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# Second International Symposium on Plant Health in Urban Horticulture

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Federal Minister of Consumer Protection, Food and Agriculture, for the conference volume of the Second International Symposium on Plant Health in Urban Horticulture, to be held in Berlin from 27 to 29 August 2003

# Preface

Every day all of us benefit from our natural living environment. Our cities would scarcely be worth living in without flower beds, without trees and green areas.

The way of living of urban dwellers has dramatically changed during the recent 100 years. While around the year 1900 only about 10 % of the world's population lived in cities, we are talking about 50% today already. According to forecasts, up to two-thirds of the world's population will live and work in urban centres in only 20 to 50 years from now. At the same time, the demand for urban gardens, green parks and sports grounds and green recreational centres on the outskirts of cities has risen: for public green spaces and squares, playgrounds, sports grounds, allotment gardens, private gardens, roadside trees, greened roof gardens, inner courtyards and balconies. They form essential parts of the cities because they substantially determine the city-dwellers' quality of life.

Our observations focus on human beings, their quality of life and hence also on preventive consumer protection. Plants with little tending and sick plants, that may even be in the wrong location, can also impair our quality of life. This is why the Federal Biological Research Centre for Agriculture and Forestry has set itself the new priority task of elaborating concepts for healthy and productive plants in urban green spaces.

Trees constitute a sensitive urban good. Some dangers are visible to everybody: in Germany, the chestnut trees in parks, squares and along avenues lose their leaves every year in the summer, and that much too early. The horse chestnut leaf-miner is just one example of the consequences that may arise upon the introduction of pests into ecdemic habitats. Ten years ago, this pest was unknown in most German regions.

Pests can spread like an explosion without natural enemies to curb them and can wreak great havoc. I highly appreciate the fact that current research findings about the infestation control of the horse chestnut leaf-miner are being exchanged and discussed here in-depth.

This summer, there is another piece of news that greatly worries the population here in the federal capital of Berlin of all places: there are fears that the cottony maple scale could infest up to 70% of tree stands here in summery Berlin.

Scientists, therefore, increasingly also address the issue: What are the actual implications for urban trees if several different damaging agents occur together? As is well known, pests represent just one of many sources of danger: We human beings expose plants to many other stress factors: This includes, for example, airborne and soilborne pollutants or damage to trunks and roots caused by traffic or construction or wrong pruning and tending measures. There are interactions between abiotic and biotic stressors that frequently cause damage to urban greenery. Intensive interdisciplinary communication is, therefore, absolutely crucial.

Already during the **First International Symposium on Plant Health in Urban Horticulture,** that was held from 22$^{nd}$ to 25$^{th}$ May 2000 in Braunschweig, around 150 scientists from 30 countries pointed out, discussed and formulated joint approaches to solving phytosanitary problems in urban horticulture, comprising various fields in an international context.

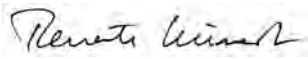
The **Second International Symposium on Plant Health in Urban Horticulture** focuses on keeping plants in public green spaces in healthy conditions. The overall aim to avoid, if possible, the application of chemical pesticides to control harmful organisms in urban areas also applies to urban gardens and amenity areas. Should these products prove necessary after all, what matters is to apply only the necessary amount and not more.

Important are innovative elements to enhance the plant's resistance to abiotic stress factors, but also to soilborne fungal disease agents, by the targeted use of symbiotic mycorrhizal fungi, for example. Just as important are the diagnosis and monitoring of tree diseases and pests as well as the analysis of the impact of damaging agents, such as soil compaction or flooding, on plant health.

These are only a few examples from a wealth of key topics which will be presented and discussed during this Second International Symposium on Plant Health in Urban Horticulture.

I am confident that this Symposium will be helpful in enhancing the urgently required interdisciplinary communication between the different stakeholders and in networking activities on a national as well as international level.

The Symposium must serve one purpose above all: to preserve the beloved greenery for city-dwellers!!



Renate Künast

# Table of Contents

## Postersession 225

# Urban horticulture – the way for the future

**NEUMANN, K.**

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## Heading for a retreat? Wealth creating poverty or poverty creating wealth - Modifications in the urban horticulture in the context of social, economic and cultural changes

### On the one hand: Value!

Berlin, October 8, 2002. The inauguration lecture of the economist Rolf Brüning in the new field "Service and society" in the faculty of landscape architecture and urban development. The lecturer begins his first lecture with a question: "What did Vincent van Gogh have in common with you, your profession as a landscape architect and your product – urban greens?" This question about person and product was followed by incredulity and silence, so the lecturer helped his students on. "You know", said the lecturer, "van Gogh, who was born in Brabant in 1853, was at first a failure as an arts vendor, then he became a schoolmaster in England, then an independent missionary for the miners in Borinage. Then he became a genius painter of cities and landscapes, maybe the biggest ever. He ended as a voluntary patient of the St. Remy asylum, where he lived in deepest poverty, and in the end he killed himself because people did not recognize the value of his product (paintings), and all his life he had sold only one painting for a symbolic value of a few Gulden."

Students were still to incredulous to break their silence. The lecturer gave a simple but convincing answer: "Just like you, van Gogh created permanent value for the society beyond all doubt. None of the created value fell back on him or his contemporaries (such as Paul Gaughin). You too create value: Greens, parks, avenues or green urban places. But often, the value is underestimated rather than recognized. What is even more worse: If the value is at all recognized, frequently others benefit from the (monetary) value creation and the resulting profits. So let us deal with the questions and objectives of your studies: Will you create value? Does your product, "greens", create value? Which value? Who benefits from the created value? Who will pay how much for the value? Who will be able to pay for it if the state has less and less money to spend?"

### On the other hand: No value!

"Greens going to waste – Berlin covered in weeds", began the acid ironic editorial of Rüdiger Thunemann in the daily newspaper Berliner Morgenpost of August 22, 2001, commenting the column of the same day which appeared under the header: "Green rules – on boardwalks, playgrounds, on road divisions, weeds growing up to your hips all over Berlin". The chronic of suffering of the last years prove that this statement is not just a pun for the day:

| | | |
|---|---|---|
| 06.06.1997 | Berliner Wirtschaft | "Don't sacrifice public greens to save public spending" |
| 29.04.1998 | Stadtforum, Journal SenSUT | "Will the last greens go to waste?" |
| 19.02.1999 | Berliner Tagesspiegel | "Greens along roads unkempt" |
| 07.04.1999 | Berliner Tagesspiegel | "No more money for parks and kindergartens" |
| 30.04.2000 | Welt am Sonntag | "Tiergarten dies – senate just sits and watches. Urban developers, environmentalists and CDU protest against the waterloo of Berlin's most popular city greens" |
| 20.12.2000 | D. Hinz, inquires Berlin Parliament | "SOS for urban greens! On the situation of the district offices for nature and greens protection" |

| | | |
|---|---|---|
| 17.01.2001 | Berliner Wochenblatt | "Public Finance Office warns against "Total loss of greens" - no money for necessary upkeep" |
| 27.11.2001 | Neues Deutschland | "Parks and greens on the brink" |
| 29.11.2001 | Frankfurter Allgemeine | "Unkempt – gardening experts complain that urban parks rot to slums– well-kept greens would be great benefit for Berlin as a location" |
| 10.02.2002 | Berliner Tagesspiegel | "No end for savings course: Does Berlin have to live in want? Dry wells, unkempt greens – small defects are a great worry" |
| 13.09.2002 | Märkische Oderzeitung | "Frankfurt greens in great danger" |
| 13.11.2002 | Berliner Tagesspiegel | City Construction Council: "Can no longer upkeep urban greens" |
| 17.06.2003 | Berliner Kurier | "Strieder kills our Linden trees" |

Of course these are only the headers of the daily gazettes. They are not a basis of scientific evaluation. But they do give a – if only psychological - impression of the valuation and attitude towards urban greens. They give us an idea of the position of urban greens, parks and public gardens in general, and plants in particular, might have when public treasuries are empty. Maybe must have in future, when the level of the past economic boost and investment in greens can't be maintained. Economy, society and culture are subject to a change of values and paradigms from which nature can't be excluded, or shouldn't be excluded.

## Greens as a mirror of social and economic systems

The appearance of cities and landscapes, urban free zones, parks and public gardens has always been a mirror of economic, social and cultural systems. Public parks and small tenant gardens were introduced to realize basic socialist ideas. Parks around castles or the gardens of villas have manifested the outstanding political, economic and social position of their proprietors. Urban wasteland, rural zones and urban biotopes have reflected a basic ecological attitude. Greens, either designed by man or left to nature's rule, have always, and still do, reflected social groups. Today, useless industrial wastelands, empty housing areas and depopulated regions, upkeep of which would be cancelled if no more subsidiaries were paid, announce a fundamental change of paradigms. For many European regions, and almost all greater urban zones and urban regions, the future tasks will be: say goodbye to expansion plans, think about new preventive concepts [7, 11]. Global studies show that in the context of globalization, growth in Europe means retreat. This is illustrated by the closing down of big economical and industrial branches such as agriculture, coalmining and shipbuilding. The transfer of production, manufacturing and processing plants to countries with the lowest wages creates domestic industrial and agricultural wastelands. Regions are created whose main sources of earning finally dry out. Rationalization and modernization of the remaining labor areas may bring profits to the shareholders, but at the same time they may vacate plants and works of their people, in particular in urban zones. In line with the Zeitgeist, this degression is euphemistically called "shrinking fit". The related unemployment causes migration. Formerly blooming industrial and agricultural zones like the Ruhrgebiet, Lausitz or Mecklenburg-Vorpommern are losing their population. This is further aggravated by the general population reduction all over Europe. Germany is going to shrink from presently 82 million to 62-65 million inhabitants by the year 2050 according to different statistics [22, 25]. Almost all cities and urban centers complain about drastic loss of citizens. In Zittau, a very drastic example, population fell by 50 %, in Leipzig by 20 %, or 100,000 inhabitants [8]. Frankfurt (Oder) has been reduced from 88,000 to 67,000 residents. Cities like Cottbus, Magdeburg, Halle have up to 40 % empty flats. In Leipzig, this means an inventory of 60,000 empty flats, and 1000 gaps in the building lines and wasteland that will not soon be utilized. Everywhere, concepts are required for demolition or reconstruction of housing areas, kindergartens, schools, even churches or churchyards. Even cities and previously prospering regions such as Düsseldorf, Cologne, the Rhine-Main area with Frankfurt and Mannheim are concerned by degressive growth. More than one million flats are empty in the new federal states. 450.000 of which are to be "taken from the market" – demolished [18]. At the same time, globalization and the growing together of Europe create new multicultural social structures and population layers, which raise different cultural

requirements to urban development, construction [21] and urban greens. Some examples are the utilization of classic parks for spontaneous family parties, barbeques and fun parties of friends, clans, and greater families, or the multicultural garden party or the Love parade. Other examples are mass-events joggers, bikers, sitters or runners in the greens. These exemplary forms and uses of greens show how the citizens' attitude towards the greens has changed. The underlying morale and values are that of unlimited freedom: Everything goes, everywhere, at all times, and for everyone [19]. Fundamental changes are ahead in the small tenant gardens and churchyards in the near and medium future. Classic small gardens will become too much [20], and the changed attitude towards burials creates very different requirements to the traditional churchyard culture. More and more people ask for anonymous burial, or cremation. This reduces space requirements from 12-15 m² for earth burials to 2-2.5 m² for urn burials, which means all over Germany, churchyard zones will become redundant. Dresden presently has excess space of approx. 7000 acres [9]. By 2010, Berlin will have approx. 60000 acres excess churchyards. Today, churchyards are still green oases in the city, zones for rest and meditation for people, frequently undisturbed biotopes where animal and vegetal species may prosper. But in future, these spaces will no longer be needed. Considering the costs for care and upkeep of 1.12 EUR/m² to 1.20 EUR/m² it becomes obvious that this is not only a problem of space, but even more an economic problem due to drained public treasuries.

| **Answer →<br>Question ↓** | **Creating parks and public greens !** | **Designing beautiful public urban green places !** | **Optimal public traffic !** | **Better parking solutions !** |
|---|---|---|---|---|
| citeria for living and staying in the city? | - Frankfurt 94 %<br>- Cologne 81 %<br>- Hamburg 78 % | - Cologne 87 %<br>- Frankfurt 90 %<br>- Hamburg 83 % | - Cologne 78 %<br>- Frankfurt 73 %<br>- Hamburg 72 % | - Cologne 70 %<br>- Franfurt 71 %<br>- Hamburg 70 % |
| criteria for moving in the city? | - - Frankfurt 85 %<br>- Berlin 71 %<br>- Leipzig 73 % | - Frankfurt 80%<br>- Berlin 64 %<br>- Leipzig 59 % | - Frankfurt 73 %<br>- Berlin 58 %<br>- Leipzig 51 % | - Frankfurt 75 %<br>- Berlin 71 %<br>- Leipzig 68 % |

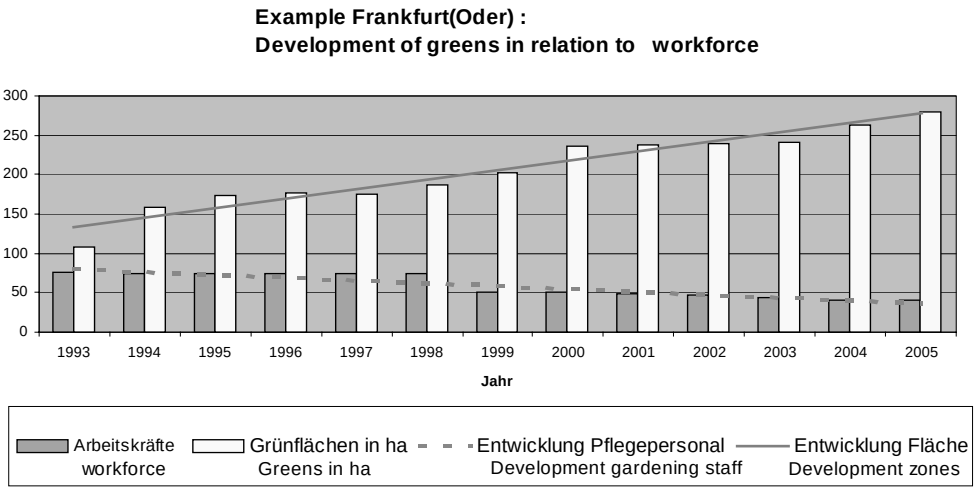
These processes of change are supplemented by manifold new requirements and expectations raised towards urban greens. The service society with its new jobs and labor processes, the investors and global players of the big industrial corporations less and less require drab gray workplaces in plants or warehouses. Living and working in the green, like "Living at the Lenne-Park", "Office center with waterfront view" or "Shopping in a green oasis " – green urban green places, cleverly designed, cleanly kept and plated with a great variety of plants will more and more become vital, soft criteria for locations, defining the image, attractiveness for investment and housing decisions in a city [6].

Before the background of growing density of construction lines, and growing sealing of cities, more and more people all over the world are getting aware of the value of urban greens for medical health [26] and psychological wellness [4].

Many facts make a change of paradigms seem inevitable. Less people, less industry, less work means less money. Money for the realization of social, cultural and social responsibility of the municipalities. Of course it also means less money for nature and ecology of cities, for the maintenance of value and health, for quality control and the necessary maintenance and upkeep of urban greens. Annette Kögel described the related slow but sure reduction of the quality and attractiveness of urban greens in her article in the Berliner Tagesspiegel in February 2002: "Interesting green scars ".

