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Working Group "Integrated Plant Protection in Orchards"

Sub Group "Soft Fruits"

Proceedings of the workshop

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PREFACE

Soft fruits are a multifarious and specialised field of fruit production. The problems and solutions for integrated and organic plant protection in this crops are different from the situation in pome fruits and stone fruits. All big symposia on integrated fruit production organised by IOBC/WPRS working groups in the last decade presented specialised contributions on soft fruit problems.

IOBC/WPRS published technical guidelines for integrated production of pome fruits and stone fruits in the last years. Within the discussions of the International Conference on Integrated Fruit Production in Cedzyna, Poland (1995) the decision was made, to establish such guidelines for soft fruits too.

This workshop focused on two goals:

- To establish a special platform on problems in plant protection in soft fruits for scientists and advisors.
- The elaboration of a technical guideline for IFP in soft fruits.

This volume summarises the oral presentations of the first part of this workshop and gives an overview on the present status of IFP in soft fruits. Even the second part of the workshop was successful. A first draft version of a technical guideline on IFP in soft fruits was elaborated and is now in discussion.

As a result of this workshop a sub group on soft fruits within the frame of the IOBC/WPRS working group "integrated plant protection in orchards" was established.

Fritz Polesny, convenor

1st WORKSHOP ON PROBLEMS IN INTEGRATED PRODUCTION IN SOFT FRUIT AND ON GUIDELINES FOR INTEGRATED PRODUCTION IN SOFT FRUIT, Vienna, Austria

PROGRAMME

DATE, TIME	CHAIRPERS.	REPORTER	TOPICS, TITLE OF PRESENTATIONS
6.10.			
12.00 -			Registration
19.00 -			Welcome
7.10.			
8.30 -			Registration
9.30	Polesny	Polesny	Opening, welcome
9.50		Polesny	The implementation of soft fruits in an existing IFP-programme, the Austrian example and general aspects as an introduction
10.10		Müller	Further developement of IFP
10.30		Joerg	What plant protection products for integrated control in soft fruits are available ? - an overview
10.50		break	
11.20	Müller	Steffek	Soft fruit production in Austria - an overview
11.40		Berrie	IFP in soft fruits in the UK
12.00		Balazs, Jenser, Veszelka	Information on integrated production of soft fruits in Hungary
12.20		lunch	
13.45	Berrie	Joerg	Integrated production of soft fruits in Germany
14.05		Jenser, Szatmari, Balazs, Meszaros	Lepidoptera living on rasperries in North-Hungary
14.15		Gajek, Olszak	Perspectives of integrated production of black currant in Poland
14.45		Demeyere, Meesters	Aspects of integrated production of raspberries and strawberries in Belgium
15.05		break	
15.30	Olszak	Szith	Difficulties in integrated production of Sambucus nigra in Austria
15.50		Cross	Forcasting black currant leaf midge and black currant gall mite as an aid to correct timing of sprays
16.10	Polesny		discussion on further activities in the field of soft fruit within the frame of the IOBC/WPRS-WG

18.00			Supper
8.10.			
8.45	Blümel	Bosshard, Neuweiler	Problems with the integrated production of strawberries
9.05		Malavolta	The application of integrated production on strawberries in Emilia Romagna
9.25		Labanowska	Some aspects of integrated production of strawberry production in Poland
9.45		Daugaard	Preliminary work on integrated production of strawberries in Denmark
10.05		break	
10.25	Malavolta	Cross	Sampling methodes, crop damage assesment and selective control methods for strawberry pests.
10.45		Faby	The influence of Tagetes and fumigation on the growth of strawberries
11.05		Berrie	Progress towards developing a assesment system for control of Botrytis and powdery mildew in strawberries
11.25		Blümel	Efficiacy of various insecticides against the strawberry blossom weevil (Anthonomus rubi)
11.45		N.N.	Summarizing discussion
12.20		lunch	
14.00 -			excursion to the BFL (Fed. Office and Res. Centre for Agriculture)
9.10.			
9.00 - 9.20	Cross	Polesny	The evolution of guidelines for integrated fruit production in the orchard groups of IOBC/WPRS
9.20 - 9.50		Joerg	Presentation of a first draft version of guidelines for integrated production of soft fruits as an entry into discussion
9.50 - 18.00			Guideline discussion
10.45		break	
12.30		lunch	
15.45		break	
10.10.			
9.30 - 12.00	Cross, Polesny		continuation of guideline discussion, further activities, end of the workshop.
12.00		lunch	

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Further Development of IFP

Walter Müller
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Abstract: Integrated Production (IP) is a dynamic system. It has to be improved steadily. In many regions IP is becoming a general practice. On this respect, the scientists have to work out new solutions according to the demands of the consumers. The consumer wishes to know more about the factors quality and environment. He asks for reliable testing systems. In addition, the consumer likes to buy food at a low price. The guidelines are an excellent tool for it. Guidelines have to be revised as soon as they are no more fulfilling the demands.

Switzerland did a lot of work to establish the Integrated Production already in the late 1970ies and 1980ies. Especially in fruits, Switzerland could do some basic work to develop the system of Integrated Production (IP).

Due to this fact and due to the discussions in the mass media, the Federal Government set a time limit as a wish for the introduction of IP and Bio-production on Swiss farms: By the year 2000, 95 % of the total food production should be produced either after the system of IP or Bio. This trend is backed strongly by the largest food retailer companies. The consumer demand for more naturally grown products is increasing steadily.

The Federal Government is subsidising the special efforts to produce ecologically grown products (in horticulture: Sw.fr. 1'800.-/ha for Bio-production, Sw.fr. 1'200.-/ha for IP). For conventional production, the farmers do not get any subsidy.

Elements of ecological production

From the scientifical point of view, there is no remarkable difference between IP and Bio-production. There are the same basic goals in both systems. There are only different standards in the technical details. The three main elements of both systems are:

Environment: There is a strong movement towards sustainability. The use of chemical products and the latest technical methods have to safeguard the nature.

Quality: On the basis of a global and of a regional market the factor qualitiy of food (fruit) is very high ranked. Both, the external and the internal qualitiy have to be best.

Efficiency: There is no way to bring food (fruits) on the market, which does not respect the environment and the qualitiy but costs to much. Therefore, all three factors environment, quality and efficiency have to be evaluated in the ecological production.

Present situtión of IP and Bio-production in Switzerland

Regarding the fruits, IP has increased in the last few years significantly and has reached a high level.

Integrated fruit production in Switzerland, 1996/97

Total surface of production and the respective percentage of practiced Integrated Production in Switzerland 1996/97.

Species	Total surface in ha	IP of the total surface
Apples	5'159	84 %
Pears	1'014	75 %
Plums	171	79 %
Cherries	440	77 %
Apricots	515	40 %
Peaches	19	36 %
Kiwis	18	98 %
Strawberries	447	85 %
Rapsberries	107	64 %
Blackberries	33	61 %
Redcurrants	29	80 %

In the Bio-production we indicate only the figures for the three farming systems in Switzerland on different levels of the altitude over sea level:

Bio-production in Switzerland, 1997

	Bio-production in %
Farms on the lowland	2,4 %
Farms on the pre-alps	5,1 %
Farms on the alps	13,4 %
Average of all farms	**7,0 %**

The guidelines for Bio-production are very severe in respect to the environment. Especially in fruit production, it is very difficult to obtain good results.

Next steps in IP of fruits

The globalisation of the fruit market is going on. IP will be the standard of many regions soon. Therefore, distinct facts and figures have to be elaborated for a further development of IP. The competition on the market will increase.

We have to work out a system that is working from the consumers wish back to the retailers and back to the growers.

The consumer first looks at the price of the fruits. Then he compares the quality with similar products. Finally, he likes to know how the fruits are produced. The external quality or the price are not answering all the questions he has. Labels might be helpful but only when there are not too many different labels and if they have a clear expression. In addition, the consumer likes to know who controlled the system to get the label.

The grower faces new signals from the retailer. The standard of fruit quality will be raised steadily, combinded with the need for more respect to the nature. The control systems for the quality has to be revised after demand of the consumer/retailer. In the near future three principles will govern the management of the quality:

- The principle of self-control with a general recognised surveillance (government, accepted organisations)
- The principle of self-declaration according to accepted standards
- The principle of self-financing organised by associations and recognised by the government.

The three principles end up with a high confidence in the producing system which is very important for the consumers acceptance.

The guidelines for the IP are an excellent help both for growers and consumers. As soon as they are becoming a standard, a minimum limit, they have to be revised. Organisations and growers have to work out new guidelines as soon as they are no more recognised as a special effort in the system.

Some suggestions for future work

We have to be very careful with the built-up system of IP. It is a real challenge to maintain it. So we need:

1. Adaptation of the national law and the rules for international acceptance.
2. Promotion of research on a high level, with first-class technology and a holistic thinking.
3. Improvement of advisory work with excellent tools (communication, prognosis, testing equipment, clear standards).
4. Strengthening of the professional organisations in increasing the reliability of IP.
5. Improvement of international co-ordination.

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Pesticide availability in European soft fruit production

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The following article gives an overview on the plant protection products (active ingredients; a.i.) registered in different European countries for the use in soft fruit crops. Quantitative as well as qualitative aspects concerning the suitability of the a.i. for IPM systems are dealt with. The overview divides the crops into four groups: 1) strawberry, 2) rasp-/blackberry, 3) currants/gooseberry and 4) minor soft fruit crops.

Data

The data about the national registrations of soft fruit a.i. were provided by the following colleagues whose help gratefully is acknowledged.

Table 1: Countries under investigation and data provision

Abbrev.	Country	Data provision
A	Austria	Fritz Polesny, Ursula Persen
B	Belgium	Philip Lieten, Annie Demeyere
CH	Switzerland	Heinrich Höhn
D	Germany	Erich Jörg
DK	Denmark	Hanne Lindgard, Holger Daugaard
E	Spain	Jesus Avilla
F	France	Jean-Paul Gendrier
GB	Great Britain	Angela Berrie
I	Italy	Carlo Malavolta
N	Norway	Atle Kvale
NL	The Netherlands	Ann Schenk
PL	Poland	Dariusz Gajek
S	Sweden	Christer Torneus

The data reflect the situation of 1997 with the exceptions of Spain and partly the Netherlands, where data are from 1996. A "?" in the following figures indicates that the data situation is unclear. Mainly this is due to a general registration of some active ingredients, e.g. for "fruit crops". In these cases it could not be clarified whether the use of those a.i. is permitted in soft fruit crops or not. Sometimes indications were given that "additional pesticides" are permittet for overall use in soft fruit crops, but these pesticides were not specified.

Quantitative aspects

At first glance the registration situation for soft fruit crops in Europe seems quite promising. a total of 85 insecti-/acaricides, 58 fungicides and 44 herbicides is registered at least in one of the 13 European countries under investigation (Table 2). The diversity is greatest in strawberries followed by currants/gooseberries and finally cane fruit, where slightly less active ingredients are registered than in the previous crop group.

The illusions of a great diversity of a.i. to solve all the plant protection problems in soft fruit crops are subdued while having a look at the average number of a.i. per country (Table 3). Less than 10 herbicide a.i. for all crops and less than 10 fungicide a.i. for cane fruit and currants/gooseberries are registered. The availability of insecticides/acaricides is higher with 14 to 22 a.i. registered. Compared to pome and stone fruit the availability of plant protection products is far worse.

Table 2: Numbers of active ingredients registered in at least one country in Europe 1997

Crop	Herbicides	Fungicides	Insecticides /Acaricides
Strawberry	33	57	77
Raspberry / Blackberry	28	36	64
Currants / Gooseberry	33	39	67
Total	44	58	85

Table 3: Average numbers of a.i. registered / Country in Europe 1997

Crop	Herbicides	Fungicides	Insecticides /Acaricides
Strawberry	9,3	15,0	22,2
Raspberry / Blackberry	9,7	6,3	14,9
Currants / Gooseberry	7,3	9,3	14,5

Strawberry

Figures 1-3 show the national a.i.-registrations for herbicides (1), fungicides (2) and insecti-/acaricides (3) for strawberry crops.
Many herbicides are available in GB und PL (more than 15). A group of countries (A, B, CH, I, N, S) have 8-12 herbicides, but in five countries less than eight a.i. are available (D, DK, E, F, NL).

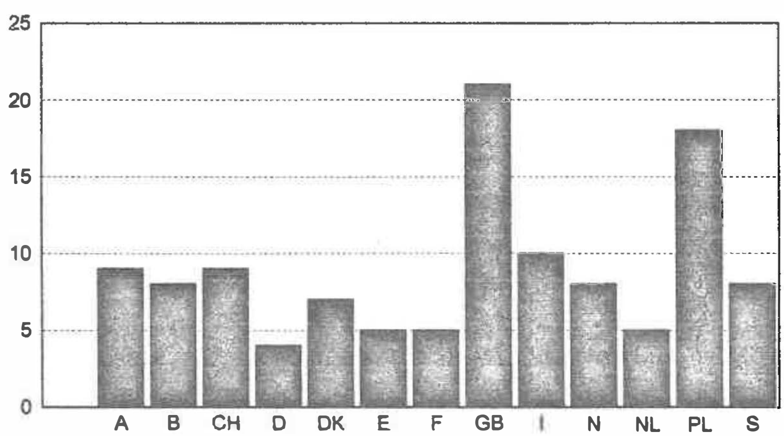

Fig. 1: Strawberry herbicides – Number of active ingredients registered in European Countries in 1997

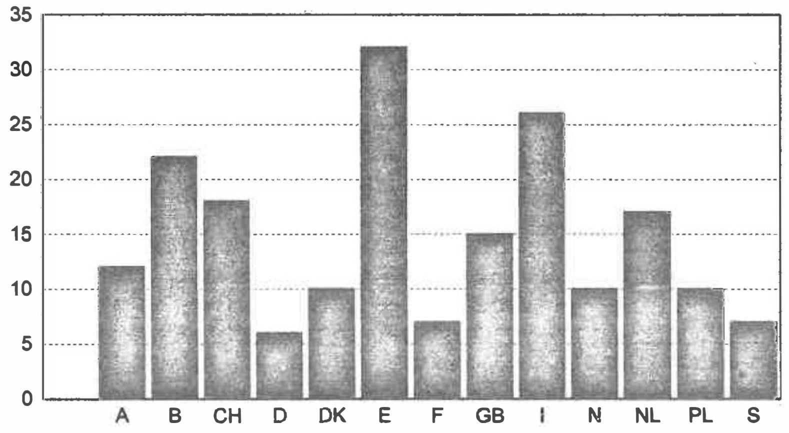

Fig. 2: Strawberry fungicides - Number of active ingredients registered in European countries in 1997

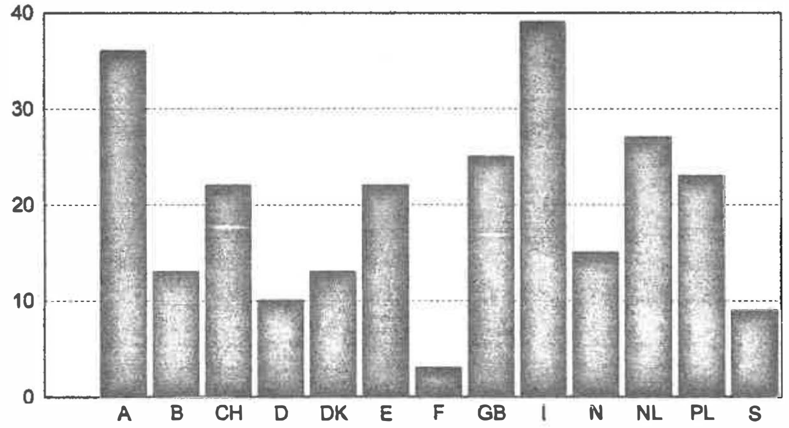

Fig. 3: Strawberry insecticides/acaricides - Number of active ingredients registered in European countries in 1997

Fungicides a.i.-numbers exceed 20 in B, E and I. 10 to 18 a.i. are registered in A, CH, DK, GB, N, NL and PL. Unsatisfactorily is the situation of D (6 a.i.) and F, S (7 a.i.).
The most striking differences concern the availability of insecticides/acaricides. Only two (!) a.i. are registered in F whereas more than 30 a.i. can be used in A and I. Also quite well equipped are B, CH,DK, E, GB, N, NL and PL. Again D and S are in a group with poor availability of a.i..

Rasp-/Blackberry

Concerning the availability of herbicides a.i. in cane fruit (Fig. 4) the countries may be divided into two groups: a group where more than 10 a.i. are registered (including E (?), GB, NL and PL) and another group where less than 7 a.i. are available (A, B, CH, D, DK, F, I, N and S). In Germany only 1 (!) a.i. is permitted.

In E (?) and GB more than 10 fungicide a.i. are registered (Fig. 5). In 7 countries (A, B, CH, DK, F, N, NL (?)) 6-9 a.i. may be used in cane fruit. Insufficient availability characterizes the situation in D (1 a.i. !), I, PL and S.
Insecticide/acaricide registration divides the countries into three groups: 1) A, CH, E (?) and PL where more than 20 a.i. are available; 2) GB, N, NL where about 10 a,i, are registered and B, D, DK, F, I and S with less than 10 registered a.i. (Fig. 6). Only three a.i. are available in F and D.

The data shown in Fig. 4-6 mainly reflect the situation for raspberry. Registrations in blackberry are very rare.

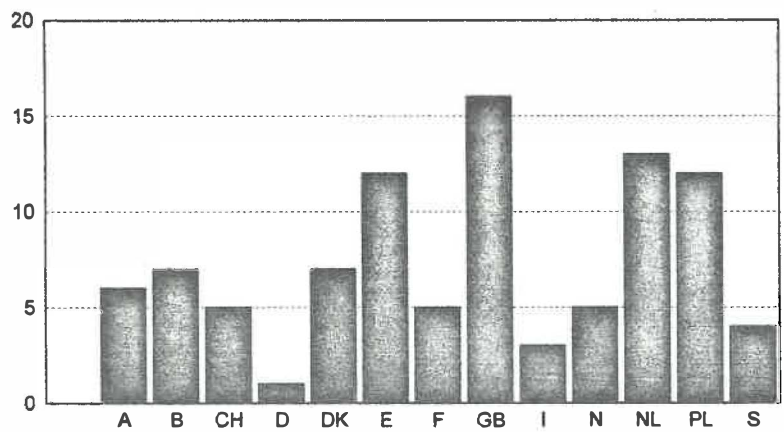

Fig. 4: Rasp-/Blackberry herbicides - Number of active ingredients registered in European countries in 1997

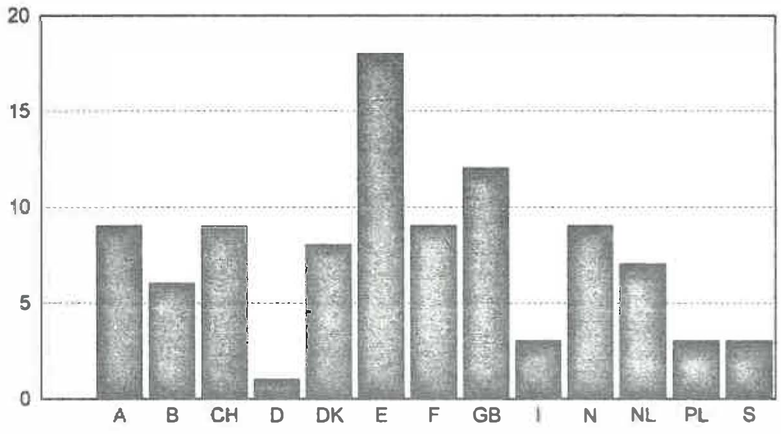

Fig. 5: Rasp-/Blackberry fungicides - Number of active ingredients registered in European countries in 1997

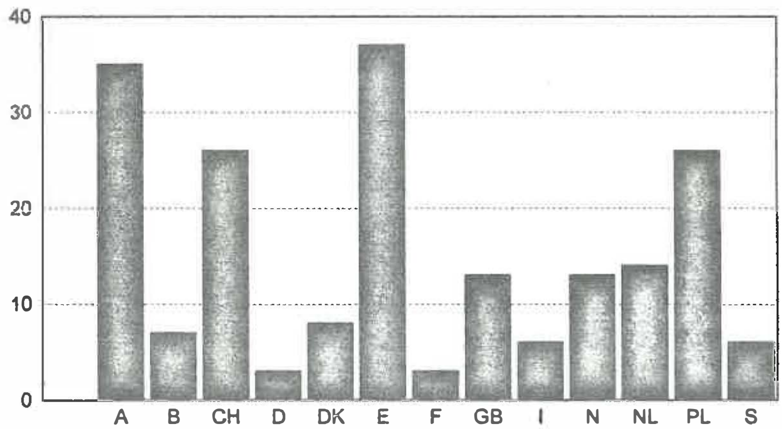

Fig. 6: Rasp-/Blackberry insecticides/acaricides - Number of active ingredients registered in European countries in 1997

Currants/Gooseberry

In general most a.i. are registered for currants (mainly black currant) whereas less a.i. are available for gooseberry. Herbicide registration (Fig. 7) resembles the one in cane fruit. More than 10 a.i. are registered in E (?), GB, NL and PL. Less than 10 but more than 5 are available in A, B, CH, DK, F and less than 5 a.i. may be used in D, I (2 a.i.!), N and S.

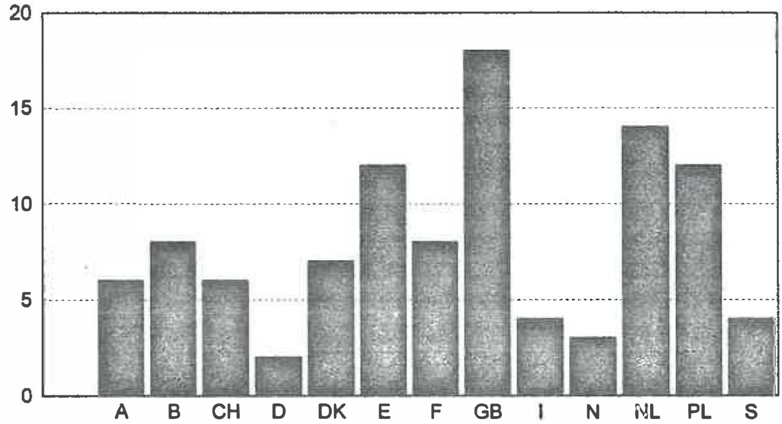

Fig. 7: Currant/Gooseberry herbicides - Number of active ingredients registered in European countries in 1997

Generally better is the fungicide registration (Fig. 8). Again E (?), GB and PL are in the first group (more than 10 a.i.), but also CH has registered sufficient a.i. to solve fungal disease problems (12 a.i.). About 10 a.i. are available in A, B, DK, F, N and NL (?), whereas D, I and S only have a few a.i..

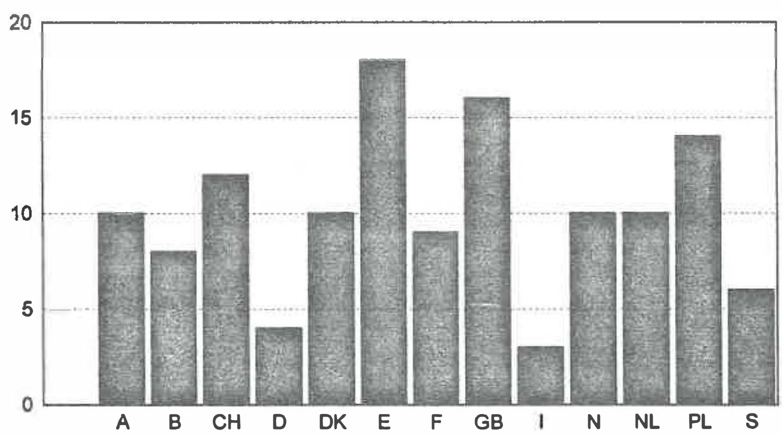

Fig. 8: Currant/Gooseberry fungicides - Number of active ingredients registered in European countries in 1997

Fig. 9 shows great national variation in insecticide/acaricide registration. 20 and more a.i. are permitted in A, E (?), GB, NL and PL. More than 10 a.i. are available in CH and N. But most of the countries have less than 10 a.i. registered (B, D, DK, F, I and S).

