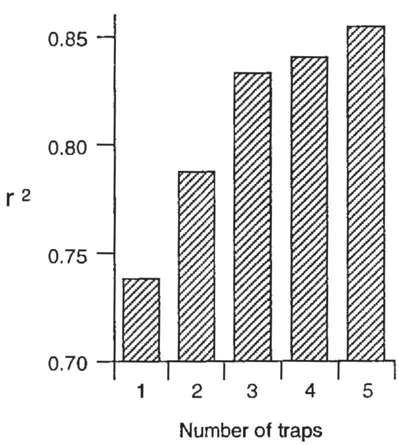


Fig. 4: Coefficients of determination (r^2) of the regressions between trap catches and infestation level when population estimates are based on 1, 2, 3, 4 and 5 traps.

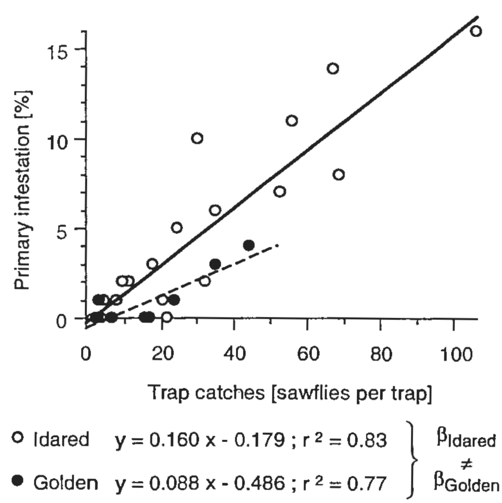


Fig. 5: Linear regressions between trap catches and infestation level for Idared and Golden Delicious.

Validation of linear and non-linear models of the rate of development of a Spanish population of *Cydia pomonella*

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Abstract

Two linear models of the rate of development of eggs and one linear and one non-linear (Logan Type III) models of the rate of development of larvae+pupae of *Cydia pomonella* have been tested under field conditions in Catalonia (NE Spain).

Samples of less than 24-h old eggs and larvae were placed under field conditions. Larvae were reared on diet. The individuals were checked daily for larval emergence in the case of the eggs and for pupation and adult emergence in the case of the larvae.

The two tested linear models of the development of the eggs predicted a duration of the development longer than the observed in the field. The non-linear model of larval+pupal development gave better predictions at high temperatures and worse predictions at moderate temperatures than the linear model.

Introduction

Several models of codling moth (*Cydia pomonella* (L.)) phenology have been developed in the last years in Europe and the USA (Blago, 1992, University of California Statewide IPM Project, 1990 (some of the models are summarized in the latter reference)). As it has been shown several times, some modifications may be needed when trying to use in one region a model developed in another one (Blago & Dickler, 1990). These modifications may be due, for example, to different population characteristics or to climatic differences in the orchards. These factors stress the importance of having data for local populations.

Usually, the first step in building a phenological model is the study of the relationship between the rate of development and the temperature, carrying out experiments at constant temperatures. The produced model is then validated conducting experiments at alternate or variable temperatures.

A set of experiments at constant temperatures (range from 15 to 36 °C) using a population from Catalonia (NE of Spain), reared on a semisynthetic diet based on desiccated apple, has led to some linear and non-linear models of the relationship between the rate of development and the temperature (Ferreira *et al.*, 1994).

The linear model of total development (from egg laying to adult emergence) showed good agreement to published data (588 DD above 10 °C). The linear model of egg development yielded a Lower Development Threshold of 9 °C and a thermal accumulation of 106 DD. Ninety DD above 10 °C is the commonest value used.

The family of curves chosen to model the development of larvae, pupae and from egg laying to adult emergence was the Logan Type III (Hilbert and Logan, 1983), that showed a good fitting ($R^2 \geq 0.98$). This family of curves is only one of the many possible and has been also used by Pitcairn *et al.* (1991). However, the fitting of the non-linear model of the egg development was not good enough and some additional experiments are under way.

The aim of this work was to validate the linear and non-linear models of *C. pomonella* rate of development as a function of the temperature under semi-natural conditions. We will focus in this paper on egg and larval+pupal development.

Material and Methods

Models

Two linear models of the development of the eggs have been tested. Model 1 was developed from the equation of the regression line derived from our experiments at constant temperatures. It assumes that 106 DD above 9 °C and below 34 °C are needed for egg development and it uses a horizontal cutoff. Model 2 has been published by UC-IPM (University of California Statewide IPM Project, 1990). It assumes that 88 DD above 10 °C and below 31 °C are needed for egg development and it also uses a horizontal cutoff.

The linear model of the development from newly hatched larvae to adult emergence was developed from the equation of the regression line derived from our experiments at constant temperatures. It assumes that 461 DD above 10°C and below 31°C are needed and it uses a horizontal cutoff.

The non-linear model was developed from the equation of the regression curve derived from our experiments at constant temperatures and it has the following form and the following values of the parameters:

$$r(T) = \psi((T-T_b)^2/((T-T_b)^2 + D^2)\text{-}\exp(-(T_m-(T-T_b))/\Delta T)),$$

where:

$r(T)$ = Rate of development (1/day)

T = Temperature (°C)

T_b = Lower Development Threshold (°C) = 9.5785

T_m = Upper Development Threshold (°C above T_b) = 24.7720

ΔT = difference between T_m and the temperature at which the rate of development is maximum = 1.0013

ψ y D = parameters = 0.0692 and 15.7643, respectively

Experimental design

The population of *C. pomonella* was collected in 1992 using strips of corrugated cardboard in an abandoned apple orchard in Lleida (41° 37' N latitude) and it was thereafter reared on artificial diet (based on desiccated apple) under long-day conditions (Pons *et al.*, 1994).

Wax paper sheets bearing less than 24-h old eggs were glued to the outer face of the bottom of a delta trap. The delta traps were hanged under the tree canopy. Twenty-two eggs samples were placed in the field, from the 27th April to the 21st September 1994. Eggs were checked daily until larval emergence. The number of eggs per sample ranged between 18 and 617.

Six samples of 150 less than 24-h old larvae singly kept in plastic cages with artificial diet were placed in outdoor conditions under the shadows of trees from the 26th April to the 30th of June (before this date no larva enters into diapause in our conditions). Larvae were daily checked to note the date when they left the diet to look for a place to cocoon, when they pupated and when adult emerged. The adults were sexed.

The climatic database used was collected from a Campbell automatic weather station located about 20 m apart from the place where the *C. pomonella* individuals were placed. The PAC-COM program (Generalitat de Catalunya, 1994) was used to compute the daily number of DD using hourly temperatures and horizontal cutoff.

Results and Discussion

Egg development

Table 1 shows the observed mean duration of the development and the predicted duration of the development by the two linear models for each sample. One hundred percent mortality occurred in those samples not included in the table.

Table 1. Observed and predicted values of the duration of the development of C. pomonella *eggs under field conditions*

DATE (mm/dd)	MEAN TEMP. (°C)	n	DURATION OF THE DEVELOPMENT (day)				
				MODEL 1		MODEL 2	
			OBS.	PRED.	DIFF.	PRED.	DIFF.
04/27	19.2	204	9	11	- 2	10	- 1
05/03	16.3	200	13	15	- 2	15	- 2
05/10	16.7	94	12	14	- 2	14	- 2
05/17	18.6	58	10	11	- 1	11	- 1
05/24	21.7	102	8	9	- 1	8	0
05/31	21.5	28	8	8	0	8	0
06/11	21.0	39	7	9	- 2	8	- 1
06/15	23.6	60	7	8	- 1	7	0
06/22	23.5	58	7	8	- 1	7	0
07/13	26.4	174	6	6	0	6	0
07/20	26.3	60	6	7	- 1	6	0
07/27	26.2	123	6	7	- 1	6	0
08/22	25.5	154	7	7	0	6	+ 1

DATE = date of placing the eggs under field conditions
MEAN TEMP. = mean temperature of the period when the eggs developed
n = number of eggs that completed the development in each sample
OBS. = observed
PRED. = predicted
DIFF. = observed - predicted

Model 1 always predicted a slower development than the observed one, being 2 days the biggest difference. Model 2 also predicted a slower development than the observed one, but more accurately than Model 1 did. The differences were bigger in April and in May, which is time of flight of and laying eggs by the overwintered generation. A possible explanation is that 1994 temperatures at this time (Table 1) were about the minimum temperature used in constant temperature experiments.

Larval and pupal development

Table 2 shows the observed mean duration of larval + pupal development and the predicted duration of the development by the linear and non-linear models.

Table 2. Observed and predicted values of the duration of the development of C. pomonella *larvae + pupae reared on diet under field conditions*

DATE (mm/dd)	MEAN TEMP. (° C)	n	DURATION OF THE DEVELOPMENT (day)				
				LINEAR		LOGAN III	
			OBS.	PRED.	DIFF.	PRED.	DIFF.
05/06	19.8	27	48	48	0	51	- 3
05/17	21.2	90	41	42	- 1	45	- 4
05/29	23.1	59	39	37	+ 2	41	- 2
06/07	23.6	72	37	36	+ 1	41	- 4
06/18	25.2	64	37	32	+ 5	36	- 1
06/30	26.0	93	35	31	+ 4	33	- 2

DATE = date of placing the larvae under field conditions
MEAN TEMP. = mean temperature of the period when the larvae and the pupae developed
n = number of eggs that completed the development in each sample
OBS. = observed
PRED. = predicted
DIFF. = observed - predicted

The linear model produced better predictions than the non-linear model when the larvae were placed in the field until the second half of June. The non-linear model always predicted a duration of the development smaller than the observed one. Minimum temperatures in may were below 15 °C many days, being 15 ° C the minimum constant temperature used in the constant temperature experiments that led to the model. So, the non-linear model needs further refinement in the lower part of the curve. As the duration of the development of *C. pomonella* at temperatures below 15 °C is great, some experiments under alternate temperatures are under way. The linear model gave accurate predictions until the second half of June in 1994.

The non-linear model made better predictions than the linear-model when the larvae were placed in the field the second half of June. At that time of 1994, the temperature was higher than 34 °C several hours a day during many days. The linear model (horizontal cutoff) assumes a constant rate of development above 31 °C without an upper threshold where development stops. So, the linear model predicted that some development occurred at temperatures above 34 °C and a duration of the development smaller than the observed one. The non-linear model assumes a decreasing rate of development above 31 °C and no development above 34 °C, and the predicted duration of the development were close to the observed one (Table 2).

As conclusions, the two tested linear models for the development of the eggs predicted a duration of the development longer than the observed in the field. The non-linear model for larval+pupal development gave better predictions at high temperatures and worse predictions at moderate temperatures than the linear model.

Acknowledgments

This work has been financed by the Programa Sectorial de I+D Agrario y Alimentario del MAPA, Project No. SC94-015. Thanks are also given to the Direcció General de Producció i Indústries Agroalimentàries of the Generalitat de Catalunya for the climatic database.

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Phytophagous *Heteroptera* and IFP - a solvable contradiction?

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ABSTRACT

Every year phytophagous *Heteroptera*, especially *Plesiocoris rugicollis* (FALLÉN) and *Lygus pabulinus* L., cause more or less severe damages in apple orchards in the northern parts of Germany. One reason for an increasing number of *Heteroptera* damages in IFP is caused by the loss of registration for parathion-ethyl in this culture. The egghatch of the bugs usually starts at the beginning of blossom (cultivar 'Boskoop'). In consequence the pesticides used against bugs should not be harmful to bees and effective against bugs. Synthetic pyrethroids fullfill these options but are harmful to different beneficial arthropods.

The effects of different chemical treatments with IFP-pesticides, synthetic pyrethroids and pesticides of ecological fruit production on bugs and beneficial arthropods are demonstrated.

INTRODUCTION

Fruit damages in IFP-orchards caused by the phytophagous bugs, *Plesiocoris rugicollis* (FALLÉN) and *Lygus pabulinus* L., induced a great number of experiments to control these species.

Applications of parathion-ethyl as well as applications of synthetic pyrethroids applied by farmers proved a good control of bugs in the last years.
After the loss of parathion-ethyl registration in Germany and the prohibition of this compound in apple culture, farmers tried to substitute this compound by parathion-methyl. The trial failed.

At that moment a control of bugs seems to be impossible within the framework of:
- national registration - all registered organophosphate insecticides (OPs) are prohibited to use after the beginning of blossom -,
- IFP acceptance - synthetic pyrethroids (SPs) reduce important beneficial species -
- and out door-situation - beginning and duration of apple blossom, duration of bug-hatch, temperature while and after treatment.

So new compounds, formulations or methods have to be found for solving the described difficulties.

MATERIALS AND METHODS

Experimental area

All experiments in the years from 1990 to 1995 were located in usual apple orchards of the "Niederelbe"-region. The size of single plots differed between 40 m² (back-pack mistblower) and 400 m² (usual mistblower).

Insecticide applications

All registered insecticides were tested in the highest permitted concentration. According to the German registration, OPs were applied directly before beginning of blossom. Applications of SPs followed about five to ten days later in the time of blossom apart from the daily bee-flight. Formulations for experimental purposes were used according to the options of customers. Replicated trials were sprayed only one time with either a usual mistblower or a back-pack mistblower (600 or 800 l/ha).

Fruit samples and efficacy of treatments

About 1600 fruits per treatment were sampled for the evaluation of fruit damages and efficacy of treatment in july and at harvest. Because of the still missing samples of harvest in 1995, data have to be looked at as provisional.

Predatory mites

Effects of OPs, SPs and "other compounds" on predatory mites were tested in an IFP-apple orchard where no SPs were used for more than five years. Most of the individuals found (96 percent), belonged to *Amlyseius* sp. The represented results were found 60 days after the treatments.
Effects of ecological compounds on predatory mites were sampled in two orchards (IFP and ecological). In both orchards an inhomogeneous population of *Typhlodromus pyri* (SCHEUTEN), *Amblyseius* sp. and *Zetzellia mali* (EWING) was present.

Other beneficial arthropods

For sampling of other beneficial arthropods, individuals were knocked down from branches and collected in a funnel. Samplings were made four times in the months of june and july in three apple orchards, 30, 45, 60 and 75 days after applications.
To compare the small numbers of individuals on a similar base individuals were calculated for 1200 knocked branches (3 areas, 4 times, 100 branches).

RESULTS

Bug-induced fruit damages in control plots (1990-1995)

In the last six years, control plots in IFP orchards showed bug-induced fruit damages between less than one percent and 16 percent. In 1994 control plots of an ecological orchard showed a proportion of nearly 20 percent bug-attacked fruits (Table 1).

Table 1. Mean percentages of fruits damaged by *P. rugicollis* and *L. pabulinus* (Region of "Niederelbe" untreated control plots, 1990-1995)

Year	kind of orchard	% mean of fruits damaged
1990	IFP	4.1
1991	IFP	5.1
1992	IFP	4.5
1993	IFP	5.5
1994	IFP	<1.0
	IFP	<1.0
	IFP	<1.0
	IFP	7.9
	Ecological	19.9
1995	IFP	(<1.0)
	IFP	(6.0)
	IFP	no fruits
	IFP	(16.0)

() provisional data of 1995

The control of phytophagous bugs

The efficacy of standard and experimental compounds tested the last years against phytophagous bugs is represented in Table 2.

Table 2. Reduction of bug-induced fruit damages compared with controls (*P. rugicollis, L. pabulinus*; trials of 1990-1995)

Compound	Conc.	Product	% reduction of damaged fruits compared with controls
Dimethoate	0.2	Dimethoat	69
Parathion-e.	0.035	E 605 POX	56, 100
Parathion-m.	0.05	ME 605 Spp .	54, 82
Parathion-m.*	0.045	exp. formul.	(0, 31)
Cyfluthrin	0.03	Bulldock	96, (56)
Cypermethrin1*	0.05	exp. formul.	(75, 100)
Cypermethrin2*	0.015	exp. formul.	no bugs
Deltamethrin	0.03	Decis fl.	89, 77, 58, 100, (25, 38)
Diflubenzuron	0.05	Dimilin 25 WP	0, 0
Fenoxycarb	0.04	Insegar	0
Imidacloprid*	0.035	exp. formul.	75, 0, (0, 69)
Propoxur	0.2	Unden fl.	57
Triazamate*	0.05	exp. formul.	(67, 97)
Pyrethrines1	0.1	Spruzit fl.	24, 29
Pyrethrines2	0.035	Bio Insekt.	35, 38
Potassium-soap	2.0	Neudosan	44, 37
Quassines*	0.2	exp. formul.	6, 5

* Formulations for experimental purposes; () provisional data of 1995

OPs, especially parathion-ethyl and dimethoate resulted in a good control of bugs. Compared to controls fruit damages decreased between 56 and 100 percent (parathion-ethyl) and 69 percent (dimethoate). Directly compared with parathion-ethyl, parathion-methyl was less effectiv in reducing fruit damages (54 and 82 percent). Also the recently in 1995 tested formulation of parathion-methyl showed no sufficient control of bug-induced damages.
Nearly all applications of SPs applied after the beginning of blossom resulted in the most effectiv reduction of fruit damages. Nevertheless provisional data of deltamethrin show an unsufficient and unexpected result (25 and 38 percent of damage reduction).
"Other compounds" showed no effect (diflubenzuron, fenoxycarb), an uncertain reduction of damages (imidacloprid 0 and 75 percent), small effects (propoxur 57 percent) or have to be tested further (triazamate, provisional 67 and 97 percent).
"Ecological compounds" like pyrethrine-formulations, potassium-soap or quassines resulted in an insufficient reduction of fruit damages for IFP. Results differed between 5 and 44 percent of reduction compared with controls.

Effects of treatments on predatory mites

The effects of single insecticide treatments on predatory mites are shown in Figure 1. Sixty days after the treatments the population of *Phytoseiidae* was not or insignificant reduced by the tested OPs parathion-ethyl and parathion-methyl. Parathion-methyl formulations tended to an increased number of *Amlyseius* sp. Whereas the none-IFP-OP compound dimethoate as well as the SPs led to a severe reduction of the *Amblyseius* sp.-population between about 50 (cyfluthrin) and 90 percent(cypermethrin1). Effects of

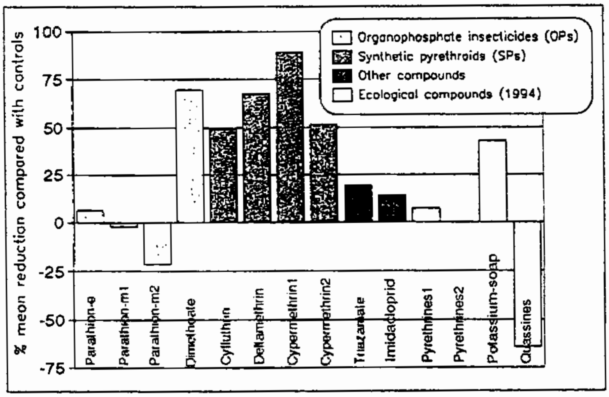

Figure 1. Long-term effects of tested compounds on predatory mites

formulation or applied concentration were found between the tested cypermethrins (50 or 90 percent reduction compared with controls).
Long-term-effects of the "other compounds" (imidacloprid, triazamate) could not be proved. Reduction tended to stay under the 25 percent line.
Also the natural pyrethrines of the "ecological compounds" showed no visible long-term-effect on the inhomogeneous Phytoseiid-popolations, whereas potassium-soap reduced (43 %) and quassines (-64 %) tended to increase the number of predatory mites compared with controls.

Effects on other beneficials

Like in former years, no significant long-term effect on beneficial arthropods like *Forficula* sp., *Chrysopidae*, *Coccinellidae* or *Syrphidae* could be ascertained in plot trials of the year 1995. The applications of parathion-methyl as well as the applications of delta-methrin showed similar or increased numbers of *Forficula* species compared with controls. *Chrysopidae* were only present at one site and were missed there in deltamethrin plots. The number of *Coccinellidae* (present in two sites) was lower or missed in parathion-methyl applied plots. *Syrphidae* were found at one site only (treated plots) but were not present in controls.

The out door-situation (1990-1995)

The last six years, first bugs appeared at least two days before (1992, 1994) or at the beginning of blossom (1990) of the variety 'Red Boskoop' (BBCH-code 62), (Table 3).

Table 3. Blossom of the variety "Red Boskoop" and first observations of hatched phytophagous *Heteroptera* in the region of "Niederelbe"

Year	Blossom start	end	Duration (days)	First hatched *Heteroptera*
1990	12/4	29/4	18	12/4
1991	9/5	24/5	16	8/5
1992	8/5	20/5	13	10/5
1993	27/4	4/5	8	26/4
1994	30/4	16/5	17	28/4
1995	2/5	23/5	21	1/5

Low temperatures in the relevant time of preblossom and blossom resulted in a slow mass hatching of the bugs and a long duration of blossom.

CONCLUSION

A conclusion of results for the control of bugs is given in Table 4.
For years characterized by high temperatures before the beginning of blossom and a rapid mass hatching of bugs, reregistration of parathion-ethyl would be very helpful.

Table 4. Conclusion of experiments

Compound	Control of bugs	Bee-toxicity	Long-term effects on *Phytoseiidae*	efficacy < 15°C
dimethoate	+++	high	++	******
parathion-e.	+++	high	0	low
parathion-m.	++	high	0	(low)
parathion-m.*	(+)	high	0	?
deltamethrin	+++	medium	++	high
cyfluthrin	+++	medium	++	high
cypermethrin1*	(+++)	medium	++	(high)
cypermethrin2*	?	medium	+++	******
propoxur	++	high	+?	******
imidacloprid*	0/++	medium?	0	******
triazamate*	(+++)	low	0	(high)
pyrethrines1	0/+	low	0	******
pyrethrines2	0/+	low	0	******
potassium-soap	0/+	low	+/++	******
quassines*	0	?	0	******

*exp. formul., 0 no effect, + small effect, +++ strong effect, ****** excluded

Other OP-compounds showed either a low control of bugs or strong long-term sideeffects on predatory mites.
All SPs showed a good control of bugs, even at low temperatures, but were also effectiv against predatory mites. The use of SPs in years with low temperatures (preblossom, blossom) and late mass hatching of the bugs will not be evitable.
If results of the compound triazamate in next years trials can be confirmed the registration would offer an acceptable solution in the conflict of IFP and control of phytophagous *Heteroptera*.

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THE DYNAMICS OF ARTHROPOD FAUNA IN THE APPLE ORCHARD OF NORTH CROATIA

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Abstract

The paper reviews the dynamic of the orchard Arthropodae population in different programs. The insects and mites were tested and determined in the period between 1991/1994.The largest number of species was found in the IPM (program A) in which exclusively bio- insecticides were used,while the smallest number of species was determined in the standard IPM,where in addition to bioproducts insect development inhibitors and organic phosphorus insecticides with secondary effect were used.The IPM (program A) showed 87 species in total,the IPM (program B) showed 29 species ,while the standard IPM showed only 14 species .Major differences in the number of species in particular programs were found in the butterfly order (*Lepidoptera*).While the IPM program A showed 42 butterfly species the standard IPM showed only 3 species.

Key words : apple, fauna, IPM, population.

Introduction

On all plants, especially those under intensive cultivation, the problem arises of the appearance of powerful populations of one more kinds of insect, mites, or other harmful organisms. Although damage resulting from individual insect or mites attacks have been known since time out of mind, in the recent period the problem of the phenomenon of pests has become very compicated, especially on large areas maintained under monoculture conditions. The phenomenon of the excessive reproduction of individual kinds of pest is the result of many factors, such as the stimulating effect of agricultural chemicals (*Chaboussou*, 1965), the disturbance of the natural balance, resistance, synergetic interactions, mutualism, and symbiosis.Modern plant production using intensive protection has a harmful effect not only on plants but on the entire eco - system. Protection of plants by exclusively chemical systems had to change. Alongside chemical preparations for plant protection , other opportunities that were available began to be taken,and integrated pest management was introduced (*Baggiolini*, 1965, *Steiner*, 1968).It is very important to know the dynamics of the populations of the fauna of orchards, especially in integrated pest control in which there is an endeavour to exploit the mutual relations between the species , and individuals among a single species . It is accordingly very important to follow up the dynamics of the population with respect to harmful fauna within an integrated pest control system (*Baggiollini*, 1965, *Van de Vrie*, *Anker*, 1967, *Beirne*, 1967). Apart from harmful fauna , the dynamics of useful and antagonistic fauna have also been investigated (*Arcanin*, *Ciglar*, 1971, *Bosch*, 1974, *Huffaker*, 1974, *Debach*, 1979, *Westigard*, 1979, *Ciglar*, *Baric*, 1992, *Lyossoufi* et al.,1992).

Alongside the dynamics of harmful and useful fauna , those of the entire faunistic structures of orchards are studied (*Ciglar*, *Schmidt*, 1983, *Ciglar*, 1985, *Kozar*, 1992, *Ciglar*, *Budinscak*, 1993). Many biotic and abiotic factors have an influence on the population dynamics of a species or several species (*Bosch*, 1974, *Debach*, 1979, *Seidel* et al.,1981),as do the regulation mechanisms in individual eco-systems.The effects species have on each other and population dynamics regulation mechanisms are very complicated, because they are subject to many factors in diverse systems (*Nicholson*, *Bailey*, 1935. *Knipling*, *Mc Guire*, 1968, *Hassel*, 1978, *Schwerdtfeger*, 1978, *Krieg*, *Franz*, 1989.).

Methods of work

To investigate the population dynamics of insects and mites an experiment was conducted with various pest control systems used by Agromedimurje orchards in Cakovec. The size of the experimental areas came to 2,5 ha in each combination, species of apple, and varieties of *Idared* and *Golden Delicious*. In the experiment three pest control systems were used :
BT insecticide, fungicide for suppressing apple scab and powdery mildew;
BT and IGR insecticides, fungicide for suppressing apple scab and powdery mildew;
BT, IGR and organo-phosphate insecticides, fungicides for apple scab and powdery mildew.
As for application times, insecticide treatments were made according to the appearance of codling moth and *Tortrix* moths and with fungicide treatments according to the onset of apple scab infection.
Checking for arthropod fauna was carried out in 1991, 1992, 1993 and 1994. Monitoring of population dynamics was done by standard methods of inspection, the visual method and the beating method. Inspections were carried out once a month during vegetation from April to September every year. Collected material was classified according to order , family and species. In all years in which the experiment was being carried out, a total of inspections were made. The number of species in every inspection is compared with the number of organisms established to be present (logistic number).
In spite of the small numbr of pairs in the inspection (species : organisms) , the correlation coefficient was worked out.

Results

By monitoring the fauna of the orchards on experimental trees, the presence was established of harmful, beneficial and neutral species. The number of species in various pest control systems is shown in Graph 1. The greatest number of species was established in the programme in which only bio-insecticides were used, and after that in the programme in which alongside bio-insecticides, growth inhibitors were employed, a programme which was still however selective . It was determined that there was the smallest number of species in the programme in which OPI s were used (fosalon, pirimikarb).
The greatest difference with respect to the number of species in the programmes was established as regards the order of butterflies (*Lepidoptera*), while in all other orders the differences were smaller. The number of species however does not correlate with

the number of individuals, that is with an increase in the population of a given individual species. Very strong populations were established in the case of a small number of species. The phenomenon of strong populations of a single species or a small number of species is always related to species selection. As is shown in Graph 2, the relation between number of species and the total number of organisms is not always according to the correlation that would be anticipated.

Conclusions

By investigating the influence of various pest control systems we determined certain changes in the fauna of orchards that relate to the number of species and their population dynamics.

Most species were identified in the integrated programme in which only bio-insecticides were used , while the smallest number of species was found in the standard programme in which , along side bio-preparations and growth inhibitors , OPIs were used.

In the first pest control programme , a total of 87 species were identified , in the second programme 29, and in the third (standard) programme 14.

The number of species in the order of *Lepidoptera* in the first programme was established to be 42 in the first programme , 4 in second , and only 3 in the standard programme.

Smaller differences in the number of species were established in the order of *Coleoptera* . There were very small differences in the *Heteroptera* and *Homoptera* orders and in other orders.

Changes in population dynamics are not exclusively the effect of the workings of insecticide , of their selectivity that is , but of the mutual relations among the species.

System stability is better in the event of there being a large number of species. Over - reproduction of a single species often occurs in a sysrem in which there are few species.

The correlation coefficient between the number of species and the total number of organisms in the experiment amounted to 0,403221.

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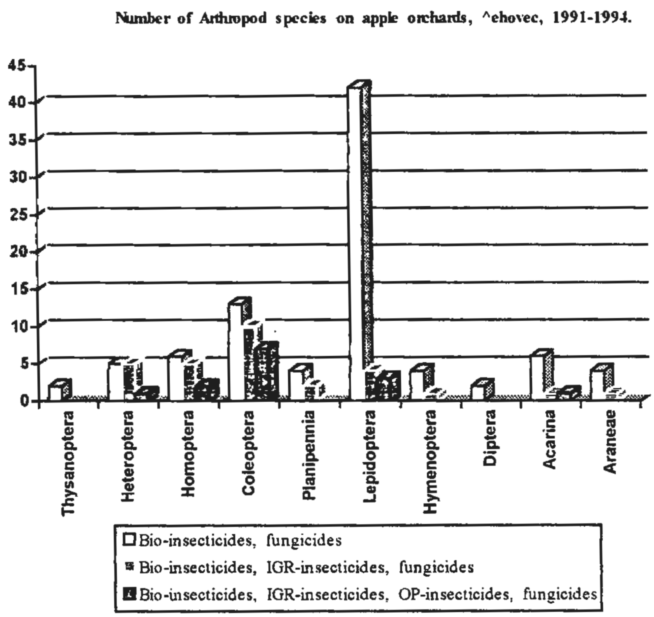
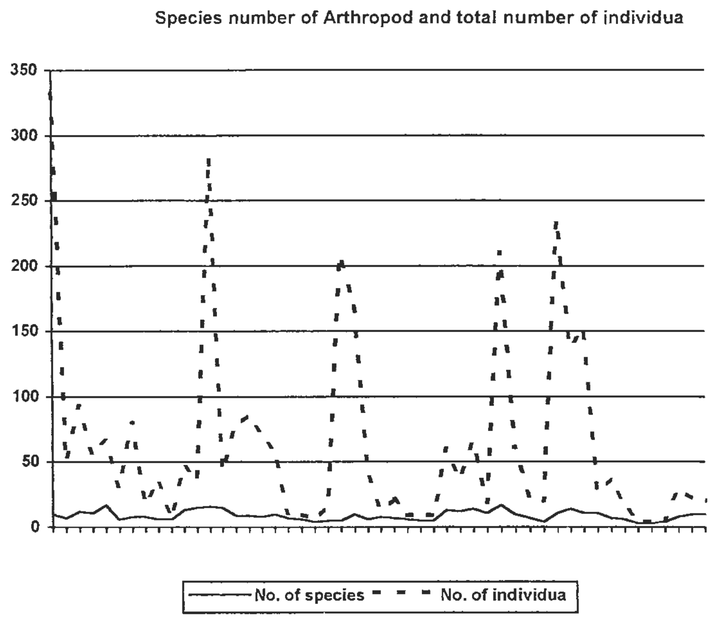
Graph 1



Number of Arthropod species on apple orchards, ^ehovec, 1991-1994.
45
40
35
30
25
20
15
10
5
0
Thysanoptera
Heteroptera
Homoptera
Coleoptera
Planipennia
Lepidoptera
Hymenoptera
Diptera
Acarina
Araneae
Bio-insecticides, fungicides
Bio-insecticides, IGR-insecticides, fungicides
Bio-insecticides, IGR-insecticides, OP-insecticides, fungicides

Graph 2


Species number of Arthropod and total number of individua
350
300
250
200
150
100
50
0
No. of species
No. of individua

INCORPORATION OF APPLE CLEARWING (*SYNANTHEDON MYOPAEFORMIS* BORK.) CONTROL INTO THE IPM SYSTEM OF APPLE

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Abstract

The apple clearwing (*Synanthedon myopaeformis* Bork.) that has been regarded until the 1960-ies in whole Europe as one of the secondary pest of apple trees weakened by other factors; it has become a significant pest and this can be attributed to changes in apple production technology. Intensive plantations were established, rootstocks with low growing capacity introduced and these may result in the early death of young trees under unfavourable environmental conditions.

In the experimental plot that had received for 8 years IPM measures it was observed that both the number and distribution of clearwing adults trapped in sex-pheromone traps differed significantly from ones of a neighbouring plot that received conventional plant protection, although their past records were identical. As in the conventiona 1 one the swarming lasted longer than in the IPM plot and the number of trapped adults was significantly higher it was assumed that the differences can be attributed to the effect of some environmentally friendly preparations applied in the IPM orchard.

Based on this hypothesis, from among the environmental preparations used against codling moth, leaf rollers and leaf miners the following were applied after the swarming peak of clearwings in 1992: Dimilin 25 WP (diflubenzuron), Insegar (phenoxycarb) and Match (lufenuron), in 1994: Dimilin 25 WP, Match, Cascade 5 EC (flufenoxuron) and Dipel (Bt).

The results with Dimilin and especially with Match, Dipel and Cascade are significant, because clearwings fly in high numbers in July and this may coincide with treatments against codling moth, tortricids or leaf miners. The environmental methods against *S. myopaeformis* can easily be incorporated into the IPM of apple. By using suitable forecasting methods the control measures can be connected with treatments against the most important Lepidopterous pests of apple and in a given case they do not even require a distinct treatment only a good choice of preparations.

Introduction

The apple clearwing (*Synanthedon myopaeformis* Borkhausen) that had been considered earlier as an occasional pest of weakened, neglected orchards has become, following changes in the apple production technology, a significant, regular damage factor in Europe and even in North Africa (Balachowsky 1966, Chestian and Lavy 1966, Baggiolini and Antonin 1976, Vanwetswinkel and Soenen 1977, Frankenhuyzen 1978, Waldner and Cembran 1981).

The females select for their oviposition the open wounds and bark crevices of trunks and main branches. The more these are presented for them in a plantation, the higher is the possibility of their colonization and damage. The establishment of intensive plantations, the spreading of mechanized pruning increased the surface of wounds and the use of soil cultivators contributed to a further mechanical injury of trees (Mikulás 1973, ciglar and Masten 1979, Kovanci 1986, Balázs and Khanh 1992, Mészáros 1993).

In recent years the technology of apple growing has changed again. The so-called intensive plantations are becoming popular, that means besides intensified pruning practice for crown formation and establishment of dense stands also the spreading of slowly growing stocks (e.g. M9). This results in favourable egglaying sites that are presented for apple clearwing females, especially at the thickened grafting points of fast growing varieties and slowly growing stocks (Khanh *et al.* 1994). The injuries may bring about a partial or even total destruction of young trees (Dickler 1984, Castellari 1987).

There have been many traditional methods tried in Europe to prevent the damage of clearwings (Mikulás 1973, Ciglar and Masten 1979, Dickler 1984), like mash-traps, wound treatments or even confusion technique (Voerman *et al.* 1978, Waldner and Cembran 1981, Stüber and Dickler 1987, Blommers 1987, Balázs *et al.* 1995). The results obtained are very variegated, sometimes even contradictory. The confusion technique is considered among them the most perspectivic.

The authors began the control experiments with all these informations in mind. We aimed to construct a control method that can easily be incorporated into the integrated fruit production programmes and can be carried out at the swarming of clearwing adults.

Material and Methods

An integrated plant protection programme is being worked out at present and has been started since 8 years in Kecskemét-Szarkás (Bács-Kiskun County, Central Hungary); to the IPM orchard a neighbouring plantation of identical record, age etc. is attached, which is, however, protected by conventional pest control methods.

In course of our work it attracted our attention that in the IPM orchard, where selective preparations had been used against different lepidopterous pests (codling moth, leaf rollers, leaf miners), the swarming process of apple clearwing and the number of clearwing males caught in pheromone traps differed from those of the neighbouring, conventionally treated area (Fig. 1). Here not only the swarming lasted longer than in the IPM orchard but also the trap catch was significantly higher (Fig. 2); it was assumed that this was the result of environmentally friendly products used.

The experiments were based upon this assumption; for this purpose a 20 year old, Starkrimson apple plantation of 2 hectares was selected.

The flight of clearwing adults was followed with sex-pheromone traps (type CSALOMON, Plant. Prot. Inst. HAS). After the peak of flight (which was established in both orchards by weekly controlled traps) the following environmentally friendly preparations were used: in 1992 Dimilin 25 WP (diflubenzuron) in form of smearing (1 %), spraying (0.1 %), Insegar (phenoxycarb, 0.1 % spraying), Match (luphenuron, 0.05 % spraying). The treatments were always combined with Agrol (vaseline oil). The whole experimnet was repeated in 1994, by omitting Insegar, but including Cascade 5 EC (fluphenoxuron, 0.1 % spraying) and Dipel (*Bacillus thuringiensis*, 0.1 % spraying).

The experiment was made in both years in 4 repetitions; in each plot 40 trees, mostly the trunks and main branches were treated. The spraying was carried out by a Japanese sprayer (typ SP6), with spraying once in 1992 (15 July) and twice in 1994 (7 July and 28 July), following the flight peak.

The results were evaluated in the following years (1993 and 1995) at the time of adult swarming. The number of extruded pupal skins (exuvia) was established weekly (4x5 trees per treatment).

The data were processed by analysis of variance (Anova, Duncan).

Results, Conclusions

Results of the weekly survey are shown in Figs. 3 and 4. In 1993 in the plot treated with Match 9.1 pupal exuvia per tree were found, compared to 30.9 exuvia/tree in the check (P 5% = 8.11). The two Dimilian treatments gave also significant differences: 13.6 exuvia/tree in the plot treated by smearing and 17,15 exuvia/tree in the sprayed area. The treatments of 1994 yielded in 1995 in all cases statistically substantiated results:

compared to the untreated (22.1 exuvia/tree) Match gave 7.1 exuvia/tree, Cascade 5 EC 7.6 exuvia/tree, Dipel 5.3 exuvia/tree and Dimilin 10.4 exuvia/tree.

The results of selective preparations (especially Match, Dipel, Cascade) are remarkable, because - in spite of its protracted swarming - apple clearwing flies in high density in July, coinciding (or possibly coinciding) with control measures applied against codling moth (*Cydia pomonella*), apple leaf roller (*Adoxophyes orana*) or any of apple leaf miners (*Phyllonorycter blancardella, Ph. corylifoliella, Leucoptera malifoliella, Nepticula malella*).

Based on our results, if it were necessary to control simultaneously codling moth, tortricids and apple clearwing, it is suggested to use Match or Dipel; if besides the earlier ones also leaf miners have to be controlled, Dimilin may be used. If besides Lepidoptera also spider mites are present, Cascade may be suggested that acts both by blocking chitin synthesis and exerting its translaminar effect.

The environmentally friendly control of clearwings can thus be well included into the apple IPM technology. By choosing reliable forecasting methods the control can be combined with the one used against the most important apple moths; in most cases it does not even call for a separate treatment but needs only attention to select a proter application date and preparation.

Acknowledgements

The authors express their acknowledgement to Dr. K.Magyar for his help in carrying out the experiment, to Dr. G.Szőcs and Dr. M.Tóth for supplying the pheromone preparations used in flight control of apple clearwings. OMFB supported the work described on the contract No. 92-97-16-0084 and USDA did the same based on the contract No. 58-319R-3-022.

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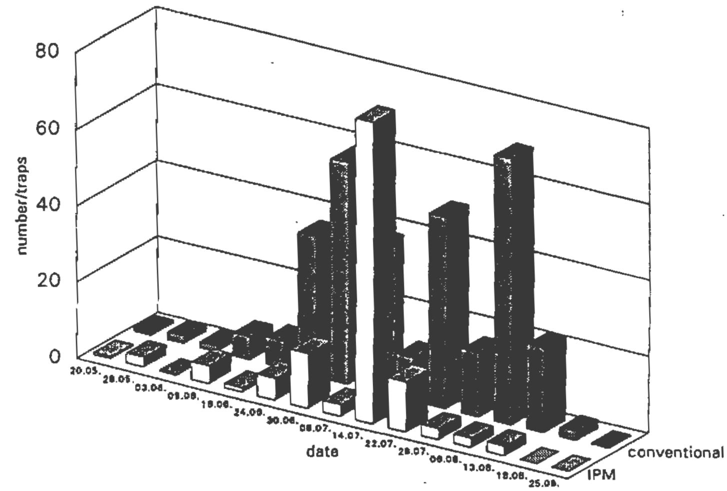
FIGURES

Fig. 1. *S. myopaeformis* males, collected by pheromone traps in the conventional and IPM orchard (Kecskemét-Szarkás, 1992)

Fig. 2. The ratio of *S. myopaeformis males* in the conventional and IPM plantations

Fig. 3. Effect of treatments on the individual number of *S. myopaeformis* (Kecskemét-Szarkás, 1992-1993)
Columns followed by different letters are significantly different, Annova-Duncan test (P=5 %)

Fig. 4.Effect of treatments on the individual number of *S. myopaeformis* (Kecskemét-Szarkás, 1994-1995)
Columns followed by different letters are significantly different, Annova-Duncan test (P=5 %)



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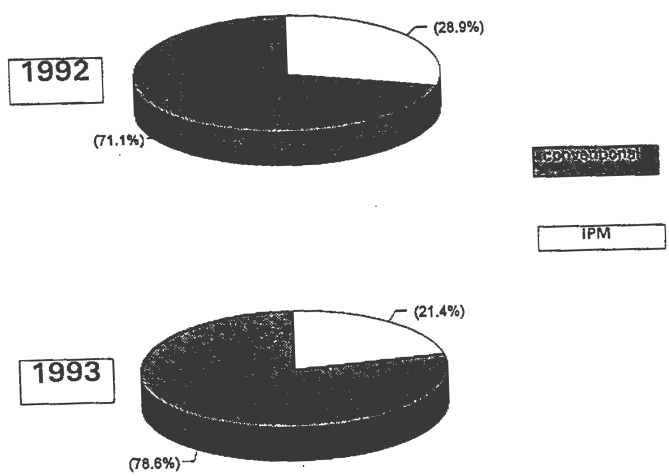

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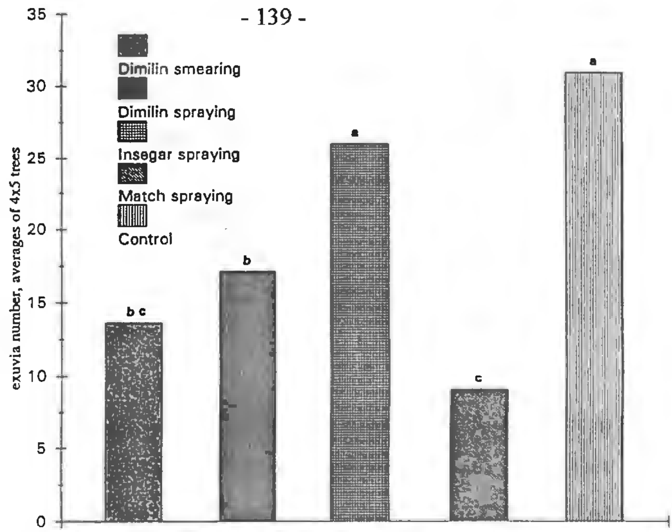

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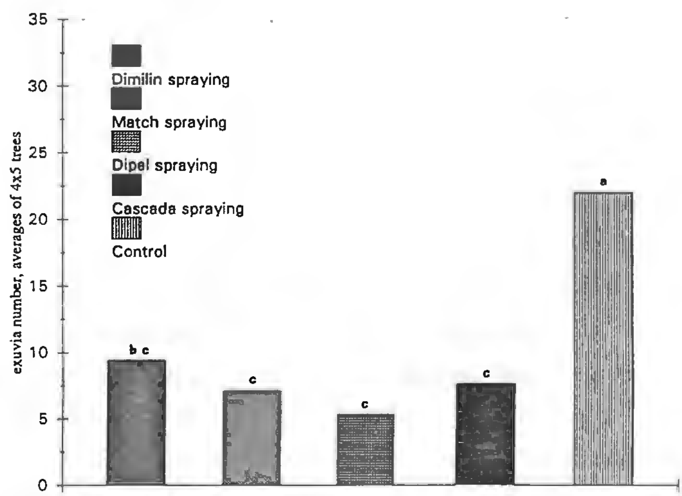

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Columns followed by different letters are significantly different, Annova - Duncan test (P=5 %)

Campylomma verbasci, a new pest on apple in The Netherlands (Heteroptera: Miridae)

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Abstract

Nymphs of the mirid bug, *Campylomma verbasci* often induce corky scar spots on apple ("dimple disease") by feeding. During the last three years (1992 - 1994) this kind of damage was found frequently on a number of apple varieties on fruit farms in the provinces of Noord-Brabant and Limburg.

Data on the life-history and field observations of *C. verbasci* are given. It appeared that this species is host alternating between deciduous trees (*Malus*, *Quercus*) and herbaceous plants (*Verbascum species*, *Solanum* and *Althaea*). On the summerhost, *Verbascum thapsus*, a third generation developed in 1994. This species is also known as a predator of mites and aphids.

Introduction

The mullein bug, *Campylomma verbasci* (Meyer-Dür), appears to be common on apple in some parts of the Netherlands. Like the related common green capsid, *Lygocoris pabulinus* (Linnaeus), it belongs to the family Miridae. The mullein bug causes damage on apple, especially on the Golden Delicious, Elstar and Jonagold varieties. This damage is referred to in practice as "dimple disease" (Stigter, 1995).

Surveys in 1994 showed that this species can be found on virtually every mullein plant (*Verbascum* sp.). However, to date, there have never been reports of the occurence of this species on apple. In Belgium several observations of similar fruit damage were reported, but initially they were attributed to hail damage. The harmful occurrence of the mullein bug on apple is also reported from other parts of Europe (Bulgaria) (Josifov, personal communication, 1994).

In North America, *C. verbasci* is an unpredictable and often serious pest on apple (Judd & Mcbrien, 1994; Reding & Beers, 1995). In Poland and the United Kingdom, however, this mirid bug is considered to be beneficial as it is known to predate on aphids and spider mites (Niemczyk, 1978; Kelton, 1982; Alford, 1984).

Field data on the occurence of *C. verbasci* on apple were collected by means of limb-tap samples and visual inspections of blossoms. The migration between summer and winter hosts was studied by operating two pheromone traps in an apple orchard in Lienden.

Description of the species

Adult *C. verbasci* are small and rather compact, greyish-green with some orange-yellow markings. They are about 3 mm in size. The legs are light in colour with dark spines on the tibiae, arising from dark spots, giving the legs a black and white " checkered" outlook. Nymphs are noticeably smaller than those of other mirid species found on apple. First instar nymphs are pale-green without dark spines on their tibiae.

Life history

The life history of *C. verbasci* (Fig. 1.) is almost identical to that of *Lygocoris pabulinus*, the well-known common green capsid (Blommers, 1994; Stigter, 1995). In early May the nymphs emerge from overwintering eggs. After more than a month the insects reach the adult stage and migrate to herbaceous plants, especially to *Verbascum* species, potato and hollyhock (*Althaea rosae*). In summer a second generation develops on these plants. From surveys in 1994 it appeared that even a third generation may develop under favourable weather conditions.
In Canada a sex attractant (butyl butyrate (BB) and 2(E)-crotyl butyrate (CB)) was developed for this bug (Smith et al., 1991). Catches in pheromone traps in an orchard in the Betuwe (Lienden) showed that migration of adults from their summer host to apple started in August and continued until the end of September (Fig. 2.). Adults were observed on *Verbascum* plants until the end of October.
The small, banana-shaped eggs (0.8 mm) are deposited deep in the one year old wood of, among others, apple and oak (Alford, 1994; Southwood & Leston, 1959).

Observations in 1994

After the first reports of damage in 1993, surveys in orchards were started in 1994. Many samples were taken just before and during the blossoming period of apple. Sampling was carried out mainly in "Golden Delicious" parcels, especially on fruitfarms in the province of Limburg. Furthermore, many samples were taken from the summer hosts *Verbascum*, potato and hollyhock.
The first nymphs on apple were found by the end of the blossoming period. The catches from beating samples, however, were lower than expected. Almost immediately after blossoming the

first reports on fruit damage came in. At that time only older nymphs were found. Apparently younger nymphs present during blossoming are difficult to collect by beating (Blommers, 1994), as was confirmed by the much higher numbers visually detected in the same orchards. It was concluded that collecting flower clusters provided a better estimate of the actual nymph population of *C. verbasci*.

At the end of June high numbers (>15) of older stage nymphs and adults of mullein bug were present in the top shoots on several fruit growing farms in the provinces of Noord-Brabant and Limburg. Moreover, at that time a remarkable increase in shoot damage caused by sucking was observed. At the beginning of July bugs seemed to have disappeared from apple.

Fruit damage on "Golden Delicious" ("dimple disease") was frequently detected in Mid and South-Limburg and in some cases it exceeded 40% (Stigter, 1995). Since no other mirid nymphs were found on these parcels, it seems likely that this damage was also caused by the mullein bug.

Adapting the monitoring technique

C. verbasci is difficult to sample, especially during the blossoming period of apple, when the young nymphs emerge. The traditional beating-net method is not suitable, because the nymphs are able to hide well. As a result *Campylomma* nymphs are far more difficult to beat than nymphs of the common green capsid. Furthermore, the nymphs of *C. verbasci* are difficult to detect because of their inconspicious colouration and behaviour. Sampling can be improved by examining blossom clusters. During the early season, a black cloth surface on the beating tray can make the transculent nymphs more visible (Beers, 1993; Niemczyk, personal communication, 1995).

Discussion

The 1994 surveys provided much information on the life-cycle of *C. verbasci*, however, many questions remain to be answered. For instance on some parcels with much fruit damage in Limburg (>40%) no bugs could be detected. Although there were surrounding potato parcels, *C. verbasci* was not found. In general little is known about the dispersal potential of *C. verbasci* (Smith, personal communication, 1995). From preliminary field experiments with pheromone traps, however, it is concluded that distances of several hundred metres can easily be covered by flying individuals of this species.

Conclusion

* Until recently *C. verbasci* was an unknown threat to Dutch apple orchards. Fruit damage on apple was credited to this bug for the first time in 1993 and 1994.

* With a beating net *C. verbasci* is difficult to sample because youngh nymphs can hide well and are not easily detected. Visual inspection of blossom clusters may support the beating results.

* Little is known about control methods. Therefore, additional research is necessary.

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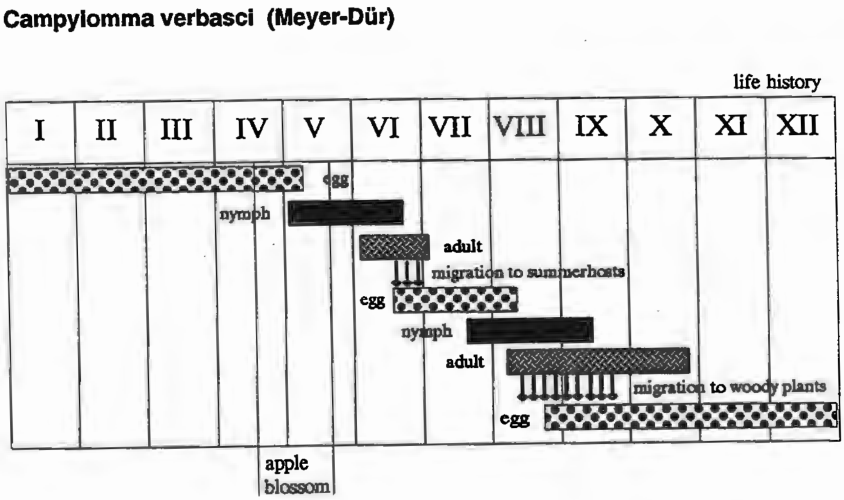

Figure. 1.

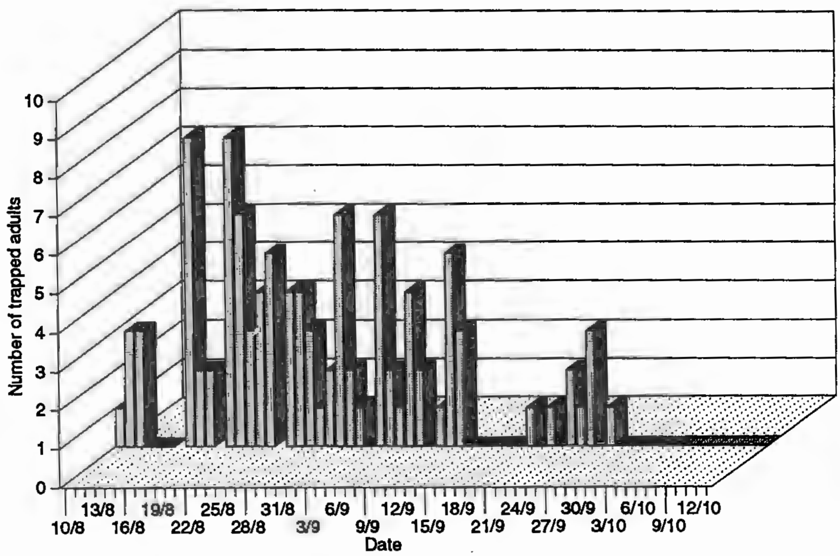

Figure. 2. Daily catches in two Pheromone traps of Campylomma verbasci, Lienden 1994.

TIMING OBSERVATION AND CONTROL OF MUSSEL SCALE *LEPIDOSAPHES ULMI*.

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ABSTRACT

The mussel scale *Lepidosaphes ulmi* (L.) is locally an important pest in apple and pear orchards. Even light infestations can cause severe economic loss due to a zero tolerance on fruits for export. The optimal moment for chemical control is when all crawlers have emerged from under the scales. A temperature sum model was developed to indicate the best moment for observation and subsequent control.

INTRODUCTION

Eggs of the mussel scale (MS), *Lepidosaphes ulmi* (L.) (Homoptera, Coccidae), are laid in August or September. A female deposits up to 80 eggs under her scale and then dies. The scale remains attached to the bark and protects the eggs throughout the winter. Eggs hatch after bloom in May or June. After some initial wandering first instar nymphs, or crawlers, settle close to the adult females, and start to form the mussel-shaped scale. The adult stage is reached by the end of July. On fruit trees in Northern Europe, MS has only one, parthenogenetic, generation per year (Samarasinghe and Leroux, 1966; Kostarab and Kozár, 1988).

In the Netherlands, MS can locally be an important pest in apple and pear orchards. Even with light infestations nymphs will settle on the fruits. Generally, if scales are found on fruits during harvest, control measures are recommended in the next season. Before bloom, white oil can be used to stifle the MS eggs. Alternatively, MS can be controlled after bloom. In Dutch IPM orchards phosalone or propoxur can be used. As eggs are not susceptible, the optimal moment for control is when all crawlers have emerged from under the scales.

Especially at low densities, direct observations to determine the optimal spraying time can be labour intensive. To minimize the time needed for observations, a temperature sum model is developed, that indicates the period of migration of the nymphs. To establish the theoretical temperature threshold for development, eggs were reared at various constant temperatures. Field observations on the first emergence of nymphs, and the warnings that were sent out by the local extension service, were used to estimate the best usable temperature sum.

MATERIALS AND METHODS

Experiments at constant temperatures

On 2 moments in the spring of 1985 (18 April and 8 May) shoots with scales were collected from apple trees. Immediately after collecting, the shoots were cut in 2.5 cm pieces, and placed in petridishes at various constant temperatures. The shoots collected on 18 April were kept at 14.5°C and 20°C, those collected on 8 May at 13, 14.5, 17.5 and 20°C. During the period of egg hatch, emerged nymphs were counted and removed daily.

Field data on emergence of nymphs

Data on the first emergence of nymphs in the field were obtained from the Plant Protection Service, which collects data on the occurrence and phenology of insect pests using a network of observers, mainly fruit growers and extension workers. Reliable observations were available from 14 years between 1978 and 1994, all from the Betuwe and direct surroundings, within a distance of 40 km from Wageningen.

The second event used in this analysis is the moment that the local extension service notified the growers in the area that massive migration of nymphs had been observed. This means that from that moment onwards sprayings are carried out. Data on this event were available from 15 years, from 1980 till 1994.

Weather data

Daily minimum and maximum air temperature data were taken from a Stevenson screen at the weather station of the Agricultural University at Wageningen. The daily temperature cycle was simulated using a sine wave approximation, from which the effective temperature sum in day degrees (DD) was calculated (Rabbinge, 1976).

RESULTS

Experiments at constant temperatures

Table 1 shows the time between collection of the shoots, and the moment that 50% of the nymphs had emerged at constant temperatures.

Table 1. Time between collecting shoots and 50% emergence of nymphs of *L. ulmi* at various constant temperatures.

Collected	Temp. (°C)	Duration (days)	Development rate (1/days)	5-95% emerged (DD>8°C)	Total number of nymphs
18 April	20	17.1	0.0585	73	24539
	14.5	31.5	0.0317	77	3507
8 May	20	12.5	0.0800	94	22517
	17.5	16.4	0.0675	84	25270
	14.5	24.7	0.0405	80	10364
	13	34	0.0294	59	17721

Least square linear regression for the scales collected on 8 May yields the following relationship between development rate (V_{dev}) and temperature: $V_{dev} = 0.0071\ T - 0.063$ ($r^2 = 1.00$). If the relationship would be linear at the lowest end too, the threshold for development is 8.9°C. The line through the development rates of the scales collected on 18 April indicates a slightly lower threshold of 8.0°C. On average, it took 78 DD>8°C from 5 to 95% emergence. Especially at the higher temperatures the last 10% of the nymphs emerged relatively late, resulting in a long tailed frequency distribution.

First emergence of nymphs in the field

Table 2 shows the dates of observed first emergence of *L. ulmi*. On average first emergence was observed on 14 May, but it varied between 28 April and 23 May. This range of 25 days makes calendar date unsuitable for forecasting.

Because of the linear relationship between temperature and development rate at constant temperatures, it is likely that temperature sums can be used to forecast the phenology of MS. The data of table 2 were used to establish the best usable temperature threshold, and corresponding temperature sum, for prediction of the phenology in the field. From the 14 years between 1978 and 1994, of which data were available, temperature sums were calculated, starting on the first of January and using different thresholds between 2 and 10 °C. For each threshold, the average temperature sum at first emergence over 14 years was used as an estimate of first emergence in the individual years. The difference in days between the predicted and the observed emergence in the field was calculated. The accuracy was expressed as the average deviation in days. In table 2 the temperature sum with threshold 8 °C and starting date 1 January is used.

Table 2. First emergence of MS in the field, with temperature sums in day degrees (DD > 8 °C) from 1 January, and the use of the average day (14/05) and average temperature sum (151 DD > 8 °C) to forecast emergence.

Year	Observed emergence		Deviation from average	Day with 151DD>8	Deviation from average
	date	DD>8	date (days)		t.sum (days)
1978	17/5	131	-3	22/5	5
1980	22/5	164	-8	21/5	-1
1981	10/5	155	4	10/5	0
1983	18/5	147	-4	19/5	1
1984	23/5	129	-9	30/5	7
1985	22/5	174	-8	19/5	-3
1986	22/5	173	-8	19/5	-3
1987	18/5	148	-4	19/5	1
1989	08/5	134	6	13/5	5
1990	28/4	153	16	26/4	-2
1991	07/5	141	7	11/5	4
1992	16/5	164	-2	15/5	-1
1993	29/4	158	15	29/4	0
1994	11/5	147	3	12/5	1
Average	14/5	151		14/5	
Average deviation			6.9		2.4
Maximum deviation			16		7

Figure 1A shows the calculated accuracy when alternative thresholds are used. The use of 8 °C as a threshold gives the best accuracy, with a standard deviation of 3.0 days and a maximum difference of 7 days between predicted and observed first emergence. The corresponding temperature sum is 151 DD > 8 °C.

During winter, in the temperate climate of The Netherlands, temperatures above 8 °C are not uncommon. Because nothing is known about the breaking of diapause in MS, the effect of the starting date for calculation of the temperature sum was analyzed. Figure 1B shows the accuracy of the prediction, using starting dates between 1 September in the preceding autumn, and 1 May, in steps of half a month. The optimum lays around the second half of December, although the effects of changes in starting date in December and January are trivial.

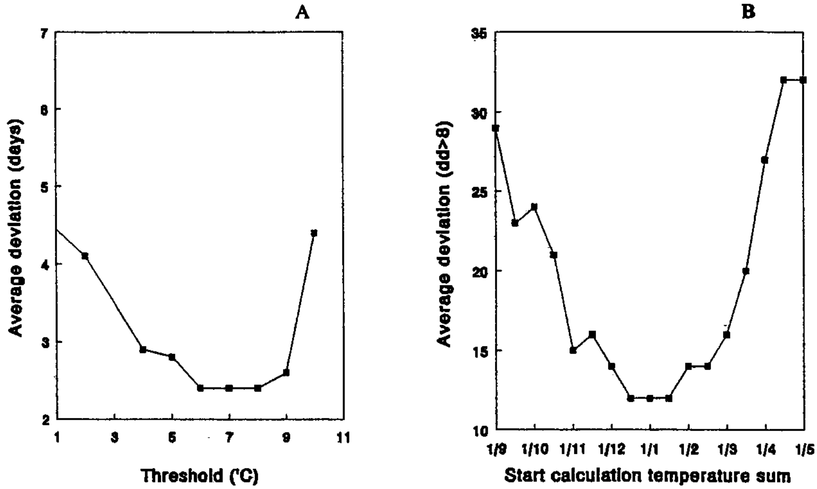

Fig. 1. Accuracy of simulation of first dispersal of MS, using different temperature thresholds (A) or starting date for calculation of temperature sum (B).

Table 3. Date on which the extension service reported massive migration of MS. The temperature sum of 151 DD>8°C (first emergence plus 40 DD>8°C is used to simulate the date the warnings were sent out. The accuracy is the difference in days (simulated minus observed).

Year	massive migration		Simulated	Accuracy
	date	DD>8	(191DD>8)	
1980	30/5	195	30/5	0
1981	18/5	207	15/5	-3
1982	27/5	207	26/5	-1
1983	30/5	177	01/6	2
1984	05/6	186	07/6	2
1985	29/5	225	26/5	-3
1986	26/5	200	25/5	-1
1987	25/5	172	30/5	5
1988	13/5	173	15/5	2
1989	16/5	168	19/5	3
1990	07/5	227	03/5	-4
1991	21/5	180	25/5	4
1992	20/5	192	20/5	0
1993	10/5	219	06/5	-4
1994	24/5	227	17/5	-7
Average	22/5	197	21/5	-0.3
Average deviation				2.7
Maximum deviation				7

Massive migration

At constant temperatures, it took on average 78 DD>8°C for 5 to 95% of the nymphs to emerge. One can assume, that massive migration in the field is observed halfway between 5 and 95% emergence; about 40 DD>8°C after the first nymphs have emerged. This would mean that we should be able to predict the date, on which the warnings by the extension service are sent out. Theoretically, this would be the day with (151 + 40 =) 191 DD>8°C after 1 January. Table 3 shows the dates on which the extension service reported massive migration of MS. The average temperature sum is 197 DD>8°C. In the same table one can see how the temperature sum of 191 DD>8°C is used to predict the date that the warnings were sent out. The average difference between predicted and actual date is less than one day and the maximum difference is one week.

DISCUSSION AND CONCLUSION

The experiments at constant temperatures indicate a development threshold of MS between 8 and 9°C. The temperatures in the tree can differ significantly from those in a Stevenson screen. Especially on sunny days in the springtime, when the tree is still leafless, the temperature on parts of the bark may be more than 15°C higher than the air temperature at 1.5m. (Mols, 1992). This means, that temperature sums established in the laboratory can not be used in the field, unless radiation or actual bark temperature are taken into account. This problem is avoided here by using field data on the emergence of nymphs. The temperature threshold estimated from the field observations coincides well with the one established in the laboratory.

Changes of the starting date for calculation in December and January have little influence on the accuracy of the predictions. As 1 January is used as a starting date for many other insect pests, it seems appropriate to use it for MS as well.

The influence of radiation will also affect the duration of the period over which nymphs will emerge. Because the scales that were used in the laboratory experiments were collected in April and May, rather short before egg hatch, it is likely that the variation found in the laboratory is a good reflection of the situation in the field. As young second instar nymphs are still susceptible to the commonly used pesticides, and it takes 78 DD>8°C for 90% of the nymphs to emerge, control should be advised after (151 + 78 =) 229 DD>8°C after 1 January.

ACKNOWLEDGEMENTS

We thank J.F. van Dijke, Geldermalsen, for kindly providing data on the massive migration of the mussel scale in past years.

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A Forecasting System for Orchard Pests

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Summary

Mathematical models have been constructed, simulating the development of *Cydia pomonella*, *Adoxophyes orana* and *Cacopsylla pyricola*. The models are driven by daily temperature records. They have been validated by comparing their predictions with field observations over several years. The models have been incorporated into a software package called PEST-MAN, for use on a PC. The system provides information on the optimal timing for monitoring operations and pesticide applications.

Introduction

Decisions involving the timing of monitoring procedures or insecticide applications against orchard pests can be made most effectively if the timing of the development of pest populations in the orchard is known. This kind of information can be provided by mathematical models that simulate the development of each developmental stage of the pest in the orchard.

Based on data from laboratory experiments to establish the rates of development of the various life stages at different temperatures, models have been constructed to simulate the phenology of codling moth (*Cydia pomonella* L.), summer fruit tortrix moth (*Adoxophyes orana* F. v R.) and the pear psyllid (*Cacopsylla pyricola* (Förster)) (Morgan & Solomon, 1993). The models have been validated by comparing their predictions with observations of the development of field populations of the pests over several years. In order to make the predictions accessible to potential users, the models have been incorporated into a software package for use on a personal computer (PC). This package, named PEST-MAN, uses an intuitive style of presentation, involving simple pull-down menus, graphical outputs, and help statements, so that it is very straightforward to use.

Temperature Data Inputs

The simulation models are temperature-driven. The user can enter manually the daily maximum and minimum temperature, and allow PEST-MAN to use mathematical algorithms to derive the hourly temperatures required by the models. It is more convenient, however, to arrange for temperature records to be fed into the PC from an orchard-based weather station, or from an electronic temperature logger. Of these options a dedicated temperature logger is cheapest, but the grower may already have a weather station installed for providing the data required by disease forecasting models. The logger or weather station may be connected to the PC by cable, or data may be downloaded via a portable PC or palmtop computer.

Any daily values missing from the temperature record are replaced by the values for that date held in a five-year mean database. The models use the current season's database until the last entry, and subsequently use the five-year mean temperatures to predict the development of the pest for the remainder of the season. The five-year mean database is updated automatically at the end of each year, so a long term temperature record relevant to the specific site is built up.

The models for *C. pomonella* and *A. orana*

The simulation models for these moth species predict the timing of flight activity, so that pheromone trap catches can be interpreted effectively, and the timing of egg hatch, so that insecticide applications can be timed optimally. The output is graphical, on a twelve month timescale, with a curve showing predicted flight activity. The start of this curve is an indication of the date by which pheromone traps should be placed in the orchard, and the peak of the curve gives the date of expected maximum trap catch. This information, together with trap catch data, enables the making of a rational and prompt decision on the necessity for pesticide application.

The graphical display also shows the predicted egg hatch curve, defining the period when the newly-emerged larvae are present in the orchard. This is the usual target stage for pesticide application, so if the interpretation of pheromone trap catches indicates that a treatment is necessary, then it can be timed optimally. This may mean that a single application is sufficient, in contrast to the two or more applications traditionally required when this precise phenological information is not available.

A. orana passes through two generations per year in S. England. *C. pomonella* usually completes one generation per year, but in exceptionally hot years it may pass through a partial or complete second generation. The model predicts this second generation in years when it is likely, giving warning of the need to continue to monitor with pheromone traps, and of the timing of any egg hatch of a second generation.

The timing of the events shown in graphical form for these moth species can also be displayed in the form of a table: this tabular display can be printed out.

There are circumstances in which the observed pattern of pheromone trap catches of *C. pomonella* or *A. orana* may differ from the predictions of the models, e.g. if the siting of a temperature logger produces temperature records different from those in the orchard. In this situation the date of observed maximum trap catch can be entered into the model, and the egg hatch date that would result from this timing of adult activity is calculated.

The model for *C. pyricola*

A number of different predators attack *C. pyricola* in pear orchards in England, but it is *Anthocoris nemoralis* (Fab.) that usually colonises orchards in greatest numbers. The IPM approach adopted by most pear growers in England is based on the relationship between pear psyllid and this predator (Solomon *et al.*, 1989). The same predator is an important natural enemy of *C. pyricola* and other pear psyllids in other European countries (e.g. Nguyen & Merzoug, 1994; Rieux *et al.*, 1994; Sarasua *et al.*, 1994). The need to cause as little damage as possible to *A. nemoralis* is an important factor in the choice of pesticide and timing of application against pear psyllid.

Of the insecticides tested against adult *C. pyricola*, the most effective have been synthetic pyrethroids. These broad spectrum materials are very toxic to anthocorids, but it is apparent that a pyrethroid application in spring against overwintered adult psyllids has little impact on anthocorid numbers in the orchard during the summer (Solomon *et al.*, 1989). This is probably because sufficient anthocorids colonise pear orchards late in the spring that the numbers surviving the winter on pear trees are not critical. During the summer however, the choice of insecticides against *C. pyricola* is restricted to those that do not damage *A. nemoralis*. These selective materials, such as amitraz and fenoxycarb, are effective against psyllid larvae but not adults. For optimal effect, it is thus necessary that they are applied when most of the psyllids in the orchard are in the larval stages.

C. pyricola normally passes through three generations per year in England. The graphical output of the model displays the times when the adults, eggs, and nymphs of these three generations are present, and highlights the "windows of opportunity" for selective insecticide use, i.e. the times when the psyllids are predominantly in the larval stages. Also indicated is the interval just before egg laying by overwintered adults, when it is possible to consider the use of a broad spectrum insecticide.

Implementation of the PEST-MAN system

Throughout the development of the PEST-MAN system, it has been a deliberate policy to make it simple to use, and to deliver only the information the grower can use in making pest management decisions. Many growers, however, are not familiar with PC software, so there is a conceptual barrier to be broken down if these growers are to be convinced of the usefulness of the system. This is being approached by involving crop protection consultants. Most UK fruit growers use such consultants for pest and disease control advice. These consultants are acting as suppliers of PEST-MAN to growers, and will be able to advise the growers on the use of the system and the incorporation of its predictions into their pest management strategy.

Once a software system of this kind is established in use, it can be readily updated with the addition of new models as they become available.

Acknowledgements

The research leading to the development of the PEST-MAN system was funded by the Ministry of Agriculture, Fisheries & Food, and by the Apple & Pear Research Council.

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THE INFLUENCE OF DIFFERENT UNDER-GROWTH AND IPM SPRAY SCHEDULES ON APPLE DAMAGE, FRUIT QUALITY AND YIELD.

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SUMMARY

In a young apple orchards divided into seven plots, on 6 plots the several insecticides recomended in IPM control method was tested. The plot 7 (check) was sprayed with non selective insecticides.

The apple damage caused by insect pests decreased with the years, from 21.5 % in 1992, 12.3 % in 1993 and 1.7 % in 1994. During first 2 years the highest apple damage caused leaf rollers, bugs and large caterpillars. Codling moth and apply sawfly affected few fruits only.

The quality of apples harvested on "IPM plots" was pretty high, but compering to "check fruits" slightly lower or lower.

The yield from "IPM plots" - compering to the crop harvested from the check trees - was the same, little lower or lower depending on the plot.

INTRODUCTION

Commercial apple orchards belong to the most heavily sprayed agricultural commodities. Consumer demands for blemish - free fruits require the establishment of economic threshold densities of zero for many diseases and insect pests. To meet these high standards under current management practice, pesticides are required to control pests, especially those, that feed directly on fruit.

However the environmental, toxicological and economic concerns are forcing changes in pest management of orchards toward a reduction of pesticide applications (Beitz, Banasiak 1989, Carnevale et al. 1991, Dickler, Schafermayer 1991). This may be realized by practicing Integrated Pest Management (IPM) method in which for pest control also non chemical methods are used and activity of natural enemies of the pests are taking under consideration (Leius 1967, Gruys 1982, Niemczyk, Piotrowski 1983). Thus in the IPM orchards only selective or partialy selective pesticides are recomended to use only when it is necessary (Dickler, Schafermayer 1991).

The objective of the experiments was to find out wheather in IPM orchards in which, beside chemical, also ecological (presence of flowering plants atracting predatory and parasitic insects) and biological (bacterial preparations, introduction of predatory mites) methods are used one can obtain the normal yield of good quality fruits.

METHODS

1. Experiment orchard and designe of the experiment.

The experiment was conducted in Centaral Poland in a young (4-6 year old) apple orchard consisting of two varieties (Lobo, Spartan) divided into 7 plots. Six plots (1-6) differed one from another in the ground cover system (flowering herbaceous plants (Table 1) and, with exception of first year (1992), the used pesticides. The plot 7 was treated as the check one, and was sprayed as ordinary commercial orchard (Table 2).

2. Pesticides treatments.

In the first year (1992) all six IPM plots were sprayed with the same selective (Bacillus thuringiensis - BT) or partialy selective insecticides -(phosalone) and fungicides (dithianon, dodine, bitertanol, captane) (Table 2).

In the second and third year all six IPM plots were treated with the same selective fungicides, but differently with selective or partialy selective insecticides (B.T., pirimicarb, diflubenzuron, phosalone, teflubenzuron, fenoxycarb, fenitrothion) (Table 2).

Project the work was partly sponsored by US Dep. of Agriculture, Agricult. Res. Service. t 58-319R-3-023.

The aim of that differentiation was to choose the best IPM spray program, highly effective in the control of the pests (mainly leaf rollers) and selective to predatory and parasitic arthropods (mainly *Typhlodromus pyri*, partialy resistant to phosalone and fenitrotion). *T.pyri* was introduced on all IPM plots at firts year of experiment). The two IPM plots (5 and 6) were always sprayed with the same insecticides and fungicides, but flowering plants were not maintained on plot 6 (Tab.2) On IPM plots the economic threshold levels of the pests - with few exceptions - were respected.

3. Cover of flowering plants beneath the trees.

In order to attract to the experimental orchards the beneficial arthropods (parasitoids and predators) on both edges of the tree rows on the IPM plots (except plot 6) the several species of flowering plants were planted. The soil beneath the trees was kept free of weeds with the aid of herbicide: glyfosphat. In tree interows the moved grass was maintained (Table 1).

In the first year the 9 different species of the plants were sown. In the following two years only four of them were selected:

- mustard (*Sinapsis alba - Cruciferae*)
- wild heliotrotrope (*Phacelia tenacetifolia - Hydraphyllaceae*)
- buckwheat (*Fagopyrum esculentum - Polygonaceae*)
- roquette *(Eruca sativa - Cruciferae)*

The flowering plants were never maintained on plot 6 and 7 (check) (Table 1).

OBSERVATIONS

The following observations - among many others - were conducted in the orchard:

a. Fruit evaluation. About 1000 in the first year and about 2000 apples in following two years (1000 Lobo cv. + 1000 Spartan cv.) randomly selected at harvest time were examined for all defects, caused by insects, diseases and other factors. At the same time grading of the fruits were made.

b. Yield estimation. The yield of the same trees of each variety (25 trees of Lobo + 25 trees of Spartan cv. was checked). The trees for yield estimation were selected from the centre of each plot. Comparision of the yield harvested from different plots were verified statistically.

RESULTS

Injury of harvested apples.

Several factors caused apple damage: harmfull insects, diseases, birds, spring frost, mechanical factors and others. However the harvested fruits were damaged most often by harmfull insects (Table 3). Also during first two years the mechanical injuries were rather high. The damage of fruits by apple scab, powdery mildew and other factors were negligable.

The apple damage caused by insect pests - expressed as averages for all plots, decreased with the years: from 21.5% in 1992, 12.3% in 1993 to 1,7% in 1994.

Out of all insect pests the highest percentage of apple damage was created by leaf rollers (*Tortricidae*) (Table 3) and then, during first two years, by bugs (*Heteroptera*) (Table 3). Also large caterpillars especially in 1992 participated significantly in the apple damage (Table 3). In all three years very few fruits were affected by codling moth (*Laspeyresia pomonella*), apple sawly (*Hoplocampa testudinea*), aphids (*Aphidoidea*) and except second year the beetles (mainly *Phyllopertha horticola, Phyllobius oblongus, Phyllobius argentatus*) on all plots (Table 3). Also phytophagous mites (*Tetranychidae*) did not affect the fruit on IPM plots due to effective control by *Typhlodromus pyri*.

It is worth to underline that on IPM plots no special sprays was directed against apple sawly, codling moth, beetles and phytophagous mites. Only leaf rollers, aphids and large caterpillars were controlled with insecticides directly.

Table 1

Cover crops (flowering plants) in experimental orchard

No of plot	1992	1993	1994
1 IPM	mustard	mustard	mustard
2 IPM	wild heliotrope	wild heliotrope	mustard
3 IPM	buckwheat	mustard	wild heliotrope
4 IPM	horse bean	mustard	roquette
5 IPM	mixture of flowering plants	roquette + mustard	buckwheat
6 IPM	bare soil	bare soil	bare soil
7 Check	bare soil	bare soil	bare soil

Table 2

Insecticide used in experimental orchard

No of plot	1992	1993	1994
1 IPM	phosalone B.t.	pirimicarb	pirimicarb 2 x
2 IPM	phosalone B.t.	pirimicarb	fenitrothion pirimicarb B.t.
3 IPM	phosalone B.t.	diflubenzuron teflubenzuron pirimicarb	pirimicarb 2 x fenoxycarb B.t.
4 IPM	phosalone B.t.	phosalone diflubenzuron pirimicarb	phosalone fenoxycarb diflubenzuron
5 IPM	phosalone B.t.	B.t. diflubenzuron pirimicarb	phosalone pirimicarb
6 IPM	phosalone B.t.	B.t. diflubenzuron pirimicarb	phosalone pirimicarb
7 Check	fenitrothion diazinon fenthion	diazinon 3 x fenthion pirimicarb	cypermetrine deltametrine fenitrothion fenthion phosalone

Table 3

Harvested apples damaged by pests (average Lobo cv.+ Spartan cv.)

1992

Plot	No of examined fruits	Total pest damage in %	Contribution of different defects in %						
			leaf rollers	bugs	codling moth	apple sawfly	tussock moth	winter moth	beetles
1	556	28.0	11.2	6.9	0	0	4.5	3.8	1.4
2	841	24.0	7.5	7.8	3.2	0.1	4.7	1.3	0.4
3	687	22.6	10.7	8.1	0	1.2	1.9	2.4	0
4	863	20.6	6.7	6.7	0.3	0.4	4.2	1.3	0
5	668	14.8	7.1	6.1	0.1	0.7	4.1	0.9	0
6	1029	15.2	6.3	2.6	0.5	0	1.4	1.3	0
7	1131	24.8	10.4	8.2	0.2	0.5	3.1	3.3	0

1993

Plot	No of examined fruits	Total pest damage in %	Contribution of different defects in %							
			leaf rollers		bugs	codling moth	apple sawfly	tussock moth	aphids	beetles
			at spring	at summer						
1	2643	19.7	5.5	6.0	3.5	0.4	0.1	2.6	0.6	1.2
2	2211	15.6	2.3	5.2	5.1	0.1	0.1	2.7	0	0.3
3	2609	9.2	3.6	1.5	1.6	0.1	0	0.6	0.3	0.2
4	2290	6.6	1.6	2.5	1.9	0	0	0.5	0	0.1
5	2132	15.3	4.4	3.2	4.8	0.2	0.1	1.8	0.3	0.8
6	2103	12.5	3.6	3.3	3.3	0.1	0.2	2.8	0.1	0.3
7	2260	7.5	1.7	3.8	1.1	0.2	0.2	0.5	0	0.4

1994

Plot	No of examined fruits	Total pest damage in %	Contribution of different defects in %							
			leaf rollers		bugs	codling moth	apple sawfly	large cater-pillars	aphids	beetles
			at spring	at summer						
1	2328	3.1	0.4	0.7	0.3	0.2	0.1	0.2	0.4	0.1
2	2321	0.7	0	0.6	0.1	0	0	0.1	0	0.1
3	2421	2.1	0.3	0.6	0.1	0	0	0.1	0.5	0
4	2381	2.2	0.8	1.4	0.1	0	0.1	0	0.4	0
5	2670	0.9	0.3	0.5	0.1	0	0	0.1	0	0
6	2325	2.7	0.5	1.9	0.1	0.1	0.3	0.1	0.3	0.1
7	2127	0.5	0.1	0.3	0.1	0	0	0.1	0	0

Table 4

The summarized data concerning percentage of extra and first grade apples of 2 varieties (Lobo, Spartan) on IPM plots and check plot.

Treatment	19 93		1994	
	Lobo cv.	Spartan cv.	Lobo cv.	Spartan cv.
IPM plots (range from 6 plots)	81.4-92.1%	85.4-92.9%	69.5-92.3%	81.3-88.1%
Check plot	93.4%	95.3%	93.7%	98.6%

Table 5

The yield of apples harvested from different IPM plots expressed in the per cent in relation to the yield on check plot *.

Plot	Lobo cv.	Spartan cv.
7 (Check)	100.0 bc *	100.0 b
1	74.1 a	80.7 a
2	90.3 a	82.7 a
3	89.9 b	90.9 b
4	71.1 a	74.2 a
5	87.9 b	77.7 a
6	105.9 c	83.4 a

Data based on 3 years results 1992-1993. Means followed by the same letter do not differ at 5 % level of significance. Duncan's multiple range t.test.

* Check plot was sprayed often with non selective insecticides.

In 1992 the per cent of damaged apples by insect pests of check trees (plot 7) was similar as on majority of IPM plots (Table 3). In next two years (1993, 1994) on the check plot sprayed more often with non selective insecticides, the amount of apples injured by harmful insects was the lowest (Table 3).

No distinct differeces were noted in per cent of damaged fruits according to the apple variety.

In 1993 the relatively low amount of fruit injured by the pests, mainly leaf rollers - beside check plot - were noted on plot 4 (treated with phosalone, teflubenzuron and pirimicarb) and plot 3 (treated with diflubenzuron, teflubenzuron and pirimicarb) (Table 3).

In 1994 the lowest pest infestation was observed on check plot and on plot 2 sprayed with fenitrothion, pirimicarb and *Bacillus thuringiensis* (Table 3).

In last two years (1993, 1994) leaf rollers were most harmful on the trees sprayed only with pirimicarb (plot 1) - (Table 3).

No differences were found in damaged fruit number during first two years (1992, 1993) on the plots 5 and 6 sprayed with the same insecticides but differed in the presence (plot 5) or absence (plot 6) of flowering plants (Table 3).
But in 1994 on plot 5 with flowering plants, the leaf rollers damaged considerably less apples then on plot 6 without ground cover (Table 5).

Fruit quality.

The quality of the apples harvested on IPM plots, was high but compering to the fruits harvested from check plot sprayed with broad spectrum insecticides, slightly lower or lower (Table 4). This was true for both varieties (Lobo, Spartan) and for both years (1993, 1994) (Table 4).

Yield.

Taking under consideration the summarized data concerning the apple yield for three years it was found that in the case of Spartan cv. the highest crop was harvested from check trees sprayed often with non selective insecticides and grown only on bare soil and from the trees reperesented plot 3 with flowering plants.

In case of Lobo cv. the significantly highest crop was obtained from check plot and IPM plots no 2 and 5 with flowering plants, treated only with selective or partialy selective insecticides. The yield of apples harvested from different IPM plots expressed in per cent in relation to the yield on check plot ilustrated Table 5.

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IPM application in peach orchards against *Lygus rugulipennis* Poppius (*)

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Abstract - Since 1990 the mirid *Lygus rugulipennis* has become a worrying pest in integrated pest management (IPM) and specific control (SC) peach orchards in an area of northwestern Piemonte, Italy. Previous investigations showed that damages to fruits caused by the feeding activity of this mirid were more severe in the orchards where ground cover was lacking. So an accurate management of orchard weeds was proposed as the most convenient control method. In 1994 further investigations were made to maintain a good ground cover from fruit setting until harvest. Mowing of alternate rows was tested as a possible control method against *L. rugulipennis* in nine orchards, five of which applied the sexual confusion method and the other four used few chemical treatments to control *Cydia molesta*. Even if the mirids were present on the herbaceous plants in all plots, at harvest-time the percentage of damaged fruits resulted lower than 1 in seven orchards and between 2 and 4 in the other two. Damages to fruits were independent from cultivars, control methods, and mirid population density. The results of this research show that a correct weed management can avoid chemical treatments to control *L. rugulipennis*. Mowing of alternate rows is a very efficient method to prevent the mirids from migrating to peach trees and is proposable in ecologically sustainable control programmes.

Introduction

Injuries to peaches caused by the feeding activity of several species of Heteroptera, like those well described for some nearctic mirids (Rings, 1958), were already recorded in various regions of Italy (Pegazzano, 1958; Ciampolini *et al.*, 1983; Cravedi & Carli, 1987a; 1987b) and induced growers to a great use of pesticides.

Previous researches, carried out in both integrated pest management (IPM) and specific control (SC) peach orchards in northwestern Piemonte, allowed to ascertain that the mirid *Lygus rugulipennis* Poppius was occasionally responsible of damages to fruit with its feeding punctures. Such damages were independent from the control method employed and seemed to be due to the lack of *L. rugulipennis* natural host plants between peach rows (Tavella *et al.*, 1994). In fact, in the investigated area this insect usually lives and feeds on herbaceous plants, it is able to accomplish three generations per year and overwinters as an adult at the base of weeds and in earth cracks (Tavella *et al.*, 1994).

Further investigations were made in peach orchards in Piemonte with the aim to test if an accurate management of orchard weeds is a convenient control method against *L. rugulipennis*.

Materials and methods

Researches were carried out in the area of Saluzzo, province of Cuneo, northwestern Piemonte, Italy, in 1994. Nine peach orchards were chosen among those in which in the years 1990-1993 heavy damages caused by the feeding activity of *L. rugulipennis* had been recorded affecting from 6 to 30% of the harvested crop. Five of the above orchards were in IPM and

(*) Studies of the C.N.R. coordinate research unit for Integrated Control of Plant Pests: 339.

applied the sexual confusion method against the main pest *Cydia molesta* (Busck), the other four were in SC and used few pesticides only when the threshold was crossed. Localities, cvs, control methods, neighbouring cultivations and borders are shown in table 1.

Table 1 - *Lygus rugulipennis* Poppius. Characteristics of the investigated orchards.

no.	locality	cultivar	control method	border			
				north	east	south	west
1	Verzuolo	Venus	sexual conf.	peach	road	road	meadow
2	Verzuolo	Glohaven	chemical	peach	kiwi	farm	peach
3	Saluzzo	Redhaven Glohaven	sexual conf.	road, hedge	wasteland	farm	wasteland
4	Verzuolo	Stark Red Gold Roberta	sexual conf.	peach	kiwi	peach	kiwi, wheat
5	Saluzzo	Nectaross Maria Aurelia	chemical	kiwi	peach	kiwi	kiwi
6	Saluzzo	Spring Red	chemical	peach	peach	wasteland	strawberry
7	Manta	Nectaross Roberta	sexual conf.	meadow	kiwi	peach	kiwi
8	Saluzzo	Flavorcrest Roberta	chemical	farm	meadow	meadow	peach
9	Savigliano	Duchessa d'Este	sexual conf.	hedge	apple	pear	apple

To maintain a good ground cover from fruit setting until harvest, mowing of alternate rows was periodically made in the nine orchards; i.e., when the weeds of a row were 20-30 cm high, those of the adjacent rows were cut.

Monthly surveys were carried out from June to the harvest, which generally occured in August. Exceptions were made only for the orchards 6 and 3, having cultivars ripening in June and July, respectively.

During every survey, mirid populations and injuries on green fruits were checked. Samples of mirids were taken on the herbaceous plants using an entomological net with 3 sets of 10 sweeps per each of the four edges and in the central row.

The green fruit injuries were checked randomly on 300 hanging fruits. Such fruits were considered damaged when they showed cat-facing, scarring, water soaked or gummosis injuries as described for nearctic species of *Lygus* (Rings, 1958).

At harvest-time, the damaged fruits were checked in samples of different numbers with relation to orchard surface and production.

Results

In the orchards, numbers and instars of *L. rugulipennis* were different in the successive surveys. At the beginning of June the population was composed mainly by adults coming from neighbouring mowed cereals and meadows, in July it reached the highest density showing all instars, in August it usually decreased. Specimens collected during the surveys are analyzed in table 2 and reported in figure 1.