## Green scars

What's so "interesting" about green scars? What is the cause for the ever growing wounds? The figures related to the cities Frankfurt (Oder) or Berlin illustrate the development all over Germany. They show the degressive growth in personal and material funds in relation to the simultaneous progressive grows of green and free zones.




In Frankfurt (Oder) we see a growth of urban green and free zones from 10800 acres in 1993 (100 %) to 23700 acres (2001) with a growth forecast up to almost 27000 acres by 2005 (250%), accompanied by constant reduction of workforce by almost 50 5 until 2005, from 76 to 40 persons. The granting and provision of funds for maintenance of greens has been reduced over the same time from almost 45 % or 356,000 EUR (1995) to 250,000 EUR (2000). A similar, but even worse development can be seen in Berlin. While the public greens have grown up to 50 %, e.g. in the Hellersdorf district, from approx. 63900 acres (1990) to 113500 acres (2000), funds to cover an average of 81 % have been granted to the district until 1996. By 2001, the funds have been reduced to 47%. Actually, after further internal saving measures in 2001, the competent authorities have only received 20 % of the required funds. No wonder that the Mayor of the district Schöneberg/Tempelhof almost had to declare the affidavit. In spring 2002 he announced "From summer 2002 on, there will be no money for gas for the maintenance vehicles." This means goodbye to the minimum care which used to be upheld in order to safeguard traffic security and eliminate possible causes for accidents. Lack of funds might lead to realization of an idea conceived in Cottbus in 2001: "employ prisoners to upkeep of the public greens, who are much cheaper than the men performing alternative national service who used to work there".

In the social, cultural and economic reality, it is by no means unusual that a poorer phase follows a prosperous phase. The bible already told us in Moses 1,41, The dream of Pharao, that seven meager years are going to follow after the seven fat years. In the business economy, there is always the option of selling an excess of goods, products, real estate etc. (or demolish houses and flats), or let them go to waste and rot. But what to do with the public greens? Even a political majority of all political parties, or a decision by the German Supreme Court, could not successfully realize a "no-growth for lawns" policy to make sure the greens wouldn't have to be upkept in the future. Not even a majority of the votes in the German Parliament or mediation council could effect that kiddies sandboxes in parks were no longer contaminated with dogs urine or birds feces to save costs for the exchange of playsand. What I want to explain is that in contrast to the economic behavior in times of recession (sales, waste, no luxuries, reduce offer etc.) such cost-saving measures can't be applied to nature and urban greens. Cities may be rich or poor – leaves will fall, plants need water, spores or insects damage our vegetation. Nature doesn't care for public exchange rates or account balances. What consequences do we have to recognize for handling or product in the future? There are two different models, two barometers of moods:

## Acceptance of sustainability of greens, confession to an investment in the future

The attitude is either lack of money, lack of headcount, or sometimes there is insight and understanding that the "Green Wealth" of a city won't come for free. "Clean greens, bubbling fountains and accessible roads. Not the great new projects, but the small, cheap things make living in a city pleasant, and support

social peace. Not much saving potential there, but great effects", announced the City Construction Council of the District Central Berlin in February 2002. The "just let it grow" mentality of many Urban Treasurers and Financial Offices may be a day-to-day solution. But how to treat the scars cut by this "don't think about tomorrow" attitude? Don't they reduce urban, housing and working quality over the medium and long term, don't they create social hotspots and don't they threaten the existence of small and medium companies, such as gardening and landscaping service providers? Interestingly, Martin Wagner, then Urban Construction Council in Berlin, later urban development consultant of the Turkish government, in 1926, in the high time of economic depression in Germany, was already committed to this long-term thinking of sustainability, when he gave following statement: In times of greatest economic troubles, the City of Berlin invested a capital in its green zones that will bear interest". To this daring decision made in a very poor time we owe our present wealth of urban places, public greens and small tenant gardens.

The other model is:

## Our claims are too high. Reduce quality!

We're not well, but on a level we can't maintain because of the general economic budget situation. Relearn modesty! "Make do with less" – that's the other political credo trying to encourage people to amicably accept the scars cut by empty treasuries. In a discussion about the application of the city of Karlsruhe for the National Gardening Show 2013, the CDU-chairman in the Karlsruhe Council, Dr. Klaus Heilgiest, on January 30, 2003 explained: "Serious reductions of the standards of plans and constructions of buildings ……. in the gardening or urban development offices won't be a problem". In the end, such statements and convictions led to the withdrawal from the application procedure for the National Gardening Show 20113. The responsible persons lacked the courage to act for the longterm, to invest in the future.

## Poverty that can make us rich

In the present situation we have to state: At the one hand, retreat is the word for urban greens as a consequence of the actual and overall public poverty. Because of the lack of funds and workforce, there is the risks of the slow and permanent loss of variety of urban greens. Quality and quantity can't be maintained. On the other hand, in the consequence of globalization, economic, demographic, and cultural changes, new zones become available, offering new potentials of richdom for nature and landscape – a new wealth. So the formulae for urban greens read as follows:

1. <u>for the quantities</u>:

$$rf + gs = np + nw$$

**r**eduction of **f**unds + **g**rowth of **s**pace = **n**ew **p**overty + **n**ew **w**ealth

2. <u>for the qualities</u>:

$$lm + lw + ms = lu + rq$$

**l**ess **m**oney + **l**ess **w**orkforce + **m**ore **s**pace = **l**ess **u**pkeep + **r**eduction of upkeep **q**uality

3. <u>for utilization</u>:

$$sd + emc + nv = ipu + lr + nfu$$

**s**ocial **d**evelopment + **e**thic-**m**oralistic **c**hange + **n**ew **v**alues = **i**ncreased **p**ressure of **u**tilization + **l**ess **r**efuges + **n**ew **f**orms of **u**tilization

As this situation is not going to change because of the economic, social and cultural changes, the answers on the questions raised at the beginning of this paper for the green value is very important, actually vital. There is an agreement that "Do as we did" is not the answer. A change of paradigms for urban greens is inevitable. The new paradigms might become the "Ten commandments for the urban green of the green

future". They are the chances to develop a perspective for future green wealth out of the threatening poverty of urban greens.

- The future of public zones and the responsible gardening offices will depend on the success of participating in the economic discussion. Besides the acknowledge esthetic, ecological and social functions of urban greens, the economic functions are of growing importance, if we want to avoid that politics disqualify green zones as uneconomic substance of urban development [2,17].

- The confession that urban greens may and must render a sustainable contribution to securing public treasuries requires careful but purposive application of new market and marketing measures to earn new funds with and in urban greens [16, 23].

- The structures in administrations and the qualifications of the staff as well as the university and training institutions have to adjust to the facts of less money and more space. Change means also change of education, qualification of Human Resources Management, and supplementing professional qualifications [2, 13, 15].

- Maintaining and securing the green qualities of a city for the longterm requires new organizational, administrative and legal standards. That's the only way to benefit from the existing commitment of the citizens for their greens, and to convert it into monetary services. Concepts such as "Waiving fees for road cleaning along public greens", entrance fees to selected parks, donations for public greens and actions such as "event culture and event nature" have to be discussed to secure the future of urban greens [23].

- Class rather than mass should be the word: Only quality counts in the global, national and communal competition for the future of housing and working, health and culture. Modern telecommunication and fast access to locations all over the world, and the possibility of used to be impossible, will leave only one criteria for the future: Quality, i.e. qualification of free zones. Replace mass by class, reintroduce the space dimensions of high-quality free zones. A green backyard becomes a private Arcadia, a restroom at the back, an expanded salon is recovered at the housefront, to be used as a playground or restroom or a market of opinions and goods. "A good salon is comfortable, clean, and – very important – accessible. The request for large, unused urban biotopes is a regrettable basic misunderstanding of nature only city people could conceive."[1]

- During the expansion phases in the past, many zones were planted with greens with questionable esthetic, ecological and functional values. Say goodbye to such zones. Maybe there is even too much green in some areas. In any case however, values, functions and assignments of urban greens have to be redefined [3].

- Many green zones and urban places defined as "public" urban greens are important first of all for direct neighbors such as hotels, banks, business facilities. These private users benefit most from the greens – not the public. Value creation is private, costs are public. Hence financing and participation models as already known from the Los-Angeles-Place in Berlin are required, that warrant a greater cost contribution from the direct users to safeguard the value of the greens [12].

- Urban greens lose their variety of vegetal species, in particular valuable biannuals are more and more reduced. Notwithstanding the budget deficiencies, courage should be used to apply new, unconventional plating concepts, and plant unusual species (e.g. adjustable "praerie plants" from former high-grass praeries), in order to develop attractive, cheap and robust vegetation [24]. In times of change everyone has to open up to new concepts. The courage to make mistake is always part of the change process.

- Growing and prospering are primates of nature as are dying and rotting. The conventional urban nature protection dedicated to statically to conservation and maintenance needs time as an important dimension. The "Time factor in the conservation of nature" [5] is just as disputed as the position "Nature is not a museum" [10]. Notwithstanding all technical discussions it can be said that natural protection, if limited with regards to time and space, might integrate waste and expansion zones created through the economy, into the urban greens concept, without taking away options for future expansion from the owners of real estate and investors.

- In our Europe of the regions local and regional identities have to be kept regardless of all necessary globalization and opening of business markets. In particular in gardening and landscaping, regional original and local suitability of construction materials, in particular of plants as a living construction material, should be complied with. In the end, cultivation and production conditions adjusted to the location are just as important for sustainable health of the vegetal species, as for the sustainable recovery of the local, regional small and medium construction and gardening companies [14].

## Literature


1 BACK, L., 1998.Verschwindet jetzt das letzte Grün? Das Planwerk und die Lebensqualität der Feiräume. Stadtforum April 1998, 12-13.

2 BAUMGARTEN, H., 2003. Die Zukunft des modernen Grünflächenamtes. Vortrag i.R. des Symposiums „StadtImageGrün-Zur Zukunft öffentlicher Freiräume“, Wiesbaden 13.6.2003.

3 BECKER, G. et.al, 2002. Freiraumstrukturkonzept Berlin. Entwicklung einer Arbeitsmethodik i.A. der Senatsverwaltung für Stadtentwicklung. Berlin 2002.

4 BRÄMER, R., 2003. Zurück zur Natur? Die Wald- und Wiesen-Therapie. Psychologie Heute 4/2003, 21-28.

5 COCH, T., 1998. „Verzeitlichung des Naturschutzes“. Provokante Neuorientierung oder vielleicht auch nur „ein Stück weit Opportunismus“? Naturschutz und Landschaftsplanung 11/1998, 362-363.

6 ECC KOHTES KLEWES, 2002. Renault Befragung in sechs Metropolen Deutschlands. Bonn, April 2002.

7 FREYTAG, A., 2002. Bereit für Brache. Veränderungen von Landschaften und Städten. Stadt+Grün 6/2003, 36-42.

8 HECK, A., 2003. Vom Tapetenzimmer bis zu Dreiecksgeschichten. Stadt und Raum 3/2003, 162-165.

9 MIES, J., 2003. Friedhofsentwicklung in den Neuen Bundesländern. Teil 1: Die aktuelle Situation der ostdeutschen Großstadtfriedhöfe. Stadt+Grün 11/2002, 31-37.

10 MENZEL, P., 1999. Die Natur ist kein Museum. Gartenbaureport 7/99, 22-24.

11 NEUMANN, K., SIEVERTS, TH., 1996. Vom bösen Bauen und der guten Natur. Von der Vorsorge zur Nachsorge, zur Integration von Stadtentwicklung, Umwelt und Naturschutz. DISP 128, Dokumente und Informationen zur Schweizer. Orts-, Regional- und Landesplanung, ETH Zürich, 1966, 44-48.

12 NEUMANN, K., 1999. Die wertsteigernde Wirkung von städtischen Grünflächen auf Immobilien. Schriftenreihe der Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau, März 1999.

13 NEUMANN, K., 2001. Bewusstes Vergessen systematisch lehren. Garten+Landschaft 11/2001, 16-18.

14 NEUMANN, K., 2001. Der Strukturwandel im GaLaBau. Stadt und Raum 4/2001, 65.

15 NEUMANN, K., 2003. Attempto. Zur Situation der deutschen Hochschulen. Garten+Landschaft 1/2003, 18-21.

16 NEUMANN, K., 2003. Reichtum der arm macht oder Armut die reich macht. Stadt und Raum 4/2003, 100-104.

17 NEUMANN, K., 2003. Zu ökonomischen Aspekten im Grünflächenmarketing. Vortrag i.R. des Symposiums „StadtImageGrün-Zur Zukunft öffentlicher Freiräume“, Wiesbaden 13.6.2003.

18 OSWALD, PH., OVERMEYER, K. et.al, 2002. Experiment und Utopie im Stadtumbau Ostdeutschlands. Berliner Debatte Initial 13, 2002, 57-63.

19 PAT, 2003. Kampf gegen zugemüllte Parks. Berliner Wochenblatt, 25.Juni 2003.

20 PREUß, W.,2001. Kleingärtner müssen etwas für die Gesellschaft tun. Garten+Landschaft 10/2001, 12.

21 PININSKI, P., 1999. Globalisierung im Bauwesen. Braucht man eine Antwort auf die Globalisierung? Baukultur 3/99, 53-56.

22 PREISLER-HOLL, L., 2003. Chancen der Nutzung von Freiraumpotentialen. Vortrag i.R. des Symposiums „StadtImageGrün-Zur Zukunft öffentlicher Freiräume“, Wiesbaden 13.6.2003.

23 RUNDER TISCH-BERLINER GRÜN, 2001. An morgen Denken - Wirtschaft, Wissenschaft und Verbände gemeinsam für das Berliner Grün. Denkschrift, Berlin November 2001.

24 SCHMIDT, C., 2003. Präriepflanzen im öffentlichen Grün. Billiger Jakob oder innovativer Impuls? GrünForum. LA 3/2003, 18-20.

25 STEINWEG, R., 2003. Das Zukunftsproblem: Bevölkerungsrückgang und Überalterung in Deutschland. AIV Forum, 1/2003, 15-29.

26 TAKANO, T., NAKAMURA, K. et.al, 2002. Städtische Wohnklimas und Langlebigkeit der älteren Bürger in den Megacitybereichen: der Wert der walkable Räume. Epidemiology und Gemeinschaftsgesundheit 2002, 913-918. Department of International Health Development, Division of Public Health, Tokyo Medical and Dental University.

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# The phytomedical situation of plants under urban conditions

The original habitats of most trees and shrubs are the natural forest and bush zones of the world where the living conditions differ very much from those in the cities. In their natural habitats plants had enough time to adapt themselves during thousands of years perfectly to the environment by genetic selection and other strategies. Those plants which were not able to adapt to changing environmental conditions diminished for ever from this planet. Nowadays, plants are grown in tree nurseries under special conditions which should assure healthy and fast growing plants of high quality as only those earn the best income in the shortest possible time. Fast grown plants which are in many cases kept healthy through plant protection measures are planted on different sites to green the cities. If the cities have enough money these plants are really lucky and get the soil changed, receive start fertilizers, skilled planting and nursing during the first 1-3 years. If this is not the case, many of them do not survive during the first year ending up in municipal compost areas or never grow good enough to fulfil their welfare functions like decoration element, shade plant, dust filter, windbreaker, noise protector, air humidity and oxygen supplier and much more. But only healthy and vital plants can fulfil the expectations, plants dying from thirst or environmental pollution or architectural parsley cannot.