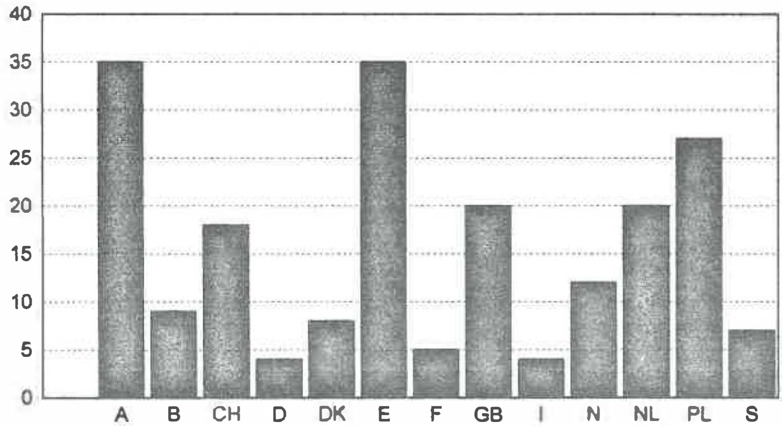

Fig. 9: Currant/Gooseberry insecticides/acaricides-Number of active ingredients registered in European countries in 1997

Note: In some countries (A, E (?), GB, partly NL) registration is quite "general", e.g. for"fruit crops". Therefore many a.i. may be used. This especially holds for insecticides. Due to the changes in registration prerequisites and requirements these general regitra-tions will not be prolonged after the end of the recent registration period; e.g. this will be the case in A, where within the next two years the availability of plant protection products in soft fruit crops will decrease dramatically.

Minor soft fruit crops

Among the minor soft fruit crops are Aronia, elderberry, blueberry, redberry, Kiwi, Sea Buckthorn and Sorbus. In most of the countries the acreage of these crops is only a few hectares, but in some countries their economic importance is quite high, e.g. elderberry in Austria.

Because of their generally low importance only a few a.i. are registered for the use in these minor crops. In B, D, DK, E, F, N, NL, PL and S there is no registration at all. In CH and I a few insecticides are permitted for the use in blueberries. One or two a.i. are registered as herbicides in blueberries (GB, F) or redberries (GB) resp. as fungicides in blue-/redberries (I) or as insecticides in redberries (I). At least at the moment the availability of a.i. is best in A due to the general registration for all fruit crops.

Qualitative aspects with respect to IFP

In IOBC-IFP Guideline for pome fruit general principles are stated on which a.i. are permitted, permitted with restriction or prohibited in IPM-systems for apple and pear. The a.i. registered in the different European countries were looked at from two points of view: 1) "In how many countries is a certain a.i. registered?" and 2) "Is it suitable for the use within an IPM-system for soft fruit crops following the principles mentioned above?". The results are shown in Table 4-6.

Looking at the **herbicides** the situation seems quite promising. The most commonly registered a.i. is Glufosinate, an a.i. permitted in pome and stone fruit IFP. Also monocot-a.i., like Sethoxydim and Fluazifop-butyl, and Glyphosate are widely registered. Simazine and Dichlobenil are two a.i. that either are permitted with restriction or prohibited (D) in pome fruit IFP. Among the most commonly registered a.i. also are Paraquat, Diquat and Lenacil, Propyzamid, which are either toxic or of long persistence and therefore their use in IFP-systems is not permitted. Phenmedipham, a semi-selective a.i. ist registered in many countries in strawberry crops.
In summary, a weed control following the IOBC-principles is possible with the a.i. available.

All **fungicides** a.i. listed in Tables 4-6 are permitted with restrictions in IFP. Dicarboximids (Iprodione, Vinclozolin, Procymidon), Dithiocarbamates (Mancozeb...) and Sterolbiosynthesisinhibitors (Fenarimol, Myclobutanil ...) as well as Copper and Sulphur are among the most frequently registered a.i.. The most common a.i. is Iprodione followed by Sulphur and Copper. For control of fungal diseases in cane fruit the basis is quite small.

Table 4: Strawberry - Commonly registered active ingredients in Europe 1997

Herbicides	**	Insecticides/Acaricides		Fungicides	
Phenmedipham (a)*	9	Clofentezin (b)	9	Iprodione (b)	13
Glufosinate (a)	8	Hexythiazox (b)	9	Sulphur (b)	10
Fluazifop-butyl (a)	8	Endosulfan (c)	8	Procymidon (b)	9
Simazine (b,c)	8	Cypermethrin (c)	8	Thiram (b)	9
Paraquat (c)	7	Pirimicarb (a)	8	Fosethyl-Al (b)	9
Glyphosate (a)	6	Dimethoate (b)	7	Copper (b)	9
Diquat (c)	6	Cyhalothrin (c)	6	Vinclozolin (b)	7
Lenacil (c)	6	Trichlorfon (b)	6	Dichlofluanid (b)	7
		Diazinon (b)	6	Pennconazole (b)	6
		Brompropylate (b)	6	Myclobutanile (b)	6
		Dicofol (c)	6	Fenarimol (b)	6
		Fenbutatin-oxide	6		
		Heptenophos	6		
		Bacillus thuring. (a)	6		
		Amitraz (b)	6		

* : (a) = permitted in IFP; (b) = permitted with restriction; (c) = not permitted in IFP

** : number of countries in which the a.i. is registerd

Table 5: Rasp-/Blackberry - Commonly registered active ingredients in Europe 1997

Herbicides		Insecticides/Acaricides		Fungicides	
Glufosinate	11	Pirimicarb	7	Iprodione	8
Simazine	9	Deltamethrin	7	Copper	7
Dichlobenil	6	Endosulfan	6	Dichlofluanid	6
Sethoxydim	6				
Fluazifop-butyl	5	Cypermethrin	5	Vinclozolin	5
		Diazinon	5	Mancozeb	5
Glyphosate	4	Tetradifon	5		
		Esfenvalerate	5		
		Clofentezin	5		
		Brompropylate	5		
		Dimethoate	5		

(for explanations see Table 4)

Table 6: Currant/Gooseberry - Commonly registered active ingredients in Europe 1997

Herbicides		Insecticides/Acaricides		Fungicides	
Glufosinate (a)	11	Esfenvalerate (c)	7	Sulphur (b)	7
Simazine (b,c)	9	Pirimicarb (a)	7	Mancozeb (b)	7
Dichlobenil (b,c)	7	Cypermethrin (c)	6	Copper (b)	7
Fluazifop-butyl (a)	7	Dimethoate (b)	6	Triforine (b)	7
		Mineral Oil (a)	6	Dichlofluanid (b)	6
				Fenarimol (b)	6
Propyzamid (c)	5	Deltamethrin (c)	5	Vinclozolin (b)	5
Paraquat (c)	5	Endosulfan (c)	5	Thiram (b)	5
Sethoxydim (a)	5	Cyfluthrin (c)	5	Zineb (b)	5
MCPA/MCPB (b)	5	Hexythiazox (b)	5	Captan (b)	5
		Clofentezin (b)	5		
		Diazinon (b)	5		

(for explanations see Table 4)

One can state generally that fungicide a.i. which fit in IFP-systems are available for soft fruit crops and are commonly registered.

The situation is different for **insecticides/acaricides** (see Tables 4-6). Among the most commonly permitted pesticides are Endosulfan and many pyrethroids (Esfenvalerate, Cypermethrin, Deltamethrin ..), which are not permitted in IFP. Pirimicarb, as a selective aphicide, on the other hand is also widely registered, although in some countries there is no registration in soft fruit crops. Mineral oil and *Bacillus thuringiensis*, two selective compounds are not very common in soft fruits. Organophosphates e.g. Diazinon, Tetradifon ... , are of medium frequency. Although they are not very selective, they may be used in IFP because of the lack of selective compounds. Commonly used selective acaricides as e.g. Clofentezin or Hexythiazox, are among the most frequently registered pesticides in soft fruit production.

To sum up the pesticide situation there is a lack of selective insecticides. Among the commonly registered a.i. many must not be used in IFP systems. The availability of acaricides is satisfying.

Summary

Pesticide availability in European soft fruit production is far less than for other fruit crops. National availability of pesticides varies strongly, especially for insecti-/acaricides. Countries can be divided into three groups:

1) countries with a high availability due to many crop-specific registrations (CH, E (?), PL and partly I, N);
2) countries with a high availability due to a general registration of a.i. for "fruit crops", as e.g. A, B(partly), GB, NL;
3) countries with poor availability due to a restricted crop-specific registration (D, DK, S and partly I, N).

Pesticide availability is best for strawberry followed by currants/gooseberry and cane fruit. For minor soft fruit crop hardly any pesticides are registered.

With respect to IFP the quality aspect for herbicides and fungicides is rather promising whereas there is a general lack of selective insecticides in soft fruit production.

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Expansion of an existing IFP-programme in Austria with the goal to include soft fruits

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The Austrian IFP-programme started in 1990 with guidelines and a special label established by the national fruit growers association with the help of public authorities. In the beginning the programme focused on pome fruits and stone fruits. Elder berries (Sambucus nigra) are an important fruit crop in Austria and soon a short special section on IFP in elder berries was added to the guidelines.

In 1995 Austria became a member of the European Union. This event influenced and changed the whole system of agricultural politics in Austria. There was the opportunity to spend subsidies to growers if they take part in special programmes for environmenal sound agriculture (based on EU regulation 2078/92). The existing IFP-programme was implemented into an national programme for environmental sound agriculture. In this situation there was the need to give soft fruit growers the opportunity to take part in the IFP-programme too. The result was an expansion of the IFP guidelines including an annex with regulations on the use of plant protection products in soft fruits except strawberries (table 1). Because of the lack of selective products for some imporatnt pests and diseases it was not possible to implement strawberries in the programme (e.g. Anthonomus rubi).

This expansion of an existing IFP programme to soft fruits was done in collaboration of a small group of scientist of the BFL, extension officers and soft fruit growers. The availlability of pesticides for soft fruits is a limiting factor for this crops in principal. Most of the pesticides listed up in table 1 have no special registration for the use in soft fruits. In such cases the pernission of use in soft fruit crops is based on regsitrations like "aphids in orchards" or "harmful caterpillars in orchards". Such wide registrations will disapear in near future and there will be a lack of modern pesticides for use in soft fruit IFP. It will be necessary to find solutions for registration of pesticides in such crops with a low economic importance for plant protection industry.

Table 1: Pesticides permitted in integrated soft fruit production in Austria
(except strawberries) in 1997

insecticides and acaricides

active ingredient		special restrictions in IFP
Bacillus thuringiensis	●	
Bromopropylate	O	max. 1 application per season
Chlorpyrifos-methyl	O	A
Clofentezine	O	B
Endosulfan	O	max. 1 application per season
Fenbutatinoxid	O	max. 1 application per season
Fenoxycarb	●	
Hexythiazox	O	B
insecticidal soap	●	
sulphur	●	
paraffin oil	●	
Phosalone	O	A
Pirimicarb	●	

A: max. 1 application per season with products of this group
B: max. 1 application per season with products of this group

fungicides

active ingredient		special restrictions in IFP
Bupirimate	●	
Kupferoxychlorid	●	
Mancozeb	O	max. 3 applications per season
Pyrifenox	●	
Vinclozolin	●	

● no special restriction of the use (within the frame of national registration)
O additional restrictions for use in IFP

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Soft fruit production in Austria

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Summary

This overview points out some characteristics of the Austrian soft fruit production and gives a short description of the development of this branch during the last 20 years. In the second part some phytopathological problems *(Botrytis cinerea, Phytophtora fragariae (var. rubi), Didymella applanata,* etc.) that soft fruit producer have to deal in the strawberry- and raspberry production are discussed.

Introduction

The Austrian soft fruit production in general is very small structured, which means that only few farmers are specialised on the growing of soft fruits, those big farms produce strawberries and they are localised in an area around Vienna called Marchfeld and in a region between Linz and Eferding.

To most of the soft fruit producer this branch is only an addition to other crops like cereals, vegetables or apples. So the sum of 2000 ha soft fruits in Austria are alloted to 4800 farms, which results in an average area of 0.42 ha.

Development of the soft fruit production area in Austria

Looking back 25 years ago currants (in particular black currants) were the most important soft fruit and beside apple the 2nd important fruit crop at all. Today there's an area left of about 170 hectare black and red currants. Figure 1 shows the development of soft fruit production area in Austria. The reason for this development can be explained by a steadily declining of prices during the last 20 years. While in the 1970ies the food industry bought black currants for the production of juice, all the currant that are produced today are proceeded on the farms to juice, liqueur or wine. All these products are sold directly by the farmers themselves.

The strawberry production area has reached a constant level of about 1000 hectare. In Austria strawberries are only produced as an outdoor culture on natural soil. Usually the strawberries remain two years on the field and the farmers grow them as a part of a crop rotation system alternating with cereals or other field crops, this might be the reason why we don't have serious problems with soil-borne diseases until now, although an increasing of red stele rot (*Phytophtora fragariae*) was observed during the last years.

Protected strawberry production and soilless cultures (peat, artificial media) play no considerable role. Some farmers use plastic foils to place harvest on an earlier date. Something typical of the Austrian strawberry production is to delay harvest by growing in regions with higher altitude (parts of Styria, Tyrol and the Mühlviertel in Upper Austria).

The centre of elder production is the (south)eastern part of Styria. The production area has been steadily growing during the last decade. This is due to a contract that guarantees minimum prizes to the farmers. Further information of the Austrian elder production draw from the detailled report in this bulletin.

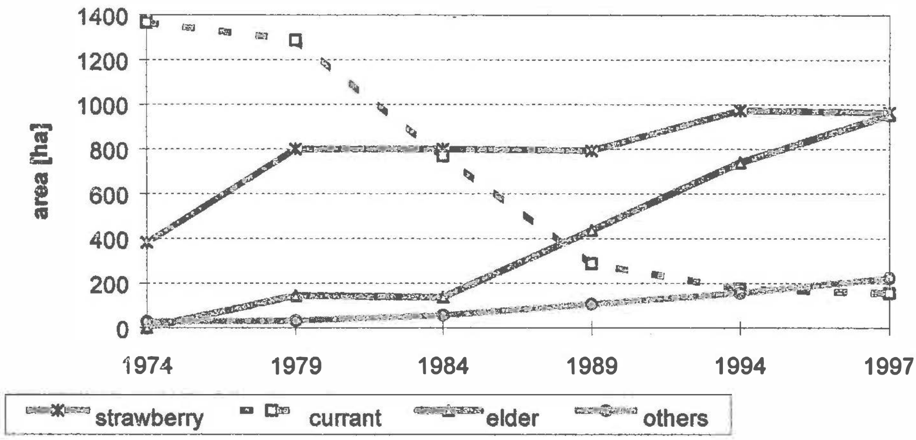

Fig. 1: The development of soft fruit production area in Austria

The production area of minor soft fruit crops (raspberry, blackberry, blueberries, cranberries, gooseberries) is slightly increasing, most of these crops are sold directly or proceeded to juice, jam or schnapps by the farmers themselves.

Phytopathological aspects:

By the example of strawberry- and raspberry production some phytopathological aspects of integrated plant production should be picked out.

Strawberries: Grey mold caused by *Botrytis cinerea* usually is controled by sanitation practise (mowing the leaves in late summer), mulching the soil with straw before flowering and 2-3 fungicide sprays during flowering. In IFP the strategy is mainly based on fungicides of the Dicarboximide-group (see table 1). In the draft version of the Austrian Strawberry guidelines of IFP Dichlofluanid and Thiophanate-methyl are restricted to 1 single spray because of their toxicity to beneficials, the use of Benomyl is not permitted. So Dicarboximides are the only fungicides which can be used without restrictions but they have a risk of development of resistance. Though resistance problems didn't yet occur in Austria, it is recommended to use fungicides with different mode of action in order to minimise the risk of resistance.

Powdery mildew caused by *Sphaeroteca macularis* as well as Leaf spot diseases (*Mycosphaerella fragariae, Diplocarpon earliana*, ...) are no general problem, nevertheless in some regions and under moist and warm conditions they might develop rapidly. In endangered sites they can be controled by the use of less susceptible cultivars, sanitation practise (mowing/mulching of leaves in autumn) and the use of foliar fungicides.

Due to the diverse crop rotation in agricultural practise soilborne diseases (like *Verticillium sp.*, *Phytophtora sp.*) are of minor importance. Nevertheless we could observe an increase of red stele rot caused by *Phytophtora fragariae* during the last years. Since the possibilities to get this diseases under control are very limited once the fungus is established in the soil and the use of soil sterilants is not permitted in Austria it is of major importance for the farmers to use healthy planting material. Other important diseases that might be spread by infested planting material are *Colletotrichum sp.*, *Verticillium sp.* and *Xanthomonas fragariae*. The requierement that the propagated planting material is free of the mentioned diseases must be fulfilled.

Table 1: Registered fungicides in Austrian strawberry and raspberry production

Strawberries	
Disease	**Registered Fungicides**
Botrytis	Iprodione, Procymidone, Vinclozolin, Benomyl**, Thiophanate-methyl*, Dichlofluanid*,
Phytophtora cactorum	Propamocarb, Al-Fosetyl
Mildew (soft fruit)	Pyrifenox
Raspberries	
Rust fungi (soft fruit)	Mancozeb
Mildew (soft fruit)	Pyrifenox
Cane blight, Spur blight	-
Botrytis	-
Phytophtora fragariae var. *rubi*	-

*permitted with restrictions, ** not permitted in the draft version of the Austrian IFP guidelines for strawberries

Raspberries: The key problems Austrian raspberry growers have to meet are Cane diseases, Grey mold and Phytophtora root rot which is again introduced by infested planting material. As you can draw from table 1 there are no fungicides available for the control of this diseases. So the strategies to manage them are mainly based on cultural methods like creating an open plant habit that allows air circulation and sunlight penetration to hasten the drying of the plants after rain or the minimising of fruit damage and splash dispersal of conidia by protecting the crop with a roof. Another important factor before planting is the choice of a less susceptible cultivar and the use of healthy planting material.

References:

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Information on integrated production of soft fruits in Hungary

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Abstract: The IPM System in soft fruit production is new not only in Hungary but all over the World. The aim of this system is to produce profitably quality product so that in the meantime the least chemical products be consumed,

In recently established plantations the basis of integrated production is primarily presented by the selection of suitable territories, plant varieties and production methods, like adequate nutrient supply. The different methods of mechanical pest control and ways of using pheromones, forecasting and other „soft" solutions, the saving of helpful natural enemies of pests and -if necessary, but only then! the use of selective chemical control: these all satisfy the conditions and requirements of IPM.

Theoretical and practical experiences are both at our disposal, but to render the system satisfactory, the choice of selective products has to be broadened, suitable staffs of consultans and networks of supervisors have to be registered both for raspberries and strawberries. These all demand a large-scale marketing activity and an economical milieu that considers among others also the financial interests of producers.

Introduction

A claim to decrease the load burdening the environment has presented itself not only in Hungary but worldwide; one of the possible ways to accomplish this goal is the introduction of integrated plant production.

The elaboration and practical effectuation of IFP was started in Hungary as well as in other countries with the most important fruits, the pome fruits and in this domain already considerable results have been achieved (Balázs *et al.* 1996, Jenser *et al.* 1997).

The soft fruits plantations possess the smallest production area in Hungary. Correspondingly, as in many other countries of Europe, their economic importance is much smaller than the one of pome or stone fruits (Cravedi and Jörg 1996, Zurawicz *et al.* 1996). This explains partly, why the demand of their integrated production emerged so late (Balázs 1990). On the other hand, it is true that although the total yield of soft fruits may be much lower than that of pome fruits, however there are regions in Hungary where the production of soft fruits (raspberry, strawberry and gooseberry) look backward to considerable traditions. Here their production constitutes the main source of income (and subsistence) of the inhabitants.

As all soft fruits demand considerable manual labour, the production has required the work of the whole family even on a smaller territory. This was also before the political changes in nineteen eighty nine and the same situation remained until now.

What has changed, nevertheless in these cultures, simultaneously with the changes in Hungarian agriculture as a whole ?

- As it happened with nearly all fruits, the area of soft fruit plantations has decreased nearly to the half of its original size; at the same time new plantations have been established by subsidy. These new plantations are characterized in many cases by good professional features: so besides suitable choice of soil quality, plant variety, also by adequate nutrien supply (compost, organic manure).

- The new grower conforms better to demands of the market, not only as regards new plants (white currant, blackberry, blackberry-raspberry). For an economically profitable production he needs at least 12-15 hectares. The most common fruits are: strawberry + raspberry + red currant or strawberry + any other (red, white) currant. Within varieties the grower produces usually two different ones, from strawberry even 3-4.

Bases and possibilities in the integrated production of soft fruits

In general

In soft fruits the environmentally safe, integrated methods are of high significance, as these plants constitute the earliest fruits of the growing season, giving fresh fruit both to children and elderly people.

To the elaboration of integrated plant protection measures in soft fruits good examples were given by methods that proved to be suitable in pome fruits (Balázs *et al.* 1996, Jenser *et al.* 1997). The technological or phytotechnical procedures that combine many mechanical control methodes against pests and pathogens can be correlated in time (Balázs 1969, Balázs and Vajna, 1971).

The foresight of the grower have to begin as early as the planting itself.

The most important is a careful selection of the area of the orchard to be planted. Low-lying, deep grounds have to be avoided in planting strawberry because of snails, in raspberry because the occurrence of grey mould and other fungal pathogens. In planting raspberry it is not advisable to commend southern slopes because the plants would show a feeble growth, the cracking of the bark may promote the infestation of raspberry cane midge, *Thomassiniana theobaldi* Barnes. Because of the possibility of the occurrence of soil-inhabiting pests, recently broken-up turf, ruderal sites, former pastures or meadows used for grazing, are hazardous. From these the common cockchafer larvae (grubs) (*Melolontha melolontha* L.) are the most dangerous. In the survey preceding the planting work, if per 1 m^2 1 L2-L3 grub is found, it is better to postpone the planting to the following year. If the grubs are younger, it is necessery apply soil sterilisation.

It is an important prerequisite that the propagating material must be free of virus, pests and pathogens. For planting strawberry early August is the most suitable (with the exception of frigo seedlings). In strawberry plantations the use of straw, in raspberry and red currant plantations the use of foils or mulch cover is recommended.

The later nursing of healthy plants that were set amongst right conditions must consist of proper watering and additional nutrient supply besides careful local pest and disease forecasting work. The appearance and individual number of pests has to be observed and followed with local surveys (observation of plants, sampling by beating, use of attractans, scent traps and pheromone traps) with the same care as the appearance of their natural enemies. In the Hungarian Plant Protection Institute a whole family of pheromone traps (CSALOMON) has been developed; among them there are many which signal the presence of pests that are significant for soft fruit growing (traps to signal and indicate the presence of *Synanthedon tipuliformis* Cl., *Abraxas grossulariata* L., *Pandemis heparana* Den. et Schiff., *Anomala dubia* Scop., *Anomala vitis* Fabr., *Agriotes ustulatus* Schall., *A. sputator* L. etc.).

At least as important for the grower of soft fruits is the forecasting (regarding the onset, later percentage and progress of infection) of pathogens and diseases.