Table 2 - *Lygus rugulipennis* Poppius. Specimens collected on the weeds of each orchard.

orchard	date	total		edge				central
		adults	youngs	north	east	south	west	row
1	07.06.94	9	0	1	2	0	6	0
	05.07.94	15	1	1	2	8	4	1
	02.08.94	8	43	13	30	7	1	0
2	07.06.94	16	0	2	1	3	2	8
	05.07.94	6	0	0	1	2	1	2
	02.08.94	3	0	1	0	0	2	0
3	07.06.94	23	0	0	8	5	2	8
	05.07.94	7	5	2	0	1	0	9
	02.08.94	already harvested						
4	07.06.94	1	0	0	0	0	0	1
	05.07.94	17	15	5	2	0	7	18
	02.08.94	5	0	0	1	0	3	1
5	07.06.94	24	0	7	4	2	6	5
	05.07.94	24	28	6	8	15	23	0
	02.08.94	6	1	1	1	0	5	0
6	07.06.94	10	0	0	2	0	7	1
	05.07.94	already harvested						
	02.08.94	already harvested						
7	07.06.94	12	1	5	6	1	0	1
	05.07.94	7	17	0	0	6	15	3
	02.08.94	0	0	0	0	0	0	0
8	07.06.94	17	0	1	6	4	3	3
	05.07.94	16	25	18	2	9	3	9
	02.08.94	4	3	2	0	3	1	1
9	07.06.94	18	4	1	4	3	9	5
	05.07.94	10	42	7	8	8	0	29
	02.08.94	40	9	11	25	1	6	6

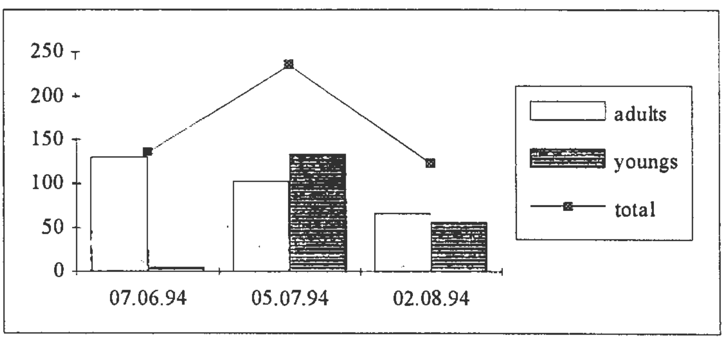

Figure 1 - *Lygus rugulipennis* Poppius. Population dynamics in the investigated orchards.

On peach trees, the greatest number of injuried fruits was localized above all on the lower branches, in close contact to weeds. Altogether, the percentage of the damaged fruits ranged from 0 to 8 and was nearly constant in the different surveys showing a slightly decreasing trend, except in the orchards 7 and 9 (table 3).

Table 3 - *Lygus rugulipennis* Poppius. Damaged fruits checked in the different surveys.

date	07.06.1994			05.07.1994			02.08.1994		
orchard	sampled fruits		%	sampled fruits		%	sampled fruits		%
	total	damaged	damage	total	damaged	damage	total	damaged	damage
1	300	3	1.00	300	0	0.00	300	0	0.00
2	300	5	1.67	300	3	1.00	300	4	1.33
3	300	5	1.67	300	5	1.67	already harvested		
4	300	13	4.33	300	7	2.33	300	6	2.00
5	300	6	2.00	300	3	1.00	300	0	0.00
6	300	3	1.00	already harvested			already harvested		
7	300	1	0.33	300	1	0.33	300	5	1.67
8	300	3	1.00	300	3	1.00	300	1	0.33
9	300	6	2.00	300	11	3.67	300	24	8.00

At harvest-time the percentage of damaged fruits resulted lower than 1 in seven orchards and between 2 and 4 in the other two, without evident differences among the cultivars and the control methods (table 4). The relatively high percentage was found in the orchards 4 and 5, where a great number of damaged fruits was present in one of the sides, respectively close to a field of wheat, which was harvested in July, and to a kiwi orchard of which the herbaceous plants were continuously mowed.

Table 4 - *Lygus rugulipennis* Poppius. Damaged fruits checked at harvest.

orchard	cultivar	date	sample size	healthy fruits		damaged fruits	
				no.	%	no.	%
1	Venus	17.08.94	28.160	28.158	99.99	2	0.01
2	Glohaven	04.08.94	650	646	99.39	4	0.61
3	Redhaven	19.07.94	2.000	1.992	99.60	8	0.40
	Glohaven	27.07.94	1.000	998	99.80	2	0.20
4	Stark Red Gold	04.08.94	26.410	26.410	100.00	0	0.00
	Roberta	31.08.94	604	581	96.19	23	3.81
5	Nectaross	09.08.94	531.000	518.481	97.70	12.519	2.30
	Stark Red Gold	19.08.94	9.326	9.014	96.65	312	3.35
6	Spring Red	27.06.94	1.100	1.093	99.36	7	0.64
7	Nectaross	12.08.94	1.000	1.000	100.00	0	0.00
	Roberta	24.08.94	63.600	63.360	99.63	240	0.37
8	Flavorcrest	03.08.94	300	297	99.00	3	1.00
	Roberta	02.09.94	1.250	1.248	99.84	2	0.16
9	Duchessa d'Este	24.08.94	1.680	1.676	99.77	4	0.23

Discussion

L. rugulipennis is a very polyphagous species dwelling on more than four hundred host plants, the most attractive of which are included in the families Brassicaceae, Asteraceae, and Fabaceae (Holopainen & Varis, 1991). In fact, this mirid prefers herbaceous plants on which it reproduces, accomplishes all its development and overwinters. Nevertheless, when its usual host plants are lacking, the adults, which are active flyers, can migrate also on fruit trees and occasionally damage the crop (Cravedi & Carli, 1987a; Tavella *et al.*, 1994).

In U.S.A. the impact of weed management on the incidence of injuries in peaches caused by mirids was evaluated and chemical treatments to suppress the growth of winter annuals were recommended to minimize fruit damages (Killian & Meyer, 1984). Also in Italy both a weed management of orchards by means of tilling, mowing or herbicide-treating and a wise choice of the neighbouring cultivations were proposed (Cravedi & Carli, 1987a). In our previous researches the management of orchard weeds by means of mowing of alternate rows was suggested (Tavella *et al.*, 1994).

In the nine investigated orchards, the damages appeared independent from cultivars, control method (IPM or SC), and above all from the number of *L. rugulipennis* collected in the orchards, in accordance with our previous researches.

In general, injuries to peach fruits were slight, except in the orchards close to fields which became suddenly inhospitable owing to cereal maturation and meadow or weed mowing. The highest percentages of damages were found along the edges bordering with a wheat field and a kiwi orchard where the ground cover was mowed more times per season.

The results of the present researches show that mowing of alternate rows is a useful method to compell the mirids on weeds and to avoid them to move onto the branches and to pierce the fruits. Furthermore, this method is ecologically sustainable in IPM programmes.

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Capsid bug problems in Danish apple orchards

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Summary

In Danish apple orchards grown according to the "Integrated Production" guidelines pest problems with capsid bugs (Hemiptera: Miridae) have occurred in recent years due to limitations in the use of insecticides. An insecticide treatment experiment compared effects of reduced dosages of azinphos-methyl (½, 1/5 and 1/10 recomm. dos.) with dimethoate and phosalone. Effects on predatory bugs, mites and tortricids were measured as well. It was concluded that there are more beneficial than harmful capsids present in the apple orchards, that dimethoate must be considered as the most efficient compound against the pest species, but that the use should be restricted to the parts of the orchard suffering from capsid attacks. The treatment should be carried out on petal fall.

Introduction

Since 1990 guidelines for "Integrated Production" have been used in Danish apple orchards. Since then the pattern of pest problems has changed. One likely explanation would be that insect species have turned into pests since they are no longer controlled by the use of the more broad spectrum insecticides such as the pyrethroids which are omitted in IP. Examples of this kind of "new pest problems" are leaf rolling and bud feeding tortrix moths and the capsid bugs. The latter have caused troubles for quite many growers over the last years.

This contribution will present results from preliminary investigations elucidating the problems and the preliminary recommandations in Danish apple orchards.

Methods

Three control experiments against heteroptera pests were carried out in 1994. According to Norweigan results, capsid bugs could be controlled by means of azinphos-methyl in reduced dosages that would be less harmfull to beneficials especially predatory mites (Taksdal, 1970; Hesjedal 1986). To test this effect reduced dosages of azinphos-methyl (Gusathion MWP 25, 250 g a.i./kg) were used in the experiments in half (1.5 kg/ha) as well as 0.2 and 0.1 the recommended dosage. Besides, dimethoate (KVK Dimethoat 400, 1.5 l/ha, 400 g a.i./l) and phosalone (Zolone Flo, 2,5 l/ha, 500 g a.i./l) were tested in the experiment. Spraying was carried out mid-May just before flowering. The amount of water used for spraying was 400 l/ha. Four trees were used per plot. There were four replicates per locality. Three localities were used (Roskilde , Glim and Idestrup).

Evaluations of mites and insect pests and beneficials were carried out through the season:

• The level of bugs, mites etc. was evaluated for the first time two weeks after treatment. One sample consisted of ten beating tray subsamples pooled per tree. Identification of the mirids followed description in Gaun (1974) and Alford (1994).
• The effect on survival of tortricid larvae was measured by counting dead and live larvae two weeks after treatment.
• The evaluation of bugs was repeated eight weeks after treatment. One sample consisted of five pooled beating screen samples.
• At harvest 50 apples per tree (two trees per plot) were examined for deformities caused by capsid bugs.

Results
Several species of heteroptera were present in the samples, but not in high numbers. Only very few specimens were registrered of *Lygocoris pabulinus* and *Plesiocoris rugicollis* - species known to be harmful to the fruits under our conditions (Rostrup og Thomsen, 1923). More abundant were the species: *Atractotomus mali, Heterotoma planicornis, Orthotylus marginalis, Psallus ambiguus* and occasionally *Pilophorus perplexus, Malacocoris chlorizans, Blepharidopterus angulatus, Plagiognathus arbustorum.* Some of these species are recorded as being partly or facultatively phytophagus. However, they showed large variation in numbers between the apple orchards at the three localities. The predatory common flower bug (*Anthocoris nemorum*) was found in all localities, but in different numbers.

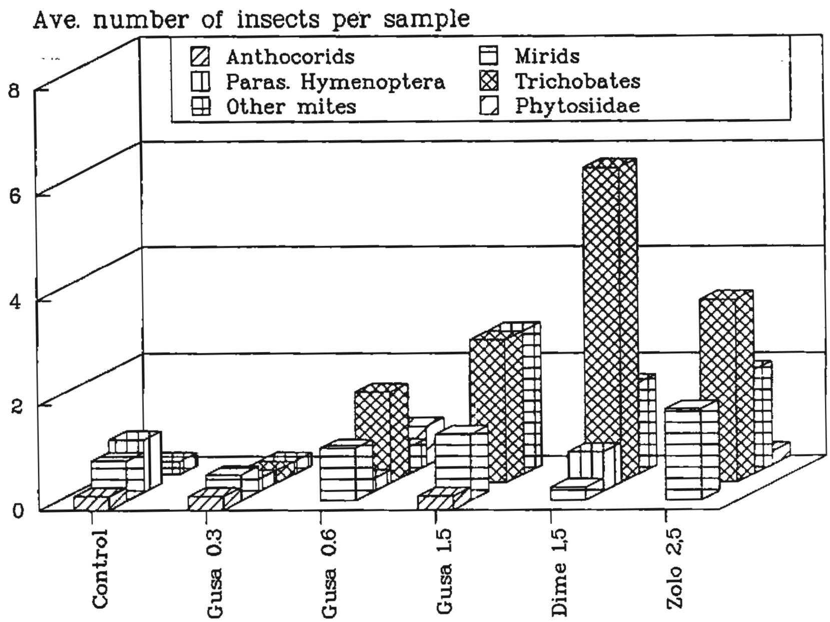

Fig 1. Evaluation of insects and mites two weeks after treatment (May 27, Idestrup). Only very few nymphs of mirid bugs show that spraying before flowering was too early. The negative correlation between abundance of *Trichoribates* - a fungus, moss and lichen eating oribatid mite - could possibly be explained by the absence of natural enemies.

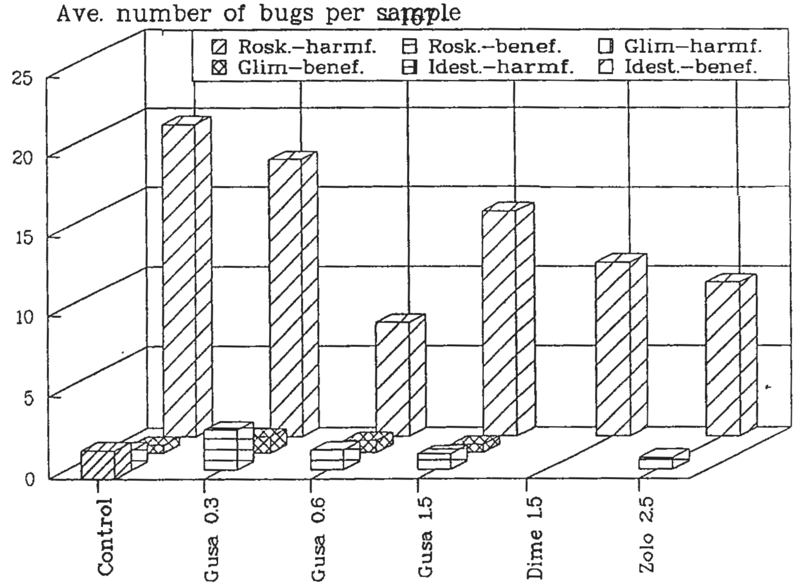

Fig. 2 Results of sampling beneficial and harmful capsids 8 weeks after treatment (July 6 + 8) on the three localities. Adult *Lygocoris pabulinus* had probably left the trees by that time and were on the herbaceous summerhosts: potatoes, beans, currant etc. (Petherbridge & Thorpe, 1928).

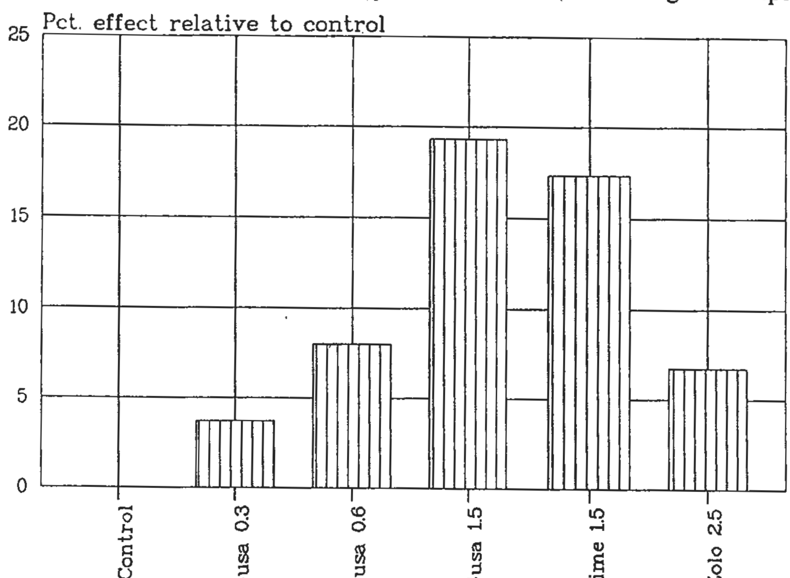

Fig. 3 Evaluation of attacked fruits at harvest, Idestrup. Of control trees untreated 38% of the apples had five or less scars from bugs. 14% were more severely attacked. The effect by increasing the dosage of Gusathion is obvious. According to Hesjedal (1986), however, in order to be harmless to beneficials, it should be 1/5 of the recommended dosage or less. With that dosage the effect is equivalent to only half of that of dimethoate.

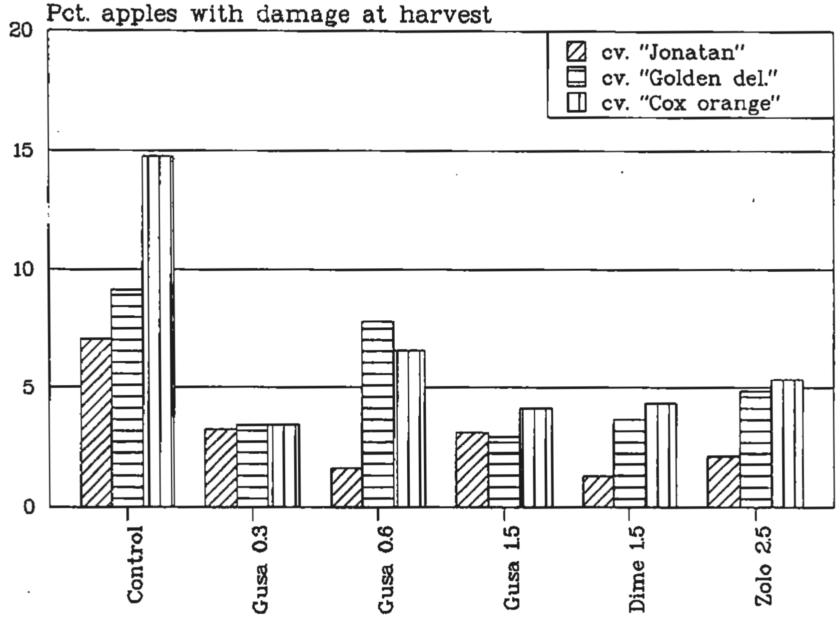

Fig. 4 Effect of treatments of attacks on different cultivars. At Roskilde three cultivars were used in the experiment. Cv. "Cox Orange" is the more susceptible. Experiments have shown that slow growing and smooth cultivars like cv. "Mutzo" at Idestrup and cv. "Lombarts" are more susceptible (Bus et al., 1985)

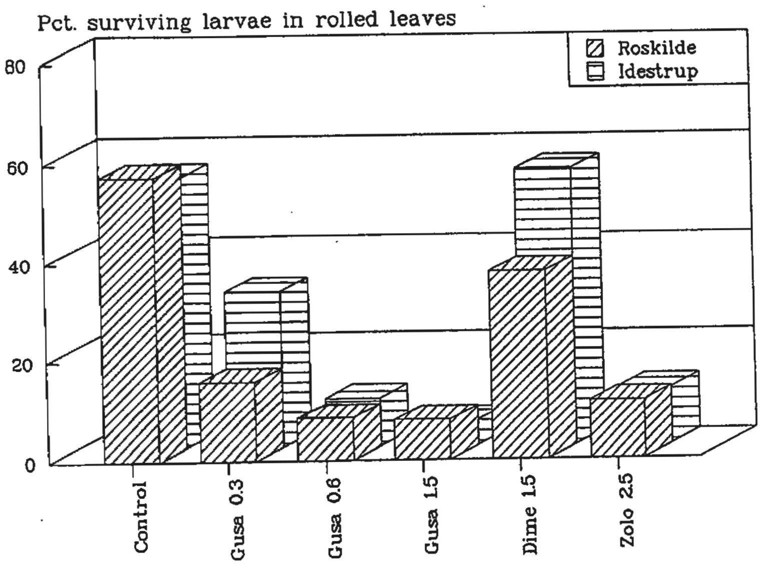

Fig 5. Effects on survival of larvae of tortricids. On the two localites 959 rolled leaves were examined. The difference between treatments was significant. Increasing dosage of Gusathione showed increasing effect. Also Zolone had heavy impact on the larvae whereas Dimethoate did not differ from control.

Concluding remarks

It seems a difficult task to find a dosage of Gusation or any other compound which is effective against the harmful bugs only. Even though *Malacocoris chlorizans* is not harmed by Gusathion at 1/5 recommended dosage, *Anthocoris sp.* seems to be (Hesjedal, 1986). So far, the results show Dimethoate to be the most efficient compound for control of bug pests. It must be recommended to use spatial selectivity in the orchard: Only to spray where the symptoms or harmful bugs are present. Early recommandations from Scandinavia were to let control take place just before flowering (Schøyen, 1911; Rostrup & Thomsen, 1923). The most favourable timing of control would be when *L. pabulinus* and *P. rugicollis* have hatched, and before the beneficial species migrate to the apple trees from their winter host. The optimal spraying time may vary from year to year. In 1994 it would have been on petal fall.

The population evaluation methods and treatment thresholds should be considered. In Norway the threshold is 1-3 bugs/sample (beating screen). In Holland it is 1-4 nymphs per 100 branches. The efficiency of the beating screen as monitoring tool could be debated as well (Bus et al., 1985).

It is a problem that many of the mirids are partly beneficial partly harmfull. The situations - eg. drought or lack of prey - in which predatory mirids will harmfully sting the fruits have to be clarified. According to Rostrup & Thomsen (1923) only *L. pabulinus* and *P. rugicollis* are harmful species. Other species may feed on the plants, but they will not harm them. Besides the fruits are succeptible only from petal fall until the fruits have a diameter of about 2.5 cm. It must be admitted although that damage in this investigation has occurred, also in plantations where the two species were not present or very few.

Finally you could have the optimism that the problems with bug damage in apples are a temporary problem only. Perhaps the problem will diminish as a consequense of the increasing self-regulation that could be expected under Integrated Production.

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EFFECT OF THE EUROPEAN RED MITE (*Panonychus ulmi* Koch) ON THE GOLDEN SMOOTHEE APPLE CULTIVAR IN GIRONA AREA, CATALONIA, SPAIN.

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ABSTRACT

Effect of European Red Mite (*Panonychus ulmi* Koch) on Golden Smoothee cultivar on MM 106 rootstock was measured over a 3 year period. Mite population level ranged from 0 to 500 cumulative mite-days (CMDs) per leaf and six target injury thresholds (0, 100, 200, 300, 400 and 500 CMDs) of five replicates each, were established. Mites were sampled each 8-15 days from June to August depending on the densities of *P. ulmi*. CMDs had a significant negative influence on the lost of the leaf colour and chlorophyll content, but no effects were found on the crop load, apple size, fruit firmness and sugar level at harvest, and total number of fruit set at the following spring. According with the results of this trial, in the natural conditions of Girona fruit area, mite feeding activity causes leaf discolouring but no evident negative effects on the production. Other factors like soil properties, water and nutrient resources, sensitiveness of the cultivar and vigour of the trees, among others, should have necessary, stronger influence on the fruit and apple trees features than mite attacks.

INTRODUCTION

The European Red Mite (ERM) (*Panonychus ulmi* Koch) is one of the most important pest in apple orchards in Europe. The occurrence of this mite is common in fruit areas and their pressure is usually higher in warm countries where pesticides are often sprayed. In recent years, biological control of this pest is done by their predators in an increasing number of apple orchards where Integrated Pest Managament or Integrated Fruit Production is established.

But the accurate effect of the activity of the phytophagous mites on the apple trees production is not determined yet and because of that, growers control ERM by spraying specific acaricides even at low populations. Chemicals often sprayed avoid the biological control of this pest by their predators and, on the other hand, increase the dependence on the products.

The aim of this trial is to determine the damaging effect of the activity of the ERM on the production of the most common cultivar of apple trees and also to get information to fix an economic injury threshold. By using a threshold it is expected that the natural regulation of this pest will take place much more often by the most important native predators phytoseiid mites which are *Amblyseius californicus* Mc Gregor and *Amblyseius andersoni* Chant.

MATERIALS AND METHODS

The trial has been carried out in the Estació Experimental Agrícola Mas Badia (Girona), from 1992 to1994. The apple cultivar has been Golden Smoothee 2038 on MM 106 roostook and the orchard which was 5 years old at 1992, was conducted by central axe at distances of 1.3 x 3.75 m.

The experimental design was randomised complete block with 5 replicates. The plot size was composed by 7 trees and the measurements were done on the 5 central trees.

The trial consisted of reaching a gradient of the ERM Cumulative Mite Days (CMDs) (Hull, 1990) at harvest from 0 to 500. Some releases of the ERM were done to the plots of 300, 400 and 500 CMD to have enough pressure of the pest, while plots which had to have the lowest levels of mite attack were repeatedly sprayed by acaricides to avoid increases of the mite populations.

At intervals of approximately 10 days, samples consisting on 10 leaves per plot were taken and individually countered in the laboratory. After counting mites per leaf, the CMDs were calculated and updated for each plot. Different rates of acaricides (i.e: Propargite, Piridaben, Fenazaquin) was used to keep the suitable level of CMDs in each plot. Where the natural occurrence and activity of the acari Phytoseiidae were not appropriate, insecticide sprayings were done to kill them (i.e.: Deltametrín, Fluvalinat).

The following parameters were measured: lost of leaf colour (at harvest) by direct eye evaluation of two people (mean value ranging from 0 to 5), total crop load per plot, average diameter of the fruits, firmness (of a subsample of 30 fruits) and sugar content (of a subsample of 15 fruits) of each plot, chlorophyll content of the leaves (10 measurements per tree) and total number of set fruits the following year. The measurements of the chlorophyll were done in 1993 and 1994 by the chlorophyll meter SPAD-502 (Minolta) directly on the leaves of the trees at the orchard.

To evaluate the effects of the populations of phytophagous mites on the trees, lineal regressions and level of correlation were determined by comparing the CMDs with all mentioned parameters.

RESULTS

The normal period of major activity of *Panonychus* begin at June and last until August . The dynamics of the mites have been different each year (see Fig. 1). In all cases the phytophagous mite has been *Panonychus ulmi* Koch. As the 1992 summer was quite rainy , the increase of the populations of the mites was later than usual. Graphics of 1993 and 1994 are quite similar though in 1994 the CMDs were better distributed through the season.

A strong hail on 14 th of April 1993 produced important damages on the trees and, consequently, the production of this year was very low.

The regression and correlation analysis of the data of 1992, 1993 and 1994 shows that there are no significant relation between total number of CMS and the parameters of load crop, fruit size, firmness, sugar content at harvest and total set fruits at the following year. And exception could be considered with the 1993 production, but it is necessary to take into account that the climatic conditions (the referred hail) may have influenced in this results. In 1994 the parameter of fruit

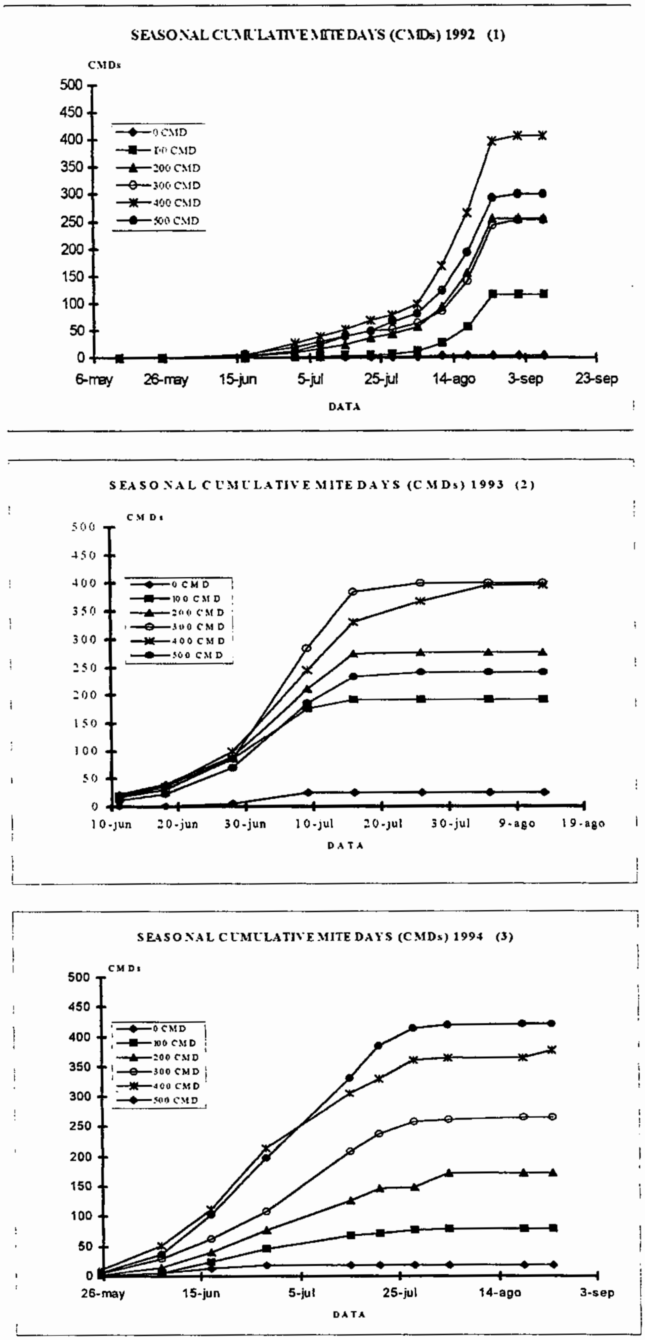

Fig. 1.- Seasonal cumulative mite days (CMDs) in the three years of the trial.

size was close to be significant (for P>= 95%) but the values show a big dispersion (R^2 = 0. 1129).

On the contrary there is significant direct relation between CMDs and leaf discolouring with good correlation while significant negative relation is done between CMDs and chlorophyll content at the beginning of September (close to harvest).

Table 1.- Lineal regressions, statistical significance levels and correlation between cumulative mite days (CMDs) and all measured parameters.

PARAMETER	YEAR	LINEAL REGRESSION	PROB>F	R2
PRODUCTION	1992	y = 106.2302+ 0.0241 x	0.3226	0.0349
	1993	y = 60.4385 - 0.0683 x	0.0029	0.2749
	1994	y = 188.5851 - 0.0362 x	0.1687	0.0666
FRUIT SIZE	1992	y = 80.9246 - 0.0012 x	0.5741	0.0114
	1993	y = 77.1224 + 0.0019 x	0.3341	0.0334
	1994	y = 75.3437 - 0.0024 x	0.0694	0.1129
FRUIT FIRMNESS	1992	y = 6.8835 + 0.0001 x	0.6105	0.0094
	1993	y = 6.1278 + 0.004 x	0.4034	0.0251
	1994	y = 7.6921 + 0.0000 x	0.9823	0
SUGAR CONTENT	1992	y = 13.0814 + 0.0006 x	0.3239	0.0348
	1993	y = 14.5249 + 0.0014 x	0.0684	0.1138
	1994	y = 12.8540 + 0.0002 x	0.7925	0.0025
LEAF DISCOLOURING	1992	y = 05100 + 0.0062 x	0.0001	0.7798
	1993	y = 0.4598 + 0.0065 x	0.000I	0.8423
	1994	y = 0.3677 + 0.0067 x	0.0001	0.8499
CHLOROPHYLL	1993	y = 48.1680 - 0.0046 x	0.0001	0.4462
	1994	y = 51.2679 - 0.0041 x	0.001	0.3246
NUMBER OF FRUITS SET	1993	y = 41.3707 - 0.0164 x	0.4817	0.0178
	1994	y = 218.5195 - 0.0208 x	0.4537	0.0202
	1995	y = 536.4237 - 0.1311 x	0.2075	0.0561

DISCUSSION

The average rainfall in June and July is 85.8 mm (10 years). In 1992 it rained 280.2 mm in this period of time. That explains that the increase of ERM did not happen until July when the temperature went up.

Some of the highest target plots were not able to reach the prefixed levels of 400 or 500 CMDs during all the season. That desagree with other studies where the highest target levels are 1000 (Hull et al., 1990) or even 2000 CMDs.

After three years of summitting plots of apples trees to different mite population, anual data of 1992, 1993 and 1994 indicate that the lost of leaf colour and the lower level of chlorophyll observed are the most clear effects of the activity of the mites on the trees, but they did not have appreciable negative effects on the other parameters of the production (crop load, fruit size, sugar content and firmness), neither on the number of fruits set at the following season.

Concerning the chlorophyll content the results agree with Zwich et al. (1976) and Mobley - Marini (1990) who found a linear reduction of chlorophyll for increasing levels of mite pressure.

The lack of effect on the crop load during the season in which mite injury occurred is similar to the results of Hull and Beers (1990). Howewer other studies (Hardman et al., 1985), had found significant reductions on the crop load when ERM reached 1700 CMDs. Sacco and Stoppa (1989) and Beers and Hull (1990) found significant smaller fruit size only when mite attacks took place at first part of the summer (until the end of July). Results of 1993 and 1994 disagree with that because the time of major activity of the pest was June -July and no effect was found on the fruit size. Sacco (1989) found no significant differences on sugar fruit content of fruits coming from apples which had suffered different levels of mite pressure. Neither Beers and Hull (1990) on the fruit firmness. The results of this trial confirm these findings.

Other studies (Hardman, 1985; Hull and Beers , 1990) reported a significant influence of ERM on total number of fruit set at the following spring. These studies reached levels of 1700 and 1250 CMDs respectively, in comparison with the maximum of 500 CMDs reached in this experience.

The depth of the ground water, the drip irrigation system , the big depth and the alluvium nature of the soil, the balanced nutrition of the trees, the vigour of the used rootstock (MM 106) and the sensitiveness of the cultivar Golden Smoothee may explain the lack of effect of the ERM on the production parameters.

Under the conditions of this trial, although intense leaf discolouration was observed, ERM did not cause any significant effect on production, fruit size and fruit set of the following season even at the highest reached level of CMDs. This may promote changes on the ERM control strategy, fostering for less use and dependence of the acaricides and making easier the biological control of the *Panonychus ulmi.*

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LECTURES

Section: Phytopathology

Reduced spray program for the control of apple scab, with the integration of fungicidal properties, climatological and biological conditions

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[1] Research subsidized by the Ministry for Agriculture, Administration for Research and Development

Abstract

In the past scab control was mainly based on a calendar spray scheme using more or less fixed spraying intervals. With the introduction of the curative DMI fungicides in the beginning of the eighties, it was possible to apply the scab treatments according to the scab warning devices. The last years these warning systems became more and more electronic which facilitated the transfer of the meteorological data to a central point for the calculation of the scab risk in different regions. The evaluation of the scab risk is based on the Table of Mills or a modified version, but includes only climatological conditions. With this system, 8 to 10 warnings were given per season. The excess in use of DMI's has led to a shift in sensitivity of the scab fungus for this fungicide family. Scab control was in some cases not sufficient. The consequence was that fruitgrowers feared for this evolution and returned to the old system of preventive scab control. With a better estimation of the scab risk by including also biological factors and the availability of new curative fungicide families, the curative scab control with a limited number of treatments per season will present new possibilities.

1. Incorporation of biological parameters for the estimation of the scab infection risk

1.1. Reduction of orchard inoculum

Besides a non-vigorous tree, all measures that reduce the inoculum of an orchard facilitate a successful scab control.
Therefore sanitary treatments which stimulate leaf decomposition to reduce pseudothecial development are important in a high PAD-orchard. The best method was given by leaf shredding. The more fragmented the leaves are, the better. The leaves were treated with different products on the ground after leaf fall (Table 1). The treatments with urea and slaked lime on the leaves on the ground had no positive effect on the leaf decomposition. Also the applications with copper and carbendazim, in general negative for earthworms, didn't show any negative effects. A hypothesis for these results can be the bad coverage of the leaves with the products applied on the soil. On the contrary, when the trees were sprayed with urea before leaf fall the decomposition was much more expressed. Nevertheless, shredding of the leaves was most promising in leaf decomposition. The leaf litter density decreased with 50 % more when the leaves were shred after leaf fall.
The prototype at our disposal manufactured by Jamaers (Borgloon, Belgium) looks like a scrub cutter. The process of cutting is different, so that the leaves coming out from the machine are stronger fragmented. The rotary speed of the brush for cleaning the tree strip can be regulated according to the humidity of the leaves. In orchards with deep wheel trails however, the leaves in the trails were left unaffected. This prototype can be

improved in order to stimulate leaf decomposition by sucking up the leaves and treating them with urea after shredding.
This method also has other advantages such as the decrease of the inoculum of fruit rot fungi on fallen fruits and the direct contact of fertilizers with the soil at the standard application in early spring.
The application of DMI's on scabbed leaves has an excellent effect on the formation of pseudothecia and ascospore release (Table 2).
On 8 November 1994 the leaves were dipped in a solution of difenoconazol and flusilazol. The dose rate was double of the normal spray dose. At the end of April 1995 the leaves were wetted and covered with microscope slides in order to evaluate the ascospore release. Especially with difenoconazol no ascospores were found. The leaves dipped in urea also gave a lower ascospore release. On the leaves which were dipped in March 1995 the effect of urea was much stronger. However, there was a remarkable difference between the 1 % and the 5 % dose rate.
These results were confirmed when the scabbed leaves were analysed on the presence of pseudothecia (Table 3). From each of 5 leaves 10 perithecia were picked out and squashed on a microscope slide. A lot of the selected perithecia were filled with ascospores of the fungus Pleospora instead of scab ascospores. Nevertheless there were remarkable differences between the treatments. With difenoconazol and flusilazol we didn't find perithecia of scab. With difenoconazol there were a lot of leaves on which no perithecia were found, neither of scab nor of Pleospora. The leaves which were dipped in urea hardly differed from the control.
The ascospores formed on the leaves which were dipped in 5 % urea in March 1995, were no longer fresh but shrivelled and dark (Table 4).

1.2. <u>Seasonal pattern of ascospore release</u>

The ascospore release was followed by two methods. In the first method heavily infected leaves were covered with microscope slides, after each rainy period the slides were replaced and controlled on ascospore release. This gives a good impression of the seasonal pattern of ascospore release. With the spore trap collecting method much lower ascospore doses were trapped but the pattern was comparable.
In 1994, the most famous scab year in Belgium since 1985, the beginning of April was the most important infection period. This period was preceeded by relatively high temperatures accompanied with a fast growth. Afterwards it started raining, which led to two light Mills infections on the first and fourth of April. However, the largest number of ascospores for the whole primary infection season were trapped in these days. The temperature dropped till 6 °C in average in the first decade of April.
Although the climatological conditions indicated a light infection, following the biological factors "leaf growth and ascospore release" it was a severe infection. Besides, there was a remarkable difference between the products used after the infection. In all plots where DMI's were used on this infection, the scab control was insufficient. As a consequence of the low temperatures and the continuous rain the uptake of DMI's was reduced. In monitoring tests it was also proved that there was a shift in sensitivity of the scab fungus for DMI's in this orchard. This could have intensified the weaker activity. In contrast with the disappointing results of the DMI's, the new fungicide family of the anilino-pyrimidines showed an excellent activity under these circumstances.

In 1994, the cumulative degree days for 50 % and 95 % spore release were 270 and 571 and the end of ascospore discharge was attained at 887 degree days.
In 1995 the peaks of ascospore release were much more concentrated and also the climatological conditions after the scab infection were more favourable to carry out a good treatment. The cumulative degree days for 50, 95 and 100 % spore release were comparable with 1994 and amounted to 262, 557 and 939. The 95 % spore release corresponded with the phenological stage "petal fall".
With the simulation model RIM (Trapman M., 1994), the ascospore release in the beginning of the primary infection period was in general overestimated, while it was underestimated at the end.
In both years the threshold value of 300 to apply a curative fungicide was never reached after the month of April. However the visual method of counting ascospore release still showed a considerable number of released ascospores in the first part of May, which led to unacceptable scab infections.
Also leaf growth is an important factor to determine the effect of a previous treatment on a new scab infection. Till now we followed the growth by taking snapshots of the phenology every 3 days. Measurement of shooth length is also possible but can only be started after bloom. With these snapshots we have a visual assessment of leaf growth also in the beginning of the season. Nowadays there are also computer programs for image analysing which can give exact figures on the increase of green infectable tissues. With the same computer program it will also be possible to count ascospores on microscope slides, which can simplify the time consuming and monotonous labour in the laboratory. The incorporation of biological factors such as ascospore release and leaf growth in the Mills infection periods characterizes in a better extent the risk of a scab infection. With the integration of these biological factors in the Mills infection periods, the number of necessary applications was reduced from 7 to 3 in 1994 and from 7 to 4 in 1995. With this system however, one must be sure that the curative product gives 100 % control and that there are no overwintering conidies on the apple tree.

2. Chemical scab control in IFP

Scab control can be carried out in a preventive or curative way. In the Integrated Fruit Production however one of the objectives is the avoidance of unnecessary fungicide sprays and the application of fungicides on an "as needed" schedule (Köllar W., 1994).
With the integration of biological factors in the scab infection risk, it will be possible to reduce the number of treatments per season but also to determine much better the positioning of the application after a real scab infection.
In this context it is important to know the after infection activity of a fungicide. Mostly the after infection activity is commonly given as "hours after the start of an infection". As the development of the scab fungus is influenced by temperature it will be better to determine the curative activity as a threshold of a temperature sum before the fungicide must be applied (Palm G., 1987).
With this "as needed" spray program, we needed curative fungicides which can attain the scab fungus which is already penetrated in the plant tissue.
Nevertheless the classic protectants remain indispensable in such control scheme.
At the moment there are two new fungicide families which can be used in a curative way, the anilino-pyrimidines and the strobilurine-analogues also described as β-methoxy-

acrylates.
The primary target of anilino-pyrimidines in the development of the scab fungus is situated just after the formation of primary stromata, when peripheral cells differentiate to form extending adventitious or "runner hyphae" (Daniels A. *et al.* 1994). In Belgium there are two anilino-pyrimidines registered : pyrimethanil (trade name: Scala, 400 SC) and cyprodinil (trade name: Chorus, 50 WG). The dose rate pro ha is 300 g for pyrimethanil and 225 g for cyprodinil. A third compound belonging to this group is in development nl. mepanipyrim. In Switzerland there is already a registration for this product (trade name: Frupica) for the control of Botrytis in vineyards.
The anilino-pyrimidines are highly effective at low temperatures. They show an excellent activity on leaves, the fruits are less protected. For this reason it will be better to preserve the anilino-pyrimidines for the beginning of the season before the end of flowering. In this period the DMI's are less active especially in years with low temperatures. In our opinion a combination of anilino-pyrimidines with classic protectants will be a better anti-resistance strategy than the combination with DMI's (Creemers P. *et al.*, 1995).
The strobilurine-analogues are derived from the natural antifungal antibiotic strobilurine A of the fungus *Strobilurus tenacellus*. The biochemical mode of action is attributed to the inhibition of the mitochondrial respiration. In contrast with other curative fungicides, they are highly effective on spore germination. With curative treatments the growth of the subcuticular stroma was not stopped, but sporulation was strongly inhibited (Gold R.E. *et al.*, 1994).
In contrast with the anilino-pyrimidines, these β-methoxyacrylates also gave a good powdery mildew control. From this group two products are described in literature: BAS 490 (common name: kresoxim-methyl) and ICI A5504. The dose rate pro ha will be about 100 g/ha. In the trials that we have carried out at our Research Station since 1992 with the ß-methoxyacrylates, we can conclude that also in curative trials, the scab control was at least equal but mostly better, compared with DMI's and anilino-pyrimidines. Compared with other curative fungicides the activity of the new group also seems less dependant on the climatological conditions during and after the treatment.

Conclusion

For the stimulation of the leaf decomposition, leaf shredding was most effective. The urea treatment gave a better approach when the leaves were sprayed before leaf fall on the tree than with an application on the soil after leaf fall. The pseudothecial development and ascospore release were more affected by the application of urea in spring than in autumn.
The integration of leaf growth and ascospore release in the revised Table of Mills gives a better estimation of the real scab risk. For ascospore release, simulation models will be helpfull in forecasting pseudothecial development and ascospore discharge. Our experience in using the simulation model RIM is promising. However the simulation of ascospore release must be adjusted so that the distribution does not follow a Gauss curve but so that the slope in the second part after the 250 degree days is more flat and so that in the primary part it is more steep.
For the assessment of leaf growth, especially in the beginning of the season, computer image analysis can help to determine the increase in infectable plant tissue.
In chemical control, with two new fungicide families at our disposal, the anilino-pyrimidines and the β-methoxyacrylates, we can choose between the different families

which one is most appropriate at the moment of infection in function of biochemical properties. Both families have no negative effects on predatory mites. The limited number of treatments in this system and the alternation between the fungicide families guarantee also a good anti-resistance strategy.
The strong inhibition of DMI's on pseudothecial development and the possibility to use other curative fungicides during the primary infection period, opens new perspectives to apply DMI's before leaf fall in high inoculum orchards.

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Table 1 : Leaf decomposition by different treatments in the orchard
Treatment : 28/11/94 Assessment : 06/04/95
(R = replicate; AVG = average)

Treatment	Dose	R 1	R 2	R 3	R 4	AVG
Untreated		70	70	70	70	70.0
+ Carbendazim	150 mg/m²	80	80	80	70	77.5
+ Copper	750 mg/m²	80	70	70	60	70.0
+ Urea	15 g/m²	80	80	80	70	77.5
+ $Ca(OH)_2$	1500 g/m²	80	80	80	70	77.5
Leaf shredding		40	30	50	30	37.5
+ Urea	15 g/m²	40	50	60	50	50.0
+ $Ca(OH)_2$	1500 g/m²	50	50	60	60	55.0

Table 2 : Effect of Urea and DMI's on ascospore release after dipping heavily infected scab leaves
Dipping : in autumn and in spring Assessment : April 1995

Dipping 08/11/94	Dose	Leaf 1	Leaf 2	Leaf 3	AVG
GORSEM					
Untreated		1048.0	1770.0	505.0	1107.7
Flusilazol	60 mg/l	4.0	12.0	0.0	5.3
Difenoconazol	50 mg/l	0.0	0.0	0.0	0.0
Urea	50 g/l	271.0	34.0	13.0	106.0
GINGELOM					
Untreated		64.0	63.0	13.0	46.7
Flusilazol	60 mg/l	4.0	4.0	15.0	7.7
Dipping 15/03/95					
GINGELOM					
Urea	10 g/l	43.0	55.0	531.0	209.7
Urea	50 g/l	0.0	2.0	0.0	0.7
DILSEN					
Urea	10 g/l	286.0	1270.0	973.0	843.0
Urea	50 g/l	0.0	2.0	1.0	1.0
GORSEM					
Urea	10 g/l	0.0	170.0	0.0	56.7
Urea	50 g/l	0.0	0.0	7.0	2.3

Table 3 : Effect of Urea and DMI's on pseudothecial development after dipping of heavily infected scab leaves (number of ascospores per pseudothecium)
Dipping : in autumn or spring Assessment : April 1995

Dipping 08/11/94	Dose	Leaf 1		Leaf 2		Leaf 3		Leaf 4		Leaf 5	
Untreated		*[1]	*	*	140	*	*	250	502	*	*
		*	736	230	160	70	*	*	660	*	*
		*	850	*	730	*	*	616	1248	*	*
		*	680	32	45	*	*	550	*	*	*
		370	*	*	*	*	*	360	*	*	*
Flusilazol	60 mg/l	*	*	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*	*	*
		*	*	*	*	*	*	*	*	*	*
Difenoconazol	50 mg/l	*	*	*	0	*	0	0	0	*	*
		*	*	*	0	*	0	0	0	*	*
		*	0[2]	*	0	*	0	0	0	*	0
		*	0	0	0	0	0	0	0	*	0
		*	0	0	0	0	0	0	0	*	0
Urea	50 g/l	8	*	520	624	*	*	*	504	*	*
		*	*	64	240	*	*	*	360	*	*
		56	112	768	432	*	*	296	296	*	*
		376	*	880	960	*	*	*	270	*	*
		*	*	64	1000	*	*	216	*	*	*
Dipping 15/03/95	**Dose**	**Leaf 1**		**Leaf 2**		**Leaf 3**		**Leaf 4**		**Leaf 5**	
Untreated		-	1136	328	704	*	*	1088	*	*	*
		*	960	2000	960	416	*	*	*	*	752
		*	1040	512	*	960	*	240	928	*	*
		856	*	600	376	*	*	408	*	*	*
		824	*	504	904	*	*	64	*	*	*
Urea	10 g/l	128	*	96	96	184	208	*	112	*	208
		104	150	224	*	*	*	*	*	*	*
		*	*	*	*	*	*	344	*	*	*
		*	*	200	*	*	136	*	416	*	*
		224	160	*	*	*	304	240	*	184	128
Urea[3]	50 g/l	*	*	*	*	90	*	536	170	*	*
		*	*	520	*	230	*	600	480	304	*
		*	*	*	*	*	*	*	*	180	*
		*	*	*	*	*	*	440	*	*	*
		*	*	224	*	190	*	*	640	*	240

* = Pleospora
(1) Perithecia of Pleospora (*)
(2) No perithecia formed (0)
(3) Ascospores were shrivelled and dark

DURATION OF *VENTURIA INAEQUALIS* INCUBATION PERIOD AND APPLICATION IN SCAB CONTROL

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Abstract
Field trials have shown that the length of *V.inaequalis* ascospore latent periods is superior to that indicated in Mills' table. Two models are presented to forecast the end of incubation periods, based upon daily temperature and cultivar sensitivity. In scab control, the maintenance of fungicide coverage on plants at the end of ascospore latent periods (calculated with these models), gave better results in 1994 than in 1995, especially with surface fungicides and cultivars such as Golden. The results were obtained by including this technique in a calendar schedule without increasing the number of treatments.

Introduction
V.inaequalis (Cke.)Wint. is a constantly severe and widespread disease, probably due to the ability of the fungus to modify and apt itself to the host, environment and fungicides. This has lead to continuous attempts to study methodologies and means to improve control. For this purpose, we decided to assess the advantages of treatments before the end of incubation periods.
For the control of *Plasmopara viticola,* knowledge of the end of the fungus primary cycles is essential for a control strategy (Goidanich *et al.*, 1957) based on application of surface compounds at that moment, to obtain a preventive action against conidia of the secondary cycles.This strategy is not appropriate in apple scab control (*unpublished data*) because primary infections of *V.inaequalis* are more severe than Downy mildew and infections must be controlled at the beginning. So apple-scab controls are based on calendar or advisory schedules (Fiaccadori, Cesari 1992), with applications just a few days after the beginning of primary infections. Recently new strategies were proposed that also take into consideration ascospore presence and leaf growth (Buhler Gessler 1993).
In every case, to improve the level of control of fungicides employed in scab control, it may be and advantage to apply treatments or ensure the presence of fungicide residues just before the end of the infection cycles. Indeed we know that IBS fungicides can have an antisporulant activity on latent infections of *Fusicladium dendriticum* in this phase(O' Leary, Sutton 1986), while contact fungicides can inhibit the germination of subsequent conidia.
The aim of this work was to evaluate the activity of contact and IBS fungicides, applied before the end of infection cycles, and included in calendar programs for apple scab control.
Before carrying out this study, it was necessary to assess the real length of natural ascospore infections, with field trials in Italian orchards employing several cultivars and comparing data with Mills' table (1946).

Methodologies
a) Duration of incubation period
The length of naturally occuring ascospore infections was verified on leaves and fruits of several cultivars, during period 1980-1991, in two stations:
- S.Vito (FE) in an 8 years old commercial orchard with a "cultivar collection" containing: Rome Beauty, Stayman Red and Cooper 7 (Red Delicious), Granny Smith and Golden B.
The orchard was divided into plots (100 m^2), each one affected by just one natural infection; this was ensured by protecting them against former and subsequent infections with surface fungicides applied 12-24 after the beginning of other infections.
-Medicina (BO) The latency periods were assessed in our experimental orchard with cv Rome Beauty, utilizing test-trees 3-12 years old and indicator plants in pots (2 years old) only affected by one infection.

We considered as natural ascospore infections, those beginning with rainfall and ascospore emission and leaf-wetting determined by traditional Mills' system.
Temperature, leaf-wetness, relative humidity and ascospore emission were measured as described below.
Data were collected and processed (Statgrafic program) in order to create the most suitable models for forecasting the length of the incubation period.

b) *Control*
The system of treating just before the end of infection cycles was included in a 7-day calendar program, anticipating or delaying the day of treatment on the basis of the forecast for the appearance of ascospore infection. This system was applied with IBS or contact fungicides (Tab n 1) when 80-90% of incubation period had passed. The incubation period was obtained from our experimental model for highly receptive cultivars. The treatment was not applied when on the day of application the plants were still protected by residual activity of the previous treatment, defined as 3 days before flowering and 4 days after.
As a comparison the same fungicides were employed with a commercial 7-day calendar schedule.

TAB. N.1 SCHEDULES AND FUNGICIDES COMPARED 1994-1995

N°	active ingredients	%	g/l	g/ha	treatment schedules
1	captan(Captan*)	50	1.25	1338(2676*)	7-day calendar
2	"	"	"	"	incubation
3	exaconazole+captan(Anvil*)	1+30	0.02+0.6	21.4+643(2143*)	7-day calendar
4	" "	"	"	"	incubation

* commercial product

Trials were carried out for two years in our experimental station at Medicina on three 5 year-old cultivars: Rome Beauty, Red Chief and Golden B. Every treatment were replicated 4 times and applications were made with a knapsack sprayer distributing 0.7 l/plant corresponding to 1071 l/ha.
Both the experimental centers were equipped with mechanical (Bazier) and electronic instruments (Metos) to provide meteorological data (temperature, leaf-wetness and rainfall). Volumetric captaspores VPPS 2000(Hirst type) and handmade models that captured ascospores from scabbed leaves in a wooden box were used to assess ascospore emissions.Results of the applications are given as the percentage of scabbed leaves and number of spots calculated with multiple range test (Statgrafic program).

Results and discussion

Duration of incubation period
Processing of our data made it possible to identify a significative correlation between daily temperature and the length of incubation period on leaves. The best results were obtained when varietal receptivity was also considered.
So two exponential curves are proposed (Tab n.2) in which length is a function of temperature: one for the most sensitive cv Rome Beauty, and the other for the less receptive cultivars including Golden, Stayman Red, Cooper 7, Granny Smith and Jonathan.

TAB N 2 Duration of incubation(days) period of *V.inaequalis* 'compared with Mills

incubation average temperature (°C)	Mills model	DURATION(days): 'experimental models: cv high receptivity	cv medium-low receptivity
5	22		
6	20		
7	19		
8	18		
9	17		
10	16	21	
11	15	20	
12	14	19	
13	13	18	
14	12	17	
15	11	16	25
16	10	15	22
17	9	14	19
18	8	13	16
19	8	12	15
20	8	11	12
21	8		11
equations		Y=exp[3.66-0.06x)]	Y=exp[5.42-0.14x)]
r^2		30.78	59.5
prob.level		0.00066	0.00018

The determination coefficients (r^2) obtained on leaves for the two parameters were generally low, but this is realistic due to the probable strong influence of many other factors.
The curve for leaves cv. Rome Beauty, available for the range of temperatures considered (10°C-20°C), showed the shorter length of incubation period, while the other cultivars, with a range 15-25°C.
In all cases, the duration of incubation period shown by two experimental curves was superior to the traditional Mills' table, especially at lower temperatures, showing analogies with Tomerlin and Jones data (1983).The results on fruits was not significant and therefore the model is not presented.

Control

In 1994, 9 treatments for scab control were made following the calendar or the incubation schedule during the critical infection period, characterized by 7 infections (Mills' system) beginning with the first ascospore emission (27 March) and ending a week after the last ascospore emission (12 May). The incubation program differed from the calendar schedule as regards the timing of the 4 treatments, applied just before the appearance of the ascospore infections (9/4, 10/4, 12/5, 18/5), that were particularly severe as confirmed by the degree of infection on indicator-plants.
As compared with the first two infections, application with the incubation schedule was respectively, 1 and 3 days earlier than with the calendar schedule, while the third and fourth application were delayed, by four and one day respectively. For the other infections, treatments were not applied just before the end of latent periods because the plants were still protected by the residual activity of the previous application.
The degree of leaf infection detected on 19/5(tab n.4), relative to the control of the first two infection , showed that captan applied with the incubation schedule gave better results than the same fungicide

using the calendar schedule. This result was more evident on cv Golden and Rome Beauty than on cv Red Chief. The fruits showed the same positive results as the leaves that were probably related to the control of infection dated 16/4 (flowering) at an early receptive stage.

When IBS (exaconazole)was added to captan the protection on leaves was good for both treatment schedules, without any significant differences.

At the second control (09.06), pratically at the end of ascospore and condial infectious cycle, there was a reduction in the differences between the schedules compared, probably due to the continuous and generalized increase in conidial inoculum.

TAB 3 'APPLE SCAB CONTROL WITH CALENDAR AND INCUBATION SCHEDULES 1994-1995

1994

infections												
rainfall(date)	27.03(1)	2.04	3.04	5,04	8,04	9,04	16,04	25,04	2,05	12,05	14,05	18,05
forecast severity(Mills)	no inf	no inf	no inf	no inf	no inf	light	heavy	light	no inf	mediu mm	mediu m	light
confirmed severity(indicator-plants)	0	4,86	n,n.	7,32	n,n.	n,n.	6,38	n,n.	n,n.	n,n.	n,n.	n,n.
forecast appearance (experimental model)						27,04	2,05	10,05		25,05	26,05	30,05
treatment schedules												
incubation	30,03			6,04		14,04	20,04		26,04*	2,05*	11,05	24,05*
7-day calendar	"			"		"	"		27,04	5,05	"	20,05

1995

infections												
rainfall(date)	28,3(1)	7,04	14,04	20,04	22,04	26,04	28,04	30,04	2,05	10,05	13,05	16,05
forecast severity(Mills'model)	no inf	medium	no inf	light	severe	light	light	mediu m	no inf	severe	severe	medium
confirmed severity(indicator-plants)	0	0	0	8,01	48,2	n,n.	n,n.	n,n.	0	n,n.	n,n.	n,n.
forecast appearance(Mills)				3,05	5,05							
forecast appear,(experim,model**)		26,04		7,05	8,05	11,05	12,05	14,05		25,05	28,05	30,05
confirmed appearance				12,05	13,05							
treatment schedules												
incubation	31,3;6,4;12,4;20,4	26,04*		6,05*	13,05				22,05			27,05*
7-day calendar		27,04		4,05	13,05				22,05		29,05	

* treatments specifically realized before the end of incubation period

In 1995, 9 treatments were applied in the same orchard, using the 7-day calendar and incubation schedules, during the critical infection period, characterized by 9 infections (Mills' criterion) beginning the 18th of March (first ascospore emission) and ending on the 16th of May.

The incubation schedule differed from the calendar schedule in the timing of the 3 treatments applied for the ascospore infections starting on 7/4, 20/4, 13/5. In the first case the application was made too early due to a mistake, while the second and the third treatment were made respectively 2 days after and 2 days before the calendar schedule.On the basis of the results on indicator-plants, only the second infection(20/4) had importance in scab severity. The apple scab control results showed, on 18/5 and 7/6(tab n.4), an analogous degree of infection for the two schedules tested. The captan treatment applied without IBS gave a constantly better but non significantly higher activity with incubation schedule.Probabably the reduced number and severity of infections on which incubation schedule was tested was responsible for the lower performance of this system as compared with 1994.

TAB N.4 RESULTS OF SCAB CONTROL WITH CALENDAR AND INCUBATION SCHEDULES 1994-1995

fungicides	schedules	1994 % scabbed leaves 04th May			09th June			% scabbed fruits 09th June			1995 % scabbed leaves 18th May		07th June	
		Golden	Red Ch.	Rome	Golden	Red Ch.	Rome	Golden	Red Ch.	Rome	Golden	Rome	Golden	Rome
captan	calendar	16.5f	'4.4bcd	23.9ef	17.1c	10.6e	14.6c	13.7d	2.4abc	19.6c	18.7b	16.7b	16.5b	24.2b
"	incubation	5.1bcd	2.2abc	14.3c	13.3c	7.1cde	12.7c	2.9ab	'9.2d	3.2ab	15.5bc	14.7b	10.5b	18.5bc
exaconazol+	calendar	10.2de	6.2cd	15.7cd	14.0c	7.9de	13.6c	9.4c	5.5abcd	5.5b	5.5bc	4.7b	6.1b	8.3c
captan	incubation	6.2cd	6.4abcd	16.1cd	11.8bc	7.0cde	12.1c	6.6bc	7.1bcd	4.7ab	3.0c	4.2b	2.3b	9.2c
control		27.0g	15.7e	25.0f	42.0c	29.4f	23.9d	17.9e	23.3e	36.7d	60.2a	54.2b	49.9a	56.7a

Conclusions

Field experience on the length of the ascosporic incubation period for *V.inaequalis* made it possible to prepare forecasting models which revealed that effective duration was higher than that indicated by Mills, confirming the findings of Tomerlin 1983h, especially at low temperatures and for cultivars with medium-low receptivity. Duration depended on temperature, cultivar receptivity and many other factors, probably related to complex correlations between pathotypes, cultivars, and environment (Van der Plank, 1963).

These models were used to forecast the appearance of ascospore infections and adopt measures to protect plants just before this moment, also with specific applications. The improvement in control were generally positive, especially with surface compounds and on cv Golden. It is not clear, however, why the results were less positive with IBS fungicides and with certain cultivars such as Red Chief.

This technique was included in a 7-day calendar schedule, that was simpler and so made it easier to modify the date of treatment as compared with advisory schedules. It must be pointed out, however, that best results seem to be obtained with these applications given just before the forecasted appearance of the most severe ascospore infections, requiring conditions that are not always possible.

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Use Patterns and Economics of Fungicides for Disease Control in New Zealand Apples.

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Abstract

Ensuring that New Zealand apple production follows environmentally sustainable management practices is a national research priority, achievable partly through reductions and more careful management of pesticide use. Only black spot (scab) and powdery mildew disease control currently depend on routine fungicide applications. Weather-based infection risk predictions are widely used by growers to schedule scab curative fungicide applications. On average 14 to 18 fungicide sprays are applied each season depending on cultivar, district and weather. In a typical spray programme, 80% of fungicides are primarily for scab control and 20% are specific mildewicides. DMI fungicides with additional activity against powdery mildew make up 15% of the scab fungicides. Pest and disease control comprises approximately 20% of direct production costs. Total fungicide costs are approximately 60% of chemical costs. Economic analysis of *average* scab fungicide use indicates potential for about 25% use reduction before disease could reduce profit. However, growers are risk averse and there is currently little economic incentive for apple growers to reduce fungicide use.

The majority of apple growers produce for export through ENZA New Zealand (International) (ENZA). ENZA determines pesticides used on export fruit, sets pesticide withholding periods and operates a random pesticide residue testing programme to ensure that fruit does not violate the residue tolerances of importing countries. All ENZA growers submit spray diaries. Diary analysis has indicated that approximately 10% of growers use far more fungicide than necessary to control disease, even though they do not exceed residue tolerances on their fruit. ENZA, in consultation with HortResearch, has proposed definition of pesticide use targets based on Acceptable Standard Application Practice (ASAP). It is anticipated that gradual reductions of ASAP targets will result in pesticide use reductions by all apple producers.

Apple disease control in New Zealand

There has been increasing recognition in New Zealand (NZ) of the need to produce fruit in an environmentally sustainable and responsible manner. Research into integrated pest and disease management is well established in NZ and ensuring that apple production follows environmentally sustainable management practices is a national research priority.

There are 63 apple fungal pathogens recorded in NZ (Pennycook 1989). However, only control of black spot (scab) caused by *Venturia inaequalis* (Cke. Wint.) and powdery mildew caused by *Phodosphaera leucotricha* (Ell. & Ev.) currently depend on routine fungicide applications. There is a NZ research programme to breed disease resistant apple cultivars, with scab and powdery mildew disease resistance targeted as the top priorities. However, all current commercial apple cultivars are susceptible to scab and show at least moderate susceptibility to powdery mildew. Dry eye rot, caused by *Botrytis cinerea* (Pers.), occurs at low levels in several production regions and is the occasional target of fungicide applications. Crown and collar rots, caused by *Phytophthora cactorum* (Leb. & Cohn.), are the only other significant diseases for which fungicides are used, but fungicide use is restricted to non-bearing trees. Some suppression of non-target diseases occurs from scab and powdery mildew spray programmes.

Table 1: Fungicides in common use on NZ pipfruit, showing target disease and type of fungicidal activity.

Fungicide active ingredient	Target disease	Activity
bupirimate	powdery mildew	C[2]
captan	scab	P
dodine	scab	P + C
fenarimol (DMI[1])	scab, powdery mildew	P + C
flusilazol (DMI)	scab, powdery mildew	P + C
mancozeb	scab	P
metiram	scab	P
myclobutanil (DMI)	scab, powdery mildew	P + C
penconazole (DMI)	scab, powdery mildew	P + C
nitrothal-isopropyl	powdery mildew	P
thiram	scab	P
triadimefon (DMI)	powdery mildew	C

[1] DMI = Demethylation inhibitor.
[2] P = Protectant activity, C = Curative activity.

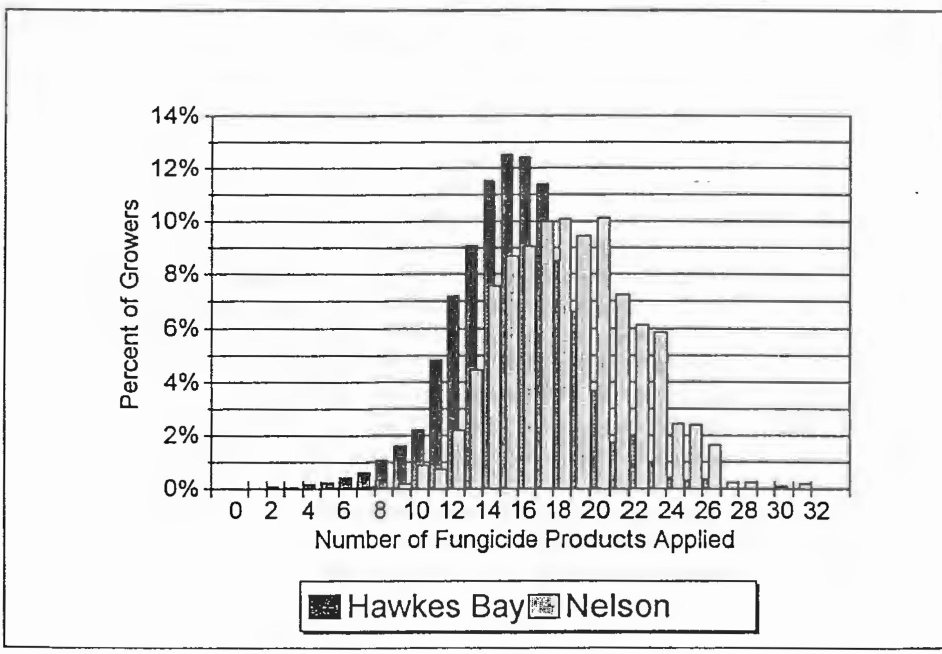
Powdery mildew control is achieved through removal of infected wood at pruning and use of fungicides. Specific mildewicides in common use by growers are listed in Table 1. Mildewicide use is frequently reduced on moderately resistant cultivars such as Red Delicious. All of the DMI fungicides applied for scab control have some activity against powdery mildew and their use contributes greatly to mildew control.

Ascospores are the principle source of primary scab infection. Mills period infection risk predictions are widely used by growers to schedule scab curative fungicide applications during the primary infection season. An important source of Mills period data is from near-real-time access of grower computers to a national network of weather data loggers, or from faxes of these data (Beresford and Spink 1992). On-going scab management research includes development of ascospore and crop disease monitoring systems to aid growers with fungicide scheduling decisions. However, fungicides still remain the primary means of scab control. Scab fungicides in common use by NZ growers are also listed in Table 1.

Fungicide use patterns

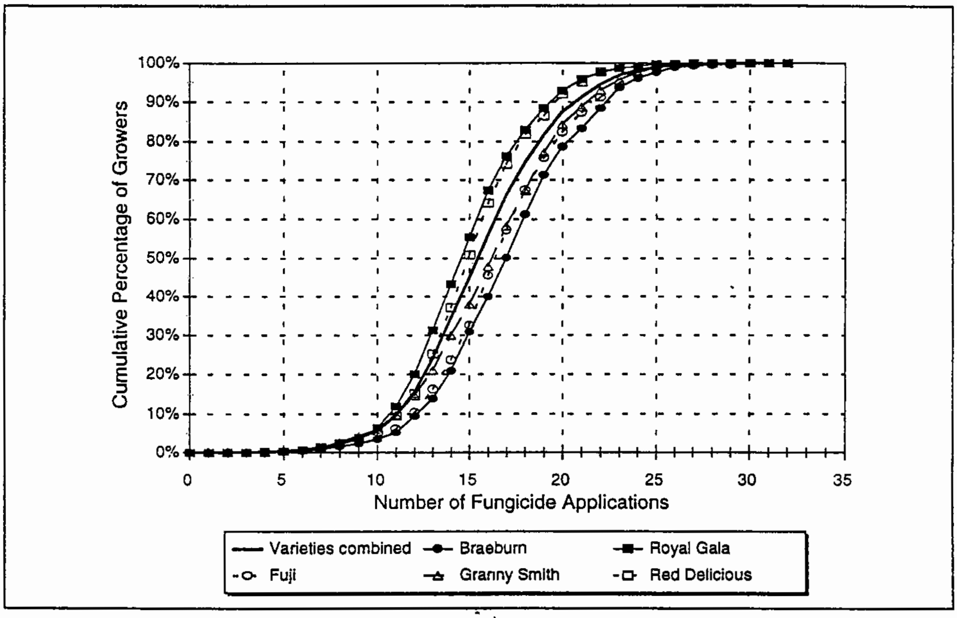
On average 14 to 18 fungicide sprays are applied each season depending on cultivar, district and weather. Figure 1 shows typical distributions of fungicide application numbers for the two main NZ apple producing regions from the 1994-95 production season across all cultivars (814 and 353 growers, 4930 and 2591 diaries for Hawke's Bay and Nelson regions respectively - spray diaries for different cultivars are treated separately). Figure 2 shows 1994-95 season cumulative application number data across the main apple cultivars for the whole of New Zealand (1707 growers, 10911 spray diaries). Fungicide application numbers, plus use and timing of products from different fungicide groups in the 1994-95 season, were essentially the same as that observed in surveys from the 1986-1988 (Manktelow 1990) and 1991-92 (Manktelow unpublished) seasons.

Figure 1: Distributions of fungicide application numbers for the two main NZ apple producing regions (1994-95 season, 814 and 353 growers, 4930 and 2591 diaries for Hawke's Bay and Nelson respectively).



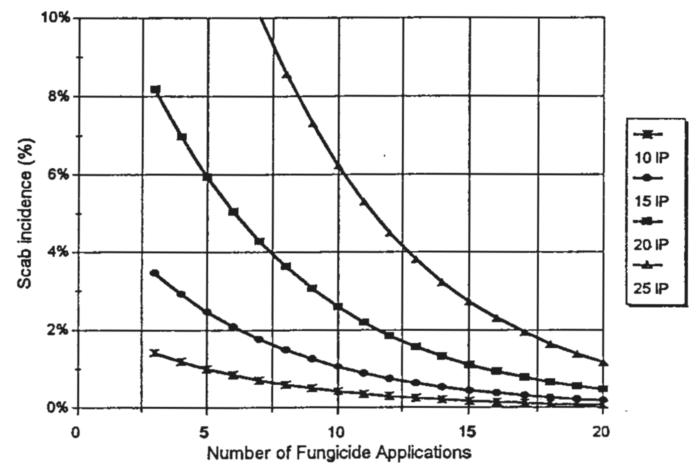
About 30% of fungicide applications contain mixtures of two fungicides with different modes of action. DMI fungicides are mixed with protectants for resistance management and powdery mildew protectants are sometimes mixed with scab fungicides. In a typical spray programme, 80% of fungicides are primarily applied for scab control and 20% are specific mildewicides. DMI fungicides with additional activity against powdery mildew make up 15% of the scab fungicides.

Figure 2: Cumulative distributions of numbers of fungicides applied to five apple cultivars for the whole of New Zealand (1994-95 season, 1707 growers, 10911 spray diaries).



Pest and disease control comprise approximately 20% of direct production costs. Total fungicide and scab fungicide costs are approximately 60% and 50% of total chemical costs respectively. Using data from seven different field experiments, Beresford and Manktelow (1994) found that scab incidence at harvest increased logarithmically as the number of fungicide applications decreased. A regression equation was derived to predict scab incidence at harvest from the total number of fungicide products applied and numbers of scab infection periods in the first four months after bud break (Figure 3). Economic analysis using this equation indicated that *average* scab fungicide use could be reduced by around 25% in most seasons, before increased scab damage would be expected to reduce profit. Scab has the potential to cause major crop losses and most fungicide programmes insure against losses under high disease risk situations, even though the majority of NZ orchards can be considered under low risk in most seasons. Until growers gain confidence in disease risk prediction systems currently under development, there is little economic incentive for them to reduce fungicide use.

Figure 3: Scab incidence at harvest predicted from total numbers of fungicide products applied and numbers of scab infection periods (IP) in the four months after bud break.



Management of pesticide use in the New Zealand apple industry

The NZ apple industry can be divided into six main regions over the length of the country, with nearly 80% of production from the Hawke's Bay and Nelson regions. There are over 1700 registered growers in the country. The industry mainly comprises owner-operated orchards with an average size of 7.7 ha.

Around 50% of the NZ apple crop is exported fresh and 42% is processed for local and export consumption. The high proportion of fresh and processed fruit exports requires the bulk of the crop to be produced using export pest and disease control measures. Most fresh fruit is exported through ENZA New Zealand (International) (ENZA), which sets fruit quality standards and pesticide residue requirements. In practice residue levels have to meet the lowest residue tolerances of most importing countries. ENZA specifies pesticides that may be applied to export fruit and their withholding periods. Growers have to submit spray diaries to ENZA, where they are checked for pesticide violations. The diary data are backed up by an extensive fruit residue testing programme, with random samples taken from 25% of growers each season. Fruit cannot be accepted for packing until spray diary clearance certificates have been issued by ENZA staff. ENZA also have a role in disseminating information to growers and both ENZA and HortResearch provide information on pest and disease management. It is now mandatory for some orchard staff to have completed training courses in pesticide use and application. In addition, annual sprayer calibration by certified calibrators is an ENZA requirement on the majority of orchards.

Access to the full ENZA spray diary records on a personal computer (PC) was obtained for the first time this year. PC analysis of the diary data has indicated that approximately 10% of growers use more fungicide than necessary to control disease, even though they do not exceed fruit residue tolerances (Figure 2). Similar use distributions were observed for all pesticides examined. A significant positive correlation was observed in pesticide use patterns between growers, whereby high users of fungicides were also high users of insecticides. These patterns have been observed in other crops and countries (Mumford and Norton 1984) and it would appear that there is little biological justification for the high fungicide use observed and that targeted grower education would enable substantial reductions to be achieved. A priority in the introduction of more sustainable orchard management practices therefore needs to be pesticide use reductions by the high pesticide users.

ENZA, in consultation with HortResearch, has proposed pesticide use targets that meet currently Acceptable Standard Application Practice (ASAP). It is anticipated that ASAP targets will be gradually modified to bring pesticide use by all apple producers to a sustainable level. Modifications anticipated include both a lowering of total pesticide use and changes to pesticide use patterns, e.g. reductions in dithiocarbamate fungicide use. The current ENZA spray diary recording system would be well-suited for monitoring grower ASAP targets. In the short term at least, there would be substantial pesticide cost savings for excessive pesticide users that meet ASAP targets. Any accepted pesticide reduction scheme requires total industry commitment. In the long term it is envisaged that ASAP targets will become part of an Integrated Fruit Production system for the New Zealand horticultural industry.

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THE EPIPHYTIC MICROFLORA OF THE APPLE PHYLLOPLANE AND ITS ROLE IN BIOLOGICAL SCAB CONTROL

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Abstract. It was established that the seasonal dynamics of the number of the apple phylloplane epiphytic microorganisms generally and microepiphytes showing a high antagonistic activity towards the scab excitant particularly was different in the gradient of the contrasting disease resistance of the host plant and depending on the presence or absence of pesticide treatments of plantings as well. It was found that under conditions of the pure culture microorganisms of different taxonomic groups which were studied displayed antagonistic features against the conidial stage of the scab excitant. Under both in vitro and in vivo conditions, the most active strains were isolated among micellar fungi and bacterial microepiphytes.

Pedoclimatic conditions of the southern zone of the Ukraine permit to grow high yields of many fruit cultures spread here. The main fruit culture in this zone, as in all the republic, is the apple tree occupying 63% of the total orchard area and providing 60-80% of the gross yield of large and small fruits.

Among many apple diseases, one of the most widespread and harmful is scab causing up to 40% of total losses inflicted on this culture by the complex of harmful organisms. Despite droughty conditions, scab practically every year inflicts a discernible damage on orchards in the south of the Ukraine. It is especially dangerous in years with rainy weather during spring and at the beginning of summer when under non-taking protective measures the disease often spreads and develops so intensively that trees of severely affected apple varieties shed a mass of leaves already in June-July, which leads to a sharp decrease of the plant productivity. The forming yield is, as a rule, of poor market quality.

In recent years, the probability of arising scab epiphytoties in commercial apple plantings of the southern zone of the Ukraine significantly increased owing to the tendency towards narrow spacing orchards, enlarging the areas of irrigated plantings and growing both aboriginal and introduced disease-nonresistant varieties on large land areas.

At present in the Ukraine, fruit culture disease protection including apple scab protection is based on taking a complex of measures among which chemical treatments occupy the main place. But, owing to the complication of the ecologic situation including by widely using plant protection chemicals in orchards, increasingly greater attention is given to the development of a biological method for apple scab protection in recent years. Main attention is given to searching for natural antagonists of the apple scab excitant among representatives of the microflora of different ecological niches. Strains of the most active antagonists can be used as agents of biological preparations against scab and other plant diseases.

In our opinion, searching for natural antagonists of the scab excitant among representatives of the epiphytic microflora of the apple phylloplane is promising since just here, on leaves, fruits, shoots of the host plant, the pathogen displays its harmfulness and just here, in this specific microbiocenosis, its antagonistic

microorganisms, most powerful and ecologically compatible with it, must be.

In consideration of the above-mentioned, the main direction of our work is screening potential microantagonists of the apple scab excitant which are promising as agents of the disease control biological method. Attention is given to studying the dependence of quantitative and qualitative indices of the apple phylloplane epiphytic microflora (the preferable station for screening) on the disease resistance of the variety as well as the presence or absence of fungicidal treatments in plantings, which will permit to carry out screening microantagonists, optimal as effective agents of biological preparations under conditions of concrete plantings.

Superficial microsaprotrophs are a highly relative idea. This is a community of microorganisms to which representatives of taxons, often diametric in environmental requirements, belong. Because of this, we tried to study peculiarities of the seasonal dynamics of quantitative parameters for representatives of taxonomic groups such as micellar and yeast-like fungi as well as bacteria. Epiphytic microorganisms were isolated from vegetating organs (shoots, leaves, flowers, fruits) of the scab-resistant apple variety Prima with and without chemical treatments as well as of the susceptible variety Reinette Simirenko with and without spraying plantings.

As a result of investigations, it was established that the seasonal dynamics of the number of apple phylloplane epiphytic microorganisms of different taxonomic groups was different in the gradient of the contrasting disease resistance of the host plant and depending on the presence or absence of chemical treatments in plantings as well.

Thus, the colonization of the shoot surface by micellar and nonmicellar microorganisms regardless of the variety resistance and pesticide press in plantings was at almost the same level. Even the time factor had no influence on this: the number of epiphytic microsaprotrophs per unit shoot surface during the spring and summer period was practically the same.

When studying the seasonal dynamics of the number of micellar microepiphytes isolated from apple leaves, it was established that the presence or absence of pesticide sprayings in plantings had a significant influence on the colonization by this group of microorganisms. In the treatment without application of chemicals, the colonization of the leaf surface by fungi was higher and differed statistically significantly from the treatment with scab protection of plants.

The colonization of apple flowers by microorganisms of different taxonomic groups did not depend on the varietal resistance.

It was established that the dynamics of the number of micellar micromycetes on apple fruits depended statistically significantly on the scab susceptibility of the variety. The immune variety Prima was characterized by the highest colonization by representatives of this taxonomic group.

Yeast-like microorganisms isolated from the surface of apple shoots proved stable in regard to the pesticide load and varietal difference. Here, as in the case with micellar microepiphytes, even the time factor did not influence their number. But the group of the same microepiphytes isolated from the apple leaf surface proved labile toward the pesticide load. The difference in the colonization by yeast-like microorganisms was especially clear during fruit maturation (6.4 propagules/mm in the treatment without pesticide sprayings as against 1.7 propagules/mm with application of pesticides).

The number of yeast-like microorganisms on fruits of the apple variety Reinette Simirenko was significantly higher than on the variety Prima.

The colonization of shoots, leaves and fruits of the apple tree by bacterial microsaprotrophs did not depend on the varietal resistance and the presence or absence of pesticide treatments of plantings.

As a result of investigations, it was established that the epiphytic microflora of the apple phylloplane (micellar, yeast-like fungi and bacteria) contained microepiphytes, highly active against the scab excitant, colonizing all vegetating organs of plants. However, as results of the variance analysis showed, the number of epiphytic microorganisms displaying a high antagonistic activity against the scab excitant was significantly higher on apple leaves than on shoots, and apple leaves without scab affection were colonized by microepiphytes, highly active against the excitant of this disease, to a greater extent than leaves with scab spots. Therefore investigations of just this ecological niche are of certain interest.

On fruits of the scab-susceptible variety Reinette Simirenko, the number of microepiphytes, highly active against the scab excitant, was 1.4 times as high as that on fruits of the immune variety Prima. In certain cases, the content of strains, highly active against the scab excitant, in the epiphytic microflora was directly dependent on both the disease resistance of the variety and the pesticide press in apple plantings.

Thus, the quantity of micellar fungi strains, highly active against the scab excitant, which colonize the surface of different apple organs was directly dependent on the presence or absence of plant pesticide treatments. Their quantity on leaves depended also on the scab resistance of the variety. In the treatment with the scab-immune variety Prima, the number of micromycetes strains, highly active against the scab excitant, was 1.1-1.3 times as high as that in the treatment with the susceptible variety Reinette Simirenko. As for yeast-like microepiphytes having antagonistic features against the scab excitant, their quantity on apple leaves was influenced by both the varietal disease resistance of the host plant and the presence or absence of pesticide treatments. At the same time,this index on shoots was stable irrespective of mentioned factors. But the number of highly active bacterial microsaprotrophs on both shoots and leaves depended only on the varietal resistance. Less strains, highly active against the scab excitant, were isolated from shoots and leaves of the immune variety Prima. Such a peculiarity took place during all the period of investigations.

The analysis of the antagonistic activity of microepiphyte isolates isolated from flowers of the apple varieties with contrasting scab resistance permits to say that the antagonistic potential of the fungal microflora of these organs in regard to the scab excitant of the scab-susceptible apple variety Reinette Simirenko is 1.3 times as high as that of the immune variety, the antagonistic potential of yeast-like microorganisms is approximately e same in both varieties and that of bacterial microorganisms is significantly higher in the immune variety.

The number of strains, highly active against the disease, on fruits of the scab-susceptible variety Reinette Simirenko was 1.4 times as high as that on fruits of the immune variety Prima.

As a result of in vitro investigations carried out with 1056 strains of microorganisms isolated from the surface of apple tree vegetating organs, it was established that 405 isolates, or 38.3% of their total amount, had antagonistic effect on the conidial stage of the scab excitant. Most of the analyzed microepiphytes are characterized by a low antagonistic activity against the scab excitant. Thus, as regards the degree of inhibiting the germination of pathogen conidia, 24.7% of the total amount of isolated microorganisms got the estimate only 1, 10.3% - 2, 2.7% - 3 and only 0.6% of them showed the highest (100%) antagonistic activity.

When considering the total antagonistic activity of microepiphytes of the apple tree phylloplane toward the scab excitant among the main taxonomic groups, it should be noted that more strains with such features occurred among yeast-like microorganisms (46.2%), less strains, highly active against the scab excitant, were found among micellar fungi (28.6%) and still less (25.2%) - among bacteria. But taking into account ability to not simply negatively influence the germination of scab excitant conidia, but the intensity of this phenomenon, it should be noted that among yeast-like microepiphytes highly active strains were not found and among micellar fungi and bacteria approximately identical quantities of them were found.

The strains of microorganisms displaying a high antagonistic activity toward the apple scab excitant under laboratory conditions were used for studying the effectiveness against the disease under field conditions.

Results of these investigations showed that under spraying plants of the apple variety Reinette Simirenko severely affected by scab with suspensions of living microorganism cultures 35 strains (79.5%) out of 44 studied provided a rather intensive inhibition of the disease. Bacterial strains showed an especially high effectiveness against scab.

As a result of tests, the most highly active microantagonists against the apple scab excitant were selected which will be studied for their use as effective agents of biologics. Among them, 9 strains of bacterial microepiphytes, 4 strains of micellar fungi and 1 actinomyces inhibiting scab development 90.2 - 97.7%.

Thus, one can draw a conclusion that the epiphytic microflora of the apple phylloplane contains microorganisms characterizing by a high antagonistic activity toward the scab excitant. Under conditions of the pure culture, a significant inhibiting influence on the germination of scab excitant conidia was exerted by representatives of different taxonomic groups which were studied. But under both in vitro and in vivo conditions the strains, most active by this index, were found among micellar fungi and bacterial microepiphytes.

LECTURES

Section: Biological Control

Measuring and understanding the impact of natural enemies on apple pest populations: life tables for the apple ermine moth, *Yponomeuta malinellus*.

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Abstract

A case study is presented of an actual biological control project of the apple ermine moth (AEM), *Yponomeuta malinellus* Zeller, for Agriculture Canada. The AEM was accidentally introduced into British Columbia in 1981, where it became a significant pest. This paper presents results of estimations of parasitoid and predator impacts on *Y. malinellus* in Europe. Life table studies were carried out to understand the role of natural enemies in controlling the pest in Europe. The host abundance at the collection site was less than 3 tents per 100 leaf cluster in 1993-1994 and over 4 in 1995. The *Y. malinellus* population at Biebesheim (Germany) was attacked by 7 different primary parasitoid species. From these parasitoids, the oligophagous larval-pupal and pupal parasitoid *Herpestomus brunnicornis* and the oligophagous egg-larval parasitoid *Ageniaspis fuscicollis* Dalman were selected as potential biological control agents for Canada. Insects predators in the present study were abundant, particularly on egg batches. Life tables indicate that the impact of these predators reached 34.9% in 1993 and 37.0% in 1994 of the total generational mortality of *Y. malinellus*. The impact of the parasitoids in relation to the total generational mortality of *Y. malinellus* was studied. Results presented indicate that parasitoids killed 6.1% of the AEM in the generation in 1993 and 3.8% in 1994. This is equivalent to 19.0% in 1993 and 13.1% in 1994 of the generational mortality.

Introduction

The promotion of biological control, as an alternative to chemical control is the overall aim of advanced apple IPM worldwide. With respect to natural enemies, IPM strategies are largely based on (1) the use of selective pesticides which are "as safe as possible" to key natural enemies, (2) the conservation of the orchard environment, its habitats and wildlife (i.e. refuges for predators, host plants for beneficials), and (3) monitoring pest and natural enemy populations (Cross & Dickler, 1994). Otherwise, the role of natural control agents has been largely disregarded and very little is known about the impact of parasitoids and predator on key pests.

In principle, the impact of parasitoids can be measured in a number of ways. Parasitoid impact has been measured by percent parasitism. The accuracy of this method depends on the way in which samples are made (see Waage and Cherry, 1992; Van Driesche, 1983; Van Driesche *et al.* 1991). The best way to measure the impact is to isolate a single generation of the pest in the field and measure the precise number of pests which die from one or another cause, and this is done either for single or multiple locations or generations. The measure of generational mortality is achieved by construction of a life table (see reviews: Harcourt, 1969; Varley & Gradwell, 1970; Varley & Gradwell, 1971; Southwood, 1978; Bellows *et al.*, 1992). A life table is nothing more than an account of the survivial of a pest as it develops from the egg through to the adult stage. Life tables can tell us not only how many pests die in a particular generation from a natural enemy, but they can also tell us what proportion of the generational mortality that is, and how it compares to other mortalities acting before, at the same time, or afterwards. Where two or more factors act contemporaneously in a stage, additional information (e.g. the temporal order of attack, the outcomes of attack by two agents, the degree to which one agent avoids hosts previously attacked by another agent) is required to permit separate calculation, of the impact of each agent (Royama, 1981). This gives us a clear understanding of how significant the natural enemy is in controlling the pest.

The univoltine AEM was accidentally introduced into British Columbia in 1981. It has scince spread to commercial apple-growing valleys in the BC interior. Biological control appers highly desirable as pesticide applications to suppress this introduced pest in commercial orchards could disrupt established integrated control programmes in Canada. As *Y. malinellus* is known to have many natural enemies in Europe, a survey of potential biological control agents was undertaken at the request of Agriculture and Agri-Food Canada. The need for an accurate assessment of parasitoid impact is obvious. Without it we cannot understand the contribution of natural enemies and we cannot determine which parasitoid species are more effective. This paper demonstrate the use of life tables to measure the impact of natural enemies of an apple pest in central Europe.

Methods

In southwestern Germany at Biebesheim, samples of *Y. malinellus* were taken in each of the six life stages (L1-L5 and pupae) in 1993 from 29th of April to 11th of June and in 1994 from 28th of April to 19th of June. The study site is a 1.5 square kilometre grass covered apple orchard situated 100-200 m from the Rhine River. It contains unpruned, unevenly spaced (10-20 m), 8 metre high trees, ranging from 50 to 60 years old.