What are now the main factors influencing the special situation of urban plants and how do they affect plant health and the occurrence of pests and diseases?

## Space and water deficiency

Due to the increasing density of buildings and traffic in the cities the space for greening is becoming increasingly scarce. Whereas in major cities in Central Europe 200 –600m2 of space exists for each inhabitant, in Manhattan (USA) less than 30m2 are available. For this reason, the available space per plant is being permanently reduced. What is the minimum for an average urban tree? The minimum space per tree is correlated to the minimum water and oxygen need of the tree species. On average 600 l/m2 are required for a sufficient water supply during one vegetation period. This corresponds to a daily consumption of approximately 55l given a vegetation period of 180 days. Accordingly, a stem disc would have to be at least 17m2 in order to be able to assure an appropriate nutrition supply. This figure has been calculated for non compacted soils where all of the precipitation water is supposed to reach the roots. As this is often not the case in urban areas the stem disc would have to be, according to many authors, two or three times as large: namely 34 to 51m2. Frankly spoken, how many tree discs in our urban green space would meet this requirement? Another problem is the precipitation collection and runoff from the roofs where large amounts of precipitation water are discharged into drains past thirsty tree roots. The groundwater level is normally very deep and cannot be used by the trees so that most of the trees which are not irrigated artificially have suffered from lack of water already for years. The consequence is a higher vulnerability to diseases and pests. As an example Vienna can be mentioned where due to sufficient water supply horse chestnut is less sensitive to the horse chestnut mining moth (Cameraria ohridella) compared to the trees in the neighbourhood.

## Soil sealing

Changing road and sidewalk surfacing have essentially contributed to a deterioration of the situation of urban trees and shrubs. Cobblestone pavement has been replaced by asphalt thus covering the remaining joints and gaps where precipitation water could eventually penetrate. In addition to the reduction of water supply, soil sealing cuts off oxygen supply and air exchange. The result is a dramatic deterioration of the living conditions of soil organisms.

## Urban climate

The average annual air temperature in the city is normally 0.5 to 2°C above the one in the rural areas. Buildings store the heat during the day emitting it during the night to the surrounding area. In addition, the increase in temperature favours the quick discharge into drains which causes a reduction of the relative air humidity in the cities. This characteristic of urban climate leads to an increase in drought stress in trees combined with an artificial prolongation of the vegetation period and reduced frost hardiness of bedding plants. In general, injured plants are more sensitive to diseases and pests. As the development of insects depends to a great extent on the temperature, urban climate favours their development. In the forest, spider mites and aphids play a minor part as damaging factor whereas since a few years urban trees have been increasingly affected by insect pests.

## Dog urine

According to estimations of the city of Berlin each urban tree has to cope with an average of 0,7 to 1,0 l of dog urine causing bark injuries on young trees, considerable nutrient input, alterations in the nutrient budget of the soil and later on of the affected trees. A number of diseases and pests take directly or indirectly advantage from this situation. Scientific studies conducted by the BBA Braunschweig and the Institut für Baumpflege in Hamburg prove that increased nutrient contents accelerate wood decay due to *Perenniporia fraxinea*.

## De-icing salts

The strong winter of the last two years required an increased use of chloric de-icing salt, at least in Austria. Here too, direct and indirect impact can be observed. The contact of above ground parts of the tree with the de-icing salt causes burns on the surface. The main problem is the osmotic stress induced by the penetration of the salt into the soil impeding water and nutrient uptake by the tree roots. Further impacts are disturbances of plant metabolism and dehydration of the protoplasm. It can be proved that the chloride remains available in the soil solution for years and obviously also in the nutrient cycle of the plant itself so that the damaging symptoms (necroses at the leaf rim) may be observed even years after the last application of de-icing salts.

## Air pollution

The damaging effect of air pollutants which reach higher concentrations in the cities than in rural areas, is very well known. Despite a number of international conventions there is no real improvement in sight. As most of the time the leaves show no attributable symptoms, the damaging influence of air pollutants is often ignored or attributed to other causes. Quite a number of publications provide scientific prove for the indirect damages caused by a general weakening of the affected plants which, in combination with other biotic and abiotic factors result in an early sickening or death of the plant.

## Summary

Unlike in their original habitats, plants in urban areas are exposed to a number of negative impacts which make them vulnerable to diseases and pests. Only through the combined effort of all decision-makers from government, administration, research, arboriculture and phytomedicine it will be possible to improve the situation of urban trees for the benefit of humankind.

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# The economic links of urban horticulture

## Introduction

Starting to write this article soon had to be recognized, that there exist two major problems related to the topic "economic links of urban horticulture". The first problem is to exactly define what urban horticulture means and the second one is a big lack of economic data. The following text tries to show at least some relevant aspects and data to describe the situation for urban horticulture in Germany.

## What does „Urban" mean?

Spontaneously one might think that the term urban horticulture is simply self explanatory and can be translated into horticultural acitivities which are carried out in cities. But what does city or urban exactly mean? The german word for city "Stadt" historically originates from "Ort/Stelle" (engl.: place) and meant "Wohnstätte/Siedlung" (engl.: residence/settlement). Up to the age of the Renaissance (1400 – 1800 AD) towns and cities had been distinct areas for living and working, most of them even sourrounded by walls.

Traditionally in the past city could be defined by the functions that had to be fulfilled, e.g.:

- Centralization of trade and production and administration,
- Density,
- Place for leisure time,
- Housing,
- Communication

This strict differentiation between „inner" and „out" or „city" and „rural" does not show the real situation we find nowadays. The German Architect Thomas Sieverts created the term „Zwischenstadt"[1] to describe the fact, that some of the above mentioned functions are moving from the cities towards the rural areas. The term „Zwischenstadt" will be translated as „intercity" in the following text. For example as a consequence the Swiss Government sees the area of Swiss from Zurich to Geneva as a coherent city where the single cities funtion like districts [2]. So most of the country Swiss is seen as a large intercity. The same idea focussing more on developing countries than on industrialized countries is described by the term „rurban zones"[3] „Rurban" describes smaller towns that are rural geographically, but urban socially. They are Semi-rural or Semi-urban, thus, „rurban." Rurban towns are populated by urban escapees seeking a small-town atmosphere. Usually they are located near the city, somewhere in that nebulous rural-urban fringe. Other examples can be found in eastern Germany as a result of the changes, which happened after the reunification. Most of the investments had been made in trade centers, production areas and housing in the souuroundings of the cities. Or as a result of the growth of the cities, which lead to the fact that areas which have been part of the periphery now are part of the centres.

For this article thus urban horticulture means horticulture for populated areas and focusses more on the utilization and the functional use of plants rather than the production of plants.

## Urban horticulture

To show the economic importance of the agricultural sector agricultural economists usually talk about the agribusiness when they describe the linkage between agriculture and other sectors of the economy. Figure 1 shows a scheme which is often used to show the interweavings within the agribusiness.

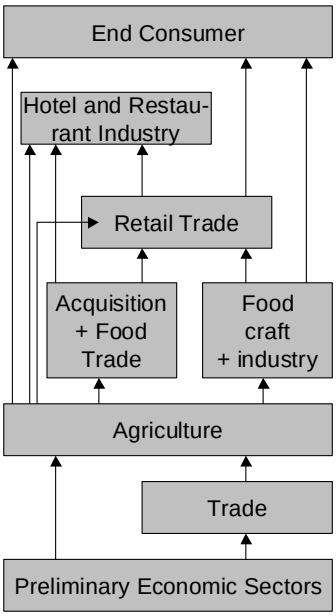


**Fig. 1** Interweavings within the agribusiness [4]

If we use an comprehensive definition of Urban Horticulture we see, that there are certain areas of the economy linked to it (see Figure 2).

Only a few quantitative details about the economic importance of these areas are known. One known fact is, that in Germany in total meanwhile the horticultural services sectors (Landscape gardening, Cemetry Gardening and Indoor Gardening) together have a higher production value than the production sectors (Ornamental Plants, Tree and shrub nurseries, Vegetable and Fruit farms) (see figure 3).

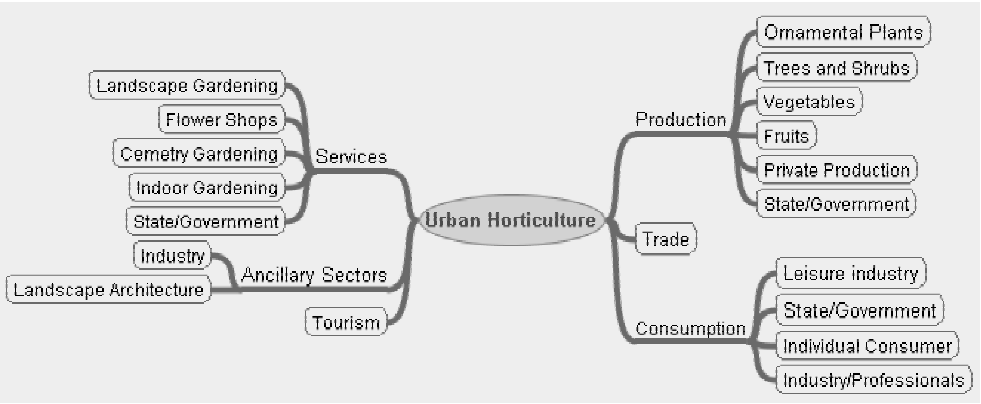


**Fig. 2** Economic links of urban horticulture

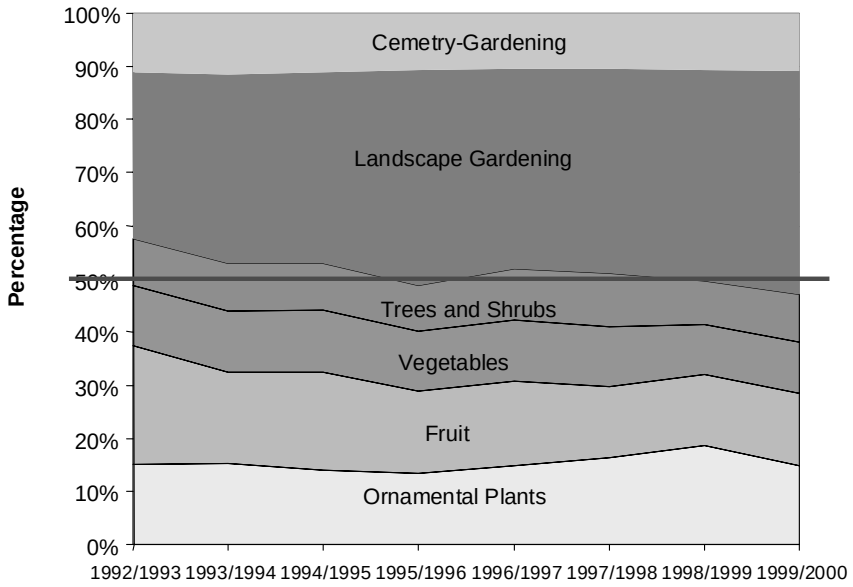


**Fig. 3** Production value of horticulture in Germany between 1992 and 2000 [5]

Not available are quantitative data about the production value of the horticultural sectors of govermental and state institutions and the value adding which is done in flower shops; experts estimate the number of flower shops in Germany to 13.000.

But already the quantitative datas show, that also horticulture is following the roadmap from agriculture to industry to services.

For the agricultural sector in total is estimated, that the production value of the preliminary economic sectors is nearly 115 % of the production value of agriculture and the production value of the subsequent economic sectors is round about 1000 % [4]. Taking this relationship as a basis for an estimation, the horticultural business has a production value of approximately 12 billon uro per year in Germany.

To get detailled quantitative informations about the economic links of urban horticulture further research has to be conducted.

## Literature

1 SIEVERTS, TH., 1998. Zwischenstadt. Zwischen Ort und Welt, Raum und Zeit, Stadt und Land, Braunschweig/Wiesbaden.

2 SIEVERTS, TH., 2002. Zur Diskussion um die Zwischenstadt, Topos European Landscape Magazine, 2002/40, S. 39-44.

3 GRIFFON, M., 2002. L'avenir des dynamiques de développement des zones rural-urbaines: Quel développement durable pour les zones rurbaines ? European Forum on Rural Development Cooperation, Montpellier, 4-6 September 2002.

4 BMVEL, 2000. Agrarbericht der Bundesregierung 2000.

5 BMVEL, Ertragslage Garten- und Weinbau, different years.

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# Garden shows - Motor for landscape management, urban development and industry

Results of a 2002 Difu study with external contributions and a summary of Difu-Materialien 6/2002 »Gartenschauen – Motor für Landschaft, Städtebau und Wirtschaft« in Stadt+Grün 11/2002

„The „Occasional Papers“ are a collection of articles in languages other than German that have been written for various events such as conventions and conferences. They also contain summaries taken from selected publications of the institute.

Among the themes which Difu addresses at the national level are issues and methods of landscaping, urban green spaces, nature conservation, organic and conventional farming, and heritage landscapes. The results have been published in the Internet, in the form of books and brochures after intensive research at the federal, state, and local levels. A new field of activity for Difu are the garden shows planned far ahead of time by the municipalities concerned, and which require early clarification of a wide range of issues. They include essentially the substantive goals of competitions, the provision of sites and venues, the financing of long-term investment, public relations, and programme planning for visitors.

## The history of garden shows


BUGA poster 1951
(source: Hanover Parks Departement)

View of the Aegidientorplatz in Hanover
(source: Hanover City Archive)

German cities look back on one-and-a-half centuries of tradition in garden shows. Such horticultural exhibitions are important projects with a major ecological, urban-development, cultural, and economic impact on the cities where they are staged and on their environs. In the post-war period international horticultural exhibitions (IGA), and federal garden shows (BUGA), and state garden shows (LAGA) have created generous green spaces in German communities. Garden shows have given impetus to the development of urban green spaces, have provided a platform for the discussion of new ideas, and have presented new trends in the utilisation of green areas and parks a broad public.

Over the past fifty years, garden shows have passed through a number of phases and fulfilled a range of functions. From 1948 until 1960 the primary purposes of such exhibitions were to eliminate bombing damage and remove debris, not least of all in combating dust and rat plagues, and to restore devastated urban parks and amenities. The concept underlying the first successful Franco-German project in Saarbrücken was to establish new neighbourly relations between former enemies on the basis of different German and French garden themes in the manner of the fifties and sixties. The enterprise was supported by the German chancellor Konrad Adenauer and the then French prime minister Michel Debré.

From the 1959 Federal Garden Show in Dortmund until well into the seventies, the conceptual focus was on establishing green spaces in densely populated residential areas as ventilation corridors and recreation areas designed as hands-on play and leisure areas for children and young people. In the late sixties car-oriented transportation planning with four-lane highways began to come under critical review. Karlsruhe (1967), Hamburg (1973), Mannheim (1975), and Stuttgart (1977) developed pedestrian traffic concepts, laying out broad vegetated strips with trees and roadside landscaping.

In 1981, the debate on ecological aspects, habitat conservation, and organic gardening in connection with the Fuldaaue and the Baroque Park Karlsaue in Kassel proved highly emotional and had a lasting impact on future garden show concepts. The differences between the opposing camps often proved irreconcilable. The first federal garden shows in the new states of the federation after German unification were staged in Cottbus, Magdeburg, and Potsdam [1]. More recent shows like those in Gelsenkirchen, Magdeburg, Potsdam, and Gera have tackled the rehabilitation and renaturalisation of derelict industrial and military sites.