The necessity and proper timing of control measures can be decided only in the possession of their data and even in case of intervention it is advisable not to use anything but to select a „green" product. The number of pesticides or active materials that are selective enough to be used safely in soft fruits is howver, limited. The reason for this situation in the fact that these plants are not grown on large areas and the firms do not extend their registrations of this pesticides to soft fruits even in case of good experimental results against their pests, or in cases when the same products have been registered against closely related other species in other plant cultures (examples: whereas Mach - lufenuron is registered in apple against the apple clearwing, *Synanthedon myopaeformis* Bork. it is not in red currant against the similar *Synanthedon tipuliformis* Cl.).

If there is no selective insecticide registered against a given pest, the competent Plant Protection Station of the region has the competence in Hungary to authorize its use. Otherwise, if no such preparation is available, the mildest organophosphate with the least side effects can be used, that has the relatively slightest harmful impact on the natural enemies of pests.

Raspberry

It is by no means accidental that the first measures of integrated plant protection had appeared first in the raspberry growing. The selection of shoots, the removal of infected, canes make possible the simultaneous mechanical control of raspberry gall midges - *Lasioptera rubi* Heeg. and raspberry metallic wood borers, *Agrilus aurichalceus* Redt. (Buprestidae). If these treatments are carried out in right time (by the end of July or early August), the density of pests decrease under economical threshold. Their parasitoids, different ichneumonid wasps contribute to this process. This mechanical control decreases also the density of raspberry cane midge, *Thomasiniana theobaldi*, even the numbers of pathogens, like *Didymella applanata* (Niees) Sacc., *Elsinoe veneta* (Speg.) Jenkins, *Leptosphaeria coniothyrium* (Fuck.) Sacc. helping this to reduce the number of sprayings.

Against what organism do we have to treat raspberry plantations?

From among the main pests and pathogens of raspberry first different tortricids and the raspberry moth, *Lamproniella rubiella* Byerk. have to be mentioned. The density of the former remains usually below the economical threshold, with the exception of *Notocelia udmanniana* L. against which the grower is inclined to spray because of its conspicuous damage. This latter is, however, seldom necessary because of the presence of its numerous parasitoids. The control of raspberry moth is more important as its larva is capable to destroy in the early spring 4-5 shoots. As long as Insegar - fenoxycarb - or some other pesticide with a similar effect are not registered against this pest, the grower has to choose among some organophosphates (like Ultracid, Danitol, Danatox). But the growers are in any case strongly advised against the use pyrethroids, even if they are registered in raspberry.

With aphids the situation is relatively simple; against the monoecic (monophagous) *Aphis ideaei* v. D. Goot. it is sufficient to treat the plants in the early period with pirimicarb (Pirimor), later the remaining aphids are kept in check by the natural enemies.

The raspberry cane midge necessitates control measures only among suboptimal growing conditions, at the omission of proper mechanical control or in case when the natural density of parasitoids had remained under 15 %. Then a treatment may be advisable after blom and later, after harvest.

The biggest problem may be caused by the ubiquitous and numerous raspberry beetle (*Byturus tomentosus* Fb.) against which only organophosphates are registered at present (according to our experiments Zolone - phosalone - and Bancol - bensultalp -, preparations beloning to be „yellow" insecticide category may give adequate control of this pest).

Against grey mould (*Botrytis cinerea* Pers.) 2, even 3 treatments may be necessary at the time of flowering, but in view of the increasing damage of canes the treatments cannot be omitted. There are possibilities to use environmentally safe fungicides (Rovral, Ronilan, Euparen) against this pathogen.

The different cane spote (*Didymella applanata, Elsinoe veneta, Leptosphaeria coniothyrium*) can be controlled by adequate mechanical treatments and fungicides containing copper and combined active materials. These treatments need to be carried out upon forecastings and have to be repeated 4-5 times yearly.

Currant (black, red, white)

The different mechanical control measures have in currant (red, black, white) different significances. The shape-forming pruning or cutting out of dense foliage parties give a good opportunity to remove, cut up and compost parties infested with currant clearwing (*Synanthedon tipuliformis* Cl.) or San José scale (*Quadraspidiotus perniciosus* Comst.). This is by all means recommended in black and red currant plantations that are infested by *S. tipuliformis* larvae, because both the quality of yield and quantity are considerably reduced by this pest (Balázs 1969). It is similarly important to remove shoot ends infested by gall mite (*Cecidophyopsis ribis* Nal.) or powdery mildew (*Sphaerotheca mors-uvae* /Schw./ Berk. et Curt.) by the end of winter, before bud-breaking.

If the mechanical treatments are completed by observations on the development, swarming, changes in individual densities of pests and by observations on conidium formation, ascospore production and dispersion of *Mycosphaerella* and *Pseudopeziza* leaf spots, only few but well timed spraying has to carry out.

From among the most important pests the individual numbers of ribes gall midges have to be established by bud surveys at the time of bud breaking. The numbers of red currant aphids (*Cryptomyzus ribis* L.) have to be estimated on the shoot ends at the blom. The raspberry clearwing adults can be studied by the end of April with pheromone traps, the flight of San José scale males can be followed by sticky plates or pheromone traps at the end of May.

By considering these, when do we have to spray our currant plantation ?

First, it is very important to carry out the dormant spray with environmentally safe pesticides. If the treatment is directed against powdery mildew and bud mite as well, Nevikén (containing sulphur and vaseline oil), if besides bud mite also San José scale is present, then Agrol Plus (vaseline oil) is recommended.

At the first treatment against aphids the grower uses pirimicarb. The timing of the spraying is very important as it should be carried out against the first colonies, before the appearance of leaf deformations.

In case of careful mechanical control, it is enough to make one spraying against the clearwing at the time of peak flight. This is especially so if the flight and egglaying are protracted and the attack of parasitoids is remarkable (8-15 %). The right timing of the treatment is possible only by the use of pheromone traps, because - as shown by observations of Szôcs et al (1995) - during a long observation period of 7 years the adult flight showed each year considerable differences.

Against powdery mildew the grower has to spray in the average three times yearly, besides the treatments at the winter-end. On these occasions Saprol (triforin), Rubigan (fenarimol) and Bayleton (triadimephon) are used whereas against leaf fall diseases (*Mycosphaerella ribis* /Fuck./ Kleb., *Pseudopeziza ribis* Kleb.) the spraying has to be done at the beginning of berry formation, in the green-berry stage and at the early stage of berry colouration. If signs of primary infection are observed, the spraying has to be repeated after harvest. The latter treatment also contact (copperoxychloride, captan, copper hydroxids) and systemic preperations (triforin) are available.

Strawberry

From among the soft fruits strawberry is the one in case of which mechanical treatments, like removal of infected leaves, mouldering fruits, collecting of snails, grubs can bring only partial results. So the principles, like proper selection of suitable plot, soil treatment and - naturally - the use of healthy propagating material are much more important.

The same importance can be attached to the presence of soil-inhabiting pests, like determination of densities of cockchafer grubs, strawberry curculio (*Otiorrhynchus ovatus* L.) especially when the latter dwell near to the soil surface. Also the use of bait plants (lettuce) may be useful in the survays.

Besides the cockchafer and strawberry curculio two other curculionid beetles, the strawberry weevils (*Coenorrhinus germanicus* Herbst and *Anthonomus rubi* Herbst) may cause difficulties. The former one is more significant, therefore its density has to be established immediately after it has shown up (white bud stage). Unfortunately no „green" preparation is registered against it, so one of the organophosphates (Hostathion, Danatox) may be chosen.

In strawberry many tortricids occur, but their density is usually under the economical threshold. In order to avoid unpleasant surprises, their presence has to be closely followed. This is done by pheromone traps, scent traps and regular plant surveys.

Since many years the most significant pest of our strawberry plantations the strawberry mite (*Tarsonemus pallidus* Banks.) has been. As it spreads mostly by infested propagating material a sharp eye has to be kept permanently on its presence. If the plantation became infested, spraying should be done before flowering and at least twice after this period. The grower can select among the numerous acaricides (Mitac 20 - amitraz, Pol-Akaritox - tetradiphon -, Hostathion - triazophos) available in the commerce.

From among the pathogens the fruit harvest is the most threatened by the grey mould fungus. Besides the agrotechnical methods (soil covering at full blom, omission of watering at harvest time) at least two sprayings with special fungicides (Rovral, Ronilan, Euparen) are recommended.

Leaf spots (*Mycosphaerella fragariae* /Tul./ Lind., *Fabraea fragariae* Kleb., *Zynthia fragariae* Laib. in order of their importance) do not cause real difficulties if in the spring, before the green bud stage a fungicide spraying was applied (copperhydroxide, copperoxychloride, faltan) and this was repeated after harvest. It is important to clean the plantation, improve the soil after harvest and, finally, find time for irrigation as well.

Conclusions

In soft fruit plantations the methods and elements of integrated production are already available; it is the task of our present days to promote their spreading and generalization.

The most important objective is the establishment of a network of consultants and inspectors, that had already been organised with pome fruits. It is indispensable to increase the number of utilizable, essential and selective pesticides and to expand a well organized marketing activity for soft fruits produced within an integrated production system.

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Soft fruit production in Germany - on the way to IFP

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Overview on Soft Fruit Production

The total acreage of German fruit production is 74000 ha (Table 1). Tree fruits are grown on 62700 ha. Apple is the most important fruit crop (40000 ha). Soft fruits are grown on 11500 ha. The average fruit farm size in Germany is 2,2 ha; but there are striking differences between western and eastern German fruit farm sizes; the relation is 1:10.

In soft fruit production the most important crop is strawberry (Table 2) with an acreage of about 7900 ha. Currants (mainly red currants) and gooseberries are grown on 2600 ha. Other soft fruit crops are of minor importance. Raspberry acreage is about 1300 ha and during the last few years elderberry orchards have been established on ca. 200 ha. The acreage of all other soft fruit crops (including blueberries and Aronia) is about 200 ha. The average soft fruit farm size is less than 1 ha.

In strawberry production the share of 1 year-crops has increased from 50 % several years ago up to 70 % today and still is increasing. On about 20 % of the total strawberry acreage strawberries are grown under plastic tunnels. Soilless culture (e.g. peat bags in glasshouses) are of minor importance. Average strawberry farm size is 2,5 ha. During the last 5-10 years farmers have become "specialists" for strawberry production and the average farm size has increased considerably.

German strawberry production aims at the fresh market. Fruit for processing normally is imported. 45 % of the harvest is marketed by self marketing (regional and local markets and the share of self-picking is 25 %). A considerable tonnage is marketed via cooperatives (23 %) and wholesalers (20 %).

One must not forget that hobby gardeners grow strawberries on more than 10000 ha in Germany.

Raspberry production also aims at the fresh market. Processing industry`s demands are met by imports from Eastern/Middle Eastern European countries. This also holds for black currants which mainly are imported from Poland. Red currants are produced for the fresh market whereas black currants and also elderberries are for juice production. Gooseberries also are produced for processing but there also is a small fresh market. Some regions offer programmes for soft fruits (financial support) to increase red currant and gooseberry production.

Table 1: Fruit Production in Germany - Area (ha)

Total	74 000
Trees **(Apple)**	62 700 (40 000)
Soft Fruits	11 500

Table 2: German Soft Fruit Production - Area (ha)

Total	11 500
Strawberries	7 900
Raspberries	1 300
Currants, **Gooseberries**	2 600
Elder	200
Others **(Aronia, Blueberry etc.)**	200

Problems in German Soft Fruit Production

The main problem is the **unfavourable structure** of German soft fruit production. The low average farm size has already been mentioned. In some regions, as e.g. the Baden region in the south-west of Germany the structure is a mere catastrophee. 6000 producers grow soft fruit on 1500 ha, which means that the average farm size is 0,25 ha! The supplying of the market is impossible to be coordinated and some quality problems arise from that unsatisfying situation. In addition to that advisory work is time-consuming and laborious and so progress in improving the quality of the production systems marches slowly on. With respect to IFP checking procedures are problematic. For quite a low production very expensive inspection systems must be installed to meet the demands of IOBC-Guidelines for Integrated Fruit Production.

Another problem is the **high susceptibility of the main cultivars** to important diseases and/or pests. Examples are Achilles for gooseberries and Elsanta for strawberries. Although less susceptible cultivars are available the market insists on the susceptible cultivars because of their good keep well and transportation features. Only on a small scale selfmarketers have introduced less susceptible cultivars in strawberry, gooseberry and black currant production.

Due to the minor importance of soft fruit production the **interest of marketing organizations in IFP** for soft fruits is quite poor. Up to now no specific efforts have been taken to enhance the introduction of soft fruit IFP.

Plant protection aspects

Only few research has been done on soft fruit production systems. Cultivar testing, resistance breeding and investigations on Nitrogen fertilization have been and still are the major topics of research. Compared to apple crops the entomological and phytopathological research of soft fruits is negligible.

An overview on the most important pests and diseases of German soft fruit crops is given in Table 3. In general *Botrytis* is of great importance in all crops. In strawberry and raspberry crops *Phytophthora* species can cause severe losses. In regions with poor crop rotation *Verticillium* can be a limiting factor for strawberry production. Fungal cane diseases and viral diseases are still unsolved problems in raspberry crops. In the southwest of Germany *Xanthomonas fragariae* epidemics occurred during the last few years.

The main pests are aphids (in all crops), weevils and other beetles (in strawberries and raspberries) and spider mites. Beside those dominant pests many other occur depending on regional climatic conditions and on the weather conditions of specific years.

Table 3: Most Important Pests and Diseases in German Soft Fruit Production

Crop	Strawberries	Raspberries	Currants & Gooseberries
Pests	Spider mites Blossom weevil Aphids	great local variability (no dominance of one or two pests in Germany)	Aphids Scales (Currant gall midge) (*Nematus ribesii*)
Diseases	*Botrytis* grey mould *Phytophthora fragariae* *Phytophthora cactorum* *Verticillium* sp.	*Botrytis* grey mould *Phytophthora fragariae* Cane diseases Virus diseases	*Botrytis* canker Powdery mildew *Nectria cinnabarina*

Table 4: Plant Protection Products in German Soft Fruit Production
- Number of applications / season

Crop	Herbicides	Fungicides	Insecticides	Acaricides
Strawberry	2/3*	4/8	2/3	1/2
Raspberry	1/2	3/5	2	1/2
Red Currants	1/2	1/2	1	0/1
Black Currants	1/2	3/5	2	1/3

* = first number: average; second number: average in intensively cropping farms

Plant protection systems of the different crops vary considerably concerning pesticide input (see Table 4). Agrochemical input is highest in strawberries followed by raspberries and black currants (also gooseberries). The least number of applications is done in red currant crops. One or two herbicide applications are the "standard" in soft fruit crops; in strawberry crops in intensified production systems a third application is done. Acaricides are used once or twice per season. In black currants a third additional measure to control black currant gall mite is applied. Insecticides are applied twice to control noxious beetles and aphids. Fungicide applications have increased in number during the last years due to the high susceptibility of the main cultivars. *Phytophthora* sp., *Botrytis* sp. and powdery mildew are the main target organisms. In intensive strawberry crops pesticide imput sometimes is higher than in apple crops in the same regions. Especially farmers who specialised on strawberry or raspberry production increased pesticide input considerably. For most of the pests and diseases no decision support systems (e.g. forecasting models, threshold concepts) are available and as a consequence pesticides are applied preventively.

Due to the low interest of chemical companies (economic reasons) only a few active ingredients are registered for the use in soft fruit crops (Table 5). For strawberry crops for many pests and diseases and for weed control sufficient products are available, although there are some gaps of vital significance, e.g. powdery mildew or weevils. The situation ist worst for rasp-/blackberry crops where mite, disease and weed control would be impossible if only registered products must be used! In general there is a lack of acaricides, fungicides and selective insecticides. Insecticides often either are very broad spectrum (pyrethroids, organophosphates) or their efficacy is quite poor (pyrethrin, potassium soap). For some of the most important diseases and pests and for perennial weeds in general no products are available (see Table 6).

Table 5: Pesticides registered for Soft Fruit Production in Germany
Number of active ingredients

Crop	Herbicides	Fungicides	Insecticides	Acaricides
Strawberry	4	6	7	3
Rasp-/Blackberry	1	1	3	1[1)]
Red / Black Currants	2	1	5	1[1)]
Gooseberry	2	3	3	1[1)]

1) including mineral oil
Insecticides: including Potassium soap and Pyrethrine + Piperonylbutoxide

Table 6: Problems with Pesticide Availability in German Soft Fruit Production
Gaps (no plant protection products available for the control of)

Strawberry	Rasp-/Blackberry	Currants	Gooseberry
Strawberry mite Nematodes (pl.m.)		Currant gall mite	
Verticillium Powdery mildew	Cane spot (B.b.) Cane diseases Root rots	Fruit rots Currant rust (Powdery mildew)	(Powdery mildew)
Perennial weeds	Perennial weeds	Perennial weeds	Perennial weeds

On the way to IFP

Although the situation of German soft fruit production is unsatisfactorily some progress on the way to implement an integrated soft fruit production has been made during the last five years.

Concerning plant protection non-chemical methods to control important pests and diseases have been developped and already introduced into practice. Control of nematodes in strawberry crops is effective by growing Tagetes sp. as pre-crop.The same efficacy of *Tagetes* pre-cropping as for chemical control with broad-spectrum nematicides could be demonstrated. Several growers already adopted this measure especially in regions where the production area ist limited and a proper crop rotation with sufficient break crops is impossibie.

On the other hand in regions where production area is not a limiting factor strawberry growers conclude contracts with arable farmers to include strawberry production into sustainable arable crop rotations, especially into cereal rotations.

For strawberry and partly gooseberry production self-marketing farmers to an increasing degree grow less susceptible cultivars thus reducing mainly fungicide input.

The application rates of Nitrogen fertilizers have been reduced considerably in the near past. This ist due to the application of depot fertilizers and also to the introduction of N_{min}-fertilization schemes.

To improve pesticide availability a project ("Lückenindikationen") has been started. A joint effort of registration authorities, chemical industries and governmental plant protection services shall result in a closure of the indication gaps of vital significance and in a better provision with selective compounds. The immediate aim is to reduce the registration costs. This is achieved by

- transferring the registration for comparable crops
- common use of data
- conducting efficacy trials and residue analyses by governmental plant protection services.

The project is quite a success. From 20 indication gaps of vital significance in 1995 10 have been closed in 1996/97. 5 fungicide gaps, 4 insecticide gaps, 4 acaricide gaps and 4 herbicide gaps are in work and expected to be closed in the near future.

IFP-guideline drafts for soft fruit crops

In contrary to the situation of pome and stone fruit no national IFP-guideline for soft fruit has been elaborated. Four soft fruit growing regions in Germany have posed up guideline drafts for IFP: Baden-Württemberg, Brandenburg, Rheinland, Westfalen-Lippe. With the exception of Baden-Württemberg all guideline drafts concentrate on strawberry production. The Baden-Württemberg draft, which is the most advanced, covers all soft fruit crops and may serve as the basis for a national guideline.

The IOBC-definition for IFP has been adopted in the drafts. They require obligatory training courses. Requirements and recommendations according to the IOBC-Guidelines for pome and stone fruit are stated as far as possible.

Concerning the **planting** systems for strawberries a maximum life span of 3 years for the crop is required.

Potatos must not be pre-crop and a break crop has to be included between two successive strawberry crops.

Recommendations for appropriate **soils** are given. A **soil sample** has to be taken prior to planting and a 4-year interval is prescribed for perennial crops.
Nitrogen soil-/leaf-analyses have to be done annually. Upper limits for Nitrogen application rates, restrictions in application periods are defined. Application rates higher than 40 kg N/ha have to be justified.
Mulching systems are required for perennial crops and recommended for strawberries as far as possible.
The integrated plant protection system also follows the IOBC-Guidelines, but by now it seems impossible to consider IPM-systems in soft fruits in Germany as "complete" or of the same standard as e.g. in pome fruit.
Spraying equipment has to be inspected and calibrated in two year-intervals.
The **checking procedures** are in accordance with IOBC-guidelines. But is seems to be impossible to implement them in some regions with very unfavourable farming structures. Field booklets and record sheets already have been elaborated.

Summary

In Germany soft fruit production is of minor importance. Soft fruits are grown on 11500 ha, with strawberry as the most important crop. General and specific problems (farm structure, pesticide registration) are slowing down the introdcution of IFP in soft fruit crops. By now an integrated soft fruit production fully in accordance with the high IOBC-standards is not possible in Germany. But first IFP-guideline drafts have been elaborated, and based on those and on promising research results and successful registration activities there is good prospect for the implementation of soft fruit IFP in Germany in the near future.

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Lepidoptera living on raspberry in North-Hungary

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Abstract: The authors wanted to elucidate the role and significance of Lepidoptera on raspberry in the raspberry growing area of Hungary and the role of natural enemies in reducing the number of raspberry pests.

It was established that many species of *Tortricidae* and *Noctuidae* occur regularly in the region, their activity, however does not exceed the ecological threshold value. This is a result partly of their low individual density, partly of the activity of their parasitoids *(Braconidae, Ichneumonidae, Tachinidae).*

The only lepidopteran that causes economic damage on shoots is *Lamproniella rubiella* Byerk. and makes a treatment necessary in the early spring.

Introduction

From among the soft fruits grown in Hungary, the demand on an environmentally safe pest control presented itself first in raspberry. The production of raspberry consumes anyhow much manual labour, but it can be conveniently combined with mechanical control operations against cane pests (*Thomasiniana theobaldi* Barnes, *Lasioptera rubi* Heeg., *Agrilus aurichalceus* Redt.). Against aphids (*Aphis idaei* v.D. Goot) that infest raspberry locally and in closed herds, the control is relatively simple if the grower is in possession of a reliable forecasting; selective insecticides against aphids are also available (Balás & Sáringer 1982, Balázs &Vajna 1971, Szalay-Marzsó 1969).

But how is the situation with different Lepidoptera that appear locally in large masses from time to time and occur only sporadically in an other area? In trying to harmonize the needs of integrated production with the ones of integrated plant protection it became clear that only very few data were available even in case of regularly occurring and damaging species; the informations on the faunistical conditions of rare or potential pests the were even more sporadic (Balázs & Vajna 1971, Jermy & Balázs 1993).

The production of raspberry concentrates itself in Hungary to few regions. The Nógrád County in North-Hungary, where our studies have been carried out, is the most important from these. Based on data of 1990 the position of raspberry plantations is presented in Table 1.

Aims

We aimed to seize up the lepidopteran species living on raspberry, together with their natural enemies and their interactions.

Table 1.: Raspberry plantation in Hungary (1990)

Department	Raspberry acreage (hectares)	% of total acreage
Nógrád	436	36
Pest	289	24
Vas	205	17
Zala	147	12
Gyôr-Sopron	47	4
Heves	46	4
Veszprém	41	3
Total	1209 hectares	100 %

Methods

During two vegetation periods regular surveys have been carried out on the presence of different lepidopteran larvae; they were then collected and reared on raspberry to adults. The same was carried out with the parasitoids. The surveys were made in 1996 at six opportunities (between 8 May and 16 August) and five occasions in 1997 (between 11 April and 6 August).

In the plantations studied first the infestation was established on 2000 shoots in 13 rows (damage on leaves and shoots by larvae of *Lampronia rubiella* Byerk., *Notocelia uddmanniana* L.) then for rearing the total larval population found was collected. On one occasion, on 26 May 1996 3000, on 21 June 1996 4500 shoots were included into the surveys.

At the surveys also the flying Lepidoptera were observed and recorded; the swarming of a Tortricid, *Pandemis heparana* Den. et Schiff. was even followed by pheromone traps.

Results

In course of two years the adults of 11 Lepidoptera species were reared from raspberry.

The list of species and the phenological data of rearings are contained in Table 2.