Ten trees selected at random were sampled. Each tree crown was divided into an upper and lower canopy and each half was divided into four equal quadrants according to the four cardinal points of the compass. This provided eight sampling sections within the tree crown. From each section 30 leaf clusters were collected at random and examined for AEM tents. Estimates of densities were therefore obtained concurrently by direct sampling. Seven host age classes were assessed, namely, eggs, first instar to fifth instar larvae and pupae. Sampling occurred when numbers in a single age class were at a maximum within leaf cluster (i.e. not between a molt). All the collected host larvae and pupae per tent were counted, and reared under outdoor conditions in Delémont, Switzerland to determined the rate of parasitism by parasitoid species and the host stages attacked. Maximum rates of parasitism of parasitoid species, observed from any of the samples taken during the season, were introduced in the life tables as a mortality factor ("parasitism"). The parameters used in the life table are as follows: (see Southwood, 1978; Bellows *et al.*, 1992). Real mortality is the fraction of hosts dying in each stage (d_x) related to the number initially entering the first stage in a life table (l_0): i.e. real mortality=d_x/l_0. This column in a a life table sums to the total mortality across all stages. Apparent mortality (q_x) is the fraction dying in a stage related to the number entering the same stage, or that dying from a factor related to the number that is subjected to that factor (i.e. $q_x=d_x/l_x$) Two general approaches are available for quantifying marginal attack rates for contemporaneous factors: (1) the marginal attack rate can be measured directly as they occur by measuring recruitment for each agent (e.g. by dissections) (Van Driesche *et al.*, 1991); (2) the marginal attack rate can be calculated from the observed death rates of individuals succumbing to the various factors (Royama, 1981). The K-values are survival rates on a logarithmic scale and are the negative logarithm of 1 - marginal attack rate for a factor. K is the total mortality or generational mortality. It is equal to the sum of all factors of k-values. It is also equal to the negative logarithm of total survival. Fertility estimates allow the construction of complete life tables, which then permits the calculation of the net reproductive rate (R_0). Such parameters integrate the effects of all existing mortality and fertility into a single value. Values of R_0 less than one indicate declining populations, while values greater than one indicate increasing populations.

Results

The AEM abundance reached on an average 0.73 ±0.07 SE tents per 30 leaf clusters in 1993 and 0.53 ±0.04 SE tents per 30 leaf clusters in 1994. For the AEM study site in Biebesheim, life tables were constructed for 1993 and 1994 (Table 1 and 2).

The generational mortality in 1993 is K = 0.438 + 0.217 + 0.056 + 0.006 + 0.056 + 0.177 + 0.305 = 1.255. The sum of the k-values (K) is also expressed as the negative logarithm of total survival (-log 435/7812). The predators, which caused the death of 4960 eggs, have a k-value of 0.438. 63.5% of *Y. malinellus* in that generation are killed by predators, and this equals 0.438/1.255x100 = 34.9% of the total generational mortality. The parasitoids have a k-value in the fifth larval stage of 0.117 (= 3.8% real mortality) and in the pupal stage of 0.121 (= 2.3% real mortality). Thus parasitoids killed 6.1% (real mortality) of the pests in this generation and this equals 19.0% (0.238/1.255x100) of the total generational mortality. In total, death of AEM by natural enemies accounted 53.9% (0.438 + 0.238/1.255x100) of the total generation mortality in 1993.

The generational mortality in 1994 is K = 0.442 + 0.217 + 0.155 + 0.017 + 0.005 + 0.060 + 0.299 = 1.195 (= -log 403/6332). The egg mortality has a k-value of 0.442 (= 63.9% real mortality), hence 37.0% (0.422/1.195x100) of the generational mortality (K). The parasitoids, which caused the death of 80 fifth instar larvae and 157 pupae of *Y. malinellus*, have k-values of 0.040 and 0.117, respectively. Thus, parasitoids killed 1.3% + 2.5% = 3.8% of the pests (real mortality) in this generation, and this equals 13.1% (0.157/1.195x100) of the generational mortality. The impact of all natural enemies accounted for 50.1% of the total generation mortality in 1994.

Fertility estimates of the pest allow construction of complete life tables. The total egg number per female varied from 7 to 131 (mean=52 ±5.9 SE, n=22) in 1993 and from 7 to 151 (mean=75 ±9.4 SE, n=20) in 1994. The reduced reproduction in 1993 may have resulted from effects of weather. The influence of abiotic factors, temperature and rainfall, on the population ecology of the AEM will be reported at another time.

Discussion

This paper presents results of estimations of parasitoid and predator impacts on AEM in Europe. The host abundance at the collection site was less than 3 tents per 100 leaf cluster in 1993-1994 and over 4 in 1995. Control is necessary when 3-5 larval tents per 100 leaf cluster sampled from one tree occur (Baggiolini *et al.*, 1980). The current study observed a *Y. malinellus* population at a low density level.

In Europe, *Y. malinellus* can be attacked by a number of primary parasitoids. In earlier studies the number of parasitoids varied from 5 to 9 species. For instances, Pag (1959) in Germany and Junnikkala (1960) in Finland reported 5 species; Dijkerman *et al.* (1986) in the Netherlands found 9 species In the present study, *Y. malinellus* populations were attacked by 7 different primary parasitoid species at Biebesheim in Germany. A comparison of the parasitoid complexes of *Y. malinellus* based on these studies indicated that 3 primary parasitoid species (*Ageniaspis fuscicollis* Dalman, *Diadegma armillatum* Gravenhorst, *Herpestomus brunnicornis* Gravenhorst) of AEM were common and widely distributed in Europe.

Insects predators in the present study were abundant, particularly on AEM egg batches. Life tables indicate that the impact of these predators reached 34.9% in 1993 and 37.0% in 1994 of the total generational mortality of *Y. malinellus*. Based on the results of this study and according to Unruh *et al.* (1993) data suggest that endemic polyphagous predators in Europe and in the western United States do produce significant mortality. These generalist predators may be largely responsible for preventing even more damaging levels of *Y. malinellus* in the western United States (Unruh *et al.*, 1993).

The impact of the parasitoids in relation to the total generational mortality of *Y. malinellus* was studied. Results presented indicate that parasitoids killed 6.1% of the AEM in the generation in 1993 and 3.8% in 1994. This is equivalent to 19.0% in 1993 and 13.1% in 1994 of the generational mortality. From parasitoids that were reared, the ichneumonid *Herpestomus brunnicornis* Gravenhorst and the oligophagous egg-larval parasitoid *Ageniaspis fuscicollis* Dalman were selected as potential biological control agents. The encyrtid *A. fuscicollis* has already been introduced and established into Canada. Its impact remains to be determined in British Columbia (Schmidt, pers. commmunication, 1995). *Herpestomus brunnicornis* is a common larval-pupal and a pupal parasitoid of *Y. malinellus* and a candidate species for introduction into British Columbia because it is oligophagous, restricted in its host range to the genus *Yponomeuta*, is univoltine and therefore well-synchronized with its host and occupies a wide geographic range. *Herpestomus brunnicornis* should be introduced into British Columbia as a mortality factor in AEM populations in addition to the parasitoid *A. fuscicollis*, especially since it is known from Unruh *et al.* (1993) that the constant low levels of parasitism by polyphagous endemic and already present exotic parasitoid species will not control *Y. malinellus* in western United States. Unruh *et al.* (1993) mentioned that introduced parasitoid species may eventually contribute to lowering populations to densities more closely approximating those in Europe.

Results of the life tables indicate that natural enemies (including predators and parasitoids) accounted for 53.9% in 1993 and 50.1% in 1994 of the total generational mortality of *Y. malinellus*. In addition it was mentioned that the reproduction of the AEM may significantly influenced from abiotic factors. Life tables studies have to be continued to carry out a key-factor analysis. This is a procedure to identify those mortality factors that are most responsible for change in population density between years (Morris, 1959; Varley & Gradwell, 1960; Podoler & Rogers, 1975).

Acknowledgements

I would like to thank Dr Klaus Carl for his invaluable contributions and discussions during this work. I am very grateful to Prof Nick Mills whose helpful ideas have improved my life table constructions. The laboratory and field help of Andrea Raps, Dirk Babendreier, Stephanie Erb and Heike Gose is greatly appreciated. I wish to express very special thanks to Stephanie Erb for help in improving the English text. I wish to thank the following specialists for determination of parasitoids: Prof Klaus Horstmann (ichneumonids), Dr Stefan Vidal (encyrtids, eulophids, elasmids), and Dr Hans-Peter Tschorsnig (tachinids). This study was supported by Agriculture and Agri-Food Canada.

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Table 1. Life table for *Yponomeuta malinellus* at Biebesheim, Germany, 1993

Stage	Factor	Stage l_x	Stage d_x	Factor d_x	Marginal death rate	Apparent mortality Stage q_x	Apparent mortality Factor q_x	Real mortality Stage $d_x l_0$	Real mortality Factor $d_x l_0$	k-Value Stage	k-Value Factor
Egg		7812	4960			0.635		0.635		0.438	
	Predation			4960	0.635		0 635		0.635		0.438
L1		2852	1120			0.393		0.143		0.217	
	Unknown factors			1120	0.393		0.393		0.143		0.217
L2		1732	211			0.122		0.027		0.056	
	Unknown factors			211	0.122		0.122		0.027		0.056
L3		1521	21			0.014		0.003		0.006	
	Unknown factors			21	0.014		0.014		0.003		0.006
L4		1500	181			0.121		0.023		0.056	
	Unknown factors			181	0.121		0.121		0.023		0.056
L5		1319	441			0.334		0 056		0.177	
	Parasitism			293	0 237		0 222		0 038		0.117
	Residual			148	0.127		0.112		0.019		0.06
Pupae		878	443			0.504		0.057		0.305	
	Parasitism			176	0 243		0 201		0 023		0.121
	Residual			267	0.346		0.304		0.034		0.184
Adults		435									
	Sex ratio	0.467									
Adult female		203									
	Potential fertility	115									
Potential progeny		23345	12789			0.548					
	Realized fertility	52		12789			0.548				
Actual progeny		10564									
Ro		1.35									

Table 2. Life table for *Yponomeuta malinellus* at Biebesheim, Germany, 1994

Stage	Factor	Stage l_x	Stage d_x	Factor d_x	Marginal death rate	Apparent mortality Stage q_x	Apparent mortality Factor q_x	Real mortality Stage $d_x l_0$	Real mortality Factor $d_x l_0$	k-Value Stage	k-Value Factor
Egg		6332	4046			0.639		0.639		0.442	
	Predation			4046	0.639		0.639		0.639		0.442
L1		2286	899			0.393		0.142		0.217	
	Unknown factors			899	0.393		0.393		0.142		
L2		1387	417			0.301		0.066		0.155	
	Unknown factors			417	0 301		0.301		0.066		0.155
L3		970	37			0.038		0.006		0.017	
	Unknown factors			37	0.038		0.038		0.006		0.017
L4		933	10			0.011		0.002		0.005	
	Unknown factors			10	0.011		0.011		0.002		0.005
L5		923	120			0.13		0.019		0.06	
	Parasitism			80	0 089		0 087		0 013		0 04
	Residual			40	0.045		0.043		0 006		0.02
Pupae		803	400			0.498		0.063		0.299	
	Parasitism			157	0 237		0 196		0.025		0.117
	Residual			243	0.304		0.302		0.038		0.182
Adult		403									
	Sex ratio	0.508									
Adult female		205									
	Potential fertility	115									
Potential progeny		23575	8200			0.348					
	Realized fertility	75		8200			0.348				
Actual progeny		15375									
Ro		2.43									

DO NATURAL ENEMIES CONTROL WOOLLY APPLE APHID?

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Abstract
To prevent unnecessary spraying and to promote biological and natural control of Woolly Apple Aphid (WAA) more knowledge has to be obtained about the role of natural enemies. Therefore, a model has been developed that integrates biology and lifecycles of WAA and its most important natural enemies *Aphelinus mali, Forficula auricularia* and *Exochomus quadripustulatus*. With exclusion and feeding experiments it is tried to qualify and to quantify the relative role of the various natural enemies of WAA. Observations showed that in early springtime *E. quadripustulatus* and during the summer *F. auricularia* and sometimes *C. septempunctata* play an important role. Parasitization level by *Aphelinus mali* in springtime is often too low to be effective in time for the farmer although during summertime parasitization may be high. Simulations revealed WAA/natural enemy ratios necessary for control.

Introduction
In apple orchards aphids play an important role. The most important species are the rosy-apple aphid (*Dysaphis plantaginea*), the woolly apple aphid (*Eriosoma lanigerum*), the green apple aphid (*Aphis pomi*), the apple grass aphid (*Rhopalosiphum insertum*) and the rosy leaf curling aphid (*Dysaphis devecta*). Their numbers fluctuate strongly from year to year depending on biotic (natural enemies, host plant) and abiotic factors (temperature, rainfall etc). In the Netherlands natural control of apple aphids is not dominated by a single factor as non of these factors can separately keep the aphid densities constantly under an acceptable level for the fruitgrowers. Therefore, the aphids are often controlled by means of spraying with Pirimicarb. To prevent unnecessary spraying and to promote biological and natural control of pests more knowledge has to be obtained about the role of weather and natural enemies and their interactions on the development of aphid populations. To gain more insight in the role of the various factors on the population dynamics of apple aphids, research has been started with unraveling on the population dynamics of the Woolly apple aphid (*Eriosoma lanigerum* Hausmann), one of the important aphid pests in the Netherlands.
To be able to quantify the role of these factors on population fluctuations of WAA, a simulation model has been developed which aims at explaining quantitatively the influence of these various factors on population density of WAA. Feeding experiments have been executed with earwigs and ladybird beetles to assess their potential role as controlling agent. Especially to make an assessment of the WAA/natural enemy ratios at the moment that the natural enemies emerge or become active in the tree. This is important for the decision whether a chemical treatment is necessary or not.

Woolly apple aphids and their natural enemies.
Woolly apple aphid (WAA) originates from North- America and has spread over the fruit growing areas of the world during the last centuries. The life cycle of WAA in the Netherlands is complete asexual because the winterhost (*Ulmus americana*) is lacking here. The offspring is parthenogenic produced, males are absent.
The parasitoid *Aphelinus mali* (Hald.) has been introduced in most of these areas to control WAA with more or less success, probably depending on the climatological conditions. The WAA has 10-11 generations per year, while the parasitoid has only 4-5. The aphid is also attacked by various predator species. With exclusion experiments it is tried to qualify the relative role of the various natural enemies of WAA (Mueller et al.,1988) It seems that in springtime the Pine ladybird beetle (*Exochomus quadripustulatus* L.) and during the summer the European

earwig *(Forficula auricularia* L.) and sometimes the seven-spot ladybird (*Cochinella septempunctata* L.) play an important role. Other predators like lacewings, hoverflies and the mite *Allotrombium* have sometimes be seen feeding on WAA but their role is not clear. These natural enemies may interact strongly. The earwig preys upon all stages of WAA and on other aphid species, also on parasitized aphids and on mummies of A.mali. Therefore, it may affect the role of *A. mali*. The ladybird *E. quadripustulatus* has a preference for WAA but can also be found eating on other aphids. Mummies with *A. mali* are not eaten but larval stages of *A. mali* in the aphids are. Thus we have an interesting system containing an aphid species whose population fluctuations mainly are governed by: weather factors, tree condition, a monophagous parasitoid *A. mali*, oligophagous ladybird beetles and a very polyphagous earwig.
The question here is what is the relative role of these factors in the population dynamics of WAA. Is it mainly the abiotic factors that determine the numbers of WAA or are they mainly regulated by biotic factors. Depending on the results of this research practical questions concerning effective WAA/natural enemy ratios can be answered and the role of alternate food (the other aphid species) can be estimated.

Approach of the problem.
To be able to quantify the role of these factors on population fluctuations of WAA more insight has to be obtained into population growth with and without natural ennemies. Therefore a multispecies simulation model is developed which aims at explaining quantitatively the influence of these various factors on population density of WAA.

Abiotic factors.
Concerning WAA the following life hostory data are built onto the model: A)The developmental rates of the nymphal stages with their dispersion (Walker,1985; Bodenheimer,1937); B)Age dependent reproduction (Walker, 1985; Evenhuis, 1958; Bonnemaison, 1965; Ehrenhardt, 1940); c) Mortality especially of the crawler stage, all in relation to temperature. The mortality of WAA in winter differs for the various stages of WAA. The younger the stage the higher its resistance for frost which may partly explain that after soft winters the chance for WAA outbreaks is higher (Jancke,1935; Ehrenhardt, 1940; Kjellander,1953). Above 15 °C the first instar nymphs (the crawlers) leave the colony and swarm out in search for the young shoots where they try to establish a new colony (Hoyt and Madsen,1960). From our experiments it became clear that during this phase mortality is very high. In the laboratory 40% succeeds in founding a new colony, while in the field only 5% is able to do so. A single wheather factor has not yet been found it is more a combination of of them.
Concerning the biology of the parasitoid *Aphelinus mali:* A) The developmental rates of the larvae in the host depending on temperature and on the age of the stages (Mueller et al, 1993); B) Induction and break of diapause (Trimble et al,1990).
Concerning the earwig and the ladybird: A) Survival of the adult stages in relationship to temperature; B) Developmental rates of the larval stages and their dispersion. This especially important for earwigs as they are present in moderate to high numbers (20-100 earwigs per tree) independently of the amount of aphids.

Biotic factors.
The influence of the the apple tree.
The apple tree as hostplant of WAA may have a strong influence on the performance of WAA. A) Resitance: Apple varieties exist which are partially resitant to WAA. Resitant rootstocks inhibit the hibernation of WAA on the roots during winter. The effect on life history data can be brought in easily but up to now the relationships hold for cv's Golden Delicious and James

Grieve. B) Plant condition (governed by ferlilization and moisture) may affect longevity and reproduction, but data are lacking. C) WAA induces gallforming on the tree. These galls are a better feeding place for WAA leading to higher reproduction. This relationship is not included into the model

Natural enemies

For the role of the natural enemies the following information is necessary for the model:

Aphelinus mali: A) Sexratio depending on the size of the host stage (Mueller et al. 1993) B) Parasitization rate in relation to weather factors and aphid density (Evenhuis,1958). Data for a functional response is lacking. A simple Holling I is assumed with a level depending on maximum parasitization and temperature.

Predators: For this model especially data on feeding behaviour of the predators and on the preferences for aphid stages and other aphid species is necessary. Therefore, investigations have been carried out to fill up this lack in knowledge.

a) Searching and feeding rate with respect to WAA as food (Noppert et al. 1987)
b) Conversion of food to weight gain and reproduction (esp. for E.quadripustulatus)
c) Preference for WAA with respect to alternative food (has to be carried out)
d) Induction and break of diapause.

Up till now the biology of WAA, *A. mali* and the earwig are integrated into the model (Mols,1993). Only the feeding behaviour of adult ladybird *E. quadripustulatusis* is taken into account as it determines the initial amount of WAA at the beginning of May.

Preliminary results of simulations.

1) Temperature and WAA population growth.

The population development of WAA without natural enemies depends mainly on the prevailing temperature. The temperature during the winter determines strongly the mortality and hence the stage composition of the population. After severe winters mainly the first instar nymphs survive and consequently reproduction starts just after the development period needed to reach the adult stage is fulfilled. During soft winters also the adults do survive and thus reproduction starts inmediately when temperatures exceeds the threshold for reproduction.

2). *Aphelinus mali* and WAA.

The parasitoid A. mali may control WAA only when she exceeds a specific ratio to WAA at the moment of emergence from diapause.

Table 1. The results of simulations for the years 1986-1995 are given. The simulation is started at the first of Januari with 100 WAA in a stable stage distribution (nl. L1=65 , L2=16, L3=8, L4=6, adult=5)

	Break of diapause				A.mali
year	daynumber	date	TS>9.4	Aphid number	females required to achieve control
1986	133	13 may	91	38	1.2
1987	126	6 may	92	15	0.5
1988	128	7 may	91	696	14
1989	129	9 may	92	934	20
1990	117	27 april	96	1209	27
1991	106	16 april	124	138	4
1992	136	15 may	97	578	10
1993	118	29 april	94	446	10
1994	132	12 may	92	489	10
1995	126	6 may	97	789	18

With a sex ratio (m/f) of A. mali of 1, a ratio of Eriosoma/Aphelinus mummies less than 23 is required at break of diapause to achieve control later in the season

3). Earwigs and WAA.

Earwigs enter the tree in the third larval stage in the course of June depending on the previous temperature. The number of WAA present at that moment determines the amount of earwigs needed to achieve control. One L3 larva consumes about 1 mg WAA per day, and the average weight of WAA is 0.29 mg (measured over all the stages). The results are shown in Table 2. The simulation starts with the same conditions as in Table 1.

Table 2.

year	50% of earwigs enter the tree daynumber	date	Aphid number	Number of Earwig L3 larvae required to achieve control	Ratio
1981	172	20 june	12023	222	54
1984	181	1 july	4186	79	53
1985	175	23 june	56	2	28
1986	169	17 june	794	15	53
1987	172	20 june	341	11	31
1988	154	1 june	14892	280	53
1989	158	5 june	7567	117	64
1990	162	10 june	23364	447	52
1991	172	20 june	3124	50	63

MeanWAA/earwigratio=50

4). *Exochomus quadripustulatus* and WAA.

To get an estimation concerning the role of E. quadripustulatus the following reasoning is followed using observations in the field and laboratory. The Ladybird is active at temperatures above 10 °C and when active it increases in weight in the pre-oviposition period. In the field this period last from the beginning of March to the middle of April depending on temperature. At constant temperatures the duration at 12 °C is 42±13 days, at 15 °C 18±5.4 days and at 20 °C 11±4 days. The weight gain is about 3.5 mg. Respiration at 20 °C is about 0.05 mg/ day, thus 11*0.05=0.55mg in total is needed for metabolism. Conversion of aphids to beetle weight (ECI) is about 0.2. Together this gives 4/0.2= 20 mg of aphid weight that potentially can be consumed.

Mainly young stages (N1-N3) are present during that period. Their average weight=0.16 mg, thus in their pre-oviposition period 20/0.16=125 young aphids can be consumed by one ladybird. In the winters of the years 1989, 1990, 1991 and 1992 *Exochomus* was present in the trees at an average 2-4 ladybirds/tree. In 1994 6 ladybirds were counted per tree while in the spring of 1995 only 0.5 per tree were present. The initial amount of WAA at that time of the year is between 50-250 aphids per tree (James Grieve, 25 years old, 3 meter tall). The conclusion is that by their feeding early in the year they may reduce the initial amount of WAA considerable.

Validation of the model in the field.

a) Simulations of development of WAA populations without natural enemies follow the situation in the field.

b) Exclusion experiments in the field revealed that earwigs are very important predators of WAA (Mueller et al.,1988), but the ratios that may lead to control still have to be verified.

c) *A. mali* is completely outnumbered by WAA after soft winters which agrees with field observations.

Conclusions.

The study of woolly apple aphid and its natural enemies leads to the following conclusions. Winter conditions determine the initial amount and the stage distribution of the aphids. This determines the potentials of WAA to reach the pest status in the course of the year.

The ladybird *E.quadripustulatus* is important at the start of the growing season and determines the initial amount of WAA. *Exochomus* can live on other aphid species as well. In fact it is known as a good predator of scale insects in Southern Europe (esp. Olive scale). This implies

that alternate food sources may influence its role in controlling WAA. Its number in spring is determined by the number of WAA in the previous year.
Earwigs are important from the moment they arive into the tree from the beginning of June to the middle of August. Their number relative to the number of aphids present at that moment determines its success..
The parasitoid *Aphelinus mali* is not well synchronized with WAA under the Dutch climatological conditions. After a warm winter it will be complete outnumbered by WAA if the predators are not present. The combination of predators and the parasitoid controls in most years the WAA population growth. Only after warm winters in absence of Exochomus a pest status can be reached.
Studies concerning interactions of natural enemies still have to be done because it is not just a summation of their seperate roles towards WAA, but they may also be counter productive, because earwigs eat *A. mali* mummies. The condition of the host, which may influence development rate and fecundity of WAA, is still an unknown factor in the system, especially when the orchard has no watering or vertigation system so that dry spells may occur that hamper the sap flow in the trees and thus the food intake of the aphids.

Aknowledgements: I thank Dick Diederik who programmed the model and many students who did an exellent job collecting data at the experimental orchard "de Schuilenburg"

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Lady Beetles (*Coleoptera, Coccinellidae*) of Leningrad Region Orchards (Fauna, Biology and Their Role in Pest Population Dynamics)

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Key-words: orchards, coccinellids, fauna, biology, aphids.

Abstract

As a result of long-term observations in the Leningrad region orchards the following species of coccinellids were found: *Adalia bipunctata L., Coccinella septempunctata L., Calvia quatuordecimguttata L., Coccinella quinquepunctata L., Propylea quatuordecimpunctata L., Adalia decempunctata L., Chilocorus renipustulatus Scriba, Ch. bipustulatus L., Stethorus punctillum Ws.* and *Coccinula quatuordecimpustulata L.*

Adalia bipunctata is the most numerous species and plays a very important role in reducing the population of *Aphis pomi Deg.* and *Disaphis dewecta Walk.* on apple-trees; *Hyalopterus pruni Geoffr.* and *Brachycaudus helichrysi Kalt.* on garden plum; *Hyperomyzus lactucae L., Cryptomyzus ribis L.* and *Nasonovia ribisnigri Mos.* on red and black currant; *Myzus cerasi F.* on sour cherry; *Aphis idaei Goot* on raspberry and *Aphis grossulariae Kalt.* on gooseberry. *C. quatuordecimguttata* is a facultative predator of different species of psyllids and plays an important role of reducing the number of *Psylla mali Schmdb. Ch. renipustulatus* and *Ch. bipustulatus* consume *Lepidosaphes ulmi L.* on apple-trees and *Chionaspis salicis L.* on apple-trees, currant and gooseberry. *S. punctillum* consumes *Metatetranychus ulmi Koch.* on apple-trees.

Material and Methods

Field observations and collections of adult coccinellids were in Lenigrad region orchards in 1962-1975 years. In laboratory the beetles and larvae were fed on aphids *A. pomi* and *H. Pruni* and on *P. mali.* All laboratory experiments were done in special boxes with regulated temperature and photoperiod.

Results

In the north-western part of Russia, where the Leningrad region belongs, aphids, psyllids, mites and scales are the main pests that damage fruit production. Predatory coccinellids play a very important role in population dynamics of these pests. As a result of long-term observation the author distinguished the next lady beetle species in the region (Table 1).

A. bipunctata is the most numerous species, and is distributed everywhere in the region. In orchards and fruit plantations this species plays a big role in decreasing of populations of *A. pomi* and *D. dewecta* on apple-trees; *H. pruni* and *B. helichrysi* on garden plum; *H. lactucae, C. ribis* and *N. ribisnigri* on red and black currant; *M. cerasi* on sour cherry; *A. idaei* on raspberry and *A. grossulariae.* on gooseberry. It develops in two generations: the first at May-June, and the second at July-August. The beetles of both generation overwinter. Duration of the life cycle under 20° C was 29.0±0.5 days, with maximum as 30 and minimum as 28 days. Each larva of the 4th instar consumed 61.0±1.7 4th instar nymphs of *A. pomi* and 50.0±3.5 of *H. pruni* daily, and an adult beetle 50.0±1.2 and 37.5±0.9 of the same species accordingly (Semyanov, 1970).

Table 1. Coccinellid species and their quantitative numeration in orchards and fruit plantations.

N	Species	Per cent from the whole number of beetles
1	A. bipunctata	50.3
2	C. septempunctata	16.3
3	C. quatuordecimguttata	12.8
4	C. quinquepunctata	6.6
5	P. quatuordecimpunctata	6.2
6	A. decempunctata	2.3
7	Ch. renipustulatus	1.7
8	S. punctillum	1.7
9	C. quatuordecimpustulata	1.3
10	Ch. bipustulatus	0.8

C. septempunctata is the second species after *A. bipunctata* in the number of beetles. It plays a big role in decreasing of populations of *A. pomi* and *D. dewecta* on apple-trees; *M. cerasi* on sour cherry; *A. grossulariae* on gooseberry, *H. pruni* on garden plum and *A. idaei* on raspberry. It develops as one generation only. The data of effect of temperature on the duration of development of *C. septempunctata* is represented at the Table 2.

Table 2. The effect of temperature on the duration of the development of *C. septempunctata.*

T°, C	Length of development, days			
	egg	larva	pupa	total
15	11	43	16	70
20	5	18	7	30
25	3	11	4	18
30	2.2	8	2.8	13
35	1.75	6.25	2	10

Each larva of the 4th instar consumed 67.0±3.0 aphids of *H. pruni* and 83.0±1.0 of *A. pomi* daily, and adult beetle 36.0±1.0 and 51.0±2.0 aphids of the mentioned species accordingly.

C. quatuordecimguttata is an effective predator on *P. mali* and decreases the number of pests as mush as up to 40-50% at some years. It develops as one generation and possesses as obligatory diapause (Semyanov, 1980).

C. quinquepunctata consumes *A. pomi* and *P. mali* on apple-trees, *M. cerasi* on sour cherry and *A. grossulariae* on gooseberry. It develops as one generation. Biology of the species is not studied in detail as yet.

P. quatuordecimpunctata consumes *A. pomi* on apple-trees and on hawthorn; *P. mali* on apple-trees, *A. grossulariae* on gooseberry, *H. pruni* on garden plum; *H. lactucae* and *C. ribis* on currant. It develops as two generations but at some years only one generation can be observed. Duration of the life cycle under 20° C is 29 days, that corresponds to the data by Olszak (1986), under 25° C - 17, and under 30° C - 10 days. Each larva of the 4th instar consumes 54±2.4 aphids of *A. pomi,* that corresponds to the data by Olszak (1988) and an adult beetle - 54.0±2.3 aphids daily.

Ch. renipustulatus and *Ch. bipustulatus* play a big role in decreasing the number of such dangerous pests as *L. ulmi* and *Ch. salicis* on apple-trees, currant and gooseberry. Both species develop as one generation, they usually occupy the same inhabitancy and their biology is very similar. But an efficacy of these species is very often increased because of pupae being highly infected by a parasite *Tetrastichus neglectus Dom.* (up to 40%).

S. punctillum is a predator of *M. ulmi* on apple-trees. But it doesn't play any meaningful role in control of mites populations because the number of *S. punctillum* is relatively low.

In a whole, positive role of coccinellids as well as other zoophagous arthropods one can calculate as an increase in crops or healing of physiological state of a plant that is equal to elimination of damage caused by a part of pest population destroyed by predators. In order to check this statement I performed a special experiment on four apple-trees of *"Papirovka"* strain. All the trees were infected by *A. pomi.* In a coarse of experiment all coccinellids were removed from the trees and afterwards 10 branches on each tree were isolated by a nylon net each. Then inside each net isolator on 2 trees 50 larvae of the 1st instar of *A. bipunctata* were introduced. Two other trees were left without lady beetles inside the isolated volumes. Together with this, all the egglays, larvae and adult beetles were removed from the two mentioned trees during all summer season. In all the isolated volumes with lady beetles larvae aphids were absent till the middle of July while the volumes without coccinellids aphids grew in number so numerously that they had covered branches and leaves as a complete layer of insects. At the end of September when the process of vegetation was over I had measured an annual growth in 50 branches and the area covered by 100 leaves (10 leaves from each isolated volume) in each of the trees. More than that I had measured a contents of sugar and nitrogen in the leaves from the isolated areas in all the four trees. The results obtained in my experiments are represented at Table 3. From the data at this table one can see that an activity of coccinellids brings to decreasing in number and, hence, harmfulness of aphids *A. pomi* and the process in its turn leads to better conditioning of trees: annual growth of branches and leaf area increase as well as photosynthetic activity and, hence, content of sugar and nitrogen in fruits.

Table 3. Damage caused by *A. pomi* on apple-trees
(data on two trees, are summarised means and SEM are shown).

Parameters of an apple-tree	Trees without coccinellids	Trees with coccinellids
Leaves area, cm^2	12.7±0.8	22.2±1.4
Annual adherence, cm	17.3±0.5	22.6±0.7
Contents of sugar, % for absolutely dry substance	4.85	6.87
Contents of nitrogen, % for absolutely dry substance	1.98	2.2

Conclusions

But together with this the role of coccinellids as pest controls varies due to climatic factors. When the summer is hot and dry the main part of *C. septempunctata* and *C. quinquepunctata* populations develop on grass and it brings to a decrease of coccinellids number in orchards. And, vice versa, when the summer is cold and moist most of the lady beetles of two species mentioned above prefer trees. As a result one can distinguish an increase in the number of coccinellids in orchards and, hence, their positive role in pest control. The use of phosphate organic pesticides and pyrethroids for control of pests bring to a high mortality of coccinellids and suppresses their positive efficacy.

In order to protect coccinellids and increase their role as effective control agents I can offer the next:

- chemical treatment against pests one has to perform on overwintering stages only, that means at an early spring period when coccinellids are absent in orchards;
- one must use only selective pesticides for an aphids control;
- in the orchards where the number of apple-eater (*Carpocapsa pomonella L.*) and leaf destroying pests is low, good and fruitful results can be obtained by a "ribbon" treatment (two to three rows).

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THE EXTRAORDINARY LIFE HISTORY OF *SCAMBUS POMORUM* (HYMENOPTERA, ICHNEUMONIDAE): PARASITOID AND PREDATOR.

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Scambus pomorum (Ratzeburg) is a well known ectoparasitoid of the larva of the apple blossom weevil *Anthonomus pomorum* (L.) (Coleoptera, Curculionidae), which lives concealed in a unopened flower bud, the capped blossom. It also parasitises the pear bud weevil *A. piri* Kollar. Several authors described the biology of the parasitic juvenile stages, but failed to keep adults alive after emergence and mating (Imms, 1918; Speyer, 1926). In our research, we succeeded in completing the life cycle of the species.

We collected parasitised *A. pomorum* and emerged adults were kept in cages in an outdoor insectary. Mating occurred from the day of emergence. All males died within a few weeks, despite the presence of honeywater as food. Females, under these conditions, lived longer. They were offered, besides honeywater as carbohydrate source, various insect larvae. Larvae of the related strawberry blossom weevil *A. rubi* Herbst were not accepted by the females, nor were exposed caterpillars of several Lepidoptera. On the concealed larvae of some leaf miners, however, a typical behaviour was observed. After the female found a leaf mine, the ovipositor was pierced into the larva at once, through the epidermal layer on either side of the leaf. Holding the larva in position with the ovipositor, the leaf epidermis was scraped off with the mandibles. The female subsequently fed from the haemolymph that emerged from the larva, sometimes after damaging the larval skin with the mouthparts. The feeding period was quite variable and often took about 20 minutes, during which the wasp was not readily disturbed.

S. pomorum appears to be a polyphagous predator. Leaves of various plants and trees containing mines of different species were offered to the wasp. Larvae of the same leaf miner genus, *Phyllonorycter* spp. (Lepidoptera, Gracillariidae), on leaves of 4 different tree families, were all accepted as prey. Mining larvae belonging to different insect orders, Diptera, Lepidoptera and Hymenoptera, on the same tree species (*Malus sylvestris* Miller or *Alnus incana* (L.) Moench) were also accepted. In general miners on trees were attacked, and on herbs were not. Females fed this way through summer were dissected and their ovaries appeared to be as undeveloped as they were at emergence.

Before winter, the adult females were provided with small conifers (*Chamaecyparis* sp.) in their cages. Hidden in these trees, the females overwintered. They were again observed in a sunny corner of the cage in March.

In a laboratory experiment it was found that after winter females fed on both host (*A. pomorum*) and non-host (*Phyllonorycter blancardella* (Fabricius)) larvae. Females provided with either prey were ready to lay eggs after 5 days at 16°C, on *A. pomorum* only, whereas females provided only with honey water needed another 5 days of host-feeding to mature their ovaries.

In conclusion, feeding on leaf miners does not result in ovarial development until after hibernation. Oviposition is restricted to host larvae, that also become available after winter. So no second generation is passed in the year of emergence and feeding on leaf miners can be regarded as true predation, in contrast to host-feeding. The detailed results of this study are currently prepared for publication.

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NATURAL CONTROL OF TENTIFORM LEAFMINER *PHYLLONORYCTER BLANCARDELLA* IN DUTCH APPLE ORCHARDS.

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ABSTRACT

Some observations in recent years are presented to illustrate the basic pest status of the tentiform leafminer *Phyllonorycter blancardella* in Dutch apple orchards. They show that the densities of this species permanently stay at an innoxious level in non-treated orchards, corroborating similar experiences in some other countries, like Hungary and Canada.

Comparison of the adult numbers captured during successive generations in suction or pheromone traps with the levels of larval parasitism suggests that parasitism is the dominatig mortality factor during the 1st larval generation, but less so during overwintering. The parasitoid species involved hardly differ from those observed elsewhere in Europe. Pesticide side effects should be avoided on the more abundant ones during their first flight around blossom time.

INTRODUCTION

The spotted tentiform leafminer (STL) *Phyllonorycter blancardella* (Fabr.) (Lepidoptera: Gracillariidae) is a common insect on apple in temperate regions of both Europe and North America (Baumgärtner *et al.*, 1981; Maier, 1994). Its densities in non-treated orchards are usually low. When outbreaks occur in treated orchards these are generally associated with the use of pesticides which are (increasingly) tolerated by the leafminer and less so by its natural enemies (also Balàzs, 1989). In this respect, parasitoids are considered of major importance (a.o.Van Driesche *et al.*, 1994).

Although STL is found in virtually every Dutch apple orchard, it rarely or never demands chemical control. In apple IPM, this is at least partly due to the side effects of other pesticide applications, notably those of fenoxycarb and some acylurea's (Blommers, 1994) against tortricids and other lepidopterous pests.

Over the last ten years, we have regularly followed the densities of STL and its parasitoids in the experimental orchard. Densities of STL remained low in the absence of insecticide treatments. Initially, most interest went to the impact of the, then, most abundant parasitoid, *Holcothorax testaceipes* (Ratzeburg) (Hymenoptera: Encyrtidae) (Blommers *et al.*, 1990). Here, we report on the population dynamics of STL, and the impact of its parasitoids in (almost) insecticide-free orchard blocks.

GENERAL SET-UP AND METHODS

Most observations and experiments were done in two 'ecological' blocks with 25-40 years old bush-type apple trees cv Belle de Boskoop. These blocks have not been treated with insecticides since more than 25 years, while the fungicides used should be safe to insects; captan and bitertanol against apple scab and bupirimate against mildew. A few observations on other cultivars were done in high density plantings of small apple trees on dwarfing rootstock M9.

Densities of full grown STL leafmines were determined twice each year: (1) on 100 or 200 growing shoots in June when the second flight is just underway, and (2) on 100 or 200 leaves above the 8th leaf, on even so many different long shoots, when leaf drop starts. The first count evidently concerns mines of the 1st generation, located on the oldest 5 or 6 leaves of the shoots. The second count covers nearly all mines of the 2nd and 3d generation, most of the former being empty.

To determine presence of STL and its parasitoids in collected mines, the inhabited mines were stored one by one in cotton-stoppered glass tubes and placed in the insectary. Emergence of animals in these depositories was scored at least twice weekly.

LEAFMINER ABUNDANCE

Figure 1 illustrates the abundance of STL mines in our orchard in recent years.

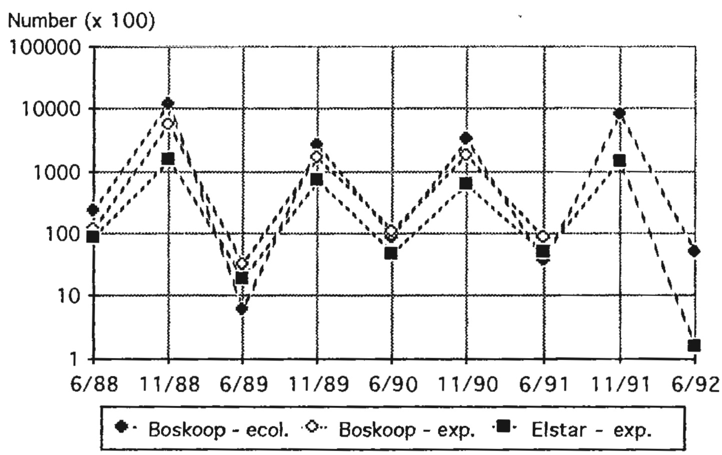

Figure 1. Average numbers of STL mines per growing shoot in June and per leaf above the 8th on long shoots in November on cv Belle de Boskoop in the insecticide-free ecological planting (ecol.) over successive years, and on cvs Boskoop and Elstar in the occasionally treated experimental orchard (exp.).

The density of the first generation rarely exceeds 1 mine per 100 shoots, equalling some 0.2 per 100 leaves as only the oldest 5 or 6 leaves are concerned, while by the end of the season still 1 mine/leaf, or less, are observed. Evidently, economical damage is not to be expected at these low population densities. These, and other similar observations, indicate that undisturbed natural control permanently prevents outbreaks of *P. blancardella* in Dutch apple orchards.

PARASITOIDS

The most numerous parasitoids of STL in Dutch orchards are the encyrtid *Holcothorax testaceipes* (Ratzeburg) and the eulophids *Achrysocharoides atys* (Walker), *Sympiesis sericeicornis* (Nees), *S. gordius* (Walker) en *Pnigalio pectinicornis* L., all known as such from other parts of Europe (Balazs, 1989; Askew & Shaw, 1974; Gijswijt, 1974). *A. atys* and *H. testaceipes* usually dominate in mines collected just before the apple leaves fall (Tabel 1).

Table 1. *Phyllonorycter blancardella* (STL) and parasitoids reared in spring from mines collected previous autumn on cv Boskoop in ecological orchard. *Sympiesis* (2 species) and *Pnigalio* (1) taken together. N = total number reared. DL = percentage dead STL larvae.

	Percentage over total emerged						DL
	*Phyll. blanc.**	*Achrys. atys*	*Sympiesis +Pnigalio*	*Holco. testac.*	other parasitoid	N	(%)
1988-89	25 + 5	46	10	13	0	262	11
1989-90	51 + 7	28	5	6	4	107	4
1990-91	45 + 3	25	6	0	0	116	5
1991-92	41 + 2	41	0	14	3	111	3
1992-93	71 + 5	57	8	9	4	329	3

*) the second number represents the not eclosed leafminer pupae

The table also shows that parasitism 'during winter' is not very elevated; it only reaches 75% in some populations and years. Overall winter mortality of STL, *i.e.* of the pupae in fallen leaves on the orchard floor, should often be several times greater.

For example, comparison of the numbers of STL adults captured in the two suction traps in an almost insectide-free block during successive flights (Table 2), indicates that the decrease over winter is usually near 90%, or more in as far as the 3rd generation is a partial one, induction of winter diapause already occurring in a minority of 2nd generation. Thus, the contribution of parisitism to 'winter mortality' is of minor importance.

Table 2. Percentage of adult *P. blancardella* captured in successive flight periods (=generations) in two suction traps among cv Cox's O.P., and the estimated decrease of numbers over winter.

	1st flight	2nd flight	3rd flight	Sum	decrease (%)
1988	5.4	39.8	58.3	2168	1988>89: 94
1989	15.0	31.8	53.2	510	1989>90: 90*
1990	[1.2]*	26.8	72.0	2222	1990>91: 86
1991	6.1	49.9	44.0	3663	

[ ] some insecticide side-effect can not be excluded

In the 1st generation, sometimes more than 80% of the STL larvae are eliminated by parasitoid action (Table 3: 1988). Assuming an average fertility of 11 female eggs/female (Pottinger & Leroux , 1971), the numbers of STL males captured during the 1st and 2nd flight in two pheromone traps in the same planting, the overall mortality between adults of the 1st and 2nd generation should have been near 84% in 1989 and 58% in 1990. Because larval mortalities due to parasitism were near 83% and 44% in these years (Table 3), parasitoids should have been the dominant mortality agents between the 1st and 2nd flight.

Table 3. *Phyllonorycter blancardella* (STL) and parasitoids reared from mines collected in June on cv Boskoop in ecological orchard. *Sympiesis* (2 species) and *Pnigalio* (1 species) taken together. N = total number reared. DL = percentage of dead STL larvae.

	Percentage over total emerged						DL
	*Phyll. blanc.**	*Achrys. atys*	*Sympiesis*** *+Pnigalio*	*Holco. testac.*	other parasitoid	N	(%)
10.vi.1988	44 + 2	31	14 + 2 + 4	8	1	243	4
17.vi.1988	32 + 1	18	32 + 11 + 0	4	1	234	8
19.vi.1989	10 + 7	12	56 + 3 + 5	6	4	119	21
15.vi.1990	54 + 2	4	27 + 2 + 1	6	5	129	7

* including already emerged pupae + (few) dead pupae
** *S. sericeicoris + S. gordius + P. pectinicornis*

DISCUSSION

Little information exists about the factors affecting the population dynamics of *Ph. blancardella* in West Europe, while studies in Central Europe and North America appear to stress the importance of parasitoids. The (selected) data presented here shows that the more abundant parasitoid species in this region are not very different from those in Central Europe, notably Hungary (Balàsz, 1989), but unlike those found in North America (Maier, 1994).

Achrysocharoides atys usually dominates by far the other species in the overwintered mines, at least in our orchard in recent years (cf Blommers *et al.*, 1990), while *S. sericeicornis* is the dominant parasitoid of the STL larvae of the first generation. Notably, *H. testaceipes* was not very abundant, somewhat in contrast to previous observations (Blommers *et al.* 1990).

The contribution of these parasitoids to the natural control in the overwintered STL generation is apparently limited. Other factors are probably more important. For example, mortality of overwintering STL, in mined leaves on the orchard floor was 58% when these leaves were protected from burial by earthworms, and 85% when not (P. Gruys 1970, unpublished; see also Laing *et al.*, 1986). Also, many mated female STL, emerging from overwintering mines, appeared to lay no, or a few, eggs in some years (Blommers, unpublished), possibly because a too early leafdrop interfered with the completion of larval development in previous autumn.

The contribution of parasitism to STL larval mortality in spring is probably most significant. Then *A. atys* and *S. sericeicornis* are usually most numerous, and in later samples (not shown) sometimes *H. testaceipes* .

Two implications should be evident. First, the parasitoid species involved should be safeguarded from pesticide side-effects, especially during their 1st flight around bloom. Their phenology should get more attention in this respect (cf Blommers, 1992). Second, when an STL outbreak looms, monitoring also should involve levels of parasitism, as previously recommended by Van Driesche *et al.* (1994) for *Phyllonorycter* spp. in North America.

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ORGANIC VERSUS INTEGRATED MANAGEMENT IN POME FRUIT IN EASTERN AUSTRIA - ENTOMOLOGICAL ASPECTS

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Abstract The seasonal development of arhropod fauna in an organic and IFP apple orchard was studied. The different spraying programme of organic and integrated fruit production did not cause big differences in the entomofauna of the trees. Population density of beneficials evolved rather similar under both management systems over the season. Only in the case of Forficula auricularia the number of individuals was much higher in the organic plot than in the IFP orchard. This correlates with the permanent aphid problem in the organic orchard. The frequent use of sulphur in low dosages in the organic orchard did not harm the *Typhlodromus pyri* population in practice.

Introduction

The effects of so-called conventional fruit production in comparison with untreated, organic or integrated managed plots in experimental orchards has been studied in different regions. But even organic and integrated plant production go on to develop further. Integrated fruit production (IFP) has became a new standard in pome fruit growing in the nineties and organic production of apple gets more and more importance. In this situation it can be interesting to look on the entomofauna of a commercial IFP and organic orchard in comparison. It will be interesting to see, if there are specific differences in the occurrence of animal pests, beneficials and in the interactions between insect pests and beneficials.

Material and Methods

To get some answers on this questions a faunistic investigation especially on the development of animal pests and beneficials in an organic and an IFP orchard in the Burgenland near the border to Hungary was started in 1993. There is a distance of 16 kilometres between the two sites, but vegetation surround the isolated orchards, planting system, varieties etc. seem to be comparable. This report refers to the results of 1994.

The organic orchard has a size of 5,4 ha. Up to 1992 it had been managed according to the Austrian IFP-guidelines and in 1993 it changed to organic production. The orchard is surrounded by field crops, vegetable and vineyards.

The IFP-plot is an orchard of 7,3 ha, surrounded by vineyards.

Both orchards have a droplet irrigation, the alleyways are covered by grass. The trees (rootstock M9) get a height of at about 2,5 m.

During the growing season both orchards were inspected in at about 14 days intervals. To get information on the fauna on the trees, strike samples of 50 strikes per orchard were taken on following days: 3.6., 24.5., 3.6. (only in the organic orchard), 16.6., 23.6., 7.7., 19.7., 27.7., 4.8., 11.8., and 6.9. (only in the IFP orchard). The absence of Strike samples in one of the plots on 6.9. respectively 3.6. is a result of sudden rainfalls, which make strike samples impossible. All strike samples in both orchards were taken from trees of the variety "Granny Smith", planted in 1988. Visual controls and leaf controls helped to get information on the occurrence of pests like aphids, leaf rollers, spider mites or rust mites as well as predatory mites. The flight activity of codling moth and leaf rollers was recorded by the use of pheromone traps. For strike samples and visual controls the methods published in the IOBC/WPRS brochures "Die Klopfprobe" (1980) respectively "Visuelle Kontrollen im Apfelanbau" (1992) were used.

Plant Protection in the Plots

Mineral oil was used in both orchards as a pre bloom spray against overwintering animal pests, especially the San Jose'scale *Quadraspidiotus perniciosus*. In the organic orchard copper and sulphur dealt as fungicides. Sulphur was applicated 14 times during the season. The total amount of product all over the year was 21 kg per ha. Aphids were controlled by one early over all spraying of Pyrethrum and later with local treatments of shoots or single trees. One treatment with Bacillus thuringiensis served as a regulation measure for leaf rollers. Cydia pomonella Granulosis Virus was used several times to control coddling moth.
In the IFP orchard Dithianon and different sterol synthesis inhibitors were applied several times to control diseases. Against animal pests the grower used Diflubenzuron as well as Fenoxycarb two times (coddling moth, *Cydia pomonella*) and Phosalone (apple saw fly, *Hopolocampa testudinea*), Chlorpyriphos-methyl (San Jose'-scale) and Fenbutadinoxid (apple rust mite, *Aculus schlechtendali*) one time.

Active ingredients of plant protection products used in the plots in 1994

ORGANIC	INTEGRATED
MINERAL OIL	MINERAL OIL
SULPHUR	DITHIANON
COPPER	SSI (sterol synthesis inhibitors)
GRANULOSIS VIRUS (CpGV)	DIFLUBENZURON
BACILLUS THURINGIENSIS	FENOXYCARB
PYRETHRUM	PHOSALONE
	CHLORPYRIPHOS-METHYL
	FENBUTADINOXID

Results

The number of insects and spiders in total per strike sample is documented in figure 1 and 2. Among the spiders the family Araneidae had the highest frequency. 41% of the spiders belonged to this family. The most common species in both plots was Araniella cucurbitina. In table 2 the total number of individuals of some groups of special interest is summarized.

number of collected individuals by strike samples all over the season		
	IFP orchard	organic orchard
ARANEAE		
Araneae in total	272	224
Araneidae	107	97
ACARI		
Anystis agilis	16	12
Thrombidium sp.	15	0
INSECTS		
aphids in total	35	73
Coccinellidae in total	19	15
Neuroptera, adults + larvae in total	7	7
Orius sp., adults + larvae in total	8	3
Forficula auricularia	12	89
Formicidae in total	81	79
leaf roller caterpillars	20	6
Orthiosa incerta	0	6
Hymenoptera parasitica	33	24

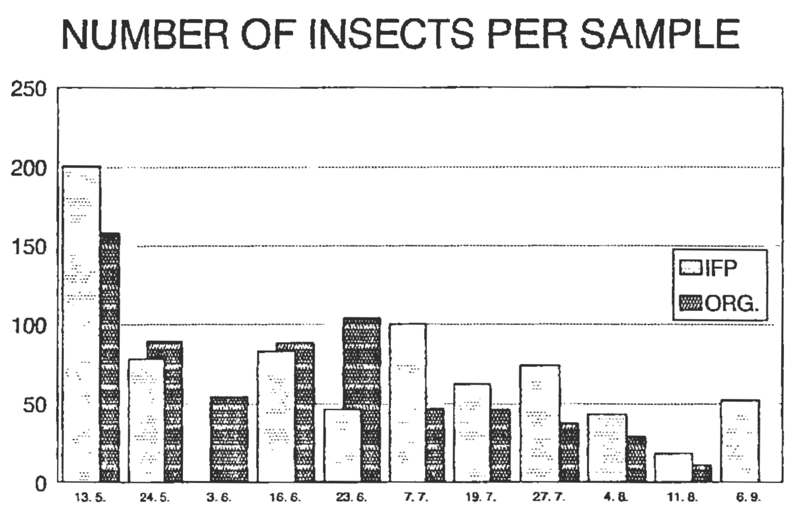

fig.1

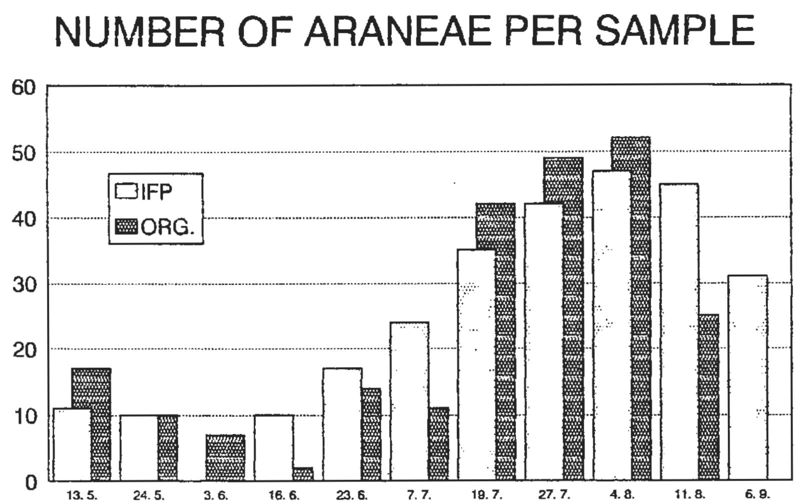

fig.2

The control of leaf samples showed, that the predatory mite *Typhlodromus pyri* was present in both orchards. During the whole summer the population density of T. pyri varied between 0,8 and 1,5 individuals per leaf in the organic as well as in the IFP plot. European red mite *Panonychus ulmi* did not occur in leaf samples from the IFP orchard at all. Some *P. ulmi* could be found in the organic orchard in July, but the population density stayed on a very low level till the end of the season (< 0,5 spider mites/leaf). In the IFP plot in July the population density of apple rust mite *Aculus schlechtendali* reached a level of more than 100 mites per leaf, in the organic orchard this species was absent in all samples.

Visual controls of shoots indicated a high population of *Orthiosa incerta* caterpillars in early summer in the organic orchard and this infestation caused even some fruit damages. The visual controls as well as thestrike samples indicated a overstep of the economic damage threshold of leaf roller caterpillars of the species *Pandemis heparana* in the IFP plot at the end of July. But the population density of leaf roller caterpillars decreased soon and no leaf roller fruit damages could be found at harvest.

Although there was a specific treatment against aphids in the organic orchard immediately after bloom, aphid colonies (Wholly Apple Aphid ....) could be found during the whole season. Permanent pruning of infested shoots and local treatments were necessary. Syrphid larvae in early June, later on earwings (*Forficula auricularia*) could be found as the most abundant aphid predators. In the IFP orchard aphid colonies could be found only seldom.

Discussion

The different spraying programme of organic and integrated fruit production must not cause big differences in the entomofauna of the trees. Population density of beneficials evolved rather similar under both management systems over the season in this investigation. Only in the case of Forficula auricularia the number of individuals was much higher in the organic plot than in the IFP orchard. But this correlates with the permanent aphid problem in the organic orchard. For organic fruit growing it is interesting, that frequent use of sulphur in low dosages can be save to predatory mites in practice.

Results of large-scale releases of predatory phytoseiid mite, *Typhlodromus pyri*, an OP-resistant population Mikulov, in apple orchards in South Tyrol and France.

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Introduction

To date, the predatory phytoseiid mite, *Typhlodromus pyri* Scheuten has become one of the foundation-stones of IPM programmes developed for commercial apple orchards and vineyards in many fruit- and vine-growing areas of temperate zones (Croft and Hoyt, 1983). Ecological and ecotoxicological aspects of practical use of this predator and its implementation to IPM programmes tailored to fruit orchards and vineyards were also intensively studied in the Czech republic (formerly Czechoslovakia) particularly in the 80th years and the studies continue (Hluchý, 1993,1994, Hluchý and Pospíšil, 1991, Šula and Zacharda, 1991, Zacharda, 1989, 1991, Zacharda and Hluchý, 1991, 1994, Zacharda, Pultar and Muška, 1988). The OP-resistant populations of the predator were released and stabilized on about 4.500 hectars of fruit orchards and 4.000 hectars of vineyards, i.e., about 26% and 40% of the total area of fruit orchards and vineyards in the Czech republic, respectively. Two popuations of *T. pyri* were used for these large-scale releases, the first one came from sprayed commercial apple orchards from the vicinity of Chelčice, south Bohemia, the second one from commercial vineyards located in a relatively dry and warm vine-growing area of the town of Mikulov, south Moravia. Predatory mites from the latter population called „Mikulov" were recently released experimentally in many states of Europe (Austria, Germany, France, Belgium, Northern Italy). Bionomical and ecotoxicological characteristics of this population are well known, efficacies of more than 120 pesticides to this population were tested, so that the population can be managed in practice well. This OP-resistant population is also applicable in situations when a broader spectrum of pesticides, particularly the OP-based ones, should be used. For example, these situations occur when the codling moth, *Cydia pomonella*, becomes resistant to diflubenzuron, or a pheromone mating disruption method or spraying a virus granulosis are too expensive.

Methods and material

The OP-resistant population of *T. pyri* „Mikulov" was released in commercial apple orchards in the central area of France and in Northern Italy (South Tyrol) in 1993-4. Hibernating females of *T. pyri* in textile carriers of the size of 14x7 cm were supplied by the Biocont Laboratory Ltd., Brno, Czech republic and stored in an air-conditioned store-house at temperature of about +6-8°C and relative humidity of 90-95% for the next two month. It was found out, using a Tullgren apparatus, that an average number of 33 hibernating females of *T.pyri* were in 1 textile carrier. In the beginning of March the textile carriers with *T. pyri* were attached to thick branches of apple trees. As indicated in Table 1, different numbers of predators were released per 1 tree canopy. Development of the released population of *T. pyri* was subsequently monitored at intervals of about 14 days. In France, samples of 100 leaves were collected and a percentage of leaves with eggs and active stages of the predator were assessed by the Euro Fruit Assistance while in Northern Italy 50 leaves were collected and numbers of all active stages per 1 leaf counted. Fruit growers received information about a spraying programme being compatible with the released population of the predator.

Results and discussion

Results are summarized in Table 1.

Table 1. Results of inoculative releases of *Typhlodromus pyri* in apple orchards in France and South Tyrol.

Locality	No. of T. pyri	Canopy		Date of collection / % of leaves with T. pyri										
FRANCE	released/1 tree	m^3		29.4.	13.5.	27.5.	10.6.	24.6.	08.7.	20.7.	04.8.	19.8.	31.8.	23.9.
Pollet	260	2-3	E	00.0	00.0	02.5	02.5	05.5	07.5	10.0	10.0	45.0	10.0	00.0
			A	00.0	00.0	07.5	17.5	25.5	30.5	25.5	25.5	40.5	20.0	20.0
Villaines	130	2-3	E	00.0	00.0	02.5	00.0	00.0	02.5	00.0	00.0	20.0	00.0	00.0
			A	00.0	00.0	10.0	10.0	05.0	10.0	32.5	30.5	35.5	45.0	40.0
Mares	130	2-3	E	00.0	00.0	07.5	00.0	07.5	00.0	00.0	05.0	00.0	00.0	00.0
			A	00.0	00.0	10.0	07.5	05.0	12.5	05.0	05.0	50.0	15.0	30.0
Mabire	130	2-3	E	05.0	05.0	00.0	07.5	00.0	05.0	05.0	10.0	00.0	05.0	00.0
			A	02.5	00.0	05.0	20.0	07.5	07.50	20.0	25.0	40.0	40.0	25.0
Demoules	150	15-20	E	05.0	00.0	02.0	02.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0
			A	02.5	00.0	02.5	02.5	00.0	02.5	00.0	00.0	00.0	05.0	00.0
Murailles	130	15-20	E	10.0	02.5	02.5	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0
			A	12.5	00.0	07.5	02.5	02.5	00.0	00.0	00.0	00.0	00.0	05.0
SOUTH TYROL								18.9.						
Kaltern	33	2						1.7 active stages per 1 leaf						

E= eggs; A= active stages (larva, protonymph, deutonymph, adult).

It is now obvious that: 1) The inoculative release and subsequent stabilization of *T. pyri*, the population „Mikulov" from south Moravia, was successful in agroecological conditions of Northern Italy (South Tyrol) and central France. 2) In case of smaller apple trees with canopies not exceeding 3 m^3, when *T. pyri* was released in average numbers of 130-260 specimens per 1 tree canopy, the predator was regularly observed on 5-50 % of the collected leaves yet during the same growing season. In contrast, predators released in average numbers of 130 - 150 specimens per big apple tree with voluminous canopy of about 15-20 m^3 were collected only sporadically. These numbers of released predators were evidenly too low to establish a more numerous population of the predator yet during the 1st growing season. Similarly in South Tyrol where the mites were released in the average number of 33 specimens per 1 tree canopy not exceeding 3 m^3, the predator achieved the population density of 1.7 specimens per 1 leaf during the 1st growing season.

In summary, actual volumes of tree canopies should be taken into consideration when *T. pyri* is inoculatively released in fruit orchards. The number of 130 specimens of hibernating females of *T. pyri* per 1 tree canopy not exceeding 3 m^3 seems to be sufficient. More voluminous tree canopies evidently need more predators. Further experiments with different numbers of released predators continue.

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Biological control of two-spotted spider mite *Tetranychus urticae* on strawberries by the predatory phytoseiid mite *Typhlodromus pyri*.

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The predatory phytoseiid mite *Typhlodromus pyri* Scheuten, a strain „Mikulov" from the south Moravian commercial vineyards, was released on strawberries infested with the two-spotted spider mite, *Tetranychus urticae* Koch, and grown under glass. The initial average number of spider mites was 9.68 active stages per 1 trifoliate leaf when the predator was introduced to every plant in the beginning of April. The initial predator : prey ratio was approximately 1 : 10, respectively. No pesticides were used subsequently. The predator gave good control of spider mites till fruiting in mid-May and henceforth despite frequent low air humidity and water deprivation of plants in a dry glasshouse.

Introduction

The two-spotted spider mite, *Tetranychus urticae*, is a serious principal pest of strawberries (*Fragaria x ananassa* Duchesne) grown in field plantations or under glass and plastic (Easterbrook, 1992, Benuzzi et al., 1992, etc.). Chemical control of the pest is often difficult because of its frequent high level resistance and hygienic risk. Alternative strategies for spider mite control on strawberries are therefore desirable.

The predatory mite *Phytoseiulus persimilis* A.-H. gives a good control of spider mites on strawberries (Wysoki, 1986, Easterbrook, 1992, Benuzzi et al., 1992, etc.) under environmental conditions being suitable for this predator. However, the potential of the predator for a successful biocontrol of spider mites declines in cases when temperature increases and relative humidity drops below 60% (Stenseth, 1979, Pralavorio and Rojas, 1980). This becomes particularly so in glasshouses or plastic tunnels when growers use a drip irrigation system to avoid a fungal disease problem (Hatala-Zsellér 1992). Hence, an alternative, or supplementary efficient predator would be desirable for situations unfavourable for *P. persimilis* .

Besides *P. persimilis*, *Typhlodromus occidentalis* Nesbitt, *Amblyseius californicus* (McGregor) and *Phytoseiulus macropilis* Banks were used for the spider mite control on strawberries in the U.S.A. (Wysoki 1985). Hadam et al.(1986) reported *T. pyri* occurring spontaneously, but in relatively low numbers, in sprayed commercial strawberry plantations in Oregon. Easterbrook (1992) observed *T. pyri* occurring on strawberries spontaneously for a few successive growing seasons and concluded that this predator was able to control *T. urticae* in some circumstances, but was less effective under hot, dry conditions. To date, probably nobody has tried to use *T. pyri* for biological control of spider mites on strawberries under glass or plastic.

Commercial sprayed vineyards in the relatively warm and dry region of south Moravia, Czech republic, are inhabitted by an OP-resistant population of *T. pyri* that gives a very good control of spider and eriophyid mites *Panonychus ulmi* (Koch), *T. urticae*, *Calepitrimerus vitis* (Nalepa), *Colomerus vitis* (Pagenstecher). This population, known under the name „the strain Mikulov", has been introduced successfully to hundred hectars of commercial vineyards and fruit orchards where the predatory mite had disappeared. We have tried to assess the potential of this population for the biological control of the two-spotted spider mites on strawberries grown in an unconditioned dry glasshouse.

Material and methods

In October 1993 50 strawberry runners (cv. *Senga Sengana*) were potted into plastic containers and infested with *T. urticae*. During winter, the plants with spider mites were kept in a dry glasshouse at temperatures ranging from 5 to 15°C (depending on sunlight) and an ambient photoperiod. Most spider mites entered a diapause but some laid eggs as well. In the beginning of April the experimental plants had 6.55 trifoliate leaves in average (2-12) and 72.6% of them were infested by spider mites in average numbers of 9.67(1-97) of active stages and 5.61(1-80) of eggs per 1 trifoliate leaf. Since June the 26th and onwards the plants had to be cultivated outside the unconditioned glasshouse where uncontrolled temperature frequently reached 40-45°C.

Hibernating females of *T. pyri* were collected in vineyards, activated in a laboratory at 20°C, 16 hr daylight, and subsequently reared on a pollen diet (Pinus spp.) for a few weeks. On April the 7th the predators in textile carriers were transferred to the experimental plants to which a small amount of the pollen diet was also added. The number of predators transferred to the individual plants corresponded to a predator : prey ratio to be approximately 1 : 10, respectively. Ten plants infested with *T. urticae* , but without *T. pyri* , were kept separately as an untreated check. Subsequently, 2 leaves were picked from each of the plants at approximately 1 month intervals and active stages and eggs of the predatory and spider mites were counted under a standard binocular microscope. Obtained data were treated statistically.

Results

Results of periodic monitoring of population densities of *T.pyri* / *T. urticae* are presented in Table 1 and 2 as summary statistics and in Fig. 1. *T. pyri* was released on strawberries infested with *T. urticae* on April the 7th and subsequently suppressed the population density of spider mites progressively till the end of May despite temperatures frequently reached 40°C and the relative humidity dropped to 35% in the dry glasshouse during sunny days. In June the population density of spider mites increased again but never reached the initial level. A period of fruiting was around May the 11th and the plants with *T. pyri* were undamaged by the spider mites whereas an outbreak of the spider mites ocurred on plants without *T. pyri* from the end of April when the plants were badly damaged.

Table 1. Summary statistics for *Typhlodromus pyri* and *Tetranychus urticae* on strawberry

Date of collection in 1994	7.4.	28.4	23.5.	25.6.	29.7.
No. of examined leaves (n)	84	85	71	80	80
Typhlodromus pyri					
occupied leaves in total %	0.00	82.40	94.30	93.80	70.40
Active stages					
occupied leaves %	0.00	80.00	93.00	87.50	71.30
average no./1 trifoliate leaf	0.00	3.25	5.73	3.45	2.17
S.D.	0.00	2.97	4.49	3.60	2.49
median	0.00	3.00	5.00	3.00	1.00
minimum	0	0	0	0	0
maximum	0	15	20	25	10
Eggs					
occupied leaves %	0.00	32.90	62.00	63.00	13.70
average no./1trifoliate leaf	0.00	0.68	2.51	2.80	0.23
S.D.	0.00	1.35	2.99	4.38	0.67
median	0.00	0.00	1.00	1.00	0.00
minimum	0	0	0	0	0
maximum	0	8	12	22	4

Table 1 (continued).

Tetranychus urticae					
occupied leaves in total %	72.60	76.50	59.20	71.30	28.40
Active stages					
occupied leaves %	72.60	69.40	54.90	71.30	22.50
average no./1 trifoliate leaf	9.68	5.46	3.75	6.87	0.39
S.D.	16.68	14.99	10.18	21.49	0.82
median	3.50	2.00	1.00	2.00	0.00
minimum	0	0	0	0	0
maximum	97	129	62	177	3
Eggs					
occupied leaves %	31.00	51.80	33.80	50.00	21.30
average no./1 trifoliate leaf	5.61	24.03	7.68	14.66	0.91
S.D.	13.48	53.24	23.25	31.25	2.57
median	0.00	1.00	0.00	0.50	0.00
minimum	0	0	0	0	0
maximum	80	350	162	158	15

(S.D. = standard deviation)
Remark: Date of harvest of ripened fruit, May 11th 1994

Table 2. Summary statistics for *Tetranychus urticae* on strawbery - untreated check without *T. pyri*

Date of collection in 1994	7.4.	28.4.	23.5.
No. of examined leaves (n)	20	20	20
Tetranychus urticae			
occupied leaves in total %	90.00	100.00	100.00
Active stages			
occupied leaves %	90.00	100.00	100.00
average	11.70	28.35	157.60
S.D.	13.89	27.04	80.42
median	7.00	20.00	129.50
minimum	0	6	66
maximum	51	127	337
Eggs			
occupied leaves %	65.00	100.00	100.00
average	8.20	142.35	189.45
S.D.	9.85	86.82	91.09
median	3.00	128.50	183.50
minimum	0	7	48
maximum	51	360	402

(S.D. = standard deviation)

Discussion

Data on actual potentials of *T. pyri* for the biological control of the two-spotted spider mites under dryer conditions in glasshouses or plastic tunnels are still sparse and sometimes controversial. Easterbrook(1992) concluded that this predator was able to control *T. urticae* in some circumstances, but was less effective under hot, dry conditions in the UK. In contrast, Croft et al.(1993) who studied lethal humidity responses at 20°C of eggs and fed/unfed larvae and protonymphs of 4 species of phytoseiid mites discovered a relatively high tolerance of *T. pyri* (a strain from Oregon) to low humidity and stressed importance of possible differences among particular populations or strains of the same species. This is the reason why a complete, detailed and definitive IPM strategy for strawberry, where *T. pyri* would play a decisive role as a key biocontrol agent of spider mites, still cannot be outlined. However, it is now obvious that *T. pyri* 1) can develop, hibernate, and, in some circumstances, control the two-spotted spider mites on strawberries (Easterbrook 1992, and our unpubl. observations); 2) can be reared on strawberries successfully and a pollen diet pulverized onto leaves can be supplied as an alternative food for and an arrestant of the predator (no problems with mold occur); 3) at least some strains of the predator are much more tolerant to lower relative humidity than *P. persimilis* (cf. Stenseth 1979, Croft et al. 1993); 4) many native strains of *T. pyri* have developed resistance in agroecosystems and are compatible with pesticides having low toxicity to phytoseiids (Hassan et al. 1987,1991, Croft 1990); 5) *T. pyri* can be supplied in a large scale by commercial companies (for example, Biocont Laboratory Ltd, Brno, Czech republic) and applied in a simple way. In the light of these positive aspects we suppose that *T. pyri*, the strain „Mikulov" from the south Moravian commercial vineyards, has the potential of being successfully used in IPM programmes for strawberries under glass. However, the population density of spider mites should be monitored before releasing the predators that should preferably be released onto each plant in respective numbers and pesticides with low efficacy to the predator should be used only if necessary. Also growing strawberry cultivars being more resistant to spider mites (Khanizadeh et al. 1992) might be useful.

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Predators of *Cacopsylla pyri* in NE Spain. Heteroptera: Anthocoridae and Miridae

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Abstract
Since 1990 we have been monitoring the populations of pear pests and beneficials in a commercial orchard free from pesticides.
The Heteroptera, Anthocoridae and Miridae, were the predators whose populations were more related to the dynamics of *Cacopsylla pyri* populations.
Within the Anthocoridae, *Anthocoris nemoralis* was able to respond to psylla outbreaks, with a stronger response when the outbreak was in summer than when it was in autumn. The group of *Orius* species was more constant in numbers and as abundant as *A. nemoralis* the years without psylla outbreaks.
The Miridae appeared every year earlier than the Anthocoridae and in numbers related to the psylla population from the previous year. The years with the higher initial numbers of Miridae showed the lower peaks of psylla. Although these predators are polyphagous, as are the *Orius* species, their populations were more related to the psylla fluctuations. These relationship can clearly be seen in *Pilophorus perplexus*, the species that could be identified every year in all its stages.

Introduction
Looking at the bibliographic review on the entomophagous fauna of pear psyllids in Europe, made by Lyoussoufi et al. (1994), in the part devoted to Heteroptera, we can see that most of the references deal with Anthocoridae. There are 52 records on *Anthocoris nemoralis*, which is considered the most effective control agent of pear psylla. The Miridae appear only in a few references and mainly in conjunction with the Anthocoridae, there are, for exemple, only 10 records on *Pilophorus perplexus* and most of them only mention its presence in low numbers and in untreated orchards, with one exception that we will mention later.
We think that the importance of the Miridae has been underestimated. This can be due in part to the difficulty to detect them, for exemple *P. perplexus* quickly hides out when one approaches (Fauvel, 1982), and to the lack of relationship of its numbers with psylla populations on a year basis. We already presented some arguments on the limitations of *A. nemoralis* (Sarasúa et al. 1994). Here we present arguments supporting the possibilities of the Miridae as they act earlier than the Anthocoridae, on the spring generations of the psylla, whose level determines the risk of outbreaks in summer.

Materials and methods
The orchard has a surface of 0.25 ha with 9 rows, of around 30 trees each, of a vigorous pear variety "Blanquilla" (Spadona estiva) planted in 1979.. Since 1989 it has been free from insecticides and acaricides to allow the development as well of the pests as of the beneficials. All the other cultural practices including diseases control were the generally applied in the area.
We present only the results from the beating method applied throughout the year, weekly from spring to autumn and fortnightly in winter, except when fruits are fully grown (end of july, august). Each time, 100 branches, each from a different tree, were beaten over a 30 cm diameter rigid plastic funnel (Fauvel et al. 1981). Insects were collected in a plastic bag, put

in a cool box, taken to the laboratory, killed in a freezer at -20° C and then identified under a binocular microscope.

Results and discussion

The species of Anthocoridae appearing every year, ordered by abundance were: *A. nemoralis*, *O. majusculus* and *O. laticollis*, other species found in low numbers and not every year were: *O. laevigatus*, *O. niger* and *Cardiasthetus nazarenus*.

Within the Miridae only *P. perplexus* has been identified to the species level every year as we obtained enough adults and it is also possible to identify the nymphs. Apart from *P. perplexus*, the capture of Miridae included mainly nymphs of several species of *Campylomma*.

Figure 1 presents the maximum number of adults of *C. pyri*, Anthocoridae (adults+nymphs) and Miridae (adults+nymphs) in 100 beats for every month during 5 years.

Comparing the peaks of psylla within and between years, we can see the trend already pointed in Sarasúa et al. 1994, the higher the peak in april, the higher in june and the lower in october. The reverse is well represented by the year 1993 with the lowest spring and summer peaks and the highest autumn peak.

There is a year that stands out, 1991. It has been the worst year, low flower induction, bad fruit setting due to frost and a high attack of *Hoplocampa brevis* (Oró et al. 1994). This resulted in an excessive vegetative growth ideal for psylla outbreak.

This outbreak resulted in the highest population of Anthocoridae, starting one month later and staying high until october. It was mainly *A. nemoralis* (fig 2.) confirming its well known effectiveness when psylla populations are high.

If we take the opposite, 1992, the best year, we had almost the same factors but reversed. The trees were more balanced between production and growth, there were a few Anthocoridae from january and the Miridae appeared in march and reached the highest levels. The low population resulting in june was not enough to attract the Anthocoridae that only appeared, in low numbers in july and even lower numbers in autumn, this allowed the increase of the psylla in autumn to a peak similar to the one in summer. This year there were equal numbers of *A. nemoralis* and the group of *Orius* species (fig 2.)

The last factor affecting the response of the Anthocoridae to a psylla peak, is whether it appears in summer or in autumn. Comparing 1993 and 1994, the autumn peak of psylla was higher than the summer one in 1994, the reverse is true for the Anthocoridae. In summer as well the psylla as the Anthocoridae are actively reproducing. The response in summer is higher in the case of *A. nemoralis*, with less differences with the *Orius* spp when it is in autumn (fig 2.)

The fluctuations of the Anthocoridae within and between years and its relationship with psylla populations is clear even with the oversimplified presentation of the data, and it is probably one reason for the importance given to *A. nemoralis*. Even with the results of just one year it is possible to detect its role.

This is not the case with the Miridae. Looking at fig 1 with the data from 5 years, at a first glance it is only clear that they appear every year between march and april, so earlier than the Anthocoridae, and in relation to the psylla at most we could say that the years with the highest initial numbers of Miridae are also those with the lowest psylla levels (1992 and 1990) because if we compare their peaks with those of psylla we would arrive to the conclusion that there is no relationship and that they must be related to other pests. As they are polyphagous predators this will be accepted as a reasonable conclusion.

The advantage of long term studies is that they allow the detection of delayed relationships. We only have to compare the peaks of the Miridae with the peaks of the psylla the previous

year, this really improves the relationship. To see this relationship at a species level we represent in fig 3 the levels of the psylla with the same data of the maximum from every month, but cumulated from january to may and from june to october to relate it to the fluctuations of *P. perplexus*, represented by the total year capture of nymphs and adults.
The order of the columns represents the sequence during the year. *P. perplexus* overwinters in the egg stage, eclosion occurs in march april, this is the first column. The second column represents the level of food available for the development of the nymphs, the psylla levels from january to may. The third column are the adults of *P. perplexus* resulting from the previous relation. The fourth represents the level of food available to the adults for survival and egg laying, the psylla levels from june to october.
It has been a more or less arbitrary division of the psylla numbers, because we found pilophorus nymphs some years since september, and adults already in may. We are also aware that the relations are not only one way, the level of psylla is not only the available food, but also the result of the feeding activity of the predator, and the number of nymphs is not only dependent on the number of eggs produced the year before but also the result of the survival conditions. But even with this limitations in mind the figure shows a really close and consistent response of pilophorus to the psylla.
There is another factor that seems to interfer, the competition with *A. nemoralis*. This can be seen if we compare the nymphs resulting from 1990 and 1991. There were twice adults and 6 times more psylla in 1991 and this was only reflected in a 30% increase of the nymphs. This is only a sugestion, but we dare to put it because it is supported by the sole reference in the bibliography where *P. perplexus* is not only recorded as appearing in low numbers in untreated orchards. Staübli et al. 1992, attributed the failure of a release of 7550 nymps of *A. nemoralis* in an orchard of 6000 m^2 to the very low psylla populations and the important competition with the Miridae, mainly *P. perplexus* found in big numbers.
We think that more attention has to be devoted to the natural enemies acting early during spring. In addition to the Miridae, reported here, there are other predators that also have been underestimated until recently, as *Forficula auricularia* (Sauphanor et al. 1994) and also the parasitoids are acting at this time (Avilla et al. 1992).

Acknowledgments
This work has been financed by the Programa Nacional de Investigación Agrícola, Projects no. AGR88-89 and no AGR91-324.

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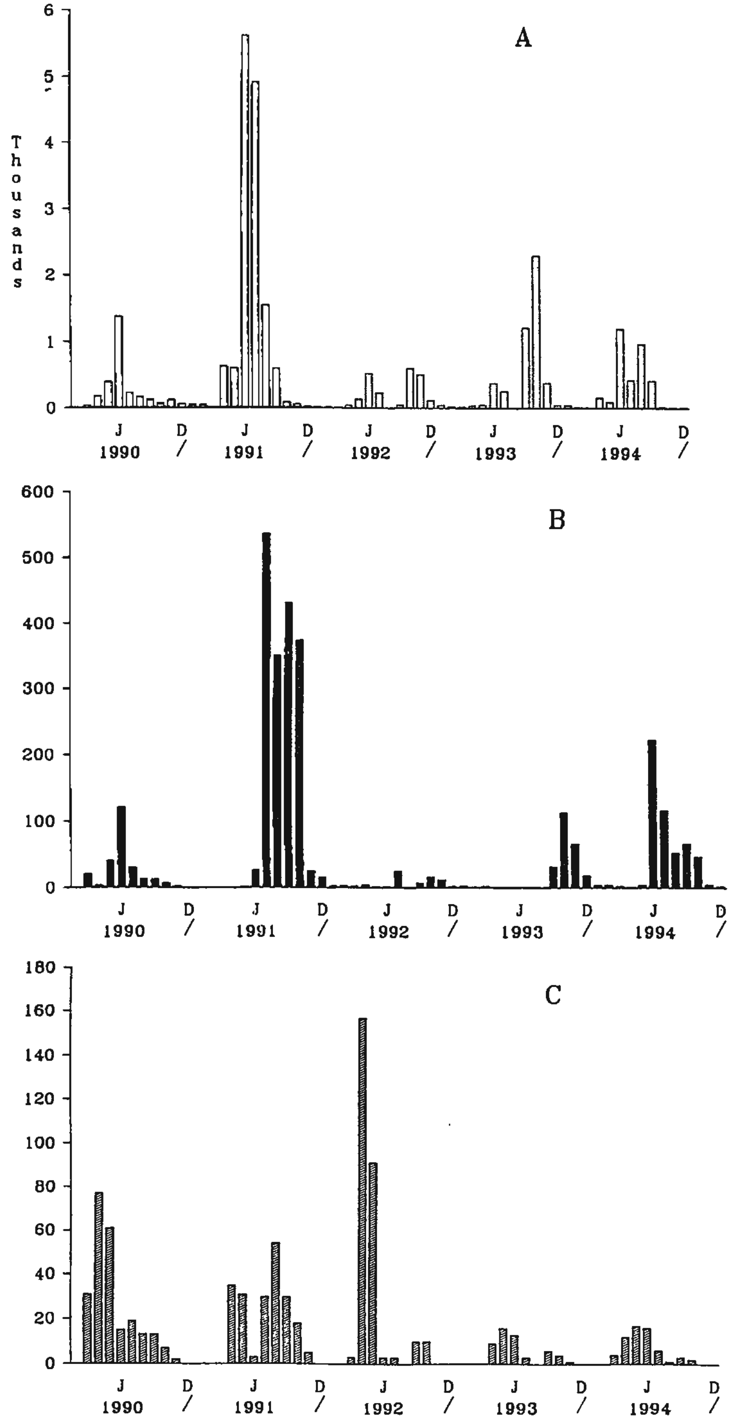

fig 1: Maximum number in 100 beats, for every month.
A: *C. pyri* (adults); B: Anthocoridae (adults + nymphs); C: Miridae (adults + nymphs)

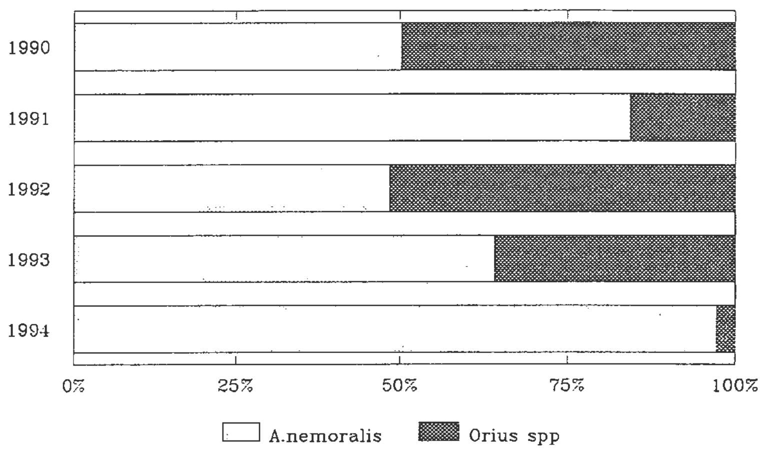

fig 2: Relative abundance of A. nemoralis and Orius spp.

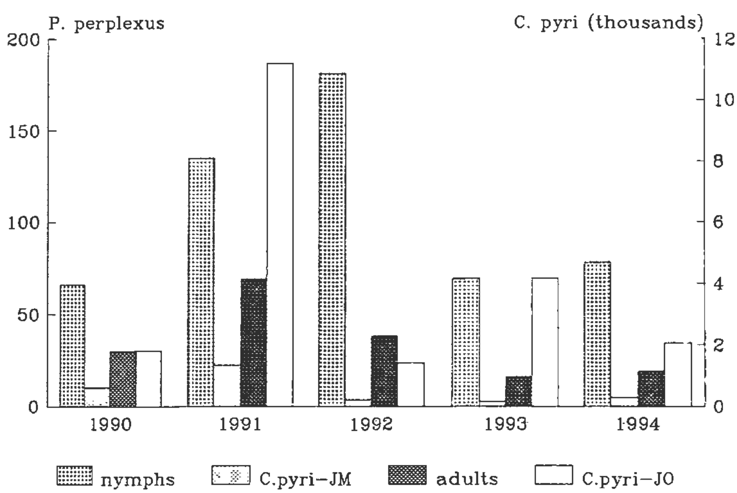

fig 3: Relation of P. perplexus with C. pyri
(see text for explanation)

Studies on two ichneumonid parasitoids as potential biological control agents of the European apple sawfly *Hoplocampa testudinea* Klug (Hymenoptera: Tenthredinidae)

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Abstract: In 1939 the apple sawfly was accidentally introduced into the eastern parts of the USA, and during the 1980s has spread over most apple growing areas of Quebec in Canada. A biological control project was started recently at the International Institute of Biological Control in Delémont (Switzerland).

A field survey was carried out in Switzerland, Germany, South Tirol and the Netherlands. Thereafter, work was concentrated on the larval parasitoid *Lathrolestes ensator* and the cocoon parasitoid *Aptesis nigrocincta*, the latter has been found for the first time on the apple sawfly. *L. ensator* is the dominant species in a comparatively small parasitoid complex and well synchronisized with its only host, the apple sawfly. The brachypteran females of *A. nigrocincta* parasitize the cocoons below ground and is able to produce two generations per year.

Here I present some data on biology, host-finding mechanisms and handling time of these two parasitoids. It is important to collect behavioural data from the life histories to attain a better understanding of their impact and success as biological control agents.

Introduction: The apple sawfly is a well known pest species in Europe and after its introduction in Eastern North America in 1939, there too. It gradually invaded the apple orchards of New England and since the 1980s it is now present in most major apple growing areas of Quebec, where it caused considerably damage (Vincent & Mailloux 1988).

Several authors have dealed with this problem and much is known about biology (e.g. Miles 1932), monitoring (e.g. Wildbolz & Staub 1986), host discrimination (Roitberg & Prokopy 1984), and chemical ecology (Boevé 1995) of the apple sawfly. In spite of these investigations and although the apple sawfly is of rising importance not only in Canada but also again in Europe, only little is known about the biology and behaviour and thus the impact of their natural enemies (but see Jaworska 1987 and Zijp & Blommers 1993). In this paper I present some important traits of this host-parasitoid system and the limiting factors for the parasitization success of *L. ensator* and *A. nigrocincta* (both: Hymenoptera: Ichneumonidae).

Material and methods: Apples infested with larvae of the apple sawfly were collected in June 1994 in three organic apple orchards in Switzerland. The apples were put on wire sreens and the emerging larvae were checked twice a day for parasitism of the larval endoparasitoid *L. ensator*. The larvae were allowed to burrow themselfes into sandy soil where they build their cocoons. In these cocoons the apple sawfly remains as a quiescent larvae to the following march. Hibernation took place under near out-door conditions in Delémont (Switzerland).

The first instar of the apple sawfly mines in a tunnel immediately below the surface. Also the second instar mines, but then starts to enter the centre of the fruit, destroying the developing seeds. One fruit is insufficient to satisfy the food requirements of the larvae and therefore a second or more fruits may be attacked. The mature fifth instar reaches full size around the middle of June and drops down to the ground for pupation in the soil.

The first *L. ensator* males emerged on 10 May the first females on 17 May; emergence was over on 26 May. Both sexes were kept together under near outdoor conditions in Katsoyannos containers and were provided with water, honey and pollen. All the experiments were carried out in two big field cages (2m by 2m by 2m) with enclosed, infested apple trees, because with *L. ensator* experiments in the lab failed completely. The used trees were about 2 m high and 1 - 1,5 m in diameter. On 9 May during bloom time I released 10 females and 5 males of the apple sawfly on each tree in the field cages to get an infestation. On 22 May the first signs of hatched larvae were visible. In this cage I released single females of *L. ensator* for one hour and observed their behaviour on the patches (i.e. the fruit clusters) as carefully as possible. In the first series on 28/29 May I observed 10 females on one tree and after one week of bad weather 6 females on 6/7 June in a second series on the other tree. After each trial the attacked fruits were removed and dissected for parasitism. After death of the females, they were dissected and the number of mature eggs was counted. Because of the small number of eggs laid during my experiments, there was no difference between females used in the experiments and not used ones. Therefore all the females were pooled.

In order to obtain data on parasitism rate, host density and larval development, field collections were carried out twice in 1995: In an orchard in central Switzerland 20 trees were chosen randomly on the 23 May and again on the 31 May. Per tree 30 fruit clusters were chosen randomly and all the infested and uninfested apples were counted. The apples of each tree were kept separately and dissected on the same day of collection.

From rearings of *A. nigrocincta* in autumn 1994, individuals emerged between 5 June and 21 June 1995; females emerging about one week later than males. They were kept in the laboratory in Kiel (Germany) in the same manner as *L. ensator*. On 22 June 1995 I exposed 240 cocoons in the soil of an organic orchard in central Switzerland.