International garden shows were held in Hamburg in 1973, in Munich in 1983, and in Stuttgart in 1993, covering a total area 339 ha. No federal garden show has yet been organised in Bremen, Hamburg, Rhineland Palatinate, Saarland, Saxony-Anhalt or Schleswig-Holstein, whereas Dortmund alone has staged three shows and Kassel, Cologne and Stuttgart have each hosted two federal garden shows.

## International, federal, or state garden show?

Over the decades, each federal state and city has, with the exception of Bremen and Schleswig-Holstein, developed its own garden show tradition. Municipalities decide what type of garden show to stage – whether international, federal, or state, or some other form of exhibition and competition – on the basis of an initial assessment of innovative urban and landscape planning concepts, competition results, and feasibility studies. International shows take place every ten years, federal shows every two years, and state shows at intervals set by the respective state. Their success depends on the joint creative initiative of the local council, political parties, professional organisations, local and regional citizens, and, increasingly, on financial resources and subsidy management.

Garden shows require five to ten years planning to present acceptable results in the target year. Hamburg and Hanover are competing to stage the international garden show to follow the Rostock exhibition, depending on whether the Netherlands decides for or against the Floriade. While North-Rhine Westphalia has organised as many federal as state garden shows, other states like Baden-Württemberg and Bavaria have more experience in staging state shows. For larger exhibitions, the Central Association of Horticulture (Zentralverband Gartenbau) and the German Federal Garden Show Co. (Deutsche Bundesgartenschau GmbH) lay down certain guidelines, and for state garden shows the competent state ministry should be responsible for avoiding double spending on feasibility studies by competing municipalities.

More or less successful cooperation with the Central Association of Horticulture and the German Federal Garden Show Co. and the financially independent realisation of an international or federal project are increasingly a subject of critical debate among the responsible authorities. In any case, ways must be sought to obtain federal and state support for, e.g., the redevelopment of deprived urban areas in inner cities and outlying areas. For the Potsdam federal garden show alone, over 100 applications for support were filed, according to the development authority. The main areas in which support is requested are:

- brownfield sites,
- contaminated soil,
- flood control,
- nature conservation,
- public transport,
- traffic control and cycleways,
- cultural facilities,
- sports and play areas.

The state garden show was revived after the unification of Germany. In 2002 Hessen, Mecklenburg-West-Pomerania and Lower Saxony organised such exhibitions for the first time. Some states have project or development corporations for state garden shows as well as state regulations that specify goals, supporting organisations, preconditions for applications, realisation, selection procedures, financing, organisational procedures, and scheduling.

Baden-Wurttemberg and Bavaria have most experience with smaller state garden shows. In these states, a state garden show alternates each year with "More Nature in Our Community/City." Looking back on 20 years of experience in Baden-Württemberg, the man in charge Erwin Beyer is convinced that a state garden show involving green space projects is to the advantage of both the sponsoring municipality and the region, as well as attracting a great deal of accessory investment [2].

Saarland and Saxony-Anhalt are staging state garden shows for the first time in 2004. Later shows are being planned in other states, for 2008 in Mecklenburg-West Pomerania and 2010 in Hessen. Some sponsoring municipalities have already supplied information on the size (in hectares) of the proposed exhibition areas and the estimated investment and realisation costs in Euro million.

## Alternative approaches and perspectives

In North Rhine-Westphalia, there was intensive discussion before German unification on the future of garden shows. The Chamber of Architects warned public sponsors with empty pockets against awarding planning contracts solely on the basis of price regardless of competence and quality [3]. North Rhine-Westphalia wanted to abolish state garden shows in general, and was the only state to opt for special forms like regional exhibitions. To date they have been financed from existing state appropriations and support programmes. Garden shows as inter-municipality events can be both pilot projects and presentation locales for a regional exhibition.

In Bavaria and Baden-Württemberg, campaigns for "More Nature in Our City/Community" are staged in annual alternation with state garden shows. These projects are generally on a smaller scale than state shows, but they are able to handle limited themes relating to built-up and greenfield areas. The projects in Baden-Württemberg are outstanding particularly in their exemplary importance and for the sustainable and lasting improvements they have brought in local conditions. Support has been given in particular to smaller towns and communities with a central place function, but also to groups of neighbouring communities or parts of communities that have presented their projects to the public. In Bavaria, support can be obtained for models of exemplary intra-community developed green spaces and recreation areas including permanent amenities.

The best-kept village competition "Beautifying Our Village" is complemented by the federal competition "Our City is Blossoming." The latter was staged for the first time in 2001 and has since been organised annually by the Central Association of Horticulture, the German Association of Cities and Towns, the German Association of Towns and Municipalities, and the German Tourism Association, and serves as a run-up to the European Entente Florale. The competition is a challenge to communities to embellish their urban space with greenery and flowers in a combined effort by authorities, industry, and residents. The criteria for assessment are public, private, and commercial/industrial areas, as well as ecology and garden culture. All communities with more than 3000 inhabitants are eligible to participate, but also towns with districts that have more than 15,000 inhabitants and their own administrative authorities.

## Future challenges

Plans for new international horticultural exhibitions or federal garden shows extend to 2015, and for state and regional shows to 2010. However, it remains to be seen how demographic change and declining municipal revenues will affect planned and projected shows. There are appeals to avoid intra-municipal competition for planning projects and to develop new forms of economically and ecologically successful cooperation in order to improve the quality of sojourn and life in towns and cities, some of which are losing and some gaining population. The regional exhibitions in North Rhine-Westphalia will show whether project quality assurance is achievable through self-commitment and quality agreements with project organisations, and whether this justifies continuing the tradition of the garden show.

Themes for a visionary garden show staged in the context of inter-municipality cooperation and urban development could include:

- subsequent use concepts and stock development in deprived urban areas,
- neighbourhood revitalisation through down-scaling redevelopment and conversion,
- historic public and private gardens and parks,
- noise-free open spaces and squares,
- water quality, waterfront uses and flood hazard areas,
- local recreation, nature conservation, and agriculture,
- pedestrian pathways and cycleways in municipal and inter-municipal green finger connections,
- public transport development and permanent access by means of rail-bound public transport.

### Literature

1 HELGA PANTEN, ZVG e.V., Grünentwicklung im Spiegel von 30 Jahren Gartenschau, offprint (Bundesbaubuch), vol. 17) „30 Jahre Wiederaufbau der deutschen Stadt“, Berlin und Bonn, s.a.

2 ERWIN BEYER, Landesgartenschauen in Baden-Württemberg – Rückblick, aktuelle Situation, Ausblick, in: Luise Preisler-Holl (ed.), Gartenschauen – Motor für Landschaft, Städtebau und Wirtschaft, Berlin 2002 (Difu-Materialien 6/2002), p. 59-73.

3 TANJA BECKERT, Duisburg an den Rhein, in: BDLA-Informationen NW 1/01, p. 19 ff., and Machbarkeitsstudie BUGA Duisburg 2011, commissioned by the city of Duisburg, Bochum 2000.

# Session 1 - Urban ecology and biodiversity

No written abstract available.

# Session 2 - Biotic disease factors pf plants in urban stands

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## The pathogenic fungi on the poplar leaves in Minsk horticulture

Poplars are the one from the most popular species in urban horticulture. Study of the poplars phytopathogenic fungi diversity, distribution and harmful activity is necessary for creation of control strategy and giving recommendations for Populus species cultivation under the modern city conditions, also for Minsk.

We have collected 8 species of the pathogenic fungi from the poplar leaves during 2001-2002 in the central, western and south-western parts of Minsk city. All this collected species are from 7 genus, 6 families, 6 orders Ascomycota, Basidiomycota and Deuteromycota: *Taphrina populina* (Fr.: Fr.) Fr., *Uncinula adunca* (Wallr.: Fr.) Lev., *Melampsora populina* (Pers.) Lev., *Melampsora tremulae* Tul., *Fusicladium radiosum* Lind., *Gloeosporium tremulae* (Lib.) Passer., *Marssonina populi* (Lib.) P. Magn., *Septoria populi* Desm. Also this phytopathogenic fungi species were observed on 9 poplar taxons.

The next pathogens were observed most often: *U. adunca*, *M. populina*, *M. tremulae* and *M. populi*. The most harmful and widespread from them is *M. populina*, which caused the diseases of 6 poplar taxons. The another fungi species have the less hosts spectrum: *M. populi* (5 poplar taxons), *T. populina* (3), *U. adunca* (3), *M. tremulae* (1), *Fusicladium radiosum* (1), *G. tremulae* (1), *S. populi* (1).

The all collected pathogens were observed as singly, so as in complex with another pathogens on the poplar leaves. We have found at the firs time the 9 various pathocomplexes with different combinations of fungi on the leaves of poplar from Minsk urban horticulture. The most part of this pathocomplexes includes only 2 fungi components. But we have fixed the three components pathocomplex (*U. adunca*, *M. tremulae* and *G. tremulae*) on *P. tremula* L. leaves. This founded pathocomplexes includes *U. adunca* and *M. tremulae* most often. The high distribution of the fungi pathocomplexes were observed on *P.* × *berolinensis* (C. Koch) Dippel and *P. tremula*.

The least number of the pathogenic fungi was found on *P. simonii* Carr. and intensity of damage was also minimal. From the other hand, we have collected the most part of the founded fungi species from *P. tremula* leaves. And the level of there leaves damage was higher then on the other poplar species.

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# Up-to-day knowledge and experience on main bark diseases of trees in Zagreb urban areas

## Introduction

During the last decade examined samples from diseased trees in Zagreb urban areas and research results revealed the important role of several bark pathogenic fungi. Some of them were found as weak parasites which occur on predisposed trees, and some as causal agents of dieback. The most frequent fungi turned out to be *Sphaeropsis sapinea* and *Apiognomonia veneta*. Pine trees have been heavily attacked by *S. sapinea* and plane trees differently infected by *A. veneta* in the last ten years. The experience and up-to-day knowledge on these two fungi are presented and discussed in this paper.

## *Sphaeropsis sapinea* (Fr.) Dyko et Sutton on *Pinus* spp.

During the last ten years significant dieback caused by *S. sapinea* have been observed in crowns of *Pinus nigra* Arnold and *P. leucodermis* Antoine. Less damage was found in *P. mugo* Turra, while on shoots of *P. sylvestris* L. the fungus caused no significant damage. Austrian pine (*P. nigra*) and Bosnian pine (*P. leucodermis*) shoots, branches and even hole trees have been heavily affected. Bosnian pine turned out to be the most susceptible to fungus attack.

The typical symptoms of fungus presence were shoots blight randomly positioned in pine crowns. From currently developed shoots the disease spread to older tissues, and the most observed symptoms were dieback of different branch parts. Very often, after some time, the hole branches were affected. Along the trunks of *P. leucodermis*, from the top of the tree and downward, the resin was significantly present. Affected trees highly suffer because of disease infection, and they have been constantly loosing their value in landscape design from esthetical and social point of view.

Concerning to the biology of *S. sapinea* it is well known that some stress factors predispose pine trees to fungus attack. Different abiotic and biotic factors have been associated or found out up-to-day to cause stress and to predispose pine trees to *S. sapinea* attack (CHOU and MACKENZIE 1988, DE KAM et al. 1991, NICHOLLS and OSTRY 1990, STANOSZ et al. 2001, SWART et al. 1987). Water stress (directly or indirectly) turned out to be the most frequent and most important. In previous researches following stress factors were analysed and discussed: drought, pure site conditions, and increased $SO_2$ concentrations, as possible pine predisposing factors for sudden fungus outbreaks not only in urban areas but also on several localities in Croatia (DIMINIĆ 1994, 1999).

Upon our observations during last decade it turned out that Austrian pines when planted in poor soil conditions in private gardens or public places were predisposed to *S. sapinea*. But, when planted in solid site conditions and well maintained parks and tree lines the symptoms haven't been observed or they were not significant. Unfortunately this was not the case with Bosnian pines as they have been observed in good soil conditions and well maintained public areas, but with significantly developed symptoms as consequence of fungus attack.

Since 1990 drought periods have been recorded in Zagreb. The variations in precipitation level have been found out comparing the same months data from year to year, e.g. in May the precipitation was in total 26.5 mm in 1992 or 19.7 mm in 1993, and 115.5 mm in 1995 or 138.1 mm in 1999. Comparing these two pine species it could be concluded that *P. leucodermis* is more susceptible to *S. sapinea* attack than *P. nigra* if planted in the same urban site conditions. Lack of precipitation (plus site conditions) can obviously cause stress to Bosnian pines, and much earlier than to Austrian pines in the same conditions.

Control method has been tested to suppress the disease since 2001. For the purpose an experimental plot was chosen in typical green urban area. Affected Bosnian pine trees were previously pruned (the infected shoots or branches) and then sprayed by carbendazim two times in May. The first treatment was at the time when current shoots were in the beginning of development, and the second approximately three weeks later. The result of applied control hasn't been satisfactory as the symptoms are still present, although the percentage of infected shoots and branches are reduced. One of the reasons for lack of better results is that we have found along the branches of affected trees necrotic lesions in the bark, from which *S. sapinea* was isolated. The infected bark tissues obviously haven't been influenced by systemic fungicide in crown treatment.

According to aforementioned the landscape architectures are advised to avoid Bosnian pine in future landscape designs, in spite of its very nice crown shape, until some progress will be obtained in controlling the disease.

### *Apiognomonia veneta* (Sacc. et Speg.) Höhn. on *Platanus ×hispanica* (syn. *P. ×acerifolia*)

More then ten years the plane trees in Zagreb urban areas have been continuously infected by *A. veneta*. Some years the fungus has caused a serious wilting of young shoots and leaves, and in case of the repeated heavy infections, severe damages have been observed. A few cases of trees dieback as consequence of the fungus attack were recorded. Along the diseased shoots, twigs and branches the small cankers and necrotic lesions, caused by conidial state *Discula platani* (Peck.) Sacc., can be very often found. Symptoms observed were similar to described by TELLO et all. (2000), and one of the frequent pictures seen in heavily affected plane crowns were numerous shoots with short internodes, growing in whorls along branches.

The preliminary results on health status research, carried out in May 2003, in one experimental tree line revealed 30 - 70 % shoots and twigs dieback in plane crowns. The symptoms were mainly observed in the base and in the middle part of the crowns.

Up-to-day the control measures were limited to prevention or sanitary pruning in practical use, and no fungicide applications have been done in urban areas. Leaves were collected in autumn and infected branches were pruned when possible. According to the common practice of pruning in urban areas affected planes were partially pruned in a way to maintain the esthetical shape of crown. Up-to-day this partially sanitary pruning revealed solid results, with aim to eliminate as much as possible the presence of *D. platani* in the infected bark of shoots, twigs and branches.

## Conclusion

During the last ten years the significant damage to shoots and branches have been observed in some pine and plane trees in Zagreb urban areas. Analyses of samples revealed the important role of two pathogenic fungi *S. sapina* and *A. veneta*. The health problem in this tree species is even more complex as the influence of some insects (*Rhyacionia buoliana*, *Leucaspis* spp., *Corythuca ciliata*, *Phyllonorycter platani*), and the rising impact of abiotic damaging factors, including urban environment *per se*, could cause the most weakened individuals to collapse. This was the case with some pine and plane trees in a few urban areas in Zagreb.