The quantitative data are presented in Table 3. According to the results the damage of *Lampronia rubiella* and the ones summarized as damages of Tortricidae played a dominant role. The latter meant practically the activity of *Notocelia uddmanniana.*

The surveys included observations on the activity of parasitoids as well, as mentioned in Table 2. The rate of parasitization of *Notocelia uddmanniana* showed a conspicuous 32 %, that stood in sharp contrast to the other species. It was unfortunate that no parasitoids could be reared from larvae of the dominant *Lampronia rubiella.* The identification of parasitoids *(Ichneumonidae, Braconidae, Chalcididae)* is being carried out.

Table 2.: List of Lepidoptera reared from raspberry in 1996 and 1997 (Nógrád County, North-Hungary)

Family, species	Time of collection of the larva	Parasitization
Thyatiridae		
Thyatira batis L.	21.06.1996	-
Noctuidae		
Mamestra oleracea L.	21.06.1996	-
	07.07.1997	
Apatele rumicis L.	21-27.05.1996	+
Amphipyra sp.	27.05.1996	+
Tortricidae		
Notocelia uddmanniana L.	08-26.05.1996	+
	25.07.1996	+
	02.06.1997	+
Ptycholoma lecheanum L.	08.05.1996	+
Pandemis heparana Den. et Schiff.	27.05.1996	-
Hedya nubiferana Haw.	26.05.1996 (pupa)	-
Archips rosana L.	08-26.05.1996	+
	02-06.1997	+
Incurvariidae		
Lampronia rubiella Byerk.	08.05.1996	-
	11.04.0997	-
Coleophoridae		
Coleophora sp.	26.05-21.06.1996	-

Table 3.: Quantitative aspects of Lepidoptera caused damage in raspberry (Hungary 1996-1997, damage/2000 shoots)

1996	**08.05**	**26.05**	**21.06**	**02.08**	**09.08**	**16.08**
Leaf roller	38	8	1	8	19	6
Damage by larva	20	22	8	11	14	8
***Coleophora* larva**	0	1	1	0	0	0
***Lampronia* larva**	25	0	0	0	0	0
Leaf miner	0	3	24	2	4	3
1997	**11.04**	**02.06**	**07.07**	**24.07**	**06.08**	
Leaf roller	0	13	0	3	4	
Damage by larva	2	21	2	1	4	
***Coleophora* larva**	0	0	0	0	0	
***Lampronia* larva**	22	0	0	0	0	
Leaf miner	2	50	18	3	1	

Conclusions

The lepidopterological surveys of two years showed that in raspberry neither the number of Tortricidae nor the one of Noctuidae justifies the costs of control, as they remain under the economic threshold.

In case of the subdominant *Notocelia uddmanniana* the presence and number of parasitoids render the chemical treatment unnecessary. Care has to be taken that control measures applied against other raspberry pests should save the parasitoids, helping thus the colonization and reproduction of *Braconidae* and *Ichneumonidae.*

Because of its extensive damage of the dominant *Lampronia rubiella* - each larva may destroy in the springtime 4-5 buds or young shoots - it is necessary to use in the early spring some selective insecticide against it.

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Perspectives of integrated production of blackcurrant in Poland

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Abstract: Poland is one of the leaders of blackcurrant production. By reason of Polish free market conditions integrated production of blackcurrant may be begun quickly. Mainly large plantings offer good prospects for economic success. Cultivars selected to IFP should be of good market usefulness, suitable for mechanical harvest and if possible resistant to diseases and pests. Weed-free strips along bush rows achieved by using a tillage machine should be preferred in soil management. Using of a pruning device could be allowed in large plantings, but only as prefatory treatment of hand pruning.

The main problem in blackcurrant protection is the gall mite. It is necessery to remove buds infested with this pest. Because there is not another chemical weapon against the gall mite, endosulfan has to be applied. Biological control of twospotted spider mite with Phytoseiidae should be developed. In case of gall stem midge occurrence, avoiding of shoot damages by the harvester and using a method of its detection are recommended. Pheromone traps for detection of flight of adult clearwing moths should be hung on the bushes. In diseases control, a selection of cultivars with regard to their susceptibility and appropriate to planting site is very important. Tunnel sprayers and sprayers with a directed air flow should be especially recommended in IFP of blackcurrant. However many aspects of blackcurrant production can be employed in IFP, such problems as the threshold levels for main pests, too short list of pesticides or too high cost of some applications are not solved.

Introduction

Among currants, blackcurrant covers the largest area in Poland. In 1995 the total blackcurrant crop (obtained from 20 000 ha) was 100 000 t. It gives an average yield of about 5t fruits per hectar, what is rather low. In spite of this, Poland is one of the leaders of blackcurrant production. Most fruits are destined for processing or freezing.

Because Polish economy is developing towards free market, the introduction of integrated production to blackcurrant may be necessary very soon. General principles for IFP in blackcurrant should be similar to that of other plants. Such problems as conserving the currant plantings enviroment, bush nutrition, and irrigation should be almost the same. Problems arise, when we analyse the size of plantation and cultivar selection for new plantings.

The size of plantation and cultivar selection

Integrated production in small areas, where hand harvest will be conducted, could be possible, but the future is in larger plantings, which allow to introduce modern equipment in plant management and protection. In new, Polish free market conditions, only these plantings may offer good prospects for economic success.

The first criterion in cultivar selection should be a good market usefulness. Resistance to diseases and pests, and - associated with that - site of planting, are not less important. These problems will be talked over further. The manner of harvesting is also important. If we plan mechanical harvest, we have to know, that various cultivars show different sensitivity to damages caused by the harvester.

Soil management

In Poland most blackcurrant plantings have a weed-free system on whole area. This is a result of herbicide application. At least one herbicide treatment is conducted in each blackcurrant planting per year. This treatment is usually supplied with mechanical cultivation. Herbicide use is all time the cheapest system of soil management in Poland. So, offering to growers something instead of, may be very difficult.

Of course, if any farm has enough straw or another safe organic materiai, the ground can be mulched, but this leads to additional problems with mice very often. Polythene covering along bush rows however, could give also some protection against pests overwintering in the ground, like shoot borer, gall midges or currant sawfly, but it is still too expensive for Polish growers and not accepted by them.

In this situation, the best solution could be maintenance of weed-free strips along bush rows, achieved by using a special cultivation tillage machine. Unfortunately, this application has a defect, a danger of root damage and therefore treatment with that machine must not be too deep. Herbicides permited in IFP of backcurrant could be used only as supplement of this method. Actually following herbicides can be proposed to IFP in blackcurrant: before planting glyfosate and MCPA herbicides, atrazine and simazine only in the first three years after planting and next years glufosinate or, if we have a problem with monocotyledonous weeds - fluazifos. In weed control conventional herbicide sprayer is less safe for environment than herbicide brush wiper, which seems to be more usefull in IFP

Blackcurrant pruning

An important element of IFP will also be the blackcurrant pruning. Until now, the most popular system is pruning each year with a machine, making the shape of bushes more suitable for mechanical harvesting, and hand pruning every third-fourth year.

In IFP, pruning by hand tools must be preferred. Branches bending down, damaged by machines, pests or disaeses, and the oldest ones, all should be removed. Sometimes, pruning of a large planting by hand tools, may be impossible, and, if any planting has really a big area, using of a pruning device should be allowed but only as prefatory treatment. After pruning, branches are often transferred out of the planting. It may be wasteful and if the branches are not much infested with pests or diseases, they should be rushed and left on the plantation.

Blackcurrant protection

A conventional production requires an intensive protection against diseases and pests. In a season 8 to 10 or even 14 treatments are necessary, depending on the degree of risk. The most important pests of blackcurrant in Poland are: gall mite, twospotted spider mite, gall migdes (mainly gall stem midge now), clearwing moth, shoot borer and aphids. Among diseases, the largest injuries are caused by blister rust, antracnoze and powdery mildew. Only eight insecticides and acaricides may be selected to IFP from actual register of pesticides recommended in blackcurrant production. They are: *Bacillus thuringiensis*, fenbutationoxid, hexytiazox, phosalone and pirimicarb. Application of endosulfan is controversial by reason of its high toxicity to man. As we have not another effective chemical against gall mite, its using in the control of this pest will probably be necessary. Pesticides propargite and triazamate can be permitted with restriction because of their limited selectivity to beneficial organisms.

Considering a selectivity of fungicides, we could select following products: bupirimate, dichlorfluanid, dithianon, fenarimol, mancozeb, perifenox and triadimefon. Use of dichlorfluanid and mancozeb should especially be limited because of their moderate selectivity to predatory mites.

It is obvious that in IFP, plant protection products may only be used when justified and priority must be given to other control methods. What possibilities do we have in case of blackcurrant ?

The gall mite, vector of reversion is the most important pest of blackcurrant in Poland. In our opinion, in IFP of blackcurrant, oppositely as to other pests, we can not tolerate even a very low population level of this pest. Presently, in Poland at least two or three treatments against gall mite are applied each year and do not give a satisfactory control. We are still waiting for blackcurrant cultivars resistant, both to the gall mite and reversion. Although this subject is actually leading in blackcurrant breeding programs, there are not cultivars resistant to the gall mite and simultaneously giving good market usefulness. So, beside removing of infested buds each winter, unfortunately we have to apply endosulfan. We hope that exact conducting of removing of infested buds could allow to reduce the number of treatments with endosulfan to one.

The second important mite species infesting blackcurrants is the twospotted spider mite. We should go towards biological control of this pest with Phytoseiid mites. However this method of mite control in blackcurrant is not accurately elaborated, it is known that in favourable conditions, these predatory mites are able to keep up the population of *Tetranychus urticae* on a very low level (Kropczynska and Czajkowska 1995). Twospotted spider mite is the sole pest which has an elaborated treshold level. This is 1-2 mites per leaf before or after blossom, and 5-6 mites per leaf after harvest. Because we have observed differences in density of the twospotted spider mite population on some common cultivars, sometimes quite considerable, we are not sure we can use the same treshold level for each cultivar (Gajek 1995). Of course, chemical treatment will sometimes be necessary, especially at the beginning of planting. Than we can apply selective acaricides: fenbutationoxid, hexythiazox and propargite.

Among midges affecting blackcurrant, the most common is the gall stem midge. In case of this pest, avoiding of shoot damages by harvester is very important. Flies of the second generation begin to lay eggs at fruit harvest, using for this purpose wounds evoked in this process. The method of pest detection is established. Artificial shoot cuts are made in which eggs are laid. It helps to set the control term (Abanowska 1996). The insecticide which could be applied against the gall stem midge is phosalone. However, phosalone is permitted in blackcurrant protection, but not registered against this pest.

Another common pest of blackcurrant in Poland is the clearwing moth. It is certain that cutting out of infested shoots during pruning is absolutely necessary. We have established a detection method of adult flight on the base of pheromone traps. Phosalone is also not registered against clearwing moth. However we have not experiences, we hope that some biological agents like *Bacillus thuringiensis* could be effective against this pest.

The blackcurrant shoot borer is a next important pest of blackcurrant. There is a similar situation to that mentioned above. Phosalone is not registered for the control of this pest on blackcurrant. In Polish climatic conditions, the best time for the control of the pest appeares to be at the bud burst stage. Maybe at this time other deeply penetrating contact pesticides (e.g. fenitrothion) would not be toxic to beneficial organisms.

In case of fungus diseases, a special attention should be paid towards good selection of cultivars with regard to their level of susceptibility. Although breeders are still working on new crossings, it is known that even commercial blackcurrant cultivars prove differences in the level of susceptibility (Goszczynski 1997). A proper selection of cultivars, appropriate to planting site may considerably reduce the number of fungicide treatments. In Poland, for example, the cultivars "Ben Lomond" or "Fertodi" by reason of their high susceptibility to powdery mildew can not be recommended in warm and dry regions, whereas "Bona" can not be planted in more cold and moist places, where especially antracnoze has favourable conditions for development. In case of blister rust and cultivars susceptible to this disease, an avoiding of forest vicinity is also important. It is well known that different species of Pinus trees are second host plants for *Cronartium ribicola*.

Methods of spray application

The standard tractor-mounted orchard sprayer is most commonly used in Poland. It has an axial fan and circumferential outlet with swirl nozzles. Lastly, the efficacy of this sprayer was compared to a sprayer with a directed air-flow, equipped with radial fans, each one supplied with two adjustable air outlets, with swirl nozzles (Doruchowski *et al.* 1995). Besides extensive tests on spraying techniques like spray deposite, penetration and distribution within the currant bushes, biological tests were also conducted. In spite of reduction of pesticide doses, which caused usually negative influence on effectiveness of pests and diseases control, in case of both tested sprayers, the rate of spray liquid might be reduced to 600, 400 and even 260 l/ha, while rates 700-1000 l/ha are commonly applied. This reduction of spray volume gave an important decrease of costs of blackcurrant protection. It was also observed, and this is especially important, that a sprayer with directed air flow enabled a significant decrease of spray loss as compared to standard sprayer, and gave more uniform distribution of spray into the bushes. Mainly because of this reasons, this kind of sprayer should be especially recomended in IFP. Naturally, the safest and the most effective chemical treatments will be achieved with tunnel sprayers, particularly with a recycling system. They allow to reduce both, spray volume and pesticide dose.

Conclusions

Actually many aspects of blackcurrant production can be introduced to IFP guidelines. Especially cultivation methods like using tillage machine or safe and efficient spray application. Unfortunately, there are also some problems: not elaborated threshold levels for main pests, too short list of pesticides or too expensive costs of some applications, all of them need to be solved.

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Aspects of Integrated Production of Raspberries and Strawberries in Belgium

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Abstract: Since 1990 several experiments are conducted with predators on strawberries and raspberries in Belgium. The main problem parasites are in both cultures two spotted spider mite, Western flower thrips, whitefly and aphids. *Phytoseiulus persimilis* gave poor results on strawberries and raspberries. The native *Amblyseius californicus* is now used in the open field and in greenhouses and *Therodiplosis persicae* can control two spotted spider mite only in greenhouses.

Amblyseius cucumeris and different *Orius* species allow to control Western flower thrips. Against whitefly *Encarsia formosa* gives good results. PFR, *Paecilomyces fumoso-roseus*, an entomopathogenic fungus will be tested in future with high expectations. Aphids were controlled best with *Aphidius* and *Aphidoletes*.

Strawberries and raspberries were produced on a practical scale in greenhouses in an integrated system. The results were satisfactory, although they can not be predicted. Many factors influence the development of the parasites and the predators.

Next to the use of predators, also other techniques can be used to produce strawberries in an integrated way : soilless production systems and propagation methods, banddisinfection and alternate cropping, using less residual pesticides, spraying against pests and diseases only to stay below an economic damashing threshold, optimize the use of fertilizers, ... In Rubus and Ribes the use of rain shelters is an advantage for the integrated production system. Also controlling weeds by covering the soil and soilless plantpropagation must be advised.

Introduction

In 1977, the Demonstratiebedrijf Tongeren, (National Research Station for Ribes, Rubus and soil grown strawberries) started experiments on strawberries and other soft fruits. As the Belgian soft fruit production is directed only to the fresh market, improvement of the fruit quality and extending the picking season were, and continue to be, the subject of most of the experiments.

In 20 years' time, there was an enormous evolution from soft fruits produced in the open field, towards systems that allow production of strawberries, raspberries, blackberries and red currants from mid April till the end of January.

Since 1990 the Research Station has tested integrated production methods for several reasons:

- limitation of chemical crop protection agents by using bees and bumblebees, especially in cultures which are forced or delayed under protection.
- the increase of resistance of parasites against pesticides
- in soft fruit, not many chemical products are registered for the control of diseases and pests
- more and more chemical products are removed from the market due to environmental reasons
- phytofirms are less interested in small cultures, because the possible profits are too small
- due to the increase of trade, problem parasites are more and more imported. A clear example of this is the Western flower thrips, *Frankliniella occidentalis*.
- the consumers are prepared - in short term - to pay an higher price for soft fruit that is produced with less pesticides and with more attention for the environment.

Experiments, discussion and conclusions

Integrated production by using predators

Since 1990, every year tests are being performed on Elsanta-strawberries in peat bags in greenhouse or tunnel, on Selva-strawberries in the open field under plastic tunnel and on raspberries in greenhouse and plastic tunnel. Rather than looking at the results of every experiment, we try to give an overview of our experiences.

In the beginning of the nineties, on strawberries, cv Selva and Elsanta, we tried to control the two spotted spider mite, *Tetranychus urticae* by using *Phytoseiulus persimilis*. But, it proved, that in our climate, this tropical predatory mite was unable to survive a dry summer. After a few years, we started using *Amblyseius californicus*, an endemic predatory mite. The larvae feed on pollen of the strawberry flowers and on eggs and larvae of the two spotted spider mite; the adult predatory mites feed on the larger stages. Sometimes controlling two spotted spider mite with *Ambyseius californicus* works well, sometimes it doesn't work at all. Maybe this is due to the existance of various strains of this predatory mite, some of which might not be able to survive on strawberries. It should be investigated whether *Amblyseius californicus* can be propagated on strawberry plants. Then it might be possible to introduce the predatory mites together with the leaves they are propagated on in the production plot.

From 1994 tests have been done putting out the predatory midge *Therodiplosis persicae* as larvae. Using these, the control of two spotted spider mite in greenhouse is very successful, but in the open field this tropical predatory midge is unable to survive, because it quickly will be parasited by a parasitic wasp, we are not yet familiar with.

In the first stage of the culture, the Western flower thrips, *Frankliniella occidentalis* is controlled by *Amblyseius cucumeris* and, later on, additionally by an *Orius* species. In *Amblyseius cucumeris*, it are mainly the larvae which eat the thrips. This predatory mite can be introduced in the crop in two ways. Or, the predatory mites are spread, forcing them to look for food on the strawberry plant. Or, small breeding bags are hung, containing predatory mites together with grain mites (*Acarus siro*) as an alternative food source. In the second way they stay active for months.

We found out that the breeding bags turn rigid in an environment which is too moist, thereby killing the predatory mites. *Amblyseius cucumeris* has the great advantage that they also have an effect on the strawberry mite, *Tarsonemus pallidus fragariae.*

Against Western flower thrips, three native *Orius* species can be used: *Orius niger, Orius majusculus and Orius laevigatus*. They work effectively until the end of September, but afterwards they enter diapause. On the other hand we can also use two subtropical species: *Orius insidiosus* and *Orius albidipennis*. Both are effective but *Orius albidipennis* is too agressive for human beings. It is important to know that all these *Orius* species also partially feed on two spotted spider mite.

As in tomatoes, whitefly *Trialeurodes vaporariorium* could be controlled successfully in cultures under protection by using the parasitic wasp, *Encarsia formosa*. PFR, *Paecilomyces fumoso-roseus*, (trade name: Preferal), an entomopathogenic fungus sprayed on various times during the growing season, is also very efficient against whitefly. The fungus grows in the larvae of the whitefly and destroys it. This year the product will be recognised in Belgium for use in cucumber and tomato culture. To obtain recognition for strawberries, more tests are necessary. PFR also has a side effect on the pupation of the Western flower thrips, which takes place in the soil.

In 1996 the tests in Selva failed, due to an invasion of an unexpected parasite, *Lygus rugilipennis*, a species closely related to the green applebug. In an integrated culture pests that never caused problems before, can cause severe problems because the use of broadspectrum insecticides is avoided (also whitefly in raspberies).

In 1997 a fairly large test set-up at a grower had to be chemically corrected against two spotted spider mite. It was shown that the plant propagator used Temik (aldicarb) and Keltane (dicofol), resulted in an insufficient development of the predatory midge *Therodiplosis persicae.*

As an example I show you a test performed on a practical scale (4000 m²) in greenhouse. The methods used in the traditional section and in the integrated section are shown in table 1 and 2.

Two spotted spider mite was kept in control efficiently by *Amblyseius californicus* and *Therodiplosis persicae*, supported by selective chemicals like hexythiazox (Nissorun). The introduction of *Phytoseiulus persimilis* nearly failed completely because the predatory mite could not maintain itself on Elsanta.

The main problem appeared to be the aphids: *Macrosiphum euphorbiae* and, on a lesser scale, *Aphis gossypii,* were the most important species. The first species is highly susceptible to low amounts of pirimicarb. The second species could easily be controlled by various predators like *Aphidius colemani* and *Aphidius ervi.*

Whitefly rarely was a problem and could easily be controlled with by *Encarsia formosa.*

In the integrated culture of primocane raspberries, cv Autumn Bliss, we introduced predators in greenhouse against two spotted spider mite, thrips, aphids and whitefly; and in tunnel against two spotted spider mite and thrips.

Because in both cases the same predators are involved, in our comments, we make no distinction between the various culture practices.

Until 1994 we tried to control two spotted spider mite by using *Phytoseiulus persimilis*, without a satisfactory result. It appeared that the relative humidity in the crop was too low to allow an effective action of the predatory mites. Therefore, since 1995, we've been using a combination of *Therodiplosis persicae* and *Amblyseius californicus,* as we did for strawberries. In small scale tests at the Research Station we did not get satisfactory results up till now. On the other hand, tested on a large scale at a grower, we noticed that the predatory midge as well as the predatory mite were effective against two spotted spider mite. Possibly other climatic circumstances and a larger test scale are an explanation for these differences.

Both *Amblyseius californicus* larvae and adults are active against two spotted spider mite; in case of *T. persicae* only the larvae are.

Against Western flower thrips, *Amblyseius cucumeris, Orius insidiosus* and the entomopathogenic fungus preparation PFR were used, with the same effects as mentioned in strawberries.

Against aphids in greenhouses we introduced *Aphidius* sp. (parasitic wasps) and *Aphidoletes* sp. (predatory midges). Both beneficials seem to work inefficiently against aphids. The reasons why are not clear.

Whitefly was effectively controlled by *Encarsia formosa.* Yet, it is useful to mention that the use of S-dampers causes the death of *Encarsia formosa.*

Up till now we always used the traditional scheme of fungicides in integrated pest management. It might be possible that the repeated use of certain fungicides is harmful to certain beneficials. In future we will have to find out whether, and to which extent, this influences the success of integrated pest management.

Our conclusions from the tests on beneficials are:

- Our experiences show that biological control is almost impossible and that integrated control of pests is not that easy.
- lots of factors, influencing the development of different beneficials, are not yet known, e.g. fungicides, climate, fruit species...
- when using integrated pest management, it is essential to know the history of the crop and the production plot
- starting a culture using plants free of pests increases fundamentally the chances of success
- climatic circumstances appear to play an essential role
- regular check-up of the crop prevents a strong expansion of harmful insects and mites.

Other Integrated Production methods

In addition to integrated control of pests, a number of practices can contribute to an integrated production. We will summarize some of them :

As in soilless cultures there is no need for soil disinfection against root diseases, this culture may be considered as an integrated production method.

The culture in peat bags is very popular, but due to loads of plastic waste and high processing costs, the interest in other systems increases. At the moment tests are done on strawberry culture tanks, developed by the Research Station of the Noorderkempen at Meerle (Belgium), and in pots standing on a tube, through which drainwater is collected. In the long term, collecting and recycling of drainwater will also be applied in the substrate culture of strawberries and other soft fruits.

Substrate culture is not only frequently used in production plots, but also in propagation fields, resulting in trayplants which are grown free of soil to avoid root infection. Because of their high production and good fruit grading, they are very popular with growers.

In the open field cultures growers more and more turn from total disinfection with dichlorpropene (Shell-DD) to a disinfection in bands under the black polythene mulch. By doing this, only 2/5 of the total amount of disinfectants is necessary. Even better is to motivate growers to change their production field every 3 years, so they don't have to disinfect at all.

The culture of strawberries in the open field on black polythene mulch reduces the use of residual herbicides. In co-operation with the growers, a machine was developed to use foliar herbicides, which are less harmful for the environment, in a fast and safe way.

We also try to convince the growers to apply sprayings only when pests are present (indicator strips). Too often spraying is still done 'by calendar'.

When looking at fertilisers, cultures can be done more friendly for the environment. It is very useful to advise growers to have their soil analysed before applying fertilisers.