To examine the parazitization behaviour and the time *A. nigrocincta* needs for a successful parasitization (patchtime), I provided a container with soil and put cocoons of the apple sawfly on the surface. Than I released single females and observed their behaviour for one hour or longer, if they were still parasitizing at this moment. In another treatment, I prepared a container in the same manner, but removed the cocoon after half an hour. Females were released one hour after the cocoon was removed. These experiments were carried out between 5 July and 18 August 1995. One part of the parasitized cocoons was carefully dissected to examine the development of the parasitoid larvae.

The means in the text are followed by its Standard Deviation.

Results: *L. ensator* showed a searching behaviour "like a honeybee": the females were mostly flying and hovering above the canopy and the fruit clusters. Than they either landed directly on a fruit cluster (23 times) or nearby on a leaf (13 times) from where they entered the fruit cluster by walking.

Tab. 1: number of visits on all counted patches of the tree in the first series

	uninfested patches	infested patches
number of patches	18	32
number of visits	6	36

As shown in table 1, *L. ensator* entered infested fruit clusters significantly more often than uninfested ones ($\chi^2 = 4{,}51$; $p < 0{,}05$). It is remarkable that the females very often landed directly on an infested fruit (22 times). *L. ensator* visited infested patches significantly longer than uninfested ones: On uninfested patches they stood 9,8 ± 3,4 sec. (n = 6), while they stood 64,4 ± 46,6 sec. (n = 36) on infested ones (Mann Whitney U-test; p < 0,01).

Once, *L. ensator* has entered an infested fruit, a typical behaviour sequence can be described as follows: the females were searching for only a few seconds, than they stung their ovipositor for a few seconds into the apple near to the mine of the sawfly larvae. This sequence happened several times until the female has found its host and oviposited. Real ovipositions were not distinguishable from probings neither by time nor by behaviour. After oviposition it rested or cleaned itself for a variable amount of time, left the fruit and most of the time the patch as well. Only 7 times females searched on more than one fruit per patch.

If they found and attacked an infested patch, females were very successful in the first series (table 2). *L. ensator* was most successful on second instar larvae; only once, a female was able to attack a first instar larva, all the 14 others were second instars. From these second instars the females only once parasitized a larva that already has entered the centre of the fruit. As shown in table 2, *L. ensator* was quite unsuccessful in the second series one week later. From 13 attacks only two were successful, both on second instars again. All the 11 other larvae were older instars (5 third instar, 3 fourth instar and 1 fifth instar) and not parasitized.

Tab 2: parasitization success of *L. ensator* in a field cage at different times

	number of parasitized larvae	number of non-parasitized larvae	deserted fruit	not attacked
first series	15	0	6	15
second series	2	11	1	2

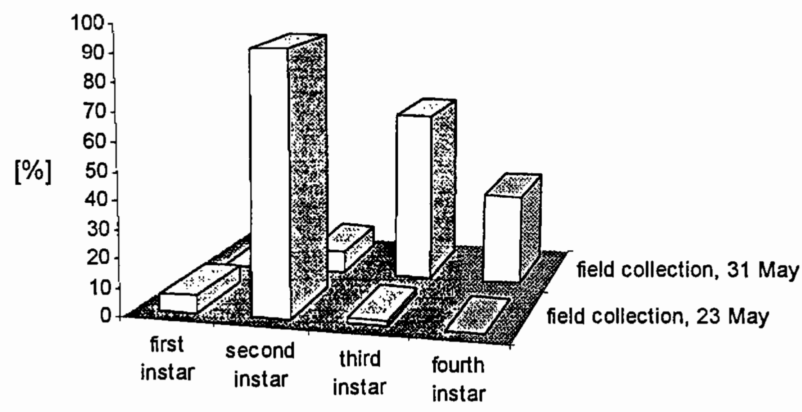

Fig. 1: Distribution of apple sawfly larvae on two collection dates.

The question arises, how many days *L. ensator* is able to use for egglaying? Field collected data (fig. 1) showed that development of the apple sawfly larvae took place quite simultaneous: From one collection of infested apples on the 23 May the dissection showed that 92% of the 201 found larvae were in the second instar. Eight days later on 31 May 60% of the 100 found larvae were in the third instar whereas 8% and 32% were in the second and the fourth instar respectively. Parasitism rate increased significantly from 4.5% on 23 May up to

30% on 31 May ($\chi^2 = 38,9$; $p < 0,001$). The host density was relatively high (12,7% infested apples).

Patchtime is one trait that might limit the parasitization success: Under the conditions of the first experimental series, patchtime for the successfully attacking females was on average 93 ± 34 sec. (n = 15), which is considerably short for finding and parasitizing a concealed living larva. In the second series, patchtime increased significantly, where it was 351 ± 336 sec. (n = 13; $p < 0,01$; Mann Whitney U-test).

One more possible limiting factor is the eggload. Dissections of females however showed that they had on average 94 ± 30 eggs in their ovaries (n = 20).

The biology and behaviour of the second parasitoid, *Aptesis nigrocincta* is quite different and complicated: the females of this species are nearly wingless, while the males are normal winged. From parasitization experiments in autumn 1994, the first generation emerged in the middle of June this year, which coincides well with the descending phase of the apple sawfly larvae. *A. nigrocincta* is a very longliving parasitoid; even under very warm conditions (between 22 and 28 °C in the laboratory) individuals lived longer than two month. Some individuals are still alive at the moment, therefore I can not present the exact data.

Mating and egglaying takes place directly after emerging. Two days after oviposition the first instar larvae hatches and about six days later (i.e. 8 days after oviposition) the rapidly growing larvae reaches maturity (at 24 ± 2°C). Development time alltogether is not exact known by now because only two individuals were observed from the time of parasitization up to emerging. In these two cases, development time was 23 days and 28 days. This indicates that *A. nigrocincta* builds up more than one generation and that the generations are overlapping eachother. This was confirmed by a field experiment: From cocoons, which were placed in the soil on 22 June and removed on 8 August, the first individuals emerged two days later on 10 August. The situation becomes even more complicated if you take into account that some individuals has a prolonged diapause as well as its hosts, the apple sawfly.

How do the females find their hosts? They do not have any morphological adaptations for digging into the soil like a mole and I never observed them trying this. If females were provided with cocoons on the surface of the soil, they found them only if they encountered the cocoons directly. Several times they passed a cocoon in only 0,5 cm distance. If females encountered a place where a cocoon was lying an hour ago, they examined this place and tried to oviposit (n = 10). If the females find a host they need on average 19,9 ± 10,75 min (n = 30) for a successful parasitization. If they find more than one cocoon on one day, patchtime increases up to 112 ± 63 min (n = 6) for the second cocoon. This indicates that a female of *A. nigrocincta* either needs some time to get mature eggs or for transporting them through the oviduct. Infact, I found that this species is synovigenous, the ovaries contending only between 0 and 5 mature eggs (2,3 ± 1,9; n = 9).

Discussion: The first attacking parasitoid *L. ensator* shows an efficient host-finding behaviour. It is able to locate apples infested with host larvae while it is flying above the canopy and the fruit clusters. And even if the parasitoid visits an uninfested patch, it soon perceived this and left. Boevé (1995) has found that small infested fruitlets already eminated a different spectrum of volatiles than uninfested ones and he concluded that the parasitoid might use these chemical cues for hostfinding. However it is not clear so far whether visual cues might be involved as well.

The results have shown that *L. ensator* is able to attack nearly only second instar larvae. It is not only that their handling time increased significantly if they tried to attack older larvae, but in addition they were very unsuccessful. Furthermore development of apple sawfly larvae takes place quite simultaneous and therefore only a very short period - about one week - is available for egglaying by *Lathrolestes* females. In this period in which suitable hosts are present, *L. ensator* is highly effective. But during this period *L. ensator* is much effected by bad weather conditions: In the field experiments hardly any oviposition attempts were observed on cold and rainy days (temp. between 13 and 18°C). Obviously this parasitoid (as many others) is also strongly affected by spraying of insecticides. Spraying occurs usually before and after petal fall, the latter time being the flight period of *L. ensator*.

The circumstances for the second parasitoid, *A. nigrocincta*, are different: In contrast to *L. ensator*, this parasitoid can use the apple sawfly as a host from the middle of June until Oktober. Here we face a system in which the parasitoid is able to build up at least two generations per year whereas the host builds up only one generation. This trait is promising if looking on the possible impact of *A. nigrocincta* on the apple sawfly population.

Patchtime is long compared with *L. ensator* and the amount of mature eggs is very small. It is not clear so far how long it does take to mature new eggs and what the females have to feed on to get mature eggs. However, if you take into account the long life span of the adults and the long period in which the ressource is available, this negative effects are neglegible most of the time. The fact that females tried to oviposit although the cocoon was already removed, indicates that they use chemical cues as an arresting pheromone. Further experiments have to examine the host-finding behaviour on a long-range scale.

To summarize, *A. nigrocincta* is a well adapted and specialized parasitoid of the apple sawfly. In contrast to the first parasitoid, *L. ensator*, here time is not the limiting factor, but the amount of eggs and the problem to find cocoons in the soil. It would be a challenge to put the knowledge on the impact of fungis (Jaworska 1992) and the knowledge on the impact of nematodes (Vincent & Belair 1992) together with the presented results to create a biological control programme against the apple sawfly.

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Factors affecting the effectiveness of the mating disruption technique: principles and necessities (*)

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Introduction

Since 1982 we gathered a considerable body of knowledge on this subject, based on experience obtained in diverse and extensive research and experimental work carried out on many thousands of hectares of vineyards and orchards in numerous European countries. The work has been carried out in cooperation with colleagues from official institutes, many of whom are gathered here to take the opportunity of exchanging views, sharing experiences and general discussion. It is notable, and also understandable since the disruption technique is relatively new, that almost everyone officially responsible for fruit and vine-growing in a particular region is eager to obtain a knowledge of this new method. This is a welcome state of affairs, but it does mean that different observations made in different places are also given varying degrees of importance. It would therefore seem necessary for the numerous results to be correlated, interpreted and questioned, in order to create a broad basis of knowledge for us all. Of the numerous factors for discussion (Cardé and Minks 1995), let us first try to examine a few in more detail, and perhaps get a better idea of how they fit together. Those factors are:

Adaptation and habituation (sensory fatigue), false trail following and competition, camouflage or masking, imbalance of sensory input, population density, pheromone composition (how important is the complete blend for disruption?), pheromone concentration per unit area, type of dispenser or curve of pheromone release, number of dispensers per hectare, uniformity of the pheromone atmosphere, environment and surroundings, proximity of untreated areas, shape of treated site, uniformity and height of trees, influence of wind, exposure of site (slope or plain), species behaviour and migration (emigration, immigration).

Mechanisms of Mating Disruption Technique and Air Movement

Even before the start of an international meeting of a few pheromone specialists in Switzerland in 1994, C. Sanders posed a number of questions, or rather touched on some problems concerning the MDT. I believe that if we look here at some of the questions that he posed we will be able to appreciate the problem. Regarding the mechanisms of the mating disruption (competition, masking etc.) he remarked: "Because of turbulence, I question wether uniform permeation plays any role under field conditions (although it is easy to achieve in a wind tunnel), and suggest that there will always be sufficient structure to air currents in the field to allow the moths to orientate, even if there are no discrete point sources for the males to home in on. This leaves competition and sensory fatigue as the mechanisms of disruption..."

Before we deal with the various points we should consider how we can approach the problem without initiating a lot of experimental work (although much of this has already been carried out). I believe that anyone who has observed the movement of any type of smoke, especially that of cigarettes, for more than 10 years and in all seasons, has learned a lot about the

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(*) This is an abridged text; in case you are interested in the full version, please contact the author "pheromone atmosphere." The question is, is this observation valid? The answer is probably "Yes", as long as the air temperature is above 30° C, i. e. when the cigarette smoke has no momentum of its own due to it being of a higher temperature than the surroundings (the smoke does not rise vertically). In this case the smoke acts only as a component of the air, and as such is only moved by air currents, in which the energy lies. It reflects, and makes visible the air currents.

At *very low wind speeds*, such as allow a dandelion-like seed to float downwards at an angle of 45°, cigarette smoke moves away from the cigarette with the wind parallel to the ground. Also in this case the cigarette smoke makes visible the absolutely turbulent air currents. Over a long distance the smoke forms a compact narrow thread, breaking up at changing distances into individual, still highly concentrated filaments, which then relatively suddenly disperse into the surrounding air at a distance of some 0,5 - 3 m from the source. Other observations, under different conditions, show us that the dispersing, thinning (less concentrated) smoke nevertheless leaves behind it fields or clouds of varying density. And if we apply this to pheromones this means that the male insects receive always pulsated signals. However, our experience with cigarette smoke also teaches us that under certain conditions, and when there are several sources of smoke (cigarettes), a more or less uniform blue-grey background-atmosphere of smoke will develop. This appears, only optically, uniform, without differences in concentration. The question is not whether this background atmopshere is really totally uniform, only the fact that a kind of "background soup" or "loaded" atmosphere is formed is of interest. The type of air movement (more or less turmoil) is naturallly largely influenced by wind speed and changes in wind speed at short intervals (a matter of seconds) caused by the presence of "stirrers", such as twigs and leaves. Thus, using an electroantennogramme (EAG), fluctuating concentrations of grape vine moth pheromone have been measured for the first generation in treated areas of grapes, even when no new shoots or leaves are present, due to the direct influence of the wind. When dense foliage is present, as for the second generation, this has a damping down effect and creates a more even pheromone atmosphere (Koch 1990, Karg 1992).

Let us come back to the females, or the scents emitted from the females. The initial pheromone trace is very concentrated, narrowly confined and thread-like, and disperses in a continually changing manner at a distance of about 30 to 50 cm (to 3 m) from the female; i. e. at that distance the concentration of the plume is reduced, but at the same time it is spread over a wider area and can certainly be detected by males a considerable distance away (100 m or more?). In other words, scent-wise, there the females appear "very large". On the other hand the dispensers set up in treated plots also produce fluctuating and even larger, more concentrated traces. For instance females may emit only about 2 ng/h (there are only a few studies on this), whereas dispensers on an average emit 50 000, and even over 100 000 ng/h. In both cases the pheromone trace is initially restricted and determined by the direction of the wind. In the case of the females it should be thread-like, in the case of the dispensers more a cloud, due to the comparatively large area from which

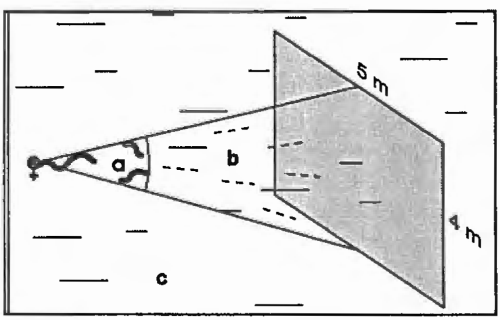

Figure 1.: Example for schematical dispersion of a female odour plume

it is released, mostly of more than 1 cm^2. In any case there is no known case in which the formulation in a dispenser resembles that of a female scent gland. Also microcapsules do not produce pheromone sources similar to females. It is thus easy to see that a female trace of fluctuating concentration will get lost, or be "masked", in a highly concentrated and fluctuating pheromone atmosphere in the surroundings... apart from in the immediate vicinity of the female where the 2-ng/h-thread is still unbroken and thus leaving an "active space" of the female (Linn et al. 1995) (Fig. 1 a: recognizable filamentous signal of female above artificial pheromone background (active space), b: female signal (---) disappearing in background, c: artificial pheromone). Calculably, 2 ng/h here is stronger than, more distant from a dispenser, a more widely dispersed and thus less concentrated trace from a dispenser or the less concentrated surrounding pheromone atmosphere between the dispensers, even with dispensers emitting more than 100 000 ng/h. The situation described here indicates that over the majority of the disruption area the female trace *is "masked" by an turbulent moving pheromone atmosphere*. One of the main mechanisms of the MDT is therefore, if attraction is concerned, a *"masking"* or considerable *limitation of the active space* of the female, or, even more simply, a drastic *shortening of the pheromone-trace-area*. But if a female is positioned directly behind a dispenser, as long as it stays there it will be totally masked, its active space reduced to nothing (Fig. 2 d: total masking).

Competition and false-trail-following

First of all, we can only speak of "competition" 1. as long as the pheromone employed is attractive (e. g. the *Lobesia botrana* and *Cydia pomonella* pheromones from BASF and Shin Etsu), 2. a competition is possible because of presence of females and dispensers and 3. "active spaces" of females and dispensers are close together (where distinct trails can still be found in a fluctuating sea of pheromones, Fig. 2 a: competition). More distant from the dispensers we may speak of the area of "false-trail-following", in which the plumes of the females, if present, are "masked" (Fig.2 b: "masking", c: false trail following) although distinct trails of pheromone do not more exist. A wandering male would leave the area of false-trail-following and subsequently the competition mechanism would come into effect, until false-trail-following begins again in the area of the next dispenser, or else it meets a female in spite of the surrounding pheromone atmosphere and mating takes place. Mating disruption with attractive pheromones would be thus a continuous fluctuation between false-trail-following and competition, whereby the false-trail-following plays a greater part, but the proportion of competition would increase when more dispensers are used per hectare.
But since the use of MDT gives good results only with low population density (that is very few females per unit of surface), competition and "masking" certainly plays only a small part in effective mating disruption, compared to false trail following.

Adaptation and habituation

Many workers have found in numerous investigations that these mechanisms are of little importance, if any at all. They have been observed in laboratory experiments when high pheromone concentrations were used. But where do we find such a high pheromone concentration in a treated field? One can only imagine that this could be directly behind the dispenser (Fig.2 e: sensory fatigue). Cardé and Minks (1995) rightly note: "In the field, a key factor modulating these processes may be the location where a male spends the portion of the diel cycle during which he is not responsive to pheromone...". If a male is located behind a dispenser and sensory fatigue occurs, the question is then how long it will remain sitting there. Presumably, though, it will alter its resting places during the course of the daily flight activity. Let us suppose (*Lobesia* lives a week longer if it has not mated [Krieg. pers. comm.]) that a male suffers from sensory fatigue for a "diel cycle not responsive to pheromone", then does it make any difference if it spends the rest of the 20 days somewhere else, away from the immediate vicinity of the dispenser?

Imbalance of sensory input and pheromone composition

Pheromon composition is an often-discussed-point. "The best attractant is the best disruptant", Arn from Wädenswill used to say. Today we think differently because we have learned more. We know, for instance that for the control of Grape Berry Moth (*Eupoecelia ambiguella)* non-attractant pheromone has proved commercially effective as a disruptant on thousands of hectares since 1986 (Neumann et al. 1986). But attractant pheromones have also proved effective (Codling Moth, *Cydia pomonella* and Grape Vine Moth, *Lobesia botrana*). In our experience we cannot see any particular difference of importance for the vine- and fruitgrower between the two types of pheromone. Sometimes it seemed possible that attractant pheromones can attract males from untreated neighbouring areas. This does happen (Feldhege 1995). But in the case of Grape Berry Moth we sometimes *also* find a higher level of attack on the perimeter, but due to fertilized females flying in. In the case of non-attractant pheromones the "competition" or "false-trail-following" factor is definitely ruled out. Here certainly only "imbalance in sensory input" (no attraction of the males to the dispensers, Schmitz 1992) takes place, although this again with *Eupoecilia* seems not to be complete "imbalance of sensory input", since once again the females retain a limited amount of "active space". This residual active space would be of no importance if the males did not make searchflights in the case of non-attractant pheromones. This seems not to be the case to the desired degree, because for Grape Berry Moth higher levels of attack are found at higher population densities, that is, the males *have* found females.

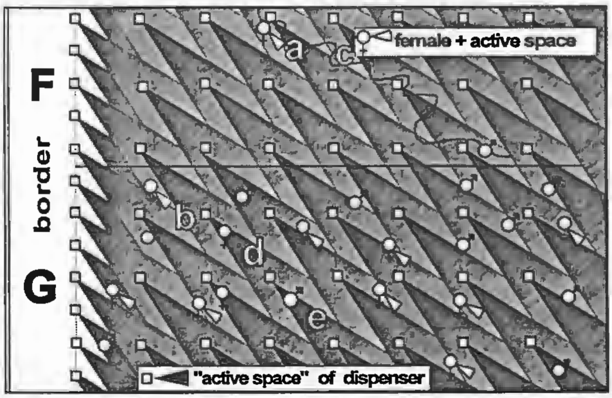

Figure 2.: Example for schematical dispersion of pheromone in treated plot and meeting possibilities of males and females in F and G (low and high population density)

What is important for pheromone treatment (either as single components or in a blend) to be successful, is the ability so to mask the female pheromone trace, or to render it unrecognizable, that the females can no longer be found (by the males) in the area concerned (except in the residual active space). And this is possible if only one component is employed. This is practised in the case of the various fruit Tortrix species, where only the component Z11-14Ac is used. Many of these species have both components (Z9 + Z11-14Ac) in their pheromone blend, and the females of the species differ from one another also in the proportion of the two components in their blend. When one component is indroduced into the air space in which the females are emitting their traces, then the proportions in the blends of all species are altered, so that they become unrecognizable to the males. This is, at least, the theory, and trial results over several years have confirmed it. The cause for the failures occasionally observed in these trials must be sought elsewhere, probably in high population density.

Population density

The most important factor responsible for success is the population density. It is unterstandable that, when the population densities are too high, too many males may reach the remaining "active spaces" of the females, after pheromone application, and mate with females. Furthermore we can trap males and females with a liquid bait, which indicates that we are observing a necessity and ability on the part of the adults to take up certain fluids. Thus it seems plausible to assume that in the natural environment there are also places to which males and females are attracted. When both sexes meet (this does not happen "without" population), mating also takes place there. This has been observed by Netter (1993) at juice traps.

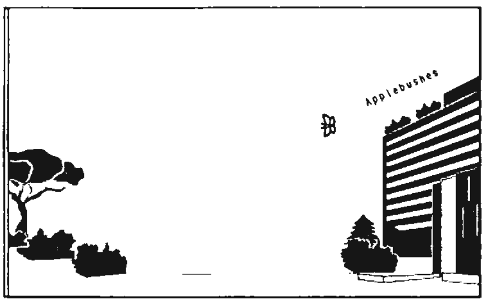

Figure 3.: Appearance of 1 codling moth female at a moment (e.g. 1 day) passing a perpendicular section of an air space

These few facts lead us to the conclusion that the MDT brings the best results when the population density of the pest is very low (Fig.2 F+G). Except that, when there is no population, no control measures are applied. However, prophylactic applications are quite normal in plant protection - one anticipates that the population will develop. This is also the case for the MDT - it is not a method of control, but a way of preventing the development of a pest population to the point where it will cause damage. Kelly et. al. (1995) have examined the MDT complex mathematically. After questioning several researchers on the parameters, the following formula for mating probability (MP) was devised: $MP = k * Nm * Nf$, where Nm and Nf are the numbers of males and females. K is a coefficient which can represent all the possible factors, such as blend of pheromones, concentration, wind speed, etc., influencing the by-square-increase of MP (1, 4, 9, 16, ..).

Migration

Our final topic is that of migration - that is, emigration and subsequent immigration, including that of fertilized females. Unfortunately we have only few opportunities to observe this phenomenon. The species that we are most interested in usually fly in the evening or at night. At any rate, at times when researchers are no longer in the orchard to make observations. From indirect observation we conclude that deplacements of 30 - 40 m can occur. It is only very seldom that we actually see the insects flying. At the IOBC Meeting in S. Michele, Italy, in 1992 I shared a few thoughts about migration behaviour, and I would like to add a few more.

Every population must be prepared to colonise new areas. It is a law of nature that "mutual togetherness" amongst species in a biotope is continually being re-organised. This "togetherness" also applies to opponents. Thus, in Europe, every newly laid-down orchard, far away from any other apple trees, is very soon colonised by Codling Moth and other Tortricids. We can find no orchards without the "togetherness" of apple trees, apple pests and their natural enemies, even in the newly reclaimed areas of the Dutch polders. It would be ridiculous to try to explain this by saying that the insects were brought in by human beings or animals, when we know that moths have wings to enable them to fly and drift on the wind. It is just that there are only a few observations which give an indication of the migration behaviour of the species we are interested in. Feldhege (1995) has reported that Grape Vine Moths can fly distances of more than 3 km. De Schaetzen (pers. comm.) found that apple trees planted in pots 30 m up in a block of flats were 100 % infected the first time that they bore fruit. Apparently a fertilized Codling Moth female must have flown up 30 m. Probably it was just one female. If one was to take a section of the air space up to, or at, 30 m without doubt in the course of the season numerous Codling Moth flights could be observed (figure 3 and 4). Four of my own grapes, far away from any other grapes, were free of any Tortricids for a number of years until suddenly a Grape Vine Moth appeared and the result was a severe attack. It seemed as if not only one female, but a whole troop of moths had arrived. In a vineyard, which had successfully been treated with pheromones for several years and where practically no infection could be found, a disturbing number of moths were suddenly caught in a trap, right in the centre of the field. Doesn't it seem as if a small group of wandering moths dropped in here? We have all made numerous observations which indirectly show that flying animals fly around more than we think or are aware of. We observe swallows and swifts and bats at night which almost only fly in search of food. Surely their food is not only flies, aphids and beetles, but also one moth or another of the species in which we are interested.

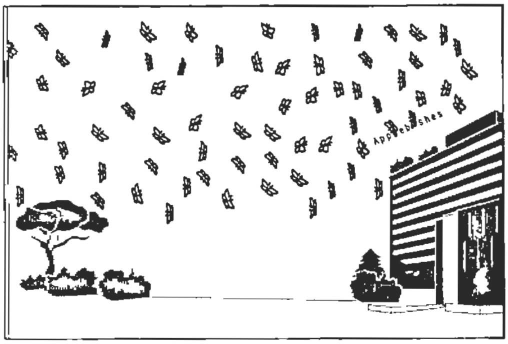

Figure 4.: Appearance of (female) moths passing a perpendicular section of an air space, accumulated during the seasonal flight period of a codling moth population

Final remarks

Should we conclude on the basis of all this that the MDT is too risky to recommend further? Certainly not, since observations carried out on areas treated with insecticides in connection with the MDT trials show without doubt that insecticide treatment is equally as inconsistent, if not more, as regards control of attack and degree of success. At the last IOBC Meeting of the vine Group in 1995 in Freiburg, Germany, the delegates were unanimous in agreeing that the MDT produces results which are just as good or better than those with insecticides. The danger of immigration of fertilized females, mentioned above, is in our experience not so great, although it should be considered, and should be limited by large-scale application. Certainly the various points discussed here should be taken into consideration when planning and employing the MDT, so as to avoid failure and discredit to the method. It is hoped that the points made will help us to interprete some of the observations made in the course of pheromone trials in a different way, and that they may also help us in improving the layout of the trials and practical applications, so that the success rate will be further improved in the future.

References (*) see page 1

EFFECTIVENESS OF MATING DISRUPTION METHOD AGAINST *LOBESIA BOTRANA* (DEN. ET SCHIFF.) (LEPIDOPTERA - TORTRICIDAE) IN APULIAN VINEYARDS (*)

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Abstract

The mating disruption method against *Lobesia botrana* (Den. et Schiff.), applied in Apulia in the same vineyards on the five-year period 1990-94, gave the following results:
1) the drastic reduction of male captures in the mating disruption plots was confirmed;
2) the wide fluctuation of the larval infestation over the years does not allow a unique interpretation of the data observed, nevertheless a reduction of the larval infestation of the second and third generation in the mating disruption plot compared with the untreated ones was recorded during 1990-94; this tendency could probably lead, within a few years, to a larval infestation under the economic injury level for wine grapes;
3) predators of European grapevine moth larvae (Neuroptera and Arachnida mainly) are few in the 2nd generation, but they increase during the 3rd and this contributes to reduce the phytophagous infestation;
4) the mating disruption method against *L. botrana* was successfully used in wine vineyards, but it failed to keep the larval infestation under the very low threshold of 2-3% required at present by table grapes market.

Key words: European grapevine moth, mating disruption method, vine.

Introduction

The attention devoted to mating disruption method against European grapevine moth *Lobesia botrana* (Den. et Schiff.) as an alternative control method to the use of insecticides is reinforced by several works carried out recently. The most suitable distribution of pheromone dispensers in the vineyard (Schmitz *et al.*, 1995), the consequences of population density and of adult flight activity on the application of the mating disruption method (Charmillot, 1992; Neumann, 1993), the evaluation of fertility, sex-ratio and different behaviour patterns of European grapevine moth adults in the disruption-treated plots (Feldhege *et al.*, 1993), are some of the aspects lately investigated. The effectiveness of the mating disruption method was evaluated in different countries: Spain (Coscollà *et al.*, 1993; Perez Marin, 1993), France (Stockel & Lecharpentier, 1993), Greece (Tsitsipis *et al.*, 1993) and Italy (Nannini & Delrio, 1993). A review of the experiences made in different Italian regions was published too (Bagnoli *et al.*, 1993).

The aim of this research was to verify the results of our previous observations (Moleas & Addante, 1991) and to acquire new data for a more profitable application of the mating disruption method in our environment.

(*) The Authors contributed to the same extent to carry out this work funded by Mi.R.A.A.F. (the Italian Ministry of Agriculture) within the framework of the Project "Biological and integrated pest management for agrarian and forest plants protection" Subproject "Viticulture".

Materials and Methods

The research was carried out in two tendone-trained vineyards of wine grapes, located in the same farm in Andria, in 1991-1994. The vineyards, both of about 7000 m^2, were planted with two different cultivars: "Pampanuto" and "Uva di Troia". The first was entirely used as control plot, the second as plot to test the disruption method. We could use two different cultivars as treated and untreated because in a previous work we had ascertained that there was no statistically significant difference with respect to the adult and larval population of European grapevine moth (Piglionica *et al.*, 1993). The treated plot was surrounded by 1 x 1 mm mesh plastic nets to avoid adult shifting. Three pheromone traps were placed in each vineyard. Nets and traps were put on the third decade of March and removed at vintage time (normally at the end of September). The pheromone dispensers for mating disruption, supplied by BASF, were made of cruets with a double chamber that contained the sexual pheromone-based mixture ((E,Z)-7,9-dodecadienyl acetate). The dispensers used in 1991 and 1992 contained each 450 mg of pheromone, those used in 1993 and 1994 contained 240 mg and this to verify the effectiveness of different pheromone concentrations. The dispensers used in 1994 were produced in 1993 and kept in the refrigerator at 4-6°C up to their use. The dispensers were put in the vineyards, all the four years, as follows: two dispensers for each vine of the external row, one dispenser for each vine of the next inner row and one dispenser for each four vines (1 dispenser/16 m^2) in the remaining part. An average number of about 1000 dispensers per hectar was distributed in the treated plot; all the four years they were placed in the vineyard at the beginning of April and removed at vintage time, without any substitution. Male captures were weekly checked from April to vintage to define the flight trend. The percentage of larval infestation of each generation was evaluated by sampling: 200 clusters per plot were observed at random following the diagonals of the vineyard (one cluster every 2-3 vines on average). The infested berries of these clusters were picked up to be examined in the laboratory. The last sampling, before harvesting, was carried out picking up 100 entire clusters and examining them in the laboratory. The presence of parasites and predators of European grapevine moth was assessed through the above-mentioned sampling. The apparent infestation, obtained as per cent ratio between the attacked clusters and the examined clusters, and the real infestation, obtained as per cent ratio between the number of living larvae and the examined clusters, were taken as larval infestation parameters (Moleas, 1984).

During the research period (1991-1994) no insecticide treatment was used in the two vineyards; in 1990 a treatment against each of the two carpophagous generations was made in the control plot ("Pampanuto"). Capture and larval infestation data of 1990 were taken from a previous work (Moleas & Addante, 1991) after being processed.

Results

Flights

The males captured by the traps in the mating disruption plot were almost always close to zero and considerably lower compared with the control plot (Tab. I). A progressive increase of male captures occurred in the control plot from 1990 to 1993, a sudden reduction followed in 1994. The total amount of the mean male captures of the three flights changed from 300 to 418, to 701, to 951, to 119 respectively from 1990 to 1994. The third flight, to which the fourth overlaps, had the highest total of captures, the second flight the lowest, while for the first were recorded intermediate values.

Tab. I - *L. botrana* flight patterns (average number of males/trap*week); total of the captures of each flight and total of the three flights approximated to the nearest entire number in both mating disruption and control plots.

	Control plot					Mating disruption plot				
Date	1990	1991	1992	1993	1994	1990	1991	1992	1993	1994
1/4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8/4	3.0	2.0	1.0	2.0	2.3	0.0	0.0	0.0	0.0	0.0
15/4	7.8	4.0	2.7	10.0	2.3	0.0	0.3	0.0	0.0	0.0
22/4	12.5	0.3	18.3	30.0	12.3	0.0	0.0	0.0	0.5	0.3
29/4	25.3	10.0	19.0	115.7	3.0	0.0	0.0	0.0	1.0	0.0
6/5	54.0	16.7	10.0	108.7	3.0	0.0	0.3	0.0	0.7	0.0
13/5	19.3	9.3	0.3	80.0	0.7	0.0	0.0	0.0	0.5	0.0
20/5	3.5	2.5	0.0	63.7	0.7	0.0	0.0	0.0	0.7	0.0
27/5	3.0	1.3	0.0	12.0	0.0	0.0	0.0	0.0	1.0	0.0
4/6	1.8	7.5	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0
1st flight total	130	54	51	426	24	0	1	0	4	0
11/6	1.0	1.8	2.7	6.3	3.7	0.0	0.0	0.0	0.0	0.0
18/6	3.0	0.3	12.0	25.3	16.0	0.0	0.0	0.7	1.0	0.3
25/6	3.3	1.8	29.3	4.3	7.3	0.0	0.0	0.7	0.0	0.0
31/6	8.5	10.5	4.0	8.7	0.7	0.0	0.0	1.0	0.0	0.0
8/7	6.0	11.0	1.0	13.3	0.0	0.0	0.0	0.0	0.0	0.0
15/7	1.8	9.0	2.3	1.7	0.3	0.0	0.3	0.0	0.0	0.0
22/7	0.5	2.8	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0
2nd flight total	24	37	52	60	28	0	0	2	1	0
29/7	2.7	1.8	4.0	0.3	2.0	0.0	0.0	0.0	0.0	0.0
5/8	6.0	10.8	44.3	2.7	3.3	0.0	0.0	0.3	0.0	0.0
12/8	16.7	44.5	145.7	24.3	13.7	0.0	0.0	2.7	0.0	0.0
19/8	32.0	70.5	140.3	155.3	34.3	0.0	0.0	1.3	0.0	0.0
26/8	47.0	54.0	83.7	123.7	12.7	0.3	0.0	0.3	0.3	0.0
2/9	27.7	89.3	104.3	95.0	1.0	0.0	0.3	0.0	0.0	0.0
9/9	8.7	30.3	44.7	41.7	0.0	0.0	0.0	0.0	0.3	0.0
16/9	0.3	24.3	21.0	14.7	0.3	0.0	0.0	0.3	0.0	0.0
23/9	5.3	1.8	10.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0
3rd flight total	146	327	598	465	67	0	0	5	1	0
Total of 3 flights	300	418	701	951	119	0	1	7	6	0

Larval infestation

II generation

The apparent infestation of the control plot had the following values in the five years considered: 35% in 1990, 12% in 1991, 77% in 1992, 78% in 1993 and 11% in 1994 (Tab. II). Conversely, the apparent infestation of the mating disruption plot always proved to be lower in all the five years with values of 31%, 5%, 69%, 30% and 4% respectively. The real infestation was higher in the mating disruption plot than in the control in 1990 (12% versus 10% respectively), more than double in the control than in the treated plot in 1991 and 1993 (11% versus 5% and 212% versus 80% respectively), the same in the two plots (equal to 10%) in 1994.

III generation

The same Table II shows that both apparent and real infestation of the control plot were almost always higher than those of the mating disruption plot; the only exception occurred in 1991 when the two indexes proved to be a little higher in the mating disruption plot.

Tab. II - Total of the 2nd and 3rd flight captures (average number of males/trap of each flight) and percentage of apparent and real larval infestation of *L. botrana* in the mating disruption and control plots.

	Control plot			Mating disruption plot		
Year	Captures	Apparent inf.	Real inf.	Captures	Apparent inf.	Real inf.
2nd flight and generation						
1990	24	35	10	0	31	12
1991	37	12	11	0	5	5
1992	52	77	---	2	69	---
1993	60	78	212	1	30	80
1994	28	11	10	0	4	10
3rd flight and generation						
1990	146	40	21	0	40	18
1991	327	37	22	0	40	25
1992	598	92	364	5	64	56
1993	465	54	12	1	18	2
1994	67	7	4	0	0	0

Parasites and predators

During the research period parasites belonging to the following families were observed: Ichneumonidae, Braconidae , Chalcididae, Tachinidae. The predators most frequently observed were Green Lacewings and Spiders, the last being the most numerous. The Spiders were mainly represented by the family Cublionidae followed by Philodromidae, Thomisidae and Salticidae. In 1990 no Spider was observed in the vineyards. They were almost always hidden in the central part of the cluster, near the grape-stalk.

Discussion and conclusions

Both the dispensers with 240 mg and the ones with 450 mg of pheromone were effective during the whole European grapevine moth flight period (from April to September), since a very small number of males was caught in the mating disruption plots. Moreover the pheromone dispensers stored in the refrigerator for one year and used in 1994, also showed the same effects on the male captures. Although the male captures of the control plot increased three-fold from 1990 to 1993, the values of the apparent and real infestation during the five years considered were lower in the mating disruption vineyard than in the control plot.

No significant differences were observed between the two plots regarding the presence of parasites and predators. The Spider populations fluctuated considerably through the years, being higher when the European grapevine moth population density was lower. In general the Spider predation was more effective during the 3rd generation.

Our observations show that the mating disruption method could be applied also in the tendone-trained vineyards, even if the great amount of leaves placed in a horizontal layer do not allow the uniform distribution of the pheromone both in the space and in time.

If the reduction of the larval infestation percentage over the years is confirmed by further observations, the mating disruption method could be used as an alternative to the insecticide treatments for the control of the European grapevine moth in the tendone-trained vineyards. This hypothesis may be more valid from a practical point of view because the economic injury level could be raised, in our environment, considering the lower incidence of indirect damages due to European grapevine moth (*Botrytis* infections and sour rots) compared with those observed in Northern Italy (Piglionica *et al.*, 1993). However, it is necessary to recognize that the mating disruption method is not able to keep European grapevine moth larval infestation down the 25-30% economic injury level (for wine grapes) in the years with a higher phitophagous population density (in fact, the real infestation reached 80% in the 2nd generation of 1993 and 56% in the 3rd one of 1992).

The mating disruption method can not be used yet in table grapes vineyards due to the high quality standards (good-looking mainly) the market requires currently (larval infestation percentage lower than 2-3%).

Acknowledgements
We thank Dr. Salgarollo, ICI Solplant S.p.A., for supplying the pheromone dispensers during the five years of the research; Dr. Arnò, Dipartimento di Entomologia e Zoologia applicata all'ambiente "Carlo Vidano" - University of Torino, for Spiders identification. Thanks are due to Provincia of Bari for putting at our disposal the vineyards located in Andria.

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LECTURES

Section: Cultivation, Nutrition and Herbology

Ammonia-Depot Fertilization of Strawberries

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Abstract

Soluble nitrate fertilizers like calcium ammonium nitrate often caused nitrate leaching in cultivation of strawberries. A field experiment was conducted in 1993-1995 to compare the conventional application of calcium ammonium nitrate over the whole area with a ammonia-depot fertilization. There were no effects of fertilization on flowering, on final fruit yield, that is number and weight of strawberry fruits and on the mineral composition of strawberry plants and fruits. Soil analysis from four weeks after fertilization until the end of September showed the reduction of nitrate in the soil with ammonia-depot fertilization.

1. Introduction

Soluble nitrate fertilizers like calcium ammonium nitrate often resulted in nitrate leaching in strawberry cultivation, the effect being larger on sandy soils without cover and wide row spacing (0.8 to 1.0 m). Drinking water can be polluted by nitrate leaching (Scharpf and Brandis, 1982; Quast, 1988). The ammonia-depot fertilization seems to be a good way to reduce nitrate leaching. Ammonia is absorbed in soil exchangeable (Page, 1975). The high ammonia concentration of the depot causes a sterilisation of the soil in the centre of the depot and an inhibition of nitrification for some weeks after injection (Ashworth, 1973; Page, 1975). Thus ammonia is protected against leaching. Applicated as a depot it is available for plants without decreasing their growth (Sommer, 1989). The generative and vegetative growth of vegetables (Sommer et al., 1987) and cereals (Sommer and Six, 1981) were not influenced negativly by the ammonia-depot fertilization. The aim of this project was to use ammonia-depot fertilization in order to reduce nitrate leaching and to observe its effects on flowering and fruiting as well as mineral composition and dry matter of strawberry fruits and plants.

2. Material and methods

A field experiment was conducted in 1993-1995 to compare the conventional application of calcium ammonium nitrate over the whole area with the ammonia-depot fertilization. The experiment was designed as a block with four repetitions per treatment. Strawberry plants planted in August of 1993 were fertilized in April of 1994. Ammonia solution (25 % N) was injected into the soil close to the plants to create the depot and calcium ammonium nitrate was applicated over the whole area by hand, both at a rate of 60 kg N/ha. Control plots were not fertilized with nitrogen.

The flowers of ten plants per repetition were counted at two dates. Fourty plants per plot were harvested. The fruits were weighed and counted after dividing them into different grades (grade I, II and unmarketable). Fruit samples were dried to determine their dry matter and mineral composition. In autum of 1994 six plants per plot were picked and leaves, shoots and roots were dried seperately to determine their mineral composition.

Soil samples were taken in a depth of 30 cm from May until September of 1994 in and between the rows to determine their nitrate concentration.

3. Results

3.1. The influences of ammonia-depot fertilization on plants development

3.1.1. Flowers per plant

The different kind of nitrogen fertilization in spring did not influence the number of flowers per plant (table 1). At the first date the plants of all treatment had between 19 and 20 flowers and between 30 and 33 at the second.

3.1.2. Yields and composition of fruits

Table 2 shows total yield and fruit numbers of 40 plants divided into different grades. Yield and number of fruits of the different grades were not influenced by the different treatments. At the different harvesting dates the dry matter content of the fruits was not influenced by the nitrogen fertilization. Fruits of plants fertilized with ammonia had dry matter contents between 10.21 and 10.67% at the first five dates, increasing to 11.85% at the end of the harvest. The fruits of plants without nitrogen and with calcium ammonium nitrate fertilization had nearly the same dry matter content and showed a similar behaviour (table 3). The mineral composition of fruits was not influenced by the nitrogen fertilization too. It must be emphasized, that the uptake of cations was not reduced by fertilization with ammonia (table 4).

3.1.3. Mineral composition of plants

The mineral composition of roots, shoots and leaves of strawberry plants in the autum of 1994 is shown in table 5. The uptake of mineral nutrients was not significantly influenced by the different kinds of nitrogen fertilization. The uptake of cations in the different organs was not reduced by fertilization with ammonia.

3.2. Soil analysis

The analysis of the soil samples showed different nitrate concentrations in and between the rows depending on the kind of nitrogen fertilization (figure 1). Four weeks after fertilization with calcium ammonium nitrate the nitrate concentration of soil in the rows increased from 16 kg to 36 kg nitrate/ha. In the plots without nitrogen fertilization and with ammonia-depot fertilization there was no increase found during the first month. During the summer ammonia-depot fertilization caused a slow increase in nitrate concentration of the soil soil up to about 20 kg nitrate/ha. In the plots without nitrogen fertilization the soils nitrate concentration of the soil did not change over time.

Between the rows the nitrate concentration in the plots with calcium ammonium nitrate fertilization decreased from 70 kg nitrate/ha four weeks after fertilization to 25 kg at the end of September. No significant differences were found between plots with Ammonia-Depotfertilization and these without nitrogen fertilization. The nitrate concentration in these plots averaged between 20 and 30 kg nitrate/ha.

Table 1 - Number of flowers per plants in 1994

Treatment	Date 30. Apr.	11. May
Ammonia-Depot	19	33
Control	19	30
Calcium ammonium nitrate	20	33

Table 2 - Yields and number of fruits per fourty plants in 1994

	Yields in g			
Treatment	total	grade I	grade II	unmarketable
Ammonia-Depot	11606.5	9437.2	1899.5	268.3
Control	11005.6	8720.0	2022.9	262.5
Calcium ammonium nitrate	11695.5	9238.3	2169.0	288.2
	Number of fruits			
Treatment	total	grade I	grade II	unmarketable
Ammonia-Depot	1033	618	352	64
Control	1009	581	378	51
Calcium ammonium nitrate	1072	617	398	58

Table 3 - Dry matter per fruit in % of fresh weight in 1994

	Harvest time					
Treatment	8. Jun.	13.Jun	15.Jun	20.Jun	23.Jun	27.Jun
Ammonia-Depot	10.62	10.21	10.67	10.67	10.54	11.85
Control	9.93	10.23	10.23	10.73	10.79	12.01
Calcium ammonium nitrate	10.26	10.56	10.17	10.25	10.34	11.79

Table 4 - Mineral composition of fruits in % of dry matter

	Mineral nutrients				
Treatment	N	K	Ca	Mg	P
Ammonia-Depot	1.13	1.77	0.13	0.11	0.15
Control	1.04	1.75	0.13	0.10	0.15
Calcium ammonium nitrate	1.12	1.76	0.12	0.11	0.16

Table 5 - Mineral composition of strawberry plants in % of dry matter

	Leafs				
Treatment	N	K	Ca	Mg	P
Ammonia-Depot	2.11	2.08	1.15	0.30	0.18
Control	2.12	2.11	1.21	0.30	0.16
Calcium ammonium nitrate	2.17	2.13	1.11	0.29	0.19
	Shoots				
Treatment	N	K	Ca	Mg	P
Ammonia-Depot	1.70	0.89	0.82	0.20	0.13
Control	1.68	0.94	0.82	0.20	0.06
Calcium ammonium nitrate	1.72	0.93	0.83	0.20	0.16
	Roots				
Treatment	N	K	Ca	Mg	P
Ammonia-Depot	1.87	1.65	0.42	0.28	0.17
Control	1.82	1.60	0.40	0.28	0.14
Calcium ammonium nitrate	1.91	1.70	0.40	0.29	0.19

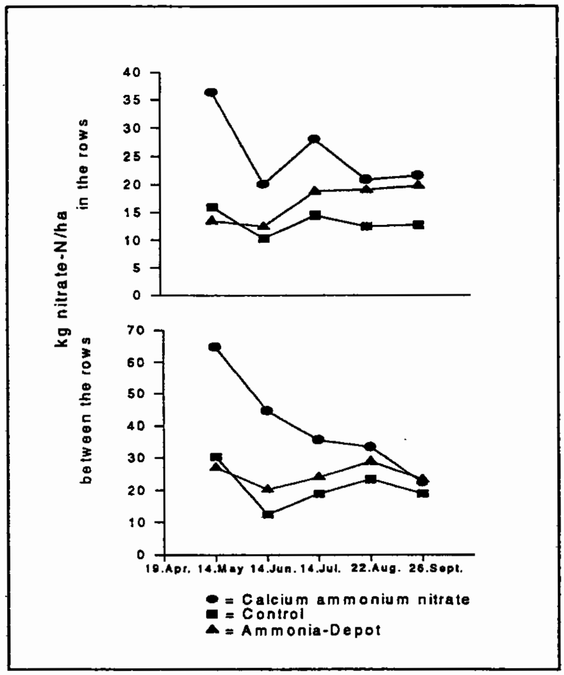

Figure 1 - Nitrate concentration in the soil from April - September 1994

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INFLUENCE OF INTERSTOCK ON APPLE TREES

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Abstract. In 1979 were planted a trial of interstock apple trees in the garden of Estonian Agricultural University. There have been tested cultivars 'Talvenauding' and 'Tellissaare'. The Tested trees were on Antonowka seedling with 10 or 15 cm-long B9 and with 15 or 20 cm-long 57-490 interstocks. The trees with interstock were compared with the trees grafted directly onto 57-490 clonal rootstock.

The roots of dwarfing interstock trees have the same circle of stretsch and vigour of growth as the rootsystem of medium growing interstock or clonal rootstock trees. Production on 57-490 was not greater than that on Ant./57-490, but production of trees 'Tellissaare' on Ant/B9 (15 cm) was greater than that on 57-490.

Introduction. Dwarf fruit-trees should be recommended for erery gardener. It is easy to take care of a head without the ladder and pleasant to pick up a yield. Advantage of lower trees in production garden is a possibility of closer planting which will elevate the efficacious of the land.

Most of the dwarfing clonal rootstocks of apple trees have a bad durability and therefore they need additional expenses for props. The experimenters have tried to better of anchorage useing dwarfing rootstock as an interstock grafted between vigour rootstock and the variety. A score cm long interstock has retained its influence to the variety raising to early fruit bearing and weaker growth of the tree. The trials with different combinations of grafting have showed that three components tree has affected by all 3 parts (Pätzold, 1986). Therefore is necessery to make experiments with selected combinations for each variety, not to have suprises later.

There are growing a lot of our own varieties in Estonia which answer to local conditions. For that reason the gardeners couldnt calculate with the results of another growers. The interstock has also the second aim in Estonia. The roots of clonal rootstocks are sensitive to frost and at the snowless winters the roots can suffer under low temperatures laying not very deeply in a soil.

Experimental conditions. In 1979 were planted a trial of "interstock apple trees" in the garden of Estonian Agricultural University. There are tested two more common wintervarietes in Estonia: 'Talvenauding' and 'Tellissaare'. There is used the seedling 'Antonovka' as a stock. Clonal rootstock B 9 (10 and 15 cm long) and 57-490 (15 and 20 cm) as the interstocks. Three components interstock trees are compared with two components (directly grafted to rootstck 57-490) trees.

Experimental garden is surrounded from north and west by spruce windbreak. There are mature apple trees in the east and strawberry plantation in the south of trial plot. In the garden is pseudopodzolic soils, there is enough phosphorus and calcium in the soil, but the lack of humus occurs. ph in the ploughlayer is acid.In young orchard branches of trees were thinned and shortened. In 1992 rejewenation pruning was carried out. Trees were fertilized three times a year. In spring nitrogen was given before and after flowering, in both times 50 kg/ha. In nonproduktive year second part after blooming was not given. Phosphorus and calcium were given between rows after harvesting in the autumn - ratio 90 kg/ha. Space between rows was cultivated four times a year.

Root-system. In 1993, the 14th year of growing there were checked the root system on the method of "profile". More exact methods were excluded since they would have disturbed trees life activity.

Roots of tested trees are on a depth down to 40 cm (Figure 1). That means that the depth of interstock apple trees roots are similar to the apple trees on clonal rootstock. One of the unifing factors is heavy loam in deeper. Therefore the soil air conditions are worser and that inhibits growth of roots.

Compareing the root-system lay-out of 'Tellissaare' and 'Talvenauding' the influence of cultivar is also noticeable. Roots of 'Talvenauding' are more shallow, exept on trees with 20 cm long 57-490 interstock. The influence of cultivars to the interstock apple trees root system has been recorded alredy befor (Коваль, 1990).

In the third variant bei 'Tellissaare, where interstock is 15 cm long B9, roots are mainly shallow and in radius of 2 m from stem. That can be explained by cultivating and fertilazeing between the rows what gives better possibilities for trees to obtain nutritiens and tthees have also bigger yield.

By interstock 57-490 the depth of roots is not significantly bigger than on the same rootstock. Can be expected that because 57-490 as an interstock is also good in producing roots, root system of a seedling rootstock reverts and tree will have roots of a clonal rootstock later. Similar record has been made also in Russia (Калита ид., 1985).Interstock B9 produces also a few roots, but these are very fine and do not weaken rootsystem of a seedling rootstock. Since single trial tree has not required support and according to above said following conclusion can be made:
- on cultivars 'Tellissaare' and 'Talvenaudind' use of interstock 57-490 is not exedient, becouse directly on the same rootstock grafted trees have similar anchorage.

Using B9 as an interstock several trees have trunly bulge on the upper grafting site. On those trees interstock is partly out of a soil because of a soil sinking. On trees with normal stem and completely soil covered interstock the root-system development is similar to the other variants. Trees with trunk bulge have significantly weaker root system and there is no roots in 2 m from stem. Can be expected that because of different vigour (dwarfing interstock between vigorous

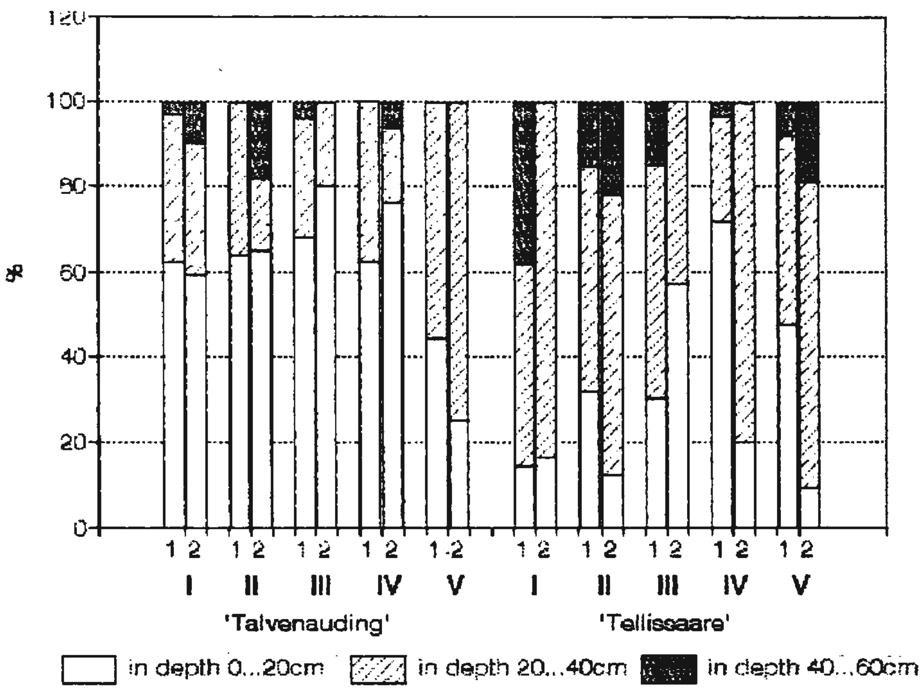

Figure 1. The amount of roots in different depths (% from total number) 1 and 2 m from stem.
I- control, II-interstock B9 (10cm), III-interstock B9 (15cm), IV-interstock 57-490 (15cm), V-interstock 57-490 (20cm)

cultivar and seedling rootstock) B9 will hinder obtaining of nutrients. For that reason dynamics of starth in roots and branches was investigated. There was no significant differences compared to other variants. Therefore the influence of growth regulators movement can be expected. This confirms the necessity to continue this trial before recommendations for establishing commercial plantions will be given. Uneven root system can cause different vigour and lenght of fruiting period.

Yield. The main reason of using interstock is to improve durability of trees, but preventing a yield decrease is also important. Comparision of productivity of two cultivars in young orchard showed that 'Talvenauding' had greater yield though 'Tellissaare' has found to be a very early cropping cultivar. That was caused by winter 86/87, when minimum air temperature was -35° C and because of frost injuries the yield of 'Tellissaare' was only 0.3...0.6 kg per tree in seventh growing season. In young orchard the mean yield of 'Talvenauding' is 4.2...6,4 kg per tree(Table 1). Differencies is not significant and though we could conclude: by 'Talvenauding' interstock has no influence in young orchard. The yield of "Tellissaare' was 2.0...4.5 kg per tree and

Table 1. The mean and total yield from 'Tellissaare' and 'Talvenauding' in 1982...1987.

Variety	Interstem and lengh	Mean yield in kg per tree	Total yield in kg per tree
'Talvenauding'	control	4,5	27,3
	B9. 10 cm	6.4	38.7
	B9. 15 cm	5.2	30.9
	57-490.15cm	5.0	30.0
	57-490.20cm	4.2	25.5
'Tellissaare'	control	2.0	11.7
	B9, 10 cm	2.5	15.0
	B9, 15 cm	4.5*	27.1*
	57-490.15cm	2.9	17.2
	57-490,20cm	2.9	17.1

* LSD 95%

significantly greater mean and total yield in young orchard was by using 15 cm long interstock on B9 trees.

Periodical fruit-bearing appeared alredy in young orchard and did not disappear in mature orchard (Figure 2). The reasons of it are above mentioned severe winters, but also pests changing a balance in trees life cycle. Main pests damaging a yield are apnids (*Arhis pomi* de Geer).Their sugarrich secretions stick petals together. Experimental garden is situated in the suburb and no plant protection has been carried out. In 1992 trees from every variant had a small yield 1,6...5.4 kg per tree. Only 'Talvenauding' with 10 cm long B9 interstock had somehow greater yield compareing directly on 57-490 grafted trees. 1994 was again nonproductive and B9 interstock trees had again a greater yield. The one reason of is smoller and thinner crowen where pests do not spread so well and more frowers will be fertilized than in thicker crown.

Very productive year was 1993, when a yield was 59...90 kg per tree, that makes 39...60 t/ha (Figure 2). The yield of 'Talvenauding' was 59...76 kg per tree and interstocks did not cause significant differencies between variants. The yield of 'Tellissaare' was 63,9...90.1 kg per tree and significantly greater yield was on trees with 15 cm long B9 interstock. Comparing with control that would have made 12.1 t/ha more. Can be expected that productivity of this variant depanded also on influence of interstock to the location of root system. Since 'Tellissaare' is very vigorous cultivar and according to the conclusions reported before, dwarfing interstock is more appropriate than medium growing interstock.

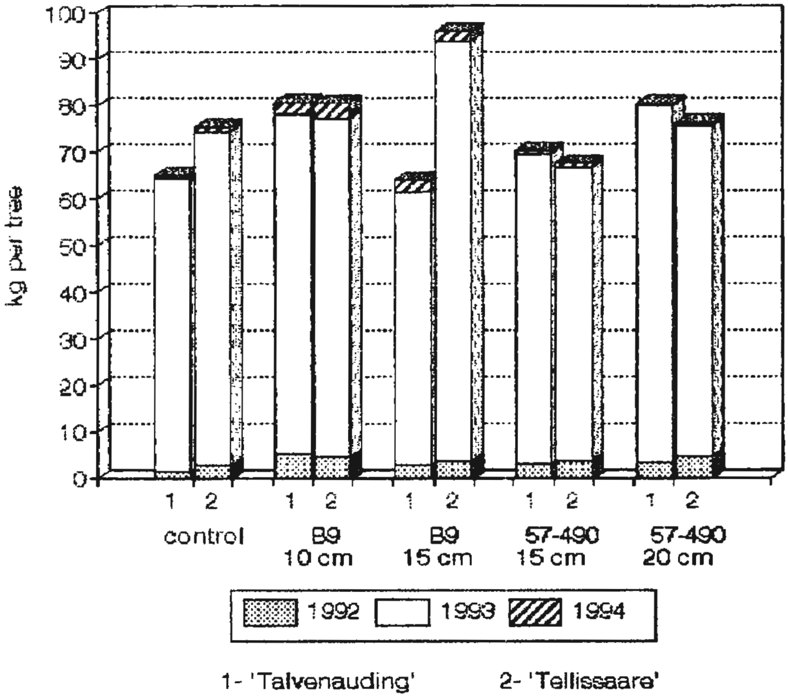

Figure 2. The yield from 'Talvenauding' and 'Tellissaare' in 1992...1994.

Conclusions:

-'Tellissaare' and'Talvenauding' on medium growing clonal rootstock 57-490 and on same interstock have a good durability and do not need support if orchard is surrounded with wind break.

-using dwarfing clonal rootstock B9 as on interstock between seedling rootstock and cultivar gives the same durability as grafting on medium growing clonal rootstock 57-490.

-using interstock does not influence a productivity of 'Talvenauding' significantly. In nonproductive year trees with dwarfing B9 interstock had greater yield.

- in productive year 'Tellissaare' with 15 long B9 interstock has greater yield both in young and mature orchard.

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IFP-compatible GROUND-COVER MANAGEMENT SYSTEMS IN A NEW-PLANTED APPLE ORCHARD

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Abstract

A new orchard has been established with the apple cv. Delia (a rather new strain of cv. Idared) on the rootstock M. 26.

Using groundcover materials like straw, livestock manure, pine bark mulch, black polypropylene proved to be favourable as regards shoot growth in new-planted trees. The total shoot growth (cm/tree) was more - by 6 to 22 % - than in trees in soil strip with clean cultivation. There is a similar, but more uniform increase in the average length of shoots (12 to 22 %). The stronger shoot growth is also reflected by the increment of trunk circumference.

There was a higher water content of soil in tree rows covered (the highest one under livestock manure), the lowest values were recorded in plots of herbicide.

According to preliminary microbiological investigatons of the soil, the numbers of bacteria belong to different physiological groups increased as a result of groundcover with livestock and straw, but no change was found under polypropylene folia and pine bark mulch. Nevertheless, under both groundcovers mentioned later the highest amount of spore of arbuscular micorrhizal fungi was found.

Material and nethods

A new orchard has been established with the apple cv. Delia (a rather new strain of cv. Idared) on the rootstock M. 26. Soil strips of 120 cm in width have been covered with various materials or, treated differently as follow:
straw: 11 kg/tree, livestock manure: 35 kg/tree, pine bark mulch 80 kg/tree, black polypropylene cover, herbicide treatment (Finale, with a.i. glyphosinate), clean cultivation. All these treatments started just after planting trees in the spring of 1994. Six plots with 5 trees in each belong to a treatment.

Maiden trees without feathering were planted in the spring of 1994, at a spacing 5 by 2 m, into a sandy soil with low humus content. Due to the 70 t/ha liverstock manure supplied before planting, there was no nutrient given in the first season. Because of the poorish rainfall this year (362 mm from April 1 to October 30), however, drip-irrigation was needed: 72 mm, 145 mm and 79 mm in June, July and August, respectively. During the 2nd season (1995) the rainfall was more (212 mm from April 1 to July 30). This year 6.7 g N was given on May 30 and July 4 again as Ferticare II (a product of Kemira Ltd, Hungary). Its nitrogen content is 24 %, mainly in form of urea and NH_4-nitrogen. These treatments were carried out by fertigation providing 23 and 17 mm of water, resp.

Bacteria and arbuscular micorrhizal fungi were investigated by the standard methods of soil microbiology, at about the end (October) of the first season and at the beginning of the 2nd one.

Shoot growth, development of spurs and increase in trunk circumference were recorded in late autumn of 1994.

Water content (and at the same time the compactness) of the soil was measured by a presspush-probe. Its test-probe, while penetrating into the soil (upto a depth of 80 cm), continuously feeds optoelectronic signals to the portable computer PSION Organizer and data-collector Digitron SF-10 (IBM PC compatible) combined with the basic instrument. Range of measurement is 0 to 1000 Newton/cm^2 (soil compactness) and 0 to 50 % of weight (water in the soil), respectively.

Results

Using groundcover materials proved to be favourable as regards shoot growth in new-planted trees. The total shoot growth (cm/tree) was more - by 6 to 22 % - than in trees in soil strip with clean cultivation. There is a similar, but more uniform increase in the average length of shoots (12 to 22 %). The stronger shoot growth is also reflected by the increment of trunk circumference (Tab. 1).

Clear growth correlations are pointed aout in Tab. 2, independently from treatments.

Preliminary microbiological investigations of the soil were carried out at the end of the first season (October, 1994). The numbers of bacteria belonging to different physiological groups (e.g. aerob proteolytic, aerob N^2-fixing, nitrifying, aerob cellulolytic) increased as a result of groundcover with livestock manure and straw, but no positive changes could be found under polypropylene folia and pine bark mulch. Spore of arbuscular micorrhizal fungi were in the rhizosphere, too, at an order of 10^2. They proved to be mainly Glomus (66%) and Acaulospora, see in Tab.3.

Water content of soil in tree rows of selected groundcover management systems can be seen in Tab. 4. Date recorded in treatments of straw and black polypropylene are similar to those of pine bark mulch.

Generally speaking, there was hardly any or only weak weed populatin in the plots with groundcovering (straw, etc.). Development of this kind of plants started even in the spring of the 2nd season (1995) rather late. During the summer, however, weed development through the straw, livestock manure and pine bark mulch became more and more intensive.

It seems so, that longevity of these groundcovering materials is not more than two seasons.

Discussion

Covering the surface of soil strips in the rows of new-planted trees is real useful to preserve the water in the soil and to try maintaining soil strips free of weeds, however, without using herbicides (see: principles of integrated - or: sustainable - fruit production).

There are tasks to be done in the next years: investigating the early flowering- and cropping potential of these young trees, furthermore, to get informations regarding soil microbiological conditions and leaching out of nutrients depending on groundcover management systems.

Tab. 1

Growth characteristics of apple trees cv. Delia/M. 26
Újfehértó, 1994 (at the end of the season)

Treatments (groundcover management)	*Shoots* total length, cm/tree	*Shoots* pieces per tree	*Shoots* average length cm	Spurs pieces per tree	Trunk circum-ference cm
Straw	374.8	6.4	58.6	1.4	5.8
Livestock manure	343.7	6.7	51.3	1.3	5.6
Pine bark	410.1	6.8	60.3	1.1	5.8
Black polypropylene	407.0	6.8	59.9	1.3	6.0
„Finale" (herbicide)	292.7	7.0	41.8	1.7	5.1
Clean cultivation	326.5	6.7	48.7	1.5	5.5
SD 0.05	17.3*	(0.3)	2.8*	(0.33)	0.2*

Planting (1-year-old trees without feathering) and start of treatments: 1994 (spring)
„Finale": treatments two-times but too late (therefore: these plots were treated as clean cultivation, from end of July on)

Tab. 2

Growth characteristics of apple trees cv. Delia/M. 26
Újfehértó, 1994, (at the end of the season)

Investigating correlations:

Total shoot length, cm/tree	**- trunk circumference, cm**	**0.74 *****
	- spurs pieces/tree	**- 0.32 *****
Shoots pieces/tree	**- total shoot length, cm/tree**	**0.35 *****
	- average length of shoot, cm	**- 0.45 *****
	- spurs pieces/tree	**- 0.25 *****
Average length of shoots, cm	**- trunk circumference, cm**	**0.63 *****
Trunk circumference, cm	**- spurs pieces/tree**	**- 0.25 *****

Tab. 3

Amount of spore of mycorrhizal fungi in soil strips with varios groundcover management
Újfehértó, 1994 (October)

- Preliminary results, only -

Treatments (groundcover management)	Level (depth) in the soil cm	Spore pieces/100 g soil	
Straw	0 - 20	110	
	20 - 40	76	
	0 - 40		186
Livestock manure	0 - 20	93	
	20 - 40	70	
	0 - 40		163
Pine bark	0 - 20	141	
	20 - 40	72	
	0 - 40		213
Black polypropylene	0 - 20	98	
	20 - 40	106	
	0 - 40		204
Clean cultivation	0 - 20	85	
	20 - 40	70	
	0 - 40		155

Spore belong to the *Glomus* sp (66%)
and Acaulospora sp (34%), resp.

Tab. 4

Water content (% of weight) in soil of tree rows with various groundcover management

Level (depth) in the soil	Clean cultivation *a*	Clean cultivation *b*	Livestock manure *a*	Livestock manure *b*	Pinebark *a*	Pinebark *b*	Herbicide *a*	Herbicide *b*
0 - 10 cm	8.5	12.5	10.7	17.0	8.1	10.2	8.6	12.5
11 - 20 cm	11.8	14.3	15.3	20.5	12.6	13.4	10.3	13.1
21 - 30 cm	12.1	13.7	15.6	18.8	13.0	13.2	11.0	12.2
31 - 40 cm	12.2	13.4	16.0	18.4	12.8	13.4	11.4	11.2
41 - 50 cm	12.0	12.9	15.6	17.6	13.2	13.2	11.1	11.1

a **= 24th of April, before rainfall**
b **= 28th of April, 24 hours after rainfall of 36.3 mm**
Note: Data of straw and black polypropylene are similar to those of pinebark mulch

EFFECTS OF DIFFERENT CHEMICAL FERTILIZERS ON THE YIELD AND QUALITY OF SOME STRAWBERRY CULTIVARS GROWN IN A GLASSHOUSE

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ABSTRACT: This study was designed to determine the effects of different chemical fertilizers on the yield and quality of some strawberry cultivars such as Douglas, Chandler, 216 (Doritt) and Oso Grande which are popular in California, Israel and Spain. Four different chemical fertilizers including Urea, Fetrilon (13 % Fe), Sheffer (S 5-3-7) and Bayfolon (enriched with amino acid 11-8-6) were used in different doses. Experiment was designed as 4 replicates. Fertilizers were administered 0.5-1 gram pure nitrogen per plant during growing season from January to early May, twice a week. Totally 40 applications were made. Pure nitrogen necessary for every application was calculated according to the fertilizers and doses and given from the soil. Honey and bumble bees alone and together were used for pollination. Phenological observations and pomological analyses were done according to the cultivars, fertilizers and doses. The highest yield was obtained from Douglas and it was followed by Oso Grande. Although all the fertilizers and their doses have given satisfactory results in yield/plant depending on cultivars, due to the economical reasons urea is recommended. Better shaped fruits were obtained in cultivars pollinated with both bumble and honey bees.

INTRODUCTION

In recent years in Turkey strawberry has been intensively grown at the Mediterranean coastal stripes, Aegean and Marmara regions and early production is becoming more and more important. In 1994 Turkish strawberry production is about 65 thousand tons and the area is 6990 ha. Owing to the several researches Turkish early and late season strawberry production developed a lot during the last 20 years. However, there are important problems in the strawberry nutrition. Since generally the Californian cvs are grown, the plants show N deficiencies and Fe-chlorosis in heavy soils and the growers either spend a lot of money to solve this problem or must be satisfied with low yield.

The objective of this work was to investigate the effects of various types of fertilizers and their different N doses on the yield and quality of Douglas, 216 (Doritt), Chandler and Oso Grande cvs grown in a glasshouse and irrigated with drip method. On this subject several investigators are working both in Turkey and other strawberry growing countries. For instance in a work at Florida University it was reported that increasing doses of K (0, 56, 112 and 224 kg/ha) increased the yield linearly but they caused to decrease the fruit sizes. In Japan at the Kagawa University it was found that the applications of 21 and 48 mg/plant doses of N prevented the production of mischapen berries by causing normal development of flower organs. May and Pritts (1993) reported that there are many inconsistencies in the response of strawberries to fertilization.

MATERIAL AND METHOD

This work is carried out during 1994-95 season in a slightly heated glasshouse of the Department of Horticulture. The soil of the glasshouse is sandy-clay-loam (52.1% sand, 11.5% silt and 36.4% clay). Its pH is 7.5 and it contains 3.55% organic matter, 71.5 kg/da P_2O_5, 1620 ppm K. 50 kg/da base fertilizer (N 15; P 15; K 15) was administered in the course of preparation of the soil. Douglas, Chandler, 216 (Doritt) and Oso Grande cvs were used as the experimental material. The plantings were performed in the first week of December 1994 with newly rooted runner plant. As nitrogenous fertilizer Urea, Sheffer, Bayfolan and as Iron fertilizer Fetrilon (13 %Fe) were used. From each nitrogen source the amounts which correspond to 0.5 or 1 g pure N was calculated and delivered to each plant by 2 weeks intervals during the whole growing season with equal amounts. A similar calculation was made for Fe source thus 0.5 g pure Fe/plant was administered as equal amounts with the above mentioned frequency. Hence the number of total deliveries was 40 (Table 1). Therefore each time 12.5 or 25 mg pure N and 12.5 mg Fe per plant were given to the soil as dissolved fertilizer in water.

This work is partly supported by NATO Research Fund.

Table 1. The fertilizers, their contents and doses used in the experiment

Application number	Fertilizer	Doses	Ingredients
1	Urea	0.5 g N	% 46 N
2		1.0 g N	
3	Sheffer	0.5 g N	5 % N, 3 % P, 7 % K, 300 ppm Fe
4		1.0 g N	150 ppm Mn, 75 ppm Zn, 11 ppm Cu, 8 ppm Mo
5	Bayfolon	0.5 g N	Enriched with amino acids
6		1.0 g N	11 % N, 8 % P, 6 % K, Fe, Mn, B, Cu, Zn, Mo, Co
7	Fetrilon	0.5g Fe	% 13 Fe (As etilendiamintetraacetic acid compound)
8	Control	Water	

In the experiments 4 replications which consist of 20 plants per plot were used in a split plot design. Besides in order to facilitate the pollination honey or bumble bees (Bombus terrestris) were used either separately or together in separated compartments. Since they can fly and pollinate the flowers at lower temperatures, the bumble bees are preferred in unheated plastic or glasshouses where the strawberry is grown. The bumble bee queens used in the experiment were captured from the nature in November 1994. They were carried to the laboratory and fed with fresh pollen and sucrose syrup, at 27 °C and 67 % RH. The queen bees were stimulated by giving several worker honey bees in the cages. As soon as the first worker bees emerged the bumble were transferred to larger styrofoam boxes. When the colony population reached to 25 to 30 worker bees they were transferred to the glasshouse for the pollination of strawberries. One compartment of the glasshouse was kept as pollination control and no bees were allowed to enter there. In each harvest the shape of berries from each compartment were examined.

The berries of the cultivars were weighed and counted from the beginning to the end of harvest and yields per plants and average fruit weights were calculated. The soluble solid (TSS) contents were determined by a hand refractometer. Acidity was measured with an automatic titrator by titration method. Flesh firmness was expressed subjectively by using 1-5 scale. Some characteristics of the berries such as fullness of the central core (hollow, half full and full) skin and flesh colors (white, light pink, pink, red and dark red), positions of the achens (raised, sunken) and sizes of the calyx (small, medium and large) were also studied (Paydaş et al. 1995).

RESULTS AND DISCUSSIONS

The harvests started in February or March depending on the cultivars and fertilizers and their doses (Table 2). First harvest of Douglas and 216 started on the 7th of February while in Chandler on 13th and in Oso Grande 23rd of February. Yield of Douglas and 216 in February were found higher than those of the other two cultivars. Generally the fertilizers in question caused to increase the yield of all cultivars in February. In some cultivars regardless the fertilizer types, 0.5 g N doses promoted the precocity (Fig. 1). With the exception of Oso Grande the March and May yield per plant of the cultivars were found higher than those of April (Fig .1). The cause of these reductions in yield seems to be related to the flower bud formation physiology of the Californian strawberry cultivars in the warm wintered coastal areas as was mentioned by Paydaş and Kaşka (1993). In such areas for the second flash of flowering the strawberry plants need some resting periods. The effect of cultivars, applications and interaction of cvs x application on the total yield/plant were found statistically significant ($P<0.05$). In all the cultivars the yields/plants of the controls were much lower than those of the treated ones (Table 2 and Fig. 1). The lowest value was found in the control of Chandler (77.44 g/plant). Although the highest figures varied depending on the application for each cultivar, in Douglas first application (288.17 g/plant), in Doritt 4th application (237.53 g/plant) and in Chandler and Oso Grande 6th application (248.00 g/plant and 273.88 g/plant respectively) have given the most satisfactory results. The responses of the cultivars to the doses of 0.5 g and 1 g N/plant changed depending on the types of the fertilizer sources. For example, in Douglas 1 g of urea N (2nd application) resulted with low yield whereas the same amount of Sheffer (4th application) or Bayfolon (6th application) fertilizer increased the yield in positive manner. Similarly in Doritt the applications of 1st, 4th and 5th have given better results than the 2nd, 3rd and the 6th applications, respectively. Moreover there are differences on the effects of the doses of different fertilizer source. The highest yield was obtained from Douglas and it is followed by Oso Grande and Doritt and the lowest yield was obtained from Chandler. Actually higher doses of N reduces the yield by preventing the flower bud formation of strawberries (Paydaş and Kaşka, 1989). However, Özdemir and Kaşka (1995), in sand dunes obtained very satisfactory results by the applications 1 g N/plant /month and they found that there were differences among the cultivars in responses to that amount of N. In addition they could not found a positive correlation between the increased doses of N and the total yield/plant. The relationships between increasing N fertilization and growth, maximum CO_2 assimilation and the initial slope of the CO_2 response curve were studied in two ecotypes of wild strawberry ***Fragaria chiloensis*** (L.) Duchn. (Moon et al., 1990). In an experiment Kaşka and Paydaş (1986) obtained satisfactory yield responses to the applications of 0.4% of 6 different foliar fertilizers in Pocahontas, Aliso, Tufts and Tioga during the whole vegetation period. However, these responses were found different in the cultivars used.

The effects of the treatments on the fruit sizes were not found statistically significant ($P<0.05$). It was related to the cultivars. The largest fruits (average* size was 14.17 g) were obtained from Oso Grande. The seasonal average* fruit sizes of Doritt, Douglas and Chandler were 11.32 g 10.23 g and 9.46 g respectively. These are quite acceptable figures for the markets (Table 2).

The TSS of the berries were not affected by the treatments. The berries harvested in the warmer months were found sweeter than those of the cooler months. The seasonal average* TSS value was highest in Doritt (7.00 %) and lowest in Douglas (6.69 %). It seems that the TSS values were somewhat affected by the 4th, 5th and 2nd applications (Table 2). Similar results were obtained by Kaşka and Paydaş (1986).

The acidity of the berries changed between 0.67% and 0.84%. These values lowered as the season progressed. The acid contents of berries were found statistically significant ($P<0.05$). In control and Fetrilon treated berries of cvs the acidities were found somewhat lower. There was not much differences between the highest (in Chandler the average* is 0.77%) and the lowest (in Doritt the average* is 0.73 %) acidity values of berries (Table 2).

Fruit flesh firmness appeared to be a varietal trait and it was not affected markedly by the treatments. The berries of Douglas and Chandler were found firmer than those of Doritt and Oso Grande. This last cultivar had the softest berries in the experiments (Table 2).

Fullness of the core, fruit color, achens' positions and easiness of capping did not affected by the treatments (Table 2). Though the flesh color seemed to be affected by the applications no clear correlations was found. In Oso Grande the core remains in the fruit, the skin color is dark red, the achens are raised and the calyx is quite large. In Chandler the achens are generally sunken in the berries.

In conclusion it was found that the yield of all experimental cvs were increased by all the fertilizer applications. The yields/plants are in acceptable levels because the first year's yields of winter plantings are generally low. For instance Kaşka et al. (1986) reported that in an experiment with winter planted 8 cvs at different growing media, maximum yield/plant was about 200 g. In this experiment urea applications have given satisfactory results from the stand point of yield and quality of berries. This finding was in accordance with the results of Papadopulos (1987). On the other hand due to its low price urea is recommended as a N fertilizer 0.5 g or 1 g N/ plant should be recommended depending on cvs.

From the compartment of the glasshouse where the bombus and honey bees were put together generally regular shaped fruits were obtained especially in the early maturing berries. Whereas from the compartment where there were neither bombus nor the honey bees the number of misshappen berries was 1.5 times higher than those of regular shaped berries. Honey bees were slightly better than the bombus in pollination activity. Similar results were obtained by Chagnon et al (1993). Bombus bees are proven to be important especially in the early seasons berries because they were able to visit the flowers at lower temperatures as well.

**** The averages were calculated as the means of 8 replications of each cultivar.***

Table 2. Berry Characteristics of Experimental cvs. Treated with Different Fertilizers

Cultivars		*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*
DOUGLAS	1*	288.17 a	11.15	6.33	0.77bcd	3.50	Hollow	Dark Red	Red	Raised	Medium	23 Feb
	2	194.36 lmn	9.75	6.96	0.75 b-f	3.50	Hollow	Red	Red	Raised	Medium	20 Feb
	3	225.82 e-k	8.96	6.84	0.76 b-e	4.00	Hollow	Red	Red	Raised	Small	20 Feb
	4	235.24 c-h	9.70	6.91	0.72 d-i	3.25	Hollow	Red	Light Pink	Raised	Medium	14 Feb
	5	256.41 b-e	10.65	6.95	0.76 b-e	3.75	Hollow	Red	Light Pink	Raised	Small	7 Feb
	6	265.33 abc	9.72	6.69	0.80 ab	3.00	Half-Full	Dark Red	Red	Raised	Medium	23 Feb
	7	218.79 f-l	10.98	6.11	0.70 f-i	4.25	Hollow	Red	Red	Raised	Medium	23 Feb
	8	108.77 o	10.92	6.76	0.74 c-g	3.25	Hollow	Dark Red	Red	Raised	Small	27 Feb
216 (DORITT)	1	220.87 f-l	10.99	6.53	0.74 c-g	3.00	Half-Full	Red	Red	Raised	Large	13 Feb
	2	164.41 n	12.57	7.36	0.70 f-i	3.75	Hollow	Red	Red	Raised	Medium	20 Feb
	3	223.15 f-l	10.20	6.67	0.81 ab	4.50	Hollow	Red	Light Pink	Raised	Medium	7 Feb
	4	237.53 c-g	9.88	7.53	0.75 b-f	3.25	Half-Full	Red	Red	Raised	Medium	7 Feb
	5	227.10 d-j	11.36	7.60	0.71 e-i	3.75	Hollow	Red	Light Pink	Raised	Medium	7 Feb
	6	213.87 g-m	12.19	6.91	0.67 i	3.00	Hollow	Red	Red	Raised	Medium	23 Feb
	7	221.51 f-l	12.23	6.67	0.73 d-h	3.00	Half-Full	Red	Light Pink	Raised	Large	23 Feb
	8	113.77 o	11.39	6.71	0.71 e-i	3.25	Hollow	Dark Red	Red	Raised	Large	27 Feb
CHANDLER	1	206.23 h-m	8.06	6.84	0.79 abc	2.50	Hollow	Dark Red	Dark Red	Sunken	Small	23 Feb
	2	198.04 j-m	8.50	6.76	0.79 abc	3.25	Hollow	Dark Red	Red	Sunken	Medium	13 Feb
	3	214.86 g-m	10.57	7.76	0.71 e-i	4.50	Half-Full	Dark Red	Dark Red	Raised	Small	23 Feb
	4	186.77 mn	9.17	6.71	0.75 b-f	3.50	Half-Full	Dark Red	Dark Red	Sunken	Small	20 Feb
	5	197.35 j-m	9.43	6.92	0.79 abc	3.50	Half-Full	Dark Red	Red	Sunken	Medium	20 Feb
	6	248.00 b-f	10.78	6.80	0.84 a	3.50	Half-Full	Dark Red	Red	Raised	Medium	20 Feb
	7	230.74 d-i	9.67	7.58	0.79 abc	3.50	Half-Full	Dark Red	Red	Sunken	Medium	23 Feb
	8	77.44 p	8.98	6.53	0.68 hi	4.25	Half-Full	Dark Red	Dark Red	Sunken	Small	23 Feb
OSO GRANDE	1	195.74 klm	13.95	6.13	0.76 b-e	2.50	Full	Dark Red	Red	Raised	Large	27 Feb
	2	234.27 d-i	14.64	6.89	0.74 c-g	2.00	Full	Dark Red	Red	Raised	Large	6 Mar
	3	257.75 a-d	12.38	6.56	0.77bcd	2.50	Full	Dark Red	Red	Raised	Medium	23 Feb
	4	199.74 j-m	13.95	7.76	0.75 b-f	2.00	Full	Red	Pink	Raised	Large	1 Apr
	5	203.67 i-m	14.27	7.22	0.76 b-e	2.50	Full	Dark Red	Red	Raised	Large	2 Mar
	6	273.88 ab	15.80	7.00	0.69 ghi	2.50	Full	Dark Red	Red	Raised	Large	6 Mar
	7	222.20 f-l	14.08	6.89	0.73 d-h	3.00	Full	Dark Red	Red	Raised	Large	23 Feb
	8	111.86 o	14.34	6.40	0.73 d-h	2.50	Full	Red	Pink	Raised	Large	6 Mar
$D_{\%5}$		30.96	N.S.	N.S.	0.059	N.S.						

* Applications — A: Yieldper Plant (g) — B: Fruit Weight (g) — C: TSS (%) — D: Acidity (%) — E: Flesh Firmness (1-5)

F: Fullness of Core — G: Skin Color — H: Flesh Color — I: Achen Position — J: Calyx Size — K: First Date of Harvest

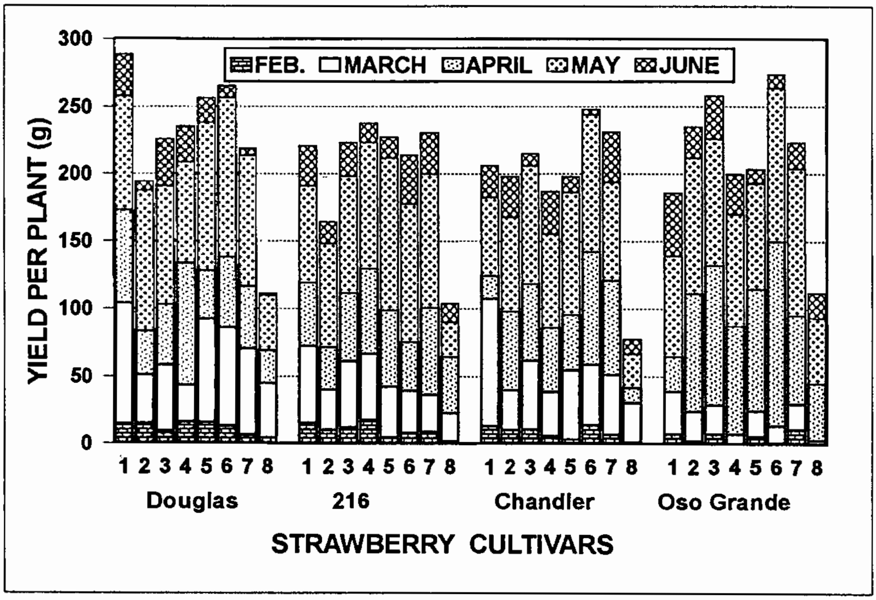

Figure1. The effect of 0.5 and 1 g N doses of different types of fertilizers on the monthly and total yield of four strawberry cvs (*1*:0.5 g urea; *2*:1 g urea; *3*: 0.5 g Sheffer's N; *4*: 1 g Sheffer's N; *5*: 0.5 g Bayfolon's N; *6*: 1 g Bayfolon's N; *7*: 0.5 g Fetrilon's Fe; *8*: Control).

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Critical period for weed competition in apple orchards: preliminary results

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Summary

The critical period for weed competition in apple orchards describes the period when the tree strip must be kept free of weeds so that tree performance, as measured in the permanently weed-free control, is not adversely affected. It is not yet known when exactly such a period starts in spring and how long it must last.

To answer this question four experiments at sites with different climatic and pedological conditions were started in 1990. Five tree strip ground cover treatments were established: permanently weed-free (control), permanent weed cover, weed-free from April to July, April to September, and May to July.

Preliminary results of the experiment in Waedenswil show that the critical period starts shortly before blossoming (cv. Jonagold on M9). The vegetative and generative performance was not reduced when winter weed cover was removed about three weeks before blossoming. If weeds were not removed before blossoming, the fruit set was reduced and there seemed to be a certain compensation of the weakened generative sink by increased vegetative development (trunk growth). The length of the weed-free period required was not so clear: Under the Waedenswil site conditions a regrowth of weeds from June/July reduced yield compared to the control. With regrowth of weeds in September/October, yield and trunk growth were at least of the same magnitudes as in the control, while in 1993 the fruit size and the coloration were better than in the control.

The results indicate that in putting down a temporary ground cover with spontaneous vegetation it would appear that N-management can be made to correspond to the requirements of the trees at a particular site.

Introduction

Tree strips in apple orchards are normally kept weed-free during the whole year to optimise the growing conditions for the trees, mainly with regard to water and nutrient (nitrogen) supply.

This soil management system is from an environmental point of view not yet optimal (Haynes 1980). There is no protection from erosion, soil crusting or degradation of soil structure (Welker and Glenn 1988). Long-term soil fertility can be reduced in comparison with other soil management systems (Hipps and Samuelson 1991, Merwin *et al.* 1994). Furthermore leaching of nutrients and pesticides in winter cannot be avoided in soil that lacks cover. Besides the environmental risks involved the ripening process may be delayed, resulting in excessive vegetative growth if in late summer an abundant supply of nitrogen to the trees is available.

Maintaining a permanent ground cover on the tree strips would make sense at least in sustaining long-term soil fertility. The soil is less exposed to physical influences, nutrients are saved from leaching. However, in the case of young trees a permanent ground cover reduces productivity considerably (Faby and Naumann 1986, Merwin and Stiles 1994).

To effectively combine the ecological advantages of ground cover with an optimal productivity of the trees the ground cover should be temporary. The aim of our investigation is to find out at what point the weed-free period should begin and how long it must last in order that fruit yield is not reduced. Formulated in this way the question corresponds to the concept of the critical period threshold (Nieto *et al.* 1968, Dawson 1986), which has not yet been determined for the apple.

Materials and methods

Experimental treatments and design. The present experiment was established in an apple orchard at Waedenswil (900 mm rainfall in vegetation period). The soil was a deep sandy loam with 10% slope, pH of 5.6-7.6 and 3% organic matter. Trees of Jonagold on M9 virus-free rootstock were planted in autumn 1990 (4m x 1.7m). Eight adjacent trees within a row were a subplot. In August 1992, a randomised block design with six replications of the following five tree strip ground cover treatments was established: a) permanently weed-free; b) permanently weedy; c) weed-free from April to July; d) weed-free from April to September; e) weed-free from May to July. Until August 1992 all the trees had been cultivated in permanently bare soil. Glyphosate and glufosinate were used to remove the weeds, completed with diuron and oryzalin on the permanently weed-free plots (from 1993). Maintenance and plant protection were the same for all treatments. From 1992 onwards the trees received no N fertiliser.