According to applied control methods, used to suppress these diseases, we have found that sanitary pruning in plane trees in general, from the practical point of view, can be satisfied. Concerning the control methods applied to pine trees the conclusion is unfortunately opposite. The landscape architectures are presently advised to avoid Bosnian pine in future landscape designs, until some progress will be reached in controlling the disease. Prevention of the disease occurrence should be the main target, according to obtained research results.

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## Literature


1 CHOU, C.K.S., MACKENZIE, M., 1988. Effect of pruning and season on *Diplodia pinea* infection of *Pinus radiata* stem through pruning wounds. Eur. J. For. Path. 18, 437–444.

2 DE KAM, M., VERSTEEGEN, C.M., VAN DEN BURG, J., VAN DER WERF, D.C., 1991. Effects of fertilization with ammonium sulphate and potassium sulphate on the development of *Sphaeropsis spinea* in Corsican pine. Neth. J. Pl. Path. 97, 265–274.

3 DIMINIĆ, D., 1994. Prilog poznavanju mikoza borovih kultura u Istri. Glas. šum. pokuse 30, 21–60.

4 DIMINIĆ, D., 1999. The presence of fungus *Sphaeropsis sapinea* on pines in Croatia. In: B. Forster, M. Knížek and W. Grodzki (eds): Methodology of Forest Insect and Disease Survey in Central Europe. Proceedings of 2nd Workshop IUFRO WP 7.03.10, Sion-Châteauneuf, Switzerland, April, 20–23, 1999. Swiss federal Institute for Forest, Snow and Landscape Research, Birmensdorf, pp. 189–193.

5 NICHOLLS, T.H., OSTRY, M.E., 1990. *Sphaeropsis spinea* cankers on stressed red and jack pines in Minnesota and Wisconsin. Plant Dis. 74, 54–56.

6 STANOSZ, G.R., BLODGETT, J.T., SMITH, D.R., KRUGER, E.L., 2001. Water stress and *Sphaeropsis sapinea* as a latent pathogen of red pine seedlings. New Phytol. 149, 531–538.

7 SWART, W.J., WINGFIELD, M.J., KNOX-DAVIES, P.S., 1987. Factors associated with *Sphaeropsis spinea* infection of pine trees in South Africa. Phytophylactica 19, 505–510.

8 TELLO, M.L., REDONDO, C., MATEO-SAGASTA, E., 2000. Health status of plane trees (*Platanus* spp.) in Spain. J. Arboric. 26, 246–254.

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# The results of phytopatological and mykological research of the trees on Sun lakes in Senec

*Ergebnisse der phytopatologischen und mykologischen Untersuchungen der Gehölze an den Sonnenseen in Senec*

## Zusammenfassung

Zur Ermittlung des Gesundheits- und des Vitalitätszustandes der Gehölze im öffentlichen und privaten Grün wurden neue Methoden ausgearbeitet. Für jedes Gehölz stellte man mit einer 6-punktigen Skala den Schädigungsgrad fest, mit 80 Kriterien bestimmte man biotische und abiotische Schadfaktoren. Numerisch von 1 bis 39 stellte man die Behandlungsart der beschädigten Bäume fest. Mit der einführenden Methode wurden 338 Bäume (35 Arten von 25 Gattungen) an den Sonnenseen in Senec bewertet. Es wurden 86 Pilzarten von 51 Gattungen an 29 Baumarten beurteilt. Am Stamm und auf Zweigen wurden 37 Pilzarten, auf Blättern und Nadeln 48 Pilzarten und an Wurzeln nur eine Pilzart beobachtet. Während der Untersuchung wurden bei 6 Baumarten keine Schaderreger festgestellt. Von den Schadinsekten wurden 8 Schädlinge differenziert.

Schlagwörter: Gehölze, Pilze, Schadinsekten, Schädigungsgrad.

## Einleitung

Nach den Meinungen mehrerer Autoren sind die Gehölze im öffentlichen Grün den Wirkungen vieler negativen Faktoren ausgesetzt, die man folgend benennen kann: Nährstoff-, Wassermangel, Schädigung durch menschliches Einwirken (Astbruch, Stammbeschädigung, Rindenabschürfung, Stammbeschädigung durch Verkehrsmittel, Feuer, etc.), fachfremde und unsachgemäße Behandlung der Pflanzen, ungenügende Pflege der Gehölze (falsches Schneiden der Äste, kein Schutz gegen Pilzkrankheiten und Schadinsekten, kein Hacken, Gießen und Düngen der Gehölze, Schwächeparasiten (sie greifen am häufigsten die Gehölze an, die durch Umweltbelastungen geschwächt sind, dringen in offene Gehölzwunden ein – die Wunden entstehen durch menschliche Tätigkeiten, sie besiedeln die Gehölze, die nicht regelmäβig behandelt werden) [38,40,42]. Ein Teil dieser Faktoren verursacht die geringe Baumvitalität, die Verminderung ihrer ökologischen und ästhetischen Funktionen und ihr vorzeitiges Absterben. Wichtige Kenntnisse aus diesem Gebiet sind in Tagungsbänden (Juhásová 1997, 1999) und in den Arbeiten der Autoren [35,37,48] aufgeführt. Große Aufmerksamkeit widmeten die Autoren dem Gehölzsortiment im öffentlichen Grün [14,36,23,24,3,4,16,39,25].

Pathogene Pilze in der Stadtumgebung wurden von zahlreichen Autoren bewertet [29,30,31,32,33,20,19], in besonderem Maß widmeten sich einige Autoren der Beurteilung des Gesundheits- und des Vitalitätszustandes in mehreren slowakischen Städten [21,28,34].

Im Rahmen eines Großprojektes mit dem Thema ”Die Bedeutung biotischer Faktoren, die Gehölze in den Städten beschädigen” wurde der Gesundheiszustand der Gehölze in verschiedenen Typen des Funktionsgrüns in den Siedlungen (Allee, Park, Großsiedlungsgrün, Siedlungen, Spezialgrün) untersucht und bewertet.

An den Sonnenseen in Senec wurde im Jahr 2002 auf speziellen Grünflächen der Gesundheitzustand der Gehölze bewertet. Die Wasserfläche wird für Regenerationszwecke genutzt und die Gehölze, die in ihrer Nähe wachsen, sind gleichzeitig ein Teil des öffentlichen Stadtgrüns.

Die Untersuchung der Gehölze im öffentlichen Grün erfolgt seit 1980. Die Gehölze in der Stadtumgebung wurden mit Blick auf die Umweltfaktoren und ihre Einflüsse studiert [40,7,41,8]. Den ökophysiologischen, phytopatologischen und entomologischen Problemen widmen sich zahlreiche Autoren [17,18,15,29,30,27,31,32,28,34,33,19,14,39,21,35,23,24,25,20,3,4,5,6]. Folgende Autoren erweiterten die Erkenntnisse über holzerstörende Pilzen in der Stadtumgebung [10,11,12,13].. Die besondere Aufmerskamkeit galt der Verwendung heimischer und fremdländischer Gehölze auf öffentlichen Grünflächen und Parks in den Städten [44,45,46].

## Material und die Methoden

Die untersuchende Fläche in Senec (an den Sonnenseen) wurden in 5 einzelne Parzellen unterteilt. Im ersten Schritt wurden die Gehölze aufgenommen und auf Karten erfasst.

Für jedes Gehölz wurden folgende Kriterien festgelegt:

- Botanischer Namen.
- Ordnungszahl des Baumes (der Gehölze).
- Stammdurchmesser in 130 cm Höhe.
- Gesamter Gesundheits- und Vitalitätszustand: 1 - 5 Punkte.

Für die Ermittlung des Schädigungsgrades wurde eine Skala in Bezug auf Vitalitätszustand der Baumkrone, Anzahl der trockenen Äste, das Vorkommen von Fäulen ausgearbeitet. Diese 6punktige Skala ist in den Texten der Autoren [28,34,43,44] beschrieben. In der Skala sind gesunde Bäume (Stufe 0) bis ganz trockene Bäume (Stufe 5) aufgeführt.

- Die Schadursachen wurden in Zahlen von 1 bis 80 ausgedrückt. Diese Zahlen beschreiben die biotischen und abiotischen Faktoren. In der vorliegenden Arbeit sind die Ergebnisse der Untersuchungen über den Gesundheitzustand der Gehölze mit Blick auf pathogene Pilze und einiger Schadinsekten zusammengetragen worden. Die aktualisierten Methoden [22,26] der Bewertung sind eingehend in den Arbeiten [28,34,43,44] beschrieben.
- Die Behandlungsart wird in einer Skala von 1 bis 39 festgelegt, die in den Arbeiten von [28,34,43,44] näher beschrieben worden ist.

Die Pilze wurden mit Hilfe von phytopatologischen Methoden nach ihren vegetativen und Reproduktionsorganen, die nicht sporulierenden Pilze im Labor genauer bestimmt. Für die Isolierung und Kultivierung wurde 3 % Malzagar und 3 % Kartoffeln-Dextrose Agar verwendet. Die Gehölze wurden nach Benčať (1982) identifiziert und die Pilze nach Bánhegyi (1985) und Brandenburger (1985) bestimmt.

## Ergebnisse

Zunächst wurde an den Sonnenseen in Senec die Gehölzzusammensetzung aufgenommen. Es wurde festgestellt, dass sich hier 35 Arten (338 Bäume) der 25 Gattungen befinden. Am häufigsten wurde das Auftreten von *Populus nigra* (105 St), *Acer pseudoplatanus* (40 St), *Aesculus hippocastanum* (27 St), *Sophora japonica* (27 St), *Acer platanoides* (24 St) registriert. Von den wertvollen Arten sind *Catalpa bignonioides*, *Juglans nigra*, *Salix matsudana* ´Tortuosa´ zu nennen.

Das Vorkommen der Schadfaktoren an Wurzeln (W), am Stamm, auf den Zweigen (S,Z) und auf den Blättern (B) stellen wir in der Tabelle vor.

**Tabelle** Das Vorkommen der Schadfaktoren auf den Gehölzen auf der Fläche an den Sonnenseen in Senec

| Artname | Schadfaktoren | beschädigte Organe |
|---|---|---|
| *Acer campestre* | *Rigidoporus populinus* (Schum. ex Fr.) Pouzar | S,Z, |
| *Acer platanoides* | | |
| *Acer pseudoplatanus* | | |
| | *Oxyporus sp* | S,Z |
| | *Mycosphaerella aceris Woron.,* | B |
| | *Mycosphaerella latebrosa* (Cke.) Schroet | B |
| | *Cercosporella acerina* (Hartig.) Arn | B |
| | *Gloeosporium acericolum* Allesch | B |
| | *Marssonina truncatella* (Sacc.) Magn. | B |
| | *Ascochyta acericola* Massa | B |
| | *Phyllosticta aceris* Sacc. | B |
| | *Cylindrosporium acerellum* (Sacc.) Died | B |
| | *Uncinula bicornis* (Wallr. ex Fr.) Fr. | B |
| | *Septoria acerinum* Pk. | B |
| | *Rhytisma acerinum* (Pers. ex St. Amans) | B |
| | *Verticillium alboatrum* (Hartig) Arn. | S,Z |
| *Aesculus hippocastanum* | *Guignardia aesculi* (Peck) Stewart | B |
| | *Phyllostica sphaeropsidae* Ell.et Ev | B |
| | *Asteromella aesculis* (Sacc.) Petr. | B |
| | *Mycosphaerela aesculi* (Cocc. ex Mor.) Tomilin | B |
| | *Septoria aesculicola* (Fr.) West. | B |
| | *Valsa ambiens* Sacc. | S,Z |
| | *Cytospora ambiens* Sacc. | S,Z |
| | *Verticillium alboatrum* (Hartig) Arn. | S,Z |
| | *Cameraria ohridella* Deschka a Dimič | B |
| *Ailanthus altissima* | *Cercospora glandulosa* Ell. et Kell. | B |
| | *Cercospora ailanthi* P. Syd. | B |
| *Alnus glutinosa* | *Microsphaera alni* Sacc. | B |
| | *Melampsoridium alni* Thum. | B |
| | *Agelastica alni* L. | B |
| *Betula alba* | *Melanconis stillbostoma* (Fr.) Tul | S,Z |
| *Betula verrucosa* | | |
| | *Cytospora betulicola* Fautr. | S,Z |
| | *Marssonina betulae* (Lib.) Magn. | B |
| | *Phyllactinia guttata* (Wallr. ex Schlecht. ) Lév | B |
| *Carpinus betulus* | gesund | |
| *Catalpa bignonioides* | *Phytophthora parasitica* Dast. | W |
| | *Phyllosticta bignoniae* West. | B |
| | *Ascochyta catalpae* Tassi. | B |
| | *Macrosporium catalpae* Ell. et Mart. | B |
| *Corylus colurna* | *Phyllactinia guttata* (Wallr. Ex Schlecht) Lév. | B |
| *Fraxinus excelsior* | *Phyllactinia guttata* (Wallr. ex Schlecht.) Lév. | B |
| | *Mycosphaerella fraxini* (Niessl.) Mig. | B |
| | *Cercospora fraxini* (DC.) Sacc | B |

| Artname | Schadfaktoren | beschädigte Organe |
|---|---|---|
| | *Phyllosticta fraxinicola* | B |
| | *Giberella baccata* (Wallr.) Sacc. | S,Z |
| | *Fusarium lateriticum* Nees. | S,Z |
| | *Nectria cinnabarina* (Tode ex Fr.) Fr. | S,Z |
| | *Eriophyes fraxinivorus* Nal. | B |
| | *Ganoderma lipsiense* (Bats) Atk. | S,Z |
| | *Ganoderma pheifferova* Bres in Pat. | S,Z |
| | *Inonotus hispidus* (Bull. ex Fr.) P. Karst. | S,Z |
| | *Ganoderma carnosum* Pat. | S,Z |
| *Juglans nigra* | gesund | |
| *Juglans regia* | *Gnomonia leptostylla* (Fr.) Ces. et de Not. | B |
| | *Marssonina juglandis* (Lib.) Magn. | B |
| *Juniperus chinensis ´Pfitzeriana´* | *Cladosporium glomerulosum* Sacc. | B |
| | *Hendersonia foliicola* Berk. | B |
| | *Gymnosporangium sabinae* (Dicks) Winter | S,Z |
| | *Lophodermium juniperinum* (Fr.) de Not. | B |
| *Juniperus squamata ´Meyeri´* | *Cladosporium glomerulosum* Sacc. | B |
| | *Hendersonia foliicola* Berk. | B |
| | *Carulaspis visci* Schr. | B |
| *Juniperus virginiana* | *Zdravé* | |
| *Negundo aceroides* | *Diaporthe pustulina* Desm. | S,Z |
| | *Phomopsis pustulinum* Grove | S,Z |
| | *Fusarium sp.* | S,Z |
| | *Phoma fumosa* Desm. | S,Z |
| | *Nectria coccinea* (Pers. ex Fr.) Fr. | S,Z |
| | *Cylindrocarpon candidum (*Lk.) Wr. | S,Z |
| *Picea abies* | *Sacchiphanthes viridis* Ratz. | B |
| *Picea pungens ´Glauca´* | *Sacchiphanthes viridis* Ratz. | B |
| *Pinus nigra* | *Diplodia pinastri* Grove | S,Z |
| | *Lophodermium p*inastri (Schrad.) Chev | B |
| *Pinus sylvestris* | *Diplodia pinastri* Grove | S,Z |
| | *Lophodermium p*inastri (Schrad.) Chev | B |
| | *Lophodermium seditiosum (*Mint.) Staley et Millar | B |
| | *Rhyacionia buoliana* (Den.) Schift. | B |
| | *Rhyacionia duplata* Hb. | B |
| *Populus nigra* | *Cryptodiaporthe populina* (Fuck.) Pat. | S,Z |
| | *Nectria galligena* Bres. | S,Z |
| | *Phellinus igniarium* (L. ex Fr.) Quelet | S,Z |
| *Prunus avium* | *Eutypela prunastri* (Pers.) Sacc., | S,Z |
| | *Valsa cincta* Sacc. | S,Z |
| | *Cytospora cincta* Sacc. | S,Z |
| | *Phellinus pomacearus* (Pers.) Maire | S,Z |