Through large scale nitrogen fertilisation tests, in co-operation with the Soil Service of Belgium, we try to find out what the optimum nitrogen amount is in every physiological stage, in cultures with or without polythene mulch.

We also try to find out whether fertigation of fertilisers is more effective than the superficial application of chemical fertilisers.

Again, encouraging the use of organic fertilisers fits completely into the integrated production method. In experiments the effect of compost on Selva in the open field throughout the years was analysed.

In Ribes and Rubus, crop protection under rain cover is prevalent. By covering we create a microclimate making it possible to spray less against a.o. Botrytis, Mildew and Leaf

Fall. In all circumstances this system generates an obvious quality improvement. Red and white currants can be delayed in this way, resulting in an higher price.
The use of antiroot cloth against weed, in tunnels, increases. By using this, lots of herbicide applications can be omitted.

The cultivation of plants is an evenly important factor. Propagation must be carried out on healthy soil, even better, free of possibly infected soil. We might think of the in vitro propagation of raspberries and blackberries. Plants propagated in vitro are clearly more vigourous than vegetatively propagated plants.

Table 1 : The combat of insects and mites in the strawberry culture 95/96 (4000 m²)

Moment	**Pest**	**Chemical compartment**	**Biological compartment Beneficials**
Preblossom 1995	Strawberry mite, Thrips	Endosulfan (Thiodan)	*Amblyseius cucumeris* (50 /m²)
Blossom 1995	Thrips	Mevinphos (Phosdrin)	*Orius laevigatus* (1/2 m²)
After Blossom 1995	Spider mites	Tebufenpyrad (Pyranica)	*Therodiplosis persicae* (1/4 m²)
	Aphids	pirimicarb (spray)	*Hippodamia convergens* (10/m²) *Aphidius colemani* (1/15 m²)
Preblossom 1996	Strawberry mite, Thrips	mevinphos	*Amblyseius cucumeris* (50 /m²)
Preblossom 1996	Spider mites	hexythiazox (Nissorun) + pyridaben (Sanmite)	hexythiazox (Nissorun) + fenbutatinoxide (Torque) *Therodiplosis persicae* (1/10 m²) *Amblyseius californicus* (1/5 m²)
Blossom 1996	Whitefly		*Encarsia formosa* (1/10 m²)
Blossom 1996	Aphids		Pirimor (1/2 dose rate) (fumigating) *Aphidius ervi* (1/10 m²)

Table 2 : Use of fungicides in the strawberry culture 95/96 (4000 m²)

Date	Chemical compartment	Biological compartment
	sulphur	Sulphur
29.08	vinclozolin + thiram (Ronilan T-Combi)	
24.09	vinclozolin + thiram (Ronilan T-Combi)	
06.10	pyrimethanil (Scala)	
15.04	procymidone (Sumisclex)	Procymidone (Sumisclex)

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Difficulties in Integrated Production of European Elder (*Sambucus nigra* L.) in Austria

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Common elder or European elder (*Sambucus nigra* L.), family *Caprifoliaceae*, is a very important soft fruit in Austria.

Fruit growing in Austria (Österreichisches Statistisches Zentralamt, Wien, year 1994)

apples	6790 ha	strawberries	970 ha
peaches and nectarines	490 ha	elder	740 ha
pears	470 ha	black and red currents	270 ha
apricots	310 ha	raspberries and blackb.	100 ha
plums	280 ha	blueberries	50 ha
cherries (sweet and sour)	130 ha	gooseberries	10 ha

Development of elder cultivation in Austria:

year:	area:
1984	140 ha
1989	440 ha
1994	740 ha
1997	1200 ha

Distribution in Austria (year 1994)

Styria	600 ha
Burgenland	70 ha
Lower Austria	60 ha
other regions	10 ha
Austria	740 ha

Today (year 1997) elder cultivation is done by about 1000 farmers on about 1200 ha. The most important cultivar is 'Haschberg' selected by Strauss in Klosterneuburg (Austria). In Austria elder plants are formed as trees, not as bushes as in other countries. The trees are planted in distances of 4m x 6m with grass strips between the rows. These are 400 trees per hectare. The yield is about 22.5 kg elderberries per tree or 9 tons per hectare.

Nearby the whole production of elderberries is put on the market by the *'Steirischen Beerenobstgenossenschaft'* ('Styrian Soft Fruit Co-operative') and used for industrial processing, e.g. for food industries as biological colouring or for pharma industries, on the one hand because of its high contents of anthocyanines and on the other hand because of its high contents of vitamin C and polyphenolics.

The most important pest of elder is the vole *Arvicola terrestris*. One vole can destroy several trees especially during winter time. The only active possibility to control voles in Austria is the use of traps. In addition to that the farmers erect high poles on which birds of prey can sit down or they build up heaps of stones as refuges for weasels. Other pests are of inferior importance as aphids *Aphis sambuci*, spider mites *Tetranychidae*, tarsenomid mites *Tarsenomidae* or the fly *Helomyza ustulata* (Höbaus, 1987). Generally treatments with insecticides are not done at elder except treatments against aphids, if you want to harvest the blooming corymbs.

The most important disease of elder berries is corymb necrosis (German: *'Doldenwelke'*). The loss caused by corymb necrosis can be very high each year, sometimes 80 till 90 percent. The cause of corymb necrosis is unknown till today. Corymb necrosis appears in August and is furthered by rainy weather. The corymb branches turn violet and become faded. The transport of water and nutrients to the corymbs is interrupted. Berries become grey and begin trickling and finally parts of the corymbs or whole corymbs die and fall to the ground.

In Austria Katschner did investigations about 1985. He found out that *Botrytis cinerea* is not the primary cause. He sprayed dicarboximides and BCM, but these fungicides had not been efficient. Of course you can find *Botrytis cinerea* later but that is a secondary infection. Müller (1987) wrote on this disease in Switzerland, too. He also did not find any fungus as pathogen. He said corymb necrosis would be a physiological disease. In Austria Redl did lot of investigations between 1988 till 1992. He also thought that there were primary physiological causes comparable to cluster necrosis on grapes. He was confirmed in his opinion because he had good effects by using foliage fertilizers ('Folifert super'). But he could also observe good effects by using fungicides especially by using the combination of mancozeb and benomyl. But the results with the fungicides had not been significant.

Nothnagl found a lot of species of fungi on leaves and corymbs:

Species of fungi found on leaves and corymbs of *Sambucus nigra* L., Nothnagl, 1988-1992

Alternaria,	*Gloeosporium,*	*Rhizopus,*
Botrytis,	*Harzia,*	*Trichithecium,*
Cladosporium,	*Penicillium,*	*Verticillium.*
Epicoccum,	*Periconia,*	
Fusarium,	*Phoma*	

Alternaria, Cladosporium and *Fusarium* prevailed. But Nothnagl couldn't find any correlation between the occurrence of fungi and the yield of sound corymbs.

On the other hand farmers made the practical experience that they have a very good securing of the yield with certain fungicides, like mancozeb, alone or in combination with benomyl. Benomyl improves the effect, alone it is not effective enough. Another effective fungicide is tebuconazole ('Folicur'). On the contrary treatments with metalaxyl or dicarboximides are not efficient.

There are also reports from Denmark on a disease called *'tØrresyge'* (English: 'dry disease'). Likely it is the same as corymb necrosis. In Denmark they also consider *'tØrresyge'* as a fungus disease and applicate captan prevently before elder berries mature.

However corymb necrosis appears at sites with static air (sites without wind and with long periods of time with drop wet leaves and corymbs after dew or rain). Around that it is an important reference to an integrated plant protection management that elder should be planted only at best orchard sites.

Today Austrian elder-farmers are spraying twice or three times with mancozeb against corymb necrosis between blossoming and harvest time dependent to the weather. But they have to pay attention to the residues. They reduce the concentration of mancozeb in comparison with other fruits (pomes and stone fruits) and extend the waiting time. The reasons are: Mancozeb is a residual fungicide and the surface of 1 kg of elder berries is 10 times larger than that of 1 kg of apples. Other treatments with fungicides are generally not done at elder berries.

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Prospects for integrated management of blackcurrant pests

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Abstract: Integrated pest management strategies are very poorly developed for blackcurrant, mainly because of the need for frequent application of sprays of broad-spectrum acaricides to control blackcurrant gall mite, the vector of reversion disease, the main limiting factor in the life of blackcurrant plantations. The breeding of new blackcurrant cultivars resistant to gall mite or to reversion disease by the Scottish Crops Research Institute offers the first realistic prospect for the development of Integrated Pest Management (IPM) strategies for the crop and a significant reduction in pesticide use.

Prospects for development of IPM methods for the four most important blackcurrant pests (gall mite, leaf midge, vine weevil and spider mites) are appraised. For gall mite, the use of a resistant cultivar is a requisite. Additionally, early season application of sprays of sulphur may be beneficial and protect the resistance from breakdown. A model that predicts the migratory activity of the mite as an aid to timing of sprays is being developed at HRI-East Malling. Inspection of plantations and roguing of infested or infected bushes may still be required. For blackcurrant leaf midge opportunities are more restricted. Although midge-resistant cultivars have been developed, the gall mite or reversion resistant cultivars available currently are not midge-resistant. There is little choice but to control the pest with a broad-spectrum organophosphorus (OP) insecticide. Of the effective materials available, phosalone is the most selective and the least harmful to bees. A phenological forecasting model that predicts the emergence of adults in spring to aid timing of sprays has been developed at HRI-East Malling. For vine weevil there are good prospects of control with low temperature strains of entomopathogenic nematodes, though these are not yet commercially available. For spider mites, natural populations of phytoseiid predatory mites, especially those that are resistant to OP insecticides, should thrive if broad-spectrum acaricides are not applied for gall mite. The introduction of the predatory mite *Phytoseiulus persimilis* could also be considered, but its effectiveness on blackcurrants has not been established.

Introduction

Most of the cultivars of blackcurrant, *Ribes nigrum*, grown throughout the world are susceptible to a number of damaging pest problems that can devastate the crop if adequate control measures are not applied. As blackcurrant is a long-term perennial crop, pest problems tend to increase from year to year if allowed to go unchecked. The blackcurrant gall mite, *Cecidophyopsis ribis*, the vector of reversion disease, is a particularly difficult pest problem. The disease, which has recently been shown to be caused by a virus, is the main limiting factor in the life of plantations. The cultivars of blackcurrant grown currently are very susceptible to both the mite and the disease. Growers struggle to maintain adequate control despite multiple applications of broad-spectrum acaricides. The only effective acaricides that have been identified as suitable for use in fruiting plantations, despite an extensive screening programme, are endosulfan and fenpropathrin. Both are extremely toxic to aquatic life and the former, an organochlorine insecticide, has been withdrawn from use for this reason in some European countries. Synthetic pyrethroid insecticides such as fenpropathrin are very broad-spectrum and are incompatible with Integrated Pest Management (IPM). Because of the need to apply gall mite acaricides, biological, cultural and other non-chemical control methods have not been developed for most blackcurrant pests. However, an important breakthrough has arisen recently. A new gall mite and a new reversion-resistant cultivar have recently been developed by the Scottish Crops Research Institute (SCRI), derived from a long-term breeding programme at HRI-East Malling (Keep *et al.*, 1982). These cultivars provide the first opportunity for development of Integrated Pest Management programmes for blackcurrant. These cultivars are the property of Smithkline Beecham who are releasing them to their contracted growers only. Further cultivars are likely to be released in future.

In the following paper we review prospects for development of IPM methods for the most important blackcurrant pests. Key components of an IPM programme are: 1) a good knowledge of the biology of the pest and its natural enemies, 2) knowledge of the relationship between population levels and crop damage including sampling methods and economic thresholds, 3) biological, cultural or other non-chemical control methods for the important pests where possible, 4) selective insecticides where no alternative control method can be identified so that the component parts of the IPM strategy can be integrated successfully. The state of development of each of these components for each of the most important pests is appraised below.

Blackcurrant gall mite

Biology and predictive model

Although numerous research papers have been published reporting various aspects of the biology of the gall mite there are still many large gaps in our knowledge of the pest. Mites spend most of their lives in galls ('big buds'), migrating to invade axillary buds and to form new galls in spring and early summer. Biology is described by Smith (1959). Work started at HRI-East Malling in 1994 to study the migration of the mites in greater detail and to develop a model to predict the migratory activity of mites to aid appropriate timing of acaricide sprays. A method of monitoring the migration using sticky traps has been developed. Traps consist of a plastic cap with a square of double-sided sellotape adhered underneath and pinned to a truncated blackcurrant shoot a few centimetres above a gall. Mites migrating from the gall are negatively geotropic and climb the stem above the gall in search of a new axillary bud to invade. They become stuck to the sticky tape where they can be counted. The numbers caught are a directly related to migratory activity.

The migration of gall mites has been closely monitored for three successive seasons on an early and late flowering cultivar. The work has clearly shown that the migration is not governed by plant growth stage or by daily temperature alone. The dynamic of the migration has been shown to be the same on both cultivars, irrespective of growth stage. Four main factors have been identified as being important in determining migratory activity. These are: 1) the degree of gall swelling, W(t), especially early in the migration, 2) the degree of gall senescence, S(t), especially later in the migration, 3) the number of mites present in the gall, N, and their rate of reproduction dependant on temperature R(T), 4) the rate of emigration from the gall which is directly dependant on temperature E(T). The migration has been shown to have a strong diurnal rhythm, the rate of emigration reaching a peak in the middle of the day and falling to zero in the middle of the night. A mathematical model that predicts the daily migratory activity is being developed. The model currently being investigated relates the number of mites present in the gall on day t+1 to those present on day t and is of the form:

$$N_{t+1} = N_t - E(T).W(t).N_t + R(T).S(t)$$

Substantial work is still required to determine the exact forms of the four functions and to fit the model to the data and prove that predictions are accurate.

Once the model has been fully developed it will provide a means of predicting when to time acaricide application rather than rely on the growth stage of the crop which is clearly inappropriate. However, though such a model would be an advantage it will not overcome the need for treatment with acaricides.

Sampling methods and economic thresholds

Reversion disease can be spread rapidly through the crop by its gall mite vector. Infected bushes yield poorly and are uneconomic. Because of the mite's capacity to increase and the difficulty of controlling established infestations, a zero tolerance of mites and/or reversion is operated in well-managed plantations (see below).

Non-chemical control methods

The need for frequent application of broad-spectrum acaricides can only be obviated by the use of resistant cultivars. The cultivars Ben Hope and Ben Gairn, resistant to gall mite and reversion disease respectively, have recently been bred by SCRI. The resistances are essentially monogenic, possibly with some minor gene components. Whilst it is difficult to see how a cultivar resistant to reversion disease alone can be sufficient to obviate the need for acaricides, the gall mite resistance should be an essential component of an IPM programme for blackcurrant.

In plantations of susceptible cultivars, the cultural practice of close inspection of each bush in winter and shortly before flowering with roguing infested or infected plants is essential.

Selective control methods

Most blackcurrant plantations receive a routine programme of three sprays of the acaricide endosulphan or, recently, of fenpropathrin for preventive control of the gall mite. Applications are made just before flowering, at the end of flowering and 10 days later.

Before the advent of modern insecticides, lime-sulphur or sulphur were used for control (Thresh, 1966). The acaricidal properties of sulphur against rust mites have long been recognised. However, both sulphur and particularly lime sulphur, are phytotoxic to blackcurrant and can only be applied early in the season. Recently, the use of sulphur has been re-instigated in plantations in the UK, in addition to the standard three-spray programme of endosulphan and/or fenpropathrin. Two applications of sulphur are made at the 'first emerged grape' and 'first visible gape' growth stages. Sulphur is a selective and comparatively safe acaricide. Modern micronised flowable formulations of sulphur are probably more active than traditional formulations and, if used at a lower dose, may be less phytotoxic. The resistance of gall mite resistant cultivars could be protected against breakdown by early season use of sulphur if necessary. Benzimidazole fungicides have also been shown to be moderately effective for control of gall mite (Smith, 1975) but they are harmful to earthworms and predatory mites.

Blackcurrant leaf midge

Biology

The blackcurrant leaf midge, *Dasineura tetensi*, is also a widespread and damaging, though more recent, pest of blackcurrant. Eggs are laid in batches in young unfurling leaves in growing points and larvae feed in the leaves causing them to twist and distort. Growing points may be killed and shoot growth severely stunted. In the UK there are three or four generations per year. Biology is described in detail by Greenslade (1941), Pitcher (1958) and Stenseth (1966) amongst others. The timing of emergence of adults in spring relative to the growth stage of blackcurrant varies considerably from season to season (Pitcher, 1958). Emergence and the first appearance of damage can occur just before, during or after flowering.

A phenological forecasting model is being developed by HRI-East Malling to predict the emergence of adults in spring to aid timing of sprays. The model gives acceptably accurate predictions based on temperature-dependent development rates derived from laboratory experiments.

Sampling and economic thresholds

Whilst adult activity can be successfully monitored with water traps, this technique is unsuitable for growers as it requires specialist identification skills. The easiest method of monitoring is by visual inspection of the shoot tips for first signs of larval damage. However, unless monitoring is frequent and thorough, the first appearance of the pest may be missed. Significant damage may have occurred and larval development completed by a significant proportion of the population before insecticidal sprays can be applied. Economic thresholds have not been determined. The pest increases rapidly and most growers base decisions on whether or not to spray on past experience.

Non-chemical control methods

Blackcurrant cultivars vary greatly in their susceptibility to leaf midge (Keep, 1985). Most are highly susceptible, but a number of resistant cultivars are available (Trajkovski & Andersen, 1991). Unfortunately, the cultivar Ben Hope which is resistant to gall mite, a trait of primary importance, is not resistant to leaf midge. However, cultivars with resistance to both gall mite and leaf midge will almost certainly be available in future.

Although leaf midge larvae are predated by non-specialised insect predators such as Anthocorids, these have little effect on populations. No significant specialised natural enemies such as parasitoids have been identified. Biological control methods have not been developed.

Selective chemical control methods

Leaf midge can be effectively controlled by organophosphate insecticides, especially those with systemic or translaminar activity or by pyrethroid insecticides (Wardlow & Nicholls, 1986). Fenitrothion, demeton-S-methyl and dimethoate are all known to be effective (Harris & Wardlow, 1984). However, they are all broad-spectrum insecticides and are harmful or dangerous to bees. They cannot be applied during flowering. Recent work has shown that phosalone is effective. This insecticide is less harmful to bees and somewhat more selective. It could probably be applied during flowering if necessary.

Vine weevil

Vine weevil, *Otiorhynchus sulcatus*, is a widespread, abundant and occasionally damaging pest of blackcurrants. Large numbers are present in most plantations but established bushes can tolerate large populations of larvae without showing obvious adverse effects, presumably because larval feeding is mainly on smaller roots. Damage symptoms are often only apparent on light or poorer, less fertile soils. Many growers ignore the pest unless obvious damage is apparent. Adults, larvae and eggs are predated on by the adults and larvae of a wide range of species of carabid beetle. However, the extent to which these and other natural enemies (e.g. earwigs, woodmice) regulate weevil populations is not clear. A very high mortality of neonate larvae due to low temperature, inadequate soil moisture or to soil compaction probably occurs in the field.

Sampling methods and economic thresholds

Populations of adults can be estimated by beating bushes over a tray or sheet at night in July, August or September. However, there is considerable night to night variation in numbers caught. We have collected up to 50 adults per bush in an heavily infested plantation that showed no larval damage symptoms. The proportion remaining in the soil is unclear. Adult populations can be roughly estimated by examining the intensity of feeding notches on the lowest leaves close to the ground. Economic thresholds have not been determined.

Biological control

Avoiding the use of pesticides harmful to carabid beetles and other possible natural enemies of vine weevil is important, but will not completely alleviate the problem. There are good prospects for biological control with low temperature strains of entomopathogenic nematodes.

Chemical control

Few insecticides are registered for the control of vine weevil on blackcurrant. Control of adults by spraying insecticides at night is widely practised in the UK. Broad-spectrum insecticides are used including azinphos-methyl, chlorpyrifos and bifenthrin. Best results are obtained by spraying newly emerged adults but control is usually only partial. The insecticides used are not compatible with IPM. Studies of the effects of Insect Growth Regulators (IGRs) on the fecundity of adults are starting at HRI-East Malling. Vine weevil larvae can also be controlled by high volume drenches with chlorpyrifos or by application of phorate granules to non-fruiting plantations. Such control methods are less than ideal in IPM programmes.

Spider mites

Both the two-spotted spider mite, *Tetranychus urticae*, and the fruit tree red spider mite, *Panonychus ulmi*, are pests of blackcurrant, but the former species is the most important and difficult to control as it has developed resistance to a wider range of acaricides.

Sampling methods and economic thresholds

Sampling methods and economic thresholds have been proposed for spider mites on blackcurrant in Poland (Gajek *et al.*, 1998). Economic thresholds are set to prevent significant leaf bronzing.

Biological control

Predatory phytoseiid mites are absent from blackcurrant plantations because of intensive use of broad-spectrum pesticides. However, *Typhlodromus pyri* is known to occur on blackcurrants and, with other species, could be exploited as a key natural enemy. Introduction of the predatory mite *Phytoseiulus persimilis* could also be considered.

Selective chemical control

As a last resort, spider mites may be controlled by selective acaricides, for example the Mitochondrial Electron Transport Inhibitor (METI) acaricide fenproxymate.

Integration

The individual measures described above could be combined into an IMP programme with good prospects of success. However, there are substantial gaps in our knowledge. Much research is needed to fully develop a comprehensive IPM programme. An outline of an IPM programme utilising the components described above is given in table 1 below.

Table 1. An outline Integrated Pest Management Programme for blackcurrant.

Pest	Sampling method	Economic threshold	Non-chemical control method	Selective chemical control
Gall mite, reversion	Visual inspection	Zero	Resistant cvs Roguing	Sulphur
Leaf midge	Visual inspection	?	Resistant cvs	Phosalone
Vine weevil	Beating for adults	High?	Carabids Entomopatho-genic nematodes	IGRs?
Spider mites	Count mites on leaf samples	2 mites/leaf	phytoseiids *P. persimilis*	METI acaricides

? = unknown

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Efforts to reach integrated production of soft fruit in Switzerland

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Abstract: Healthy young plants are a necessary prerequisite for the integrated production of strawberries and other soft fruit. The European countries should try very hard to improve the quality of the young plant material to make integrated production possible. Crop adapted spraying should be developed for all soft fruit cultures in order to increase the efficacy of the chemical treatments. The increase of plant volume between the first and the last treatment has to be considered when determining the volume of the spraying broth necessary for good protection.

Introduction

In Switzerland the production of soft fruit has increased during the last few years (tab.1).One reason for this development lies in farmers' gradual shift to high value crops which are perceived to offer higher profitability than common field crops. However, growers often have difficulties associated with problems of cultivation and plant protection. We therefore had to increase our efforts in advising the soft fruit producers in integrated crop production.

Reto Neuweiler (horticulture) works on the effect of soil coverage with different fabrics and raised bed systems on plant growth, root diseases, fruit quality and N-mineralization. An important part of his work is the testing of selections of all soft fruit crops under Swiss climatic conditions, with fruit quality and resistance to pests and diseases being the main interests.

Jacob Rüegg (phytopathology) is responsible for the registration of fungicides, for the organization of field trials for testing different fungicides, and for the improvement of application techniques in strawberry, cane berry and bushberry cultures.

Elisabeth Bosshard (phytopathology) is advising on fungal, bacterial and viral diseases of all soft fruits, and their control. In addition she is in charge of the tests of imported young strawberry plants for latent diseases in the diagnosis lab of the research station, in collaboration with the colleagues who test the plants for mites and nematodes.