The evaluation of soil and tree parameters was according to standard methods. All data were subjected to analysis of variance and statements in the text refer to $P \leq 0.05$.

Results and discussion

Weed cover on the tree strips. The weed soil cover on the tree strips was the only parameter that was influenced by management - all other applied treatments were identical throughout. Weed management consisted in herbicide application at different dates in spring and repeated applications depending on the desired duration of the weed-free period.

The flora present on the tree strips changed in botanical composition according to the duration of the weed-free period. The permanently covered strip was dominated by perennial grasses, partly originating from the alleys (*Poa pratensis, P. trivialis, Agrostis stolonifera, Lolium perenne*). These creeping perennials are promoted by mulching on the strip. The chemical weed control in the other treatments favoured the growth of annual weeds which were infiltrated in autumn also by creeping perennials such as *Glechoma hederaceum* or *Agrostis stolonifera*.

The influence of the date of the spring application of the herbicide was very obvious: early April application resulted in a weed-free tree strip until blossoming (Fig. 1). During this period in April the weeds are themselves vigorously growing, with the result that they may compete strongly for N before and during blossoming (treatment "May-July", Fig. 1). It is likely that this competition is detrimental to the generative development of the trees, as shown below.

The periods from April to July and April to September were kept weed-free by 1-2 and 2-3 applications, respectively, of leaf-applied herbicides, depending on the growth conditions; the permanent weed-free control needed 1-2 applications of leaf-applied herbicides and 1 application of residual herbicide.

Available N in the top-soil. The total amount of available N in the most relevant layer of the soil (0-25 cm depth) in the tree strip depended mainly on soil temperature and precipitation. In spring with increasing soil temperature the amounts of mineralised N, mainly nitrate, increased from 10-20 kg/ha in winter to 20-50 kg/ha. In all soil management systems the maximum peaks were found from June to August. This was in general earlier than the peaks in August/September observed by Nedwed (1991) or Dierend and Spethmann (1994). After August the nitrate content dropped again to the levels of winter, possibly caused by renewed up-

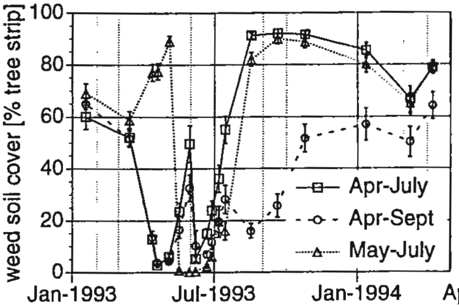

Fig. 1: Weed soil cover [%] on the tree strip for selected treatments (means ± s.e.)

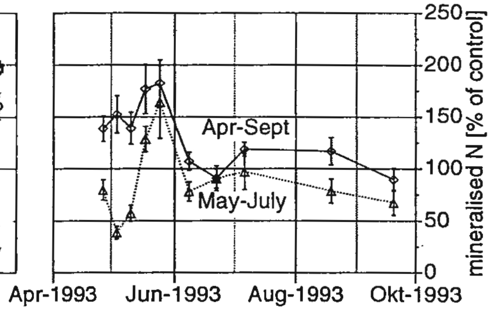

Fig. 2: Available N [% of control] in the top soil layer (0-25 cm) of the tree strip for selected treatments (means ± s.e.)

take and vigorous growth of the weeds on the tree strips. The small amounts of nitrate present would possibly indicate that nitrate leaching was not a significant factor in these experiments.

Weed management on the tree strips affected the level of available N. Permanently weedy plots had during the whole year the smallest amounts of nitrogen. Removing the winter cover increased N concentration at least to the level present in bare soil (Fig. 2).

In the treatment with early removal of the weeds in April weed competition was reduced just prior to blossoming. Therefore the amount of N was higher not only compared to the strips still covered in weeds, but also to those with permanently bare soil (Fig. 2).Whether this was due to a higher mineralisation potential of the weedy plots (Hipps and Samuelson 1991) or due to a release of N from the dead mulch will be examined in further experiments.

Weed removal shortly after blossoming led to a lag in the increase of nitrate until mid-May (Fig. 2). During this period N amounts were significantly lower than in the weed-free plots, caused also by the vigorously growing weeds. This competition during blossoming might be one of the reasons for the reduced fruit set.

Water content of the soil. The available soil water is an important factor in tree growth and N mineralisation. At the site in Waedenswil, with precipitation of about 900 mm during the vegetation period, there was in 1993 and 1994 practically no water stress for the trees. There were seasonal fluctuations in the water content of the top soil (18-27% fw), but the weed-control measures did not appear to influence the water content significantly. The permanently bare soil tended to be slightly drier than even the permanently weedy strip (data not shown). This indicates clearly that water was not a limiting factor on this site in reducing yield and vigour of the trees.

Yield quantity and quality. The cumulative total yield 1992-1994 was significantly reduced by weed competition during blossoming (Fig. 3). A permanent green cover reduced yield to a greater extent than a weed-free strip from May to July. In the latter treatment the N seemed to become available too late for a high fruit set (Fig. 2).

When the weed cover was destroyed before blossoming, the cumulative yield was about 30% higher than with weeds (Fig. 3). Hence a winter green cover which was removed in time did not reduce the total yield as compared with permanently bare soil.

The gradation by weight and background colour according to Swiss specifications showed for the first grade yield the same tendency as for the cumulative yield: the first grade fruit yield was mainly influenced by the weed competition during blossoming. Without competition it was about 45% higher (1994, Tab. 1). In 1993 the differences between the weedy and weed-free treatments for total and first class yield were about 15% and 19% respectively.

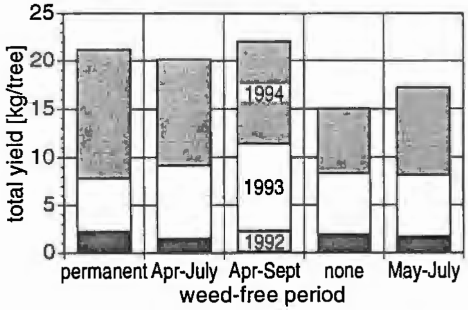

Fig. 3: Cumulative total yield [kg/tree] from 1992 to 1994

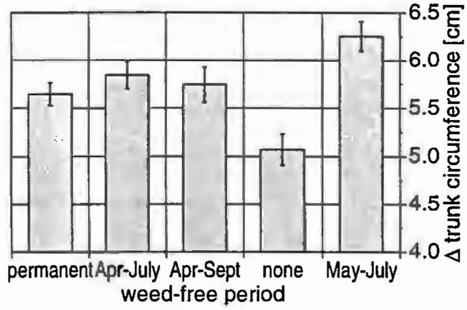

Fig. 4: Trunk circumference growth [cm] from 1992 to 1994 (means ± s.e.)

Fruit size affected the gradation more strongly than the coloration. In 1993, the third year after planting, the proportion of oversized fruits was, as is usual for young Jonagold, very high (55 to 61% of total yield, Tab. 1). The treatments did not influence significantly this proportion. In 1994 the treatment "May-July" had a significantly higher proportion of oversized fruits. This might be due to the increased vigour of these trees: the fruit set was reduced by competition of the weeds for nitrate during blossoming (c.f. Robbie and Atkinson 1994), but the subsequent increase in available N led, in addition to a somewhat higher vegetative growth (Fig. 4), also to a greater increase in the size of the fewer fruits present (Tab. 1).

Vigour of the trees. Vigour was measured as trunk circumference growth. It was affected by the timing of the weed removal in spring (Fig. 4). Without removal the trees showed reduced trunk growth, a well-known effect of long lasting weed competition (Faby and Naumann 1986, Merwin and Stiles 1994).

Weed removal after blossoming tended to induce strong vegetative growth (Fig. 4, "May-July"). The reduced fruit set in this treatment might have affected the trunk growth. The relatively weaker generative sink strength seemed to favour vegetative growth later on in the vegetation period. The same effect can be observed when trees are thinned to different crop loads (Quinlan and Preston 1968).

Tab. 1: Effect of weed-free period on yield composition (LSD: P≤5.0%)

		weed-free period					
		permanent	April-July	April-Sept	none	May-July	LSD
1993	Grade I yield [kg/tree]	2.1	2.8	3.2	2.3	2.3	1.1
	Oversized fruits [%]	54.6	55.5	57.7	61.2	58.3	13.0
	Insufficient coloration [%]	11.5	11.1	10.2	6.8	8.5	7.1
1994	Grade I yield [kg/tree]	7.3	6.8	7.0	4.5	5.2	1.5
	Oversized fruits [%]	24.0	27.4	22.0	21.5	31.7	9.3
	Insufficient coloration [%]	22.7	12.0	12.9	7.4	13.9	6.9
	Number of fruits per tree	57.4	45.9	46.9	28.8	37.4	10.7

On strips kept weed-free during blossoming trunk growth was similar to that of trees grown on permanently bare soil, but slightly less than in the trees from plots where weeds were removed after blossoming.

Conclusions. The positive effects of maintaining a green cover in winter in order to enhance soil fertility must be weighed against the influence of the cover on tree performance. Under the site conditions of the present experiment, the performance of trees (measured as first grade yield and vegetative development) with a winter weed cover at least equalled that under permanently weed-free control, if weeds were removed in time to ensure a weed-free blossoming. This led in two of the three years to higher amounts of available N during blossoming than in the control. It appears therefore that N management can be made to correspond to the demands of the trees at a particular site.

It is not yet clear at what point during summer or autumn regrowth can be tolerated without negative effects on the performance of the trees. This question is of particular interest, since it influences the number of leaf-applied herbicide treatments required.

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Acknowledgements. The authors wish to thank W. Stadler, S. van Nierop and G. Haldimann for their scientific and A. Husistein and M. Jampen for their technical assistance.

LECTURES

Section: Application Technique

SCAB AND MILDEW CONTROL WITH EMISSION REDUCING SPRAYERS IN APPLE GROWING

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ABSTRACT

For integrated fruit production a reduction in contamination of the environment by pesticides is essential. With modern orchard sprayers these goals can be achieved as they are equiped to reduce emissions towards the environment. Two tunnel sprayers, one with the "Closed Loop System" and the other equiped with rotary atomisers and a cross flow sprayer with reflection shielding were tested for their emission reducing properties and biological efficacy. These sprayers were compared to a standard cross flow sprayer. These sprayers recycle part of the spray liquid (denoted as recirculation). The percentages recirculation were measured. Emission to the ground inside the orchard was measured as well as the emission to the ground in the neighbouring field. The drift to the air was measured next to the orchard. The tunnel sprayers reduced the emission to the neighbouring field with over 80 % in comparison to the standard cross flow sprayer. To compare the efficacy of the sprayers, 25 % and 75 % of the standard recommended rate of fungicides was sprayed weekly to control apple scab (*Venturia inaequalis*) and powdery mildew (*Podosphaera leucotricha*). The tunnel sprayer equiped with rotary atomisers was less effective than the other sprayers in the control of these diseases. The tunnel sprayer with "Closed Loop System" and the cross flow sprayer with reflection shielding were as effective as the standard cross flow sprayer.

INTRODUCTION

Essentially, integrated plant protection is a combination of conventional chemical control and biological control measurements. Integrated fruit production has a wider scope than integrated plant protection. Integrated fruit production comprises all measures to produce high quality fruit in such manner that the environmental contamination is limited as much as possible. In the Netherlands, much emphasis is laid on the reduction of environmental pollution by pesticides. The policy goal of government is to reduce the use of pesticides by 50 % and the drift to surface water by 90 % in the year 2000 (Anonymous, 1990). Modern spray application techniques can contribute to reach this goal.

In apple growing, air-assistance is essential to convey spray droplets to the inside of the tree canopy. Inevitably, it has the negative side-effect of projecting droplets high into the air, causing drift of pesticides outside the orchard. The use of the tunnel sprayer concept can reduce these negative side-effects of air-assisted radial flow or cross flow sprayers (Huijsmans *et al.*, 1993).

Apart from the property to reduce contamination with pesticides to the environment, sprayers should be easy to use and especially important, effective in the control of pests and diseases. It has been suggested that the tunnel sprayer with rotary atomiser was less effective than the standard cross flow sprayer (Heijne *et al.*, 1993). Since then, tunnel sprayers have evolved further though. In this paper we report the efficacy and the emission of two tunnel sprayers, one with rotary atomisers and one with the so-called "Closed-Loop System" (van de Werken, 1991), and one cross flow sprayer with reflection shielding in comparison to a standard cross flow sprayer.

MATERIALS AND METHODS

In 1993, experiments were carried out to compare four commercially available sprayers, all of them with air-assistance. These were a conventional cross flow sprayer, a cross flow sprayer with reflection shielding (denoted as cross-RS), a tunnel sprayer with the "Closed-Loop System" (denoted as tunnel-CLS) and a tunnel sprayer with rotary atomisers (denoted as tunnel-RA). The conventional cross flow sprayer (Munckhof) was used as reference. Some characteristics of the sprayers during applications are shown in Table 1.

The cross flow sprayer with reflection shielding (Holder; cross-RS) basically was a standard cross flow sprayer, but with a frame mounted over the tank that holds two shields. There is one on each side of the tank and opposite of the trees sprayed at. Hence, 2 rows are treated at one time. These reflection shields have a concave side (like an airplane wing) directed towards thee sprayer. The air stream with remaining spray droplets that passed the tree is re-directed towards the backside of the trees. This "return flow" is further supported by 3 hollow cone nozzles mounted in the lower side of the shield. In the bottom of the shields was a tray for collection of spray liquid caught on the shield. The collected spray liquid was pumped back into the tank.

The tunnel sprayer with the "Closed-Loop System" (Munckhof; tunnel-CLS) was 2.5 m high, 2.5 m wide and 2.05 m long, with the side walls on an angle 10°, being wide at the bottom and narrow at the top. To implement the principle of CLS, the tunnel had double side walls. Air used to convey droplets is sucked from the inside the tunnel at the rear into the double wall towards the front and released behind the nozzles inside the tunnel. At the underside of the side walls were trays to collect spray liquid. The collected spray liquid was pumped back into the tank.

The tunnel sprayer with rotary atomisers (Noric-Joco; tunnel-RA) was 2.9 m high, 2.4 m wide and 2.65 m long. The Noric rotary atomiser consisted of a rotor with bent blades. From the inside of the rotor spray liquid is pumped to the blades and droplets were formed by rotation. Thus, droplets were formed according to the "Controlled Droplet Application" principle. The size of the droplet is dependent only on the speed of rotation (de Schaetzen, 1991). Behind the atomisers were fans. At the underside of the side walls were trays to collect spray liquid. The collected spray liquid was pumped back into the tank.

Table 1. Some characteristics of the sprayers during application.

parameter	cross-flow	cross-RS	tunnel-CLS	tunnel-RA
number of nozzles	2 * 8	2 * 10	2 * 5	2 * 2
type of nozzles	Albuz lila	Albuz lila	Albuz lila	Noric
pressure (bar)	8	9	9	2
speed (km/h)	6.5	6.3	6.0	6.5
spray volume (l/ha)	207	153	148	98

The experiments were carried out in a commercial apple orchard with Cox's Orange Pippin and Elstar cultivars on M.9 rootstock. Trees were 6 years old and planted in a single row system (3 x 1.25 m). For the biological evaluation, the experiment was arranged following a randomised block design with plots of 5 rows wide and 21.25 m long. There were 5 replicates. From 22 March, weekly sprayings were carried out. Products used and their recommended rate are Captan (83 % captan; 1.2 kg/ha), Pallicap (55.3 % captan + 16.7 % nitrothal-isopropyl; 2 kg/ha) and Dorado (25 % pyrifenox; 0.2 kg/ha). To obtain differences in disease incidence, products were applied at 25 % and 75 % of their recommended rate.

Except for the conventional cross flow sprayer, all sprayers collected part of the spray liquid not deposited on the leaves. This was recirculated to the tank. The rate of recirculation was measured several times after spraying of an area of at least 0.5 ha.

For measurements on emission and drift, the fluorescent dye Brillant Sulfo Flavine was added to the spray solution. After spraying the dye was extracted from collectors and leaves and measured by fluorimetry. The collecting tissues for measuring emission to the ground were 8 x 100 cm. Nine of them were placed per replicate. Emissions to the ground outside the orchard was measured at a distance of 2.5 up to 7.5 m leeward from the last row. There were 4 replicates. To measure drift into the air a pole was placed at 7.5 m from the last row. On this pole, ball shaped collectors were attached on 2 sides at different heights.

RESULTS

The recirculation, expressed as the percentage of the sprayed dose per ha, was highest for the tunnel-RA (Table 2). The recirculation with the cross-RS was far lower than that with the tunnel sprayers. The two cross flow sprayers showed similar emission rates to the ground inside the orchard. However, the tunnel sprayers, especially the tunnel-CLS, had a lower emission rate to the ground inside the orchard. Outside the orchard, the rate of emission to the ground was lowest for both the tunnel sprayers and highest for the conventional cross flow sprayer. The cross-RS and the conventional cross flow sprayer had similar emission rates into the air outside the orchard. Emission rates of the tunnel sprayers into the air was lower than that of the cross flow sprayers.

Table 2. The mean recirculation, emission to the ground inside and outside the orchard and the emission into the air outside the orchard expressed as a percentage of the sprayed volume per ha for the different sprayers.

type of sprayer	cross flow	cross-RS	tunnel-CLS	tunnel-RA
recirculation	-	5^{c}	17^{b}	26^{a}
emission to ground inside orchard	28^{a}	29^{a}	13^{c}	22^{b}
emission to ground outside orchard	9.1^{a}	2.5^{b}	1.6^{bc}	1.1^{c}
emission into air	7.5^{a}	4.9^{a}	1.1^{c}	2.5^{b}

Data with no letters in common are statistically different at a significance value $P \leq 0.05$.

The biological evaluation showed that the cultivar Elstar is more susceptible to both powdery mildew and apple scab (Table 3). As expected, the higher fungicide rate was more effective than the lower one for all sprayers. The conventional cross flow, the cross flow with reflection shielding and the tunnel-CLS were not statistically different from one another as regards efficacy. However the tunnel-RA was less effective than the other sprayers.

Table 3. The mean percentage of shoots with powdery mildew (*Podosphaera leucotricha*) and apple scab (*Venturia inaequalis*) of Elstar and Cox's Orange Pippin treated with 25 or 75 % of recommended rates of fungicides with different sprayers.

		powdery mildew			apple scab		
sprayer and dosage		Elstar	Cox's		Elstar	Cox's	
untreated		47.3	18.3	a	67.5	36.0	a
cross flow	25%	5.5	2.0	d	2.1	4.9	ed
	75%	1.5	1.3	e	1.4	2.1	ef
cross-RS	25%	9.8	2.1	cd	0.8	3.0	ef
	75%	2.5	0.8	e	0.4	2.0	f
tunnel-CLS	25%	12.0	3.1	c	3.3	4.9	d
	75%	2.8	0.6	e	1.5	2.3	ef
tunnel-RA	25%	15.4	5.5	b	17.8	22.0	b
	75%	9.6	3.8	c	4.8	12.5	c

There was no significant interaction between cultivar and treatment. Therefore data for Elstar and Cox's Orange Pippin are pooled for statistical analyses. Data with no letters in common are statistically different at a significance value $P \leq 0.05$.

DISCUSSION

In this paper results are presented of slightly improved models of sprayers also tested in 1992. Then, the lower efficacy of the tunnel sprayer with rotary atomisers was explained by not having corrected the dosage taking into account the clean water in the tubes of the machine and by a relatively low quantity of spray liquid which is directed towards the tree (Heijne *et al.*, 1993). In 1993 concentrations were adjusted for the clean water in the machine. Hence, only the latter reason is valid to explain the lower efficacy of the tunnel sprayer with rotary atomisers. This is in agreement with deposits on leaves, which were about half that of the cross flow sprayer (Porskamp *et al.*, 1994). Primarily, the droplets leaving the blades of the rotary atomiser are directed parallel to the side walls of the tunnel. Only thereafter, the droplets are blown in the direction of the tree by the fans behind the rotary atomiser. We believe that too large a portion of the spray liquid is never directed towards the tree. Part of it is caught directly on the same side wall from where it came or on the trays at the underside of the side walls. That explains the relatively high recirculation rate compared to the other tunnel sprayer.

The results of 1993 and previous years (Huijsmans *et al.*, 1993) demonstrated that tunnel sprayers can strongly contribute to reduce the environmental pollution by pesticides used in apple orchards. It is estimated that the tunnel sprayer with CLS can reduce the emission rate to the ground inside the orchard by over 50 % and outside the orchard by even over 80 % in comparison to the conventional cross flow sprayer. The emission into the air can be reduced too. It is estimated that the tunnel-CLS can reduce drift of droplets into the air outside the orchard with over 80 % as compared to the conventional cross flow sprayer.

For fruit growers, the good efficacy of the tunnel-CLS and the cross flow sprayer with reflection shielding is important. The latter is interesting for growers since two rows can be sprayed at one time. This reduces labour costs. The price of the new sprayers is higher than that of a conventional cross flow sprayer. It is estimated that the extra investment is compensated by savings on pesticides by recirculation and labour (van Rossem, 1994).

CONCLUSION

Tunnel sprayers can substantially reduce the pollution to the environment by pesticides. At the same time the tunnel sprayer with CLS is as effective as a conventional cross flow sprayer. Under production circumstances in the Netherlands, with relatively small trees and flat terrain, the use of a tunnel sprayer is possible and should be stimulated to contribute to the goals of integrated fruit production.

ACKNOWLEDGEMENT

We thank fruit grower C. den Boer for making available his apple orchard. We are indebted to H. Veijer and A. de Bes, who applied sprays and J. Westerlaken for organising the sprayings and the contacts with the fruit grower. We owe many thanks to E.A. van Hermon and J.M.G.P. Michielsen for laborious counting and laboratory analyses.

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EFFICIENT SPRAY DEPOSITION IN THE ORCHARD USING A TUNNEL SPRAYER WITH A NEW CONCEPT OF AIR JET EMISSION

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ABSTRACT

A prototype of low cost, small-dimension and light tunnel sprayer with a new concept of air-jet discharge system was developed. The air outlets were directed 40° upward aiming the top of the tree canopy. Spray distribution within the tree canopy for the prototype tunnel sprayer was compared with that for the commercial cross-flow tunnel sprayer (JOCO) and standard directed air-jet sprayer (SEPIA). The ratios of spray deposit on upper and lower leaf surface, being a measure of spray distribution uniformity, were as follows: 1.5-3.0 for the prototype tunnel, 7.5-14.6 for the commercial JOCO tunnel and 5.0-12.7 for directed air-jet sprayer.

Key words: tunnel sprayer, apple orchard, spray deposit, spray recycling.

INTRODUCTION

Tunnel spraying is one of the most effective and relatively safe method of orchard spraying. In recent years the tunnel sprayer concept has been developed in many countries, also in Poland. The first ever constructed air assisted tunnel sprayer was designed at the Research Institute of Pomology and Floriculture (ISK) - Skierniewice and equiped with two axial fans with rotary atomisers directed ca 40° upward (Bera 1984). Satisfactory apple scab (*Venturia inaequalis*) control was obtained at spray volume 10 l/ha and 1/2 dose of fungicides. Results of later experiments showed that pest and disease control obtained with tunnel sprayers was as effective as that for traditional air assisted sprayers (Cross and Berrie 1993; Heijne *at al* 1993; Sigfried and Hollinger 1994).

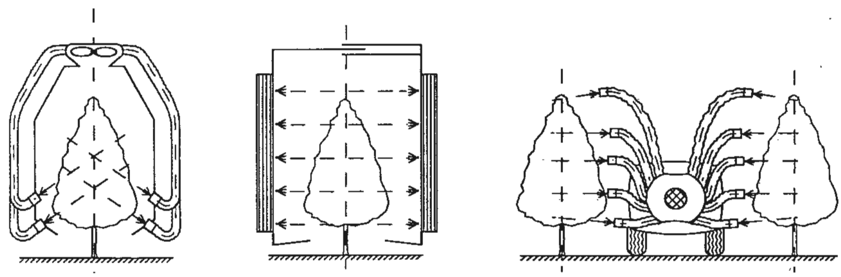
The air stream produced by conventional air-assisted sprayers can penetrate tree canopy easier than in tunnel sprayers, where opposite tunnel wall is a barrier to the natural air flow of the jet. Additionaly opposite directions of air jets decrease velocity of droplets which often results in decrease of spray retention on lower leaf surface. To minimize this undesirable effect a model of tunnel sprayer with a new air jet discharge system was developed at ISK - Skierniewice. The air outlets were directed 40° upward aiming the top of the tunnel. The air is sucked from the tunnel with a radial fan placed at the top of it and conveyed through flexible pipes back into the tunnel's chamber. The sprayer was equiped with only four outlets (two on each side) with hollow cone nozzles to obtain the lowest possible volume rates.

The objective of this study was to compare spray deposit within tree canopy and loss to the ground obtained with tunnel directed air-jet, tunnel cross-flow and standard directed air-jet spreayers in the orchard.

MATERIALS AND METHODS

Three sprayers were used in the apple orchard: Experimental Tunnel Sprayer (ETS), JOCO OSG-N1 tunnel and SEPIA (made in Poland) standard sprayer (Figure 1). Application were made on LOBO/M26 planted 3.0 x 1.5 m with use of fluorescent tracer (sodium salt of fluorescein at 0.04%). Spray volumes and travel velocities are given in table 1.

Artifical targets (filter paper) were placed in the tree to evaluate within-canopy deposit and on the ground for spray lose assesment (Figure 2). Four trees (replicates) were selected for each treatment.



ETS tunnel directed air-jet

JOCO tunnel cross-flow

SEPIA standard directed air-jet

Figure 1. Air-jet discharge systems.

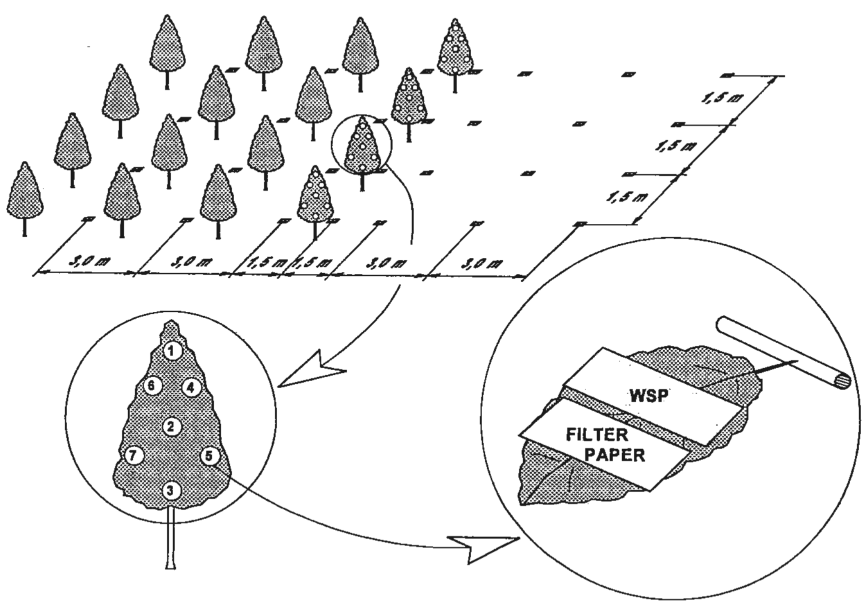


Figure 2. Samples layout.

Table 1. Design of experiment.

Sprayer	Discharge system	Travel velocity (km/h)	Volume rates (l/ha)
ETS	tunnel directed air-jet	4,0 ; 6,0	75; 150; 250
JOCO	tunnel cross-flow	4,0 ; 6,0	150; 250; 350
SEPIA	standard directed air-jet	4,0 ; 6,0	150; 250; 350

RESULTS AND DISCUSSION

No significant effect of spray volume rate and travel velocity on the total spray deposition (on upper+lower leaf surface) was obserwed (Table 2). Increase in driving speed caused decrease in total deposit for standard sprayer and slight increase for tunnel sprayers. The possible explanation is that higher travel velocity caused the jets to turn backward, so they did not interact so intensively which might had been a cause of non-uniform deposition. Deflected jets did not disturb each other so air velocity did not drop so rapidly.

Table 2. Mean deposit of fluorescent tracer on upper + lower leaf surface (ng/cm)

Sprayer	V (km/h)	Spray volume (l/ha)			
		75	150	250	350
ETS	4,0	179,2 ab	256,6 c-f	233.5 b-f	-
	6,0	202,0 a-e	239,7 b-f	241,8 b-f	-
JOCO	4,0	-	167,6 ab	278,3 d-f	148.3 a
	6,0	-	155,9 a	299,8 f	184,2 a-c
SEPIA	4,0	-	192,9 a-d	205,0 a-e	292,4 ef
	6,0	-	176,3 ab	197,3 a-d	196,6 a-d

Means followed by the same letter are not significantly different
(Duncan Multiple Range Test, $P<0,05$)

Table 3. Mean deposit of fluorescent tracer on lower leaf surface (ng/cm)

Sprayer	V (km/h)	Spray volume (l/ha)			
		75	150	250	350
ETS	4,0	75,0 a-i	104,8 i	82,8 f-i	-
	6,0	71,6 d-i	87,8 g-i	89,5 h-i	-
JOCO	4,0	-	23,1 ab	41,9 a-f	21,0 a
	6,0	-	21,0 a	38,5 a-e	24,5 a-c
SEPIA	4,0	-	43,4 b-g	48,1 c-h	55,3 d-i
	6,0	-	35,7 a-d	53,0 d-i	38,2 a-e

Higher deposit on lower leaf surface was caused by all treatments with ETS as well as at lower travel velocity (4 km/h) with traditionlal sprayer (table 3).
The ratio of spray deposit on upper and lower leaf surface (U/L) being a measure of spray distribution microuniformity was significantly higher for SEPIA and for JOCO (table 4). This can be possible explanation of slightly lower efficacy of disease control with tunnel sprayers (Cross and Berrie 1993; Hołownicki *at al* 1995)

Losses to the ground, expressed as percentage of spray volume applied, were significantly lower for both the tunnel sprayers, particulary in dormant stage (table 5).

The recycling rate at dormant stage (table 6) was similar for both tunnel sprayers at all treatments. At full foliage stage it was reduced by 40 %. Recycling rate decreased significantly for ETS at higher driving speed, possible reason of which was shorter tunnel (only 1,5 m) without recycling shields.

The results of experiments with a new concept air jet discharge system applied in ETS tunnel sprayer are very promising. Higher air velocity and lower air volume directed 40° upward, aiming the top of the tree gave more uniform spray distribution on upper and lower leaf surface

Table 4. Deposit of fluorescent tracer - U/L ratio

Sprayer	V (km/h)	Spray volume (l/ha)			
		75	150	250	350
ETS	4,0	1,5 a	1,8 ab	1,9 ab	-
	6,0	2,4 ab	3,0 bc	2,5 ab	-
JOCO	4,0	-	9,2 e-h	14,6 h	11,6 f-h
	6,0	-	9,5 e-h	10,1 e-h	7,5 d-g
SEPIA	4,0	-	5,8 de	5,0 cd	9,3 e-h
	6,0	-	8,9 d-h	6,6 d-f	12,7 gh

Table 5. Spray deposit on the ground - (%) of the sprayed liquid:

a) dormant stage

Sprayer	V (km/h)	Spray volume (l/ha)			
		75	150	250	350
ETS	4,0	41,6 ab	50,2 b	32,0 a	-
	6,0	40,2 ab	43,7 ab	33,3 a	-
JOCO	4,0	-	29,4 a	28,4 a	28,3 a
	6,0	-	41,4 ab	31,1 a	26,1 a
SEPIA	4,0	-	70,1 c	81,6 cd	78,2 cd
	6,0	-	83,6 cd	87,1 d	81,6 cd
b) full foliage					
ETS	4,0	11,0 b-d	8,5 ab	6,7 a	-
	6,0	22,9 h	14,9 d-f	9,2 a-c	-
JOCO	4,0	-	8,8 ab	6,9 a	5,5 a
	6,0	-	13,1 cde	11,0 b-d	9,3 a-c
SEPIA	4,0	-	19,1 gh	17,7 fg	16,7 e-g
	6,0	-	22,7 h	22,6 h	20,1 gh

Table 6. The average spray volume collected for recycling (%):

a) dormant stage

Sprayer	V	Spray volume (l/ha)			
	(km/h)	75	150	250	350
ETS	4,0	35,6 a	37,2 a	39,3 ab	-
	6,0	33, 3 a	38,3 ab	36,3 a	-
JOCO	4,0	-	36,1 a	34,1 a	34,5 a
	6,0	-	43, 1 b	37,7 ab	38,1 ab

b) full foliage

Sprayer	V	75	150	250	350
ETS	4,0	20,2 b	20,6 b	19 b	-
	6,0	22,9 c	15,2 a	14,7 a	-
JOCO	4,0	-	23,0 bc	20,3b	24, 3 c
	6,0	-	27,8 cd	22,1 bc	29,5 d

than for commercialy avaible JOCO tunnel sprayer. Improoving ETS discharge system by adding 2-3 pairs of air outlets and more efficient spray recycling system will be continued in ISK.

Discharge systems in tunnel sprayers is still not as effective as that in standard sprayer and therefore it should be improved. The droplets in tunnel sprayers move slower and can be more likely influenced by electrostatic forces. It seems that electrical charging of droplets can improve deposit uniformity and decrease airborne drift.

CONCLUSION

Based on the obtained results the following conclusions may be done from this experiment:

- air jets used in ETS tunnel sprayer directed upward to the top of the tunnel caused higher deposit uniformity in the apple trees;
- ground speed did not have a significant effect on spray deposition. However tunnel sprayers seem to be more "tolerant" for higher velocities;
- losses to the ground obtained with the tunnel sprayers were significantly lower than those with the standard sprayer.

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SPRAY DEPOSIT WITHIN APPLE TREES OF DIFFERING SIZES AND GEOMETRY AT LOW, MEDIUM AND HIGH SPRAY VOLUMES.

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ABSTRACT

Spray volumes 120, 200 and 400 l/ha were applied in three apple orchards of differing sizes and geometry of tree canopies. The average dimensions [height x width] of the trees were as follows: bush trees - 2.5 x 2 m, hedgerow trees - 1,8 x 1 m, super spindle trees - 1,7 x 0,5 m. All the trees were sprayed from one side with a cross-flow sprayer at driving velocity 6 km/h and air-jet velocity 24 m/s. Volume retained on targets increased with volume applied and was the greatest for super spindle trees. Deposit of a.i. increased with decreasing volume of spray and tree size. When applying 120 l/ha the concentration of spray liquid should be twice as high as for 400 l/ha to obtain similar deposit of a.i. in the tree canopies which means that use of 120 l/ha allows for almost 50% reduction of chemicals. Very good spray distribution uniformity obtained for 120 l/ha applied in super spindle allows for alternate row spraying.

Key words: spray deposit, spray volumes, tree geometry, TRV, cross-flow sprayer.

INTRODUCTION

The use of high and medium spray volumes in modern orchards and hence generating high emission of chemicals to the environment is an anachronism that should not be accepted. The spray volume must be adjusted to the shape and size of target trees if the treatment is to be safe and economical and in agreement with IPM requirements. A lot of studies have been done on interaction between the tree canopy and air jet carrying the spray as well as on spray deposit and distribution within the canopies for different spray volumes (Herrington et.al.,1981; Nielsen,1985; Wicks & Nitschke,1986; Travis et.al.,1987; Cross,1991; Hall & Cooper,1991). The Tree-Row-Volume (TRV) concept has been developed to simplify adjusting spray volume to the size of trees and to establish coherent recommendations about application parameters for orchards of differing types (Byers et.al.,1984; Sutton & Unrath,1984). TRV method is now officially recommended by advisory services in many countries. Further studies are needed to verify the TRV concept and to deliver argument supporting it.

The objective of this experiment was to study the effect of spray volume rate on spray retention and chemical deposit in the apple trees of differing size and shape in order to better understand relationship between volume rate and potential pest control efficacy.

The experiment was curried out in September 1992 at the Swedish University of Agricultural Sciences, Section of Park and Horticultural Engineering in Alnarp, Sweden.

MATERIALS AND METHODS

Trees, samples and trial layout

Three types of apple tree canopies were chosen: super spindle, hedgerow and bush trees (cultivars, spacings and dimensions are given in Table 1). Three trees (replicates) of each type were selected to place samples for collecting the spray. Seven samples attached to poles were placed in each tree: two on the east side ("sprayer-side" of canopy), three in the center and two on the west side (Fig. 1). Each sample consisted of four artificial targets (stripes of filter paper 25 x 60 mm), two of which were oriented vertically and the other two horizontally (Fig. 1).

Spray volume

The spray volumes were established according to TRV method assuming required spray volume per tree volume unit, amounting to 0.033 l/m^3 (practically recommended in Poland). Calculation considering above assumption, dimensions of the trees and row spacing for super spindle, hedgerow and bush trees gave TRV based volumes 112, 198 and 412 l/ha respectively. Thus the sprayer was calibrated for 120, 200 and 400 l/ha. All three volumes were applied to each type of the tree canopy and applications were made from the east side only, with the sprayer passing at ca. 0.5 m from the trees. Thus, the actual volumes applied were 1/2 of nominal mentioned above.

Sprayer

A cross-flow sprayer (Holder QU 41) set up at air jet volume 30 000 m^3/h was used at driving velocity 6 km/h. The air jet velocity in the outlet was 24 m/s and at 0.5 m from the outlet (fan-to-tree distance) 19 m/s. Albuz ATR nozzles were assembled in the air outlet (see Table 1 for details). Diameter of droplets (VMD) generated by different nozzles varied slightly and was in the range 80-95 μm (IMAG - Malvern Ins.).

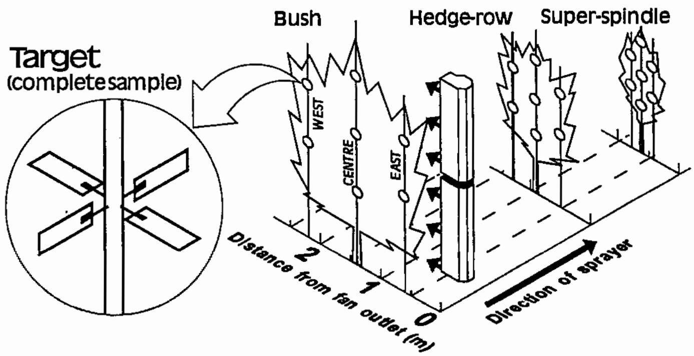


Figure 1. Samples layout in the tree canopies.

Table 1.
Details about the trees, the sprayer and the treatment parameters used in the experiment.

Tree canopy *Cultivar*	Spacing (m) *Trees/ha*	Height x width (m) *TRV (m³/ha)*	TRV spray volume (l/ha)	Spray volume applied[1] (l/ha)	Albuz ATR nozzles Number[2]	Albuz ATR nozzles Type	Pressure (MPa)	VMD[3] (μm)
Super spindle *Jonagold*	2.5 x 1 *4000*	1.7 x 0.5 *3 400*	112	120	5	Lilac	0.35	80
				200	5	Brown	0.55	80
				400	5	Orange	0.50	95
Hedgerow *Lobo*	3 x 2 *1666*	1.8 x 1.0 *6 000*	198	120	6	Lilac	0.35	80
				200	6	Brown	0.55	80
				400	6	Orange	0.50	95
Bush tree *Katja*	4 x 3 *833*	2.5 x 2.0 *12 500*	412	120	8	Lilac	0.35	80
				200	8	Brown	0.55	80
				400	8	Orange	0.50	95

[1] As the trees were sprayed from one side the actual volume applied was 1/2 of nominal one, given in the table
[2] Number of nozzles at one side of the sprayer
[3] VMD according to measurement made with Malvern Instrument in IMAG, Wageningen

Sample analysis procedure

The applications of 80 g/ha of fluorescent tracer (sodium salt of fluorescein) with a surfactant (Lisapol) at three spray volumes were made in each type of orchard. After the spray deposits had dried on filter paper all the samples were collected and each one, consisting of four targets was placed into the separate snap-seal sample container. In the lab 20 ml of washing solution (0.005 N solution of sodium hydroxide in deionized water + Lisapol at 0.06% v/v) was added to each container to extract fluorescent tracer. The tracer content was determined with fluorescence spectrophotometer (Hitachi - Model F-3000) and converted to ng/cm^2 for a.i. deposit (tracer), and nl/cm^2 for retention analysis.

Statistical analysis

CV% of a.i. deposit for treatments was calculated based on raw data (one-side spraying). Data was converted so that it simulated both-sides spraying and CV% was calculated based on so converted data. The log transformation ($y = log_{10}x$) was used to stabilize the variance of data prior to performing ANOVA with Duncan's multiple range test at P=0.05 in order to check means for significant differences. Both-sides log transformation was also used to analyze regression of spray volume retained on samples versus volume applied and regression of tracer deposit on samples versus volume applied. The method of multiple regression with dummy variables was used.

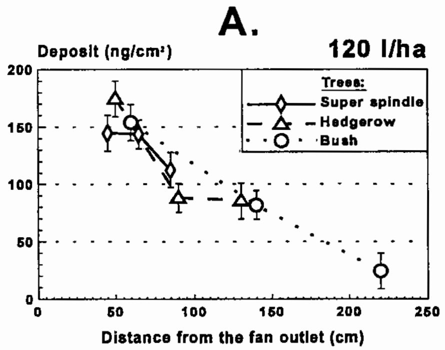
RESULTS AND DISCUSSION

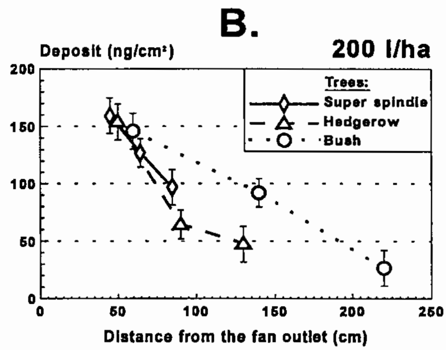
Figure 1 shows a decrease in a.i. deposit as the distance from the sprayer fan increases. When 120 l/ha was applied no significant decrease in deposit was observed in super spindle tree while it was very distinct in hedgerow and bush trees amounting to 50 and 85% respectively. This is consistent with the results obtained by Hall and Cooper (1991) and can be explained by higher spray capture efficiency of bigger and denser canopies which makes the penetration difficult. The similar relationship between spray deposit and distance from the sprayer was observed for 200 and 400 l/ha with relatively low deposit at east and center position in super spindle trees.

Table 2.
Mean spray retention and a.i. (tracer) deposit with their statistics for treatments. CV% given for one-side and both-sides applications (the later estimated on simulated data). Results for TRV based volumes are underlined.

Tree canopy	Spray volume (l/ha)	Retention (nl/cm2)	Deposit (ng/cm2)	Recovery (%)	CV (1-side) (%)	CV (2-sides) (%)
Super spindle	<u>120</u>	<u>202.8</u> d	<u>133.7</u> a	<u>33</u>	<u>24.1</u>	<u>20.1</u>
	200	319.3 bc	127.8 ab	32	38.5	33.2
	400	386.9 ab	77.2 d	19	33.9	30.5
Hedgerow	120	168.4 d	116.3 bc	29	61.3	45.3
	<u>200</u>	<u>214.3</u> cd	<u>89.2</u> d	<u>22</u>	<u>61.6</u>	<u>33.1</u>
	400	477.6 a	100.3 cd	25	58.4	36.3
Bush tree	120	166.5 d	86.5 de	22	70.6	37.0
	200	222.1 cd	88.3 de	22	63.2	34.7
	<u>400</u>	<u>340.5</u> b	<u>69.4</u> e	<u>17</u>	<u>75.2</u>	<u>38.8</u>

Means within columns followed with a common letter do not differ significantly (Duncan's multiple range test at P=0.05)





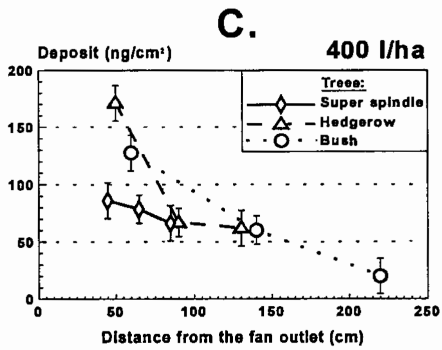


Figure 2.
Deposit of a.i. (fluorescent tracer) on artificial targets in super spindle, hedgerow and bush trees sprayed from one side with a cross-flow sprayer at spray volumes:
A. 120 l/ha
B. 200 l/ha
C. 400 l/ha

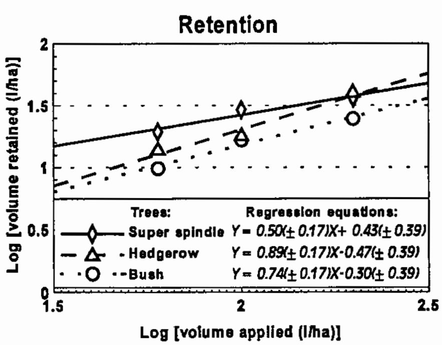


Figure 3.
Regression of spray volume retained on artificial targets in the canopy versus volume applied to super spindle, hedgerow and bush trees.

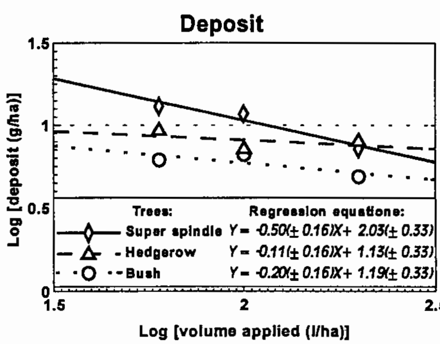


Figure 4.
Regression of fluorescent tracer deposit on artificial targets in the canopy versus volume applied to super spindle, hedgerow and bush trees.

A very big difference in deposit between east and center position and no difference between center and west side of hedgerow canopy for all three volumes was due to relatively dense outer zone of foliage, so shielding the inner part of these trees.

CV% of deposit for one-side application (Table 2) was 24-34% in super spindle compared to 58-61% in hedgerow and 71-75% in bush trees. Both-sides application (based on simulated data) is likely to reduce CV% considerably in hedgerow (36-45%) and bush trees (37-39%) but it will be still higher than that for one-side application to super spindle. This excellent spray distribution in small trees means that alternate row application technique can be used in high density orchards with spindle-like trees.

As expected, the volume of spray retained on the samples increased with the volume applied and was greater in super spindle and hedgerow than in the bush trees (Table 2). The relationship between log[volume retained] and log[volume applied] for each type of the tree can be expressed with linear regression (Figure 3) with non-significant deviation from linearity at $P=0.05$. The slopes of regression lines are significantly different from each other at $P=0.001$. The rate of retention with increased volume applied is greater for bigger trees, which means that small trees are more tolerant to spray volume reduction in terms of spray retention. The results and regression features are consistent with those reported by Herrington et.al. (1981).

Deposit of a.i., unlike retention, decreased with increasing spray volume applied (Table 2). It was growing in the order bush-hedgerow-s.spindle with significant differences between each other which is consistent with what was reported by Warman and Hunter (1981) and Travis et. al. (1987). Regression lines of log[deposit] versus log[volume applied] had negative slopes, relatively low for hedgerow and bush trees and much greater for super spindle (Figure 4). It means that reduction of spray volume is likely to cause considerable increase in a.i. deposit on small, spindle-like trees and only moderate one in bigger canopies. It is reflected also in recovery rates for treatments given in Table 2. However, use of different nozzles (different VMD of droplets) mounted on axial fan sprayer for applying very low, low and medium spray volumes (the lower volume the finer spray) may result in positive slope of regression, which actually was observed by Cross (1991).

Twice higher deposit obtained in super spindle sprayed with 120 l/ha than that in bush trees at 400 l/ha allows for statement that nearly 50% reduction in chemical dose can be used when applying very low volumes to very small trees. Furthermore, if on-leaf spray retention is not a crucial factor for the chemical applied (e.g. systemic chemicals) the alternate row application technique at as low volume as 60 l/ha, and 50% reduction in pesticide dose could be used in super spindle orchards. However, despite of sufficient deposition of a.i. for contact chemicals this may result in poor control efficacy due to low retention and hence fewer spray drops per leaf surface (Nielsen, 1985). In these cases spray volume may be crucial in terms of pest and disease control efficacy. On the other hand Wicks and Nitschke (1986) obtained the same satisfactory control of two-spotted spider mite *(Tetranychus urticae)* and European red mite *(Panonychus ulmi)* as well as powdery mildew *(Podosphaera leucotricha)* with the same chemical dose applied at 200 and 800 l/ha to Golden Delicious, Granny Smith and Jonathan cv. cv. They observed better apple scab *(Venturia inaequalis)* control for the lower volume.

When analyzing results obtained only for TRV spray volumes (underlined figures in Table 2) one can notice that applying 120 l/ha to super spindle trees resulted in the best performance in terms of a.i. deposit, recovery (the greater recovery the lower spray loss) and distribution uniformity (CV%). Applying 200 or 400 l/ha in this orchard will only make the result worse. That means that spraying small trees is more efficient with low volumes than with middle or high volumes. It is in agreement with Byers et.al (1984) who said that reduced rates of chemicals would be necessary to obtain similar a.i. deposits for smaller than full-size trees. The only estimator of application quality that was increasing with the spray volume was spray retention. In some cases it may be an important factor influencing the efficacy of chemical treatments which is discussed above. Assuming that application quality obtained for 400 l/ha in bush trees gives efficient control of pests and diseases one can see that applying TRV based volumes to smaller trees gives even better quality of treatment which ensures satisfactory biological effect. Applying 120 l/ha to bush trees enhanced significantly a.i. deposit with simultaneous significant reduction in spray retention compared to 400 l/ha.

CONCLUSIONS

1. Decrease in a.i. deposit as the distance from the sprayer increased was the greatest in bigger and denser canopies.
2. Retention of spray increased while deposit of a.i. and spray recovery decreased with increasing spray volume applied. Both retention and deposit were greater in super spindle than in hedgerow and bush trees.
3. The best spray distribution uniformity was obtained in super spindle trees. Generally it was better for low spray volumes than for middle and high ones.
4. Small trees should be sprayed with lower volumes, adjusted to their size in order to obtain optimum quality of application.
5. Reduction in chemical dose by 50% and alternate row application technique are possible in super spindle trees with chemicals for which spray retention is not a crucial factor affecting control efficacy.
6. TRV concept is a reliable method of adjusting spray volume to the size of tree and may be practically recommended.

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LECTURES

Section: Pesticide Use

The fitness of some insecticides for integrated fruit production

by

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1 Abstract

The review of data on lufenuron and fenoxycarb indicate that these insect growth regulators (IGRs) are suitable substitutes for organophosphate compounds still used to a large extent for pest control in top fruits. An established acaricide such as bromopropylate can also be integrated into a non-disruptive control programme due to its ongoing good performance. Its different chemical class from most of the other acaricides makes it attractive in an anti-resistance strategy in situations where a miticidal treatment becomes necessary. A final rating on the suitability of the products regarding their safety to beneficials is only possible by field studies over several seasons on a large scale. A long term experiment established in the context of such an evaluation will reveal the interactions between the product of choice and the arthropod complex.
In this paper, results are reported from reviews of available data on the selectivity and IPM fitness of the IGRs lufenuron and fenoxycarb, and the acaricide bromopropylate.

2 Materials and methods

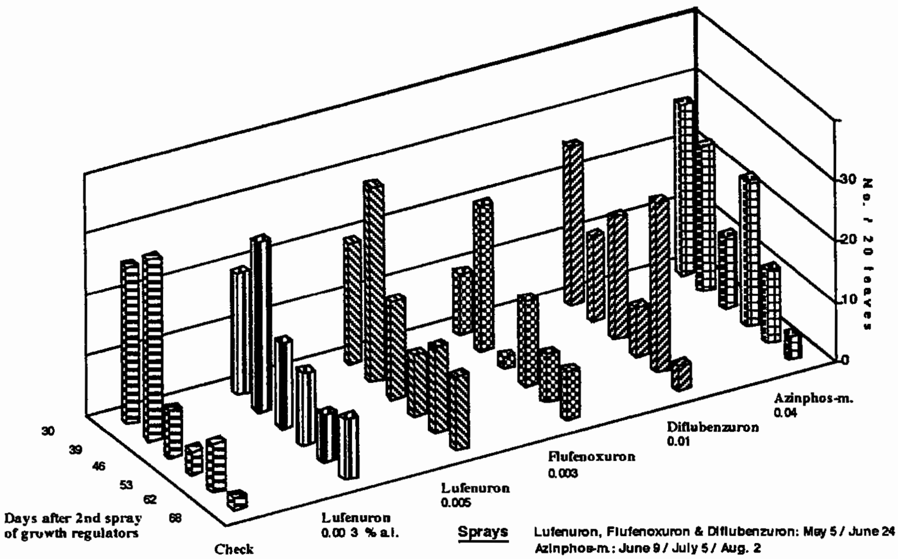
The available literature and internal Ciba reports on the selectivity and other relevant IPM features of lufenuron, fenoxycarb and bromopropylate were evaluated and selected relevant findings and summaries are presented.

3 Results

3.1. Lufenuron

Lufenuron is an IGR interfering with the chitin synthesis (Buholzer et al. 1992). Because only immature stages (larvae, nymphs) form chitin, lufenuron does not affect adults. It acts mainly by ingestion and is not systemic. For some insects it acts also as an ovicide. Because it does not affect adults and has a weak contact action, it shows a good degree of selectivity towards beneficial insects and mites. Representative data were taken from an internal Ciba brochure (Bourgeois 1994).
In deciduous fruit the product is neutral to spider mites and also harmless to predaceous phytoseiid mites. Two spray applications of lufenuron at rates of 0.003 and 0.005% a. i., two other IGRs flufenoxuron and diflubenzuron, and azinphos-methyl on apple trees in Italy demonstrated a population development pattern of *Typhlodromus pyri* similar to that of the untreated control (Fig. 1). There was no rate response of the two concentrations of lufenuron. A temporary reduction is not considered to have any long term negative impact based on many field trials (Buholzer et al. 1992).
The recovery of larval/nymphal populations is dependent on the beneficial group and the rates used (Tab. 1). Larvae of hover flies (Syrphidae) and predaceous gallmidges (Cecidomyiidae) were not at all affected by lufenuron up to a rate of 0.005% a.i. . Detrimental effects on nymphs of *Anthocoris* spp. can last up to 7 weeks at the rate of 0.005% a. i., but at half the rate not more than 2 weeks.
In summary, lufenuron can be regarded as a soft product to beneficial arthropods and therefore as suitable for an IPM strategy in top fruit crops.

Fig.1 The impact of insecticides on Typhlodromus pyri in an apple orchard, Italy, 1989



Tab.1 Selectivity rating of lufenuron in top fruit crops

Beneficial species	Rates (a. i.) in %	DAT[1)]	Rating (IOBC)	Crop	Country
Agistemus	.005 x 7	*	3	Apples	S. Africa
Amblyseius	.005 x 7	*	1	Apples	S. Africa
	.003	28	2	Apples	Italy
	.005 x 2	35	1	Apples	Italy
	.001-.005	17	3	Apples	USA
	.005 x 3	13	3	Apples	Switzerland
		36	1	Apples	Switzerland
Anthocoris I	.005 x 1	50	4	Pears	Switzerland
		63	1	Pears	Switzerland
	.005 x 3	7	4	Pears	Switzerland
		21	2	Pears	Switzerland
	.0025 x 3	15	2	Pears	Switzerland
Orius A + I	.005 x 3	7	3	Apples	Switzerland
		28	2	Apples	Switzerland
Orius I	.005 x 3	13	4	Appless	Switzerland
Syrphidae I	.001-.005	17	1	Apples	USA
Cecidomyiidae	.001-.005	17	1	Apples	USA

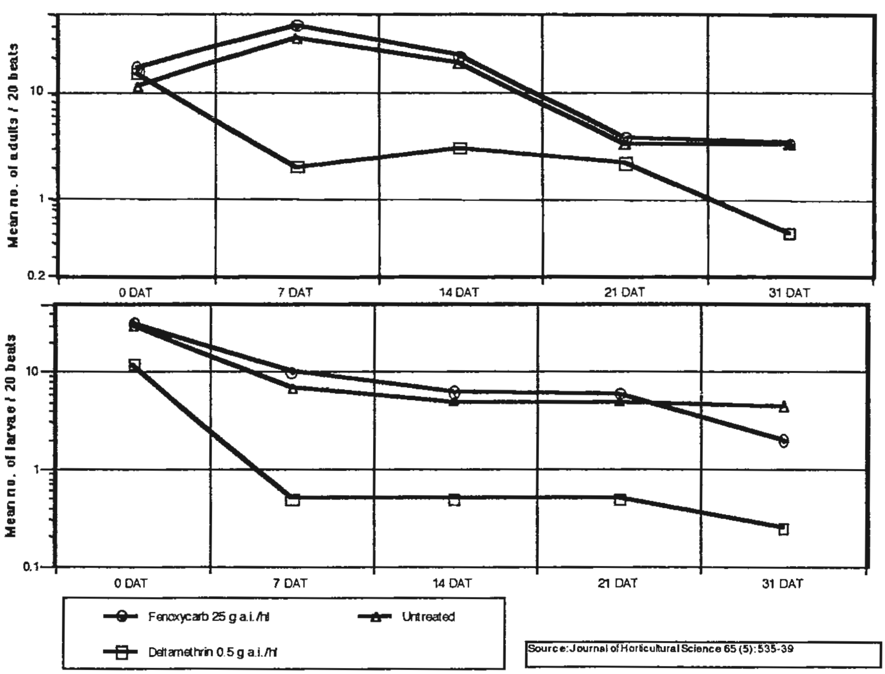
I - immature A - adult [1)] days after treatment
* several counts in programme spraying

IOBC	1 < 25% reduction	harmless	3 51-75% reduction	moderately harmful
rating	2 25-50% reduction	slihtly harmful	4 > 75% reduction	harmful

3. 2. Fenoxycarb

Fenoxycarb is an IGR which disrupts the transformation from the egg to the larva and from the larva to the pupa in lepidopterous species (Dorn et al. 1981). It also blocks the development from the crawler to the sessile stage in scale insects. Although the substance has no activity on adults, it may reduce the egg-laying rate or block the hatching process of the embryos ('transovarial effect') after ingestion by females.
Fenoxycarb acts by contact and ingestion. It has translaminar activity and a very good residual life on plant parts.
The data on the selectivity of fenoxycarb have been summarized recently by Scheurer and Bourgeois (1994). According to these data, fenoxycarb can be considered as safe to heteropterous predators under field conditions, as can be seen from the results of trials on several *Anthocoris* species in pear orchards in the UK (Fig. 2). The population development of nymphs and adults was similar in the fenoxycarb and in the non-insecticidal control plot, while deltamethrin caused some reduction of both stages. Predatory bugs seem to be less affected at the end of the immature development stage, since they do not have a pupal stage.

Fig.2 The impact of insecticides on Anthocoris spp. in a pear orchard, UK, 1990



The key for the fitness of a product under European fruit production conditions is the effect on predatory mites. Applied at the upper rate of 10 g a. i. / hl in a Swiss apple orchard, fenoxycarb followed the same pattern of population development of *Typhlodromus pyri* as the untreated control (Fig. 3). Dimethoate wiped out this non-resistant predatory mite strain.
The overall selectivity rating of fenoxycarb showed a very favourable picture. Under the stringent laboratory conditions, the product got the worst rating according to the IOBC scale of 4 (harmful) for *Chrysoperla carnea* and *Anthocoris nemoralis*, while the vast

majority of the classifications are in the categories 1 (harmless) and 2 (slightly harmful) (Hassan 1991). The potential negative impact on the brood of honey bees can be overcome by the proper timing of the spray application and by the mowing of flower plants in the spray area.

The mode of action of fenoxycarb and of lufenuron are completely different. This property and the relative safety of both substances make them ideal partners in an integrated pest and resistance management system. Both compounds can be positioned in early and mid season applications against the codling moth, the summer fruit tortrix moth and leafminers (e. g. *Lithocolletis blancardella*). According to the type of action, the sprays must be timed against the egg, and/or the young and/or the last larval instars.

3. 3. Bromopropylate

In addition to the IGRs, older established compounds can still play a useful role, provided they have an acceptable degree of selectivity and their target species have not developed resistance. An example for that is the acaricide bromopropylate. Being on the market since 1967, it is still active against all stages of tetranychid and eriophyid mites on pome and stone fruit. As a strict acaricide it has no effect on insect predators and parasitoids (Bourgeois 1993). The decisive feature is the impact on typhlodromid mites. Under the severe conditions in the laboratory it immediately and strongly reduced eggs and mobile stages of *Amblyseius fallacis* when exposed for four days on a fresh deposit (Fig. 4). The same exposure time on an eight days old spray deposit showed that the recovery had started. Aged by another week there was no residual activity any more.

4 Discussion

A final rating on the suitability of pest control tools is only possible based on large scale field studies over several seasons (Hardman et al. 1995). Insect growth regulators can give equal or better control of pests than standard organophosphates (Westigard and Gut 1986). They offer better possibilities for integrated pest control than older materials for this purpose (Sechser et al. 1984). The long term experiment established in the context of this evaluation will reveal the interactions between the product choice and the arthropod complex, and its results will depend on the colonization pattern of pest and beneficial species from the surrounding habitat.

Fig.3 The impact of insecticides on Typhlodromus pyri in apple orchards, Switzerland, 1990

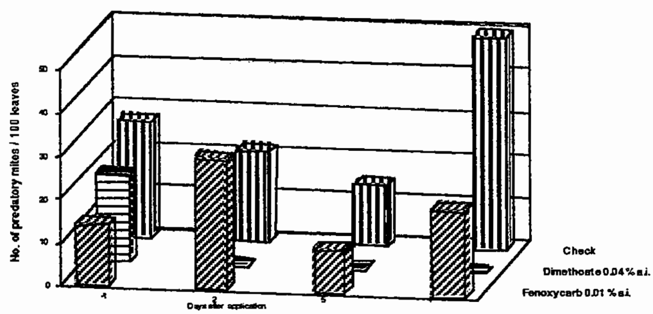
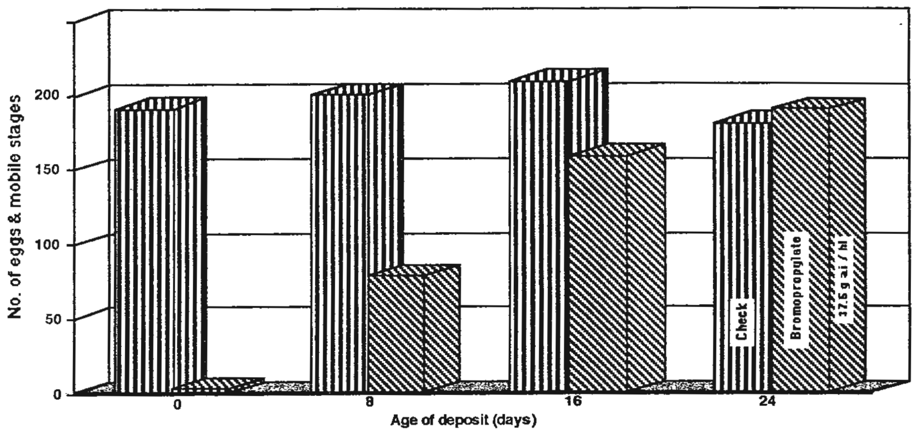


Fig.4 The effect of bromopropylate on the predatory mite Amblyseius fallacis in a laboratory persistence test

Population density of Amblyseius fallacis after 4 days exposure on deposits of different age



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THE CURRENT POSITION OF THE IGR DIFLUBENZURON (DIMILIN) IN EUROPEAN FRUIT PRODUCTION.

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Abstract

Diflubenzuron, the active ingredient of the insecticide DIMILIN, is an Insect Growth Regulator (IGR) belonging to the group of the benzoylureas.

The commercial introduction of diflubenzuron in the late seventies for control of the codling moth (*Cydia pomonella*), and several lepidopterous leafminers, which are key-pests in apples and pears, greatly enhanced the possibilities for Integrated Pest Management (IPM) in these crops.

The unique position of diflubenzuron is based on its safety to honey bees, and most predators and parasites. In 1994 new GLP semi-field and field studies with twice the highest rate specified on the label, confirmed that Dimilin is non-toxic to honey bees.

Other insect pests in apple and pear which can be controlled with diflubenzuron are: leafminers (viz. *Phyllonorycter spp.* and *Leucoptera spp.*), wintermoth (*Operophtera brumata*), browntail moth (*Euproctis chrysorrhoea*), ermine moths (*Yponomeuta spp.*), pear psylla (*Psylla pyri*), apple rust mite (*Aculus schlechtendali*), fruitlet mining tortrix (*Pammene rhediella*), apple fruit moth (*Argyresthia conjugella*), and the occulation gallmidge (*Resseliella oculiperda*).

Due to a continuous over-use of diflubenzuron in some fruit growing areas with high codling moth pressure, especially in the south of Europe, local resistance of codling moth to diflubenzuron (and other benzoylureas) has been observed in recent years. As only a few products are currently available for use against codling moth in IPM, moderation of use is required to decrease the selection pressure in areas where codling moth is still susceptible to diflubenzuron. For this purpose a resistance-management-program is being communicated to the growers.

Examples of new application areas in which diflubenzuron has been developed in recent years, are its uses against the citrus leafminer (*Phyllonoctis citrella*) in citrus, and the raspberry beetle (*Byturus tomentosus*) in raspberries.

Introduction

Diflubenzuron is a member of the chemical group of the benzoylureas. Its tradename for agricultural uses in Europe is DIMILIN.

Diflubenzuron acts by interfering with the deposition of chitin, one of the main components of the insect cuticle. Based on this mode of action, the compound is also classified as a Chitin Deposition Inhibitor, and as an Insect Growth Regulator (IGR).

The mode of action of diflubenzuron can result in larvicidal and ovicidal effects. The larvicidal activity is mainly through ingestion and generally becomes visible at moulting. Therefore, in order to avoid excessive feeding damage, the product should be applied earlier than classical neurotoxic insecticides with a fast initial activity. Some examples in fruit growing to which this applies are the early feeding caterpillars of the wintermoth (*Operophtera brumata*), the clouded drabmoth (*Orthosia incerta*) and of some leafroller species (e.g. *Archips podana*, *Pammene rhediella* and *Spilonata ocellana*).

Diflubenzuron can cause ovicidal effects by contact activity on eggs or by uptake by gravid females ("transovarial" activity). In both cases the embryo in the egg stays alive and appears to develop normally but, due to inhibition of chitin deposition in the cuticle, the larva is either unable to hatch, or it dies soon after hatching. To obtain an ovicidal contact action on eggs for control of e.g. the codling moth (*Cydia pomonella*) and lepidopterous leafminers, it is obvious that early application - preferably just prior to egg laying - is essential.

Diflubenzuron exhibits a rather long residual activity on foliage. As a result, the number of spray applications in certain situations can be much lower than with many other insecticides.

Due to its specific mode of action, combined with a generally low contact activity on insects, and absence of systemic activity on plants, diflubenzuron is safe to honey bees and to most predators and parasites.

Honey bees

The unique position of diflubenzuron in fruit growing is, amongst other properties, based on its safety to honey bees. Consequently, no restrictions are necessary with regard to the time of application as far as flowering of trees or ground cover is concerned.

In previous reviews on the effects of diflubenzuron on non-target organisms, we have already concluded that diflubenzuron at the registered rates for orchard and forestry uses, is safe to the honey bee (*Apis mellifera*) (See viz. Grosscurt, 1994). The highest label rate for forestry use is usually 75 g a.i. per ha, whereas for uses against orchard pests, the highest label rate goes up to 20 g a.i. per 100 l (which equals 200 g a.i. per ha at 1000 l water per ha).

In 1994 we additionally tested diflubenzuron in Germany, in both semi-field and field tests at double the maximum application rate for orchard use (40 g a.i. per 100 l), according to the BBA guidelines. The semi-field tests at several locations were performed in test cages of about 17 m^2 with *Phacelia tanacetifolia* as a test plant. The same test plant was used in the field tests. Application with the test compound was made during active flight of the bees. All studies were conducted in compliance with the principles of Good Laboratory Practice.

In all tests diflubenzuron was classified as harmless to foraging bees and their brood up to the test concentration of 40 g a.i. per 100 l. These data underline the unique status of diflubenzuron as the only benzoylurea which is safe to honey bees.

DIMILIN and IPM in apples and pears

The commercial introduction of diflubenzuron in the late seventies in a number of European countries (The Netherlands: 1977, Italy: 1978 and France: 1979) for control of some key pests in apples and pears, like the codling moth and leafminers, coincides with the development of Integrated Pest Management (IPM) in these crops and greatly enhanced the possibilities of this type of pest management (Gruys, 1979).

Apart from the control of the key pests mentioned above, an application with diflubenzuron efficiently controls simultaneously occuring pests such as ermine moths (*Yponomeuta* spp.), the apple fruit moth (*Argyresthia conjugella*), certain diflubenzuron-susceptible leafroller species (e.g. *Archips podana, Pammene rhediella* and *Spilonota ocellana*) (De Reede, Gruys and Vaal, 1985) and also suppresses pear sucker (*Psylla* spp.), the European apple sawfly (*Hoplocampa testudinae*) and the apple blossom weevil (*Anthonomus pomorum*). The latter activity is achieved by the transovarial action of diflubenzuron (Hoehn and Wildbolz, 1992; Gruys, 1977).

In the Netherlands diflubenzuron is also recommended for control of the occulation gall midge (*Resseliella oculiperda*), which can cause damage after summer pruning of apple (Anonymous, 1993).

IPM in apples in Europe is mainly focussed on natural control of phytophagous mites by the phytoseiid predatory mite *Typhlodromus pyri*. In Italy and other southern European countries also the predatory mite *Amblyseius andersoni* and the predatory bug *Stethorus punctillum* have been proven to be successful predators (Pasqualini et al., 1992; Blommers, 1994).

Diflubenzuron is classified as harmless to all these predators (Hassan et al, 1994, Pasqualini and Malavolta, 1986).

Due to its side effect on the apple rust mite (*Aculus schlechtendali*), diflubenzuron can also be helpful in solving the problems with this mite species during the transition period from classical pest control to IPM (Young, Talbot and Balderston, 1990).

In pears, IPM is mainly based on the natural control of the pear sucker by predators (mainly the predatory bugs *Anthocoris nemoralis* and *Orius* spp., and earwigs (*Forficula auricularia*).

According to the OILB classification diflubenzuron is harmless to *Anthocoris nemoralis* (Hassan et al., 1994). Although in laboratory studies diflubenzuron was toxic to the 2nd nymphal stage of the earwig, in orchard trials at a rate of 12.5 g a.i. per 100 l, diflubenzuron has been classified as only slightly harmful (Sauphanor & Staubli, 1994).

The success of such an approach is, amongst others, demonstrated by Trapman and Blommers (1992). In a study in the Netherlands (from 1980-1984), the use of selective compounds (diflubenzuron on codling moth, fenoxycarb on leafrollers and primicarb on green aphids) allowed such a quick recovery of the natural control of pear sucker, that this pest did not need further chemical control for 2 years in succession. Nowadays, in IPM-practice in the Netherlands pear sucker is no longer a problem.

However, it is known from other countries, that the development of natural enemy populations does not always result in an efficacious suppression of this pest. In such situations field studies and practical experience proved that a spray-program with diflubenzuron, directed at young instars of the pear sucker, greatly reduced the pest population and at the same time allows the build up of a natural enemy population (see a.o. Ciglar and Baric, 1992).

Recent developments

In recent years diflubenzuron has also been developed for control of some key-pests in other fruit bearing crops like soft fruits and citrus.

In soft fruits good results have been obtained in raspberries for control of the raspberry beetle larva (*Byturus tomentosus*). Adult beetles lay their eggs on flower buds or young fruits. The larvae (commonly called fruitworms) bore into the fruits thus making it unfit for consumption.

In field trials in Switzerland, one treatment with diflubenzuron (10 g a.i. per 100 l) at the beginning of flowering gave nearly complete control, whereas the standard (0.05% phosalone) gave only about 50% control. The activity of diflubenzuron on this pest is achieved by its ovicidal activity following contamination of adult weevils. In Switzerland, diflubenzuron has now been registered for control of the raspberry beetle, and is specified in the list of products approved by the Swiss Working Group for Integrated Fruit Production (Anonymous, 1995[a]).

Since 1993 the citrus leafminer (*Phyllonoctis citrella*) has become a serious threat to citrus in a number of Mediterranean countries, including Spain, Portugal and Turkey.
Larvae of this leafminer mine tender foliage and stems of citrus trees, killing leaf tissue and causing leaf drop. Egg deposition coincides with leaf flushing of the trees which, depending on region and citrus variety, can occur many times per year. (In hot climates even > 10 times per year). In Spain this pest has now spread over all the major citrus areas, at this moment threatening some 160.000 ha of citrus.
Diflubenzuron already proved to be effective against this pest in the Far East, being registered for control of citrus leafminer in China, Japan and South Korea. Recently obtained results from field studies in Spain confirmed the good activity of diflubenzuron against this pest. Based on these results, diflubenzuron obtained an emergency registration in Spain in the spring of 1995.

Update of the resistance situation

In 1991 we reviewed the status with respect to cross-resistance and resistance development to diflubenzuron (Grosscurt and Stoker, 1991).
Though larval selection with diflubenzuron in the laboratory could lead to resistance, resistance development in field strains had only occured in a limited number of species until 1991. With regard to orchard pests, cases of resistance were discussed for the apple leaf blotch miner (*Leucoptera scitella*) and the spotted tentiform leafminer (*Phyllonorycter blancardella*) in Northern Italy. For the codling moth, an unidentified case of tolerance in the US was mentioned. We also studied cross-resistance between several benzoylureas on two diflubenzuron-resistant strains of *L. scitella* from Italy (from the Ferrara and Verona regions). The data indicate cross-resistance between diflubenzuron and all the other benzoylureas tested. In both strains, triflumuron had the highest level of cross-resistance with diflubenzuron.
Since 1991, the most serious new cases of resistance in orchard pests were observed in codling moth, in France and Italy. In 1993 resistance was reported from three orchards in the Vaucluse and the Bouches-du-Rhone (Anonymous, 1994).
An explanation for this outbreak of resistance is a dramatic over-use of the compound. This is illustrated by Sauphanor et al. (1994), who mention that in a commercial orchard in Eyrague, the number of insecticide applications (on 2 to 3 generations per year) increased from 4 in 1989 (of which 3 with benzoylureas) to 30 in 1992 (of which 13 with benzoylureas).

In Süd Tirol, Italy, resistance to diflubenzuron in the codling moth has spread from 1200 ha in 1992 to about 6200 ha in 1993 (Waldner, 1993). Laboratory experiments showed cross-resistance between diflubenzuron and "all other known inhibitors of chitin synthesis". The resistant strains furthermore showed lower susceptibility to the O.P.'s azinphos, phosalone and diazinon. Fenoxycarb showed no decrease in activity in laboratory experiments. However, in field trials on resistant strains only 70 % control was obtained (rate not mentioned).

In Italy, areas with and without diflubenzuron resistance are monitored. In areas without resistance, diflubenzuron still can be used. In areas with resistance to diflubenzuron, the advice depends on the level of infested fruit in the previous season. The advice is mating disruption alone (< 1 % infestation), or combined with either phosalone (1-5 % infestation) or azinphos (> 5 % infestation).

A strong disadvantage of O.P.'s is that they have much more negative ecological effects than diflubenzuron. The increased use of the O.P. compounds has already resulted in a sharp increase in the use of acaricides, due to high mortality of their natural enemies.
In France, the advice for control of the first generation of the codling moth in areas with resistance to diflubenzuron is to switch to azinphos-methyl or a combination product of chlorpyriphos and dimethoate. Furthermore, it is strongly advised to use a combination of one of these chemicals with a microbial insecticide (codling moth virus or *Bacillus thuringiensis*), for control of O.P.-resistant individuals. The products in the combination should each be applied at the full registered dose. If the treatment results in more than 3 damaged fruits per thousand, the same treatment should be used on the second generation, with the restriction of switching to an alternative active material. If less than 3 damaged fruits per thousand are observed, the choice of chemical insecticides can be enlarged with representatives from other chemical groups (Anonymous, 1995[b]).

The general tendency nowadays is to reduce dosages of insecticides. With older products sometimes a considerable "safety margin" did exist between the real dosage needed for insect control and the label dosage. However, we are convinced that for diflubenzuron label rates are realistic, considering the commercial requirement that good control has to be achieved under all circumstances. It is clear that the level of control not only depends on the chemical compound, but is also influenced considerably by other specific crop properties (crop variety, physiological conditions, micro-climatical variability, and spray method and -equipment).
Chemical control also can be part of a locally developed Integrated Pest Management Program in which dependency on chemicals is partly replaced by non-chemical control methods (cultural and biological (e.g. predators and parasites)). In this case, careful monitoring of pest and predator numbers is necessary, as is a clear knowledge of damage thresholds. Recommendations of lower dosages should remain the responsibility of the local extension service.
Furthermore, it should be kept in mind that advising dosage rates which are lower than the registered rates is punishable by law in certain countries (a.o. in Belgium). Our general recommendation therefore is not to reduce dosages mentioned on the product label.

To avoid resistance development, moderation of use is required to decrease the selection pressure. In our most recent version of the Technical Information Brochure on DIMILIN (10th edition) we have included a chapter on "Resistance Management", with the following guidelines.

* Use products only when pests reach acknowledged thresholds.
* Apply products at the correct time and observe conditions suitable to optimize results (correct application, most susceptible life-stage etc.).
* If products are alternated, then choose products with different degradation mechanisms in the insect.
* Avoid multiple applications of the same product on a single generation.
* Do not reduce dosages. Manufacturers' recommended dosage rates have been tested and shown to give reliable levels of control when used according to the product label.
* Make use of non-chemical means of control, e.g. cultural and biological, where this is compatible with commercial expediency.

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RELATIVITY OF THE TOXICITY OF BROAD SPECTRUM INSECTICIDES TOWARDS THE PREDATORY MITE, *TYPHLODROMUS PYRI* (OUDEMANS).

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Abstract

The selectivity of insecticides and fungicides towards the predatory mite, *Typhlodromus pyri* (Oudemans), is in many countries a major criterion to consider whether a plant protection product can be used in integrated pest management of pome fruits. This selectivity can be tested by means of lab-tests, semi-field or field tests. All test methods have their own disadvantages. Differences in sensitivity of local strains, the time of application, the time of assessment and many other parameters have important effects on the final toxicity on this beneficial if field tests are used. However, too many information resulting from field tests can not be obtained by lab testing. Therefore, both results should be carefully compared. Finally, attention is drawn to the possibilities for the management of pests that are very difficult to control with selective compounds. Short and long term effects of less selective compounds are considered to reduce the side effect on the population of *Typhlodromus pyri* as much as possible, if they are used in "emergency" situations.

Introduction

A range of arthropods can be considered as beneficial with respect to their impact on insect and mite pests because of their activities as a predator or a parasite. Although most beneficials occur more or less in most agricultural systems, their importance is crop specific. The decision whether a new compound can be used in IPM of apple orchards depends however so far mostly on its selectivity towards the predatory mite, *Typhlodromus pyri*. This beneficial is commonly used to control the populations of red spider mite, *Panonychus ulmi*, apple rust mite, *Aculus schlechtendali*, and two-spotted spider mite, *Tetranychus urticae*. However, there is nowadays a tendency to consider at least the effects on four beneficial species, of which two are likely to be chosen because of their importance for the relevant crop (SETAC-Europe, 1995).
The selectivity of pesticides for predatory mites can be tested by lab tests, semi-field or field tests. All methods have their own advantages and disadvantages. Lab tests are more uniform with regard to the genetic origin of the test species, are better to control and hence more reproducible. Field tests might suffer from extreme weather conditions and are often heterogeneous, making it difficult to interpret them. With lab tests, it is easy to test the effect on different live stages. On the other hand, the worst case conditions in the lab tests might be artificial. In field tests the test species might for instance escape or hide for the compound as might occur in nature. Field tests resemble Good Agricultural Practice with treatments at the phenological stage at which the compound will be applied in practice. Local applications to avoid negative effects can be tested. Especially for fungicides, it is important to test the effects of repetitive applications, which is easier with field experiments (Sterk *et al.*, 1994). Furthermore, the effects of predation of contaminated preys and changes in prey/predator ratios can easily be monitored in field tests.
This paper aims to illustrate the risks of drawing false conclusions from field tests if not all parameters are taken into consideration. Finally, we discuss some aspects of the difficulties that Belgian growers encounter when practising IPM in apple. Secondary pests that reappear and

Abbreviations: a.i.: active ingredient; F.P. formulated product; H.T. Henderson-Tilton

This paper aims to illustrate the risks of drawing false conclusions from field tests if not all parameters are taken into consideration. Finally, we discuss some aspects of the difficulties that Belgian growers encounter when practising IPM in apple. Secondary pests that reappear and locally diminishing efficiencies of the first (and still very important) selective compounds are leading to discussions whether a limited use of more or less selective compounds with broader spectrum is possible.

Methods

Field tests were carried out according to Boller *et al.* (1988). Apple orchards were located in Halen and Kozen (Belgium) which have been infested for many years with an organic phosphoric ester and carbamate resistant strain imported from The Netherlands. Trials were organised as randomized plot designs, each plot consisting of 8 trees. For each compound there were 2 or 4 repetitions per location. Treatments were done with a knapsack sprayer, using 1500 l water per ha. Treatment dates were 19/6/95 (Kozen) and 30/5/95 (Halen). Dates of assessment were 30/5/95, 9/6/95, 3/7/95 and 10/8/95 (Halen) and 19/6/95, 26/6/95, 6/7/95 and 17/8/95 (Kozen).
In each plot 30 leaves were examined with a binocular (12x) for the number of predatory mites. Side effects were calculated using the Henderson-Tilton formula :

$$\text{Effect (\%)} = (1-((K1*P2)/(K2*P1))*100$$

with K1 and K2 the number of predatory mites in the untreated plot, before and after application, respectively. P1 and P2 are the number of predatory mites in the treated plot, before and after application, respectively.
Classification of the selectivity of the compounds was done according to the principles of the International Organisation of Biological Control of noxious animals and plants (IOBC):

% Mortality	Classification	Evaluation.
< 25	1	harmless
25-50	2	slightly harmful
51-75	3	moderately harmful
>75	4	harmful

Results

Generally no significant differences in effects were observed between the two locations. Therefore, all repetitions were considered for statistical analysis. However, in one case the difference was striking (Table 1). Three months after application of Meta-isosystox the population of predatory mites was still too low in Kozen whereas they were well recovered in Halen. The same observation was done for Gusathion MS. Whether this effect was only due to demeton-S-methyl is so far not clear.

Table 1 : Differences in side effects of insecticides on the predatory mite, *Typhlodromus pyri*, probably due to local differences in sensitivity.

a.i.	g a.i./hl	F.P.	g or ml F.P./ha	Location	H.T.	Class
demeton-S-methyl	10	Meta-isosystox	300	Halen	3	1
demeton-S-methyl	10	Meta-isosystox	300	Kozen	89	4
azinphos-methyl + demeton-S-methyl	33 10	Gusathion MS	2000	Halen	11	1
azinphos-methyl + demeton-S-methyl	33 10	Gusathion MS	2000	Kozen	56	3

It was also shown that the negative side effects are not always only due to the active ingredient. In case of E605 and PenncapM, both containing methyl parathion, a significant difference (at the 90 % confidence level) was shown with regard to the toxicity towards the predatory mite (Table 2). Assessments were done 1 month after application.

Table 2 : Differences in side effects of insecticides on the predatory mite, *Typhlodromus pyri*, due to the formulation of the pesticide.

a.i.	g a.i./hl	F.P.	ml F.P. per ha	H.T.	Class
methyl parathion	25	E605 EC	1500	55	3
methyl parathion	25	PenncapM CS	1500	3	1

Looking at short and long term effects of different organic phosphoric esters and carbamates on predatory mites, we were able to distinguish between several groups (Table 3). Diazinon, carbaryl and endosulfan were shown to be harmless for predatory mites. Chloropyriphos and propoxur were shown to be only slightly toxic, but the effect is maintained for a long term. In opposite, the negative effects of phosalone, parathion and chloropyriphos-methyl diminish sooner, making them more preferable for an eventual use in IPM of apple. Predatory mites recover well from the negative effect of demeton-S-methyl and the coformulation of demeton-S-methyl and azinphos-methyl but the decrease of the population of predatory mites has probably been too important (Table 3). Finally vamidothion, methidathion and dithiocarb show untolerable toxic effects for predatory mites.

Abbreviations: a.i.: active ingredient; F.P. formulated product; H.T. Henderson-Tilton

Table 3 : Long and short term side effects of different compounds on predatory mites

a.i.	g a.i./hl	F.P.	ml or g F.P./ha	H.T. June	H.T. July	H.T. August
* harmless						
carbaryl	50	Sevin 50 WP	1500	1	1	1
endosulfan	53	Endosulfan 350 EC	2250	1	1	1
diazinon	22	Basudine 162 EC	200	1	1	1
* slightly toxic						
chloropyriphos	72	Dursban 480 SC	2250	1	2	2
propoxur	33	Unden 50 WP	1000	2	2	2
* negative effects are rapidly disappearing						
phosalone	60	Rubitox 350 SC	2250	2	2	1
methylparathion	25	PenncapM 25 CS	1500	2	1	1
chloropyriphos-methyl	67	Reldan 225 EC	4500	2	2	1
* recovering but temporary too harmful						
azinphos-methyl + demeton-S-methyl	33 10	Gusathion MS	2000	2	3	2
demeton-S-methyl	10	Meta-isosystox 500 EC	300	2	4	2
* harmful						
vamidothion	50	Kilval 400 EC	1875	3	4	3
methidathion	40	Ultracid 400 EC	1500	3	4	4
dithiocarb	38	Larvin 375 SC	1500	4	4	4

With the aim to look for a possible control of the woolly aphid (*Eriosoma lanigerum*) different applications of vamidothion were tried and assessed for the effect on predatory mite. Some statistically insignificant differences occured when half or one fourth doses were applied, but all different applications were harmful one month after application (Table 4).

Table 4 : Effect of vamidothion at decreased dose rates and applied on the whole three (WT) or lower half of the three (LHT).

a.i.	g a.i./hl	F.P.	g or ml F.P./ha	Site	H.T. June	H.T. July	H.T. August
vamidothion	50	Kilval	1875	WT	3	4	3
vamidothion	25	Kilval	938	WT	2	4	4
vamidothion	12.5	Kilval	469	WT	2	4	3
vamidothion	50	Kilval	938	LHT	3	4	2

Discussions

Farmers using IPM in apple orchards encounter problems as reappearing secondary parasites and decreasing of the first and still very important selective compounds as pirimicarb for the control of rosy apple aphid (*Dysaphis plantaginea*) and woolly aphid (*Eriosoma lanigerum*) and diflubenzuron for the control of codling moth (*Cydia pomonella*). They are experimenting with more or less selective organophosphoric esters and carbamates with broader spectrum to control these parasites. Scientists have to be aware of this problem and are in a dilemma.

As scientists we have to increase our efforts to test the efficacy of other beneficials than predatory mites. In that case we have to be more restrictive for new molecules to be allowed in IPM. Scientific research should be focused on very selective compounds.

However, if we restrict yet the number of compounds for practice, this might be very disadvantageous for anti-resistance strategies. Furthermore, too many secondary pests -which have yet become locally of economical importance- are so far not sufficiently controlled by the present selective compounds. As far as these problems are not solved, the limited use of insecticides with broader spectrum should be allowed in IPM. If -based on scientific research- we will be able in the future to avoid the use of these broad spectrum insecticides (but selective for predatory mites), it will be a scientific progress and it will be generally accepted. If the present and future selective compounds are not able to control secondary pests and if resistance will generally occur, and if we should have forbidden the use of these broad spectrum insecticides (selective for predatory mites), it will be a shame for the scientists and the pioneers of IPM because fruit growers and consumers will not accept this development.

Ignoration of fruit growers' problems might lead to illegal actions or terminating IPM. Field tests can help fruit growers to choose between the broad spectrum pesticides in case of "emergency". However, attention has to be drawn on the risk of false conclusions from field tests because of local differences in sensitivity of the predatory mite, differences in formulation, differences in application time and/or assessment dates. Data of different field tests should never be merged unless the same compounds were used in both tests. Finally, conclusions of field tests always have to be based on more than one field test at different locations.

Acknowledgments

This research was supported by the Belgian Ministery of Middle Class and Agriculture, Administration for Research and Development

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SPATIAL DISTRIBUTION OF TEFLUBENZURON RESISTANCE BY PEAR PSYLLA IN WESTERN SWITZERLAND

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Abstract

In recent years, pear producers in the region of Lake Léman observed an efficacy reduction of teflubenzuron against pear psylla (*Cacopsylla pyri* L.). Thus, in 1994 and 1995, we conducted experiments in the laboratory to confirm the efficacy reduction and to study the spatial distribution of the resistance in western Switzerland.