| Artname | Schadfaktoren | beschädigte Organe |
|---|---|---|
| | *Trametes hirsutum* (Wild. ex Fr.) Fr | S,Z |
| *Quercus cerris* | gesund | |
| *Robinia pseudoacacia* | *Ascochyta robiniaecola* Hollós | B |
| | *Cylindrosporium robiniae* Desm | B |
| | *Nectria cinnabarina* (Tode ex Fr.)Fr | S,Z |
| | *Camarosporium robiniae* Karst | S,Z |
| | *Cucurbitaria robiniae* Fuckl. | S,Z |
| | *Phyllosticta advenae* Pass. | B |
| *Rosa sp..* | *Phragmidium subcorticum* (Schr.) Wint. | B |
| | *Marssonina rosae* (Lieb.) Died | B |
| | *Sphaerotheca pannosa* (Wollr.) Lév | B |
| | *Phyllosticta rosarum* Pass. | B |
| | *Septoria rosae* Desm. | B |
| *Salix caprea* | *Venturia chlorospora* (Ces.) Karst. | S,Z,B |
| *Salix matsudana ´Tortuosa´* | *Fusicladium saliciperdum* (All. et Tub.) Linda | S,Z,B |
| | *Ramularia rosae* (Fuck.) | B |
| | *Valsa salicina* (Pers.) | S,Z |
| | *Cytospora personata* Fr. | S,Z |
| | *Diatripe bullata* (Hoffm.) | S,Z |
| *Sambucus nigra* | gesund | |
| *Sophora japonica* | *Fusarium lateritium* Nees. | S,Z |
| | *Giberella baccata* (Wallr.) Sacc. | S,Z |
| | *Nectria cinnabarina* (Tode ex Fr.) Fr. | S,Z |
| *Sorbus aucuparia* | *Cytospora rubescens* Fr. | S,Z |
| *Tilia cordata*<br>*Tilia platyphylla* | *Mycosphaerella millegrana* Desm | B |
| | *Gnomonia tiliae* Kleb. | B |
| | *Eriophyes tiliae* Nal. | B |
| | *Hypoxylon deustum* (Hoffm. Ex Fr.) Grev. | S,Z |
| | die saprofytischen Schwärze (Pilze) | B |
| *Ulmus carpinifolia* | gesund | |

Erklärungen: Wurzeln (W), Stamm und Zweige (S,Z), Blätter (B)

## Diskussion

Die Ergebnisse der bisherigen Arbeiten bestätigen die Meinungen mehrer Autoren, dass man den Gehölzen im öffentlichen Grün mehr Aufmerksamkeit hinsichtlich der Pflege und des Schutzes widmen sollte. Große Mengen von Pilzen sind an den untersuchten Bäumen nachgewiesen worden (Bernadovičová 2000, 2003, Hrubík, Juhásová 1994, Juhásová, Hamšíková 1996, Juhásová 1983, 1985, 1993). Ebenfalls verursachten Schadinsekten Schäden an den untersuchten Gehölzen (Siviček, Hrubík, Juhásová 1997, Hrubík, Juhásová 1994). Von Bedeutung ist auch ie Ermittlung des Gesundheits- und Vitalitätszustands (Machovec 2000, Pejchal 1995, Supuka 1991, Šimek 1993). Zum Unterschied der zuvor genannten Autoren sind die untersuchenden Methoden mit den neuen Angaben ergänzt worden (Juhásová, Serbinová 1996, 1997, Juhásová, Hamšíková 1996, Juhásová 2002, 2003).

## Schlußbeitrag

Speziell im Gebiet der Sonnenseen in Senec sind die Gehölze untersucht worden. Dabei wurden an 338 Bäumen 86 Pilzarten und 8 Arten von Schadinsekten nachgewiesen. Vorschläge für

Verbesserungsmaßnahmen wurden dem Grünflächenamt unterbreitet, die das Entstehen und die Verbreiterung der schädlichen Faktoren einschränken sollen.

## Literatur


1 BANHEGYI., J. et al., 1985. Magyarország mikroszkópikus gombáinak határozókönyve l.Budapest-Akadémiai Kiadó.1152.

2 BENČAŤ, F., 1982.Atlas der Verbreiterung der fremdländischen Gehölze in der Slowakei und ihr Pflegen.368.(In Slovak)

3 BERNADOVIČOVÁ, S., 2000b.Der Pilzzweck der Gattung *Phytophthora* in dem Ziergartenbau.Das Konferenzbuch.127-130.(In Slovak).

4 BERNADOVIČOVÁ, S., 2000a.Parasitic fungi damaging roots ornamental and commercial of woody plants. Proceedings "Arborets, variability and introduction of woody plants".185–188.(In Slovak).

5 BERNADOVIČOVÁ, S., 2003a. Proceedings "Woody plants in public greenery".Institute of Forest Ecology SAS Zvolen.182.(In Slovak).

6 BERNADOVIČOVÁ, S., 2003 b. Withering of ornamental woody plants of *Rhododendron* sp. as a result of damage by parasitic fungi of *Phytophthora* sp. and unsuitable planting site condition. Proceedings "Woody plants in public greenery".105-107.(In Slovak).

7 BERTA, F., SUPUKA, J.,CHLADNÁ, A.,1997.The composition of terpenes in needles of *Pinus sylvestris* L. in a relatively clear and in city environment.71-78.

8 BERTA, F., SUPUKA, J.,CHLADNÁ, A.,1997.The influence of urban environment on the composition of terpenes in the needles of Black pine.176-182.

9 BRANDENBURGER, W., 1985. Parasitische Pilze an Gefässpflanzen in Europa. New York.1248.

10 GÁPER, J.,GÁPEROVÁ, S., 1999.Die vergleichende Studien der Vertikalverbreitung der Pilze in der Stadtumgebung und in anderen Ökosystemen.41-46.(In Slovak).

11 GÁPER, J.,GÁPEROVÁ, S., 2000.Die Sporulation *Heterobasidion annosus* in den Waldökosystemen.159-162.(In Slovak).

12 GÁPEROVÁ, S.,2001.Die synantropische Arten in der Gattung *Ganoderma*.93-98.(In Slovak).

13 GÁPEROVÁ, S., KRÁTKA, E., 2003.Die Database der infizierenden introduktiven Gehölze der Slowakei am Beispiel am meisten infizierender Gehölze. 130-136.(In Slovak).

14 HRUBÍK, P., JUHÁSOVÁ, G.,1998.Die Verbreiterung und die schädliche Tätigkeit von *Cameraria ohridella*...Acta horticulturae of Regio Tecturae.21-23.(In Slovak).

15 HRUBÍK, P., 1988. Die Tierschädlinge in dem Stadtgrüne.196.(In Slovak).

16 HRUBÍK, P., 1976. Die biotische Schädlinge der fremländischen Gehölze in der Slowakei.72.(In Slovak).

17 HRUBÍK, P., 1996.Insect pests on everygreen woody plants in Slovakia.Acta Horticulturae et Regio Tecturae.93-112.(In Slovak).

18 HRUBÍK, P., 1996.Insect pests on introduced coniferous.14-17.(In Slovak).

19 HRUBÍK, P., JUHÁSOVÁ, G., 1994. Diseases and pests of evergreen woody species at the Arborétum Mlyňany. A Kertészeti és Élelmiszeriparti Egyetem Közleményei, Budapest.18-19.

20 IVANOVÁ, H., JUHÁSOVÁ, G., ADAMČÍKOVÁ, K., 1999. Fusarium lateritium Nees, Der Verursacher von Zweigsterben Sophora japonica L. Die Landwirtschaft 45. 496-507.(In Slovak).

21 JUHÁSOVÁ, G. HAMŠÍKVÁ, A., 1996. Fungal diseases of woody plants at Pezinok. Folia dendrologica.. 261–266.

22 JUHÁSOVÁ, G., SERBINOVÁ, K., 1996. Die phytopatologischen Probleme der Gehölze in den Stadtsiedlungen am Beispiel Komárno.I.Jubiläumkonferenz Die Ökologie und die Bieldung der Siedlungslandschaft und der landwirschaftlichen Landschaft 181-183.(In Slovak).

23 JUHÁSOVÁ, G., IVANOVÁ, H., 2001a. Parasitic mykoflora of thr genus Acer. Hort. Sci.28.71-79.

24 JUHÁSOVÁ, G., IVANOVÁ, H., 2001b. Importance of the Fungus *Cytospora rubescens* Fr. In relation to Dieback of *Sorbus aucuparia* L.Plant Protection Science 37.5-9.

25 JUHÁSOVÁ, G., PRASLIKA, J., 2002.Occurence and Harmful Effects of *Gymnosporangium sabinae* (Dicks.) Winter in Slovakia. Plant Protection Science.89-93.

26 JUHÁSOVÁ, G., SERBINOVÁ, K., 1997.Die Methoden von dem Taxen des Gesundheitszustands der Gehölze in der Stadtumgebung. Das Konferenzbuch von dem Seminar Das Pflegen und der Schutz der Pflanzen in der Stadtumgebung, die Behandlung der schützenden Bäume und Gedenkbäume.42-68.(In Slovak).

27 JUHÁSOVÁ, G., 1985.Die Pilzkrankheiten des Grünes in der Stadtumgebung .Folia dendrologica.291-302.(In Slovak).

28 JUHÁSOVÁ, G., 2002a. Die Methoden von dem Taxen des Gesundheitszustands der Gehölze auf dem Beispiel des Parks in Topoľčianky. Folia oecologica.55.(In Slovak).

29 JUHÁSOVÁ, G., 1983a. Parasitic fungi on verdure in urban area. Die tschekische Mykologie.112.

30 JUHÁSOVÁ, G., 1983b Die parasitischen Pilze auf den Blättern der Gehölze.131-137.(In Polen)

31 JUHÁSOVÁ, G., 1993.Rezuľtaty izučenija mikoflory gorodskich nasaždenij.Study results on the microflora of urban greenery. Bjuletin glavnogo botaničeskogo sada RAN.Moskau.64-71.

32 JUHÁSOVÁ, G.,1996.The importance of fungi in dekorative horticulture. Folia dendrologica. 255-259.

33 JUHÁSOVÁ, G.,1997. Das Konferenzbuch von dem Seminar Das Pflegen und der Schutz der Pflanzen in der Stadtumgebung, die Behandlung der schützenden Bäume und Gedenkbäume.103.

34 Juhásová, G., 2002b.Die mikroskopischen Pilze auf den Gehölzen in Arboretum Feľaťa.Folia oecologica.219 – 265.(In Slovak).

35 JUHÁSOVÁ, G., HRUBÍK, P., 1984. Die Krankheiten und die Schädlinge der fremdländischen Gehölze in der Slowakei .168.(In Slovak).

36 JUHÁSOVÁ, G., IVANOVÁ, H., 1999.Die Pilzkrankheiten der Arten der Gattungen *Platanus* L.Folia oecologica.183-194.(In Slovak).

37 NIENHAUS, F., BUTIN, H., BÖHMER, B.,1998. Atlas der Krankheiten und Schädlinge der Ziergehölze.268. (In Czech).

38 PEJCHAL, M.,1995. Das Taxen der Bäume in den Stadtstrassen .21-30.(In Czech).

39 SIVIČEK, P., HRUBÍK, P., JUHÁSOVÁ, G., 1997.Die Verbreitung der Rosskastanienminiermotte in der Slowakei. Forstchutz Aktuell.6.

40 SUPUKA, J. et all., 1991. Die ökologischen Methoden der Bildung und des Schutzes des Grünes.306. (In Slovak).

41 SUPUKA, J., 1995. Biomonitoring in urban Slovakia by the accumulation of proline and inorganic elements in tree leaves. Bioindicators of Environmental Health.133-140.

42 ŠIMEK, P., 1993.Das Taxen der Gehölze und ihres Wuchses für Gebrauch der Bildung in dem Gartenbau.136-142..(In Czech).

43 TKÁČOVÁ, S., 2003a. The instances of the trees injuring in the streets of the town Nitra.137-145.(In Slovak).

44 TKÁČOVÁ, S., 2003b.Das Taxen der Vitalität und der Resistenz der Zierpflanzen gegen abiotische und biotische Schadsfaktoren.62.(In Slovak).

45 TOMAŠKO, I., 1991.Utilising the urban forestry in Czechoslovakia.Seed in time.Proceedings of an international symposium.237-240.

46 TOMAŠKO, I., 1992.Contribution of Arboretum Mlynany to activities in horticulture, forestry, gardening and environment creation. Proceedings of an international symposium.1-11.(In Slovak).

47 TOMAŠKO, I., 1996. Urban ecology and urban vegetation. Folia dendrologica.235-240.

48 VESER, J., 2001. Der Schutz der Pflanzen in dem Garten.200.

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## *Phytophthora ramorum* – a serious pathogen in urban horticulture?

*Phytophthora ramorum* is a fungal organism that causes oak mortality (common name: sudden oak death) in California (USA) and also occurs in Europe (1, 3, 4, 5). In California and in a small area in Oregon, the pathogen mainly occurs in the wildland along the central coast, killing native oaks (*Lithocarpus* and *Quercus*) and damaging a wide range of other tree and shrub species. Recently *P. ramorum* has also been found in Washington DC and Canada (www.suddenoakdeath.org). The pathogen's host range used to be much smaller in Europe: *Rhododendron* and *Viburnum* were known to be favourite hosts. In 2003, however, the pathogen was also isolated from diseased *Camellia japonica*, *Pieris formosa* var. *forrestii*, *P. japonica*, *Kalmia latifolia* and *Syringa* in the UK (EPPO Reporting Service 2003/039; SCHLENZIG, personal communication). In Europe, *P. ramorum* has been found in nurseries, home gardens, and parks but, as opposed to North America, never on forest trees or shrubs. In an effort to prevent the threat the pathogen poses to forestry and other native stands as well as to urban horticulture throughout Europe, the European Community implemented phytosanitary measures in 2002.

*P. ramorum* predominantly attacks the upper parts of the plant and causes three different main symptoms: stem canker (cambium necrosis), twig blight and leaf spots. The kind of symptom or symptoms an infested plant shows, the number of symptoms appearing simultaneously on one and the same plant, and the mortality of the infestation all depend on the host.

The presentation is giving an overview of the present situation with respect to *P. ramorum*, including disease symptoms, disease development (2), current known distribution, and native host range. Furthermore, it provides some information about the biology of the pathogen and its possibilities of spreading as well as suggesting control measures.