Chemical control of pests and diseases

Under Swiss climatic conditions soft fruit easily get attacked by pests and diseases (tab.2). However, small fruit crops are not a high priority for the chemical industry both in Switzerland and abroad, since the acreage of the respective crops and hence the related pesticide markets are usually rather limited. Growers read and hear about new fungicides sold and used successfully in other crops such as apples, grapes and cereals. Understandably they wish that modern disease control tools such as for example anilinopyrimidine or strobilurine fungicides are made available to them as well. The Swiss registration and pesticide testing authorities encourage the industry to register these modern products for minor uses such as the soft fruit sector. To aid this process the authorities carry out field experiments for biological efficacy testing. Samples for residue analysis are taken as well. Despite these efforts uses of fungicides on berry crops continue to exist on farmer's fields which have not been registered at all. To rectify this situation and to improve the advice given by the regional extension services the federal research stations will persevere in properly registering all pesticides for use on so called minor crops. However, given the limited and shrinking resource base this is very likely to remain an incompletely fullfilled task.

In order to increase the number of fungicides available for the protection of soft fruit a number of products was tested 1996 and 1997 by J. Rüegg in collaboration with R. Neuweiler and M. Kopp. Efficacy trials were set up for the control of *Botrytis*, powdery mildew, *Colletotrichum* (anthracnose), *X. fragariae* (angular leaf spot) and *Phytophthora fragariae* (red stele disease) of strawberry, *Didymella* cane rot of raspberry, *Peronospora sparsa* (downy mildew) of black berries, and *Colletotrichum* of red currant.

As berries are picked during several days or weeks, it is very difficult to protect them against *Botrytis*, *Mucor* or *Colletotrichum* during this long harvest time without risking high residue levels. In order to determine reasonable waiting times fruit samples were collected in all trials for residue analysis.

As a result of 1996 trials Thiram is registered for the control of Anthracnose and *Gnomonia* of strawberry, Frupica, Scala and Switch (Anilinopyrimidine) for *Botrytis* on strawberry, Ridomil-Gold and Ridomil viti for *Peronospora sparsa* on blackberry.

Application technique

A second area, which we believe should be given much more attention, relates to the methods and techniques by which pesticides are applied on minor crops. Firstly, the interpretation of the results of efficacy trials is difficult under conditions where the quality of the spray broth application is uncertain. Secondly, the biological efficacy of a treatment is likely to be enhanced if the spray broth volume and the application techniques are well managed and truly adapted to the given crop and its consecutive growth stages. Preliminary trials by J.Rüegg, M. Kopp and R. Neuweiler in collaboration with Haruwy (the Swiss representative of the Danish company Hardi) have clearly demonstrated that spraying strawberry crops with conventional spray booms as well as with air assisted spray booms did not result in a satisfactory spray cover of both sides of the leaves and of the core of the plant. Preliminary tests with Hardi's minivariant and with a motor knapsack sprayer (atomiser) further showed that better spray coverages are likely to be obtained and spray volumes can be significantly reduced compared to current conventional spray volumes. Crop Adapted Spraying (CAS), both in berry and vegetable crops will require a lot more work in the future. It is hoped that a project focusing on CAS can be initiated in 1998 jointly by the industry and the Swiss Federal Research Stations.

Obstacles for integrated plant production

The experts at FAW are convinced that healthy young plants are an absolutly necessary prerequisite for integrated production of all plants. They are very concerned that it is not self-evident that young strawberry plants are free of pests and diseases, even if they are accompanied by a health certificate. It is alarming that imported plants are often contaminated by fungi and bacteria like *Colletotrichum, Gnomonia, Phytophthora fragariae, Verticillium* and *Xanthomonas fragariae*. If freedom of young plants from microorganisms causing diseases can't be guaranteed, integrated production cannot be realized.

Conclusion

Our group is convinced, that we have a long way to go in order to reach CAS and an effective integrated plant production. Nevertheless, in Switzerland already most growers cultivate their soft fruits more or less in accordance with the IP regulations.

Tab. 1 Soft fruit production aerea (a) of Switzerland 1996 and 1997

	1996	1997	difference in %
Strawberry	42811	44679	4
Raspberry	9836	10666	8
Blackberry	3260	3344	3
Currants	2489	2887	16
Blueberry	1241	1419	14
Gooseberry	354	403	14
Elderberry	320	268	16
Black currants	248	257	4

Tab. 2 Main pests and diseases of soft fruit in Switzerland

crop	pests	diseases
strawberry	strawberry bud weevil	gray mold (*Botrytis cinerea*)
	two-spotted spider mite	powdery mildew (*Sphaerotheca macularis*)
	cyclamen mite	red stele disease (*Phytophthora fragariae* pv *fragariae*)
	aphids	crown rot (*Phytophthora cactorum*)
	strawberry root weevil	anthracnose (*Colletotrichum acutatum*)
	thrips (tunnels only)	wilt (*Verticillium spp.*)
	nematodes	angular leaf spot (*Xanthomonas fragariae*)
cane fruit	raspberry bud weevil	gray mold (*Botrytis cinerea*)
	two-spotted spider mite	downy mildew of blackberry (*Peronospora sparsa*)
	dryberry mite	cane diseases of blackberry and raspberry
	redberry mite	root rot of raspberry (*Phytophthora fragariae* pv *rubi*)
	aphids	rust of blackberry (*Phragmidium sp*)
	raspberry fruit worm	
	raspberry cane midge	
bush fruit	aphids	powdery mildew of gooseberry (*Sphaerotheca mors-uva)*
	clearwing moth	anthracnose of red currant (*Colletotrichum acutatum*)
	scales	
	gooseberry saw fly	

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The application of integrated production on strawberries 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 1997, approximately, a total area of 27,800 hectares of fruit orchards and 33,400 of arable and vegetables (200 hectares of strawberries, more or less 20% of the total regional surface) covering over 8,700 farms.
The project aims to improve the application of integrated production methods in Emilia-Romagna by improving technicians activity and applying a quality trade-mark to promote the produce of farms involved.
The text provides details of methods used for integrated pest management and other agronomic methods applied in strawberries and some of the results obtained.
An analysis of the emerging problems and research and experimentation status is also 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 hectares, mainly peaches, apples and pears (34, 14 and 25,000 hectares respectively).

In order to apply the methods of integrated pest management and integrated production, the regional Government organises the "Regional Crop Advisory Service" ("Servizio Assistenza tecnica alle coltivazioni"). The techniques applied are defined following the principles of integrated production (IP) (IOBC, 1993) and other specific technical document (Regione Emilia-Romagna, 1997).

This service involved, in 1997, approximately, a total area of 27,800 hectares of fruit orchards (200 hectares of strawberries, more or less 20% of the total regional surface) covering over 8,700 farms.

At present (1997), IP is practised 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 180 technicians employed, through contributions from RER, by producers' associations. The contribution from RER is about 35% 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, fertilisation, irrigation and the other main agronomy techniques).

12 other technicians work as co-ordinators and are responsible for training activities of newly employed technicians and for drawing up weekly bulletins which are recorded on

telephone answering machines and publizised in the local TV network, newspaper, videotex and on internet pages.

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 50 strawberries) 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 ministry institutes.

The representatives of these bodies, and also of producer's organisations, are divided into commissions to define the Regional integrated production guidelines. CRPV (Regional body for research on crops) is responsible for the co-ordination of this activity. The regional Agricultural development service takes care of scientific and technical co-ordination of the service as a whole.

Integrated production in strawberries

Complete information about the integrated production methods adopted on strawberries is available in the Regional integrated production guidelines (Disciplinari di produzione integrata) published by Regione Emilia-Romagna (1997).

IPM techniques

The guidelines for sampling methods and economic thresholds for the principal strawberry pests and diseases were initially based on IOBC principles. Biological control of aphids and mites was strongly experimented and promoted and is now considered as a normal practice in protected crop. In outdoor crops it is not yet applied at practical level. After several years of experimentation and adaptation, (also of the most suitable chemical product) a clearer, more standardised and practical frame of reference has emerged and can facilitate the diffusion of IPM in strawberries (Celli *et al.* 1986, Benuzzi & Nicoli 1990, Celli *et al.* 1991, Antoniacci & Cobelli, 1995, Benuzzi & Antoniacci 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 hectares 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 is always required when available. Concerning pesticide choice, a list of advised active ingredients is given: it normally permits the optimal application of integrated and biological control. In particular emergency conditions the use of partially selective active ingredients is also admitted due to technical and/or economical problems. The major problem to be solved during next years is the use of soil sterilisation against bottom-rot (Botrytis, etc.). At present the average dimension of the farm growing strawberry is very low (less than 1 ha) and the intensity of land use does not permit a rotation sufficiently large to avoid these problems. Solarisation is now under experimentation as a possible physical solution.

Fertilisation

In this case a standardised soil analysis is required every 5 years in order to apply a balanced program calculated according to soil content of nutrients for P and K. Both P and K fertilisers are applied at planting. For N supply is applied a simplified balance based on N demand (uptake * yield) and availability (N available at planting + N from nitrification + N from organic fertilisers + N residue from previous crop). An absolute maximum quantity is fixed at 150 kg/ha.. This program relates soil content to fruit quality, pest management and environmental protection. Both organic and synthetic fertilisers 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. Nitrogen fertilisers have to be split in several applications in order to increase the nitrogen use efficiency (NUE) and reduce leaching. Normally by using fertigation. Maximum 30% of the total nitrogen can be applied during winter, the remaining during growing period before harvest.

Table 1. Maximum nutrient input (kg/ha/year) permitted on strawberry.

Nutrient	Soil content			without	with
	high	medium	low	organic fertilisers	organic fertilisers
N	-	-	-	150	120
P_2O_5	50	120	150	-	-
K_2O	100	280	300	-	-

Weed management

On the row the weed control is made by mulching (black polyethylene film). Between the rows mechanical weed control and straw mulching (after blossoming) are advised. The use of glyphosate (and also of gluphosinate-ammonium and gluphosinate-trimesio) 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 practising traditional pest.

Main pest and diseases treated and active ingredients employed on average per year are listed in Table 2.

Furthermore, this initiative has had some influence on the type of protection methods recomended by other agricultural technicians in RER, thus contributing to a rationalisation 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.

Fertilisation

During 1996, average N supply on strwberry was 80-90 kg/ha, mainly supplied at planting by organic fertilisers (70% of farm use this technique). By fertigation was distributed the rest of N. Only 12% of farms used mineral fertilizers for open field distribution after planting. An average of 90 and 80 kg/ha of P and K was supplied.

Table 2. Main pests and diseases treated and active ingredients employed (1996)

Pest and diseases	Nr.Comm. products
Aphids	0.7
Red spider mite	0.0
Caterpillars	0.15
Flea beetle / Leafhoppers	0.25
Black vine weevil	0.0
Grey mould	1.4
Powdery mildew	3.6
Leaf spot	1.5
Brown fruit rot	0.95
Soil born fungal pathogens	0.25
Bacteria	1.5
Total	**10.05**

Active ingredients/Benefical organisms	Nr.Comm. products
acephate	0.6
Bacillus thuringiensis	0.0-0.05**
methyl bromide	0.28
Chrysoperla carnea	0.0-0.3**
copper	3.0
dichlofluanide	0.95
heptenophos	0.4
Heterorhabditis	0.0-0.1**
penconazople	0.7
pyrethrin	0.1
Phytoseiulus persimilis	0.0-0.3**
procymidone	1.4
sulphur	2.9
Total	**10.05**

* number commercial products applied / year

** possibility of biological control

Weed management

About 98% of strawberry fields apply only mechanical weed control and mulching.

Commercial promotion and Perspectives

The final aim of the project is to involve as many farms as possible during next years. For this purpose the improving of technicians' activity is already in progress (by using e.g. 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 been 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 1996 about 15% of the total regional fruit production will be commercialised under this label.

The programme includes the financing of a laboratory for the rearing of beneficial organisms. This laboratory , built at the Centrale Ortofrutticola 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 both open field and protected crops.

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Some aspects of integrated production of strawberry in Poland

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Abstract: Poland is one of the biggest strawberry producers in the world (about 200 000 t.). The largest part of the crop is Senga Sengana cv., destined mainly for processing and freezing. In recent years number of producers grow strawberries for fresh fruit market. The most common dessert cultivars are Elsanta, Marmolada, Kent and Syriusz. Some producers are interested in Integrated Fruit Production (IFP), because these fruits are more attractive for consumers. The principles of IFP for strawberries were elaborated and published in 1995 in the Research Institute of Pomology and Floriculture at Skierniewice.
In Poland the first group of farmers, begun to produce dessert strawberry fruit according to IFP rules in 1993, in Warsaw region. They got IFP certificates in 1996. Now there are 4 groups of producers practising IFP methods and some new groups will be organized in the next year. Some aspects of pests and diseases control on strawberry plantations in Poland according to IFP rules are presented.

Introduction

Poland is one of the biggest strawberry producers in the world with average crop about 200000 ton. The largest part of the crop, even 75% is destined for processing and freezing. The most useful for processing are Senga Sengana fruit, grown on about 75% of commercial plantations. Dukat variety occupies about 10% and Kama 5% of strawberry growing area. The most of plantations are small with size from 0.10 ha to 0.25 ha.

In the last few years a number of producers see their future in growing good quality dessert fruits, which are marketable in bigger towns, and bring higher profit than these destined for processing. The most common dessert cultivars are Elsanta, Marmolada, Kent, Syriusz. Some producers are interested in Integrated Fruit Production (IFP), because they are more atractive for consumers. On the begining, IFP methods were introducted in apple orchards. The first principles of integrated apple production were printed in 1991 in the Research Institute of Pomology and Floriculture at Skierniewice and still improved (Niemczyk et al. 1993, 1997). Later, IFP method was extended to strawberry production. The principles were published also in the Research Institute of Pomology and Floriculture at Skierniewice (Zurawicz *et al.* 1995). They are in agreement with those accepted in the USA (Hollingsworth *et al.* 1992), however in Poland there are some differences in natural conditions, agricultural structure, size of plantations and cultivated varieties. Polish conditions have to be respected.

Guidelines of integrated strawberry production in Poland were discussed thoroughly on international strawberry meeting in the Netherland in spring 1996 (Zurawicz *et al* in press). The following conditions must be fulfilled to classify fruit as produced according to the IFP rules:
- Certified planting material must be used to set the plantation
- Plantation has to be localized on field free of soil existing pests and pathogens

- All strawberry plantations on the farm must be included in the IFP program
- Disease and pest control have to be based on threshold levels
- Only pesticides allowed to be used in IFP can be employed (Zurawicz *et al* 1995)
- Mineral fertilizing should be based on soil analyses made before setting the plantation. Only fertilizers labelled as free of heavy metals presence and other contaminations can be used
- Analyses of fruit for residues of the above toxic substances ought to be made by authorized laboratories
- Sprayers should be tested and calibrated at least once a year
- In future, the predatory mite to control twospotted spider mite will be recommended, if available
- IFP strawberry plantations can not be located near ecologically menaced regions

In Poland the first group of farmers began to produce dessert strawberry fruit according to IFP rules in 1993 in Warsaw region. They got IFP certificates in 1996. In spring of 1997 new groups of farmers have joined, so there are 4 groups of producers practising IFP methods. In the next year some new groups will be organized.

Some aspects of pests and diseases control on strawberry plantations in Poland according to IFP rules are presented.

Soil pests and diseases

As it was mentioned before, strawberry plantation should be localized on field free of soil existing pests and root diseases. There should not be grown as aftercrop for many years standing papilionaceous plants, e.g. clover or alfalfa. These plants are usually attacked by strawberry root weevil, which is one of the most important soil pest on strawberry plantations. The fields should be free of weeds, especially perennial ones, e.g. wheat-grass, which is very often attacked by wireworms, the dangerous pest for young strawberry plants.

The next problem is nematodes. If they are present in the field, the soil is not suitable for strawberry planting. If there is no chance for any better field, the cultivation of *Tagetes* sp. during at least 4 months, is recommended.

Susceptible cultivars of strawberry (Elsanta, Kent, Gerida) should not be planted on field infested by *Verticillium* fungus, and as a second crop after plants which are susceptible to *Verticillium dahliae* as: raspberry, strawberry, tomato, potato, cabbage, cauliflower, cucumber.

Planting material

The plants should be certified, free of strawberry mite, virus and fungus diseases. Healthy planting material gives the possibility do not use any pesticides against some important pests (f.e. strawberry mite) and the most diseases on commercial plantations.

Control of pests and diseases during growing season

On IFP plantation, if chemical control of **strawberry mite** is necessary, only propargite (Omite 30 WP) and endosulfan (Thiodan 35 EC) are allowable. Two treatments at 7 day interval before bloom or after fruit harvest are recommended (Labanowska 1992).

On commercial plantations one of the most important and widespread pest is **strawberry blossom weevil**. It must be controlled on many plantation every year. On strawberry with IFP method fosalone is advised. In recent experiments it showed similar or only slightly lower effectiveness, as compared to standard insecticides, mainly pyrethroids.

Twospotted spider mite is also a common pest on strawberry and has to be controlled in some cases. In future the predatory mite will be useful for control of twospotted spider mites. Now, we use some fungicides or selective acaricides to control them.

On plantations where dichlofluanid (Euparen 50 WP) was used 2-3 times during bloom against grey mould, the control of twospotted spider mite is assured. Also good results in control of this mite selective acaricides such as: propargite (Omite 30 WP), fenbutatin oxide (Torque 50 WP), hexythiazox (Nissorun 050 EC, Nissorun 10 EC, Nissorun 10 WP), tetradifon, mixture propargite + hexythiazox (Omite 30 WP + Nissorun 050 EC) demonstrated (Labanowska,1990,1995). Single treatment with one of the mentioned acaricides before bloom on infested plantations is recommended. If nedeed, one application with propargite or hexythiazox after full bloom is advisable.

The most important and common disease of strawberry is **grey mould**. Chemical control of disease is necessary every year. Susceptible cultivars as Senga Sengana should be sprayed 4-5 times during blooming stage, and for the less susceptible ones as Kent, Elsanta, Marmolada 2-3 sprays are enough.

There are several fungicides possible to use: dichlofluanid (Euparen 50 WP), which also controls other diseases and twospotted spider mite and dicarboximides (Sumilex 50 WP, Rovral 50 WP Rovral Flo 255 SC) or TMTD (Thiram Granuflo 80 WG).

Spray application techniques strongly influences on the effectiveness of chemical control of pests and diseases on strawberry plantations. In our experiments we have obtained satisfactory results in the control of twospotted spider mite and grey mould with Sepia, Hardi and Fragaria sprayers.

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Preliminary work on integrated production of strawberries in Denmark

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Abstract: In order to prepare the formulation of strawberry IFP guidelines in Denmark, a project with 20 strawberry growers was carried through 1994-96. The aim was to test and develop a number of tools and remedies to be used in pest registration as well as in registration of plant nutritional status and water supply. Pest registration remedies tested include field sampling with white plastic trays and the use of yellow sticky traps for flying insects. Registrations of plant nutritional status include soil and N_{min} analyses and leaf analyses. Registration of water supply was performed with the use of tensiometers. The results showed that the remedies tested were useful although some were too difficult to handle by the growers. Careful handling and regular control of the remedies are important for reliability. There is a need for further development of simple remedies to be used in practice. Also, there is a need for further development of standard values in the evaluation of pest registration methods as well as registration methods of plant nutritional status, whereas for the use of tensiometers for registration of water supply there were good results.

Introduction

In Denmark, integrated fruit production (IFP) was introduced in apples in 1990. Since then, a need for further IFP research has increased in all fruit crops. In order to develop IFP of strawberries, a project was started in 1994 with 20 experienced strawberry growers located in different parts of Denmark. The aim of the project was to test and develop a number of tools and remedies in strawberry growing, forming a basis for the preparation of a set of IFP strawberry guidelines in Denmark.

Materials and Methods

The investigation includes strawberry plots of 20 growers during 3 years. The main variety was 'Elsanta'. The following methods were selected:

a. Plant health test. An investigation of 3-5 selected strawberry plants from each plot with clear symptoms of growth suppression was made in order to register the possible occurrence of a number of pests and diseases. The test was made i one year old strawberry plants and only the first year of the project.

b. Pest registration. Frequently, the growers had to collect samples of pests from the plots. A white plastic tray was used, placed under the foliage. A couple of light strokes on the foliage made insects fall into the tray where they could be counted, and the growers were meant to fill in a registration scheme.

c. Yellow sticky traps were placed in all plots in order to catch flying insects.

d. Soil analyses. A standard sample to a depth of 20 cm was taken on the first year of the project, and N_{min} analyses to a depth of 50 cm were made each year in March. Standard samples comprised soil pH and content of P, K and Mg.
e. Leaf analyses were made on leaf samples, taken each year at the beginning of bloom, 100 leaves per sample. Samples were analyzed for the following elements: N, P, K, Mg, Ca, Na, Cl, S, Fe, Mn, B, Cu and Zn.
f. Water irrigation management by the use of tensiometers. A tensiometer consists of a water filled tube with a porous ceramic bottom and a vacuummeter at the top. It is placed with the ceramic bottom in the strawberry root zone. When the soil humidity declines, water in the tube will be sucked out and the suction force (tension) can be read on the vacuummeter at the top Two tensiometers were placed in every plot, 1 meter apart in the same row, in order to registrate the need for irrigation, one to a depth of 20 cm and the other to a depth of 40 cm.

Results and discussion

a. Plant health test

The investigated plant material showed the following distribution for a number of pests and diseases, i % of 20 different plots: *Botrytis cinerea* 85%, *Fusarium spp.* 70%, *Sphaerotheca macularis* 50%, *Mycosphaerella fragariae* 35%, *Ditylenchus spp.* 30%, *Rhizoctonia sp.* 25%, *Phytophtora fragariae* 20%, *Verticillium albo-atrum* 20% and *Aphelenchoides spp.* 20%. This pathological test has demonstrated a widespread presence of pests and diseases in a number of Danish strawberry fields. However, the distribution of each disease in the fields cannot be determined on the basis of the results. It can be concluded that a number of serious diseases can be identified, some of which undoubtedly have been brought into the field with the plant material. Therefore, an important part of strawberry IFP guidelines must include the use of healthy plant material (Bisgaard, 1996; Svensson, 1997). Crop rotation is another important IFP guideline to be recommended in order to minimize the spreading of plant-borne pests and diseases.

b. Pest registration

The aim of IFP in general is not to spray against pests and diseases unless there is a clearly defined need. One of the goals of this project was to test and develop a pest registration system which is easy to use by growers. This system should form a basis for monitoring specific pests and the growers' registrations were meant to be reported to the advisory service. In spite of thorough grower demonstrations, however, it seemed difficult to implementate the system to the growers. The requirements were too ambitious and they found it difficult to spend the time which was necessary. As a result, a practice since then has been introduced in which the growers collect samples only and leave the counting and registration to the advisory service. In conclusion, however, there is still a need for better tools and more education of growers in this field.

c. Yellow sticky traps

Another means of pest registration is yellow sticky traps which have shown to be a useful tool in a number of fruit crops in order to register which flying insects can be found (Lindhard 1997; Norin 1997; Ravn *et al.* 1997). In this project traps were placed in the strawberry plots in 3 specific periods after which insects were counted. Several species were caught in the traps, harmful as well as beneficial species. As a method of insect registration it is useful although it has a number of disadvantages. Not only the harmful insects are caught, and skilled personnel is required in the evaluation. Besides, no damage thresholds are yet defined and so the sticky traps can only be used as an instrument of registration. There is a need of further investigations before this method can be used as a means of monitoring pests.

d. Soil analyses

The results of standard soil analyses showed a wide variation between plots. In general, the soil pH was too high compared to Danish recommended values, pH 6,2-6,8 (Anon., 1997), and magnesium contents were too low. A a result, fertilization practices have been balanced.