After application of a registered dose of teflubenzuron, all eight samples from orchards of the region of Lake Léman showed low mortality rates whereas the nine samples from the Valais showed normally high mortality rates. The dose-mortality response of psylla from one orchard of each region is currently being estimated.

We conclude that the psylla of the Lake Léman region were resistant to teflubenzuron. Also, psylla from an organic orchard without any teflubenzuron treatment were resistant. This indicates that movement played an important role in psylla resistance development.

Introduction

Pear psylla developed resistance against insecticides in many places and times. Fundamental studies were conducted in the northwestern United States on *Cacopsylla pyricola* which became resistant to pyrethroids and organophosphates (Follett *et al.*, 1985). In addition to subsequent studies from that part of the US, new reports of resistance of pear psylla appeared from Ontario, Canada (Pree *et al.*, 1990), France (Delorme, 1993), and Italy (Barbieri *et al.* 1986). In Switzerland, organophosphates lost their efficacy against pear psylla during the late seventies (Stäubli, 1984).

Pear production is important only in western Switzerland and, therefore, pear psylla (*Cacopsylla pyri* L.) cause problems only in this part of the country. In Switzerland, organophosphates are no longer used in pear psylla management. In recent years, a typical treatment program was based on treatment thresholds and the following treatments were used when necessary: DNOC against overwintering adults, teflubenzuron in early May against eggs and young larvae, and amitraze in the summer against larvae. Teflubenzuron was registered in Switzerland in 1988 and was widely used until resistance was suspected in 1994. Until then, the official recommendation was to apply teflubenzuron twice at a two week interval to kill early instars of the second summer generation.

In 1993, pear producers in the region of Lake Léman observed an efficacy reduction of teflubenzuron against pear psylla. Extension service personnel confirmed in the summer of 1994 that the problem was widespread and verified that the application technique and treatment period were generally appropriate. The resistance hypothesis was the most plausible. We conducted a small study the fall of 1994, and a more extensive study in 1995, to investigate the situation of resistance of pear psylla against teflubenzuron in western Switzerland.

Material and methods

In the study, we included the pear growing regions of the cantons of Geneva and Vaud along Lake Léman and the pear growing region of the canton of Valais. We included the Valais because of its importance in pear production and the lack of experiences of teflubenzuron inefficacy.

In the fall of 1994, we sampled adults from one orchard in the canton of Vaud and from one orchard in the Valais. The Vaud orchard was treated according to integrated fruit production guidelines. In the Valais, we chose an orchard which was part of an organic farm in order to find pear psylla as susceptible to teflubenzuron as possible. In 1995, we extended the study to seven orchards in the Lake Léman region and to eight orchards in the Valais. One orchard in the Lake Léman region and two orchards in the Valais were organic, thus not treated with synthetic insecticides, the others were integrated orchards.

Laboratory test method

On a given collection day, only orchards in close proximity were visited and adults from each orchard were collected for laboratory testing of insecticide efficacy. On each collection day, adults were collected from one of those orchards for the untreated control. Adults were transported to the laboratory and transferred the same day into cages containing a small pear seedling. Cages were cylindrical, had a height of 15 cm, a diameter of 10 cm and were of transparent PVC with muslin windows. Pear seedlings were rooted in potting soil. Each cage received at least 10 adults of unknown sex which were left to oviposit during 24 hours. Each procedure was composed of 10 cages, which served as replicates. Cages were kept during the entire test in a glass house with 20°C average temperature.

Psylla eggs were counted on the seedlings until the cumulative number of eggs on the leafs, starting counting at the tip, reached at least 100 eggs. Extra leaves and their eggs were discarded. Counting of eggs was repeated to minimise systematical counting errors.

Treatment with teflubenzuron (Nomolt®, 150g active ingredient per litre) was usually performed two days after first oviposition. The registered dose of 0.1% was applied with a hand sprayer until dripping.

Surviving larvae were counted at the end of egg hatch, 12 days after oviposition.

Insecticide efficacy was calculated based on eggs before treatment and on larvae after treatment on the treated and untreated plants according to the correction of Henderson & Tilton (1955).

Experiments are presently being conducted to observe the influence of the dose of the insecticide on the mortality of psylla eggs. The results of these experiments are not part of this paper. With these results we will be able to determine the LD50 of psylla from the cantons of Vaud and Valais.

Results and discussion

In the 1994 study, teflubenzuron induced no mortality to the eggs from the Lake Léman region, but caused a mortality of 96% of eggs from the Valais. These results were confirmed in 1995, when psylla from the Central Valais were susceptible and psylla from the Lake Léman region were resistant (fig. 1). The only orchard with an intermediary efficacy level of teflubenzuron in the canton of Valais is situated close to the border to the canton of Vaud. This area is known for regular and strong thermal winds toward Central Valais. The organic orchard in the canton of Vaud had a similarly low efficacy level of teflubenzuron as the other orchards of this region. It is likely that resistant psylla immigrated into the organic orchard.

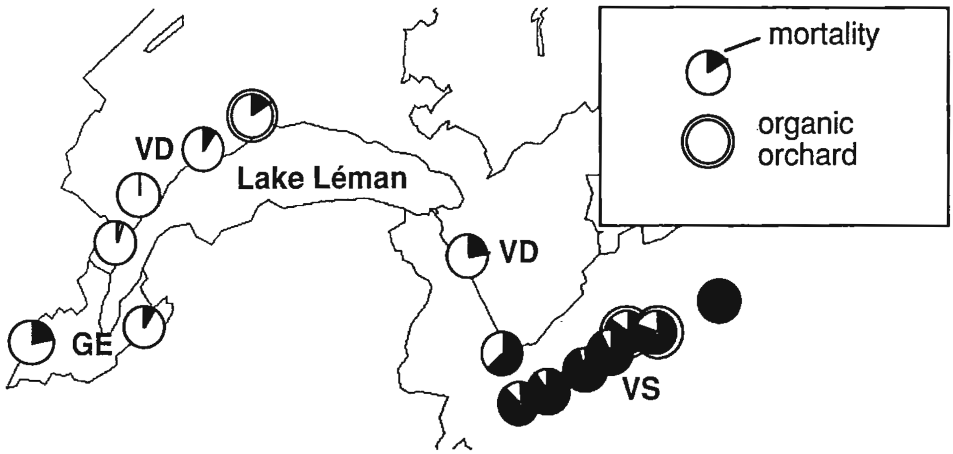

Figure 1. Efficacy of teflubenzuron against pear psylla eggs from organic and integrated pear orchards in the cantons of Geneva (GE), Vaud (VD), and Valais (VS) in 1995.

The differences in resistance levels between orchards of the Lake Léman region and the Valais were probably due to the more frequent use of teflubenzuron in the Lake Léman region (Fig. 2). Inversely, growers in this region may have applied this insecticide more often because they observed a decrease in efficacy. Pear psylla were less of a problem in the Valais than in the Lake Léman region. Before the suspicion of resistance, the extension service in the cantons of Vaud and Geneva recommended teflubenzuron, while the extension service in the Valais preferred other control methods. Therefore, Valais farmers were less encouraged to use teflubenzuron.

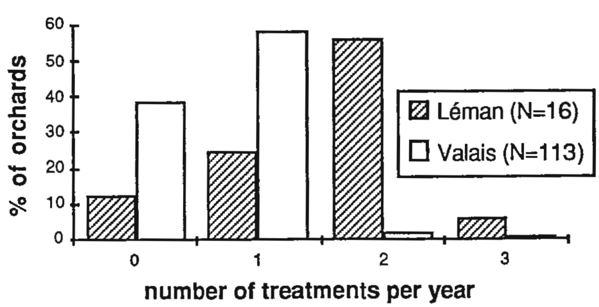

Figure 2. Comparison of teflubenzuron use between the Lake Léman region and the canton of Valais in 1994.

Conclusions

Pear psylla typically evolves resistance in many areas of pear production within 5-10 years after a new insecticide is introduced (Tabashnik *et al.*, 1990). In the northwestern US psylla became resistant against pyrethroids after a total of 10-20 treatments. In the Lake Léman region, teflubenzuron resistance occurred eight years after registration with approximately two applications per year. Concurrently, diflubenzuron, which is functionally related to teflubenzuron, was usually applied once a year against lepidoptera pests. Pear psylla resistance generally develops quickly because almost the entire population lives on managed pear trees which are treated (Follett, 1995). If most of the farmers use the same insecticide, as in the Lake Léman region, even psylla populations in untreated organic orchards become resistant. The same phenomenon of movement was observed by Croft *et al.* (1989). The risk of pear psylla resistance to insecticides certainly can be reduced if applications are reduced in time and space.

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POSTERS

<u>Section: IFP General Problems</u>

EXPERIENCE OF INTEGRATED PROTECTION OF PEACHES AND APRICOT TO BE USED IN INDUSTRIAL PROCESSING IN GREECE

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ABSTRACT - A project has been developed in Greece with the purpose of producing fruit suitable to be processed in puree for baby - food companies. The areas of cultivation are Macedonia for peaches and the Peloponnese area for apricot cultivations. The results of two years of entomological monitoring as well as information about the most important pests found and about pesticides and residue levels are reported.

INTRODUCTION

Baby-food industries require produce with very high quality standards. One of the most current requirements is the minimal presence of contaminants such as pesticides. In some cases baby food industries make special contracts directly with farmers (Laurita 1991).

MATERIALS AND METHODS

To meet these needs an integrated pest control programme was started in Greece, in order to produce apricots and peaches destined to be processed into puree for baby food companies. The project was developed during 1993-1994, and in 1995 it is still under way. The data of this report refer to 1993-1994.

APRICOT. The area of cultivation of apricot is located in the Peloponnesian region, at Agios Dimistrios (Argolida). We followed 14 allotments covering 9.9 hectares. The fruit orchards are well-watered areas of old plants of the Hassiotiko variety, grown in a vase shape.

PEACH. The peach orchards are located in Macedonia at Mylotopos (Giannitza). We followed 7 allotments covering a surface of 7.5 ha. The trees belong to the Loadel variety.

The programme was based on several integrated pest control experiences developed in Italy and Greece (Cravedi & Molinari, 1993; Kyparissoudas, 1989). At the start we had to install various pheromone traps (*Adoxophyes orana* traps in peach orchards and *Anarsia lineatella*, *Archips podanus*, *A. rosanus*, *Cydia molesta*, *Enarmonia formosana* and *Spilonota ocellana* both in peach and in apricot orchards) because we were not sure which phytophagous species were actually present in the cultivations. Weekly field controls were performed. In 1994 we followed only those species which we considered important (*A. lineatella* in apricot and *A. lineatella*, *C. molesta* and *A. orana* in peach orchards). In order to monitor the presence of *Ceratitis capitata* cromotropic traps activated with trimedlure were placed.

RESULTS

APRICOT. - A. *lineatella* came out as the most important phytophagous species. The male adults' flight starts at the end of April and continues until October. The number of catches was high (on average 80 adults/week). We detected three generations. The traps for *A. rosanus* and *A. podanus*, also made many catches. The traps for *C. molesta* only caught specimens of the *C. funebrana*. *Tetranychus urticae* specimens were noticed in almost all the fruit orchards. In this region this mite is the phytophagous species which most concerns local farmers. Probably the frequent use of phyrethroids in the fruit orchards nearby and the high summer temperatures contribute to the diffusion of this tetranichid. As for fungi diseases, we detected attacks of

Monilia sp. facilitated by fruit orchards with closely planted frameworks and by the fact that usually farmers do not remove the attacked branches and fruit. The Sharka virus (Plum Pos Virus or PVV) was present in all the fruit orchards we followed. In some fruit orchards there were bacteriosis symptoms.

PEACH. - We made substantial captures of *A. lineatella* and *C. molesta* in all the orchards. The treatments carried out on the basis of pheromone trap monitoring turned out to be effective. *A. orana* is the most important tortrix and can cause much harm if hibernating larvae are not controlled. We observed isolated catches of *A. rosanus* and *A. podanus*. Infestations of *Panonicus ulmi* requested the use of specific acaricides. All the fruit orchards turned out to be attacked by the Sharka. The damage however does not seem to be as important as that on apricot orchards. Substantial catches of *Pseudaulacaspis pentagona* were noticed in old fruit orchards made of decayed trees.

PESTICIDES - We only used phytopharmaceuticals allowed by dietetic industries and featuring good dissipation rates after their transformation in fruit puree, with specially low risks for humans, above all as concerns the carcinogenecity (Table 1).

Table 1 - Pesticides utilized

APRICOT	1993		1994
copper oxychl.	January	copper oxychl.	29.02
ziram	3.03	iprodione	13.03
clofentazine	10.03	bitertanol	1.04
triforine	26.03	diazinon	1.04
diazinon	14.04	triforine	14.05
azinphos meth.	16.05	azinphos meth.	14.05
iprodione	16.05	benzomate	24.05
propargite	10.06		
phosalone	10.06		
PEACH	**1993**		**1994**
copper oxychl.	January	copper oxychl.	December
ziram	3.03	ziram	1.03
triforine	22.04	bitertanol	1.04
fenoxicarb	22.04	chlorpirifos meth.	1.04
azinphos meth.	10.05	azinphos meth.	10.05
sulfur	12.05	azocyclotin	8.06
propargite	10.06		
azinphos meth.	26.06		
diazinon	13.07		

Table 2 - Residue (in ppb) of pesticides in fruit and puree in 1994 (N.R.:not detectable).

PESTICIDE	APRICOT		PEACH	
	fruit	puree	fruit	puree
azinfos ethyl	93	6	N.R.	
azociclotin			50	10
benzomate	232	10		
bitertanolo	10			
chlorpirifos methyl			N.R.	
diazinone	N.R.		3	
MBC	N.R.		N.R.	
triforine	50	N.R.		

We did not use pyrethroids. We found very low residues in fruit puree (100 ppb or less, or non-detectable) which therefore comply with the requirements of most European baby food manufacturers. An example of residues in fruits and puree found in 1994 is reported in table 2.

CONCLUSIONS

Results achieved are satisfying and have made it possible to get high quality yields as requested by the international market. The great diffusion of Sharka virus is not a big obstacle for the industrial processing of disfigured fruits, not valued for fresh consumption.

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DEVELOPMENT AND STATUS OF IFP IN POLAND

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SUMMARY

The official establishmend of Integrated Fruit Production (IFP) in an organized form commenced in Poland in 1991. Until now (1995) IFP has been practised in all over the country only in apple orchards on a total area of 4239 ha, by 776 growers, organized in 39 groups.

The first labelled apples from IFP orchards were produced in 1993. In 1994 - 289 orchardists obtained certificates for about 40 000 tons of the fruits. It is estimated, that in 1995 about 500 fruit growers may obtain the certificates for about 60 000 tons of apples.

In Poland, research dealing with biological control and integrated pest management began over 30 years ago and investigations into use of environmentally-friendly agricultural practices about 15 years ago.

However the official establishment of Integrated Fruit Production (IFP) in an organized form began in Poland in 1991. The animator and propagator of IFP is Research Institute of Pomology and Floriculture at Skierniewice. Until now IFP has involved only apple orchard which cover about 65% of the fruit growing area.

During last 5 years 2540 volunteers, mainly fruit growers, participated in 42 three-days courses on IFP organized by Institute and Agricultural Service. Fifty five orchardists and extension workers participated in 2 profesional trips to Holland, Belgium, Germany, Italy, Switzerland and Austria. Additionaly 4 extension workers took part in 40 days courses at the scientific institutions engaged in IFP in Germany, Belgium and Holland. The growers practicing IFP are obliged to follow the Polish IFP guideline based on the "standard guidelines" valid in Europe (Dickler, Schafermeyer 1991, Cross, Dickler 1994). Growers are obliged also to fulfil the special "field book" in which they note all events dealing with their orchards in actual year. Especially important are data concerning occurrence of the pests and establishment the threshold levels.

The trained extension workers which cooperate with the growers visit the IPM orchards several times during the season, teach the farmers and help them to conduct observations and to make decisions, especially concerning the timing and use the proper pesticide.

All growers runing their orchards according to IFP rules are the members of Integrated Fruit Production Section of Polish Fruit Grower Union. They may obtain the special certificate and label.

The development of IFP in Poland.

Specification	1991	1992	1993	1994	1995
No of regions/localities	3	7	24	32	39
No of fruit growers	70	117	430	570	776
No of extension workers	18	31	55	65	72
Area of apple orchard in hectares	178	470	about 2000	about 3000	4239

Apple production in IFP orchards confirmed by certificates

Year	No of fruit growers having certificates	Amount of apples confirmed by certificates in tons	Percentage of total apple production
1993	117	about 7.000	about 0.4%
1994	289	about 40.000	about 3%
1995	about 500 *	about 60.000 *	about 5%

* estimation

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Responsible Choice - An IFP Approach

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Stemilt Growers is a private company that contracts with 250 orchardists representing more than 12,000 acres from across Washington State to store, pack and market their fruit. In 1993, Stemilt launched an IFP program entitled "Responsible Choice". This dynamic program encompasses all aspects of growing, harvesting, storing and packing fruit including: IPM and pesticides, fertilizers, herbicides, irrigation, postharvest treatments, packaging and marketing. The objective of Responsible Choice is to maximize efforts in IPM, worker safety, consumer safety and the environment with the recognition that economics influences each of these factors. The philosophy of Responsible Choice is to insure the grower's ability to pursue a sustained livelihood using practices and technologies that promote IPM, biocontrol techniques and minimize impact on consumers and the environment. As an example of this commitment an extensive temperature monitoring network has been established to augment pheromone trap information and provide data from four insect phenology models to assist growers in spray application decisions.

Within the program each potential chemical input (fungicide, insecticide, miticide and herbicide) has been ranked based on its efficacy, physical properties and effects on IPM strategies (Table 1). Data from the eight factors with their associated coefficients are summed to arrive at a cumulative score for each chemical. A lower score indicates a more friendly or desirable option. Growers are given point budgets which are reviewed annually as guidelines to produce their crops. Currently apples, pears and cherries are allotted 260, 230 and 200 points, respectively. Spray records are entered into a database system to track points (prorated on the amount of active ingredient applied), grower practices and variety differences. The historical distribution of points for apple, pear and cherry crops is presented in Table 2.

To date fertilizers, nutrients sprays and irrigation practices have not been indexed into the point system. Traditionally growers have applied 40-50 lb nitrogen/acre in late fall or early spring. Scheduling smaller multiple fertilizer applications at key physiological tree growth stages results in increased efficiency and reduced risk of leaching. Growers are also encouraged to use water efficiently by scheduling irrigation according to: knowledge of each soil type's holding capacity; monitoring soil moisture content with a neutron probe, capacitance probe or tensiometer; and tracking daily evapotransporation values.

Communication is the key for the successful implementation of the Responsible Choice program. A nine member horticultural staff works with growers on a one-to-one basis. Annually growers receive a suggested materials list based on the points associated with each chemical available for potential pests. The Responsible Choice program is discussed at annual grower meetings. Monthly newsletters update growers with recent developments.

Although not as highly visible as preharvest aspects, postharvest efforts go beyond the basic choice of packing and shipping materials that lend themselves to recycling. In an attempt to reduce dependency on conventional fungicides, Stemilt is actively participating with biotechnology developers of postharvest biocontrol agents. Successful commercial sized pilot test drenches of beneficial bacteria (*Pseudomonas syringae*) and yeast (*Candida oleophila*) have been run in apples and pears. Results indicate a synergism between biocontrol agents and reduced rates of fungicides.

Phytosanitary concerns of some apple and cherry export markets require fruit to be fumigated with methyl bromide prior to shipping. In 1994 Stemilt initiated and successfully tested the first commercial sized methyl bromide capturing and recycling system. The zeolite based technology has proven to be >95% efficient in capturing ozone depleting methyl bromide. In addition Stemilt is currently collaborating with the USDA on an Environmental Protection Agency funded grant to research the use of heat shock in combination with cold storage in modified atmosphere as an alternative to methyl bromide fumigation of cherries.

The biggest challenge facing the Responsible Choice program is communication with the consumer. To date there is no market incentive for Stemilt and its growers to pursue the ideals as set forth by the environmental program. To address this situation Stemilt is an active collaborator on an Integrated Farming Systems grant sponsored by the W. K. Kellogg Foundation. The Responsible Choice program is being used as the model system from which state wide stewardship guidelines are being formed. The guidelines include a scoring system, a list of best management practices and an educational and certification program for growers. A main emphasis of the grant is to research marketing aspects of "environmental friendly" fruit and develop financial incentives for growers. A test marketing program with a major retailer is planned for the fall of 1995.

Responsible Choice is an evolving IFP system. It is recognized that debatable issues exist within the program including: gaps within the database; coefficients within the equation are subjective value judgments; environmental conditions can vary across relatively short geographic distances; and lower point scores do not necessarily mean lower total active ingredient. At the same time Responsible Choice has proven to be a valuable tool in: providing IPM documentation; addressing issues of reduced use and reduced risk; tracking pests and differences associated with varieties; and grower education and motivation. Stemilt and its growers are both open minded and committed to the philosophy and ideals of Responsible Choice.

Table 1. Example of Responsible Choice's eight factors, coefficients and total scores for the available options in Codling Moth control. Numbers in parentheses indicate individual scores for each factor. Total points equal the sum of coefficient x score of the eight factors.

Pesticide	Efficacy Coef = 3	Dermal LD50 Coef = 1	Leaching Potential Coef = 2	Soil Sorption Coef = 1	Preharvest Interval Coef = 2	Soil Halflife Coef = 1	Effect on Beneficials Coef = 1	Biological Disruption Coef = 1	Total Points
Mating Disruption	3,4 (1.5)	2,000 (1.5)	NA (0.0)	NA (0.0)	0 (0.0)	NA (0.0)	(0.0)	(0.0)	6.00
Phosmet	4 (1.0)	>4,640 (1.0)	Sm (1.0)	612 (2.5)	7 (1.0)	12 (0.6)	(2.0)	(0.0)	13.10
Azenphos Methyl	4 (1.0)	220 (2.5)	Sm (1.0)	1,000 (2.0)	7 (1.0)	40 (2.0)	(2.5)	(0.0)	16.00
Carbaryl	2 (3.0)	>4,000 (1.0)	Sm (1.0)	200 (3.0)	1 (0.1)	10 (0.5)	(3.0)	(0.0)	18.70
Diazinon	2,3 (2.5)	3,600 (1.0)	Med (2.0)	500 (2.5)	14 (2.0)	40 (2..0)	(3.0)	(0.0)	24.00
Methyl Parathion	3 (2.0)	5,400 (0.5)	Sm (1.0)	5,100 (1.0)	14 (2.0)	5 (0.25)	(5.0)	(25.0)	43.75

Table 2. Historical mean points for apples, pears and cherries received at Stemilt Growers during the four years prior to and the two years of the Responsible Choice program.

Year	Apples - Mean (SD)	Pears - Mean (SD)	Cherries - Mean (SD)
1989	255 (85)	212 (71)	160 (57)
1990	240 (114)	228 (50)	161 (54)
1991	224 (155)	196 (79)	170 (64)
1992	220 (112)	222 (68)	150 (51)
1993	184 (67)	263 (89)	180 (70)
1994	180 (81)	231 (93)	131 (69)

Integrated Pest management (IPM) in Belgian orchards in 1995

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Introduction

The problems caused by the resistance of the pear sucker (*Psylla Pyri*) against insecticides forced the practice in 1985 to change to integrated pest management on pear. Eversince all growers have been using selective insecticides. In the Belgian pear culture, the use of Cycocel as a fructification stimulance is a standard cultural measure for most of the growers so that the integrated fruit production is out of the question according to the IOBC. Since 1987 the first fruitgrowers started to introduce the predatory mite (*Typhlodromus Pyri*) in the apple orchard. The application of IPM in apple orchards didn't go as smoothly as it did in pear orchards. This is due to different circumstances:

- No problem of resistance, as with the pears.
- The beneficials, *in casu* the predatory mite, have to be put out in the apple orchard, requiring more man-hours and higher expences.
- The whole system of crop protection had to be adjusted to the predatory mites. A lot of growers were afraid for the loss of quality.
- The first years only Captan and Dithianon were recommanded, resulting in a background colour that was more yellow. In Belgium there is a difference of about 5 to 10 BEF in price for the same quality but with a yellow background. The fruitmarket prefers a red Jonagold with a green background colour. This restricted the growth of the IPM area.
- From the government, the fruit sector and the auctions, there was no positive motivation to switch over to IPM on apple.
- The growers who wanted to switch over to integrated crop protection or fruit production had extra costs for the education and the counselling.
- Last but not least fruit growers couldn't sell their fruit under a separate label and therefore had no extra profit or satisfaction.

Due to all these circumstances, the application of the integrated crop protection - production is not as develloped in the apple culture in Belgium and especially in the Flemish part of the country. Belgium is divided into two language zones being the French speaking part, Wallonia, and the Dutch speaking part, Flanders. Because of this, the education and the counselling of the growers is divided into two. Both have their own growers organisation.

Education

In the winter of '87-'88 the first lessons were given by the department of Zoology of the Research Station of Gorsem. This course for fruit growers was and still is the basis for IPM and later integrated fruit production (IFP).

These lessons are given during two successive years.

In the first year a more theoretical approach is made. During 10 evenings, each lasting three hours, the fruit growers learn the advantages of IPM as a superior plant protection system, an anti-resistance strategy and a more friendly way of fruit growing with regard to the environment. They learn about the biology of important noxious and beneficial insects and mites, and the selective compounds available, (insecticides, acaricides and fungicides). An introduction to IFP is also given. During the season some more practical lessons are given in the field. Participants who are interested will be advised in practice during that year in their

own pear orchards. Also one apple orchard of each fruit grower is prepared for the introduction of the predatory mite, *Typhlodromus pyri*.
During the second winter and the following season a more practical course is given, consisting of 10 lessons of about 4 hours each. Beside a more practical approach to IPM, attention is given to IFP and important topics like spraying techniques, use of herbicides, nutrition, pruning, IFP, etc. About 62% of the Belgian fruit growers have taken the first course and 29% the second one.

Counselling

In Wallonia (the French speaking part of Belgium) the growers using IPM are united in an association called GAWI (Groupement d'Arboriculteurs pratiquant en Wallonie les techniques Integrées), which is served by three advisors. Since 1990 they have followed guidelines which are in accordance with the Euro-guidelines. Supervision of the IFP scheme is in accordance with the IOBC guidelines, and is exercised by the organisation PROMAG. The analysis of residues is carried out by a recognized laboratory, ELAN, at Namur. The fruit cultivated according to the guidelines is labelled FRUITNET and is sold on the ordinary trade market. Different supermarket chains buy this labelled fruit and are prepared to give a higher price for it. In Flanders (the Dutch speaking part of Belgium) the advisory and supervisory functions are conducted by two different organisations : The Advies- en Ombudsdienst of the Research Station of Gorsem with 6 advisors and the Fruit Consult of the Netherlands with 4 advisors.
Up to now, in Flanders no fruit was sold under label. In the course of this year negotiations have been taking place for the official recognition of IFP with a Royal and Ministerial Order. The surveillance has to be carried out by independant laboratories and control organisations. We hope we can start selling the fruit production 1996 under label.

The state of affairs in 1995

Pear

IPM in Belgium fully started in 1988 in pear orchards. This was a rather easy switch from a classical program with broad spectrum insecticides to a system with selective compounds because no changes in the fungicide scheme were required. Nowadays, 98% of all Belgian pear orchards are treated in this way.
In pear culture Cycocel is a cultural measure which means that the trees are adapted to it. We can't suppress it at once. The new plantations have to be planted in a way that the use of this product isn't necessary.
The last few years we notice that some of the pests return, the Pear Bud Weevil (*Anthonomus pyri*). This one has caused a bad harvest locally. The last two years we also notice an increasing presence of the Mussel scale (*Lepidosaphes ulmi*). Because of the absence broad spectrum insecticides the secondary pests can evolve to primary pests. This evolution has to get the necessary attention. In 1995 damage of the Pear sucker (*Psylla pyri*) showed up again. In most of the plantations one or two treatments had to be carried out with amitraz. The last few years we carried out no or only one treatment. We remark that in the pear culture the total of insecticide treatments is increasing again in the last few years after a spectacular drop in the years '85-'88.

Apple

The application of IPM, as already mentioned in the introduction, in apple orchards was not as obvious as it was in the pear orchards. Especially the fear for a loss of quality and green background colour are of importance. In the mean time, research has proved that this doesn't have to be the case and that this problem can be prevented by an optimal nutrition of the tree. Other fungicides can be used if there is a settled population of predatory mites.
Especially prejudice, a lack of motivation of the growers by the government and the fruit sector as well as the absence of a label and the selling of integrated fruit cause that the increase of the area used has slowed down.

At this moment 31% of the fruit growers have predatory mites on 16.17% of the total apple area. This means that a lot of the growers have at least one or more parcels with predatory mites and that there is something that is restricting them from expanding.
In 1995 there were a few specific problems in apple culture.The Rosy apple aphid (*Dysaphis plantaginea*) needed 2 to 4 treatments in most of the cases. The Mussel scale (*Lepidosaphes ulmi*) has been noticed in the orchards. In some of the cases the fruits were contaminated. The Apple blossom weevil (*Anthonomus* pomorum) and the Apple saw fly (*Hoplocampa* testudinea) have caused important losses in several orchards.
Up to now we haven't had problems with the Codling moth (*Cydia pomonella*), but we expect resistance to appear within a few years as in the other countries.
Due to the lack of a label in the northern part, only the French speaking part of Belgium has integrated fruit production (IFP). In the Dutch speaking part, most of the fruit growers only use selective compounds.

Conclusion

Integrated crop protection (IPM) and fruit production (IFP) are the future but practical implementation is still difficult and specific problems have to be solved.
The presence of secondary pests has to make us realize that there has to be a place for the limited use of broad spectrum compounds. Too strict IOBC rules can have negative effects in practice, some more practical aspects have to be included such as anti-resistance strategies, cost price,...
We hope, especially for the Flemish and the Belgian fruit growers, that there will be a guideline and an official recognition in 1996 so that the fruit growers who used IFP can be rewarded for their efforts and that they can sell their fruits with a label.

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The Integrated Fruit Production in the Region Lake Constance

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The following features are first results of the research project: "Environmental safe production of vegetables and fruit". In this project German and Swiss scientists work together. To combine theory and practice, a working group with 8 German and 8 Swiss fruit growers was established.
The aims are:

- to describe the production (area, kind of production, input factors etc.) and
- to analyse the environmental impact of the production in a second part (1996-98).

Pomefruit is the main fruit with nearly 9000 ha (96% apples). IFP reached an extend of 90% in the German and 81% in the Swiss part. According to the working group the German growers need 5.3 h and the Swiss growers 2.6 h per ha and year for the orchard control. In the average in the German/Swiss part fungicides are applied 14.6/13.4, insecticides 3.9/3.5, acaricides 1.1/0.6 and herbicides 2.6/2.1 times per year. In the Swiss part with a total of 696 h, 197 h (40%) more labour is done per ha and year than in the German part.

The area Lake Constance
The Lake Constance has an altitude of 395 m above sea-level. The fruit growing is concentrated in the area near the lake and follows the rivers into the back country. The average temperature per year ranges from 8.6 °C to 9.2 °C, depending on the sites around the lake. The average rainfall per year extents from 800 mm in the west to 1650 mm in the east. The sun shines about 1600 h per year.

Fruit area: Pomefruit is the main fruit. There from 8587 ha (96%) are apples. The nearly 400 ha of stonefruit consist of 253 ha cherries and the rest are plums. From the 469 ha of berries 351 ha (75%) are strawberries (Table 1). The 6989 ha pomefruit represent 17% of the German and the 1904 ha 32% of the Swiss production. The main cultivars in the German part are 'Jonagold', 'Boskoop', 'Elstar' and in the Swiss part 'Golden Delicious', 'Idared'. The fruit production in the Austrian Part is very small and not analysed.

Table 1. Area with fruit production in the region Lake Constance in ha (figures Germany 1992, Switzerland, Austria 1994)

Area in	Pomefruit	Stonefruit	Berries
Germany	6989	365	349
Switzerland	1904	29	105
Austria	35	3	15
Total	8928	397	469

Today the IFP of pomefruit represents with 90% in the German and 81% in the Swiss part the most common form of production. The ecological production has only a small extent (Table 2).

Table 2. Pomefruit area according to the kind of production in the region Lake Constance in ha (figures 1994, Switzerland only Kanton Thurgau)

Area in	Tradition. production	Integrated production	Ecolocical production
Germany	559 (8 %)	6280 (90 %)	150 (2 %)
Switzerland	296 (18 %)	1330 (81 %)	20 (1 %)

Main factors to describe the production
The following figures are from the 16 fruit farms of the working group.

Planting system: For the planting system the single row is prefered. The distance between the rows is 3.6 m (2.8 m - 4.4 m) and in the row 1.4 m (0.6 m - 2.3 m). In new planted orchards the smaller distances are choosen more often. The hight of the trees is in the German part 2.5 m (2.2 m - 3.0 m) and in the Swiss part 3.1 m (2.3 m - 4.0 m). The main reasons for the single row plantations are better fruit quality and simpler soil managment in the tree rows.

Mineral analysis and fertilisation: Every 3 to 4 years soil analyses are usually done. Leave analyses have a subordinate importance and fruit analyses are of scientific interest only. The used amounts of fertilisers are generally little and the difference between the German and Swiss part is small (Table 3).

Table 3. Used amount of minerals in kg per ha and year

	German Part	Swiss Part
Nitrogen (N)	40 (0 - 100)	35 (0 - 80)
Phosphorus (P)	7 (0 - 22)	8 (0 - 35)
Potassium (K)	33 (0 - 83)	39 (0 - 100)
Magnesium (Mg)	11 (0 - 36)	13 (0 - 68)

Orchard control and pesticide application: For the orchard control the German growers need 5.3 h per ha and year, the Swiss growers 2.6 h. The visual control is the main kind of checking the orchards for harmfull organisms.
In the German part all kind of pesticides are used more often, the fungicides with +9%, the insecticides with +12%, the acaricides with +83% and the herbicides with +24% (Table 4).

Table 4. Number of pesticide applications per year

Pesticide	German Part	Swiss Part	Average
Fungicide	14.6 (9-20)	13.4 (10-18)	14.0
Insecticide	3.9 (3- 6)	3.5 (2- 5)	3.7
Acaricide	1.1 (0- 3)	0.6 (0- 1)	0.9
Herbicide	2.6 (2- 3)	2.1 (2- 3)	2.3

Working time: In the Swiss part with a total of 696 h, 197 h (40%) more labour is done per ha and year than in the German part (Table 5). These hours are from full-time workers. For the fruit growers in the Swiss part it is possible to invest more labour, because they get a higher price for their fruit than in the German part.

Table 5. Working time in pomefruit production in h per ha and year

	German part	Swiss part
Full-time	227	427
Part-time	272	269
Total	499	696

SANITARY STATUS AND SANITATION OF STONE FRUIT TREES IN SOUTH EAST ITALY

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Abstract
In Apulia the phytosanitary status of fruit tree crops is unsatisfactory much the same as in other Italian regions, but it is improving thanks to the adoption of preventive measures, such as the use of "virus tested" budwood. To this effect, a regional programme for the certification of propagating material produced by local nurseries was established. Sanitary selection was carried out in the main horticultural areas of Apulia by visual inspection, mechanical transmissions onto herbaceous hosts and immunoenzymatic tests (ELISA). The minimum requirements for admission to the certification scheme were absence from *Prunus* necrotic ring spot (PNRSV), apple mosaic (ApMV), prune dwarf (PDV) ilarviruses, apple chlorotic leaf spot trichovirus (ACLSV) and plum pox potyvirus (PPV). For many cultivars it was not possible to indentify candidate mother plants of a sanitary condition compatible with certification requirements. Thus, heat therapy (two months exposure to 38°C in an artificially lighted heat cabinet, removal of shoots tips or buds to be grafted onto healthy rootstocks) was applied whenewer necessary.

Introduction
In Apulia the phytosanitary status of fruit tree crops is unsatisfactory much the same as in other Italian regions, but it is improving thanks to the adoption of preventive measures such as the use of "virus tested" budwood.
Before the establishment of a regional programme for the certification of propagating material produced by local nurseries, extensive field surveys were carried out for assessment of the sanitary status of the local fruit tree industry at large (native and newly introduced cultivars).
Sanitary selection was carried out in the main horticultural areas of and several selected clones of different cultivars were sanitized by heat therapy.

Materials and methods

Field survey and laboratory tests
Surveys were carried out in the main horticulture areas of Apulia. The orchards were inspected in spring and samples (flowers and leaves) were collected to be tested.
Mechanical transmission onto herbaceous hosts were made with sap expressed in the presence of 0.1M phosphate buffer pH 7.2 containing 2.5% nicotine in the 1.5:1 ratio (v/w). The host range included the following plant families: *Chenopodiaceae*, *Solanaceae*, *Cucurbitaceae* and *Leguminosae*.
Immunoenzymatic tests (ELISA) were made for the detection of: *Prunus* necrotic ring spot (PNRSV), apple mosaic (ApMV), prune dwarf (PDV) ilarviruses, apple chlorotic leaf spot trichovirus (ACLSV) and plum pox potyvirus (PPV).

Sanitation
Sanitary selection in the field did not always allow identification of the candidate mother plants with a sanitary condition compatible with certification requirements. Thus, heat

therapy was applied to the selected clones of 27 cultivars of five different stone fruit species: almond (5), apricot (5), peach (7), cherry (4) and plum (6), plus one accession of *Prunus mahaleb* and two of *Prunus cerasifera* infected in various measure and combination by PNRSV, ApMV, PDV and ACLSV.

One-year-old infected plants were maintained for two months at 38 °C, with 80% of relative humidity and 16 hours artificial illumination (6-8000 lux). The plants were placed in the heat therapy chamber while dormant.

Apical shoots of about 0.5 cm were taken from heat treated plants, grafted onto healthy young seedling of GF305 and protected by plastic bags for ca. 10 days before gradual acclimatization to glasshouse conditions.

Cherry cultivars plants were submited to heat treatment as above when the shoots were semi woody, but buds instead of shoot tips were collected to be grafted on healthy seedlings of *Prunus mahaleb*.

Results and discussion

Field survey and laboratory tests

The studies carried out in Apulia on virus and virus diseases of stone fruit trees provide a comprehensive picture of their sanitary status. The most affected species proved to be almond and cherry, with ApMV and PDV prevailing over the other viruses. This is likely to be due to the degraded sanitary conditions of the most widespread varieties. The major almond cultivars, namely Tuono, Genco and Filippo Ceo, showed infection levels from 94% to 100% (Savino *et al.*, 1994), whereas infections of cherry cultivars, such as Ferrovia and Bigarreau Moreau, ranged from 66% to 87% (Grayaa *et al.*, 1993). The sanitary status of other species was relatively better, (Choueiri *et al.*,1993; Di Terlizzi *et al.*,1992) despite of the presence of PPV in some plum and apricot orchards.

Heat therapy

The results of heat treatment differed according to the species and the virus considered. Almond, apricot, peach and plum were freed from ApMV, PNRSV and PDV at different rates. Whereas ApMV was eliminated from the totality of treated plants (almond), lower sanitation rates but still significantly high, were obtained with other viruses, i.e. 91% for PDV, 83% for PNRSV and 68% for ACLSV. Plants with mixed infections were also sanitized.

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APPLE, PLUM AND BLACK CURRANT CONTROL FROM PESTS USING ECOLOGICALLY SAFETY TECHNOLOGIES

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For the first time for Ukraine's eastern forest-steppe zone technologies which give opportunity to control fruit and berry crops from pests using ecologically safe methods only, for example, for apple, plum and black currant, are worked out and grounded.

As a result of 19-year observations (1975-1994) of orchard and berry-field pests we noted 135 species of animals which fed on different apple, plum and black currant organs in the conditions of eastern forest-steppe of Ukraine. Among them: insects - 119 species, ticks - 7, molluscs - 2, mammals - 7 species. We divided these animals by harmfulness relatively into 5 groups: constantly dangerous pests - 25 species, periodically dangerous - 62, rarely harmful - 28, rarely noted - 13 species, and 7 species are rare and need preservation.

We refer these animals to constantly dangerous animals: Laspeyresia pomonella L., Grapholitha funebrana Tr., Sciaphobus squalidus Gyll., Anthonomus pomorum L., Coenorinus pauxillus Germ., Melolontha melolontha L., Agrilus viridis L., Synanthedon myopaeformis Bkh., Synanthedon tipuliformis Cl., Archips rosana L., Archips variegana Schiff., Adoxophyes orana F.R., Pandemis heparana Den. u. Schiff., Archips xylosteana L., Archips crataegana Hb., Archips podana Scop., Biston hirtaria Schiff., Lithocolletis blancardella F., Lepidosaphes ulmi L., Eurytoma schreineri Schr., Thomasiniana oculiperda Rubs., Brachycaudus cardui L., Tetranychus viennensis Zacher., Tetranychus urticae Koch., Microtus arvalis Pall.

In our opinion, these animals need preservation: Smerintus ocellatus L., Arctia caja L., Arctia villica L., Papilio podalirius L., Argynnis paphia L., Gastropacha quercifolia L., Cervus elaphus L.

Last 15-20 years in the industrial gardens in eastern forest steppe of Ukraine, to our observations, a species composition replacement of main pests took place.For instance, in 50-70-ies the most harmful pests were white thorn-butterfly, brown-tail moth, tent caterpillar moth, gypsy moth, apple-tree moth, etc. In 80-90-ies in orchards the most harmful were fruit tree tortrix moth and other species of leafrollers, some species of miners and others. In orchards more and more tangible and appreciable harm is being done by Phylobius oblongus L., Coleophora hemerobiella Scop. and other pests. The main reasons for such composition replacement of pests, to our mind, becides development recurrence of pests, are: purpose annual control by chemical methods from pests which were considered basic, and rise in temperature of climate and pest areal exstention which are connected.

In the years of researches we took part in determining and specifying the harmfulness economic threshholds for several pests. For instance, according to our data, harmfulness economic threshhold for Aporia crataegi L. is 1-2 winter niduses with 15 caterpillars, not infected by entomofags, per 1m^3 of crown; for Yponomeuta malinellus Zell. - 3 egg layings per 1tree not older than 10 years; for Eurytoma schreineri Schr. - 1-2 larvae per 1 tree during spring observation; for Grapholitha funebrana Tr. - 12 and more males per 1 feromone trap for 7 days (with stable warm weather and if the damages were less than 20% last year).

During our researches we met the problem of forest belts. The matter is that the predominant species of these lines are different types of poplars. Poplars have several positive points, among them we should note easyness of reproduction, ability to take roots quickly, quick growth, easyness of obtaining. At the same time poplars have serious drawbacks: oppression of significant quantity of fruit trees by shading and owing to strong developed root system and root shoots. Besides, poplars have significant quantity of the same pests as fruit crops' ones. To our opinion, in eastern forest steppe of Ukraine negative aspects considerably exceed positive ones. We consider walnut to be the best species for protective lines.

One of the ecologically safety methods of fruit and berry crop control from pests is use of biological preparations. During researches we studied following biopreparations: dendrobacillin, lepidocid, astur, turicid, X-100, bitoxybacillin, neemazal, novodor, demicid and others.

For the purpose of observing pests and pest control we widely used sex feromones. Since 1977 we observed codling moth and since 1979 - tortricid plum moth. Since 1988 we hold of significant quantity of pests, using feromone traps: currant and apple clearwing moth, 13 species of leafrollers, gypsy moth, 4 species of moths and other pests.

Since 1981 we hold researches directed to working out of tortricid plum moth control by the method of dezorientation. As a result of zone tests, in which we took part, feromone rings ПАК-1 K were put into "The list of chemical and biological methods for pest control ... allowed for use in agriculture in 1986-1990". Last years we tested feromone cords, which are not less effective than feromone rings. We found that the method of dezorientation has after-effects, which can be used in pest control. In control of several pests of fruit and berry crops we used a method of male vacuum.

Among biologically active substances we used dimilin, insegar and others.

We also took part in researches, as a result of which the realestimation of volume and importance of entomofags and acarifags dominant groups. Much attention was given to study of hymenoptera, which, to our data, in some cases make a half of total amount of insects in coenosises.

For activization of useful pests we used sowing in addition of melliferous herbs and making artificial places of nidification and wintering, and we also used micropreserves of useful pests. Besides, we used several agrotechnical methods, attracting of insectivorous birds to orchards and other non-chemical measures.

All these researches gave possibility to work out and to ground technologies, , which give opportunity, for the first time in eastern forest-steppe zone of Ukraine, to control friut and berry crops from pests using ecologically safe methods only.

POSTERS

Section: Biological Control

Investigation of spider communities in different treated apple orchards in Hungary

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The spider fauna was investigated in the ground level by pitfall trapping and on the trunk by corrugated paper traps in different treated apple orchards between 1992-94 in Szarkás (surrounding of Kecskemét). The orchard was divided into three different plots: one sprayed with broad-spectrum insecticides (commercial - COM) and two integrated pest management (IPM) plots.

During our work 786 spiders were collected in the ground level. The adult spiders were indentified, one part of the juvenile spiders are not determinable. The main spider family (at about 70 % of all collected spiders was the **Lycosidae** (dominant species were *Alopecosa sulzeri, Pardosa lugubris, Xerolycosa nemoralis, Pardosa agrestis).*
The differences between the plots in number of individuals were not significant in 1992-93. In 1994 the number of individuals was twice higher in IPM plots than in COM plot. The traps collected 2-4 times more spiders in the edge of the orchard. To follow the population dynamic it was determine that the intensive moving activity of spiders in the ground level were in April-May. In the edge we could observe the higher number of spiders till August.

In the treebands we collected only clubionid spiders (**Clubionidae**). The dominant species was the *Clubiona pallidula* in all investigated plots. The number of collected spiders was 3-6 times higher in IPM plots. We observed that these spiders prey on pear lace bugs (*Stephanitis piri*) this pest overwintered in treebands together with spiders and positive correletion was found between the number of bugs and the number of spiders.

The experiment was supported by USDA /agreement number: 58-319 R-3-022/ and OTKA /F 00632/

Impact of Ground Cover Plants on Beneficial Arthropods in an Apple Orchard in West Virginia, USA

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Abstract. A conventionally managed orchard was compared with an orchard with a ground cover of clover and rye and managed to conserve biological control organisms. In the first three years after planting the orchard with diverse ground covers had a more diverse biological control community than the conventional orchard even though the trees were less vigorous and had fewer aphids. Use of ground cover plants can enhance biological control in apple orchards but care must be taken not to reduce tree vigor.

There is strong pressure from consumers and governments to reduce the amount of pesticides used in agricultural production. In this study we examined how a change in cultural management of apple orchards could affect biological control of insect pests. Diversification of agricultural systems can enhance biological controls by offering alternate sources of food and shelter. In this study we diversified the agroecosystem by planting ground cover plants under the trees. In holistic ecosystem studies such as this, effects of management changes can have far-reaching effects on apple disease epidemiology and horticultural properties of the production system. Before recommending any changes in management for pest control, ramifications in other aspects of the system must be evaluated to ensure compatibility.

Two apple orchards were planted in West Virginia, USA, in the Spring of 1992, to test the effects of orchard diversification on the insect community. One orchard, conventional, was managed according to standard commercial practices, including a 2.5 m herbicide strip under the trees. The other orchard, IPM, was planted with *Secale cereale* (rye) and *Trifolium pratense* (clover) in 1 m strips underneath the trees leaving only 0.5 m of herbicide strip at the tree base. The IPM orchard also received an introduction of mite predators in a bouquet of apple branches from an unsprayed orchard and a *Bacillus thuringiensis* spray in May 1993 when the conventional orchard had an application of azinphosmethyl (Guthion). Fungicide applications were similar for the two orchards. Sampling was conducted monthly through the growing season with whole tree visual observation of ten randomly selected trees per orchard per sample and sweep net sampling at five locations per orchard per sample.

The introduction of bouquets of branches did accelerate the establishment of biological control of *Panonychus ulmi*. Although mite populations never reached threshold levels, population growth was reduced in the IPM orchard before the conventional. In the year after introduction of the branches, the mite predators *Leptothrips mali* and *Orius insidiosus* were found earlier in the IPM orchard than in the conventional.

Adult parasitic hymenoptera, sampled with a sweep net, were more abundant and diverse in the IPM orchard than the conventional orchard. Role of these hymenoptera in pest control is unknown because of the lack of host records. However, these results showed that the ground cover provided more habitat for parasitic hymenoptera than the conventional system.

The IPM orchard did have lower aphid populations than the conventional orchard, but the primary reason was a reduced vigor of the trees rather than an increase in biological control. This was reflected in fewer aphidophagous species in the beneficial community in the IPM orchard. However, the beneficial community had similar diversities in both orchards, indicating a more diverse community of non-aphidophagous predators. The most abundant predators in the conventional orchard were chrysopids, cecidomyiids, *O. insidiosus* and *L. mali.* In the IPM orchard the dominant predators were spiders, especially salticids, and in 1994, *Forficula auricularia.*

The community of phytophagous insects in the IPM orchard was also more diverse than in the conventional orchard, thus providing a more stable food source for predators. The most notable difference between the two orchards was in June of 1993, after an application of azinphosmethyl in the conventional and Bt in the IPM orchards, when there was a complete absence of lepidoptera in the conventional orchard but not in the IPM orchard. The lack of all lepidoptera would be detrimental to populations of natural enemies of lepidoptera, further disrupting long-term biological control of this major group of pests. Stability in the food availability in an orchard is important for maintaining high levels of biological control. Not only does the diverse food resource, as in the IPM orchard, provide alternate prey when the pest population may be low, but it also supports a more diverse biological control community that would be more able to react to a new pest entering the orchard.

Apple disease pressure was low and fungicide applications were similar, but there were minor differences in disease occurrence. In 1993 there was twice as much powdery mildew (*Podosphaera leucotricha*) in the conventional orchard (2.8% of the trees infected) than in the IPM orchard (1.5% of the trees infested). Apple scab (*Venturia inaequalis*) was also slightly more common in the conventional orchard (15% versus 14% of the trees infected). Fire blight (*Erwinia amylovora*) was found only in the conventional orchard in 1994. Differences in disease occurrence is probably related to tree vigor more than any specific property of the ground cover plants.

Ground cover plants were shown to enhance the beneficial insect community in a young apple orchard. Selection of ground cover plants and their management must be done carefully so as not to reduce the growth and productivity of the orchard.

PARASITATION RATE OF THE LARVAE OF PEAR PSYLLA (*Cacopsylla piri* (L.)) IN ORCHARDS WITH DIFFERING INTENSITY OF CHEMICAL CONTROL

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INTRODUCTION During the last five years a growing number of pear psylla has been observed in Poland. Inspections carried out since 1993 in pear orchards have shown that the dominant species is *Cacopsylla piri*. Much less commonly observed were *Cacopsylla pirisuga* and only single specimens of *Cacopsylla piricola* were found. There are problems with efficient chemical control of pear sucker in some orchards in Poland (particulaly when synthetic pyrethroids and organophosphate isecticides are used), as in many other countries. At the same time, in other orchards despite constant occurence of these pests, their incidence remains on low or medium level. The main role in reducing the number of pear psylla is attributed to predators, however parasitoids are also important (Armand et al., 1992; Mc Mullen, 1966). The aim of the observations was to recognize the parasitation rate of pear psylla in Polish pear orchards and to study the composition of their species.

MATERIAL AND METHODS Pear shoots 20-25 cm long were examined for the total number of pest larvae. Parasited larvae were collected to test-tubes and kept in room temperature to breed parasites in order to determine their species. The samples were collected as follows: from 100 trees of each of 3-5 pear cultivars, one shoot per tree was cut.

RESULTS Observations carried out in 1994 (Table 1) have shown that in orchards with medium or low intensities of psylla occurrence, usually not sprayed with insecticides or having only a single or two applications, the incidence of *Cacopsylla piri* has risen from 0.1% to 7.7% in June-July and from 3.1% to 24.5% in August-September. In those orchards which had a massive incidence of *Cacopsylla piri*, intensive spraying (7 or 9 times per season) with synthetic pyrethroids and organophosphate insecticides resulted in single or no observations of parasited larvae, the level of which reached 0-0.5%.

The total number of parasited larvae was ca. 516 and that of parasitoids bred ca. 232, among which three species (Table 2) were identified. *Trechnites psyllae* (Ruschka) was dominant, 30-86.6%, *Prionomitus mitratus* (Dalman) ranked second with a range 1.7-70% and *Pachyneuron concolor* (Forster) third with 0-19%.

CONCLUSIONS

1. A distinct difference in the parasitation rate between the orchards with intensive insecticide control and those without or sparse spraying was observed.
2. In orchards intensively treated against pests, parasitoids are not be important in reducing the number of pear psylla. However, in orchards with low number or no sprays parasitoids can play a certain role.
3. Out of the three parasitoid species identified *Trechnites psyllae* was dominant.

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Table 1

Number of larvae of pear sucker (*Cacopsylla piri* (L.)) and the percentage of their parasitation in pear orchards with differing intensivity of chemical pest control

Locality	Number of tre-atment against pests*	Date of observation			
		June-July		August-September	
		Number of lar-vae per shoot	Percent of pa-rasited larvae	Number of lar-vae per shoot	Percent of pa-rasited larvae
Dąbrowice	0	9.0	0.9	1.0	19.3
Grudynia W.	1	2.6	7.6	1.9	3.1
Miłobądz	0	1.8	0.1	-	-
Nacpolsk	1-2	3.7	1.8	1.9	24.5
Olszanka	0	3.6	7.7	-	-
Prusy	3**	0.3	0	0.02	0
Świebodzin	9**	0.5	0	1.2	0.5
Trzcińsko-Z.	7**	57.8	0	6.9	0

* besides of 7-9 treatments against diseases
** synthetic pyrethroids and organophosphate insecticides were used

Table 2

The percentage of three parasitoid species bred from infected larvae of the pear sucker (*Cacopsylla piri* (L.))

Locality	Trechnites psyllae (Ruschka)*	Prionomitus mitratus (Dalman)*	Pachyneuron concolor (Forster)**
Dąbrowice	66.7	24.2	9.1
Grudynia W.	54.8	34.4	10.8
Miłobądz	86.6	6.7	6.7
Nacpolsk	79.3	1.7	19.0
Olszanka	52.4	47.6	0.0
Świebodzin	30.0	70.0	0.0

* Encyrtidae
** Pteromalidae

CHANGES IN THE POPULATIONS OF TETRANYCHID MITES AND THEIR PREDATORS

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The population density and population dynamics of some *Tetranychidae* and *acarophagous Arthropoda* species were investigated in an apple orchard at the Experimental Station of the Research Institute for Fruitgrowing and Ornamentals at Kecskemét-Szarkás, in Hungary.

In the first year of the experiment (1992) three species of tetranychid mites, *fruit tree red spider mite (Panonychus ulmi* Koch*), two-spotted spider mite (Tetranychus urticae* Koch*), hawthorn red spider mite (T. viennensis* Zacher*)* occurred in the experimental orchard. *Predacious mite* did not occur previously in this orchard. Among them *Zetzellia mali* (Ewing), a *stigmaeid mite,* appeared at first in the IPM plot in June and in a few number at the end of the summer in the conventional plot. The specimens of the *minute black ladybird (Stethorus punctillum* Weise*)* and *flower bug (Orius niger* Wolff*)* appeared in the experimental orchards. Their population level was higher in the conventional plot, connected with the high population density of the *fruit tree red spider mite.*

In the second year of the experiment (1993) the population density of the *Zetzellia mali* appeared both in the conventional and IPM plots. It has become an effective regulating factor of the *phytophagous mites.* The specimens of the *phytoseiid mites* appeared in both plots, but in the conventional plot they were present only occasionally, in low numbers.

In the third year of the experiments (1994) the regular use of the selective insecticides made it possible to develop such a community which involved *phytophagous* and *zoophagous* populations and as well as the *alternative food* sources of the *zoophagous* species. In these communities the density of the *tetranychid* mites can not extremely fluctuate, their population level does not reach the economic threshold.

The experiment was supported by USDA /Agreement number: 58-319 R-3-022/ and OTKA 1436

Non-Chemical Control of Grapholitha molesta (Buck) in Michigan Peaches

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ABSTRACT

Replicated small-orchard studies compared control of Oriental fruit moth, Grapholitha molesta (Buck) in Michigan peach orchards from 1990-1993. Three control regimes were compared: 1) Conventional control measures with pesticides applied on a 'calendar' or scheduled basis; 2) IPM strategy using pheromone traps and degree-day models to time controls; and 3) Lo-Input (non-chemical) control using mating disruption pheromones for behavioral control.
In all four years of the study, all treatments provided excellent control of oriental fruit moth, meaning that the lo-input treatment performed as well as the conventional pesticide approach. Insecticide applications in the IPM and Lo-Input orchards were significantly reduced from the conventional control orchards. Secondary pests, such as Japanese Beetle, Popilla japonica, Rose Chafer, Macrodactylus subspinosus, and Plum Curculio, Conotrachelus nenuphar, became numerous in treatments with reduced pesticides, and required additional control applications.

INTRODUCTION

Peach production in Michigan has traditionally relied upon synthetic chemical pesticides for insect, disease and weed control. Pesticide applications are generally made on a 7-14 day basis throughout the growing season, resulting in full cover spray totals ranging from 2 to 8 fungicides, 0 to 2 herbicides and 1 to 9 insecticides/miticides per year (Jones et.al, 1995, Flore et.al, 1992).

More recently, increased pressure from U.S. consumers and federal and state governments to reduce the usage of pesticides in agriculture. Concems range from issues of food safety, ground water contamination, farm worker protection, to pesticide resistance. A number of pest management technologies have emerged from that have real promise for low-chemical input peach production in Michigan.

Oriental fruit moth pheromone mating disruption is one such technology (Rice and Kirsch, 1990). The senior author (Johnson 1990-1991, unpublished data) demonstrated that damage to Michigan peaches from the oriental fruit moth (OFM), *Grapholita molesta* (Busck), could be successfully prevented with the use of pheromone mating disruption and orchard perimeter sprays of insecticides to control the immigration of gravid female OFM.

The study reported here was a portion of an overall system trial that included novel control practices for insects, diseases, weeds, and nematodes. This three year study was conducted to demonstrate the appropriateness of these novel control techniques by comparing them to two different levels of conventional and IPM management.

MATERIALS AND METHODS

Six .41 ha plots (center .3 ha planted with 'Newhaven' peaches, *Prunus persica*), with two replicates per treatment, were established in 1990 through 1993 at the Southwest Michigan Research and Extension Center, Benton Harbor, MI. The plots were located a minimum of 200 m apart and the treatment of each plot randomly selected. The first treatment was conventional peach management (based on spray 'schedules'),the second was standard IPM (based on weekly scouting and spraying upon reaching sampling thresholds), and the third was a low-chemical input management strategy (using mating disruption as the focal management tool).

RESULTS AND DISCUSSION

Pesticides applied to the plots differed substantially in 1992 and 1993. The Lo-Input strategy made substantial reductions in the number of pesticides needed to produce the crop, while maintaining fruit quality. Pheromone trap monitoring of OFM show successful 'trap shut-down' in the low-chemical input plots, indicating that the disruption pheromones successfully prevented mating inside the plots .

The harvest evaluations show that all three management strategies provided excellent control of OFM. Secondary pests, such as Rose chafer (*Macrodactylus subspinosus*) was responsible for the greatest amount of insect damage in all treatment plots, doing significantly more in the IPM plots than the conventional or low-chemical input plots. Conventional strategies provided the highest % insect clean fruit, being significantly higher than both the low-chemical input strategy and the standard IPM strategy . The conventional management strategy provided the highest percentage of 'blemish free' fruit, being significantly higher than the standard IPM strategy, which was significantly higher than the low-chemical input strategy. All fruit residues detected were well below the U.S. EPA tolerance levels for peach fruit with no treatment differences.

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Regulations of *Psylla pyri (L.)* by selective insecticides and natural antagonists in IPM of pear orchards

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Abstract: The control of pear psylla is made by selective inhibitors of chitine formation. The timing of insecticide application is based on monitoring of pear psylla abundance and temperature-driven model of its development. The efficiency of protection against pear psylla populations resistant to classical insecticides is enhanced by presence of their natural enemies which further maintain population density below the damage level.

Damage of pear psylla to pear trees

The damage cased by pear psylla increased in intensive orchards of the Czech Republic, particularly in the last years. The cause is growing of susceptible pear cultivars, resistance of pear psylla to clasical insecticides (organophosphorus compounds, pyrethroids), and decreasing abundance of natural enemies. The dominant species is *Psylla pyri* (L.) while *P. pyrisuga* (Foerster) is less abundant.

Methods of monitoring *Psylla pyri*

a) Counting of eggs and nymphs on twigs (average number per 1m of twig)
   Timing: from sprouting to formation of leaf rosettes
   Sample size: 25 twigs of 20 cm lenght

b) Counting eggs and nymphs on leaf rosettes (average number per 1 leaf and fruit)
   Timing: from development of leaf rosettes to August
   Sample size: 25 leaf rosettes

c) Sampling of adults and the natural enemies by limb jarring
   Timing: whole vegetation period
   Sample size: 50 strokes (50 twigs), collecting nett of 0,25 m^2 area

In the Czech Republic, *P. pyri* has 2 complete and a partial 3rd generation. In warm years it may have a partial 4th generation. First and 2nd generations make a great damage.

Timing of insecticide application

The timing of insecticide application may be determined as the sum of effective temperatures (from January 1) above 2.6° C development threshold. The sum correspond to the maxima of egg presence. For the 1st generation, application is recommended after attaining 200 day degrees. For the 2nd one after attaining 650 day degrees. The proposed terms are best for determining pear psylla abundance. The spraying of selective insecticides is recommended if abundance is greater than the damage threshold (provisional value: 0.1 eggs/leaf). The spraying is made at the time of maximum egg hatching.

Selective insecticides against *P. pyri*

The efficiency of selective insecticides against *Psylla pyri* was tested in field experiments (0.5 - 1 ha plots for each pear cultivar). In 1992 -1994, the experiments were made at Doksany (60 km west of Prague), in a highly infested orchard. In 1995, the experiments were made in the intensive orchards at Slaný and Lažany. In both years, pear psylla was abundant so that pear harvest was completely destroyed. The efficiency of insecticides (Tab. 1) was evaluated as percent of reduction of nymphs in a given plot compared to number of eggs in the control. Table 2 indicates the relative efficiency of the insecticides compared to Dimilin (standard: 100%). The efficiency of Dimilin, Nomolt and Consult on pear psylla is good. Nomolt and Consult cause greater mortality than Dimilin. The mortality increases with the precision of timing of application. Against the 1st generation of pear psylla insecticides should be applied at the end of pear flowering. With high abundance of psylla, oil-based pesticides (Oleoekalux) may be applied before flowering. Against the 2nd generation selective insecticides should be apllied at the end of May. The 3rd application is needed only exceptionally, in years of very high pear psylla abundance.

The pesticide tested

Name	**effective substance**	**dose/ha**	**effect on *P. pyri***
Nomolt	teflubenzuron	1 l	good
Dimilin	diflubenzuron	0.25 l	good
Consult	hexaflumuron	0.75 l	good
Andalin	flucycloxuron	0.60 l	insufficient*

* The pesticide has a good effect on *P. pyri* when applied against other pest species (mites, tortricids).

Tab. 1

Rank	**Roudnice 1992**	**Roudnice 1993**	**Roudnice 1994**	**Lažany 1995**	**Slaný 1995**
1. Nomolt	-	-	91.2	93.6	99.6
2. Consult	88.7	71.4	89.0	97.2	99.4
3. Dimilin	80.2	86.1	80.3	93.1	96.4
4. Andalin	-	75.8	45.6	-	-

Tab. 2

Name	**Roudnice 1992**	**Roudnice 1993**	**Roudnice 1994**	**Lažany 1995**	**Slaný 1995**
Dimilin	100	100	100	100	100
Nomolt	-	-	+56	+59	+92
Consult	+43	-106	+44	+46	+82
Andalin	-	-74	-176	-	-

Natural enemies of pear psylla

Predators Heteroptera: 6 species, dominant are Anthocoris pomorum, Anthocoris nemoralis, Nabis ferus, Orius majusculus

Coccinellidae: 14 species, dominant are Adalia bipunctata, Adalia decempunctata, Coccinella septempunctata, Coccinella quinquepunctata, Propylea quatuordecimpunctata, Synharmonia conglobata

Neuroptera: Chrysopa carnea, Hemerobius humuli

Coleoptera: 6 species, dominant are Cantharis, Staphylinidae

Arachnida, Dermaptera, parasitic Hymenoptera, Formicoidea

The abundance of dominant species of natural enemies was not decreased by using selective pesticides.

Investigation of ground beetle communities in differently treated apple orchards in Hungary

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The ground beetle communities were investigated at the ground level of the apple orchards in Szarkás / Hungary / by pitfall trapping during 1992 - 1994. The orchard was divided into three different plots. One was commercial /COM/, mainly sprayed with organophosphorous insecticides and two were integrated pest management /IPM/ plots. The habitats were investigated herbologically in each plot. /between the rows and in the rows/ and in different types of surroundings.

During our investigations a total of 20 680 ground beetles were collected. The dominant species in the orchards were *Harpalus flavescens, H. froelichi, H. tardus* and at the margin were the *Calathus ambiguus* and *C. erratus* . The carabid communities were more or less the same in all investigated apple plots but in IPM plots the size of the communities were 2-8 times higher. The ground beetle communities at the margin were completely other than in apple orchard plots. It was determined that the carabid communities were lower but more diverse there. The lower densities were probably caused by the more dense covering of weeds, which could caused decreased movement of individuals .

We learned that mowing in IPM plots between the rows did not cause the increase of covering but the species richness there was higher significantly in comparison with the COM plot. The covering and species richness of grass-like plants in the rows /between the trees/ was higher; there were fewer carabids caught in those traps which were placed here than in traps that were placed between the rows.

The experiment was supported by USDA /agreement number: 58-319 R-3-022/ and OTKA /F 00632/

Efficacy of *Bacillus thuringiensis* var. *kurstaki* against leafrollers in Emilia-Romagna

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INTRODUCTION

The main species of leafrollers present on apple and pear orchards in Emilia-Romagna are: *Pandemis cerasana* (Hb.), *Archips podana* (Scop.), and *Argyrotaenia pulchellana* (Hw.). The first two species overwinter as young larvae and complete two and three generations per year respectively. The third hibernates as a pupae and completes three generations. The larvae feed on leaves and fruit, producing highly visible, deep lesions. By and large control is based on the use of organo-phosphoric active ingredients (e. i. azinphos-methyl, chlorpyriphos, etc.), but *Bacillus thuringiensis* var. *kurstaki (B.t.k.)* is also widely employed. It is mainly recommended to effect treatment against the first larval generation, based on the capture of adults in sexual traps (15 for *P. Cerasana*, 30 for *A. podanus* in two weeks and 50 for *A. pulchellana* per generation). A threshold value of 5% of shoots attacked is also used to decide if to take action against the larvae. The species on which this experiment was carried out - *P. cerasana* - is the most dangerous one. Our research had the aim of comparing the effectiveness of preparations based on *B.t.k.*, available at present or in the future, with that of certain synthetic products.

MATERIALS AND METHODS

Table 1 illustrates the products, their main characteristics and how they were used. A phonologically predictive model was used to decide when to commence action and apply the treatments. Generally speaking, microbiological products were applied shortly after eggs had started to hatch, thus to the first young larvae. Action was then repeated on the basis of the product characteristics declared by the manufacturers. The experimental design used was plots in randomised blocks. Samples (a total of four sampling for the first generation alone) were taken of both shoots and fruits (100 per plot). Sampling results were analysed statistically (ANOVA).

Tab. 1.- Experimental parameters.

N. tesi	active ingredient	commercial product	U.I % a. i.	dose g/hl	timing
1	B.t.k.	Biobit HPWP	32.000	75	35% young larvae-repeated after 12 days
2	B.t.k.	Biobit XL	10.600	250	35% young larvae-repeated after 12 days
3	B.t.k.	Delfin	32.000	75	35% young larvae-repeated after 12 days
4	B.t.k.	Dipel	16.000	100	35% young larvae-repeated after 12 days
5	B.t.k.	Cutlass	24.000	135	35% young larvae-repeated after 12 days
6	B.t.k.	MPV	8.000	300	35% young larvae-repeated after 12 days
7	tebufenozide	Mimic	23	80	First young larvae- 1 treatment only
8	AC 303.630	Pirate	24	100	First young larvae- 1 treatment only
9	c. methyl	Reldan	22	200	First young larvae- repeated after 12 days.
10	test	-	-	-	-

RESULTS

The results are shown in Figures I-IV. It was observed that preparations as yet not authorised were more active than those already registered (Delfin and Cutlass). The synthetic active principles tested (tebufenozide and AC 303,630 - neither yet authorised) were considerably effective compared both with the chemical check plot and - obviously - the untreated one.

CONCLUSIONS

Both the preparations based on *B.t.k.* already available for some time, and others which will come into use in the future, were highly effective against *P. cerasana* larvae. In particular some of the latter type are competitive with new, highly promising, synthetic active principles to control some species of Tortricidae. In conclusion, the results obtained confirm previous observations: some products based on *B.t.k.* are highly active. Some in particular provide better results than traditional synthetic products.

BIOCONTROL OF *BOTRYTIS CINEREA* AND *PENICILLIUM EXPANSUM* ON POSTHARVEST APPLES BY ANTAGONISTIC BACTERIA

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Abstract

Out of 215 isolates of epiphytic bacteria originated from apple leaves and fruits 12 isolates showed outstanding activity in limitation of gray mold and blue mold on apple fruits. Some of those isolates showed better efficacy when they were used in higher concentration. Generally, the tested bacterial isolates better protected fruits against *B.cinerea* and *P. expansum* in cold storage than in room temperature. Also, as fruits were more matured their protection was more difficult. Most of the selected isolates were not active in inhibition of the growth of both pathogens on agar medium.

Introduction

At present, fungicide treatments are the primary method for controlling postharvest diseases of apples. However, their effectiveness is sometimes doubtful because of the resistance of target pathogens. Also, there is an increasing public awareness, mainly due to eventual chemical residues. Therefore, there is an urgent need to find alternatives to fungicides use.

Study on application of bacteria for protection of apple fruits against gray mold and blue mold was initiated on practical scale about 10 years ago in the United States (Janisiewicz, 1991). Recently in Europe research on biological control of postharvest diseases was undertaken (Droby and Chalutz, 1994; Sobiczewski and Bryk, 1995).

The aim of our studies was isolation of epiphytic bacteria colonizing apple leaves and fruits and determination of their activity and applicability for control of gray mold (*Botrytis cinerea*) and blue mold (*Penicillium expansum*) on postharvest apples.

Material and methods

Isolation of bacteria from apple leaves and fruits

Apparently healthy leaves were collected from apple trees cv. Idared during the vegetation period. Apple fruits of various cultivars were selected in 2 cold storages during storage time. Fruits and leaves were washed in distilled, sterile water. After serial dilutions the washings were plated on potato dextrose agar or nutrient agar supplemented with sucrose. After 3 days of incubation the bacteria were counted and representants of various morphological groups were selected for further screening.

Determination of antagonistic activity of bacteria in relation to *B. cinerea* and *P. expansum* on agar medium

The bacteria were streaked on PDA medium in Petri plates as 4 cm line at the 1.5 cm distance from the plate edge. After 3 days of incubation, in the centre of plate a disk of 5 mm diameter of 7-days-old mycelium of respective pathogen was placed. The size of the inhibition zone of mycelium growth was determined after incubation at 24°.

Determination of protective activity of bacteria on apple fruit

Apples used in all experiments were washed in a tap water and disinfected by swabbing with dabber saturated in ethanol. Then, they were wounded in 3 symmetrically located places. Twenty microliters of water suspension of a test bacterial isolate was applied to each wound. This was followed by applying 20 microliters of the respective pathogen suspension to each wound within 30 minutes. Fruits were evaluated for rot development after 3 days of incubation at 20°C or after 30 days of incubation at 4°C.

Table 1. Control of postharvest diseases on apples cv. Jonagold depending on storage temperature[a], time of treatment[b] and concentration[c] of some antagonistic bacterial isolates

Isolate number	20°C[a]						4°C[a]					
	9 Jan.1995[b]			10 Mar.1995[b]			9 Jan.1995[b]			10 Mar.1995[b]		
	A[c]*	B[c]	C[c]	A[c]	B[c]	C[c]	A[c]	B[c]	C[c]	A[c]	B[c]	C[c]
Gray mold												
90	I**	I	I	III	III	III	I	I	II	II	III	IV
123	I	I	II	III	III	IV	I	II	IV	III	IV	IV
144	I	II	I	III	III	III	I	I	II	III	IV	IV
Blue mold												
90	I	II	I	II	IV	III	I	I	I	I	II	II
123	I	II	II	III	III	IV	I	I	I	II	II	IV
144	I	II	II	IV	III	IV	I	II	I	II	III	III

*A, B, C: concentration of bacterial suspension expressed by extinction 0,3; 0,16; 0,025 respectively, measured on spectrocolorimeter by 630 wave length; ** Inhibition classes: I - no decay; II - inhibition of disease in 99.9-80.0% as compared to check; III - inhibition in 79.9 - 60.0%; IV - inhibition in less than 60%.

Results

On apple leaves cv. Idared occurred from several hundreds epiphytic bacteria per leaf in the first part of the vegetation period to about two hundred thousands at the end of the vegetation period. From apple fruits stored for several months in cold storage with a normal atmosphere, depending on cultivar and place of storage, even more than 2 million of the bacteria were isolated from one apple. Twelve bacterial isolates, independent of origination (leaf or fruit), showed high protective activity against studied postharvest diseases. However, most of them were not active in inhibition of *B. cinerea* and *P. expansum* on agar medium. Lower concentration of antagonist suspension used for apple protection decreased its effectivity (see table 1). Higher degree of fruits maturity decreased degree of their protection by antagonists.

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POSTERS

Section: Insect Problems

Life-history parameters of *T.urticae* Koch on selected cultivars of black currant.

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Abstract

The life histories of *T.urticae* Koch were studied under laboratory conditions (temp.25°C, RH 65%) on five black currant cultivars. The intristic rate of increase r_m ranged from 1.217 on cv. Bona to 1.818 on cv. Titania. The results indicated that the population of two-spotted spider mite increased more rapidly on cultivar Titania than on other cultivars studied. Under the field conditions the highest population of *T.urticae* are usually observed on Ben Lomond rather than on other tested cultivars. The relation between the rate of development of mite population and total leaf area accesible to mite on the studied cultivars are discussed.

Introduction

The two-spotted spider mite is one of the major pests of black currant. In literature there is only very limited information regarding the dynamics of *T.urticae* population and its effect on the development and yield of this crop. Therefore, acquirement of the basic biological data reflecting the rate of pest reproduction on various balck currant cultivars, was required for the adequate assessment of the pest harmfulness. Laboratory tests did not confirm field observations on the infestation rate of various cultivars, thus, it was worth checking whether the density of spider mite population was associated with certain attributes of a cultivar, such as number and surface area of leaves.

Material and methods

The experiments were carried out on the following black currant cultivars: Titania, Triton, Ben Lomond, Bona and Ojebyn. Under field conditions these cultivars varied in the susceptibility to *T.urticae* feeding.

Laboratory tests carried out at 25°C, 65%RH and 17L:7D photoperiod, were to determine: time of development, fecundity, and longevity of mite on each cultivar. The data obtained have been compiled upon a method of life-tables, according to Andrewartha & Birch (1954).

The field observations included a comparison of the surface area and number of leaves on 25 shoots of each cultivar.

Results and discussion

The research revealed a significant effect of black currant cultivar on the development time and mortality of *T.urticae* juvenile stages. The lowest mite mortality was recorded on cv. Ojebyn (7%) while its highest level occurred on cvs Titania and Triton, reaching 21 and 25% respectively. In the case of the two last cultivars a high mortality was compensated by a significantly shorter time of generation development (11 days on cvs Titania, Triton and Ben Lomond; 22 days on cvs Bona and Ojebyn). On most examined cultivars the fecundity did not significantly differ and oscillated between 63 and 79 eggs per female, with the exeption for cv. Ben Lomond, on which only 49.0 eegs per female were recorded.

Data reflecting the rate of *T.urticae* reproduction on the five examined cultivars showed that the fastest increase of the pest population occurred on cv. Titania (R_o=48.0) whereas the slowest was

According to Labanowska (1989) and Gajek (in press), under field conditions the most substantial populations of *T.urticae* occur on cv. Ben Lomond, while Titania (showing the highest rate of pest reproduction in our study) is a cultivar of moderate infestation.

Table 1. Parameters related to potential rates of population increase of *T.urticae* on five black currant cultivars

cultivar	r_m	R_o	T	
Ojebyn	1.275	33.730	2.760	3.578
Bona	1.217	33.070	2.875	3.377
Triton	1.719	42.906	2.187	5.579
Titania	1.818	48.043	2.128	6.166
Ben Lomond	1.630	29.800	2.080	5.104

r_m - intrinsic rate of population natural increase
R_o - rate of netto reproduction
T - the generation time
- the finite rate of natural increase

It appears that assessment of black currant cultivar susceptability to *T.urticae* feeding should also take into account characteristics such as the growth rate as well as number and surface area of leaves. Measurements of the two last parameters on black currant shoots of the five cultivars showed significant differences in a total area of all leaves on the plant, whereas the average area of an individual leaf did not differ amongs the cultivars. Among them, Ben Lomond showed the smallest total area of leaves and also a relatively high density of *T.urticae* population. This could be a result of a reduced leaf area for spider mite dispersal as compared to cvs Titania, Bona and Ojebyn.

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BLACK CURRANT CULTIVARS RESISTANT TO THE GALL MITE (*CECIDOPHYOPSIS RIBIS* WESTW.) AS AN ELEMENT OF INTEGRATED PEST MANAGEMENT

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ABSTRACT. The study on selected black currant cultivars resistant to the gall mite (*Cecidophyopsis ribis* Westw.) began in 1993. It was also found that many cultivars demonstrated variable density of mite population depending on the place of observations and the year. Changes in peroxidase activity showed that on *Ribes* species resistant to the gall mite induced antibiosis might occur.

INTRODUCTION. In present program of black currant breeding for resistance to gall mite two main sources are used: species of black currant *Ribes nigrum* var. *sibiricum* W.Wolf., *R.ussuriense* Jancz., *R.pauciflorum* Turcz. and *R.petiolare* Doug. (Anderson 1971) and gooseberry (*R.grossularia* L.) (Knight and Keep 1957, Knight et. al. 1974).

Up till now resistance mechanism of these species is not thoroughly known. Herr (1991) found both antixenosis and antibiosis in black currant, antixenosis in gooseberries and antibiosis in red currant.

The aim of the study was the selection of black currant cultivars, the most resistant to the gall mite. Chemical analyses of some plant parts were devoted to the resistance mechanisms.

METHODS. The surveys were conducted in cultivar collections and variety-comparison plantings located at several Experiment Stations. Criterion for cultivars classification was the average percent of infested buds or their number per plot (1,4 or 5 bushes according to the place of observations). Activity of peroxidase (POD) was studied on sensitive cv. 'Ben Lomond', resistant cv. 'Ceres' and resistant crossing *R.nigrum x R.grossularia* cv. 'Josta'. Samples of leaves from check and artificialy infested plants were taken five days after beginning of mite migration. Here are presented selected results.

RESULTS and CONCLUSION. Among the collection cultivars of very high resistance (without infested buds) were: 'Nariadnaja', 'Korelskaja', 'Ri 1650', and 'Ri 1715'. To compare, standard cvs: 'Ben Lomond' or ' Ben Nevis' showed over 30% of infested buds.

Between other cultivars evident differences in mite density population were also observed. At Konskowola (Fig.1) in experiment I the most sensitive was cv. 'Roodknop', in exp. II cv. 'Titania', whereas in exp. III cv. 'Ben Nevis'. No infested buds were found on cv. 'Titania Z' (cultivar of unknown origin). Cultivars in variety-comparison plantings (Fig. 2) demonstrated a variable number of damaged buds depending on the year. At Dabrowice in 1995 each cultivar presented lower number of infested buds than in 1994. It was probably due to spring bush pruning and chemical control of this pest. Opposite situation was observed in 1995 in Milobadz where every cultivars showed higher density of mite population as compared to the previous year.

The most evident differences in enzymes activity were established on cv. 'Josta' (Tab.1). It was found that five days after gall mite infestation the peroxidase activity of leaves has increased. It suggested that on *Ribes* species resistant to the gall mite the induced antibiosis might occur.

Tab.1 Enzyme activity of black currant leaves

Cultivars	Peroxidase (A.g-1.min-1) Cheack plants	Peroxidase (A.g-1.min-1) Infested plants
Ben Lomond	5.5 bc	5.9 c
Ceres	4.9 abc	4.5 ab
Josta	3.0 a	5.2 bc

Fig.1 Black currant cvs. infestation with the gall mite at Konskowola

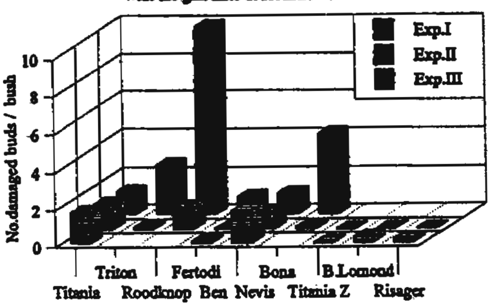
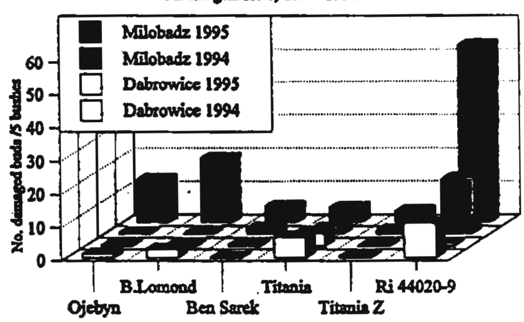


Fig.2. Black currant cvs. infestation with the gall mite, 1994-1995



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EFFECTIVENESS OF YELLOW GLUE TABLES IN MONITORING AND CONTROL OF CHERRY FRUIT FLY (*RHAGOLETIS CERASI* L.)

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ABSTRACT. During investigations carried out in 1994 - 1995 three types of visual traps to establish the presence and volume of *R.cerasi* were tested. The best results were obtained with the Swiss tables of the 'Rebell' type.

INTRODUCTION. Resently in many Polish cherry orchards a violent increase of cherry fruit fly population is observed. Before that time the importace of this pest was rather insignificant and treatments were rare. Actually, poor effectiveness of cherry fruit fly control is often a result of improper spray terms, established on inaccurately calculated daily temperature sums or fenological stage of plants.

The subject of study was the improvement of effectiveness of cherry fruit fly control by elaborating suitable trapping method. In other countries good effect is obtained with visual traps of the 'Rebell' type (Beliet et al., 1981; Remund et al., 1983; Vasev et al., 1984).

METHODS . In several cherry orchards Swiss and Polish tables of the 'Rebel' type were tested. Beside this, the study included English visual traps, additionally equipped with attractant capsule. The tables were inspected and cleaned three times a week. Here are presented the selected results.

RESULTS AND CONCLUSION. The obtained results have shown that in Polish

Fig.1 The number of flies caught during the flight period in 1995

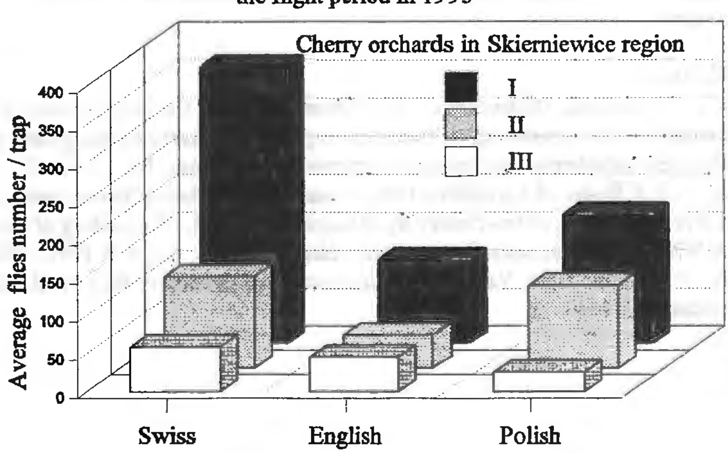
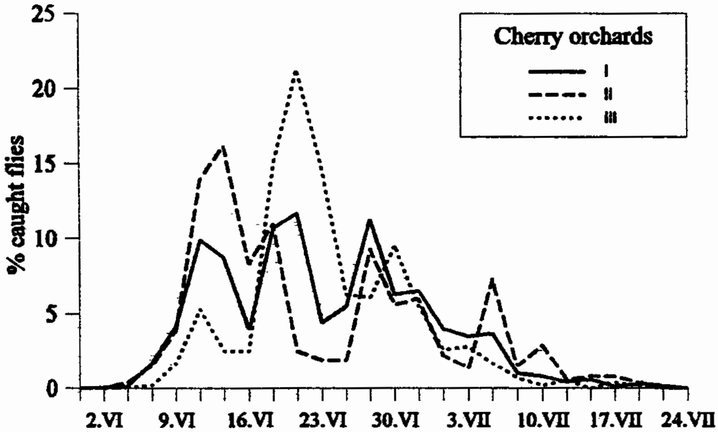


Fig.2. The flight period of R.cerasi
in Skierniewice region in 1995



conditions, trapping method by yellow, visual traps can be used not only to settle the presence and abundance of the cherry fruit fly but also to determine the duration of the flight period. All trap types showed similar schedule of the pest flight but differences in their effectiveness were evident. In each orchard the highest number of flies caught was on Swiss traps of the 'Rebell' type (Fig.1). Effectiveness of Polish and English traps, depending on the place of observation, was more or less similar. Additional equipment of English traps with attractant capsule has not given expected effect.

The course of the cherry fruit fly was almost the same in each tested orchard in the neighbourhood of Skierniewice. It permited to elaborate satisfactory control strategy for this region.

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The effect of integrated and conventional pest control on different aphid and coccinellid populations in an apple orchard in Hungary

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Experiments were carried out on aphid and coccinellid populations of an experimental apple orchard in Hungary in 1993. The orchard was divided into two different treated plots: conventional protected and IPM-plots.The samplings were taken weekly from April till October.

- The most important aphid species wich were found on apple were: the green apple aphid /*Aphis pomi*/, rosy leaf-curling aphid /*Dysaphis devecta*/ and rosy-apple-aphid /*Dysaphis plantaginea*/.
- The density of Dysaphis devecta populations increased in the IPM - plot, their numbers were year by year higher.
- The *Aphis pomi* was in whole vegetation period present in the orchard in every plot. In July, on some trees their number was so high, that appeared red sucking-points on the fruits.
- The most important aphidophagous Coccinellidae species were *Coccinella septempunctata* and *Hippodamia variegata*.

-Between the plots the species richness of aphidophagous Coccinellidae assemblages was similar (N_{IPM}=6, N_{COM}=7), but the density of assemblage in IPM plot was three time higher (n_{IPM}=173, n_{COM}=60).

The experiment was supported by USDA /agreement number: 58-319 R-3-022/ and OTKA /1740/

The potential of pheromones in combination with juvenoids and/or entomopathogenes in IPM of the codling moth, *Cydia pomonella*

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Abstract: The potential of attracto-sterilants and attracto-pathogens in codling moth control is examined. Codling moth males attracted by pheromone into the pheromone trap are not killed but contaminated by the biologically active agent. Contaminated males will search for females and transfer the sterilant or pathogen to females during copulation.

Modified pheromone traps

Several designs of codlemone baited pheromone traps were tested. The aim was to find a suitable trap design, which would assure efficient attraction of codling moth males, their contamination with a biologically active agent (viral preparation, JHA) inside the trap, and release of contaminated males.

The method of marking of males attracted by pheromones was used. The inner surface of „modified trap" was coated and dusted with fluorescent paint. The „modified traps" tested were placed in tree canopies in apple orchards at three different locations. Three „modified traps" of each design were placed triangularly 8 m apart, while standard delta pheromone trap with sticky insert was located centrally.The efficacy of different „modified pheromone trap" designs to contaminate the codling moth males was assessed by monitoring the catch in standard delta traps. Contaminated males were distinguished using UV lamp („black light"). High contamination of males, up to 30-50 % , was obtained when the most efficient „modified trap" E was used (Fig. 1).

Sterilants: Juvenile Hormone Analogs

Juvenile Hormone Analogs (JHAs, juvenoids) were selected for experiments as agents affecting reproduction capability of lepidopteran pests.

The efficacy of the carbamate derivative of 2-(4-hydroxybenzyl)- cyclohexanone (W-328), one of the promising compounds synthetized in IOCB Prague, was compared with fenoxycarb (Insegar). According to the data available, W-328 is extremely toxicologically and ecologically safe:

Rat acute oral toxicity LD 50 (mg/kg) > 9 000

Fish toxicity *Poecilia reticulata* LC 50 (ppm) > 10 000

Water crustacean toxicity *Daphnia magna* LC 50 (ppm) = 6 050

Sterilizing effect of W-328 in comparison with fenoxycarb was tested by topical administration of 1 ∝g (in acetone solution) of the compounds to young (up to 24 hrs) imagoes: a) females, b) males which were later mated with untreated females.