### Literature

1 DAVIDSON, J.M., S. WERRES, M. GARBELOTTO, E.M. HANSEN, D.M. RIZZO, 2003. Sudden oak death and associated diseases caused by *Phytophthora ramorum*. Plant Management Network (www.plantmanagmentnetwork.org/pub/php/diagnosticguide/2003/sod/) 23 pages.

2 POGODA F., S. WERRES, 2002. Pathogenicity of European and American *Phytophthora ramorum* isolates to Rhododendron. Proceedings of the Sudden Oak Death Science Symposium, 15.-18.12.2002 in Monterey, USA.

3 RIZZO, D. M., M. GARBELOTTO, J.M. DAVIDSON, G.W. SLAUGHTER, S.T. KOIKE, 2002. *Phytophthora ramorum* and sudden oak death in California: I. Host Relationships. In: Standiford, R., D. McCreary: 5th Symposium on California Oak Woodlands. USDA Forest Service, Gen. Tech. PSW-GTR-184, 733-740.

4 RIZZO, D.M., M. GARBELOTTO, J.M. DAVIDSON, G.W. SLAUGHTER, S.T. KOIKE, 2002. *Phytophthora ramorum* as the cause of extensive mortality of *Quercus* spp. and *Lithocarpus densiflorus* in California. Plant Disease 86, 205-214.

5 Werres, S., R. Marwitz, W.A. Man in `tVeld, A.W.A.M. De Cock, P.J.M. Bonants, M. De Weerdt, K. Themann, E. Ilieva, R.P. Baayen, 2001: *Phytophthora ramorum* sp. nov., a new pathogen in Rhododendron and *Viburnum*. Mycological Research 105 (10), 1155-1165.

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# The mycobiota of healthy and declining oaks in an urban setting

## Introduction

The 'urban forest' is an artificial ecosystem that specialists in biological and ecological disciplines are increasingly having to concern themselves with as sensitivity towards this system grows. Current demographic trends mean that ever greater numbers of people will live in urban and periurban areas, and as a result urban horticulture with its various functions will acquire increasing importance.

The urban forest is a very multidependent, variable and dynamic system with its own flows of energy and climatic niches, whereby it influences organisms and micro-organisms.

It has its own specific nature and mode of functioning, quite different from that of the original natural forests, and demands its own mode of management, with special growing and pruning techniques, that may further stress trees already growing in an environment to which they are unsuitable.

The artificial state in which these trees are grown in terms of their structure and functional activity creates favourable conditions for the appearance of numerous pathogenic micro-organisms, some of which already occurring in nearby plantings, and some introduced from other areas on the same host plants.

But unlike what happens in natural forests, in an urban setting the damage caused by such agents is enhanced because the trees here are already subjected to numerous stresses, and consequently the threshold at which micro-organisms will cause damage is much lower.

Well known micro-organisms in this context are the rot agents, and pathogens of long standing such as *Ceratocystis fimbriata* Ell. et Halst. f.sp. *platani* Walter, the causal agent of canker stain of plane tree, *Ophiostoma ulmi* Buisman Nannfeldt, causing Dutch elm disease, and *Seiridium cardinale* (Wag.) Sutton and Gibson, which causes cypress bark canker.

In recent years, however, the attention of researchers has been drawn to a different group of fungal micro-organisms, which normally act like endophytes: they include *Apiognomonia quercina, Biscognauxia mediterranea, Colpoma quercinum, Diplodia mutila* and *Phomopsis quercina.* These fungi are commonly found in both healthy and declining oaks growing in urban and periurban parks [11, 12, 13].

These endophytic fungi have of late been studied on trees in natural and artificial stands and in urban plantings. The aim of the present work was to compare the endophytic composition of oaks in towns and natural forests.

## Materials and methods

Samplings were made from some *Quercus cerris* L. individuals growing in a predominantly *Q. cerris* stand mixed with a few individuals of *Q. pubescens* Willd., at Ulignano (Pisa), and from some *Q. cerris* trees skirting the city of Florence.

In each of these two locations, thirty declining oaks were sampled in 2000: ten each in April (budbreak), June (full bloom) and August (leaf fall).

The decline index was determined in accordance with an international scale [4], in which: 1 = slight decline (11-25% defoliation); and 2 = medium decline (26-60% defoliation).

At each sampling date, 10 current-year twigs, 10 buds and 10 leaves were sampled from each tree. Five 5-$mm^2$ wood fragments were excised from each twig; two 3-$mm^2$ fragments from each bud after removal of the leaf bud scales; and five 5-$mm^2$ fragments from each leaf. All fragments were taken 72 h after sampling. Samples were sterilised by immersing the twig fragments in 10 % oxygenated water for 15 min., and the bud and leaf fragments for 5 min.

Samples were seeded in 9-cm-diameter Petri dishes containing 20 ml PDA (DIFCO LABORATORIES, Detroit, MI, USA) with 0.06 g/l streptomycin. Incubation was at 20 °C for 7 days in the dark.

After incubation colonies were transferred to malt extract agar (DIFCO) at 2% w/v and stored at 4 °C.

All isolates were grouped by cultural and micromorphological characteristics and identified according to the keys of Booth [1], Gams [5], Sutton [14], Carmichael et al. [2] and Von Arx [15].

The isolation frequency (IF) of each taxon was calculated according to the formula IF = Ni/Ntx100, where Ni is the number of fragments from the various organs and Nt the total number of fragments seeded.

Fungi with an IF less than 2% were considered occasional fungi only.

The monthly weather data from March to October 2000 are shown for each location.

## Results

All the tree organs contained fungi belonging to different species and genera, with varying rates of isolation. From the Ulignano area (natural forest) 16 fungal species in 13 genera were isolated from all organs, while the trees skirting Florence yielded 11 species and 11 genera.

In the Ulignano area the greatest number of species found was 16, on the current-year twigs, whereas in Florence it was 10, which came from the buds.

The species most frequently isolated from current-year twigs in the Florence area were *Diplodia mutila* (IF 16.4%), *Discula quercina* (15.2%) and *Phomopsis quercina* (21.4%); all these species are considered to be pathogenic (Table 1).

**Tab. 1** Isolation frequency of fungal species isolated from different organs of *Quercus cerris* trees at Ulignano and Florence

| **Fungus** | **Ulignano** | | | **Florence** | | |
|---|---|---|---|---|---|---|
| | **Current-year twigs** | **Buds** | **Leaves** | **Current-year twigs** | **Buds** | **Leaves** |
| *Acremonium murorum* | 6,9 | 7,1 | 18,2 | 10,6 | 10,1 | 22,7 |
| *Acremonium sp.2* | 4,3 | 4,9 | - | - | - | - |
| *Alternaria alternata* | 5,2 | 13,6 | 17,8 | 4,1 | 10,6 | 24,2 |
| *Aureobasidium pullulans* | 2,1 | 2,0 | 5,2 | - | 2,1 | 3,3 |
| *Cladosporium cladosporioides* | 6,0 | 5,0 | 14,2 | 10,0 | 7,9 | 16,1 |
| *Colpoma quercinum* | 7,4 | 7,8 | - | 4,1 | 6,6 | - |
| *Diplodia mutila* | 10,6 | 7,4 | - | 16,4 | 8,4 | - |
| *Discula quercina* | 8,8 | 7,6 | 5,8 | 15,2 | 11,9 | 3,4 |
| *Epicoccum niger* | 4,7 | - | - | - | - | - |
| *Monochaetia sp.* | 6,5 | 6,0 | - | - | - | - |
| *Phoma cava* | 5,2 | - | - | 3,7 | - | - |
| *Phomopsis quercina* | 10,5 | 9,2 | - | 21,4 | 10,2 | - |
| *Phomopsis sp.2* | 4,9 | 4,0 | - | - | - | - |
| *Phomopsis sp.3* | 4,0 | - | - | - | - | - |
| *Trichoderma viride* | 12,4 | 25,4 | 19,0 | 14,5 | 28,3 | 21,9 |
| *Ulocladium sp.* | - | - | 19,8 | - | 3,9 | 8,4 |

Table 2 shows that in the two months of June and October, when the mean temperatures were higher in Florence than at Ulignano, the IF of most fungal species was higher in Florence, particularly that of the three pathogenic species already mentioned, *D. mutila* (19.6% in June, 18.3% in October), *D. quercina* (12.6; 11.7%) and *P. quercina* (17.6; 17.1%).

**Tab. 2** Isolation frequency of fungal species isolated from *Quercus cerris* trees at Ulignano and Florence at three sampling dates in 2000

| **Fungus** | **Ulignano** | | | **Florence** | | |
|---|---|---|---|---|---|---|
| | **April** | **June** | **October** | **April** | **June** | **October** |
| *Acremonium murorum* | 8,9 | 10,3 | 28,1 | 10,3 | 13,2 | 11,1 |
| *Acremonium sp.* | 2,3 | 3,3 | - | - | - | - |
| *Alternaria alternata* | 3,0 | 7,0 | 19,8 | 7,1 | 7,0 | 7,1 |
| *Aureobasidium pullulans* | 3,1 | 2,0 | 2,1 | 2,0 | - | 6,4 |
| *Cladosporium cladosporioides* | 7,1 | 3,0 | 14,9 | 2,4 | 3,7 | 3,6 |
| *Colpoma quercinum* | 13,6 | 13,7 | - | 13,6 | 15,7 | |
| *Diplodia mutila* | 13,4 | 10,6 | - | 10,8 | 19,6 | 18,3 |
| *Discula quercina* | 10,1 | 9,7 | 8,6 | 12,4 | 12,6 | 11,7 |
| *Epicoccum niger* | 2,0 | 3,1 | - | - | - | - |
| *Monochaetia sp.* | 3,1 | 6,5 | - | - | - | - |
| *Phoma cava* | 4,1 | - | - | 2,1 | 2,0 | 2,8 |
| *Phomopsis quercina* | 13,7 | 11,6 | - | 15,2 | 17,6 | 17,1 |
| *Phomopsis sp.2* | 2,2 | - | - | - | - | - |
| *Phomopsis sp.3* | 2,0 | - | - | - | - | - |
| *Trichoderma viride* | 11,4 | 19,2 | 26,5 | 24,1 | 6,5 | 18,9 |
| *Ulocladium sp.* | - | - | - | - | 2,1 | 3,0 |

On the other hand, species that are in some degree biological antagonists, *Acremonium murorum*, *Cladosporium cladosporioides*, *Trichoderma viride*, had a higher IF in Florence than at Ulignano, irrespective of the tree organ sampled (Table 3).

**Tab. 3** Mean monthly temperatures in the Ulignano area and at Florence, March-October, 2000

| **Location** | **Month** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** |
| Ulignano | 13,2 | 15,7 | 18,9 | 21,3 | 24,5 | 25,3 | 24,7 | 22,0 |
| Florence | 13,9 | 17,8 | 19,1 | 23,8 | 24,8 | 26,0 | 25,3 | 24,3 |

Differences in IF between both location and tree organ were highly significant ($P \leq 0.01$) (Table 4).

**Tab. 4** Analysis of variance on isolation frequency values (% data transformed to ARCSIN)

| **Variation** | **df** | **Deviation** | **Variance** | **F** |
|---|---|---|---|---|
| Total | 8 | 1747,06 | | |
| Between sampling dates | 2 | 926,03 | 463,01 | |
| Between sampling locations | 1 | 415,21 | 415,21 | 162,82 |
| Between organs | 2 | 398,16 | 199,08 | 78,07 |
| Error | 3 | 7,66 | 2,55 | |

## Discussion and conclusions

A total of 16 endophytic species were isolated from Ulignano; this was consistent with Ragazzi et al. [12] on *Q. cerris* but was low compared with other reports on *Q. cerris* and on other species [9, 10].

By contrast, 11 fungal species were isolated from *Q. cerris* trees growing in the area skirting Florence. There are no reports in the literature to which this number can be compared, but it is less than that in the natural forest at Ulignano.

The conclusion seems to be that an urban environment supports fewer species than does a natural forest, presumably because of the lower biodiversity of the former. In a town there are fewer tree species than in a forest and as a result there are also fewer micro-organisms, including polyphagous ones, that can pass to oak species from other plants.

However, it should be remembered that not all endophytic mycobiota are harmful to the higher plants. Indeed, many mycobiota form true mutualistic interactions with plants. Though research on the ecological significance of plant-microbial mutualism is still scanty, several micro-organisms have recently been reported to protect plants against their natural enemies (parasitic fungi and insects). Viewed in this light, the more limited range of species of endophytic mycota in urban trees may account for the greater susceptibility of these trees to insect pests and fungal diseases.

The greater IF in the urban forest of Florence of those endophytic fungi (*Diplodia mutila, Discula quercina* and *Phomopsis quercina*), which under certain circumstances may become pathogenic [3, 6, 7, 12, 13, 16], can be attributed to the temperatures in the city, which are always higher than in the more outlying areas [8] while these again are higher than those in a natural forest.

Moreover, the increase in temperature is accompanied by an increase in the evaporative process, and this further worsens the health state of the trees, to the point that it may cause some fungi to switch from a neutral or mutualistic phase to a pathogenic one.

That higher temperatures increase the IF of *D. mutila, D. quercina* and *P. quercina* is clear also when the isolation data of Ulignano and Florence are compared for October, a month that comes immediately after a high-temperature period, particularly in the urban trees skirting Florence. This confirms the effect of temperature on IF found within the city.

Since city councils are committed to safeguarding urban green areas, and that includes increasing the number of tree species planted, among which oaks are favoured as being very hardy and adaptable to artificial environments such as those of towns and cities; since the IF is increased by higher temperatures, as was shown by the present study; and since global warming (a phenomenon which has already started, but which is certain to get worse in coming decades) can only continue this trend, it is necessary to pay greater attention not only to the well researched micro-organisms of long standing but also to the less well-known endophytic fungi, and the effect they have on urban forest trees.

This need is not yet reflected in the research literature, but it is to be hoped that workers in the field will become increasingly aware of the problems caused to the urban environment by endophytic fungi, including those that have only recently begun to be studied, but which could become the new enemy in an environment, that of towns and cities, which is already precarious.

## Summary

The composition of endophytic fungi in *Quercus cerris* trees in a natural forest at Ulignano (PI) and in a belt skirting the city of Florence was compared. Isolates were taken from current-year twigs, buds and leaves of declining trees in April, June and October. The trees in the forest had a richer composition of endophytic fungi than those in Florence. In addition, it was found that in June and October endophytic fungi that under certain circumstances become pathogenic, namely *Diplodia mutila, Discula quercina* and *Phomopsis quercina,* had higher isolation frequencies in Florence than in the Ulignano area. The findings provide evidence for the belief that the relatively higher temperatures of cities affect fungal diversity and behaviour.

## Literature


1 BOOTH, C., 1971. The Genus *Fusarium*. Commonwealth Agricultural Bureau, Kew, Surrey, England, 237 pp.

2 CARMICHAEL, J. W., KENDRICH, W. B., CONNER, I. L., SIGLER, L., 1980. Genera of Hyphomycetes. University of Alberta Press, Alberta, Canada. 386 pp.

3 CELLERINO, G.P., ANSELMI, N., ESPOSITO, L., 1991. Deperimento delle querce in Campania: problematiche, agenti fungini connessi, tentativi di interventi selvicolturali. *Atti del Convegno "Aspetti Fitopatologici delle Querce"*, Firenze, 19-20 novembre 1990, 63-77.