Results of N_{min} analyses also showed a wide variation between plots, in 1994 from 13 to 70 kg N per hectare in soil depth 0-50 cm. Between years there was a wide variation too. Within plots, variation between years was bigger with higher values. In Denmark no standards have been developed so far, but according to Swedish research the N uptake of 2 year old strawberries is approx. 60 kg per hectare (Svensson, 1997), and according to German and Swiss research a N_{min} content of 50-80 kg N per hectare in early spring (0-60 cm depth) is probably suitable (Quast, 1979; Dellinger, 1994; Tränkle, 1994; Neuweiler *et al.*, 1996). Further work will be performed in Denmark in the forthcoming years in order to determine standard values.

e. Leaf analyses

Traditionally, leaf analyses in Denmark have been performed at the time of harvest. This is due to documented variations in leaf mineral content throughout the season, with the lowest values found at harvest time (Anon., 1972). However, with this practice it is not possible to make corrections in fertilization during the season if necessary. In this project leaf analyses were taken at the beginning of bloom, where leaf N contents are expected to be higher. No Danish standard values exist for this kind of analysis, but the number of simultaneous results together constitute a useful standard. The range of N-content was relatively great (2,0-4,0 % N), with average values around 3,15 % N. This is within the normal range for pre-bloom leaf N content according to German recommandations (Bergman, 1983). Much more work needs to be done in order to optimize fertilization practices in accordance to IFP principles.

f. Irrigation management

Strawberry plants generally need good water supply, especially during berry development. To make sure that sufficient amounts of water is available, growers often irrigate too often. In this project a method of control was introduced, using tensiometers placed in the strawberry plots (Jørgensen, 1990). These instruments were read by the growers regularly during the season and water irrigation was managed according to soil type and time of the season. The results showed that with tensiometers it is easy to register water supply of strawberries, although in some instances the measures are not reliable. It is important for reliability that the instruments are in good contact with the soil humidity. Another factor to be considered is the soil type. On heavy soil the reaction by the tensiometer was too slow. Finally it was demonstrated that tensiometers can easily be damaged by machines and should be handled carefully in the field.

Conclusion

Although the tools and remedies tested in this project generally have shown good results there is a need for further development of standard values. This is true for methods of pest registration as well as for methods of plant nutritional status. For irrigation management control by means of tensiometers has shown good results. The results also showed that some of the remedies were too difficult to handle by growers and there is a need for further development of simple remedies, easy to read and handle i practice.

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Integrated management of flower pests of strawberry

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Abstract: Strawberry blossom weevil and capsid bugs, especially the European tarnished plant bug, are important pests of strawberry flowers and thrips and pollen beetles are minor pests. The state of development of the components of an IPM strategy for these pests, including biology, crop damage, sampling methods, economic thresholds and biological and selective chemical control methods are appraised.

The effects of severing damage by the blossom weevil on flower buds on the yield and quality of strawberry depend on the intensity of flowering in relation to plant size. Plants with few flowers are unable to compensate fully for severing, though fruit size may be increased. Plants with an excess of flowers can tolerate high levels of severing through maturation of alternative replacement flowers as well as by increasing fruit size. Economic thresholds need to take these factors into account. Populations of blossom weevil adults can be determined in early spring by beating or suction sampling but such methods are time consuming. Control of the weevil currently relies on the application of a broad-spectrum insecticide when flower truss stems are extending. Biological or selective chemical control methods have not been developed.

The European tarnished plant bug is a hitherto unrecognised, important pest of strawberry, especially late season crops, causing fruit malformation by feeding in flowers. Populations as small as 1 bug per 50 plants have been shown to cause significant damage. Populations can be assessed by beat or suction sampling. Control is achieved with sprays of short-persistence organophosphorus insecticides. Biological or selective chemical control methods have not been developed.

The integration of chemical control methods for flower pests with biological control of two-spotted spider mite by phytoseiid predatory mites is discussed. Downward directing of sprays to achieve good cover of flowers but minimum cover on the undersides of leaves reduces the possible adverse effects of insecticides harmful to predators.

Introduction

In recent years the season of strawberry fruit production has been extended from the traditional June period to include July through to October. This has been achieved by growing the June bearer cv. Elsanta as a '60 day plant' i.e. by planting cold-stored runners in sequence in early summer so they fruit c. 60 days later, or by growing day-neutral (ever-bearer) cultivars that flower and fruit continuously through summer into the autumn.

The fruit from these crops is of high value but the extended flowering period has resulted in changes in the pest status of several insect species. Capsid bugs, especially the European tarnished plant bug, *Lygus rugulipennis*, have become important pests. Thrips and pollen beetles have become minor pests. Other well-known flower pests of June-fruiting crops such as the strawberry blossom weevil, *Anthonomus rubi*, have been found to cause serious damage to crops fruiting later.

Very few selective, non-neurotoxic, insecticides are registered for use on strawberry and those that are (*Bacillus thuringiensis*, diflubenzuron) are active mainly against caterpillars. Broad-spectrum organophosphorus insecticides such as chlorpyrifos and malathion are relied on currently to control the flower pests of strawberry in the UK. This poses a dilemma because these insecticides are harmful to bees and should not be applied during flowering. However, application during flowering is unavoidable if flower pests are to be controlled on ever-bearer cultivars that flower continuously in summer. The compatibility of broad-spectrum insecticides with biological control agents and natural enemies is also an important consideration.

In this paper we discuss the prospects for developing IPM systems for the flower pests of strawberry and include discussion of recent relevant research at HRI-East Malling. The most important components of an IPM system are: 1) a knowledge of pest biology and crop damage 2) sampling methods to determine pest population density 3) economic damage thresholds 4) biological or other non-chemical control methods 5) selective insecticides and integration of the control methods for each pest with the control methods for other pests and diseases on the crop. The state of development of these components is discussed for each of the flower pests and is followed by a general discussion of integration. Progress towards the development of Integrated Pest and Disease Management systems for strawberry is discussed by Cross & Berrie(1994).

Strawberry blossom weevil (*Anthonomus rubi*)

A. rubi is a common pest of strawberry throughout Europe. Adult weevils which have over-wintered amongst dry leaf litter in hedge bottoms emerge in early spring and fly to nearby strawberry fields on warm sunny days. After laying a single egg in an unopened flower bud, the adult female moves to the bud stalk (pedicel) and punctures it with her rostrum a few millimetres below the bud, partially severing it. The partially severed bud withers, often falling off the plant. Larval development occurs within the withered bud, adults emerging in mid-summer. Egg-laying and severing damage by over-wintered females continues over a long period and can be severe on ever-bearers as late as July and August, though the numbers of over-wintered adults gradually decline as summer progresses. There is only one generation each year. New adults emerging in summer do not reproduce or sever flower buds (Cross *et al.*, 1995). They feed on young leaves. They may be sexually immature or in reproductive diapause. Detailed accounts of the biology of *A. rubi* are given by Jary (1931, 1932) amongst others. A similar species, *A. signatus*, is an important pest of strawberry in the north-eastern part of the USA and in Canada.

Crop damage

Severing damage is not distributed randomly. Kovach (1995) showed that damage by *A. signatus* spread across a field at roughly 10m per year. Cross *et al.* (1995) showed that damage was not distributed evenly between plants or between trusses (inflorescences) on individual plants. Secondary and higher order flower buds are more likely to be severed than primary buds. The effects of severing on yield and quality depend on the numbers of flower buds present relative to the size of the plant (Cross and Burgess, in press). Two mechanisms of crop compensation are apparent: 1) an increase in mean berry weight and 2) the maturing of alternative replacement flowers. Plants with insufficient flower initials are able to compensate only partially for severing. The yield of plants with numerous flowers may not be affected, even by the loss of 50% or more flower buds. Older (>1 year old) plants tend to have an over-abundance of flower buds. Indeed, severing may be beneficial as fruit size is increased. However, severing can delay the time of harvest by up to a few days. The importance of such delays depends on the purpose for which the fruit is grown and market conditions.

Sampling methods

The population density of adults needs to be determined in Spring when truss (inflorescence) stems are extending and before significant damage is done. Currently, this can be done by gently tapping the plant over a collecting tray or by suction- sampling and counting the insects collected. Investigations at HRI-East Malling indicate that ideally 40 plants should be sampled per field. However, such an approach is time-consuming and not ideal for use by growers. Our work is also showing that visual traps are insufficiently sensitive. We have recognised the need to identify the pheromones of *A. rubi* and research to this end has started recently.

Economic thresholds

Economic thresholds based on the population density of adults in Spring have been set in Yugoslavia (Lekic, 1962) and Russia (Popov, 1996) and for *A. signatus* in the USA and Canada (Schaefers, 1978; Watson and Walker, 1992). Economic thresholds based on the density of severed buds in Spring have also been set for *A. rubi* in Russia (5% buds severed) (Popov, 1996) and for *A. signatus* in Canada (2 buds severed per metre of row) (Kovach, 1995). However, these thresholds appear to be nominal, set to limit the occurrence of severing to very low levels and are not based on experimental evidence of the relationship between adult population density and the intensity of severing or the effects of severing on yield or quality.

Setting thresholds according to the density of severing only is flawed logically as the damage has already been done when severing is apparent, though subsequent damage may be reduced. For this reason a threshold is needed based on adult population density and varying according to flowering intensity relative to plant size. Research to establish such thresholds is in progress at HRI-East Malling.

Biological and other non-chemical control methods

Ichneumonid parasitoids have been recorded from *A. rubi* but the intensity of parasitism are usually very low, especially in commercial crops where insecticide sprays are applied frequently. Parasitoids do not appear promising as biological control agents.

Plant breeders at HRI-East Malling have shown that cultivars of strawberry vary considerably in their susceptibility to *A. rubi* (Simpson *et al.*, 1997). Resistant or partially resistant cultivars offer one option to consider. However, the relative susceptibility of available cultivars has not yet been quantified. Furthermore, cultivars are chosen generally for other important attributes such as season, yield and quality.

Chemical control methods

In the UK, *A. rubi* is controlled currently by the routine application of a spray of chlorpyrifos to kill adults before flowering as the flower truss stems are extending and before significant damage occurs. The efficacy of selective insecticides such as Insect Growth Regulators has not been investigated but they do not seem to offer much promise. Synthetic pyrethroid insecticides, though probably highly effective, are likely to be harmful to predatory mites. However, Cross *et al.* (1996) showed that the harmful effects of such sprays can be reduced by downward-directed spray application with a horizontal boom sprayer.

European tarnished plant bug (*Lygus rugulipennis*)

L. rugulipennis has been shown to be a serious, previously overlooked, pest of later season strawberry (Taksdal & Sorum, 1971; Easterbrook & Cross, 1993; Easterbrook, 1996). Adults and nymphs feed in the flowers probing the surface of the receptacle, locally preventing swelling of the flesh of the fruit. Uneven swelling occurs and the resultant fruits are malformed, 'buttoned' or 'nubbined' with furrows or sunken areas. There is a 3-4 week interval between feeding damage occurring and malformed fruit being picked by the grower. Damage easily goes unnoticed until picking. Although nymphs and adults feed on young foliage and growing points, severe distortion to foliage, such as that caused by *Lygocoris pabulinus,* is not evident from *L. rugulipennis*.

L. rugulipennis is a very common species with a wide host range including numerous common weeds. It over-winters as an adult amongst debris, including in strawberry fields, emerging on warm days in March or April, usually in small numbers as winter mortality is high. Eggs are laid during May, inserted in the surface of flower buds and the stems of various plants. They hatch after a short time and the nymphs feed in the flowers, usually becoming adult in late June or early July (Easterbrook, 1997). There is then a second, late-summer generation. The insect can be very abundant at this time of year. The second generation becomes adult in September and there is considerable pre-hibernation flight activity as the insects disperse to over-wintering sites. The phenology has been investigated recently by Easterbrook (1997).

Crop damage and economic threshold

Crop damage assessment experiments at HRI-East Malling are in progress; the results of research done already indicate that significant damage can be done at low population densities (Easterbrook, 1996). A provisional threshold of 1 capsid per 50 plants has been proposed.

Sampling methods

Although capsid bugs can be observed feeding in the flowers, unaided visual inspection is insufficiently effective as the insects are often hidden amongst foliage and are disturbed easily from open flowers. Tapping the plant gently over a beating tray or the use of suction-sampling is effective but unsuitable for use by growers. Work at HRI-East Malling in 1997 examined the use of coloured sticky traps. A white colour was shown to be most effective but significant numbers of capsids were only caught at high population densities and sticky traps have proved insufficiently sensitive to detect low but damaging populations. The identification of the capsid's pheromone(s) would be a significant advantage.

Biological and other non-chemical control methods

Some non-specialised insect predators such as Nabid bugs prey on capsids, but control is not usually sufficient to prevent fruit damage. The levels of parasitism are low in the UK. Prospects for biological control do not appear promising at present. If the pheromone of *L. rugulipennis* can be identified, there are prospects for exploiting it for mass trapping, mating disruption or for manipulating the pest's distribution.

Other non-chemical methods of control are being investigated at HRI-East Malling. The effect of planting a 'trap crop' near strawberries to attract capsid adults away from the crop when they invade fields in July is being evaluated. Sources of host-plant resistance are also being sought.

Chemical control

L. rugulipennis and related capsid pests of strawberry are controlled readily by sprays of broad-spectrum insecticides. Malathion, heptenophos and trichlorphon are effective insecticides of short persistence. Selective insecticides have not been identified, though little effort has been devoted to the task of screening candidate materials.

Thrips

Several species of thrips feed and reproduce in strawberry flowers. The most common are *Thrips atratus*, *T. major* and *T. tabaci* (Alofs, 1987; Easterbrook, 1991). Adults migrate into flowering strawberry crops on warm days in summer, especially when the humidity is high. They appear to be attracted by strawberry flowers, finding shelter on the surface of the receptacles amongst the styles. They suck sap from the surface cells leaving brown fleck marks on the surface of the developing fruit. Eggs are laid and nymphs develop in the flower. Often several thrips invade the same flower and the numbers of thrips can increase rapidly thereafter. Feeding damage intensifies and the flower gains a brown, unsightly appearance. Feeding can continue through to the green fruit stage. Damaged fruits have a dull, brownish appearance when ripe. At one time it was thought that feeding damage caused by small numbers of thrips resulted in fruit malformation, but it now appears probable that this view was mistaken and that the damage was caused by capsids. A low damage threshold of an average of 2 thrips per flower was used as a treatment threshold in the UK, but this level is now considered to be too low. A threshold of >10 thrips per flower would be more realistic. At HRI-East Malling, thrips were caged on strawberry flowers in the laboratory but no fruit malformation was observed. However, crop damage assessment experiments have not been done in the field.

Growers in the UK control thrips by applying a spray of malathion to open flowers when a damaging infestation is detected. Heptenophos is also effective. The prospects for effective biological control are poor. Phytoseiid mites which predate thrips such as *Amblyseius* sp. are unlikely to respond sufficiently quickly to regulate the numbers of thrips. Thrips populations are sometimes reduced by *Orius* spp.

Pollen beetles

Pollen beetles, especially *Meligethes aeneus*, frequently feed in strawberry flowers. Occasionally, very large numbers occur, especially where strawberry crops come into flower immediately after the flowering of an adjacent oilseed rape crop, a favoured host of *M. aeneus*. The mechanism by which pollen beetles cause damage is unclear.
Control is achieved currently by the application of a foliar spray of malathion to damaging populations where they occur.

Integration with predatory mites

Naturally-occurring insecticide-resistant phytoseiid mites are common on strawberry and are important in the natural regulation of populations of the two-spotted spider mite, *Tetranychus urticae*, an important pest of strawberry. The main species are *Amblyseius* sp. and *Typhlodromus pyri*. These species appear to have developed resistance to OP insecticides. However, they are often insufficiently numerous to prevent outbreaks of spider mite, especially in the first season after planting. In commercial practice, the predatory mite

Phytoseiulus persimilis is introduced in early summer to control the spider mite biologically. Laboratory tests indicate that the broad-spectrum OP insecticides commonly used to control flower pests of strawberry are harmful to *P. persimilis*. Growers believed that long safety intervals (up to 8 weeks) were needed between the application of insecticides and the introduction of predators. However, recent research at HRI-East Malling (Cross *et al.*, 1996) has shown that the insecticides are less harmful than believed previously and that applications one week before or one week after the introduction of predators have little or no adverse effects. Probably *P. persimilis* has developed some resistance to OP insecticides and incomplete spray cover on the under-surfaces of strawberry leaves where the mites are found allows them to escape the possible harmful effects of insecticides. Downward-directed spraying to avoid significant spray deposits on the undersides of strawberry leaves was shown to alleviate the harmful effects of the pyrethroid insecticide cypermethrin.

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Influence of *Tagetes* and fumigation on the growth of strawberries

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Abstract: Reported were the results of an investigation of the influence of *Pratylenchus sp.* - nematodes on the growth of strawberries. For controlling the nematodes four treatments were compared: 1. Arable mustard, 2. *Tagetes patula nana* 'Sparky', 3. Basamid Granulat (40 g/qm), 4. Mocap 20 GS (5 g/qm). In the second year cold-stored plants of 'Elsanta', quality A+, were planted. The growth of the plants in the planting and second year was highly corelated to the treatments and the density of the nematodes. The best results gave the fumigation and *Tagetes* and the sadest arable mustard.

In our Experimental Station we grow strawberries since some years at the same place without fumigation. Because growth and yield were no more satiesfied, we took a soil sample for an investigation of nematodes. The result showed a density of 500 until 1000 *Pratylenchus sp.* in 250 ml soil. So we decided to start a trial to control the nematodes with *Tagetes* and follow with strawberries. The results of this trial are presented in this paper.

Material and methods

1. As a standard we used the green manure arable mustard with 30 kg per hectare, which was sowed on 26 th May 1994.
2. The results from other authors and also our own experiences have shown, that we can control the *Pratylenchus* with *Tagetes*, but that there are large differences in the efficiency of the different species and also varieties (1,2,3). In this trial we used *Tagetes patula nana* 'Sparky' from the Company Sperling in Lüneburg with 6 kg per hectare on 26 th May 1994.
3. For fumigation we took Basamid Granulat (active substance Dazomet) with 40 g per qm, which was applicated at 30 th August 1994. Before this the soil was also protected with arable mustard as green manure as in treatment number 1.
4. As a special nematicide we tried Mocap 20 GS (active substance Ethoprophos) with 5 g per qm 14 days before planting the strawberries in the middle of May 1995. Mocap is a potato nematicide with special effects against cystdeveloping nematodes. In the year before the soil was protected with arable mustard comparable treatment 1.

The plots had a size of 4 x 10 m, in the total 40 qm, with 4 replicates for each treetment. The trial was planted with cold-stored plants of 'Elsanta', quality A+, in a distance of 1 m x 0,25 m, that means 4 rows per plot with 40 plants per row, accordingly alltogether 160 plants per plot.

Results

Table 1 shows the yield and fruit size of the four treatments in the planting year. Yield and fruit size were well correlated with the development of the plants. The lowest yields and smallest fruits gave the plots with arable mustard with 263 g per plant and 12,9 g per fruit. *Tagetes* brought the highest yields and largest fruits with 395 g per plant and 15,6 g per fruit. *Tagetes*, Basamid and Mocap were nearly similar. The differences are not statistically significant.

Table 2 shows the results in the second year. Yield and fruit size were again well corelated with the development of the plants. Arable mustard had the lowest yield and fruit size, second Mocap, third *Tagetes* and the best result brought Basamid.

What was responsible for this obvious differences ?

Before and after treatment in 1994 we looked for the density of *Pratylenchus* in the soil. The results are presented in table 3. It gives the number of nematodes in 250 ml soil. The values were low and not as high as in the previous year. The reason for this is a different method of extraction the soil with water. Here it was done by the so-called Behrmann-funnel, in the year before with the Seinhorst-apparatus. Nevertheless the effect of the treatments was clear. With arable mustard the density was constant or increased, while after *Tagetes* and Basamid the population decreased to 4 and 2 nematodes per 250 ml soil.

At the beginning of the harvest in the planting year (1995), when we had obvious differences between arable mustard and the other treatments, we took again a soil sample for nematodes. The results are presented in table 4. The left column shows the values with Behrmann-funnel and the right with the Seinhorst-apparatus. The values after Seinhorst are 1,5 to 6 times higher as after Behrmann. The differences between the treatments, however, are similar, and confirm the results from half-a-year before. Mocap was not very efficient in controlling the *Pratylenchus* and gave large variations between the replications. The same situation we had in the arable mustard-plots. In all cases there was no corelation between the density of the nematodes and the development of the plants. That means in all four replications of the arable mustard-plots the growth was similar poor and in all Mocap-plots similar good.

So we looked for other growing factors, as microbiological activity, organic matter, total nitrogen and nitrate-nitrogen in the soil, but we could not find an explanation for this phenomenum ?

In 1996 we started this trial again to see, whether we can repeat this results. After the first yield this year the experience was similar. So we have to ask:

1) Are the *Pratylenchus* responsible for the obvious differences in plant development, yield and fruit size between the treatments ?
2) Or is only arable mustard as green manure negative ?
3) What is the reason for this obstructive effect of arable mustard, because many strawberry grower in our region use it with very good results ?

Further trials will be nescessary to answer this questions ?

Another important aspect, which we should recognize, are the results with the different methods of extraction the soil for determination the nematodes. With the Seinhorst-apparatus the values are always higher, as you see in table 5 for 20 different samples, but it is not a constant factor. This means, for the interpretation of soil samples of nematodes you should know the method of extraction and their effect of the result.

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Tab. 1: Influence of *Tagetes*, Basamid and Mocap on the yield in the planting year (1995) (cold-stored plants, A+, Elsanta)

1995

	yield g / plant	fruit size g
Arable mustard	263	12,9
Basamid	354	15,2
Tagetes	395	15,6
Mocap	367	15,5

Tab. 2: Influence of *Tagetes*, Basamid and Mocap on the yield in the second year (1996) (COLD-STORED PLANTS, A+, ELSANTA)

1996

	yield g / plant	fruit size g
Arable mustard	441	14,2
Basamid	879	16,9
Tagetes	785	16,6
Mocap	607	15,7

Tab. 3: Density of *Pratylenchus sp.* before and after treatment in 1994 (number in 250 ml, method Behrman-funnel)

	14.04.1994	31.10.1994
Arable mustard	185	329
Basamid	178	2
Tagetes	127	4
Mocap	198	189

Tab. 4: Density of *Pratylenchus sp.* during harvest 1995 (number in 250 ml)

	Behrmann-funnel	Seinhorst-apparatus
Arable mustard	168	1090
Basamid	4	10
Tagetes	14	55
Mocap	143	220

Tab. 5: Comparison between Behrmann - funnel andSeinhorst – apparatus (number *Pratylenchus sp.* in 250 ml)

	Behrmann - funnel	Seinhorst - apparatus	Faktor
20.04.95	38	200	5,3
	13	90	6,9
	10	320	32,0
	55	130	2,4
	116	740	6,4
10.07.95	165	760	4,6
	15	90	6,0
	60	220	3,7
	5	10	2,0
	10	20	2,0
	280	1420	5,1
	3	20	6,7
	40	140	3,5
	578	2680	4,6
08.05.96	135	380	2,8
	63	240	3,8
	128	860	6,7
	220	450	2,0
	105	420	4,0
	223	320	1,4
	130	310	2,4
	203	330	1,6
	1207	3310	2,7

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Progress towards integrated control of Botrytis and powdery mildew of strawberry in the UK

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Abstract: Most fungicide sprays applied to the June-bearer strawberry cv. Elsanta are targeted at control of Botrytis fruit rot and powdery mildew. While routine sprays are no longer acceptable, only high quality fruit can be marketed. Alternative approaches to disease control are aimed at developing integrated disease management that includes disease warning systems and cultural methods of control. For Botrytis fruit rot, studies have been conducted to quantify the relationship between flower infection, inoculum and weather. Results to date indicate that it may be possible to relate the incidence of flower infection to two easily measurable components of weather – vapour pressure deficit and temperature: including inoculum did not improve the infection model. Inoculum concentration could also be related to weather but further studies are required to produce a consistent model. Studies on overwintering inoculum sources have confirmed that *B. cinerea* is able to colonise and produce inoculum on all aerial parts of the strawberry. From this, and the fact that the fungus can colonise and regenerate on a wide range of plant species, it appears that the availability of inoculum is unlikely to be a limiting factor in determining disease incidence.