In *Cydia pomonella*, *C. molesta* and *Lobesia botrana* used in our tests W-328 was superior to fenoxycarb in reduction of hatchability of eggs. The number of non-hatching eggs of topically treated females was higher than in females mated with treated males. The difference was low in *C.pomonella* (Tab. 1) but high in *C.molesta* and *L. botrana*.

Pathogens

In our experiments the *Cydia pomonella* granulosis virus (CpGV) is used.

Modified pheromone traps in which the protection of viral particles against UV is assured are used for contamination of males. The formulation technology of CpGV for use in pheromone traps is under investigation. Dissemination of the pathogen through the pest population (i.e. in larvae infesting fruits and in larvae trapped in the monitoring cardboard strips) is detected by Elisa. In this season (1995) experiments in one hectar plots of apple orchards at three locations were set up. Twenty to thirty „modified traps" treated with CpGV were used per plot. The efficacy of this method to controle the codling moth population will be followed in next years.

Conclusions

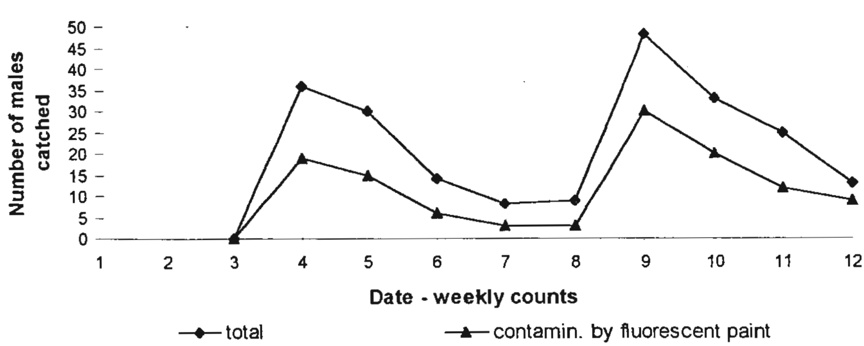
Pheromones in combination with juvenoids or entomopathogens can play a positive role as a part of the IPM in orchards. Attracto-sterilants and attracto-pathogens are extremely species-specific and ecologically safe and may be useful for keeping the codling moth under economic threshold in situations when the target pest occures at low population densities.

Table 1: Effects of juvenoids W-328 and fenoxycarb administered topically (1 μg) to codling moth females and males: prercentage of hatched and non-hatched eggs

Treatment	hatch	non-h.	hatch	non-h.
	female treated		male treated	
W-328	7	67.1+25.9/1	28.9	38.8+32,3.8
	n=35/2		n=31	
fenoxycarb	22.5	55.9+21.6	31.1	48.1+20.8
	n=30		n=36	
untreated	hatch 70.5	non-h. 11.5+18		n=41

/1 segmented + non-segmented embryos
/2 number of ovipositing pairs

Fig.1: The codling moth male flight curve according data from the "modified trap" design E at Doksany, 1994



Occurrence and Pest Status of Lesser Apple Worm *Grapholita prunivora* Walsh in Michigan Apple Orchards.

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Abstract: Lesser apple worm (LAW) *Grapholita prunivora* Walsh (Lepidoptera: Tortricidae), a native North American fruit pest is a quarantine insect in Europe and Asia. The presence of LAW in Michigan apple orchards and flight biology were studied during 1991- 1994. Observation in four commercially managed orchards and four abandoned orchards were used for evaluating the lesser apple worm fruit infestation level. Under Michigan weather condition LAW has two generation per season. Study on flight biology showed insect activity only during the crepuscular light, no later than 30 min. after sunset and when air temperature was above 16 °C. In commercial managed blocks we found no fruit with injury caused by this insect. In abandoned orchards lesser apple worm caused up to 5% injuries, significantly less than other common fruit feeders as codling moth *Cydia pomonella* (L.) or oriental fruit moth *Grapholita molesta* (Busck).

Introduction: Current literature provides little information about the abundance and significance of the lesser appleworm *Grapholita prunivora* (Walsh) in fruit production except for work done on apples in New York State (Glass & Lienk, 1971) and on cherries in Oregon (Brown, 1953). The known hosts of this insect include: apples, pears, peaches, cherries and wild hosts as hawthorn, Christmasberry, oak, and crabapple (Quaintance, 1908).

The LAW has not been considered to be an important pest in Michigan and Oregon fruit systems within the past forty years (Howitt 1993, Beers et al. 1993), possibly because of the intensive use of broad spectrum insecticides.. Use of mating disruption for controlling codling moth *Cydia pomonella* (L.), or oriental fruit moth *Grapholita molesta* (Busck) may increase the significance of former occasional pests such as LAW in orchard pest complexes.

The objective of this study was to determine LAW potential pest status and current significance in commercial and abandoned apple orchards.

Materials and Methods: Observations were conducted in four abandoned and four commercial apple orchards. Experimental sites were located in four different fruit growing areas of Michigan. Within the region an apple commercial block and abandoned block, separated by a distance of 5 -10 km, were chosen for observation. There have been no insecticide application in any of the abandoned blocks for at least five years.

During 1993 and 1994 fruit samples were collected weekly from each orchard. On each site, four trees were chosen every week for fruit collection. In abandoned orchards 100 randomly chosen fruit per tree were collected from different sides of the tree. In commercial blocks, apples were evaluated on the tree and only fruit with visible damage were collected for further observation. Observations on lesser appleworm daily flight biology in relation to timing and temperature were done during the flight of first and second generations of moths.

Results and Discussion: Under Michigan weather condition LAW has two generations per year. The first generation starts in the early May while maximum flight occurs during mid June. Flight of the second generation starts in late July/ early August and lasts until the end of September, with peak activity in late August.

The highest lesser appleworm moth flight activity was observed at temperatures between 19-25 °C and only during late afternoon and early evening hours, starting 3 hours before and ending no later than 30 minutes after sunset.

In commercially protected orchards, where pesticides were applied according to current needs, we found no lesser appleworm injury on fruit, even when moths were caught in pheromone trap present in orchards. The presence of adults moths may result from migration from wild hosts, especially since each commercially protected block was located near the border of the orchard.

Lesser appleworm and other internal fruit feeders were reared from fruit collected from all observed abandoned orchards. Numbers of reared moths were significantly different among four observed species. There were no significant difference in lesser appleworm fruit infestation among different abandoned orchards and between years.

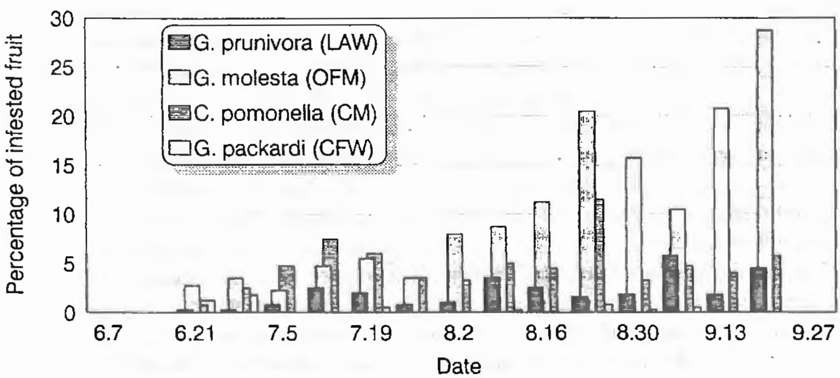

Fig. 1. Seasonal occurrence of four internal fruit feeders in fruit collected in abandoned apple orchard. Data represents mean number of infested fruit from 4 x 100 fruit sample, collected weekly in abandoned orchard. Douglas MI. 1994.

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MONITORING OF APPLE PESTS BY PHEROMONES

by

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Abstract

Monitoring the most important pest of larger apple orchards in Serbia was done with pheromone traps of the delta, funnel and Jackson type. Checking the possibility for the use of the OILB pheromone catch threshold was checked on basis of determining the action thresholds and damages made. With the K-pests such as the *Cydia pomonella* L., the pheromone catch threshold, spraying threshold and damage threshold proposed by OILB can be applied even in large fruit orchards. The only difference is that the pheromone traps are set close to gathering sites and around the edges of the apple orchards. With the RK-pests, whose appearance in orchards are caused by the pesticide application and ecologically unstable orchards, the OILB thresholds are excepted with those that can damage fruits, such as the *Pandemis heparana* D. et S and the *Adoxophyes orana* F.v.R. With the other RK-pests, the pheromone catch thresholds are more flexible, because the damages leave less consequences on the yield and fruit quality.

So with the leaf mites (*Phylonorycter blancardella* F. and *Ph. corylifolieалla* Hb.) followed by the *Synanthedon myopaeformis* Borkh. the pheromone catch and spraying thresholds are adapted according to the production conditions. With the *Aspidiotus perniciosus* Comst., whose presence is not permitted, the pheromone traps are used to detect their presence.

Use of the pheromone traps and action threshold is determined on basis of the results that were gathered on smaller orchards, lesser than 10 ha. Their use on orchards of larger area, specially which are enclosed by other field crops is not always acceptable (Injac et al., 1983; 1987 a., 1987 b.) and requires a certain adaptation period (especially if it concerns determining the right time for spraying, such as application of the granulose virus (Audemard et al., 1992; Granham, 1980; Injac et al., 1992). The aim of the research was to establish the possibility for the use of the pheromone catch threshold for major apple pests, through monitoring and determination of the action thresholds, but also through the respect of the OILB damage thresholds.

The following pheromone traps were used: AgriSense and Zoecon, delta, funnel and Jackson type. The bellow pests were monitored:
- <u>*C. pomonella*</u> is a typical K-selected species, which has a special affinity towards fruits and is a major competitor to man. It has regular flights that are separated into 2 flights. In the IPM production, the population management was in the 0.5% range of damaged apple fruits at the time of picking (Acta, 1977). The numbers of the 1^{st} and 2^{nd} flight regularly cross the

pheromone catch threshold of 3-5 males in 6 days of the first generation and 3 males in the 2nd generation. In greater fruit orchards the pheromone traps must be placed closer to the fruit collection place and around the edges of the orchards. The pheromone catch threshold is the same as in OILB.

- *Ph. blancardella* and *Ph. corylifoliella* are RK-pests whose massive appearance is caused by insecticides with a wide range effect and good fungicide protection. The thresholds are 200 butterflies in 6 days. Spray thresholds are 600 eggs on 100 leaves.

- *A. orana* and *P. heparana* were forest pests which moved also to fruit orchards because of the pruning and watering and their hidden way of life. *A. orana* has two separate flights, the *P. heparana* has two connected flights. They can cause greater damage on the summer apple variety. The OILB pheromone traps catch threshold of 20 males for 6 days has shown efficiency even on greater orchards.

- *S. myopaeformis* is also an RK pest that was selected by introduction of intensive apple growing technology. It flies from May to the middle of September. The butterflies come to the pheromone traps later because of there added feeding. The threshold of the pheromone catch is 150 males in 6 days. This was determined on basis of monitoring made on the tolerance threshold of 50 pupa's skin on 50 younger or 40 pupa's skin on 20 older trees.

-*A. perniciosus* falls into the introduced pests whose tolerance in apple orchards is not permitted. The aim of the pheromone traps is mainly to discover the presence of this pest. By reducing the insecticide pressure, the presence is increased. *A. perniciosus* male has regularly 3 flights. The maximum flight was on September 15, 1995, when 268 males were caught during 6 days by the Jackson trap.

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The development of two-spotted spider mite (*Tetranychus urticae* Koch) injury on black currant leaves.

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Abstract

The leaf injury of two black currant cultivars caused by *T. urticae* feeding during the periods of 3, 6 and 10 days was studied. The density of mite population used in the experiment was about 0.6 mite per cm2. The observations were carried out on: fresh green leaves; leaves with removed pigments, by boiling in 80% alcohol; cross sections of leaf tissues. The intensity of photosynthesis of injured leaves was also studied. After a short period of spider mite feeding the symptoms of injury on fresh green leaves were barely visible. After chlorophyll extraction the brown spots on the leaf-blade, in the place of mite feeding were noticed. The size of brown area was related to the period of mite feeding. Cytological observations indicated that within mite injured area both spongy and palisade mesophyll cells were filled with safranin positive material before they were destroyed. The photosynthesis was strongly inhibited in the leaves with minor visible symptoms of mite feeding.

Introduction

Tetranychus urticae is one of the most important pest of black currant, however, until now, there has not been a great deal of information regarding harmfulness of spider mites to that host plant. The differences in the mite population density among cultivars were found (Gajek, in press). The symptoms of spider mite feeding can occur on black currant quite late in the season (July/August) as yellowing or browning of the leaf. This leaf discoloration is probably connected with oxidative processes in injured leaf. It was found that black currant leaf tissues contain a high level of phenolics

predominantly phenolic carboxylic acids and flavonoid pigments (Trajkovski 1972, 1974). It is possible that mite feeding can induce the oxidation of phenolics to the corresponding quinones resulting in discoloration of leaf tissues. The growth of infested plants in the seasons following a heavy infestation is inhibited and the yield is decreased (Tomczyk & Kropczynska 1995).

Material and methods

The experiments were carried out on two black currant (*Ribes nigrum* L.) cvs: Titania and Ben Lomond, uninfested and infested with the two-spotted spider mite (*Tetranychus urticae* Koch).

<u>The progress of injury</u>

Injuries caused by mite (females) at the density of 0.6 individuals per cm2 were observed after 3-10 days of feeding on: fresh green leaves (visually and in stereo microscope transmission light); leaves with partly removed chlorophyll, by boiling in 80% ethanol (visually and in stereo microscope); thin leaf sections stained with 1% safranin (in light microscope).

<u>Measurements of photosynthesis</u>

The measurements were carried out on leaves with visually estimated injury: 10-15% or 30-50% of leaf area (LI-COR 6200).

Results and discussion

After a short period of two-spotted spider mite feeding (till 6 days) the symptoms of injury on fresh green leaves of both black currant cultivars were barely visible. When chlorophyll was partly removed from injured leaves, by boiling in ethanol, the brown spots on leaf-blade in the place of mite feeding were noticed. The size of brown area was related to the period of mite feeding. The places of mite feeding were also visible in transmission light (Fig.1). The thin leaf sections stained with safranin showed the differences between uninfested and infested leaves. Within mite injury areas both spongy and palisade mesophyll tissues were partially destroyed (Fig.2).

Fig.1.

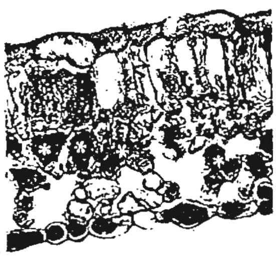

Fig.2.

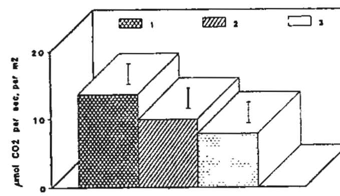

Fig.3.

Fig.1. Spots on leaf-blade visible in microscope transmission light.

Fig.2. Cross section of Ben Lomond cv. leaf tissues showing the appearance of mite injuries (arrows) and location of phenolic compounds (asterisks).

Fig.3. The intensity of photosynthesis of black currant leaves. Control (1); injured leaf area 10-15% (2); Injured leaf area 30-50% (3).

After 3 days of mite feeding the safranin positive material was usuall red, while in uninfested tissues the reaction of these substances with safranin gave yellow and amber colour. The difference in colour of safranin positive material (mainly phenolics) between control and mite injured leaves was probably connected with oxidized complexes of phenolics formed. The phenolics can be easily oxidized to quinones which polymerize to form brown reaction products. The black currant leaves are rich in phenolic compounds (Trajkovski 1972, 1974).

The intensity of photosynthesis was strongly inhibited in injured leaves (Fig.3), although they showed minor visible symptoms of mite feeding. This was probably connected with the serious changes in mesophyll tissues of the leaf before they could be observed visually.

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EFFECT OF THE FILBERT LEAFROLLER FEEDING ON GROWTH AND YIELD OF APPLE TREES

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Abstract

Field studies in apple orchard on two cultivars: Jonathan and Wealthy at three levels of population: 5, 10 and 20 egg masses per tree were conducted. The results showed that the size of leaf and fruit damages was related to density of larvae. A positive correlation between the number of larvae/tree and the number of damaged leaves (leafrolls), as well as the number of damaged fruit has been found only for cv. Wealthy. The effect of larvae feeding on yield of both cultivars depended on the total number of fruit/tree mainly.

Indroduction

The filbert leafroller, *Archips rosanus* (L.) (*Lep., Torticidae*) is a key pest of fruit trees, small fruit bushes (Koślińska, 1970, 1978; Koślińska and Markowski, 1978; Krakowiak, 1974; Łabanowski, 1979) and on ornamental crops in Poland (Burdajewicz and Kokot, 1978).

Material and methods

The apple trees about 10 year old of two cultivars: Jonathan and Wealthy with 5, 10 and 20 egg masses/tree were infested in first days of April were infested. After five weeks the number of eclosed larvae was counted, amounting about 45 larvae/egg mass. In the middle of July the number of damaged fruitlets and leaves as leafrolls was estimated on each tree. The leaf damage was determined in samples of 50 leaf rosettes/tree, according to 7-degree scale, where 1-st degree means undamaged leaves and 7-th degree expressed 81-100% damaged leaf area. At harvest all fruit on trees were checked and the number of damaged fruits by the filbert leafroller was scored.

Results

The results showed that the size of leaf damages was related to density of larvae per tree for cv. Wealthy only (Tab.1). Positive correlation for cv. Wealthy between the number of larvae per tree and the number of leafrolls was found ($Y = 0.063X + 17.371$ $r = 0.731^{**}$), and the number of damaged leaves ranged from 20.3% at density 5 egg masses/tree to 33.3% at level of 20 egg masses/tree, however the total damaged areawas not larger than 5%. Significant correlation was found between the number of damaged fruit and the number of total fruit/tree for both cultivars, which expressed for cv. Wealthy as $Y = 0.406X + 12.163$ $r = 0.954^{**}$) and for cv. Jonathan as $Y = 0.081X - 0.8.222$ $r = 0.560^{*}$. However the number of damaged Jonathan apples was independend on the level of larvae contradictory to cv. Wealthy (Tab.2)). For both cultivars high significant correlation was found between the total number of inflorescences/tree and the total number of fruits/tree, expressed as the linear equations for cv. Wealthy ($Y = 0.713X + 44.882$ $r = 0.914^{**}$) and for cv. Jonathan ($Y = 0.548X + 471.969$ $r = 0.563^{**}$).

Conclusions

1. Damage of apple fruit by filbert leafroller larvae depended on the total number of fruit/tree mainly and the apple yield is significantly correlated with the number of inflorescences/tree.
2. Larvae eclosed from five or more egg masses deposited on trunk tree caused severe damage of cv. Wealthy and insignificant ones cv. Jonathan leaves.

Table 1. The effect of filbert leafroller larvae feeding on apple leaf damage

No. eggs masses/tree	No. larvae eclosed/tree		No. leafrolls per tree		Degree damage of leaves *	
	Wealthy	Jonathan	Wealthy	Jonathan	Wealthy	Jonathan
0	Check		21.4 a	21.1 a	1.21 a	1.16 a
5	183.9 a	93.7 a	35.0 ab	24.3 a	1.44 b	1.16 a
10	485.3 b	162.2 b	38.8 b	28.9 a	1.54 b	1.15 a
20	915.3 c	345.4 c	70.1 c	27.2 a	1.77 c	1.16 a

Remark: means followed by the same letter are not significantly different (P=0.05) according to t-Duncan's multiple range test
* 1 degree - undamaged leaves, 2 degree 1-5% damaged leaf area

Table 2. The effect of filbert leafroller larvae feeding on apple yield damage

No. eggs masses/tree	No. total fruits/tree		No. damaged fruits/tree		Yield damage in %	
	Wealthy	Jonathan	Wealthy	Jonathan	Wealthy	Jonathan
0	207.1 ab	1074.8 a	92.6 ab	89.2 a	44.8	7.3
5	245.2 b	947.6 a	121.3 b	71.8 a	48.4	5.8
10	315.8 b	944.9 a	137.8 b	55.7 a	43.3	6.4
20	117.6 a	1090.0 a	56.1 a	72.8 a	48.1	6.5

Remark: see under Table 1.

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EFFECT OF THE RUSTY TUSSOCK MOTH FEEDING ON GROWTH AND YIELD OF APPLE TREES CV. FANTAZJA

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Abstract

Field studies on 15 year old apple trees artificially infested by 1, 3 and 5 egg clusters per tree were carried out. The results showed that the damages of leaves on shoots are much greater than on spurs, but generally leaf damage had no effect on quantity an quality of yield. The damage of fruitlets caused by first generation of larvae and the fruit in summer made by the second generation was very important. It was found that the fruit damages slightly depended on number of larvae, but very strongly on yield size.

Introduction

The rusty tussock moth, *Orgyia antiqua* (L.) (*Lep., Lymantriidae*) is an occasional pest of apple orchards in Poland, but very dangerous in some years when it needs chemical or biological control (Dronka, Niemczyk and Olszak, 1978).

Material and methods

Apple trees cv. Fantazja 15 year old were infested with 1, 3 and 5 egg clusters per tree at the end of April, from which eclosed about 240 larvae/egg cluster, otherwise 75.5-95.3%. In June the damaged fruitlets in sample of 100 apple cluster were counted. In August the leaf damage in sample of 45 leaf of spurs and 5 shoots taken from upper part of tree was estimated according to 7-degree damage scale, where the 1-st degree means undamaged area and the 7-th degree coressponded with 81-100% leaf area destroyed. At harvest time all apples from trees were checked and the number of fruit damaged by the rusty tussock larvae was scored. The relationship between the total yield and apples damaged by larvae was determined with the linear regression method.

Results

The degree of leaf damage on shoots is much greater than on spurs (Tab.1), and the total damaged area of leaves was about 10%. This had no effect on quantity and quality of apple yield. It is in agreement with data of Łabanowski (1977), Łabanowski and Golik (1979) which showed the effects of artificial defoliation of apple trees cv. Wealthy and Jonathan.

Conclusions

1. The rusty tussock moth larvae eclosed from 3 to 5 egg clusters deposited inside tree crown damaged about 15% apple yield.
2. The intensivity of larvae feeding on fruit was significantly correlated with the density of apples.
3. The injouries of leaves by larvae are insignificant, however these on shoots are much greater than on spurs.

Table 1. The effect of the rusty tussock moth larvae feeding on leaf and fruit damages

Number egg clusters/tree	Number larvae/tree	Damaged leaf area *		Damaged yield per tree		
		spurs	shoots	No.fruitlets	No. fruit	in %
0	check	1.07 a	1.79 c	2.1 a	29.9 a	3.5 a
1	236 a	1.25 ab	2.47 d	4.0 a	42.6 ab	5.9 a
3	806 b	1.52 bc	2.59 d	10.2 b	102.2 bc	14.0 b
5	1220 c	1.48 bc	2.97 e	12.2 b	127.2 c	15.7 b

Remark: means followed by the same letter are not significantly different (P=0.05) according to t-Duncan's multiple range test
* 1 degree - undamaged leaves, 2 degree 1-5% and 3 degree 6-20% damaged leaf area

Very important were the damages of fruitlets caused by the first generation of larvae and fruit by the second generation at level infestation amounting 3 egg clusters/tree and more (Tab.1).
The size of apple yield strongly depended on the total number of inflorescences per tree, which was expressed by the linear equation $Y= 0.081X + 20.493$ ($r = 0.938^{**}$), however fruit damage was slightly related with the number of larvae per tree ($r = 0.345$), but very strongly with the yield size, which was expressed by the linear equation $Y = 0.084X + 2.859$ ($r = 0.515^{**}$).

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EFFECT OF DIFFERENT LEVELS OF THE TWOSPOTTED SPIDER MITE INFESTATION ON GROWTH AND YIELD OF BLACKCURRANT

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Abstract

The influence of blackcurrant cv. Öjebyn infestation with spider mites of four different levels under the field conditions was studied. Only the highest level of population decreased the yield quality and leaf size.

Indroduction

The twospotted spider mite (*Tetranychus urticae* Koch) is one of the most important pest of blackcurrant plantations in Poland (Łabanowska, 1992).

Material and methods

Four different levels of motile mites on blackcurrant cv. Öjebyn plots were arranged by spray-treatments and compared with untreated check. Three populations treated with chemicals from May 7 until June 16 maintained average levels 1.2; 5.5 and 9.6 motile forms per leaf, which were expressed by hiperbolic functions according to equations $Y = 1/X\ 30.714 + 3.886$ ($r = 0.927^{**}$), $Y = 1/X\ 27.167 + 0.438$ ($r = 0.986^{**}$) and $Y = 1/X\ 7.476 - 0.163$ ($r = 0.999^{**}$) respectively. Fourth level of mite population on check plot averaged 34.8 motile forms per leaf and during the observation increased according to linear function expressed by equation $Y = 0.602X + 16.828$ ($r = 0.769^{*}$).

Results

Durring current season no significant differences in yield size as related to different infestation levels of bushes were found (Tab.1).

Table 1. The effect of different levels of spider mite infestation on blackcurrant yield

Number of motile forms per leaf	Yield in kg/bush	30 strigs		Number of berries				
		berry weight in grams	number of berries	Size classes in mm				
				< 6	6-8	8-10	10-12	>12
1.2 a	0.49 a	79.0 c	108.1 c	0.7 a	5.8 b	26.1 f	49.1 h	23.3 ef
5.5 b	0.43 a	69.1 bc	92.6 ab	0.1 a	2.8 b	17.8 de	42.9 gh	27.1 f
9.6 c	0.54 a	64.2 ab	96.7 bc	0.3 a	5.0 b	26.4 f	48.9 h	14.6 cd
34.8 d	0.39 a	54.0 a	81.7 a	0.3 a	5.3 b	25.4 f	38.2 g	11.9 c

Remark: means followed by the same letter are not significantly different (P=0.05) according to t-Duncan's multiple range test.

The quality of the berry yield depended on mite density; at the highest level both weight of berries and their numbers in 30 strigs were the lowest and the number of largest berries (10 mm and more in diameter) was significantly smaller (Tab.1). These results confirmed the data on varying twospotted spider mite infestation levels on strawberry yield given by Wyman et al., 1979.
The feeding of mites at level infestations of 5.5 and higher motile form/leaf and higher significantly decreased leaf growth (Tab.2).

Table 2. The effect of different levels of spider mite infestation on blackcurrant leaf size

Number of motile forms per leaf	Average leaf size in cm	
	length	width
1.2 a	9.7 c	9.8 c
5.5 b	9.,3 bc	9.6 c
9.6 c	8.8 b	8.9 b
34.8 d	8.2 a	8.1 a

Remark: see under Table 1.

Conclusions

1. The level of twospotted spider mite level infestation amounting 5 and more motile forms per leaf significantly affected the quality of yield of blackcurrant cv. Ojebyn, but was insignificant on quantity of yield is concerned.
2. The twospotted spider mite level infestation amounting about 10 and more motile forms per leaf significantly decreased the size of blackcurrant leaves, both length and width.

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SOME ASPECTS OF *PSEUDAULACASPIS PENTAGONA* (TARGIONI TOZZETTI) (HOMOPTERA: DIASPIDIDAE) BIOLOGY, IN RELATION WITH CLIMATIC CONDITION, USEFUL TO DEVELOP A FORECASTING MODEL

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ABSTRACT - Various observations on the biology of *Pseudaulacaspis pentagona* (Targioni Tozzetti) (Homoptera: Diaspididae) were carried out in field and laboratory conditions in order to improve defence strategies and develop a forecasting model. To assess the developmental rate of each stadium, constant temperature readings were taken and the moulting process was examined in slide-mounted specimens by analysing the detachment of the new cuticle from the old one or the renewal of stylets. The reproductive potential was investigated by recording the duration in days of egg-laying, and counting the number of eggs produced daily. The aim was to develop a population forecasting model.

INTRODUCTION

The availability of a forecasting model for the White Peach Scale, *Pseudaulacaspis pentagona* (Targioni Tozzetti) (Homoptera: Diaspididae), may be important to choose the best time to carry out onerous samplings to decide control strategies (Benassy *et al.*, 1983). Moreover, the availability of a forecasting model could be a very useful tool to study new control strategies in peach orchards. Therefore the aim of this work is to collect and to quantify information, not available in literature or that need more verification, on the biology of this scale. The collected data will be useful to develop a forecasting model.

MATERIALS AND METHODS

The research has been carried out in peach orchards, and mainly in climatic chambers, breeding *P. pentagona* at different constant temperatures (21, 24, 26 °C), 65-70 % R.U. and 16:8 light-dark period on potato tubers. To obtain contemporary specimens the crawlers were allowed to spread on new fresh tubers only for less than 24 hours; then the potatoes were set apart and crawlers not yet settled were removed. Starting from a few days later, some specimens were collected daily and slide mounted using Hoyer's medium for a light microscope observation. Every specimen was classified considering the evolution in time of some anatomical and morphological characters, such as the detachment of the cuticle and the renewal of stylets. Male and females were considered separately.

In mated females also the oviposition was checked and the presence of new crawlers recorded. A few mated female specimens were also used for histological studies on the evolution of the ovarians.

RESULTS

At the beginning degree-days were used to characterize some aspects of *P. pentagona* phenology in field conditions: especially crawlers hatching and adult males emergence (Mazzoni & Cravedi, 1995). Later, to develop a more accurate model, the measurement of the developmental rate of each stadium of *P. pentagona* reared at a constant temperature was begun. Using this method with more than 4000 females and more than 5500 males we assessed the developmental rate at 24 °C. The collected figures point out that contemporary specimens have very different developmental time. The first moult in females occurs in a period ranging from 9 to 15 days after the crawlers' birth. The first adult females appear 21 days later after the beginning of the cycle; but 10 days more are needed to have the 95 % of the females in the adult stage. Males' development is much more variable: while the transition from the first to the second stage occurs more or less as in females, following moults are widely scattered in time, so that, when the first emerging males were found (21 days) second stage larvae were still present and developing.

The oviposition was checked at 26 °C, to integrate figures from other researchers that collected data at the same temperature (Ball, 1980; Park & Kim, 1990). With consecutive observations the reproductive potential and the number of eggs laid daily by females according to their age was assessed. Data collected till now are not complete but show that the first eggs are laid by 40 days old females. The maximum of egg laying, on the average 9.3 ± 5.1 eggs/female/day, was recorded in 50-day-old specimens. Very few eggs, on the average less than 1 egg/female/day, are laid by 60-day-old females. The first crawlers were found near 45-day-old scales. At 21 °C and 24 °C the first crawlers of the new generation appear respectively 60 and 50 days after the beginning of the cycle.

Preliminary observations on the anatomy and histology of ovarians in mated females confirm data from other authors (Tremblay, 1958): the embryonic development occurs partly inside the mother's body and the variability in the development of eggs between contemporary specimens is always very high.

CONCLUSIONS

To set up a mathematical model for a pest development is not only to get a tool (a demographic model) to increase the efficacy of the treatments; but also to improve our knowledge of the insect. The need to quantify biological events and to improve data collecting methods incite us to better understand the observed phenomena and point to new questions such as: quantify the growth of the ovary; check when the diapause is broken in overwintering females; evaluate the effect of high temperatures on White Peach Scale survival; measure the influence of the different mating times between females on the egg laying.

The next goal will be also to consider also the effects of biotic antagonists on the reduction of *P. pentagona* populations, to obtain a tool to asses integrated production strategies.

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FIRST NOTE ON PLUM SAWFLIES IN EMILIA ROMAGNA (NORTHERN ITALY)

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SUMMARY

Research was carried out in Emilia Romagna in order to assess the economic importance of plum sawflies. The study started in 1989 and involved 67 plum orchards; 2-8 white sticky traps per orchard, model Rebell® were placed before flowering, and checked until fruit setting.

In addition to the assessment of the species present, a study to define an economic threshold, based on adult catches, was performed in 1991-93.

The sex-ratio of trapped adults and the level of infestation in terms of number of eggs on flowers were taken into consideration.

Hoplocampa flava L. was the most widespread species in the region, and an interesting relationship between adults trapped and percentage of flowers with eggs was pointed out; no such a relationship was noticed for the other species.

A tentative threshold can be 80 adults per trap per season but, as the percentage of damaged fruits depends on the number of fruits set, other observations could be necessary. Chromatotropic traps can make, however, a substantial contribution to the forecasting of hazardous situations.

INTRODUCTION

Sawflies (*Hoplocampa* spp.) can occasionally cause heavy damage to plum fruits in northern Italy; among the three species reported on this crop - *H. flava* L., *H. minuta* Christ. and *H. rutilicornis* Klug (Servadei, 1941; Roberti, 1950; Nucifora, 1958) - the first two seem to be more widespread in northern Italy and the third one in southern. The adults can be trapped on white sticky boards (Blaisinger, 1975); Wildbolz and Staub (1984 and 1986), studied the possibility of defining a threshold based on trap catches in Switzerland. In 1989 a study had been started to evaluate the distribution and harmfulness of sawflies in Emilia-Romagna (northern Italy).

MATERIALS AND METHODS

In 1989, 1991, 1992 and 1993 white sticky traps Rebell® had been delivered to technicians of Regional Project for IPM of Emilia Romagna; the traps have been placed in the orchards in the first half of March and cecked till the end of blossoming. In 1991-93 the species and sexes had been separated, to find out their occurrence in different locations; trials have been also carried out to study the possibility of defining a threshold based on trap catches. The number of adult trapped has been put in relation with the number of flowers with eggs.

RESULTS

Data of 147 traps from 67 farms have been considered. As a whole 5504 adult sawflies were counted.

In 47 farms, in which different species have been separated, 2614 adults of *H. flava* (*sex-ratio* 1.3-1) and 1213 of other species, mainly *H. minuta* (*sex-ratio* 2.1-1) have been found. In 19 orchards only adults of *H. flava* have been collected, in 26 *H. flava* with other species, in 1 orchards only *H. minuta*, in 1 other no catch has been recorded.

The level of catches has been higher for *H. flava* (tab. 1).

catches/trap	frequency	
	H. flava	*H.* spp.
0	14	48
1- 5	30	27
6-20	25	11
21-50	14	3
> 50	12	8

Tab. 1 - Frequency of different catch levels for *Hoplocampa* species

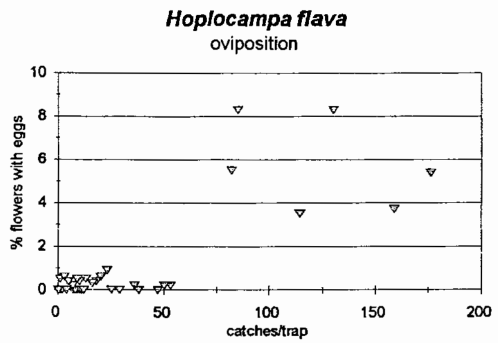

Fig. 1 - Relationship between catches per trap and number of flowers with eggs of *H. flava*

Catches of *Hoplocampa flava* up to 50 adults during flowering period were followed by an oviposition on 1% or less of flowers, while higher levels of catches gave 4-8% of flowers with eggs; no such a relationship was found considering the other species.

CONCLUSIONS

Hoplocampa flava is the most widespread species in the area considered, having been found in all but 2 farms. Trap catches show a good correspondence with the level of oviposition, only considering this species: when other species are taken into account, the correlation becomes worst, as found by Wildbolz and Staub (1984). Chromatotropic traps can make a substantial contribution to the forecasting of hazardous situations: a starting point can be to lower the threshold suggested by these authors to 80 adults per trap, but the percentage of damaged fruits depends on the numbers of fruits set, which is hard to predict. So, when fruit setting is particularly poor or with particularly prized cultivar, oviposition and the first damage must be controlled.

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INFESTATION OF NOCTUID LARVAE IN PEACH ORCHARDS IN NORTHERN ITALY

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SUMMARY

In some peach growing areas in Piedmont (Northern Italy), damages to fruits by Noctuid larvae were recorded in the last years. Damages were up to 40% of total yeld.

The species involved were: *Peridroma saucia, Mamestra brassicae, Axylia putris, Xestia c-nigrum* and *Diataraxia oleracea,* with a greater abundance of *Peridroma saucia, Mamestra brassicae* and *Axylia putris.*

Nocturnal inspections of the trees to find active larvae and monitoring with pheromone traps were poorly significant; ground examination gave data concordant with previous infestation on fruits.

The orchards concerned had a grass cover, that was as high as lower branches of the trees, where damaged fruits were mainly found.

All the species found are polyphagous and some of their host plants were present in the orchards concerned; this is probably one of the major factors influencing the attacks.

INTRODUCTION

In the last years Noctuid larvae caused damages (up to 40% of total yeld) to fruits in some peach orchards in Piedmont (Northern Italy).

Previous reports can be found in the literature: *Mamestra brassicae* (Linnaeus) (Bongiovanni, 1959; Sansavini, 1961; Ugolini, 1966) and *Peridroma saucia* (Hübner) (Castellari, 1976) were found on peach and nectarine fruits. Other species, as *Agrotis ipsilon* (Hufnagel), have been on occasion injurous to vegetable cultivations (Castellari and Ugolini, 1970).

We have thought it suitable to make deeper observations in order to identify the responsible species and find out, if possible, the cause of such a behaviour.

MATERIALS AND METHODS

The research was carried out in 1990-92 and has been based on samplings:

- of adult insects with pheromone traps
- of active larvae on damaged trees
- of larvae and chrysalis at the base of the trees, digging in the soil 15-20 cm deep. Larvae and chrysalids caught with samplings were reared separately to verify the exact identification.

Controls have been done every fifteen days, firstly in the orchards were damage had been evidenced, then a wider number of orchards have been involved in the sampling.

Pheromone traps were placed for the following species of Noctuidae, reported in literature as occasional pests of fruit trees: *Mamestra brassicae* (Linnaeus), *Diataraxia oleracea* (Linnaeus), *Mythimna unipuncta* (Haworth), *Peridroma saucia* (Hübner), *Agrotis ipsilon* (Hufnagel) and *Agrotis segetum* (Denis & Schiffermüller).

Results

Catches with pheromone traps have been extremely low, both in heavy damaged orchards and in undamaged ones. The relationship between presence of adult Noctuids and infestation is therefore impossible to be established.

Inspections of active larvae have been unsatisfactory, even during the night. Several larvae and above all of chrysalis were found during ground examinations at the base of the trees.

The first erosions on fruits were found in mid July and the activity of the larvae lasted till the end of August.

In damaged orchards larvae and chrysalis of the following species of Lepidoptera Noctuidae were found: *Peridroma saucia*, *Mamestra brassicae*, *Axylia putris*, *Diataraxia oleracea*, *Xestia c-nigrum*. The most represented of them were *Mamestra brassicae*, *Peridroma saucia* and *Axylia putris*.

Larvae preferred mature or ripening fruits; there was not a clearcut evidence that nectarines were more attacked than peaches and no particular difference between cultivar was noted.

Fruits on the low branches were mostly damaged, particularly when near the soil and in contact with the grass under the trees. More than one attack per fruit can be found, near the stalk or at the base; the damage can attain a portion of the fruit up to 1-2 cm wide.

Conclusions

In the orchards, adventices can influence the presence of different species of Noctuid larvae. Larvae, usually feeding on grasses, can climb on trees in particular conditions, and cause severe damages. From mid July to late August larvae can be active on fruit crops.

Some conditions can favour the presence of damages:

- proximity of woods, rivers and streams;
- grassy headland and edge with thick wild plants;
- presence of adventices under the trees, particularly when in contact with lower branches;
- lower branches of the trees touching the ground.

Some treatments can reduce the risk of damage on fruits:

- mowing wild vegetation before ripening of the fruits or a timely application of insecticides under the trees can prevent the climbing of larvae.

Among suitable products, *Bacillus thuringiensis* preparations are to be preferred, in particular the new Kurstaki strains (es. SA11), that are more effective against noctuid larvae than HD1 strains.

Treatments on the foliage can be done with products used against *Cydia molesta*; the latter strategy is advisable only when the larvae are already on peach trees, but in any case their efficacy is modest.

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THE OCCURRENCE, SPECIES COMPOSITION AND EFFECTIVENESS OF PREDATORY MITES (*Phytoseiidae*) TO TWO SPOTTED SPIDER MITES (*Tetranychus urticae* Koch.) APPEARING ON BLACK CURRANT.

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SUMMARY

The experiment on effectiveness of 3 predatory mite species (*Phytoseiulus persimilis, Neoseiulus fallacis, Typhlodromus pyri*) and their mixture, in controlling *Tetranychus urticae* on black currant plantation, was conducted in south part of Poland.
The predators were introduced only once in first year of experiment. During 2 years the plantation was inhabited by other native species of Phytoseiids (mainly *Euseiulus finlandicus*) which almost entirely displaced the introduced predatory mites. The native predators kept *T.urticae* population on very low level during whole season.

INTRODUCTION

Tetranychus urticae Koch. is considered as one of most important pests of black currants. Thus majority of black currant plantations in Poland has to be sprayed several times a year against two spotted mite. But used acaricides, beside pest control, create also several disadventagues.

OBJECTIVES

- To estimate the effectiveness of three Phytoseiid species: (*Phytoseiulus persimilis, Neoseiulus fallacis, Typhlodromus pyri*) in the control of two spotted spider mite (*Tetranychus urticae*) on black currant.
- To state whether introduced Phytoseiid species may overwinter on plantations and increase their population to high level during the year.

METHODS

The experiment was established on small (0.1 ha) 6 year old unsprayed plantation located in mountain region in the point souronded with rich vegetation (meadow, forest). The observations were conducted for 2 years.

Five treatment were included:
Treatment 1 - mixture of 3 predatory species (*P.persimilis + N.fallacis + T.pyri)* introduced in amount 25 specimens of each, per bush
Treatment 2 - *P.persimilis* - 75 specimens /bush
Treatment 3 - *N.fallacis* - 75 specimens /bush
Treatment 4 - *T.pyri* - 75 specimens /bush
Treatment 5 - Check - no introduction of Phytoseiid

All predatory species were introduced only once in early June 1993. Each treatment was represented (in 1993) by 4 bushes. The bushes of each treatment were isolated from the other treatments by two rows of black currants.

Since June (1993) or May (1994) through whole vegetation season, the leaf samples were randomly taken from black currant bushes in about 2 week intervals and mobile stages of *T.urticae* and Phytoseiids were counted under stereomicroscope.

RESULTS

During the first year of experiment (1993), beside introduced predatory species, also the other native Phytoseiids occurred on experimental black currant bushes. The *T.urticae* population found on the bushes representing particular treatments was low and only in three treatments (2, 3 and 4) this species overcrossed threshold level in few occasions (Fig.1)

In the lowest numbers phytophagous mites occurred on the bushes inhabited by the mixture of three Phytoseiid species (treatment 1) (Fig.1).

The number of Phytoseiid predators on all treatments were usually distincly lower comparing to the number of the observed pest (*T.urticae*) (Fig.1).

In next year (1994), *T.urticae* on bushes representing particular treatments appeared in very low numbers, much bellow the threshold level. At the same time, the Phytoseiids were more numerous then *T.urticae*.

It was also observed that introduced Phytoseiid species were almost entirely displaced by 7 native species. Among them the most abundant was *Euseiulus finlandicus* and then *Typhlodromus rhenanus*, *Amblyseius bryophilus* and *Amblyseius andersoni*.

CONCLUSION

In Polish conditions on the unsprayed currant plantations surrounded by a rich vegetation, native Phytoseiid species may control very efectively the two spotted mite (*Tetranychus urticae*).

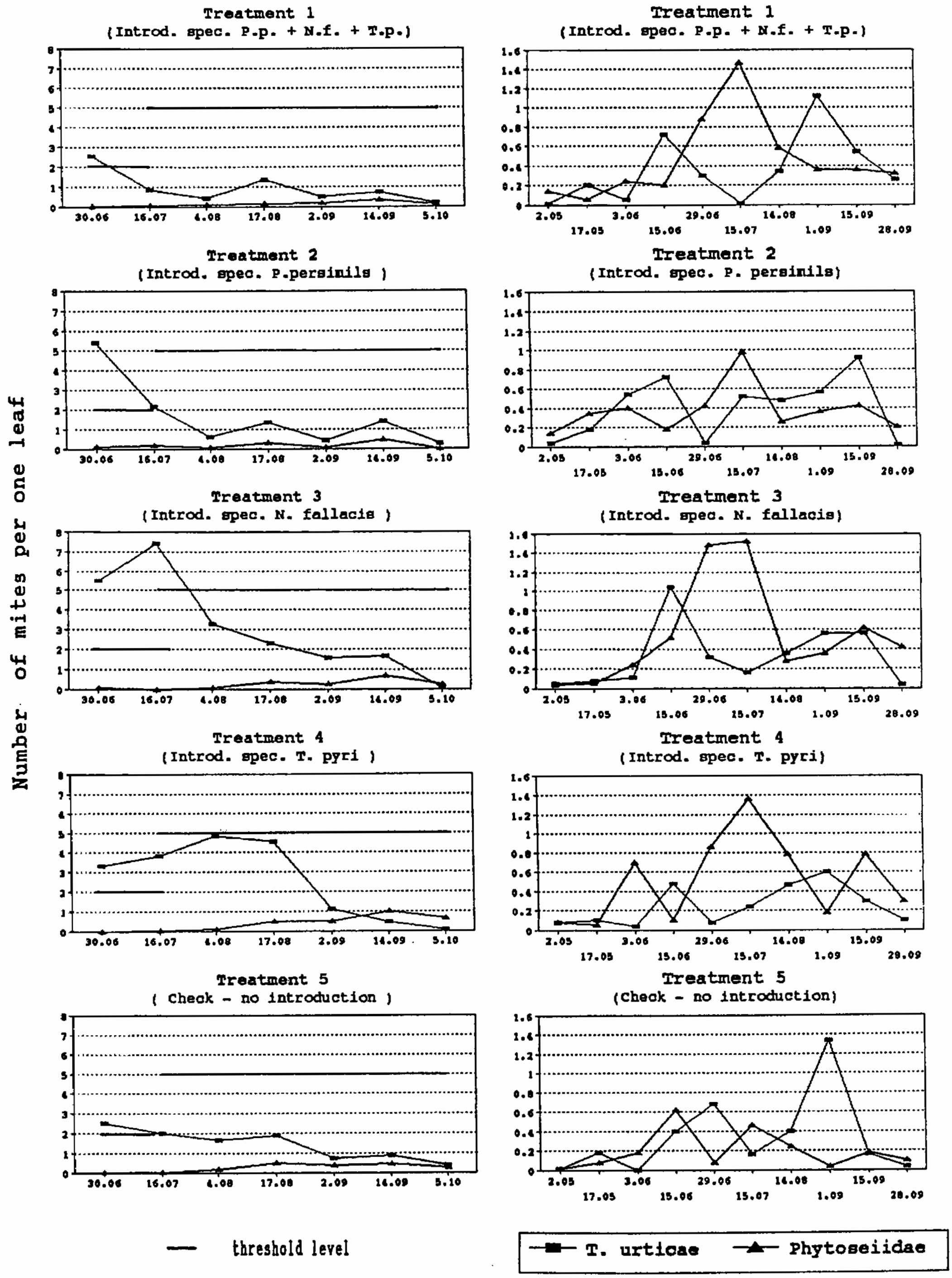
Fig.1

Occurrence of *Tetranychus urticae* Koch. and introduced + native Phytoseiids on black currant plantation. Skrudzina 1993.

Fig.2

Occurrence of *Tetranychus urticae* Koch. and native Phytoseiids on black currant plantation. Skrudzina 1994.

Note diffrent scales for particular years



SITUATION AND IMPORTANCE OF SAN JOSE'-SCALE PARASITATION IN AUSTRIA

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Abstract Up to 1978 a programme for biological control of Quadraspidiotus perniciosus with mass reared Prospaltella perniciosi was carried out. In the present situation all investigated Qu. perniciosus populations showed acceptable parasitation rates (from 11% up to 63%, mean 30%). On many sites the endemic endoparasitic wasp Aphytis sp. has a higher importance than Prospaltella.

Introduction

The first records of San Jose'scale *Quadraspidiotus perniciosus* in Austrian orchards go back to 1931. Endemic parasites of other scale insects seemed to be rather inefficient as a regulative for *Qu. perniciosus*. Böhm reported 1963, that in Austria natural occurring species of Chalcidoidea wasps cause only parasitation rates of 0,5 % up to 2 % as maximal value.
In the sixties in Austria like in other European countries a mass rearing of the very effective San Jose' scale parasitoid *Prospaltella perniciosi* for biological control of *Qu. perniciosus* in infestation areas was established. In 1978 the mass rearing and the activities for biological control of Qu. perniciosus were discontinued.
Since 1990 the importance of *Qu. perniciosus* as a pest in commercial orchards raises again. In this situation it is of interest to know, if there is still a considerable and effective population of parasitoids especially of P. perniciosi in infested areas. If not, a re-establishing of P. perniciosi mass rearing would be a chance to support chemical treatments by biological control.

Materials and Method

In summer fruits, shoots and pieces of bark with dense population of scale insects were collected from trees in orchards with Qu. perniciosus infestation. The samples were stored cool. In the lab the scale insects from the samples were prepared under the binocular and then heated up in 70% ethanol for 20 minutes followed by a 20 minute bath in warm lactic acid. The insects were stained with a mixture of histological colours and mounted on slides in Marc Andre II solution. The slides were estimated insect by insect under the microscope and the rate of parasitation analysed.

Results

From 21 sites samples were analysed exactly. All examined San Jose' scale populations showed parasitation rates on unexpected high levels. The parasitation rates in % are summarised in the table. In addition to the endoparasitic wasp *P. perniciosi* in a lot of samples ectoparasitic wasps of the genus *Aphytis* could be found (presumably the species *A. proclia*, but because of the mode of preparation no adults are available for determination).

SAN JOSE SCALE PARASITATION IN AUSTRIAN ORCHARDS

	PARASITATION RATE IN %		
	in total	**P. perniciosi**	**Aphytis sp.**
old orchards with P. perniciosi establishment in the seventies			
Riegersdorf	**40 %**	**36 %**	**4 %**
Zelting	**17 %**	**17 %**	-
commercial fruit orchards			
Lutzmannsburg 1	**63 %**	**63 %**	-
Lutzmannsburg 2	**30 %**	-	**30 %**
Podersdorf	**25 %**	**18 %**	**7 %**
Neusiedl /S.	**16 %**	**1 %**	**15 %**
Markt Hartmannsdorf	**53 %**	-	**53 %**
Nitschaberg	**26 %**	**18 %**	**8 %**
Pöllau	**48 %**	**46 %**	**2 %**
Lieboch	**19 %**	**18 %**	**1 %**
Puch	**30 %**	**30 %**	-
Brunnkirchen	**29 %**	**5 %**	**24 %**
Rossatz	**32 %**	**20 %**	**12 %**
Thallern	**26 %**	**18 %**	**8 %**
Sittendorf	**11 %**	**11 %**	-
Rührsdorf	**15 %**	**14 %**	**1 %**
extensive orchards			
Mautern	**33 %**	-	**33 %**
Gösing	**13 %**	-	**13 %**
Markt Hartmannsdorf	**57 %**	**57 %**	-
Gersdorf	**20 %**	**20 %**	-
private gardens			
Neu Essling	**12 %**	**6 %**	**6 %**

Discussion

Of course such investigations show only snapshots of the population dynamics of *Qu. perniciosus* and its parasitoids. But the high parasitation rates created by *Aphytis* point out the importance of this ectoparasite. On many sites the endemic parasitic wasp *Aphytis sp.* has a higher importance than Prospaltella perniciosi.
The data indicate, that the present increased importance of *Qu. perniciosus* is not a result of supposed reduced occurrence of parasitic wasps. The other way round the parasitoids help to reduce the fast propagation of San Jose'scales in the orchards. It could be seen, that over some years the *Qu. perniciosus* infestation in commercial orchards can be limited to some single trees with a relatively high parasitation rate of the scale insects at the same time.

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The outbreak in the IPM plot was caused by the following factors:

1. warm and dry weather, continuous from 1992 (HTQ values for the vegetation period of the years 1992 -1994 were 0.53 - 0.59, cf. the corresponding formula),
2. lack of effect of selective pesticides used.

In 1994, in a sour cherry plantation we set up a preliminary experiment to investigate the effect of some pesticides against *Stephanitis pyri*. The "green" pesticides Insegar (phenoxicarb, 0.06 %), Match (luphenuron, 0.05 %), and Cascade (fluphenoxuron, 0.1 %) proved ineffective. The "yellow" pesticide Trebon 10 F (etophenprox, 0.1 %), and the "red" Danatox 50 EC (methylparathion, 0.2 %) were found to be effective.

On the basis of the preliminary results, in 1995, in the IPM plot we could stop the build-up of the dense starting population and prevent the outbreak of *Stephanitis pyri* by spraying Trebon 10 F. According to the guide of the producing firm this pesticide can successfully be used against *Eurygaster* spp., *Corythuca ciliata* and *Aelia* sp., and is not harmful to the predaceous mites and various useful insects.

Acknowledgements

We thanks Cs. Erdélyi for reading our manuscript, as well as Gyöngyi Nyiri, Mária Hornok and Krisztina Mihályi for the help in accomplishing the experiments. This experiments were supported by USDA (agreement number 58-319R-3-022) and by the Hungarian Scientific Foundation OTKA (agreement number 1436).

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STEPHANITIS PYRI (F) AS A SECONDARY PEST IN AN IPM APPLE ORCHARD

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Abstract

In Hungary *Stephanitis pyri* was mainly a pest of apple trees standing in abandoned sporadic orchards. While conventional, organophosphorous esteric insecticides were used, no damage caused by *Stephanitis pyri* was noted.

After selective, environment safe technology was introduced, under weather conditions suitable for build-up of population of *Stephanitis pyri*, in 1994 inside the IPM plot an outbreak was observed, with considerable damage done to the leaves.

In the experiments accomplished in a sour cherry plantation the "green" insecticides Insegar, Match and Cascade 5 EC showed no effect against *Stephanitis pyri,* while the "yellow" Trebon 10 F (etophenprox 0,1 %) suppressed it successfully.

In apple plantation, in the spring of 1995 owervintered population of *Stephanitis pyri* caused severe leaf damage. However, increase of its density could be stopped by using Trebon 10 F.

Introduction

In Hungary *Stephanitis pyri* (F.) was a pest of abandoned orchards and sporadic fruit trees not treated with insecticides. In the conventional orchards organophosphates provided complete protection against it, preventing its propagation and the damage caused by it.

In 1992 we introduced a selective, environment safe technology in an apple orchard. Density of *Stephanitis pyri* gradually increased during the 3 years of experiments, which led to an outbreak in the IPM plot, with considerable leaf damage caused.

Various insecticides were tested for preventing the build-up of population of *Stephanitis pyri.*

Methods

1. Beating

Sampling was made weekly from the second half of April to early October. One branch of each of six neighbouring trees was beaten with five repetitions in each of the traditionally treated and the IPM plot, i.e. 2 x 30 = 60 trees were sampled. Arthropods that fell onto a plastic sheet of 400 by 610 mm from the same foliage surface were collected.

2. Counting the leaves damaged within a standard time period

Results

During the 3 years of the experiments the density of *Stephanitis pyri* continuously increased. In 1994, in the IPM plot an outbreak occurred, causing striking leaf damage. In 1995, at the same site, a considerable starting population was found, and, as a consequence, marked leaf damage was observed again. Density also increased in the conventionally treated plot but the increase was not significant compared to the IPM plot, and leaf damage did not occur.

POSTERS

Section: Application Technique

Deposit and Loss of Spray in Orchard as Affected by Spray Discharge System and Air Jet Setting.

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ABSTRACT

Three sprayers: conventional, cross-flow and directed air jet were used in orchard to compare spray deposit within the canopy of apple trees and off-target loss obtained at different air jet settings. Each of three sprayers was set at two air jet parameters and three spray volumes: 150, 200 and 300 l/ha. The highest spray deposit and the lowest loss were obtained for directed air jet sprayer. Increase in velocity and volume of air jet caused higher deposit in the canopy but, for cross-flow sprayer, also higher loss of spray. The off-target loss caused by conventional sprayer was higher than that from the other sprayers. No significant effect of air jet settings on spray deposit and loss was observed for conventional sprayer.

Key words: air-assisted application techniques, spray deposit, off-target loss.

Introduction

The air sprayer jet which is to transport and deposit the spray particles on the target affect the quality of application and the spray loss (Wiedenhof, 1991). The arrangement of the fan outlets, namely spray discharge system, determines the air jet direction and finally upper and lower limits of liquid distribution. The more target-matched discharge system the more precise application of spray, more uniform liquid distribution and less spray loss (Derksen, 1993). Both direction and velocity of the air jet can be adjusted in most of the sprayers presently being manufactured. The air jet settings should be, like the spray volume, adjusted according to the geometry and density of the target. Both too strong and too weak air jet may cause inadequate deposit, uneven distribution and increased spray loss (Raisigl & Felber 1991). Thus, the proper calibration of the sprayer is a must if it is to meet the general requirements of IPM about the effective use of pesticides.

The objective of the study was to determine the influence of spray discharge system and air jet setting such as jet velocity and volume on spray deposit within the apple tree canopy and off-target loss.

Materials and Methods

Three sprayers of different spray discharge system were used: conventional sprayer - radial air discharge, cross-flow sprayer - horizontal air discharge, directed air jet sprayer - converging air discharge. Each of three sprayers was set at two air jet parameters (see Table 1) and three spray volumes: 150, 200 and 300 l/ha.

Apple trees of Lobo cv. (height - 2.6 m; width - 1.7 m) were sprayed with fluorescent tracer. Spray deposit and loss were evaluated by analyzing artificial samples located as follows: 7 samples on the leaves (upper and lower surface) in selected areas of the tree canopy, 3 samples on the soil, under the tree, and 8 samples on the vertical frame located right behind the tree (Fig. 1).

RESULTS AND CONCLUSIONS

The results (average for spray volumes 150, 200 and 300 l/ha) are shown in table 1. Directed air jet sprayer with converging spray discharge system caused the highest deposit within the tree and the lowest spray loss despite of three times lower air volume than that produced by two other sprayers. With directed air jet sprayer higher velocity of jet caused higher deposit in the tree without any increase in the spray loss while for cross-flow sprayer (horizontal spray discharge) it resulted in both higher deposit in the tree and higher spray loss. The loss of spray caused by conventional sprayer (radial spray discharge) was higher than that from the other sprayers. No significant effect of air jet setting on spray deposit in the tree and loss was observed for conventional sprayer.

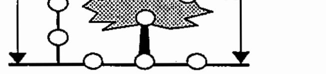
Adequate deposit within the tree canopy and reduction of spray loss is possible with precise, converging spray discharge system even at relatively low volume of the air jet.

Table 1. Deposit of spray in the apple tree canopy and loss to the soil and frame during treatments with different emission systems and air jet settings.

SPRAY DISCHARGE SYSTEM Air jet setting	Deposit [nl/cm²] Tree	Soil	Frame
RADIAL			
I: 15 m/s; 17250 m³/h	162 bc	204 ab	194 a
II: 20 m/s; 23700 m³/h	155 bc	220 a	166 a
HORIZONTAL			
I: 18 m/s; 17000 m³/h	139 c	237 a	92 c
II: 25 m/s; 27000 m³/h	217 ab	257 a	155 ab
CONVERGING			
I: 20 m/s; 5350 m³/h	158 bc	289 a	110 bc
II: 30 m/s; 8000 m³/h	235 a	136 b	106 bc

Means in columns followed by a common letter do not differ significantly (Duncan's Multiple Range Test, P=0.05)

Figure 1. Location of artificial samples for spray deposit evaluation.



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COMPARISON OF APPLE SCAB CONTROL WITH TRADITIONAL AND TUNNEL SPRAYERS AT FULL AND REDUCED CHEMICAL RATES

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ABSTRACT

Biological efficacy of apple scab (*Venturia inaequalis*) control on Gloster/P2 - 4,0 x 2,5 m was evaluated for three sprayers: tunnel with directed air-jet discharge system, tunnel with cross flow fans and standard directed air-jet sprayer. The trees were treated 7 times at spray volume 250 l/ha and 100 %, 50 %, 25 % rates of chemicals. The percentage of leaves infected by apple scab was 1,2 - 3,4 % for the tunnel sprayers and 0,2 - 0,5 % for directed standard air- jet sprayer. The difference in scab control efficacy for the sprayers may be explained by different air-jet discharge system affecting spray deposit pattern in the tree canopy.

Key words: tunnel sprayer, apple orchard, apple scab, biological efficacy.

INTRODUCTION

Tunnel sprayers are better suited to modern orchard chemical control than traditional sprayers. Spray drift and hence environmental contamination can be significantly reduced due to recirculation system used in the tunnel sprayers. Results of experiments (Cross and Berrie 1993; Heijne *at al* 1993; Sigfried and Hollinger 1994) show that apple scab (*Venturia ineaqualis)* control with tunnel sprayers was as effective as that with traditional air assisted sprayers. Air-jet discharge system used in the tunnel may affect spray deposit pattern an hence control efficacy (Hołownicki *at al* 1995).

Objective of this study was to compare the biological efficacy of apple scab control obtained with tunnel sprayers equipped with different air-jet discharge systems and standard directed air jet sprayers.

MATERIALS AND METHODS

The experiment was carried out at Experimental Orchard in Skierniewice on fully established apple trees Gloster cv. planted 4,0 x 2,5 m (height - 2,8 m; width - 1,7 m).Spray timing was based on critical infection periods of apple scab. Meteorological data were collected by the automatic weather station Metos-DAT. The fungicides were used at 100; 50 and 25 % of recommended doses.The spray volume was 250 l/ha and travel velocity 4,3 km/h. Apple scab assesments were made on 200 leaves picked from two trees in each of four replicates for each treatment. Three observations during the season were made.

RESULTS AND CONCLUSIONS

The control of apple scab (table 1) was generally satisfactory (below 5 %) for all the treatments used and significantly lower than that in untreated plot.
The best results were obtained with conventional directed air-stream sprayer.

The possible explanation for lower biological efficacy of tunnel sprayers is that air stream produced by conventional sprayer can penetrate tree canopy easier than that used by tunnel sprayer.

Table 1. Mean percentage of leaves infected with scab.

	31.V	21.VI	26.VII
untreated	6,7 e	57,0 a	90,0 c
tunnel ISK			
100 %	1,6 bcd	1,9 bc	1,6 ab
50 %	2,1 cd	2,5 c	3,4 ab
25 %	0,3 ab	2,0 bc	2,1 ab
tunnel JOCO			
100 %	1,2 bcd	1,9 bc	1,5 a
50 %	2,7 d	2,9 c	4,6 b
25 %	0,5 abc	2,1 bc	2,4 ab
conventional			
100 %	0,0 a	0,1 a	1,0 a
50 %	0,0 a	0,4 ab	1,0 a
25 %	0,0 a	1,0 abc	1,4 a

Means in columns followed by the same letter do not differ significantly at P=0,05
(Duncan's Multiple Range Test)

Date of treatment	04/27	05/ 5; 12; 17	06 / 6; 13; 23
Product	Ef	Ef Ef De	PuD1 PuD2 Cap

Ef	- Efuzin	500 SC	(dodine 50 %)	-	2,5	l/ha
De	- Delan	750 SC	(dithianon 75 %)	-	0,75	l/ha
PuD1	- Punch	400 EC	(flusilazol 40 %)	-	75,0	ml/ha
	+ Delan	750 SC	(dithianon 75 %)	-	0,5	l/ha
PuD2	- Punch	400 EC	(flusilazol 40 %)	-	112,0	ml/ha
	+ Delan	750 SC	(dithanon 75 %)	-	0,5	l/ha
Cap	- Captan	50 WP	(captan 50 %)	-	4,5	kg/ha

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Comparison of two spraying techniques in the control of twospotted spider mite (*Tetranychus urticae*) and grey mold (*Botrytis cinerea*) on strawberry

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INTRODUCTION

Strawberry is one of the most important small fruit in Poland (production about 200 000 ton a year). The yield is reduced by some pests and diseases, which have to be controled every year. Spray application technique influences spray coverage uniformity and pests and diseases control effect. For control of strawberry mite the youngest leaves have to be covered, for control of twospotted spider mite, both sides of the older leaves need to be sprayed, but to control the grey mold - the flower clusters and flowers have to be treated. It means, that for chemical protection of strawberry plantations special sprayers are needed..

The aim of this work was to compare chemical control of twospotted spider mite and grey mold on strawberry with two spraying techniques.

MATERIAL and METHODS

The experiments were carried out on 2-3 year old strawberry plantations, cv. Senga Sengana at Pamiętna, near Skierniewice (Central Poland) in 1991-92. Two different sprayers were used for the control of twospotted spider mite and grey mold:

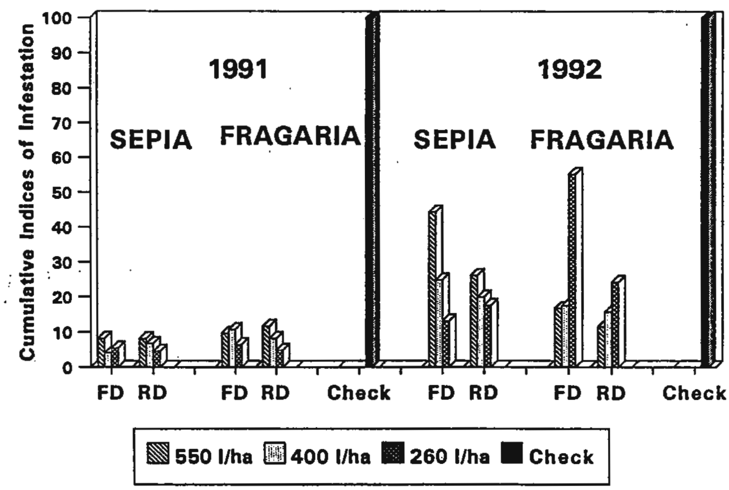
1. Pressure sprayer "Fragaria" equipped with a row-frames,discharging liquid downward from the central nozzle and horizontally from two side nozzles.
2. Prototype directed air stream sprayer, "Sepia"

Three different spray liquid volume, 260, 400 and 550 l per hectar and two doses of pesticides, standard and reduced by 25 % were tested. Spider mites were counted just before spraying, before blossom of strawberry, and 4-5 times afterwards. For control of grey mold, 3-4 treatments were made during bloom. The percent of damaged fruit with grey mold symptoms was counted 2 times during harvest. The obtained results are shown in Fig. 1-2.

RESULTS

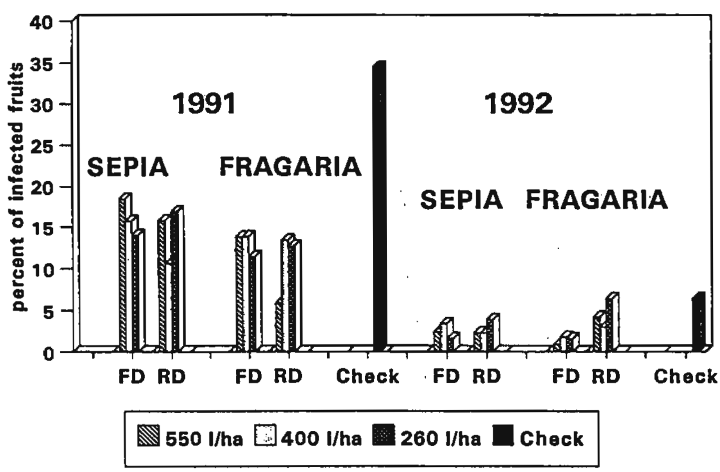
The obtained results showed, that strawberry spraying with two tested sprayers, which gave good coverage of leaves and flowers with spray liquid, resulted in good control of twospotted spider mite as well as grey mold on the strawberry plantations. The spray volumes 260, 400 and 550 l per ha were sufficient, but full dosage of pesticides must be used . The reduced dose by 25 %, gave poorer control of twospotted spider mites, and grey mold during low disease incidence in 1992.

Effectiveness of different sprayers, acaricide doses and spray volumes in the control of twospotted spider mite. Senga Sengana cv.



Terms of spraying: 1991 - 05/15 Nissorun 10 EC 0.75 l/ha - FD
1992 - 05/17 Nissorun 050 EC 0.9 l/ha - FD
RD= 25% less acaricide

Effectiveness of different sprayers, fungicide doses and spray volumes in the control of strawberry grey mold. Senga Sengana cv.
Mean values from two terms of assessment under field and laboratory conditions



Terms of sprayings: 1991 - 05/24, 29; 06/5, 12
1992 - 05/20, 27; 06/3
Fungicide - EUPAREN 50 WP /dichlofluanide/ FD= 5 kg/ha RD= 4 kg/ha

OPTIMALISATION OF RODENTICIDE APPLICATION IN ORCHARD PROTECTION

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Abstract
From 1990-1994 a high and very high population number of the *A. sylvaticus and M. arvalis* was determined in the fruit orchards of the southeast Vojvodina.A very high efficiency rate was also determined for EKOROD A, KLERAT, BARAKI, MURISAN A and ZINC-PHOSPHIDE, but in 1993 and 1994 because of a very large rodent population the product quantity used was much greater.

The experiments were made on young apple (150 ha) and peach (50 ha) orchards in southeast Vojvodina (Serbia), during arid conditions from 1990-1994.

By isolating rodents, along the trapping lines and in isolated area of 1 a, it was determined that the *Apodemus sylvaticus* prevailed by 78%, in relation to the *Microtus arvalis* (22%), which does not agree with the findings of Mike{ and collaborators (1986.), stating that the *M. arvalis* was greater in number, as there was no cyclic overrating of the *Apodemus species* over than last 30 years (Ru`i} 1983.). The results are shown in table 1.

Table 1. Rodent species count in (%) from 1990-1994.

Year	Species	Spring (Feb./Mar)		Autumn (Oct)	
		n	%	n	%
1990.	*Apodemus sylvaticus*	13	74,0	29	67,8
	Microtus arvalis	5	26,0	9	32,2
1991.	*Apodemus sylvaticus*	57	72,8	96	78,1
	Microtus arvalis	21	27,2	21	21,9
1992.	*Apodemus sylvaticus*	232	80,2	432	83,1
	Microtus arvalis	46	19,8	73	16,9
1993.	*Apodemus sylvaticus*	526	84,8	1211	82,0
	Microtus arvalis	80	15,2	218	18,0
1994.	*Apodemus sylvaticus*	1829	78,2	3059	80,1
	Microtus arvalis	400	21,8	611	19,9
Average	*Apodemus sylvaticus*	531	78,0	965	78,2
	Microtus arvalis	110	22,0	186	21,8

On the basis of active holes by mathematical correlation the dynamics of the rodent number was determined for the period of 1990-1994 (table 2.). It was established that the rodent population number had also increased during autumn of 1993. and 1994 reaches the 4th (500-2000 a.h./ha) and 5th category (2000 -10.000 a.h./ha) and in particular tables, the 6th category-calamity. We feel that overrating in autumn of 1993 and especially in 1994 occurred because of three consecutive droughtful years, less intensive agrotechnology and reduced application of rodenticides. Generally speaking , in the greater areas in Serbia (in autumn 1994) that are under fruit orchards (20.000 ha) and especialy areas that are under alfalfa and crops (100.000. ha) the number of rodents was in the 5th and 6th category.

In the protection of orchards from rodents the following products were applied; EKOROD A (2,5% alphachlorochydrine), KLERAT ((),005% brodifacoum), BARAKI (0,0025% difetialon), MURISAN A ((),0375% kumatetralil) and ZINC-PHOPSPHIDE (2% Zn_2P_3). The active ingredients of EKOROD A and MURISAN A are products of Yugoslavian synthesis. With MURISAN A, a new formulation with impregnating action and micrioincapsulation with PEG was applied. The products were applied putting the bait (2-5 g) directly into the holes and the experimental plots for every product and for the control were 10 a each. Experiments with KLERAT and ZINC-PHOSPHIDE were made during a fife year period, while experiments made with EKOROD A and BARAKI were made during a 3 year period (1992-1994). MURISAN A was experimented with for 2 years (1993-1994).

In order to achieve an 89-99% efficiency rate with the mentioned rodent number from 1990-1992, bates with the following basis were applied: 3-5 kg/ ZINC-PHOSPHIDE and KLERAT, 5-6 kg/ha BARAKI, 6-7 kg/ha MURISAN A and EKOROD A. With a much greater number of rodents (1993-1994) the following amounts of baits were applied: 5-7 kg/ha ZINC-PHOSPHIDE, 5-6 kg/ha KLERAT, 6-8 kg/ha BARAKI, 8-10 kg/ha MURISAN A and EKOROD A.

Table 2. Rodent numerocity from 1990-1994

Year	Spring (Feb./Mar)			Autumn (Oct.)		
	Number of active holes/ha	Number of rodents/ha	Category of numerocity (1-6)	Number of active holes/ha	Number of rodents/ha	Category of numerocity (1-6)
1990.	18	32	2	22	48	2
1991.	32	78	2	58	117	3
1992.	131	278	3	204	505	3
1993.	303	606	3	1987	3939	4
1994.	2229	4235	5	3670	8074	5

Note - In some tables the rodent number was greater than 20.000/ha (6)

Table 3. Efficiency of different rodenticide products in fruit orchards (average for period 1990-1994.)

Active ingredient	Product	Product applicated kg/ha	Spring and Autumn			Test (years)
			Number of active holes	Number of rodents	Efficiency %	
Control	-	-	37	75	-	5
	-	-	132	276	-	
Alphachloro-chidrine	Ekorod A	6-7 (90-92)	16	35	96,4	3
	AB-2,5	8-10 (93-94)	425	84	95,8	
Brodifacoum	Klerat	3-5 (90-92)	27	53	97,3	5
	BR-0,005	5-6 (93-94)	399	798	92,4	
Zn_2P_3	Zn-fosfid	3-5 (90-92)	19	42	99,1	5
	AB-2	5-7 (93-94)	449	921	96,4-	
Difetialon	Baraki	5-6 (90-92)	24	51	95,3	3
	BB-0,0025	6-8 (93-94)	510		84,6	
Kumatetralil	Murisan A	6-7 (9-92)	-	-	-	2
	AB-0,0375	8-10 (93-94)	430	99	89,1	

It is possible to control rodents with applied products. With a greater rodents population, a somewhat greater amount of bates must be used. Our results are agreed with results of other authors (Godfrey, 1988; Byers, 1984., Kankeinen,1984.).

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POSTERS

Section: Phytopathology

A contribution to the study of some properties of the sour cherry necrotic ring spot virus

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According to long-year observations the sour cherry necrotic ring spot belongs alongside with the plum pox virus respectively with other economically important diseases to the most extendend diseases of susceptible stone fruit species. In the present work the properties of the sour cherry necrotic ring spot virus was studied on three isolates gained from *Prunus cerasus* L. in our ecological conditions. The virus from diseased leaves and pollen was positively mechanically transmitted on the woody and herbaceous indicators. In the juice of the infected cucumber plants the dilution end point ranged from 10^{-1} to 10^{-2}, the termal point of inactivation from 48°C to 56 °C and the stability in vitro at ambient temperature from 1 to 2 days. In the sedimentation profile two peaks were achieved. The virus showed a typical absorption spectrum in the UV region. The percentage of the ribonucleic acid was settled to 18% and the isoelectric point at pH 4,4. A special antiserum was prepared with antibodies 1:256.

Introduction

Mechanical transmision of the ringspot virus from sour cherries to cucumber (*Cucumis sativus*) accomplished by Moore *et al.* (1948) was one of the important achievements in the study of these viruses which opened new possibilities of a further and nearer study of their properties. In this paper we present results the experimental study on the sour cherry necrotic ring spot virus.

Material and methods

The properties of the necrotic ring spot virus have been compared on the woody and herbaceous indicators. All expriments on both woody and herbaceous indicators were performed in glasshouse conditions, from January to April. The woody indicators were infected using the method of chip budding. Among herbaceous plants such indicators were chosen for mechanical transmission in wich the virus can easly and quickly reproduce, or such which are of importance for differential diagnostics. Woody and herbaceous indicators used are listed in the results. Crude extracts from infected cucumber cotyledons obtained after the maceration with phosphate buffer pH 8,0 (1:1) were used for the determination of the physical and biochemical properties of the virus. Rabbits were immunized intramuscularly and intravenously. For each immunization a fresh antigen was always used. Immunological tests were using: the method of double-diffusion agar gel test and the drop precipitation test. For the determination of the isoelectric point were using the Oster°s method (1951). The percentage of the ribonucleic acid were determined with Paul°s method (1959).

Results and discussion

Necrotic ring spot virus of the sour cherry trees has been positively transmitted to the following woody indicators: *Prunus persica* (L.) Batsch., *Prunus cerasus* L. cv. Montmorency, *Prunus avium* L. cv. Bing, *Prunus avium* L. "F 12/1". From the herbaceous indicators the positive transmission has been obtained on: *Antirrhinum majus* L., *Cucumis sativus* L. cv. Delicates, *Cucurbita maxima* Duch. cv. Reisen Melonen Gelber, *Chenopodium quinoa* Willd., *Leonurus sibiricus* L., *Momordica balsamina* L., *Petunia hybrida* hort ex Vilm., *Tithonia speciosa* Hook., *Vinca rosea* L. Thermal inactivation point of NRV isolates is between 48 to 56 °C, ageing in vitro end-point is 1-2 days, dilution end point ranges from 10^{-1} and 10^{-2}. For sour cherry ring spot virus purification the best method used was differential centrifugation with the saturation of the final purificate with an antiserum containing antibodies against normal proteins. In the sedimentation profile of the virus in the saccharose density gradient two peaks have been obtained. Virus have typical absorption spectrum of the purified virus in the UV sphere, with a maximum at 260 nm and minimum at 240 nm. The isoelectric point of the studied virus has been determined for NRV at pH 4,4. The ribonucleic acid of virus was 18 %. The best results were achieved by intramuscular immunization. The titer of antibodies in the antiserum has been determined by agar gel diffusion test, drop test. The obtained specific antiserum againts necrotic ring spot virus of sour cherry had the titer 1:256. The sour cherry necrotic ring spot virus belongs to the group of ring spot disease viruses the common characteristic of which is the possibility of the transmission through seeds and pollen (George & Davidson 1963). Fulton (1968) has specified this group of viruses as ILAR-viruses (Isometric Labile Ringspot Viruses). These viruses, especially the sour cherry necrotic ring spot virus, are known to be widely distributed to individual species of the genus *Prunus*. In our experiments we tried to characterize more closely isolates of the necrotic ring spot virus under our conditions and to compare our data with those given in the literature. We found out that the obtained results correspondet with those of other authors.

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EFFECT OF UREA APPLICATION ON ASCOSPORE PRODUCTION OF *VENTURIA INAEQUALIS*

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Abstract
The effect of 5% urea application was tested in different regions of Poland. The leaves were treated at the start of the leaf drop period. In Dąbrowice fallen leaves were dipped in 5% urea suspension. Perythecia production was checked at the time of first significant ascospores discharge. Significant reduction of perythecia was found in these places where 5% urea was applied. Perythecia on treated leaves were poorly developed in comparison to untreated leaves. Also, reduction in primary apple scab on all tested cultivars was found.

Introduction
The number of mature ascospores in an orchard greatly effects primary infection.
One of the ways to reduce ascospores is applying 5% urea at the start of the leaf drop period.
In the sixties the method was tested in Poland, the expected results were not achieved due to the strong winters. In 1994 method was checked again. Several previous winters were worm with temperature often well above 0°C during the day. The temperature probably is the one of the most important factors responsible for effectiveness of urea applying.

Materials and methods
In the autumn of 1994 the method was tested in four different regions of Poland; Sinołęka, Grudynia, Miłobądz and Dąbrowice placed in east-central, south, north and central Poland, respectively. In three commercial orchards autumn 5% urea was applied using 1000 litres of liquid per hectare. The application was done with Ślęza axian fan sprayer at the early leaf drop stage(Sinołęka, Grudynia, Miłobądz). In Dąbrowice heavily scabbed leaves were dipped in 5% urea suspension. The fallen leaves were collected from treated and untreated trees and then stored in nylon mash bags on the orchard floor over the winter. Assessing of perythecia development took place at the time of the first ascospore discharging observed in an orchard. A hundred leaves were taken from each sample and 1 cm^2 of the leaf surface was checked for perythecia production randomly in four replicates. After that, perythecia were removed from leaves, crushed on microscopic slides and then checked for ascospores productivity. Also, at the middle of May trees were assessed for apple scab lesions.
Two programs were checked in tested orchards, standard spraying and delaying with first spray until the pink bud stage.

Results and discussion
The leaves taken from sprayed orchards did not show any developed perythecia on untreated leaves so we could not establish effectiveness of treatment. On the treated leaves from Dąbrowice significant reduction in perythecia development were found. Untreated leaves bore in average of 20 and 17 perythecia on 1 cm^2 on McIntosh and Jonagold, respectively. In contrast, on treated leaves only 0.04 on McIntosh and 0.7 on Jonagold, perythecia were born. The similar trend but different levels of perythecia development was observed on different cultivars. The leaves treated with urea were totally destroyed in comparison with untreated. Assessing of early apple scab

took place in the middle of May, after primary infection. An improvement on apple scab control was found always where 5% autumn urea was applied. The best result was obtained when urea applying was associated with the spraying program started at the green bud stage. Similar results were obtained in New Hampshire (Mac Hardy, 1994), Chile (B.A.Latorre, 1982) and The Netherlands (H.A.Th. van der Scheer, 1992). Using urea at the leaves drop period is an inexpensive sanitation practice that can lower costs of protection and improve the efficiency of standard spraying.

Table 1. Perythecia production on treated and untreated leaves

Dąbrowice, 1995

	5% autumn urea		without urea	
	A	B	A	B
McIntosh	1	0,04	100	20
Jonagold	14	0,7	93	17

A - % of leaves with perythecia

B - average number of perythetia on 1 cm^2 of the leaf surface

Table 2. Percent of infected leaves

	Standard		Delayed		Check	
Cv./ orchard	A	B	A	B	A	B
Gala/Grudynia	1,1	2,25	1,1	2,6	1,4	8,4
McIntosh/Miłobądz	1,5	11,6	8,1	11,0	42,4	71,3
Šampion/Grudynia	0	0,25	0	0,25	0	0,75

A- 5% urea

B- without urea

Conclusions

1. Better results of the method can be achieved when treated area is large.
2. After scab free season and urea applying the PAD action threshold can be employed.
3. A great improvement in protection of scab - susceptible cultivars can be achieved.
4. Urea does not have negative influence on environment and is inexpensive.

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Effectiveness of RIM program in control of apple scab.

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ABSTRACT

Four treatments on very susceptible McIntosh cv. or three sprayings on Gloster cv. in conditions of relatively low PAD gave good apple scab control in 1994. In 1995 six treatments on McIntosh cv. showed good efficacy of the program, however seven treatments on Gloster cv. were not enough effective due probably to much higher PAD value. In 1995 RIM's terms were closely related to dates of critical periods indicated with standard apparatus. Further studies should explain accuracy of RIM's terms, necessity of spraying in lower RIM values and some other problems connected with ascospores survival after discharge or Biofix date.

INTRODUCTION

Proper terms of spraying play the most important role in apple scab control. Electronic or mechanical devices for indication of 'critical periods' are often use. These do not calculate the presence or activity of spores of *Venturia inaequalis* but only weather conditions necessary to infection.

RIM - computerized apple scab risk program proposed by Trapman (1994) includes both factors of apple scab critical period. It was assessed in apple scab control in 1994 and 1995.

MATERIALS and METHODS

Apple trees of McIntosh and Gloster cvs. were sprayed on terms showed by RIM program with curative fungicides by hand lance, tunnel sprayer Joco or air directed sprayer Sepia. 8-12 trees of each variety were established as a combination (four replications each of 2-3 trees plot). Apple scab assessment was made on 200 randomly taken leaves in each replication and on 100 of fruits.

Statistical analyze was done by means of variance analyze and significance of differences was assessed by Duncan's test with $P=0.05$

RESULTS and DISCUSSION

In 1994 RIM program showed two terms of high infection risk during primary infection. Three sprayings / bloom , petal fall and additionally during secondary infection/ resulted with 4.2% of infected leaves and 0.8% of infected fruits of Gloster cv. at the orchard with low PAD /Table 1/. On McIntosh cv. 4 spraying / 3 during primary infection and additionally one during secondary infection/ resulted with 2.2% of infected leaves in orchard with relatively high PAD. Trees bared no fruit that year, so fruit assessment was not made. Program RIM showed no risk period at the end of April, however leaves infection on McIntosh cv. was observed. Extension of spore survival to 84 hours for ungerminated spores, 60 hours for germinated and 72 hours for appressorium formed ones /Becker and Burr, 1994/ resulted with high RIM value at this term and additionally on 1st and 29th-30th of May. The recalculated data showed also end of ascospore discharge on second half of June what was in agreement with field observations. Original data established by author /477 degreedays, after Gadoury and MacHardy, 1982/ showed end of ascospore discharge about one month earlier. In Polish conditions in 1994 about 820 degreedays /base 0°C/ was necessary for total ascospore discharge.

In 1995 six sprayings made only at high RIM values on McIntosh cv. resulted in 0.8% of infected leaves. Omitting individual spraying gave higher scab incidence with the highest at petal fall /Table 2/.

On Gloster cv. results were not so satisfactory and the best control of apple scab was obtained when sprayings were made according to high RIM values and additional spraying in bloom with Delan 750 SC at 0.25 l/ha. Other treatments resulted with higher scab incidence probably due higher PAD and to insufficient penetration of spray liquid to very dense trees which bared no fruits in 1995. In both experiments one spraying at the and of April /27-29th/ was omitted due to leafwetness sensors failure. Simulating leafwettness at this time resulted with high RIM value and some changes in next term /4th of May/. Spraying at the end of April gave good control at another experiment. In 1995 experiments we used higher values for ascospore survival /after Becker and Burr, 1994/ than recommended by author of the program. Extension of time of spore survival after discharge showed generally higher RIM values and necessity of one-two spraying more than for values recommended by author. In 1995 RIM program showed end of ascospore discharge at the second half of June. However, field observations /5 km from Skierniewice/ showed end of ascospore discharge on 21 of May.

CONCLUSIONS

1. 1995 version of RIMpro seems to indicate correctly the terms of high apple scab risk. Weather data, especially leafwettness ones, seem to be essential for accurate operating of the program.
2. Additional sprayings with a low dose of Delan in periods of lower RIM value /about/above 100 ?/ improved the effectiveness of scab control. Further studies on this subject are necessary.
3. Our observations suggest that the Biofix date should be rather set on time of about 80% of mature perythecia /all asci mature and olive colored ascospores/ than date of first olive colored ascospores as suggested by author.
4. Extension of a time of ascospores survival after discharge makes RIM program more 'sensitive' and thus more safe for practice.
5. Further investigations on: influence of PAD value, spraying technique and varietal susceptibility to apple scab on effectiveness RIM's program control are necessary.

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Table 1

Effectiveness of RIM's terms of spraying in apple scab control. Skierniewice, Gloster cv., tunnel sprayer Joco, 230 l/ha

Terms of spraying									Program	Date of observation		
April		May				June		July		% of infected:		
										leaves		fruits
21	25	9	13	20	25	6	20	11		06/7	08/23	10/13
-	-	-	-	-	-	-	-	-	Check	29.8 c	55.4 d	26.4 c
-	-	-	PD	Car	-	-	-	-	RIM 2x	3.5 b	12.0 c	6.8 b
-	-	-	PD	Car	-	-	-	Pu	RIM 3x	-	4.2 b	0.8 a
De	De	De	Pu	Car	De	De	De	Pu	Delan 500 SC 0.4 l/ha+RIM 2x	0 a	1.2 b	1.1 a
D	D	Ca	-	Car	At	At	ST	Pu	Commercial	0 a	0 a	0.2 a

PD- Punch 400 EC 75 ml/ha+Delan 500 SC 0.4 l/ha;
Car- Carpene 65 WP - 2.25 kg/ha; Ca- Carpene 65 WP 1.5 kg/ha;
Pu -Punch 75 ml/ha; De- Delan 500 SC 0.4 l/ha;
D- Delan 500 SC 1.125 l/ha; At- Atemi C 1.5kg/ha;
ST- Score 250 EC 0.2 l/ha+Thiram Granuflo 2 kg/ha

Critical periods /Metos-Dat/, Skierniewice:
04/13, 27, 05/12, 13, 16, 19, 20-24, 27, 30, 31; 06/5, 13, 17, 18, 23; 07/8, 9, 10

Table 2

Effectiveness of RIM's terms of spraying in apple scab control Skierniewice, 1995; McIntosh cv. sprayer: Sepia 500 l/ha

Terms of treatments:						Spraying program	Date of observations		
May			June				% of infected leaves		
5 I	12 II	23 III	6 IV	13 V	23 VI		06/1	06/20	07/26
-	-	-	-	-	-	Check	28.1 b	39.0 e	92.8 e
Ef	Ef	PuD	ScD	ScD	Cap	Full program	1.4 a	0.9 a	0.8 a
-	Ef	Pud	ScD	ScD	Cap	Without I treatment	2.6 a	4.7 c	5.1 bc
Ef	-	PuD	ScD	ScD	Cap	Without II treatment	1.1 a	7.9 d	8.0 cd
Ef	Ef	-	ScD	ScD	Cap	Without III treatment	1.6 a	4.8 c	13.1 d
Ef	Ef	PuD	-	ScD	Cap	Without IV treatment	1.0 a	2.1 b	3.4 abc
Ef	Ef	PuD	ScD	-	Cap	Without V treatment	1.0 a	0.4 a	2.6 ab
Ef	Ef	Pud	ScD	ScD	-	Without VI treatment	-	0.4 a	3.7 ab

Ef - Efuzin 500 SC 2.5 l/ha, PuD - Punch 400 EC 75 ml/ha+Delan 750 SC 0.5 l/ha;
ScD- Score 250 EC 0.2 l/ha+ Delan 750 SC 0.5 l/ha; Cap - Captan 50 WP 4.5 kg/ha

Virulence analysis of *Venturia inaequalis* populations

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To study virulence variability in scab populations, a cross infection trial was carried out in a phytotron. Specific virulences of monoconidial inoculum from 5 different orchards were detected with a set of 8 to 10 old cultivars (differentials). The number of phenotipically distinguishable isolates and their complexity (average number of specific virulences per isolate) generally increased with the number of varieties in the orchard. In orchards with 3 or more cultivars, no isolate could infect all the cultivars present in the orchard. All differentials, even very susceptible ones like Golden Delicious and Champagner Reinette, showed differential resistances. To achieve the aim of a durable resistance, differential resistances could be an important tool for future breeding strategies.

Introduction

Apple scab caused by the fungus *Venturia inaequalis* is in many areas the most serious disease. Breeding for scab resistance is therefore an important approach to reduce the usage of chemicals. Several wild species of apple carry resistance to scab. However, almost all breeding programs focus on the Vf resistance, derived from *Malus floribunda* 821. A single resistance type is generally known to be unreliable. If resistant varieties will be grown on a large scale in the future, it is important to enlarge the genetic base of the incorporated resistances and to study pathogenic variation of the fungus and its relation to different apple genotypes.
We report on the variability of specific virulences in natural populations of *V. inaequalis* and on differential resistances in susceptible cultivars.

Materials and methods

Variability in virulence was studied in a cross infection trial with a set of 8 cultivars (differentials) and isolates from 5 orchards (Table 1). The inoculum consisted of spores originating from monosporic cultures, isolated from primary or early secondary lesions. The incubation conditions were 19° C and 100% relative humidity for the first 48 hours. The macroscopic symptoms were classified after 17 days.

TABLE 1. Orchards used for virulence analysis.

location	plantation	surface (ha)	orchard design	nr. of cultivars
Oberwil	1984	0.3	8 trees of each cultivar in a row	26
Wädenswil 23	1977	0.2	2 rows of each cultivar	3
Güttingen 30	1983	1.3	isolated blocks, each with single rows of the 3 cultivars	3
Wädenswil 20	1984	0.3	monoculture, surrounded by cultivar mixtures	1
Gland	1980	1	monoculture[a]	1

[a] Golden Delicious with pollinators

Results and discussion

The number of distinguishable isolates increased with the number of cultivars in the orchard. From the 23 Oberwil isolates tested, all could be distinguished phenotypically. For the orchards with only 1 cultivar, the data base is too small for a comparison yet.
The reactions of the apple cultivars towards monoconidial inoculum of *V. inaequalis* originating from different host cultivars were highly dependent on the particular cultivar. Strongly

sporulating lesions were mostly observed when the inoculum originated from the same host cultivar (Table 3).

TABLE 3. Detected specific virulences in natural populations of *Venturia. inaequalis* from different orchards.

orchard	cultivars used for isolation	nr. of isolates	specific virulences towards main host	other cultivars
Oberwil	Ananas R.	5	5/5[a]	Champagner R.[b]
	Boskoop	3	2/3	Champagner R.
	Champagner R	10	10/10	
	Glockenapfel	5	5/5	Golden Del.
Wädenswil 23	Boskoop	9	9/9	Spartan
	James Grieve	8	4/8	
	Spartan	7	6/7	Golden Del., Maigold, Spartan
Güttingen 30	Golden Del.	15	15/15	
	Gravensteiner	3	3/3	
	Jonathan	5	4/5	Golden Del.
Wädenswil 20	Golden Del.	5	5/5	Maigold, Spartan
Gland	Golden Del.	7	6/7	Maigold

[a] out of 5 isolates from Ananas Reinette, 5 produced sporulating lesions on Ananas Reinette (main host)
[b] only cited when more than half of the isolates produced sporulating lesions

The average number of specific virulences per isolate (complexity) generally increased with orchard diversity (number of cultivars). In orchards with 3 or more cultivars, no isolate could infect all the cultivars planted in the orchard. This means that the frequency of a particular specific virulence is highest in a monocultural orchard.

All cultivars, even very susceptible ones like Golden D. and Champagner R., showed differential resistances. Virulence patterns of some chosen isolates are presented in Table 4.

TABLE 4. Virulence patterns of some chosen isolates.

inoculum	symptoms on differentials Ananas	Boskoop	Champagner	Glockenapfel	Golden Del.	Gravensteiner	Jonathan	Klarapfel
Gland 93[b]								
Golden 4/8	-[a]	-	-	-	+	-	-	-
Oberwil 93								
Boskoop I 4/1	-	+	+	-	-	n.a.[c]	2	-
Boskoop I 8	-	+	-	-	+	-	-	-
Glocken H 3/2	+	+	+	+	+	+	2	2

[a] + = obvious and strong sporulating lesions; - = no visible symptoms (or), small, chlorotic flecks; 2 = weakly sporulating flecks
[b] the 93 isolates from Gland all performed the same virulence pattern
[c] n.a. = not available

In a monocultural system, differential resistances are overcome by specific strains of the fungus. However, they could be used to reduce selection pressure either by mixtures of cultivars or by pyramiding genes. Future breeding strategies should be based on the possibility of recognising differential resistances with isolates with the corresponding specific virulence or by marker assisted breeding (1, 2).

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Identification of tomato ringspot virus in Slovakia

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The tomato ringspot virus (TomRSV) has been successfully detected in sap from the leaves of naturally field-infected red raspberry and grapevine. Our study involved raspberry with varying degrees of chlorosis and yellow spots on the leaves and grapevine with yellow veins, yellow flecks and leafroll symptoms as well. Identification of TomRSV was based on the reaction of herbaceous hosts, electron microscopy and serology. These results provide experimental evidence, for the first time in Slovakia, that TomRSV occurs in our naturally infected grapevines and raspberries.

Introduction

The tomato ringspot nepovirus causes significant losses in tree fruit, berry, and grape crops in the United States, but only locally was established in Europe. The objectives on this study were to determine TomRSV incidence in naturally diseased grapevine and raspberry in Slovakia.

Material and methods

In host range studies, *Chenopodium quinoa, C. amaranticolor, C. murale, Petunia hybrida, Cucumis sativus* and *Gomphrena globosa* were tested. Extracts from naturally infected young leaves were prepared by grinding, in a mortar and pestle, 1 g tissue with five volumes of 0.01 M phosphate buffer containing 2.5% nicotine (final pH 9.8).

For electron microscopic investigations tissue-dip preparations from young infected grapevine and raspberry leaves were negatively stained by 2% aqueous uranyl acetate. The virus was extracted with 3 vol of cold 2% polyvinylpyrrolidone (m.w. 25 000) in phosphate buffered saline (PBS, pH 7.4). For immunosorbent electron microscopy, as described Milne & Leseman (1984), an antiserum, or Anti-TomRSV-IgG, diluted from 1:5 to 1:400 in PBS was used, at coating time 30 min at 37 °C and a trapping time of 30 min at 37 °C. Grids were decorated with the same antiserum or IgG and examined in a Tesla BS 500 electron microscope.

For agar gel double-diffusion tests antiserum to TomRSV-G (titer 1:512), kindly supplied by E. Podleckis, Rutgers University, Blueberry/Cranberry Research Center, Chatsworth, U.S.A., was used.

The amount of TomRSV antigen in naturally field-infected red raspberry and grapevine leaves was determined by the classical ELISA technique reported by Clark & Adams (1977) with the TomRSV ELISA Set from Loewe Biochemica GmbH, Germany.

Results and discussion

TomRSV was mechanically transmitted from grapevine and raspberry tissues and readily infected test plants. The inoculated leaves of *C. quinoa* reacted with necrotic local lesions and systemic infection. Similar reactions were also observed in inoculated plants of

C. amaranticolor, C. murale, Petunia hybrida, Cucumis sativus and *Gomphrena globosa.*

Negatively stained tissue-dip preparations from infected grapevine and raspberry leaves contained spherical virus-like particles of about 28 nm in diameter. Only in extracts from grapevine affected by leafroll symptoms also closterovirus-like particles of grapevine leafroll virus were seen. TomRSV particles decorated with antiserum or IgG were revealed by immuno-electron microscopy.

In agar gel double-diffusion tests with antiserum to TomRSV-G isolate (Podleckis & Corbett, 1987) precipitin zone of serological identity was obtained with our grapevine isolate of TomRSV.

The enzyme-linked immunosorbent assay has been also used for detecting TomRSV from naturally infected grapevine and raspberry leaves and confirmed above mentioned results (Table 1).

Table 1. ELISA A_{405} readings from red raspberry and grapevine naturally infected with TomRSV. The background values of unspecific reactions (healthy control) were substracted.

Isolate	Symptoms	Absorbance
RED RASPBERRY - *Rubus idaeus*		
cv. Gatineau	yellow mosaic, chlorosis along leaf veins	1.180
cv. Granát	yellow mosaic	0.996
cv. Norma	yellow mosaic	0.813
cv. Hybrid Bulharský rubín x NŠ 22	yellow mosaic	0.691
cv. Bulharský rubín	fine yellow vein chlorosis	0.662
GRAPEVINE - *Vitis vinifera*		
cv. St. George	yellow flecks	0.760
cv. Cabernet Sauvignon	leafroll, reddening between the major veins	0.580
cv. Burgundské biele	leafroll, yellowing between the major veins	0.550
cv. Veltlínske zelené	leafroll, yellowing	0.490
cv. Burgundské biele	yellow veins	0.460

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The evidence of new natural hosts of the plum pox virus (PPV)

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Simultaneously with the investigation of PPV distribution and the verification of the strains occurring in the strongly infected plum tree alleys and orchards in Slovakia, also some bushes and trees occurring there were tested. We used ELISA test to detect the PPV in *Sambucus nigra* L., *Rosa canina* L., *Prunus avium* L., *Acer* sp. and *Tilia* sp. The extracts prepared from the leaves of *R. canina, S. nigra, Prunus avium* and *Acer* sp. reacted positively to the PPV antibody (Loewe Biochemica GmbH). The aphids present on positively reacting trees and bushes were also tested by ELISA. The presence of PPV was detected in bodies of the aphids *Aphis sambuci* L., *Macrosiphum rosae* L. and *Chaetophorella aceris* L.

Introduction

Plum pox virus (PPV) is among the most destructive plant viruses because of the heavy losses it causes as well as its large area of distribution. Different plum cultivars belong to the main natural hosts of PPV (Németh, 1986) which has been transmitted to many other *Prunus* species. The presence of the virus was also detected in many weeds as well as in some ornamentals occuring in orchards near infected plum trees (Zawadska & Smolarz, 1978). The virus spreads not only by infected propagating material but also by insect vectors. Till now 11 insect species transmitting the PPV have been described: 10 from the family *Aphididae* (Labonne *et al.*, in press) and the leafhopper *Empoasca flavescens* Fabr. (Jordovic, 1963).

The aim of this work was to test some bushes and trees as well as aphids occuring on the plants growing near strongly PPV infected plum tree alleys and orchards in Slovakia in order to find out new possible sources of this disease.

Material and methods

Plant material: leaves from *Euonymus europaeus* L., *Sambucus nigra* L., *Rosa canina* L., *Prunus avium* L., *Acer* sp. and *Tilia* sp. collected from trees and bushes growing in heavy PPV infected plum orhards.

Aphids: tested were *Aphis sambuci* L., *Eucallipterus tiliae* L., *Chaetophorella aceris* L., *Macrosiphum rosae* L., *Myzus cerasi* L.,; *Myzus persicae* L., bred on rape (*Brassica napus* L.) in the greenhaus, as the negative control was used.

The ELISA method (Clark & Adams, 1977) was used to detect virus in leaves and aphids (in batches of 25 individuals) using polyclonal antibodies (Loewe Biochemika GmbH). The ds-RNA method (Morris & Dodds, 1979) was used for isolation and analysis of double-stranded RNA from tested leaves and aphids.

Results and discussion

Out of the tested bushes and trees growing near the plum orchards infected with PPV, this virus was detected by ELISAin leaf tissues of *Acer* sp., *P. avium, R. canina* and

S. nigra (Table 1). PPV virus was detected also in *Lycium halimifolium* and many weeds occuring in orchards, i. e. *Lamium album* L., *Lupinus albus* L., *Ranunculus acer, Trifolium repens*, in the ornamental *Zinia elegans* and others (Zawadska & Smolarz, 1978). In *S. nigra*, the virus was detected by the method of isolation of ds-RNA patterns of virus RNA. Ds-RNA Aphids-transmissible and nontransmissible strains of PPV was detected by this method also in infected *Nicotiana clevelandii* (Maiss *et al.* 1987).

Infected bushes and trees - which have not been reported to be PPV-infected - may be potential source of spreading of this virus. This assumption is also supported by the finding that in the bodies of ahids, occuring on these plants, the presence of PPV was detected (Table 1). The insect can transmitt the virus to other plants also during test feeding period.

Table 1. Absorbance values (A_{405}) obtained by ELISA test for plant and aphids using polyclonal antibodies against PPV

Test plants	A 405 nm*	Test aphids	A 405 nm*
Acer sp.	0.203/+	*Ch. aceris*	0.268/+
E. europaeus	0.040/-		
P. avium	0.125/S	*M. cerasi*	0.104/-
R. canina	0.152/+	*M. rosae*	0.333/+
S. nigra	0.237/+	*A. sambuci*	0.342/+
Tilia sp.	0.086/-	*E. tiliae*	0.033/-
Source of PPV	0.290		
Negat. control	0.035	*M. persicae*	0.070

+ positive, - negative, S-suspicious, A_{405}-average values from 4 experiments with 2 replicates

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POSTERS

Section: Pesticide Use

EVALUATION OF IGR INSECTICIDES IN THE CONTROL OF THE RUST MITES *ACARI:ERIOPHYOIDEA*

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ABSTRACT. Some insect growth regulators (IGR's) were evaluated in 1992-1995 in the control of apple rust mite *Aculus schlechtendali*, plum rust mite *Aculus fockeui* and pear rust mite *Epitrimerus piri*. The insecticides were applied twice, in pre- and post bloom control program in the orchards or in May and June in the stoolbeds. Flucycloxuron 25% and flufenoxuron 5% were the most effective and they kept mite populations at a low level during vegetation season. Diflubenzuron 25% and teflubenzuron 15% showed lower efficacy against rust mites.

INTRODUCTION. In recent years in Poland, the rust mites *A.schlechtendali* and *A.fockeui* reached high damaging level in commercial apple and plum orchards, nurseries and stoolbeds of vegetative apple rootstocks. (Suski et al., 1992). In many cultures, they are serious pests for some varieties and their control is required. (Badowska-Czubik et al., 1991). Some IGR insecticides were evaluated against rust mites.

METHODS. Field studies on the control of *A.schlechtendali* were carried out in apple orchards on cv. Jonagold, Bancroft and in stoolbeds of the vegetative apple rootstock M26. Experiments on the control of *A.fockeui* and *E.piri* were carried out in plum and pear orchards of different cultivars. Chemical treatments were made on 20-50 plants with a minimum of four replicates in each treatment. They were applied twice, in pre- and post bloom control program in the orchards and in May and June in the stoolbeds. The insecticides were applied with "Ślęza 1001" sprayer, using 1000 l of liquid per ha. The effectiveness was estimated by counting rust mites on 20 leaf disks of 1 cm^2 area, replicated 4-6 times for each treatment. Rust mites were counted under microscope and the results were analyzed according to Abbott's formula. In case of *E.piri* the number of damaged leaves were counted.

RESULTS and CONCLUSIONS. The obtained results have shown that the applied pesticides afforded good control of the apple and plum rust mites. Flucycloxuron and flufenoxuron were the most effective. They caused above 95% mortality of apple and plum rust determined 3 weeks after the second treatment (table 1). Diflubenzuron and teflubenzuron showed lower efficacy. Also, the above insecticides decreased percentage of damage leaves caused by pear rust mite. Moreover, what is a very important for IPM program, the tested preparations are more selective and neutral toward mite and insect predators than other insecticides. (Olszak et al., 1993)

Table 1. Effect of IGR's in the control of *A.schlechtendali* (A), *A.Fockeui* (B) and *E.piri* (C)

Insecticide and concentration in %	Active ingredient	Average mortality (%) 3 weeks after second treatment		
		A	B	C*
Andalin DC 25 0.06	flucycloxuron 25%	99.6	96.5	-
Cascade 050 EC 0.15	flufenoxuron 5%	99.3	94.3	23.2
Dimilin 25 WP 0.08	diflubenzuron 15%	84.8	-	28.6
Nomolt 150 EC 0.05	teflubenzuron 15%	83.2	82.4	33.4
Mitac 200 EC 0.2	amitraz 20%	99.9	99.1	10.3
Check		-	-	62.8

* Average % of bronzed leaves in August

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INFLUENCE OF GLYPHOSATE-TRIMESIUM AND PIRIMICARB, ON PREDATOR POPULATIONS

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AVANS is a non-selective systemic herbicide for total weed control in orchards, vineyards, berry-crops and non-crop areas. It's active ingredient *glyphosate trimesium* is rapidly absorbed by leaves and translocated into roots and rhizoms.
Glyphosate trimesium interferes the synthesis of aromatic *aminoacids*. AVANS is very effective for control of *annual* and *perennial mono- and dicotyledonous weeds* in topfruits grown under IPM conditions.
Toxicity of *glyphosate trimesium* to beneficial arthropods:
In laboratory tests *glyphosate trimesium* 480 g/l SL formulation AVANS was tested on 2 beneficial arthropods, the carabid beetle *Pterostichus melanarius* and a *Pardosa* spider.

The maximum single application rate (7.5 l/ha or 3.6 kg ai/ha) was applied to the beetles/spiders and the soil surface, while the maximum total annual application rate
(15 l/ha or 7.2 kg ai/ha) was applied to the soil surface only in order to simulate worst case residual exposure from successive applications in one season. *Dimethoate* was applied at
700 g ai/ha to the test animals as a standard.
The carabid beetles showed an increase in mortality (27%) only in case with the residual plus direct contact application, but this was not found with the residual application. Both treatments had no significant effect ($p = 0.05$), on lycosid spiders.
Eating activity for both species was not significantly reduced when compared to the controls.

According to the IOBC Classification Scheme the *glyphosate trimesium* 480 G/l SL formulation AVANS may be regarded as "harmless" (category 1, <30% mortality), and is not expected to cause any adverse effects to carabid beetles or lycosid spiders under conditions of normal field use.

References:

CANNING, L., LLOYD, E.J., LEWIS, G.B.
"*Glyphosate trimesium*: Investigation of the toxicity of a 480 g/l SL formulation (AVANS) to the carabid beetle *Pterostichus melanarius* and a Lycosid spider"

ZENECA Agrochemicals Jealott's Hill Research Station, UK, report no. RJ 1066B (March 1992)

PIRIMOR is a selective aphicide with very benign characteristics to beneficial insects.
Its active ingredient *pirimicarb* has got a very specific mode of action against a wide range of aphid species in many field crops (cereals, oilseed rape, sugar beets, leguminose, potatoes etc.), vegetables, ornamentals and topfruits.
Pirimicarb is worldwide used between 100 g and 250 g/a.i. per hectare in a.m. outlets and has contact-, translaminar- and vapour activity. This triple mode of action shows rapid and thorough aphid control with virtually no impact on their natural enemies.
Pirimicarb does not harm bees, ladybirds, carabid beetles, phytoseiid mites, predatory bugs (anthocorid), lacewing flies and parasitic wasps.

Fruit growers welcome the good activity of *pirimicarb* against *Aphis pomi, Dysaphis plantaginea, Eriosoma lanigerum, Myzus cerasi, Myzus persicae, Brachycaudus persicae, Brachicaudus schwartzi* whilst utilizing additional attack by natural enemies of aphids.
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POSSIBILITY OF REDUCTION OF HERBICIDE USE IN SOUR CHERRY ORCHARD

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Abstract
With narrow (1 m) herbicide strips a good growth and yielding of sour cherry may be obtained with 60 kg N/ha. Fertilisation should be applied over whole soil area and should be continued, considering that trees successively extend their roots under grassed alleyways which occupy 80 % of whole soil area.

Introduction

At the present time a prevailing practice of soil management in sour cherry orchards consists in maintaining a mown sward in alleyways and applying herbicides along tree rows. With wide herbicide strips a major portion of cherry roots is distributed in herbicide treated soil (Baghdadi 1991). Effect of width of herbicide strips and of N fertilisation has been studied since 1989; preliminary results were presented by Sadowski et al. (1994).

Materials and methods

The experiment was carried out at Wilanów Research Farm of the Warsaw Agricultural University, situated in the valley of Vistula River, on alluvial silty loam soil, rich in organic matter. The experiment was set up in split-plot factorial randomised block design with 5 replications. Five N fertiliser and soil management treatments were distributed as sub-blocks: (1) N_0 -check I, without nitrogen, wide (3 m) herbicide strips; (2) N_0 -check II, without nitrogen, narrow (1 m) herbicide strips; (3) N_{60} - 60 kg N/ha applied over the whole plot, 1 m herbicide strips; (4) N_{60} - the same as treatment 3, fertiliser applied in first 3 years only; (5) $N_{60herb.}$ - 60 kg N/ha applied in herbicide (1 m) strips only. Split doses (3), 20 kg N per ha each, were applied at bloom time, before June drop and after harvest.

'Schattenmorrelle' maiden trees were planted in spring 1989 at 5 x 3.5 m spacing. Mid - shoot leaves for analysis were sampled shortly after harvest. N content was determined by the Kjeldahl method. Tree growth was estimated by the increase of trunk cross section area (TCSA) at the height of 30 cm, for biennial periods. Yield was registered every year, since 1990. Data were subjected to analysis of variance and Newman - Keuls test was applied for separation of treatment means.

Results

In 1991 a tendency to a slight reduction of leaf N concentration was observed in the treatment without N fertilisation and with 1 m herbicide strips; however, it was always within the optimal range of leaf N content (Table1). In successive years (1992 -1994) leaf N concentration was always optimal when fertiliser was applied over whole area (treatment 3). In other treatments, and particularly in treatment 2 (N_0, with narrow herbicide strips), leaf N concentration progressively decreased and in 1993 or 1994 attained the low range (< 2,3 % N) according to Polish criteria. With wide herbicide strips leaf N content did not drop to the low range before 1994.

During first four years of study (1989 - 1992) neither fertilisation (60 kg N/ha vs N-O, with 1 m herbicide strips) nor width of herbicide strips (3 m vs 1m, with N-O) had any significant effect on growth tree (Table 2). Significant differences were observed in the last biennial period (1993 - 1994). Trunk growth of sour cherry in the treatment fertilised with 60 kg N/ha over whole area (treatment 2) was more intense compared to the other treatments. The same tendency was observed in yield (Table 3). In the treatment 2 cherries yielded less though significant differences were observed in 1994 only.

Table 1. Leaf N concentration (% d.m.)

N fertiliser and soil management treatment	1990	1991	1992	1993	1994
1. N_0, 3 m herbicide strips	2.62 a *a*	2.60 ab *a*	2.54 a *a*	2.40 ab *ab*	2.25 ab *a*
2. N_0, 1 m herbicide strips	2.69 a *a*	2.56 a *a*	2.54 a *a*	2.28 a *a*	2.14 a *a*
3. N_{60}, 1 m herbicide strips	2.62 a *a*	2.68 ab *ab*	2.66 a *b*	2.60 b *b*	2.39 b *b*
4. N_{60}, in first 3 years only	2.64 a *a*	2.73 b *b*	2.63 a *ab*	2.46 ab *ab*	2.18 a *a*
5. N_{60}, in 1 m strips only	2.65 a *a*	2.61 ab *a*	2.55 a *a*	2.46 ab *ab*	2.21 a *a*

Separation of means by Newman - Keuls test at $\alpha = 0.05$ or $\alpha = 0.10$ (*italics*).

Table 2. TCSA increase (cm^2) in biennial periods.

N fertiliser and soil management treatment	1989 - 1990	1991 -1992	1993 - 1994
1. N_0, 3 m herbicide strips	15.54	27.54	26.14 a
2. N_0, 1 m herbicide strips	14.34	27.34	22.79 a
3. N_{60}, 1 m herbicide strips	14.96	28.75	31.33 b
4. N_{60}, in first 3 years only	15.54	26.67	25.21 a
5. N_{60}, in 1 m strips only	15.32	27.07	24.49 a

Table 3. Yield (kg/tree).

N fertiliser and soil management treatment	1990	1991	1992	1993	1994
1. N_0, 3 m herbicide strips	0.85	11.0	26.1	28.7	17.5 *a*
2. N_0, 1 m herbicide strips	0.81	9.5	25.0	25.4	16.0 *a*
3. N_{60}, 1 m herbicide strips	0.78	10.4	27.4	30.0	22.2 *b*
4. N_{60}, in first 3 years only	0.91	10.8	26.4	30.4	16.2 *a*
5. N_{60}, in 1 m strips only	0.80	10.8	25.3	26.4	16.0 *a*

Conclusions

On the alluvial soil, rich in organic matter, no response to N fertilisation may be expected in young trees. With narrow herbicide strips, N fertiliser is needed for older trees when roots apparently occupy soil under grass; nevertheless moderate doses of N are sufficient to meet sour cherry nutrient needs.

Narrow (1 m) herbicide strips, compared with wide (3 m) ones, slightly diminish cherry N nutrition, however without negative effects on growth or yield, provided that N fertiliser is applied in a moderate dose.

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Usage of pesticides in Norwegian apple production

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Abstract
In 1993 a survey of pesticide use in Norwegian apple orchards was undertaken. A total of 1250 growers were asked to report on the usage of pesticides in the orchards. In 242 (85%) of a total of 283 orchards the number of insecticide sprays ranged from 1 to 4. Except for dimethoate, dosages applied per ha ranged from 15 to 58 percent of maximum recommended dosage. Number of fungicide sprays ranged from 5 to 8 in 72 percent of a total of 286 orchards. Dosages of fungicides applied per ha ranged from 19 to 74 percent of maximum recommended dosage.

National strategy for food production
In Norway **Integrated Fruit Production** is part of a national strategy: **The Norwegian Food Competetive Strategy** launched in 1991 by The Ministry of Agriculture. This strategy requires the growers to comply only with parts of the requirements outlined in our guidelines for integrated fruit production, i.e. documentation of the usage of pesticides, herbicides and fertilizers. This production scheme is named **"Documented production"**.

Usage of pesticides
In 1993, as part of a test program for **"Documented Apple Production"**, a total of 1250 growers were asked to report on the usage of pesticides by filling in a field notebook similar to the one used in integrated fruit production. Of a total of 394 returned notebooks, 286 were filled in satisfactorily. The percent distribution of growers as related to number of sprays per season of insecticides and fungicides is presented in table 1. Tables 2 and 3 show the actual usage of pesticides in relation to recommemded dosages and the percentage distribution of orchards in which the actual pesticide has been used.

Table 1. Percent distribution of orchards as related to number of sprays per season.

Number of sprays	Percent distribution of growers	
	Fungicides	Insecticides
1 - 2	-	47.3
3 - 4	-	37.7
5 - 6	39.5	11.6
7 - 8	32.8	2.8
9 - 10	18.5	-
11 - 12	7.0	-
13 - 14	1.4	-
15 - 16	0.7	-

In 242 (85%) of a total of 283 orchards the number of insecticide sprays ranged from 1 to 4. The average number of insecticide applications was 2.9. The number of fungicide sprays ranged from 5 to 8 in 72 percent of a total of 286 orchards. The average number of fungicide applications was 7.5.

Table 2. Amount of insecticides used per ha. Average of 283 orchards.

Insecticide	Average dosage/ha	Percent of max. dos.	Recom. dosage/ha	Percentage of orchards*
azinphos-methyl	1.16 kg	58	0.3[1] - 2.0 kg	45
endosulfan	0.4 l	20	0.2[1] - 2.0 l	28
fenthion	0.425 l	21	2.0 l	9
dimethoate	0.3 l	100	0.3 l	2
demeton-S-methyl	0.3 l	15	0.06[1] - 2.0 l	12

* Percentage of orchards where the actual insecticide has been used
[1] Recommended dosage in IFP

Except for dimethoate, the actual dosages of insecticides used in Norwegian apple production (table 2) are well below the maximum dosages recommended. The low dosages recommended in integrated apple production can be used without any harm to the beneficials.

Table 3. Amount of fungicides used per ha. Average of 286 orchards.

Fungicide	Average dosage/ha	Percent of max. dos.	Recom. dosage/ha	Percentage of orchards*
copper oxychloride	3.72 kg	74	5.0 kg	66
lime sulphur	18 l	45	30 - 40 l	61
sulphur	2.83 kg	47	3.0 - 6.0 kg	47
bitertanol	0.57 kg	19	1.0 - 3.0 kg	45
tolylfluanid	1.03 kg	34	2.0 - 3.0 kg	45
dodine	0.88 kg	49	0.6 - 1.8 kg	32

*Percentage of orchards where the actual fungicide has been used

Also the fungicides are used in dosages well below recommended maximum limits(table 3).

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EFFECTIVENESS OF NEW GENERATION ACARICIDES IN THE CONTROL OF TWOSPOTTED SPIDER MITE (*TETRANYCHUS URTICAE*) ON STRAWBERRY

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ABSTRACT

Experiments were carried out during 1988-94 on the strawberry plantation in central part of Poland. New generation acaricides - diafenthiuron (Pegasus 250 SC), fenazaquin (Magus 200 SC), pyridaben (Sanmite 20 WP), tebufenpyrad (Pyranica 20 WP), fenpyroximate (Ortus 050 SC), abamectin (Vertimec 1,8), and others were used for control of the twospotted spider mite (*Tetranychus urticae*) on strawberries. These acaricides used before blossom of strawberry showed satisfactory control of the mites.

INTRODUCTION

Twospotted spider mite - *Tetranychus urticae* Koch has been recently a major problem for many strawberry growers. Spider mites can cause severe damage to plants, particularly during the period of fruit growth and ripening, when the possibilities for chemical usage are limited. On strawberry twospotted spider mite, if needed, should be controlled early in the spring, before blooming. Azocyclotin, bromopropylate, cyhexatin, fenbutatin oxide, propargite, tetradifon, flucycloxuron and other pesticides showed good control of twospotted spider mite on strawberry and black currant (Łabanowska 1990abc, Łabanowska and Tkaczuk 1991).

This report gives the results of twospotted spider mite control with some new generation acaricides.

MATERIAL and METHODS

The experiments was carried out in 1988-94 on 2-3 year old strawberry plantations cv. Senga Sengana in Skierniewice region, (Central Poland). A knapsack "Turbine" or "Solo" sprayer was used to apply the sprays. A single treatment was applied before flowering. Mobile forms were counted before spraying and 4-6 times at 1-2 week intervals afterward. The selected results are presented in table.

RESULTS

Single treatment with new acaricides before blooming of strawberry, gave good control of mites during 4-7 weeks after spraying, depending on acaricide and year. The results are in agreement with earlier experiment, where one treatment in spring, gave good control of mite during bloosom and fruiting period.

CONCLUSIONS

1. Standard acaricides: azocyclotin, bromopropylate, hexythiazox and fenbutatin oxide were effective in the control of twospotted spider mite on strawberry.

2. New generation acaricides: abamectin, diafenthiuron, fenazaquin, flucycloxuron, flufenoxuron, mixture of propargite + hexythiazox and amitraz + clofentezine were similar in effectiveness to standard acaricides.

3. Fenpyroximate, pyridaben and tebufenpyrad gave high immediate effect, similar to the standards, but their residual effect was shorter.

Comparative effectiveness of acaricides in the control of twospotted spider mite *Tetranychus urticae* Koch on strawberry

Active ingredient	Commercial name	Direct effect	Residual effect
Azocyclotin	Peropal 25 WP	A	C
Hexythiazox	Nissorun 050 EC	A	C
Hexythiazox	Nissorun 10 EC	A	C
Bromopropylate	Neoron 500 EC	A	C
Fenbutatin oxide	Torque 50 WP	A	D
Propargite+ +Hexythiazox	Omite 30 WP+ +Nissorun 050 EC	A	C
Amitraz+Clofentezin	Mitac 200 EC+Apollo blue	A	C
Flufenoxuron	Cascade 050 EC	A	D
Flucycloxuron	Andalin DC 25	A	D
Diafenthiuron	Pegasus 250 EC	A	D
Fenazaquin	Magus 200 SC	A	D
Pyridaben	Sanmite 20 WP	A	E
Tebufenpyrad	Pyranica 20 WP	A	E
Fenpyroximate	Ortus 050 EC	A	E
Abamectin	Vertimec 1.8	A	D

A - High direct effectiveness
C - Long lasting residual effect
D - Satisfactory residual effect
E - Poor residual effect

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EVALUATION OF SELECTED INSECTICIDES IN THE CONTROL OF PEAR LEAF BLISTER MOTH (*LEUCOPTERA SCITELLA* ZELL.) IN COMMERCIAL ORCHARDS

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ABSTRACT

At last few years an evident increase of pear leaf blister moth in apple orchards was observed. During the year 1991 the effectiveness of fenoxycarb, hexafluron and teflubenzuron against this pest was evaluated in commercial orchards. All mentioned chemicals were highly efficient in the control of both first and second generations when once applied on low infested trees (about 1 mine per leaf on the untreated trees). In the orchards highly populated (6-8 mines per leaf) the treatment gave satisfactory results but the number of second generation mines was more numerous than in the less infested ones.

It proves that one treatment is not suffticient to control high population of pear leaf blister moth.

INTRODUCTION

Recently, pear leaf blister moth had caused economical losses in Polish orchards. High effectiveness of selected pyretroids against this pest was documented both in Poland (Maciesiak,1987; Maciesiak and Krawczyk,1992) as well as abroad (Ciglar,1981; Injac,1981). In Poland (Maciesiak and Krawczyk,1992) satisfactory results with single treatment have been received when the population was low (1 mine per leaf on the untreated trees). However, when the trees were heavily infested (about 7 mines per leaf in check combination) even 2-3 sprays did not give full control of the pest.

The aim of this work was to evaluate the effectiveness of the fenoxycarb, hexafluron and teflubenzuron against pear leaf blister moth.

MATERIAL and METHODS

The experiment was conducted in 1991 in commercial apple orchards. It was set in a compact block system on the area ot 0.5-1.0 ha. The sprays were applied with a tractor mounted sprayer. In orchards no.1 and no.2 - 500 l/ha of spraying liquid was used, but in orchard no.3 - 1500 l/ha.

Number of mines was counted in a random sample of 100 leaves picked at the end of larvae feeding period for each replicant and generation separatelly.

RESULTS

Before spraying the populations of pear leaf blister moth in orchards 1 and 2 was on a medium level, but in the orchard no.3 it was extremely high. All the selected insecticides: fenoxycarb, hexafluron and teflubenzuron were highly effective in the control of first generation in all 3 experimental orchards. However, in the orchard no.3, where the pest was abundant, the number of second generation mines was more numerous than in the less infested ones.

The obtained results confirme earlier data (Maciesiak and Krawczyk,1992). It proves that in the condition of high infestation 1 treatment is not sufficient to control this pest.

The effectiveness of pear leaf blister moth control

Active ingredient	Dose rate in g a. i./ha	Number of mines/100 leaves					
		Number of the orchard*					
		1		2		3	
		Generation					
		I	II	I	II	I	II
Fenoxycarb	225	0	23.5	0	3.7	-	-
Hexafluron	75	0	10.4	0	1.2	5.0	84.9
Teflubenzuron	112.5	0	3.0	0	1.5	1.3	10.4
Standard**	-	1.2	3.6	0	9.3	2.2	29.7
Check	-	97.2	163.6	95.2	166.6	884.9	642.4

* Date of treatment:
Orchard 1 - May 31
Orchard 2 - May 31 and June 13
Orchard 3 - May 29

** Standard insecticides:
Orchard 1 - acrinatrine 135 g a.i./ha
Orchard 2 and 3 - alphamethrin 15 g a.i./ha

CONCLUSIONS

1. Fenoxycarb, hexafluron and teflubenzuron were highly effective against pear leaf blister moth.
2. In case of heavy infestation at least 2 treatments are required.

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EFFECTS OF MULTIPLE TREATMENTS OF DIFFERENT INSECTICIDES ON THE ARTHROPOD FAUNA OF APPLE TREES

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Abstract The effects of 6 insecticides in multiple application (active ingredients Diflubenzuron, Esfenvalerate, Fenoxycarb, Parathion and Parathionmethyl, encapsulated) on the arthropod fauna of apple trees were studied by strike sampling in large single plots. Diflubenzuron and Fenoxycarb caused only little effects on the insect fauna. Among the phosphorus insecticides Phosalone was the most harmless one. Encapsulated Parathionmethyl and Esfenvalerate showed to be rather persistent and caused negative effects on some groups of beneficials, especially *Typhlodromus pyri.*

Introduction, Materials and Method

Codling moth (Cydia pomonella) is the key pest of pome fruit production. A successful control of codling moth is in most cases is linked with several treatments of insecticides. All other animal pests of apple do not occur in such a periodical way. In this investigation the effects of 6 different insecticides in multiple application (4 times) as used for codling moth control on the arthropod fauna of apple trees were studied. The experiments were carried out in 1993 and 1994 in the experimental orchard of the institute in Netheraustria.

product	active ingredient	g. a.i. per l product	concentration
DIMILIN	Diflubenzuron	250g/l	0,04%
EKATOX	Parathion	200g/l	0,15%
INSEGAR 25 WP	Fenoxycarb	250g/kg	0,04%
PENNCAP M	Parathionmethyl, encapsulated	240g/l	0,125%
RUBITOX fl.	Phosalone	342,5g/l	0,15%
SUMI ALPHA	Esfenvalerate	50g/l	0,025%
untreated control	-	-	-

Dimilin, Ekatox, Insegar and Penncap were tested in 1993, Penncap, Rubitox and Sumi alpha in 1994.
The size of the large single plots was 50 respectively 60 trees of Golden Delicious, planted in 5 x 5 distance for the insecticide treated variants. A plot of 30 trees Golden Delicious and James Grieve each served as untreated control. The application of the tested products was carried out with a motor sprayer by hand. All other necessary sprayings (e.g. fungicides) were done in an uniform way in the plots with a tractor sprayer. Only products, from which it can be expected, that they have minimal effects on non target organisms, were used for this.

Strike samples of 40 strikes in 1993 resp. 50 strikes in 1994 were taken at about all 10 days in the plots following the Steiner method. In addition leaf samples and visual controls have been done.

Results and Discussion

In 1994 from July onwards in the Sumi alpha and in the Penncap plot the population density of red spider mite (Panonychus ulmi) increased and in August it was over the economic threshold. At the same time Typhlodromus pyri disappeared in this variants. Although a lot of other predators of spider mites like Stethorus punctillum or Orius sp. settled down in this plots and their population density was much higher there than in the other plots. The spider mite population did not collapse till winter egg laying. In the other plots of 1994 and in 1993 there was no appreciable increase of spider mite populations. This result points out the eminent importance of Typhlodromus pyri as a regulative for spider mites in IFP.

The relatively fast immigration of high mobile beneficials in plots, treated with broad spectrum insecticides in the moment, when there is a high amount of prey points out, that even plots of 1 500m^2 can be to small for experiments on the effects of treatment strategies on arthropod populations.

In total in all insecticide plots a decrease in the number of individuals of insects and spiders in comparison with the untreated plots could be found in the strike samples. Among the three phosphorous insecticides Rubitox turned out to be the most harmless one for beneficials. In the case of Ekatox immediately after the applications strong effects on the entomofauna occurred. But because of the fast decomposition of the active ingredient the fauna recovered relatively fast. Encapsulated Parathionmethyl (Penncap M) showed to be rather persistent and caused negative effects on some beneficials (Typhlodromus pyri or Forficula auricularia as examples). In total Sumi alpha showed the strongest effects on beneficial and on the arthropod fauna at all. The two insect growth regulators Dimilin and Insegar especially compared to Penncap M and Sumi alpha created only little effects on the insect and spider fauna.

THE EFFECTS OF GRANULOSIS VIRUS AND JUVENOIDES ON *Cydia pomonella* L.

by

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Abstract

In the control of the K-pest such as the *Cydia pomonella* L. selective insecticides such as Baculoviruses (granulosis), fenoxycarb, triflumuron, imidacloprid and acetamiprid were used. The assays have been separated in field conditions of smaller apple orchards with the possibility of the *C. pomonella* butterfly to overfly, and even on greater areas where this possibility is minimal. Triflumuron has shown satisfactory results in the IPM range because it has an ovicidal and ovilarvicidal effect. Granulosis virus can be used in apple fruit production as food for special purposes because the damage thresholds are lower than permitted in the IPM program range, and fenoxycarb only as an ovicid. Imidacloprid and acetamiprid are aphicides and effect on the *C. pomonella* is an added broadening of the spectrum.

Cydia pomonella L. belongs to the typical K-pest of the apple and pear orchard. In order to avoid a massive appearance of the R and RK pests, the presence of the *C. pomonella* is tolerated up to the spraying thresholds (action thresholds), but in the protection of beneficial organisms more selective insecticides are searched for, like the Baculoviruses (granulosis) (Hubner 1979; Injac et al., 1992), juvenoid fenoxycarb (Audemard et al., 1986, Galli 1986), followed by insecticides on basis of benzoil urea (Mori et al., 1979 and some new insecticides (Elbert et al., 1990, Matsuda 1995). The purpose o this assay research was to determine the possibilites and conditions under which these insecticdes can be used, so these results will be shown in this work.

The insecticdes were tested under field condtions on small apple orchards where the *C. pomonella* moths fly over from Zemun, while the moths fly over from Subotica to greater area. The *C. pomonella* moths was monitored by AgriSense traps. The optimal tmefor use is the beginning of F_1 caterpillar hatching. The effects of the insecticides was determned on several occasions until the end of the generation. Methods: review of at least 300 fruits by nsecticides, dissection and review of trap bands made of corrugated paper. The followng insecticides were used:

Baculoviruses granulosis *C. pomonella* (Carpovirusine, Calliope-France) 1.5 l/ha
Fenoxycarb (Insegar WP 25, Ciba, 600 g/ha
Triflumuron (Alsystn WP 25, Bayer, 400 g/ha)
Imidamiprid (Confidor 200 SL, Bayer, 500 ml/ha)
Acetamiprid (Ni-25, Nipon Soda, 125 g/ha).

During 1994-1995, under conditions of Zemun, where overflight is possible of the C. pomonella moths after application of the granulose virus, the initial penetration of the caterpillar was estimated from 6.40% and 9.68% by years. But because of the death of the caterpillar from granulosis under the epidermis of the fruit and even later on, the number of active holes had reduced to 3.50 % in 1994. and 4.36 % in 1995. A small number of caterpillar and pupae were found in 12 band traps (9 in 1994 and 2 in 1995). In conditions of apple orchards of great areas (Subotica - 1994) and a small number of the *C. pomonella* moths, there were 0.5% damaged fruits. After the use of the virus, the number of *Aphis pommi* Deg., *Dysaphis plantaginea, D. devecta* Walk and phytophagous mites increased. The number of the polyphagous predators had also increased, specially the spider mite.

Fenoxycarb at the beginning of caterpillar hatching acted ovicidal as an insecticide and as a juvenoid. In relation to the check were 43.19% in 1994. and 37.82% in 1995. of fruit with penetrated caterpillars was estimated, with fenoxycarb 18.80% was found in relation to 19.73% damaged fruits. Only one pupae was found in 12 band traps, which represents a greatly reduced number of the F_2 *C. pomonella*.

Triflumuron acts ovicidal and larvicidal when used during the caterpillar hatching period. 4,6% of fruits were found by discarded larvicidal frass after the first treatment, but because of the death L_1 *C. pomonella* caterpillar, in the second spraying the number of damaged fruit had reduced to 0,9%.

Imidacloprid and acetamiprid acts on the *C. pomonella* ovicidal, but do not have deep penetrating action on the caterpillar. With imidacloprid 8.33% damaged fruit was found, while with acetamiprid 25.64%.

Conclusions

The granulosis virus can successfully be used in the protection of apple fruits but for special purposes, because they protected from 80.75 % to 96.64 % fruits.

Fenoxycarb showed a low level of efficiency in 1994 - 81.2% and in 1995 - 80.27%, so fenoxycarb can be used as an insecticide and as a juvenoid only to reduce the number of the *C. pomonella* generation to follow.

The efficiency of triflumuron after two treatments in 1995 was 99.1 % and can successfuly be used in comercial orchards in the IPM program range

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POSTERS

Section: Cultivation and Nutrition

VEGETATIVE PROPAGATION OF THE LIGNONBERRY (*Vaccinium vitis-idaea* L.)

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Abstract. The rooting performance of lignonberry (*Vaccinium vitis-idaea* L.) depending on predator fungus *Trichoderma* T-6RC and growth stimulator IAA was investigated. *Trichoderma* promoted the root-system growth but IAA showed a negative effect.

Introduction. Cultivation of wild berries is a new challenge for Estonian farmers. To establish the plantations large amounts of planting material are needed, but problems concerning the propagation and cultivation of lignonberry are poorly investigated in Estonia yet.

This research was commenced in 1994. The main attention was paid to the lignonberry propagation from stem cuttings as the seed propagation is not recommended for producing plants on a commercial scale (Gustavsson,1994) and micropropagation is more complicated and expensive. A successful propagation procedure results in at least 80% rooted plants and takes normally one year from propagation to planting out into the field (Gustavsson,1994).

Treatment with root promoting agents (IAA, IBA, cytokinin) has not resulted in significantly increased rooting in lignonberry (Bandzaitene, 1975; Gustavsson ,1975; Lehmushovi, 1975). Soil micromycetes from genus *Trichoderma* are known as biological control agents against fungal plant diseases and the potential of some strains to induce increased growth of various horticultural and floricultural crops has been determined (Chang *et al.*,1986). There is no records of using *Trichoderma* in lignonberry.

Material and methods. Cuttings were taken from wild-growing lignonberry plants on July 20. Substrate used was milled sphagnum peat and sand 3:1 (v/v). There were three variants in the experiment: 1)cuttings were dipped in 0.5% IAA solution in 50% ethylalcohol before planting, 2) the substrate was treated with culture of *Trichoderma* T-6RC containing at least 10^8 cfu/g before planting. The amount of Trichoderma added to the surface of the substrate was 5 g/m^2, 3) untreated (control).

Cuttings were planted into plastic boxes. There were 100 cuttings in each variant. Boxes were held in cold frames and sprinkled 3 times a day. After 8 weeks rooted plants were harvested and measured.

Results:
1. Treatment with 0.5% IAA solution in ethylalcohol decreased rooting of lignonberry cuttings significantly (P=99.9%) (Figure 1).

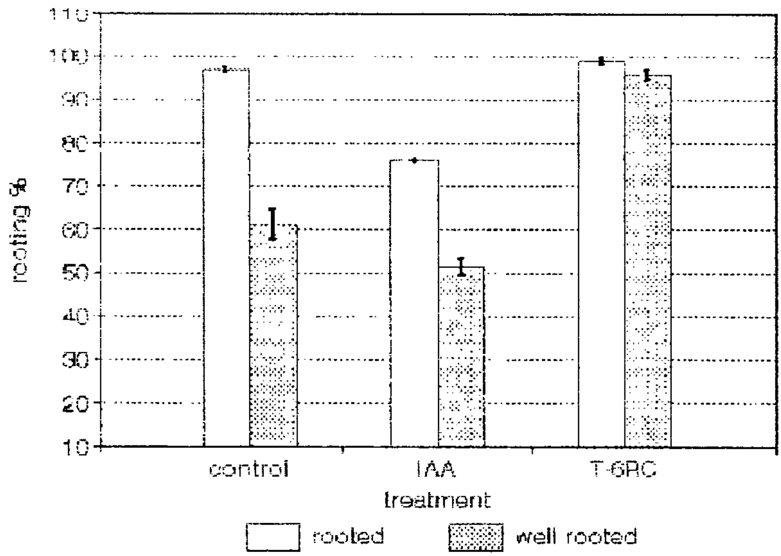

Figure 1. Influence of IAA and predator fungus T-6RC on rooting of lignonberry cuttings.

2. *Trichoderma* T-6RC did not influence the rooting percentage of lignonberry cuttings but the percentage of well rooted plants (with strong and compact rootball) was significantly (P=99%) higher (Figure 1).

As data presented here were collected during one vegetation season, the results must be treated as preliminary and the study of factors influencing root-forming ability of lignonberry cuttings has to be continued.

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POMMIT EKSTRA 110 SL AN APPLE THINNING AGENT SAFE FOR THE ENVIRONMENT

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Abstract

Pommit Ekstra 110 SL , the product of Varichem (Poland), is a mixture of low concentrations of NAA-potassium salt, urea and adjuvant. At present time it seems to be the best preparation for apple fruitlets thinning in integrated fruit production in Poland.

Introduction

Chemical fruit thinning is a standard practice to improve fruit size, increase return bloom, and reduce biennial cropping. In Poland the preparation Pomonit R 10 (Organika, Poland) containing 10% NAA -K salt (IV class of toxicity) is used for thinning most often. The integrated fruit production requires methods of thinning more and more safe for the environment. One of these would be the application of NAA - K salt at low concentration together with urea as an accelerator of NAA (Yamada et al., 1965). Urea known to be safe for environment as the natural product and is quickly metabolized by plants. Additionaly, urea at high concentration acts as a thinning agent (Basak 1993). Trials have been undertaken to produce the preparation safe for thinning in integrated fruit production that composed with low concentrations of NAA - K salt and urea.

Materials and methods

Tests were carried out in 1991-1993 on 8-12-year old apple trees cvs. Gala, Lobo, Empire, Spartan in Research Institute of Pomology and Floriculture at Skierniewice. The apple trees were spraying soon after bloom with 6 formulations of Pommit Ekstra 110 SL containing the different amounts of NAA - K salt and urea but with the same amount of adjuvant. The preparation was used by hand gum sprayer, at concentration 0.02-0.04%, and in amount of 1500 liters per ha. All formulations of Pommit Ekstra 110 SL were supplied by polish Laboratory "Varichem." The trees sprayed with NAA - K salt alone (as Pomonit R 10), the hand thinned trees and unthinned ones were used as controls.

Eight uniform apple trees were used for each treatment.The number of fruits per 100 blossom clusters , yield, the quality of apples at harvest time and after storage and the intensity of blooming next season were determined.

Results and discussion

In most cases the experimental formulations of Pommit Ekstra 110 SL, in spite of low concentration of NAA - K salt, caused similar apple fruitlets thinning as Pomonit R-10 preparation (Table 1). The effect depended on concentrations of both NAA - K salt and urea in the preparations as well as the susceptibility of apple cultivars to the constituents. Urea in this preparation acted as an accelerator of NAA increasing the effectiveness of low concentrations NAA. Urea and adjuvant caused the effectiveness of Pommit Ekstra 110 SL more uniform under different weather conditions. Moreover, urea in this preparation acted as a fertilizer resulting often in an additional increase of fruit size.

Conclusion

Since 1995 the preparation of Pommit Ekstra 110 SL containing NAA - K salt (80 gram/1 liter) and urea (30 gram/1 liter) plus adjuvant has been commercially used in Poland. It is less toxic than Pomonit R 10 (because of the lower concentration of NAA) and therefore is safer for the environment.

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Table 1 - The results of apple fruitlets thinning after application of Pommit Ekstra 110 SL in 1993.

Treatments	Fruit weight (g)		No. fruit per 100 blossom clusters	
	cv.Lobo	cv.Empire	cv. Lobo	cv.Empire
Control unthinned	136	85	83	83
Control hand thinned	162	106	65	67
*Pommit Ekstra 110 SL 40mg/l:				
No. 308	165	101	49	45
No. 309	176	100	33	35
No. 310	172	104	25	44
No. 311	192	107	25	26
Pomonit R 10 : 25mg/l	167	101	48	68
40mg/l	169	106	28	42

* Pommit Ekstra 110 SL composed:
No. 308 - 15 mg/l NAA + 1500 mg/l urea + adjuvant,
No. 309 - 25 mg/l NAA + 1500 mg/l urea + adjuvant,
No. 310 - 20 mg/l NAA + 450 mg/l urea + adjuvant,
No. 311 - 28 mg/l NAA + 1000 mg/l urea + adjuvant.

Vitamin E (α-Tocopherol) against oxidative stress in apple trees

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1. Introduction

In plants the influence of oxidative stress brought about by heat, ozone, water deficiency or pesticides, is known to induce peroxidation of unsaturated membrane fatty acids and release of free oxygen radicals during photosynthesis. The aggressive oxygen species of H_2O_2 and OH^- can initiate the breakdown of lipids and proteins, and rapidly inhibit photosynthesis (DAUB, 1982). Protection against phytotoxic peroxidation may be achieved by several antioxidants, such as glutathione and the vitamins E and C (FRYER, 1992).Vitamin E, however, seems to be the most effective lipophilic radical-chain-breakdown substance. α-Tocopherol biosynthesis takes place inside the chloroplast membranes of the plant (SCHULZ, 1990). Its antioxidant activity is thus quite useful in plant leaves as a means of protection against metabolic disorders.

2. Material and Methods

`Jonagold` apple trees were sprayed every 14 days from May to September 1994 in the field with a vitamin E preparation (0,25% a. i. of α-Tocopherol) in the aqueous spraying solution. After 6, 24, 48 and 96 h of vitamin E treatment, randomized samples of fruits and leaves were taken and treated with the herbicide paraquat (1,1`-Dimethyl-4,4`-bipyridinium-dichlorid) at concentrations of 0.1, 0.2 and 0.3 mM. Paraquat is known to generate free radicals which in turn induce lipid peroxidation. Unsprayed fruits and leaves served as control.
Chlorophyll bleaching is one of the characteristic symptoms for plant diseases caused by infection, by certain physical parameters or by chemicals specifically for paraquat action. Four hrs after paraquat treatment of fruits and leaves, the chlorophyll bleaching was measured with a chroma meter-II Reflectance systems (a*-CIELAB). Chlorophyll-fluorescence [Fx=(Fp-Fi)/Fp] was recorded with a PAM 101 fluorometer (Walz Co., Effeltrich, Germany) to measure the herbicide effect on photosynthesis (electron transport).

3. Results and Discussion

Due to Paraquat treatment, electron transport activity in the leaves and fruits was inhibited and chlorophyll degraded. This is documented in the time-course study both by chlorophyll flourescence Fig. 1, left column) and CIELAB-a* measurement (Fig. 1, right column) Interestingly, prophylactic treatment with vitamine E significantly reduced the deleterious effect of the subsequent herbicide application.
Paraquat clearly affected the electron transport (chlorophyll fluorescence) and caused membrane damage by inducing lipid peroxidation.. α-Tocopherol is known to have antioxidant activity, which prevents autooxidation of unsaturated lipids. As a conseqeunce, one of its function may be the protection of membrane lipids. α-Tocopherol is associated with the

chloroplast membrane and is thought also to be present in mitochondria The vitamin E treatment was effective in protecting apple fruits and leaves (results not shown here) against membrane damage from the herbicide.

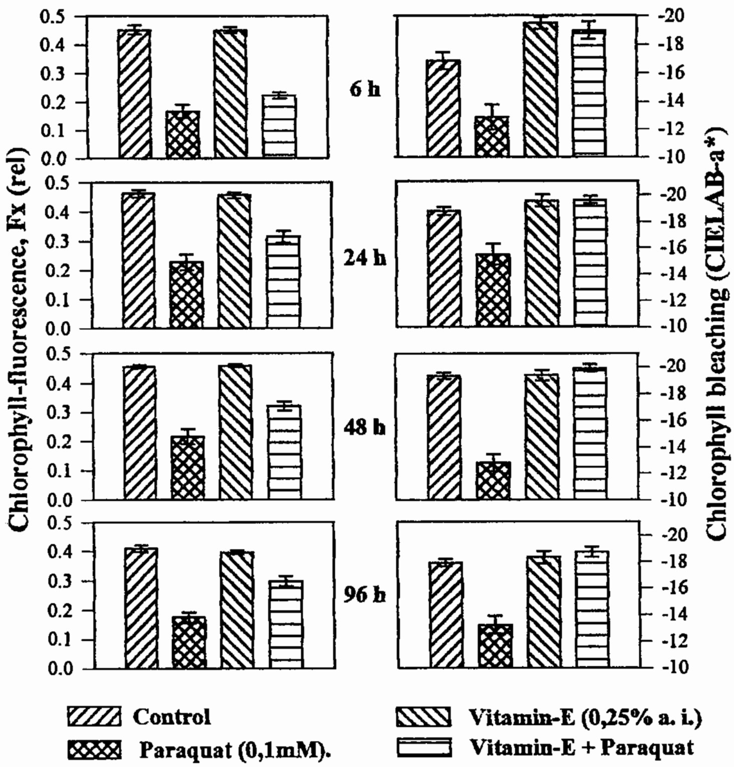

Figure 1: Influence of paraquat treatment on Chlorophyll-fluorescence and Chlorophyll bleaching of apple fruit cv. Jonagold as a time-course-study of Vitamin E (α-Tocopherol) based treatment

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ECOLOGICAL METHODS OF SOIL MANAGEMENT IN SCAB RESISTANT APPLE ORCHARD

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Abstract
Scab resistant apple cultivar 'Sawa' on M. 26 was grown under different soil management treatment, i.e. herbicide in the rows compared to pine bark mulch or overall sward. In the first and second year after planting use of pesticides was limited to pirimicarb applied against apple aphids. Apple powdery mildew was effectively controlled by pruning of infected shoots. Overall grass reduced growth of trees to a great extent, reduced leaf N, K and Ca and increased leaf P concentration. Bark mulch in the rows resulted in the best growth and overall grass in the worst one. N fertilisation at the dose of 100 kg ha^{-1}, used over all area or in the strips only had a less pronounced effect on growth or on leaf mineral content than methods of soil management. N fertilisation did not influence soil nitrate and ammonium content in the topsoil and subsoil. After the first year of study, N fertilisation lowered soil pH on plots where herbicides were used. In the second year, N fertilisation enhanced leaf green colour index on overall grassed and mulched plots. On non-fertilised plots mulching and especially overall grass diminished leaf green colour index. The serious problem of the weeds on the bark mulched rows appeared in the second year.

Introduction
The overall herbicide system proposed by Robinson (1982) has been limited due to problems of weed resistance and of herbicide toxicity to the environment. Soil management systems may alter nutrient supply especially N absorbtion by apple trees (Rupp 1993, Ystaas and Froynes 1993), and exert different effect upon environment. In this study three different methods of soil management were compared in the orchard grown with minimum use of pesticides.

Materials and methods
One-year-old maiden trees of scab resistant cv. 'Sawa' bred recently at the Department of Pomology, Warsaw Agricultural University chip-budded on M.26 at the height of 15 cm, were planted in autumn 1993 on plots with different soil management. In contrast to the herbicide strips in the rows, pine bark mulch or overall sward have been used as more environment friendly methods. Alleways were maintained in sward, frequently mown in all treatments. Against the background of soil management treatments, three N fertiliser treatments, i.e. 100 kg N ha^{-1} over all area, 100 kg N ha^{-1} in 1 m strips only and N-0 control, were compared.

Results
In the first and the second year of study pirimicarb (Pirimor) was applied against green apple aphid and rosy apple aphid, and no other pesticides were used. Apple powdery mildew was effectively controlled by pruning of infected shoots, once in the first and twice in the second year. In the second year a serious problem of weeds on bark mulch strips appeared. Creeping thistle (*Cirsium arvense,Scop.)*, knot-grass *(Polygonum arviculare, L.)* and couch grass (*Agropyron repens, L.)* were dominating on mulched strips, whereas saw thistle (*Sonchus ssp.)* and willow weed *(Polygonum persicaria L.)* on herbicide strips. The N fertilisation did not affect the spectrum of weeds. The overall grass reduced growth of trees to the great extent and reduced leaf N, K and Ca concentration (table 1).

Table 1. Growth of trees, topsoil nitrogen and ammonium content, leaf macronutrient content in 1994 and leaf green colour index in June 1995.

Soil management	Increase of TCSA (mm^2)	$N\text{-}NO_3$ (mg/l^{-1})	$N\text{-}NH_4$	Leaf content (% d.m.) N	K	Ca	Mg	Leaf green colour index*
Herbicides	31.7	9.3	7.1	2.12	1.43	1.01	0.29	4.07
Mulching	51.2	5.5	5.5	2.01	1.55	1.09	0.27	3.45
Grass	19.4	6.7	5.3	1.87	0.98	0.99	0.36	3.05
$HSD_{0,05}$	7.7	3.5	0.6	0.10	0.17	0.04	0.08	0.35

* Scale: very light - 1; very dark - 10.

Use of herbicide resulted in the increase of soil available N and leaf N contents. In the second year after planting trees grown under herbicide treatment had darker green leaves whereas trees grown under grass showed a lighter green leaf colour. On non-fertilised plots mulching, and even more overall grass, diminished leaf green colour index. On the other hand, N fertilisation significantly enhanced green leaf colour of trees grown under overall sward.

Conclusions

1. It is possible to reduce pesticide use when scab resistant cultivars are planted in an apple orchard.
2. Overall grass reduced tree growth to a great extent. Overall grassed trees need more N fertilisation.
3. The bark mulch increased growth of trees in the first year, but had a lesser effect in the second year, apparently because of perennial weed problem.
4. Herbicide strips improved growth of trees, nitrogen, potassium and calcium uptake and leaf colour index of apple trees. Trees grown on herbicide strips did not respond to N fertilisation.
5. N fertilisation in the rows only had, so far, the same effect as fertilisation over whole orchard area.

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POSTERS

Section: Herbology

THE COVER OF HERBACEOUS PLANTS IN AN IPM APPLE ORCHARD AND ITS INFLUENCE ON THE OCCURRENCE OF RODENTS

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INTRODUCTION The common vole (*Microtus arvalis* Pall.) is a dangerous pest of fruit trees in Poland. During a big infestation and in good conditions (thick snow cover) it can destroy even 100% trees in the young apple or cherry orchard. It is estimated that mechanical soil cultivation and using herbicides reduces the number of rodents from Microtidae family in 60-90%. Cutting high weeds once per season reduces the number of common vole several times (Byers & Young, 1978; Wieland, 1994). As in the IPM orchards sowing herbaceous plants between trees is recommended to maximise biological control, a series of observations was carried out researching the effect of these plants on occurance of rodents.

MATERIAL AND METHODS The observations were carried out in Prusy, in an 4-6 years old experimental IPM apple orchard. The herbicide fallow was maintained in the tree rows, with or without sowing various herbaceous plants. Intercrops had grass mowed 6-7 times during season. Observations on incidence of rodents were carried in autumn. Active rodent colonies were counted on four areas in each combination. One area covered a row of trees and an intercrop. During first season it amounted to 450 sqm and during next seasons further 900 sqm. The species were recognized by their burrows, excrements and other marks, as well as by collecting dead animals after chemical treatment.

RESULTS *Microtus arvalis* Pall. was a dominant species in the orchard. It's share in a rodent population amounted to 70-90%. *Apodemus sylvaticus* L. was the second largest species with it's share between 10 and 30%. During all seasons the least number of rodent colonies was found on the plots with herbicidal weeding, the most colonies were found on those with herbaceous plants not cut untill autumn (table 1). The detrimental effect of mustard and buckwheat was not observed - although these plants are noxious to the vole. Quite opposite, in areas where they were grown - the incidence of colonies was larger than in herbicide fallow. This is consistent with observations by Romankowowa & Taborski (1969) stating that noxious effect of these plants comes one only when they are the sole available food.There was an obvious correlation observed between the time of cutting plants and occurence of rodents in the years 1992-1993. Cutting plants in summer reduced the numbers of rodents to the level observed on the plots with herbicidal weeding. This effect was not observed in 1994 because of self-seeding of the most of plants. As the result, growing herbaceous plants were observed again on all plots in autumn.

CONCLUSIONS

1. Cultivation of herbaceous plants in orchards, including mustard and buckwheat increases the incidence of rodents.
2. In these orchards where herbaceous plants are cultivated to maximise biological control it is necessary to pay more attention to control of rodents.

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Table 1. The cover of herbaceous plants* in an IPM apple orchard and its influence on the occurence of rodents

Plots, plants and dates of their cutting during three seasons	Number of rodent colonies per 450 sqm		
	1992	1993	1994
1. Mustard - 08 & 09.92, mustard - 07.93, mustard - 08.94	7.0 a	2.4 a	7.1 b
2. Wild heliotrope - 08 & 09.92, wild heliotrope - 07.93, mustard - 08.94	4.5 a	4.1 a	7.2 b
3. Buckwheat - 08 & 09.92, mustard - 09 & 10.93, wild heliotrope - 08.94	11.1 bc	12.2 b	13.7 c
4. Horse bean - 08 & 09.92, mustard - 09 & 10.93, roquette - 08.94	8.5 abc	25.3 c	10.8 bc
5. Composition** 1 - 11.92,	29.0 d		
composition** 2 - 08 & 09.92,	14.4 c		
mustard + roquette - 09 & 10.93,		21.7 c	
buckwheat - 08.94			13.6 c
6. Herbicide fallow	7.3 a	1.9 a	2.2 a

* Plants were sown in 1-3 rows on the border of herbicide fallow. Many of plant sowed themselves again, particularly in 1994. Roundup in the rate 4-5 l per ha plus amonium sulfate in the rate 5-6 kg per ha were used in tree rows. Azotop in the rate 0.5 kg per ha instead of amonium sulfate were added once in 1993 on plot number 6.

** Composition 1 - mustard, buckwheat, roquette and persian clover; composition 2 - wild heliotrope, persian clover, dill, horse bean, coriander, buckwheat and other.

EFFECT OF DIFFERENT DOSES OF 2, 4, 5-TP ON THE PRECOCITY AND QUALITY OF SOME LOW-CHILL APRICOT CULTIVARS

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Abstract: The aim of this study is to determine the effect of different doses of 2, 4, 5-TP (0, 20 ppm, 30 ppm) on the precocity and fruit quality of six apricot cultivars (Beliana, Canino, Feriana, Precoce de Colomer, Precoce de Tyrinthe, Priana) grown in the Mediterranean region of Turkey. For this purpose 2, 4, 5-TP was sprayed at the beginning of endocarp hardening. 30 ppm 2, 4, 5-TP in Priana, Beliana, Precoce de Colomer and Precoce de Tyrinthe and 20 ppm of the same PGR in Canino and Feriana improved the fruit quality markedly. No effect of the PGR was observed on the precocity.

Introduction: Turkey is a leading apricot producer country in the world with about 378 thousand tons in 1992. However, most of this production is obtained from cvs for drying. Although Turkey has a very suitable areas for early production of table apricot growing in the Mediterranean coastal region, this subject was neglected until the last two decades. The problem was to find productive cvs with low chilling requirements, precoce with high sugar content, big in size, free stone, resistant to transport, attractive with its bright red chick color. Some other investigators were also studying the effect of different PGR such as GA and ethephon on the yield and quality of apricots (Rabeh and Kamal, 1987). In this study we wanted to see whether there is any effect of 2, 4, 5-TP (2,4,5-trichlorophenoxyacetic acid) especially on the production of early fruits.

Material and Method: The pomological characteristics of the experimental cvs were given elsewhere (Paydaþ and Kaþka, 1993). 2, 4, 5-TP were sprayed to 20 selected branches in 3 trees of each of the cvs at the time of pith hardening. The harvested trees were subjected to pomological analyses, such as precocity, average fruit weight, fruit sizes (width, length, height), seed weight, flesh/seed ratio, acidity, TSS and skin color.

Results and Discussion: Application of 2, 4, 5-TP did not effect markedly the precocity of the fruits. However, 30 ppm 2, 4, 5-TP caused 2 days earliness in Priana. Due to the unusual increases in temperatures at the period of fruit maturations the fruits of other cvs were harvested at about the same dates with the control fruits.

Table 1 shows the results of the measurements of the fruit characteristics of the cvs in question. Both 20 and 30 ppm 2, 4, 5-TP significantly increased the fruit sizes in comparison to the controls in all cvs (Column 1). However, the responses of each cv was found somewhat different. Depending on the cv and used doses the average fruit weights changed between 4.50 and 15.31 g. In percentage the minimum and maximum increases of fruit weights were calculated as 11.90 % and 46.84 % higher than those of the control fruit. Fruit characteristics such as fruit width (Column 2), fruit length (Column 3), fruit height (Column 4), seed weight (Column 5), flesh/seed ratio (Column 6), acidity (Column 7) and TSS (Column 8) were more or less affected by 2, 4, 5-TP in comparison to those of the controls. The effect of 2, 4, 5-TP on the skin color of the fruits is not prominent. In conclusion, 30 ppm 2, 4, 5-TP in Priana, Beliana, Precoce de Colomer, Precoce de Thyrinthe and 20 ppm 2, 4, 5-TP in Canino and Feriana were recommended because of their positive effects on the fruit quality of these cvs. Those types of works will be continued in future with new cvs in different ecologies.

Table 1. Effects of Different Doses of 2,4,5-T P on the Fruit Quality Characteristics

Cultivars (harvest time)	*Doses of 2,4,5-T P*	*1* (g)	*2* mm)	*3* (mm)	*4* (mm)	*5* (g)	*6* (rates)	*7* (%)	*8* (%)	*9* (1-5)
BELIANA (23/5/95)	0	25.69 b	33.79 b	34.33 b	35.81 c	2.30 b	10.11 b	0.38 b	12.67 a	4.31
	20	35.08 a	37.68 a	37.67 a	38.89 b	2.70 a	11.96 a	0.39 b	12.84 a	4.18
	30	36.94	38.62 a	38.64 a	40.82 a	2.81 a	12.13 a	1.15 a	10.13 b	4.39
	$D_{\%5}$	*4.94*	*2.14*	*1.98*	*1.81*	*0.24*	*1.19*	*0.35*	*1.57*	*N. S.*
CANINO (31/5/95)	0	37.81 b	38.22 ab	40.57	40.52	2.71	12.97	1.51	9.40 b	3.69 b
	20	44.07 a	34.98 b	37.66	38.47	2.86	14.61	1.51	10.31 a	4.30 a
	30	42.31 a	40.67 a	42.11	42.51	2.84	13.96	1.43	8.93 b	4.21 a
	$D_{\%5}$	*4.39*	*4.31*	*N. S.*	*N. S.*	*N. S.*	*N. S.*	*N. S.*	*0.74*	*0.37*
FERIANA (24/5/95)	0	24.47 c	28.71 b	29.67 b	30.15 b	2.31 c	9.56 b	1.49	9.27 b	4.05
	20	35.93 a	37.54 a	37.04 a	39.62 a	2.96 a	11.27 a	1.42	10.33 a	4.00
	30	29.24 b	32.45 ab	31.18 ab	34.08 ab	2.61 b	10.32 ab	1.38	9.93 ab	4.11
	$D_{\%5}$	*3.21*	*6.75*	*5.98*	*5.70*	*0.19*	*1.07*	*N. S.*	*0.88*	*N. S.*
Precoce de COLOMER (30/5/95)	0	26.79 b	34.43	35.40 b	35.78 b	2.67 b	9.09 b	1.36 b	9.84	3.32
	20	37.31 a	36.54	37 33 b	38.30 ab	2.86 a	11.99 a	1.57 a	10.16	3.48
	30	42.10 a	39.74	42.22 a	42.11 a	3.02 a	12.77 a	1.69 a	9.82	3.41
	$D_{\%5}$	*9.97*	*N. S.*	*4.73*	*4.87*	*0.30*	*2.74*	*0.19*	*N. S.*	*N. S.*
Precoce de TYRINTHE (26/5/95)	0	27.35 b	35.13 b	36.68 b	35.89 b	2.63	9.40 b	1.53	8.53 b	3.31
	20	32.14 a	36.53 ab	39.89 a	38.57 ab	2.69	10.95 a	1.58	9.89 a	3.38
	30	34.48 a	37.54 a	39.20 a	38.96 a	2.92	10.81 a	1.47	9.80 a	3.32
	$D_{\%5}$	*3.14*	*2.15*	*1.99*	*2.72*	*N. S.*	*1.01*	*N. S.*	*1.23*	*N. S.*
PRIANA (15/5/95)	0	35.26 b	39.29 b	40.28 b	41.03 b	2.32 b	14.57	1.08 a	10.67	4.09 b
	20	45.72 a	40.91 a	41.40 ab	43.32 a	2.92 a	14.72	0.91 b	10.71	4.36 a
	30	46.93 a	40.81 a	42.59 a	43.98 a	3.06 a	14.43	1.37 a	10.87	4.36 a
	$D_{\%5}$	*3.46*	*1.44*	*1.23*	*1.29*	*0.30*	*N. S.*	*0.31*	*N. S.*	*0.25*

1: Average Fruit Weight, 2: Average Fruit Width, 3: Average Fruit Lenght, 4: Average Fruit Height, 5: Average Seed Weight, 6: Flesh/Seed Ratio, 7: Acidity, 8: TSS, 9: Skin Color

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Summarizing of presentations

Summary of the presentations on IFP - General Problems

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1. Implementation of IFP-IPM in practice

A review of the current status of Integrated Fruit Production shows a strong expansion during the last few years. In **Western European countries** 42 % of the pome fruit area (ca. 250.000 ha) are grown according to IFP-schemes or similar quality assurance. This means an increase of 40 % on the basis of the 1991-status. A total of 32 regional or national organizations are promoting IFP. In stone fruit production several IFP-systems already have been introduced into practice. The greatest successes that have to be emphasized are: well-trained fruit growes, increase in beneficial organisms, reduction in pesticide use and the availability of EC 2078-regulation grants for IFP in several regions of western Europe. Nevertheless some problems up to now could not be solved: use of residual herbicides, application of growth regulators and antioxidants (post-harvest) and heterogeneous control and checking procedures for IFP in the different regions. In **Eastern Europe** the first steps to implement IFP have been taken. IFP-standards have been adopted in Poland and on a small scale are already introduced into practice. In Ukraine integrated pest management methods are evaluated. Three remarkable efforts have been reported from the **USA** (Washington, Massachusetts, Michigan). IPM is tested and partly established. Special attention is directed to connecting IPM to public opinion.

Concerning the definition of common standards for IFP the situation is as follows. For integrated production of pome fruits IFP-guidelines have already been published by an IOBC/ISHS-joint group. A stone fruit guideline is in preparation. In 1996 the work on a IFP-guideline for soft fruit crops will start.

2. Problems within IFP-Systems

Now data on long-term experience with IFP-systems for pome fruits are available, e.g. from Hungary and several regions of Germany. From these data and other investigations from Denmark, England and South Tyrol, several problems of IFP-systems are plain to see.

- Secondary pests become more and more important and the dominance structure of the main pests is changing. This may be due to e.g. the introduction of cultivars resistant to scab or the use of selective compounds. An increase of infestations with several Tortricids, capsids, leaf miners, weevils or mussel scales frequently occurs. Among the fungi tree canker and storage diseases become of greater importance..

- Pest resistance to selective compounds is reported from some regions. The frequent use of insect growth regulator pesticides led to resistance of the codling moth. Aphids are becoming less susceptible to the selective aphicides that are used in IFP-systems. In view of these problems we should ask ourselves, if our understanding of IFP, espec. IPM, in practice is not too one-sided. It seems that we still rather rely on single (chemical) measures instead of applying a complex of measures to solve our problems.

- IFP-systems in the short run may be more expensive than conventional systems due to the fact that selective compounds mostly are more expensive than broad-spectrum pesticides.

- IFP-systems may require higher pesticide input than conventional systems because selective control of several pests needs more applications.

3. Approaches to Systems Research

Although systems research is laborious, difficult and expensive first efforts have been taken. Comprehensive pest/disease-assessments and monitoring of beneficials was carried out in research programmes in The Netherlands and Denmark.

Single measures, e.g. the introduction of apple cultivars with resistance or low susceptibilities to scab, are investigated within the context of the whole IFP-system.

Some attempts have been made at evaluating whole subsystems, e.g. the IPM-subsystem of IFP, in order to compare them to conventional or biological subsystems. But still this approach is in its infancy and needs further research.

Modelling of biological processes, e.g. prey-predator relationships, offers good prospect in several aspects. Firstly it is quite a cheap way of research. Mostly long-term monitoring data are sufficient for modelling. Gaps in our knowledge of the biology of pests or beneficials can be identified and this research efforts may be directed to essential aspects. In addition to that playing with models is useful for solving extension problems.

4. Future Work

The future work on IFP shall concentrate on the following fields of work.

a) **Reduction of the Pesticide Load of IFP-Systems**

Still the use of pesticides is enormous in IFP-systems. The reduction of pesticide load must be one of the most important aims in the short-term work on IFP. Several approaches offer good prospect to reach this goal. Pesticide dosages can be reduced strongly according to the pest that shall be controlled, the infection resp. infestation level and the weather conditons. Application technique must be improved. A good supporting measure would be directing EC 2078-incentives more directly to the introduction of individual biological/biotechnical control measures.
All this would lead to an improval of internal quality of IFP-fruits.

b) **Resistance**

Work on resistance is i mportant in two respects. Firstly strategies of complex nature to avoid pest resistance have to be worked out. The strong dependence on the application of selective compounds must be reduced.
Secondly host resistance, most promising to fungal diseases, must be introduced into the IFP-systems and a strategy to preserve the resistance as long as possible has to be developped. This also requires employment of a complex of measures.

c) **Research on Biological/Biotechnical Control**

The most successful biological control within IFP-systems is done by the predatory mites feeding on spider mites. For almost all the other pests nothing comparable exists. But several studies revealed that for some pests parasitoids may be effective. Little is known on their efficacy and on the side-effects of pesticides on them.For many pests key beneficials have not yet been identified. Having in mind the comprehensive work on Typhlodromic mites one can imagine that the introduction of further biological control systems is a long-term task for the next years.

Pheromones to monitor pests with traps or for mating disruption of some important Lepidoptera-pests proved to be important tools for biotechnical control. The successful work has to be expanded to other pests.

d) **Extension**

Beside the extension work on the single measures or IPM/IFP we must start to focus the growers' interest rather on sustainability of production than on short-term profit. To achieve this the long-term behaviour of IFP-systems must be demonstrated to the growers, a way of extension work that has been successful in integrated production of arable crops.

Summary of the presentations on INSECT PROBLEMS

POME FRUITS

Jesús Avilla. Centre UdL-IRTA de R+D de Lleida. Rovira Roure, 177. 25198 - Lleida. Spain.

Eleven oral presentations dealt with insect problems in pome fruits. Three of them were devoted to problems caused by Heteroptera Miridae in different countries. The main species were *Lygocoris pabulinus* and *Campylomma verbasci*, a species known as pest in North America, but not mentioned as pest in Europe in apples until now. Some discussion about Miridae was carried out, as some of them can behave as phytophagous and as predators. Modeling and forecasting of population dynamics of *Cydia pomonella* and *Cacopsylla pyricola* were treated in two oral presetations and in one poster, and two models from United Kindgom and Germany were proposed. Some presentations dealt with faunistic studies under different pest control strategies. The difficulties in defining what "conventional pest control" means were stressed.

Among the poster presentations, six dealt with Lepidoptera and three with Homoptera. The use of pheromone traps for monitoring and for the disemination of virus and juvenoid insecticides through the males were discussed in three posters. Other topics treated were the biological control of San Jose scale and aphids and the importance of secondary pests such as *Grapholita prunivora* and *Stephanitis pyri.*

STONE FRUITS

Fabio Molinari - Istituto di Entomologia e Patologia vegetale - Facoltà di Agraria - Università Cattolica del Sacro Cuore - Piacenza. ITALY

Five contributions have been presented. Except one, carried out in Poland, all the presentations and posters on stone fruit problems were italian. Three were dealing with peach problems: the biology of *Pseudaulacaspis pentagona* in order to build up a model; the possibility of controlling the capsid bug *Lygus rugulipennis* by means of agronomic measures; the occurrence of different noctuid species on nectarine fruits. On this culture a lot of work has already been done and reported by the former Subgroup "Peach" and, although important questions are still open, as *Anarsia lineatella* biology and harmfulness, the application status of IFP is one of most advanced in stone-fruit.

Apricot and almond are cultivated in few countries, and require generally a limited effort in pest control operations, especially the former species, therefore the complete absence of works was somehow predictable. Neverthless, a recent field of interest, represented by the study of vector insects, is worthy of attention.

Rather surprising, plum and cherry have received little attention in this meeting: an investigation on the presence and harmfulness of different species of plum sawflies (*Hoplocampa* spp.) in Northern Italy and a study on the effectiveness of yellow glue tables in monitoring and control of cherry fruit fly (*Rhagoletis cerasi*). These crops are widespread all over Europe, and insect problems have been pointed out and investigated, especially in central Europe, but more specific research is needed to improve IP techniques: to rationalize monitoring and control of *Cydia funebrana* and sawflies, or to assess the importance of insects in carrying MLOs.

SOFT FRUITS

Fabio Molinari - Istituto di Entomologia e Patologia vegetale - Facoltà di Agraria - Università Cattolica del Sacro Cuore - Piacenza. ITALY

Among soft-fruits, numerous successful trials for reducing pesticide applications have been performed on strawberry in many countries (see the wide application of predators in protected crop), but it is a hard discussion to define standards in IFP.

The situation is different for other species of soft fruits, that are often cultivated in semi-natural conditions: Jörg (1995), asserting that "several important 'tools' to warrant an integrated fruit production still are not available", draws up a list of problems to be investigated.

In this meeting, the attention of the authors, all from Poland, has been focused on black currant problems caused by mites: one poster has been in the trend of introducing resistance genes against the gall mite (*Cecidophyopsis ribis*); 4 posters faced different aspects of two spotted spider mite (*Tetranichus urticae*) infestations.

The studies on the influence of different varieties on the mite biology, the development of the injury on the leaves, the effect of different levels of infestation on the growth and yield, and the species composition and effectiveness of predatory mites occurring on black currant plantation contribute the building up of a picture that will help the improvement of IFP on soft-fruits.

Summary of the presentations on BIOLOGICAL CONTROL

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The posters and oral presentations summarised in the section biological control covered a wide field of different topics. A lot of studies dealing with entomological subjects focused on three main themes.

1. Biology of parasitoids, life tables
Detailed knowledge on the biology of parasitoids of animal pests are necessary to evaluate the potential effectiveness of species as antagonists.

2. Long term ecological studies
Long term studies play an important role in two different ways. Investigations on faunistic effects of different treatment or management strategies point out ecological aspects. Even the effectiveness of parasitoids or predators in different situations can be evaluated in studies, carried out over some years and in different situations. This data will supply the creation of life tables of species.

3. Modelling
Modern technologies give the opportunities to bring together all available data on biology of (animal) pests and antagonists. This way the development of populations of pests and/or beneficials and their interactions can be predicted by computer modelling including actual data from climatic situation, life tables and so on. This development is still at the beginning.

The use of antagonists is not a privileg of entomology. Even in control of fungal diseases of fruits there are chances to work with antagonists like bacteria or funghi. The use of Bacillus thuringiensis is well established and offers a lot of effective applications. Confusion technique (especially against tortricides) can work very well and is applied in many regions. The use of a confusion technique against a mirid bug (Campyloma verbasci) is a new aspect in pheromone technology. The extraordinary importance of predatory mites as regulatives of spider mites is well known and was pointed out in the presentations.

Summary Application Technique

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During the conference several speakers (e.g. Polesny) mentioned the importance of application techniques as a means to reduce environmental pollution in integrated fruit production (IFP). In lectures and posters only a few aspects of application techniques were discussed. Emphasis was laid on the use of tunnel sprayers and deposits on leaves.

Both in the Netherlands and in Poland, tunnel sprayers were effective in the control of apple scab. However, differences in efficacy were noted between the different designs. In the Netherlands, the sprayer with "Closed Loop System" was more effective than the one with rotary atomizers (Heijne and Porskamp). In Poland, a higher percentage of leaves was infected by apple scab using the tunnel sprayer with cross-flow fans than the tunnel sprayer with directed air-jets (Holownicki, Goszczynski, Doruchowski and Nowacka). Typical for these tunnel sprayers is that they recycle part of the sprayed liquid not deposited on leaves. The recovered spray liquid is not lost into the environment and is re-used. A cross-flow sprayer with reflection shielding also recovered part of the spray liquid (Heijne and Porskamp). This sprayer was as effective as the standard cross-flow sprayer in controlling apple scab, while two rows were treated at one time compared to one row with a tunnel sprayer.

Deposits on upper and lower leaf surfaces were distributed more uniformly using a prototype tunnel sprayer with directed air-jets (Holownicki, Doruchowski and Godyn). In this sprayer the air-jets were slightly upwards directed. Another directed air-jet sprayer (without tunnel) gave the best distribution of deposits on upper and lower leaf surfaces in comparison to a cross-flow sprayer and an axial fan sprayer (Doruchowski, Holownicki and Godyn). Furthermore, this sprayer had highest total deposits on leaves and lowest losses to the environment compared to the other sprayers. The axial fan sprayer had highest losses to the environment.

Another form of a directed air assistance was demonstrated in strawberries (Labanowska, Doruchowski, Goszczynski and Godyn). This technology was compared to another new sprayer, which not only had one nozzle spraying vertically downward on to the strawberry bed, but also two nozzles spraying horizontally from either sides. Both sprayers gave good coverage and good efficacy in the difficult to control pests and diseases as demonstrated for spider mites and grey mold.

Doruchowski, Svensson, and Nordmark demonstrated that it is worthwhile to adjust the spray volume to the tree size and volume. The deposit on leaves increased with decreasing spray volume and tree size. They estimated that a 50 % reduction of chemicals was possible adjusting the spray volume to 120 l/ha compared to 400 l/ha for super spindle trees. This "Tree Row Volume"-concept (TRV) can significantly contribute to reduce unwanted emission in IFP.

Several aspects of application techniques need further attention, such as optimum spray volume and improvement of the process of depositing droplets on to leaves with minimum losses of product into the environment. The efficacy of the deposits might be improved by all sorts of adjuvants. It should be stimulated to combine measurements of deposits on leaves with an evaluation of the biological efficacy of the pesticides. I recommend that in IFP, the droplet size should be restricted to droplets larger than 80 µm, to reduce drift.

SUMMARY OF THE SESSION 'PESTICIDE USE'

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The session chairmen/women were asked to summarise posters and stimulate discussion on related topics from oral presentations. In the Pesticide Use session the following topics were presented:

- Experiments on efficacy of pesticides
- Reflections on side effects of pesticides on beneficials
- Quantification of pesticide use
- New resistance development of pests against pesticides

The chairman took the liberty to ask provocative questions which created an animated discussion.

The posters describing efficacy tests were all presented by official research institutes. Why does an official organisation conduct research on pesticide efficacy? Among other reasons, research institutes may have responsibilities in registration of pesticides. The tests are in this case conducted to confirm under local conditions the data furnished by the company.

In Europe, registration officials routinely confirm efficacy data with their own experiments. In the United States, the registration organisation puts less emphasis on this issue and assumes that the market will take care of it. Advocates of registration efficacy tests mentioned a lack of confidence in private companies and the risk that unnecessary chemicals would be applied if the efficacy data was not checked officially. Opponents were of the opinion that companies invested too much money in development to apply for registration of a pesticide that is not efficient. A condition for this alternative has to be that side effects on humans and the environment are negligible.

Two representatives of chemical companies presented papers that showed experiments demonstrating negligible side effects of their products. IFP apparently has developed into a big enough market that large corporations reorient their strategies.

Several papers and posters presented field experiments studying effects on the beneficial fauna on a systems level. These experiments are important because laboratory experiments can never simulate complex natural situations. Because field trials on a systems level require a large time/money investment, scientific requirements on representativeness are often neglected. Participants in the discussion agreed that only specific conclusions should be drawn from one experiment and general conclusions can only result from many experiments at different locations in different years.

Pesticide use is measured in many countries by estimating the number of treatments applied. At this conference and elsewhere, grading systems are proposed and used that take into account the side effects on humans and the environment. Grading systems were criticised for their simplicity, but also for their complexity and subjectivity.

Pesticide resistance has been a permanent problem in conventional pest management. Recent developments of resistance against insecticides in regions known for their efforts in IFP are surprising. IFP seems to be no guarantee against development of resistance. The chairman initiated a discussion by proposing that the existence of pesticide resistance is proof that IPM principles were violated. Differences in the understanding of IPM were apparent. For some participants, using novel and selective compounds were enough of a condition for IPM. For others, IPM implied that non-chemical control methods have priority and pesticides only present a last resort.

Evaluation of resistance of a pest population is conducted by comparison with a population considered susceptible. Because populations with zero contact with a certain pesticide are difficult to find, it would be very useful if base data could be developed at the time of introduction of a new pesticide.