On cv. Elsanta, the use of fungicides for control of powdery mildew is most intensive post-harvest. Trials over four seasons (1992-6) have shown that the effects of post-harvest mildew epidemics on yield are small, inconsistent and not statistically significant. Plots heavily infected with mildew in the autumn did not always develop mildew the following spring. However, where early spring epidemics of powdery mildew did occur, they appeared to be associated with the presence of cleistothecia. Further studies are needed to clarify their significance in the overwintering of powdery mildew.

Introduction

In the UK, strawberries are attacked by several fungal diseases (Table 1) which cause significant reductions in yield and quality, and which require routine fungicide treatment to prevent or limit damage. Soil-borne diseases such as those caused by *Phytophthora* species or *Verticillium dahliae* may be avoided by the use of healthy planting material and pathogen-free land. However, it is almost impossible to avoid the airborne diseases grey mould and powdery mildew, whose incidence and severity is governed by seasonal weather conditions. Thus, most fungicide sprays in strawberry fruit production are targeted at control of *Botrytis* fruit rot and powdery mildew. Up to nine sprays per season can be applied from before flowering to harvest and, despite this, disease control can be poor if weather conditions are favourable for disease. Public concern over the use of pesticides is causing routine sprays to be no longer an accepted practice. However, high standards of disease control are essential in order to achieve the high fruit quality demanded by the market. Therefore there is a need to explore alternative approaches to disease control.

Table 1. Main fungal diseases of strawberry in the UK

Plant part affected	Disease	Fungus
Foliage	Powdery mildew	*Sphaerotheca macularis*
	Leaf spots	*Gnomonia comari*
		Mycosphaerella fragariae
Fruit	Botrytis fruit rot	*Botrytis cinerea*
	Black spot	*Colletotrichum acutatum*
Root/crown	Red core	*Phytophthora fragariae*
Vascular system	Crown rot	*Phytophthora cactorum*
	Wilt	*Verticillium dahliae*
	Root rots	*Fusarium / Cylindrocarpon*

Botrytis fruit rot

Background

Botrytis primarily causes a fruit rot but can attack all of the plant above ground. The fungus usually overwinters as mycelium or sclerotia in dead leaves and plant debris (Braun and Sutton, 1987) and is favoured by moderate temperatures and high humidity. Previous research has shown that the fruit rot develops from infection that occurred during flowering (Gilles, 1959; Jordan, 1978) and fungicide sprays are targeted at protecting flowers. Additional sprays are applied near and during harvest if weather is conducive to *Botrytis*.

Some alternative strategies for control of *Botrytis* have been investigated previously (unpublished data). These included an integrated approach, where removal of dead leaves in early spring to minimise overwintering inoculum was combined with reduced fungicide use, by either reducing the dose or the frequency of spraying. Acceptable control of *Botrytis* was achieved, compared to conventional control, in years unfavourable to the disease, but not when weather was conducive to *Botrytis*. The management of *Botrytis* could be improved if the effect of the weather on the disease could be used to determine when spraying was necessary.

Biological control of *Botrytis* in field plots using a commercially available formulation of the antagonistic fungus *Trichoderma* (Binab T), in combination with low doses of iprodione, was also evaluated. Use of *Trichoderma* did not improve the control of *Botrytis* compared to plots treated with low doses of iprodione only. Disease control was poor in years conducive to *Botrytis*.

The purpose of this study is to review existing biological data on *B. cinerea* of spore production, dispersal and infection, and to collect new data where gaps in knowledge have been identified. Sources of disease inoculum are being re-examined and confirmed. The information will then be used to construct a model for use in decision-based disease control.

Inoculum sources

Sources of overwintering inoculum were studied by sampling plants of cvs. Elsanta and Calypso from experimental plots at HRI-East Malling at intervals from October to April over two seasons. Samples were dismembered and incubated under moist conditions and examined for conidiophores of *B. cinerea.* Direct observations of *Botrytis* in field plots were also made during this period. Observations were also made in commercial crops of Elsanta. Young or mature green leaves, or senescent strawberry leaves and weeds were sampled on several occasions in each year and similarly incubated and assessed for *B. cinerea.*

The results from these studies confirmed that *B. cinerea* is able to colonise and produce inoculum on all aerial parts of the strawberry. It was detected on leaves and other organs (attached or detached) either as mycelium in the tissues or as sclerotia from October to April. Inoculum can also be generated prior to flowering from damaged, colonised leaf tissue following severe spring frosts. These observations and the fact that *B. cinerea* can colonise and regenerate on many types of plant material indicate that the availability of inoculum is unlikely to be a limiting factor in determining disease incidence in strawberry crops.

Factors affecting flower infection

The relationship between various components of weather, inoculum in the air and the incidence of infection of flowers by *B. cinerea* was studied in field plots over two years (1995-96). The incidence of flower infection on Elsanta during 15 successive two-day periods during flowering was determined. The numbers of conidia of *B. cinerea* in the air over the strawberry plants during the sampling period were estimated using a Burkard spore trap and weather components (air temperature, relative humidity, rainfall, leaf wetness) were recorded electronically using a Metos (Pessl, Weiz, Austria) logger.

The data collected over the two seasons (1995-96) were modelled to identify the quantitative relationships between flower infection and weather and between the numbers of *Botrytis* spores and weather. The data analyses showed that the factors relating best with flower infection were the daytime vapour pressure deficit (VPD) and night-time temperature (Fig. 1). This result is consistent with the known characteristics of *B. cinerea,* ie the importance of sustained high humidity for infection with an optimum temperature of about 20°C. Including inoculum concentration did not improve the model. Inoculum concentration was also affected by weather, but the models produced differed between the two years in several aspects and require further study.

These results indicate that it may be possible to identify periods with a high risk of infection by *Botrytis* on the basis of two easily measurable components of weather. These studies will be continued to further validate the model for June-bearers and to test the validity for everbearers. Clearly, additional studies are needed but eventually it should be possible from these studies to develop a strategy for the management of *Botrytis* on strawberry with minimum dependence on pesticides.

Powdery mildew

Background

Powdery mildew, caused by the fungus *Sphaerotheca macularis,* attacks all aerial parts of the plant but it is the damage done to flowers and fruits at all stages of development that can result in heavy losses. The disease is reported to overwinter on infected green leaves (Peries, 1961). Cleistothecia, which are not found commonly in crops, are thought to play no part in the perennation of the fungus (Gilles, 1961). In the UK the disease is most severe on everbearer cultivars such as Rapella, Calypso and Tango, where flowers and fruits can be attacked severely. Control of the disease during flowering and fruiting with fungicides is difficult because of the need to use products with a short harvest interval. The problem in everbearer crops has been solved partly by breeding resistant cultivars such as Evita. Under UK conditions, on susceptible June-bearer cultivars such as Elsanta, control of powdery mildew pre-harvest is usually easy to achieve. Conditions post-harvest are much more conducive to disease. The regrowth after mowing-off strawberry plants is particularly susceptible. Even in fungicide-treated crops, 30% leaf area may be mildewed at this time. Mildew attack post-harvest could contribute to crop damage in two ways: firstly by affecting flower initiation and plant vigour, and secondly by contributing to high levels of overwintering mildew. Both could result in effects on subsequent yield and fruit quality. Previous studies, however, on cv. Cambridge Vigour showed that such epidemics had no effect on yield in the following year (Freeman and Pepin, 1969). The purpose of the study described here was to determine the effect of post-harvest mildew epidemics on the yield and plant vigour of the very susceptible cultivar Elsanta, and if mildew control at this time would improve disease control in the following season.

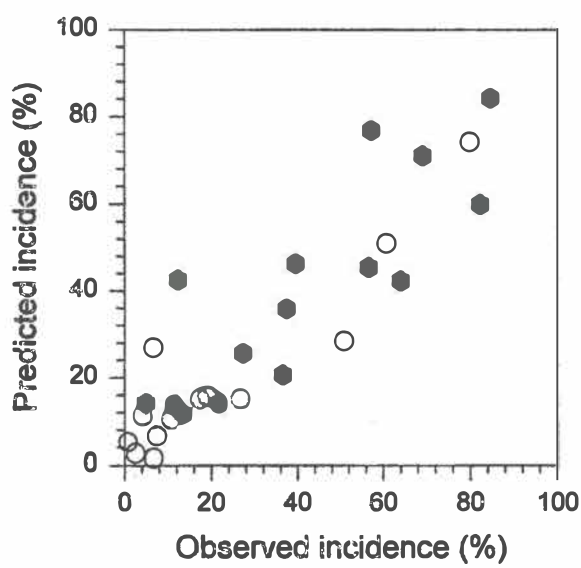

Fig. 1: Incidence of infection of strawberry flowers by *B. cinerea* predicted by the regression model against the observed: open – 1995; filled – 1996.

Effect of powdery mildew on yield

The effect of powdery mildew on yield was studied in a replicated small plot field experiment at HRI-Efford. This was established in June 1992 and continued for two cropping seasons. The experiment was repeated in 1994 and also continued for two cropping seasons. The yield of cv. Elsanta in plots where mildew was controlled by an intensive programme of sprays of myclobutanil or bupirimate was compared with that in unsprayed plots. Additional treatments were included where mildew was controlled either in the autumn or spring using myclobutanil. The treatments applied and the numbers of sprays used are shown in Tables 2 and 3. The incidence of mildew was assessed monthly as the percentage mildewed leaf area. Fruit was harvested twice weekly and total yield and quality were recorded. An assessment of plant vigour was made by estimating the mean plant volume in the winter.

The use of intensive programmes of myclobutanil or bupirimate in the autumn maintained significantly lower levels of mildew on treated plots compared to unsprayed plots (Table 4). No mildew was recorded in the spring in any plot, despite the high levels the previous autumn. The effects of treatments on yield (Table 5) were small, inconsistent and not statistically significant in any of the four years. Plants heavily mildewed in autumn 1992 and 1993 were significantly smaller (Table 6) compared to those on sprayed plots. However, these differences, though very obvious in winter, soon disappeared when growth resumed in the spring.

Table 2. Treatment timing and fungicides applied to plots of strawberry cv. Elsanta in trials 1 and 2

Treatment	Autumn post-harvest	Spring pre-harvest
A	Nil	Nil
B	myclobutanil	myclobutanil
C	bupirimate	bupirimate
D	Nil	myclobutanil
E	myclobutanil	Nil

Table 3. Numbers of sprays of myclobutanil or bupirimate applied post-harvest and pre-harvest to strawberry cv. Elsanta in 1992-4 (trial 1) and 1994-6 (trial 2)

Year/timing	Treatment	Nos. of sprays
1992 autumn	B, C, E	14
1993 spring	B, C, D	3
1993 autumn	B, C, E	10
1994 spring	B, C, D	4
1994 autumn	B, C, E	11
1995 spring	B, C, D	4
1995 autumn	B, C, E	11
1996 spring	B, C, D	4

Table 4. Percent mildewed leaf area in Trials 1 and 2 recorded in Autumn (October or November)

Treatment	% leaf area mildewed			
	Trial 1		Trial 2	
	1992 8 Oct	1993 13 Oct	1994 2 Nov	1995 3 Oct
A Untreated	17.0	10.6	10.7	39.1
B Full myclobutanil	2.4	0.9	3.2	2.9
C Full bupirimate	1.2	1.0	3.7	7.0
D Spring myclobutanil	20.2	9.6	11.9	39.7
E Autumn yclobutanil	3.0	0.8	2.6	4.0
S.E.D. (12 df)	0.8	2.0	1.4	2.2

Overwintering mildew

In the trials conducted at HRI-Efford described above, powdery mildew was not recorded in untreated plots in the spring, despite the high incidence the previous autumn. Previous research (Peries, 1961) concluded that green leaves are the main means of perennation by mildew in strawberry crops in the UK. Overwintering of mildew in the Efford trial was studied by tagging mildewed green leaves in autumn in 1994-6 and monitoring their fate over the winter and spring.

Almost all tagged leaves in most of the years had senesced and died by the spring. The new leaves which had developed over the winter were mildew-free in spring.

Table 5.: Mean total yield per plant (g) for strawberry cv. Elsanta in Trials 1 and 2 (1993-6)

Treatment	Mean yield/plant (g)			
	Trial 1		Trial 2	
	1993	1994	1995	1996
A Untreated	787	1050	962	1468
B Full myclobutanil	909	1019	1078	1493
C Full bupirimate	852	1013	1028	1384
D Spring myclobutanil	725	997	879	1400
E Autumn myclobutanil	854	1092	992	1388
S.E.D. (12 df)	58.9	58.6	59.1	89.5

Table 6. Mean plant volume* (litres) in December 1992 (Trial 1) and January 1996 (Trial 2)

Treatment	Mean plant volume (litres)	
	1992	1996
A Untreated	4.7	19.3
B Full myclobutanil	8.0	25.1
C Full bupirimate	7.3	24.2
D Spring myclobutanil	4.4	19.5
E Autumn myclobutanil	7.5	22.9
S.E.D. (12 df)	0.7	1.5

* Estimated from measurements of plant height and spread in two directions and using the formula for a sphere segment ($\pi h\ (C^2/8 + h^2/6)$ where C = mean spread, h = height).

Cleistothecia may appear occasionally in mildewed strawberry crops in late summer but were considered by Gilles (1961) to be unimportant in the perennation of mildew. Cleistothecia were never observed in the trials at Efford. However, there was a consistently high incidence of cleistothecia on mildewed plots of cvs. Elsanta and Calypso at HRI-East Malling. Unlike the Efford crops, early spring epidemics of powdery mildew were observed in these plots and appeared to be associated with the presence of overwintering cleistothecia. These observations indicate that the significance of cleistothecia in mildew epidemiology needs to be re-appraised before strategies for managing powdery mildew to minimise fungicide use can be established.

Conclusion

For *Botrytis cinerea,* the results indicate that it may be possible to identify flower infection periods on the basis of two easily measurable components of weather – VPD and temperature -while the inoculum concentration model needs further refinement. Further work will build on the results obtained so far to validate and modify the models where necessary. Eventually it should be possible to develop a management strategy for control of Botrytis fruit rot that combines a disease warning system, to optimise fungicide use, with strategies to minimise the risk of the development of resistance to fungicides and incorporates cultural methods to reduce overwintering inoculum if appropriate.

For powdery mildew, the studies have confirmed the results of previous research which showed that post-harvest epidemics of powdery mildew had no effect on yield. However, further work is needed to establish the role of cleistothecia in the epidemiology of the disease. Once these facts are known, the importance of mildew control post-harvest can be established. It may then be possible to develop a simple management strategy to optimise fungicide use.

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Efficacy of various insecticides for the control of *Anthonomus rubi*

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Abstract: The insecticidal compounds Phosalone, Endosulfan, Quassia, Pyrethrin, *B.t. tenebrionis* were tested for their efficacy against the strawberry blossom weevil as commercial formulations in crop relevant application rates in Burgenland, in Austria. The compounds were intended to be used in integrated strawberry production, but could not sufficiently reduce plant damage, compared to the effect of the reference pyrethroid compounds. Decis, the only authorized insecticide for the control of *A. rubi* in Austria (Decis) exhibited low efficacy. The reasons for the variation of efficacy levels of insecticides against *A. rubi* and consequences of the test results for IPM strategies are discussed.

Introduction

The strawbernry blossom weevil *A. rubi* is considered as one of the main arthropod pests on strawberry in Austria. Actually only Decis (Deltamethrin) at an application rate of 0,03-0,06% is authorized for the control of this pest. However pyrethroids are usually not accepted as suitable plant protection products for integrated fruit production in general. Experiences about the efficacy of other, more selective chemical or biological control agents were lacking. Therefore trials were initiated at the BFL to test the efficacy of various compounds which were known to achieve good control against other blossom weevils in pome fruits and which are suitable with regard to integrated pest management.

Material and Methods

The trials were carried out in two successive years with five test compounds. As trial site served a one year plantation covered with approximately 1700 strawberry plants in 12 rows of the cultivars ElSanta and Marmolada at a proportion 1:1.
Plot design included 4 replicates per treatment each consisting of about 90 plants in three parallel rows and the plots arranged in a block design.

In 1994 as test compounds
- Rubitox (Phosalone) 0,2%
- Novodor *(B. t. tenebrionis)* 0,5%
- Thiodan (Endosulfan) 0,3%

and the reference product Sumi-alpha (Esfenvalerate) 400ml/ha were applied.

In 1995 as test compounds
- Bionomic Bitterholz Extrakt (Quassia) 0,2%
- Spruzit (Pyrethrum) 0,1%

and the reference product Decis (Deltamethrin (0,06%) were sprayed.

Control plots were treated with water. The application volume ranged between 600-800l/ha. Two treatments in a 7 day interval were carried out in both trial seasons with a commercial knap sack sprayer. Applications were started after the first occurrence of damaged blossom stems.

For evaluation the number of damaged blossom stems per plant from 10 plants from the middle row of each block (replicate per treatment) was counted. Assessments were carried out at d 0 shortly before the first treatment, at d +7 after the first treatment and at d +7 after the second treatment. The differences in the percentage of damaged blossom stems between and within the different treatments was statistically evaluated per each evaluation date with an ANOVA (SPSS). Percentage data were angular transformed before processing.

Results

Neither in 1994 nor in 1995 statistically significant differences were found in the percentage of damaged blossom stems between the different treatments or replicates before the first application.

In 1994 the infestation level in the control plots reached 45,5% at the last evaluation date (fig. l). Treatments with Thiodan 0,3%, Rubtiox 0,2% and Novodor 0,5% did not lead to a significant reduction in the infestation level, whereas the reference product Sumi-alpha 400 ml/ha reduced the percentage of severing by 81%.

In 1995 the infestation rate in the control amounted up to 66% , while no significant reduction of infestation rate was achieved after the application of Quassia 0,2% or Pyrethrin 0,1%. Decis 0,06% as reference product reduced the infestation by 47% (fig. 2).

Discussion and conclusions

None of tested chemical or biological insecticides sufficiently controlled the strawberry blossom weevil. In contrast the reference products belonging to the chemical family of the pyrethroids achieved better control. Surprinsingly however the only authorized product for *A. rubi* in Austria, Decis only reduced the percentage of damaged blossoms by approximately 50%. A comparison of results from trials conducted at the BFL during the last 10 years demonstrates however that the efficacy of the same test compound can be varying to a great extent in different trial years at different trial sites (tab. 1). This can be explained by several factors influencing the infestation level of strawberry blossom weevil. The damage is usually higher in younger plantations than in older ones, or in cultivars with fewer blossoms or in cultivars early ripening. Economic treshold levels applicable to a majority of field situations are not available for *A. rubi* in strawberries. Additionally temperature differences can be responsible for the different extent of efficacy an insecticide can exhibit. This could also be the reason for the differences in the effect of Decis 0,06% towards *A. rubi* in the different trial years. The results of the presented trials are not encouraging for the the use of the tested compounds in IPM-strategies, because of insufficient control of the key pest. Further trials with other compounds perhaps from other chemical families have to be carried out or different ways of biological or biotechnical control have to be considered to provide a tool for selective control of the strawberry blossom weevil within integrated production of strawberries.

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Tab. 1: % reduction of infestation with *A. rubi* in strawberry

Product name	Active Ingredient	Appl.1 + 14 days	Appl.2 + 7 days	Appl.1 + 7 days
Decis	Deltamethrin	57-71 %	47 %	11-100 %
Fastac	Alpha-cypermethrin	0-66 %	/	60-100 %
Mavrik	Fluvalinate	63-74 %	85 %	65-77 %
Sumicidin	Fenevalerate	35-98 %	/	19,7-99 %
Sumi-alpha	Esfenvalerate	62-100 %	80,7 %	53-100 %
Evisect	Thiocyclamoxalat	68-78 %	88 %	83-90 %
Thiodan	Endosulfan	/	2,9-44 %	0-66 %
Rubitox	Phosalone	/	8,1 %	8,9 %
Spruzit	Pyrethrum	/	9,7 %	26,8 %
Bionomic	Quassia	/	6,6 %	10,4 %
Novodor	*B.T. tenebrionis*	/	0,0 %	16,0 %

Fig. 1. : Infestation rate with *Anthonomus rubi* and efficacy of test compounds in 1994

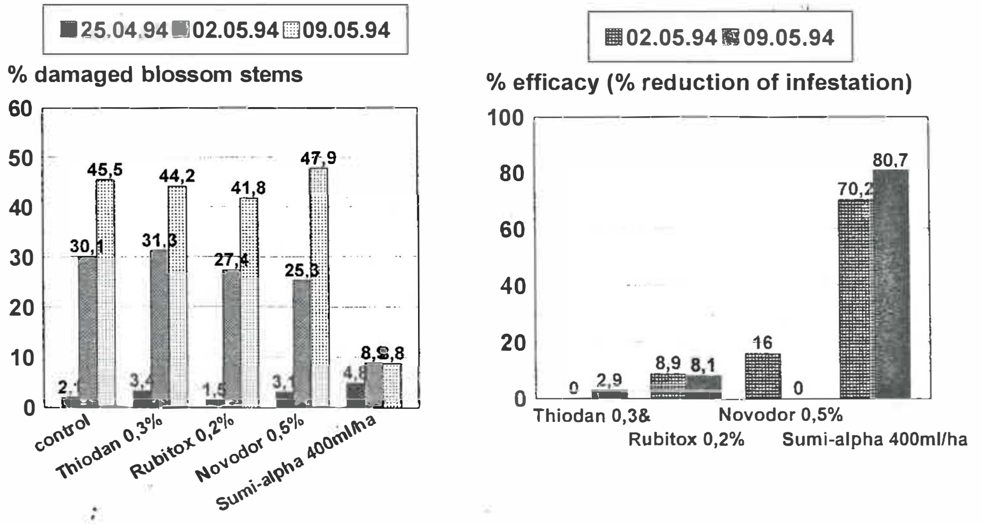

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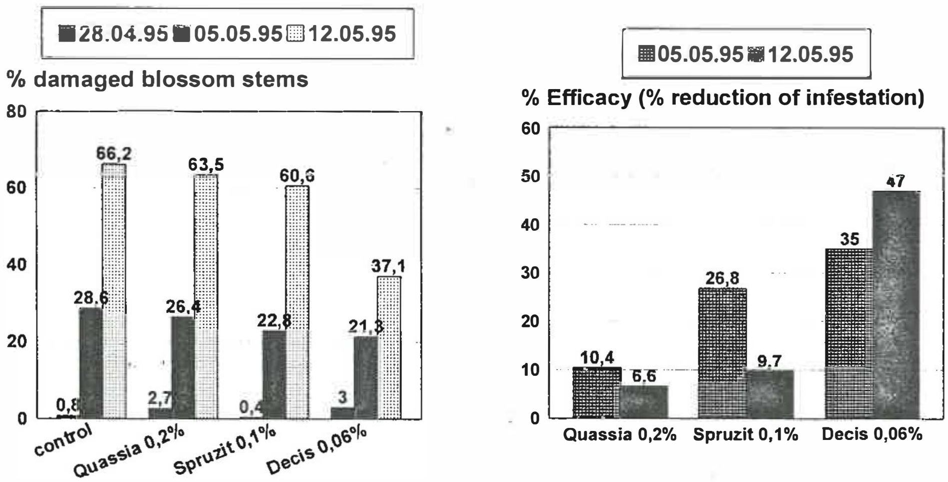
Fig. 2. : Infestation rate with *Anthonomus rubi* and efficacy of test compound 1995



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