4 FERRETTI, M., 1994. Mediterranean forest trees. A guide for crown assessment. CEE. UN/ECE, Brussels, Belgium, 15 pp.

5 GAMS, W., 1971. *Cephalosporium*–artige Schimmelpilze (Hyphomycetes). Gustav Fischer Verlag, Stuttgart, Germany, 262 pp.

6 HALMSCHLAGER, E., BUTIN, M., DONAUBAUER, E., 1993. Endophytische Pilze in Blättern und Zweigen von *Quercus petraea*. Eur. J. For. Path. 23, 51 – 63.

7 KOWALSKI, T., 1991. Oak decline: I. Fungi associated with various disease symptoms on overground portions of middle aged and old oak (*Quercus robur* L.). Eur. J. For. Path. 21, 136 – 151.

8 LORENZINI, G., 1999. Le piante e l'inquinamento dell'aria. Edagricole, Bologna, Italy, 335 pp.

9 PETRINI, O., 1986. Taxonomy of endophytic fungi of aerial plant tissue. In: *Microbiology of the Phyllosphere* (N.J. Fokkema, J. Van den Henvel, eds.), Cambridge University Press, Cambridge, UK, 175-187.

10 PETRINI, O., FISHER, P.J., 1990. Occurrence of fungal endophytes in twigs of *Salix fragilis* and *Quercus robur*. Mycological Research 94, 1077-1080.

11 RAGAZZI, A., MORICCA, S., TURCO, E., 2000. Sanitary aspect of oak in the urban ecosystem. Mitt. Biol. Bundesant. Land – Forstwirtsch. 370, 262-265.

12 RAGAZZI, A., MORICCA, S., CAPRETTI, P., DELLAVALLE, I., MANCINI, F., TURCO, E., 2001. Endophytic fungi in *Quercus cerris*: Isolation frequency in relation to phenological phase, tree health and the organ affected. Phytopath. Mediterr. 40, 165-171.

13 RAGAZZI A., MORICCA, S., CAPRETTI, P., DELLAVALLE, I.,TURCO, E., 2003. Differences in composition of endophytic mycobiota in twigs and leaves of healthy and declining *Quercus* species in Italy. For. Path. 33, 31-38.

14 SUTTON, B.C., 1980. The *Coelomycetes*. Fungi imperfecti with Pycnidia, Acervuli and Stromata. Commonwealth Agricultural Bureau, Kew, Surrey, England, 696 pp.

15 VON ARX, J.A., 1987. Plant pathogenic fungi. J. Cramer, Berlin, Stuttgart, Germany, 288 pp.

16 WILSON, D., CORRELL, G.C., 1994. Infection studies of *Discula quercina*, an endophyte of *Quercus garryana*. Mycologia 86, 635-647.

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# Investigations on interactions between the rhododendron leafhopper (*Graphocephala fennahi* Young) and the rhododendron bud blast disease (*Pycnostysanus azaleae* (Peck) E. Mason)

## Introduction

Rhododendron bud blast disease caused by the fungal pathogen (*Pycnostysanus azaleae)* has been a major problem for several years, particularly in private gardens. The main reason for this is believed to be the increasing occurrence of the rhododendron leafhopper (*Graphocephala fennahi),* which was introduced into Europe last century from North America and which has spread rapidly since then [1, 2]. The cicada lays its eggs in autumn in the bud scales of the flowers. It is assumed that the damage caused to the buds by laying the eggs creates entrance portals for the pathogen, *P. azaleae*. Clear scientific studies are however not available. In the course of writing a thesis, a large rhododendron park in Bremen was examined to see whether this assumption was correct and whether a link existed between the leafhopper infestation and bud blast disease [3].

## Materials and Methods

To this end, plants from different locations and varying stocks with divergent morphologic characteristics were selected and examined for infestation with *P. azaleae* and *G. fennahi*. During the course of the plant inspection, various features were recorded which could influence the occurrence of bud blast disease or rhododendron leafhopper.

Specific features:

- Number of exuvia of the rhododendron leafhopper
- Proportion of buds infested with *Pycnostysanus azaleae*
- Location (sunny, half shade, shady and solitary or compact)
- Stock
- Bud (size, shape, hairs, colouring, and surface)
- Leaf (size, hairs, colouring, and surface)

Since examining whole plants would have taken too long, the number of cicada exuvia on the underneath of the leaves were recorded per plant on 10 false whorls from the current year. Simultaneously, the buds of the false whorls from the previous year were also examined for infestation by *P. azaleae*.

## Results and discussion

The statistics did not show a link between rhododendron leafhopper infestation and bud blast disease. Numerous plants were found to be heavily infested with *P. azaleae*, and at the same time, there was a negligible occurrence of cicada, and vice versa. This is contrary to the common belief that the occurrence of rhododendron leafhopper is largely responsible for the increase in bud blast disease. The park research indicates that bud blast disease is largely influenced by other factors.

The research showed, for example, that bud blast disease and rhododendron leafhopper have different preferences as far as the rhododendron stock is concerned. *P. azaleae*, for instance, was found above all on *R. catawbiense* hybrids. An increase in bud blast disease on Pontica series rhododendrons, as described by MAETHE [4], was not witnessed. On the contrary, *G. fennahi* preferred Pontica series rhododendrons and rhododendrons cross breeded with *R. catawbiense* hybrids. For example, the most exuvia were recorded on the *R. caucasicum* hybrid, 'Cunningham's White'. This particular plant however showed no bud blast disease. American varieties were clearly shown to be affected in a more extreme manner by bud blast disease than German varieties. As to infestation with rhododendron leafhoppers, there seemed to be no difference between the different origins.

Evidence pointed to the location factor as having a definite influence on the plants. Rhododendron plants which stood in groups were affected in a particularly extreme manner by bud blast disease. The three *yakushimanum* hybrids, 'Anuschka', 'Silberwolke' and 'Polaris' were compared in two different locations (normal and waterlogged). There was evidence of increased bud blast disease from the waterlogged soil, whilst the same varieties showed no signs of infestation with *P. azaleae* in a normal location. These results confirmed the observations made by WIETING [4], who observed bud blast disease above all on rhododendrons suffering from nutrient deficiency and waterlogged soil. The most extreme infestation by *G. fennahi* was recorded in the locations 'solitary/sunny' and 'compact/half shade'.

The studies showed that bud features also seem to influence the way in which the cicadas lay their eggs and the occurrence of bud blast. Sticky buds were thus more likely to be infested by *P. azaleae* than varieties with non-sticky buds. As far as rhododendron leafhoppers are concerned, exactly the opposite is the case: the cicadas clearly preferred the non-sticky buds to the sticky buds for laying their eggs.

## Literature

1 STARK, C., 1985. Das Rhododendron-Knospensterben. Rhododendron und immergrüne Laubgehölze Jahrbuch 1985, 76-79.

2 VESER, J., 1998. Zikaden öffnen Pforte für Pilz. Deutsche Baumschule 50(5), 29.

3 DIEDERICH, F., 2002. Neue Untersuchungen zum Knospensterben. Rhododendron und immergrüne Laubgehölze Jahrbuch 2002, 43-60.

4 MAETHE, H., 1995. Neuer Schadpilz an Rhododendron problemlos bei gutem Standort. Deutsche Baumschule 37, 170.

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# Occurrence of virus diseases in parks and public gardens

Plant viruses are wide-spread in urban as well as forested areas [2, 3]. They might cause visible symptoms and lead to a decline. From the economic point of view one should be aware that virus diseased plants may increase production costs because of the possibly decreased growth of infected stock plants and that they may damage subsequent field performance. Virus infection alters plants predisposition and these trees become more susceptible to abiotic and biotic stress impact. Therefore tree seedlings with a long generation cycle planted in parks, public gardens or avenues should be virus-free and vital to overcome the changing stress impact for decades.

Referring to the International Committee on Taxonomy of Viruses (ICTV) there are 32 groups of well-characterized viruses but only about twelve of these have been commonly detected in trees and shrubs [2]. The virus diseases we often observed in trees and shrubs grown in urban areas are summerized in table 1. Only a few virus groups with a marked preference for woody perennial hosts use pollen and/or seed to an important extent for their dissemination as there are nepoviruses (e.g. ArMV, CLRV), ilarviruses (e.g. ApMV) and cucumoviruses (e.g. RoMV). Seed transmission may be of very considerable economic importance, because viruses may persist in seed for long periods so that commercial distribution of a seedborne virus over long distances may readily occur [1].

**Table** Virus diseases we often observed in european deciduous trees. Host plants of the virus are marked with an X.

| **Species \ virus** | **AMV** | **ApMV** | **BMV** | **CLRV** | **EmoV** | **PopMV** | **RoMV** | **TNV** | **Tobamo-viruses** | **ringspot disease** |
|---|---|---|---|---|---|---|---|---|---|---|
| Acer | | | | | | | | | X | |
| Aesculus | | X | | | | | | | | |
| Betula | | X | | X | | | | | | |
| Carpinus | | X | | X | | | | | | |
| Cornus | | | | X | | | | | | |
| Fagus | | | X | X | | | | | | |
| Fraxinus | X | | | X | | | | | | |
| Juglas | | | | X | | | | | | |
| Populus | X | | | | | X | | | | |
| Quercus | | | | | | | | | X | X |
| Rhamnus | | | | X | | | | | | |
| Robinia | | | | | | | X | | | |
| Salix | | | | | | | | X | | |
| Sambucus | | | | X | | | | | | |
| Sorbus | | X | | X | | | | | | X |
| Ulmus | | | | X | X | | | | | X |

AMV = arabis mosaic virus; ApMV = apple mosaic virus; BMV = brome mosaic virus;
CLRV = cherry leafroll virus; EmoV = elm mosaic virus; PopMV = poplar mosaic virus;
RoMV = robinia true mosaic virus; TNV = tobacco necrosis virus;
Tobamo-viruses = viruses belonging to the tobamo-virus group;
Ringspot disease= chlorotic ringspots induced

## Literature

1 BÜTTNER, C., BANDTE, M., 2000. Virusübertragung bei Gehölzen durch Saatgut und vegetative Vermehrung. In: Jahrbuch der Baumpflege 2000. Eds. D. Dujesiefken and P.Kockerbeck. Thalacker Verlag, 194-199.

2 COOPER, J.I. Virus diseases of trees and shrubs. Chapman and Hall, London , 205 p.

3 NIENHAUS, F., CASTELLO, J., 1989. Viruses in forest trees. Annu. Rev. Phytopathology 27, 165-186.

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# Virus diseases of elms (*Ulmus laevis* Pall.) in public gardens

Plant viruses are widely spread in deciduous trees [4]. They might cause visible symptoms and lead to a decline. Virus infection alters plants predisposition and these trees become more susceptible to abiotic and biotic stress impact. Therefore tree seedlings with a long generation cycle planted in forests, public gardens or along streets should be virus-free and vital to overcome the changing stress impact for decades. Elm trees have become rare in Europe during the last decades due to Dutch elm disease caused by the fungus *Ophiostoma ulmi*. However, elm trees are popular in urban areas and are often cultivated in public gardens.

Virus-like leaf symptoms and dieback were observed on elm trees in a public garden as well as in forest stands close respectively in Berlin. The investigation focuses on the identification and characterization of the casual pathogen to develop a specific assay, which is suitable for routine diagnosis and necessary to conserve and to preserve endangered elm species.

The oldest observed elm trees were planted in 1830. The diseased trees showed virus like leaf symptoms as there are chlorotic ringspots, chlorotic line patterns and distinct chlorotic or necrotic spots leading to a decline. No fungal or bacterial pathogens were found to be associated with the symptoms. An infection with previously described viruses of elm trees such as *Cherry leaf roll virus* (CLRV), *Elm mottle virus* (EMoV), *Arabis mosaic virus* (ArMV) and *Tobacco ringspot virus* (TRSV) was excluded applying biological, serological and electron microscopic assays.

Poty- or carlavirus-like flexible particles of approximately 750 nm were isolated repeatedly from diseased elms. These particles are transmissible in plant sap of diseased elm leaves to herbaceous indicator plants such as *Chenopodium* species. *C. quinoa* and *C. album* showed chlorotic local lesions whereas red ringspots developed on *C. amaranticolor* leaves. These symptoms induced on *Chenopodium* sp. also verify that the pathogen involved in the disease is not *Elm mottle virus* or *Cherry leaf roll virus* because these viruses exhibit other characteristic symptoms as reported by Jones and Mayo [3] and Ford et al. [2].

The virus disqualifies as a member of the Potyviridae family based on an ELISA and a RT-PCR assay using a potyvirus genus-specific broad-spectrum polyclonal antibody [5] and family-specific primers [1], respectively. Also no potyvirus-like pinwheel inclusions were found in leave cells of infected indicator plants in electron microscopic studies. Further characterization of virus isolates obtained from diseased elms is under way applying molecular techniques.

## Literature

1 CHEN, J. , ADAMS, M.J., 2001. A universal PCR primer to detect members of the *Potyviridae* and its use to examine the taxonomic status of the several members of the family. *Arch. Virol.* 146, 757-766.

2 FORD, R.E., MOLINE, H.E., MCDANIEL, G.L., MAYHEW, D.E., EPSTEIN, A.H., 1972. Discovery and Characterization of Elm mottle Virus in Iowa. Phytopathology 62, 987-992.

3 JONES, A.T., MAYO, M.A., 1973. Purification and properties of elm mottle virus. Ann. Appl. Biol. **74**, 211-217.

4 NIENHAUS, F., CASTELLO, J., 1989. Viruses in forest trees. Annu. Rev. Phytopathology 27, 165-186.

5 RICHTER, J., RABENSTEIN, F., PROLL, E., VETTEN, H.J., 1995. Use of cross-reactive antibodies to detect members of the Potyviridae. Journal of Phytopathology 143, 459-464.

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# Pests of ornamental plants in streets and public gardens of Lleida (Spain)

## Introduction

The town of Lleida is an inland urban agglomeration of near 115.000 inhabitants located in the north-east of the Iberian Peninsula, 150 km west of Barcelona. It has a Mediterranean-continental climate with mild winters, short springs and hot summers.

The ornamental vegetation in the town has greatly increased in the last twenty years and most of plantations are quite new. Trees are distributed mainly in tree lines on avenues, streets and small public gardens. The number of trees inventoried in 2002 was about 25000, belonging to 65 genera and 140 species or cultivars. Furthermore, 50 additional genera of shrubs are planted individually or in shrubberies on squares and gardens.

Pest management in Lleida is usually based on insecticide applications according to a routine, a previously established calendar or crisis treatments, without taken in account other elements such as pest population levels or the presence of beneficial organisms. This pest control strategy involves a risk for the inhabitants, the destruction of beneficial fauna and the development of pest resistance [1].

In 2001, we started collaboration with Lleida City Council in order to define the k-pest problems affecting ornamental plants in the town. To this end, we determined the relative abundance and phenology of the pest species and the presence of beneficial fauna related to them and evaluated the control strategies used. We present here the results on the plant-pest associations and the occurrence of natural enemies.

## Material and methods

The study was conducted during 2001 and 2002. In order to obtain a representative sample, the town was divided into several sectors and a few avenues, streets and squares were selected in each of these sectors for sampling.

Samplings were performed every two weeks from April to September and once per month from October to March. Several plants of the most abundant trees and shrubs species were visually inspected and the occurrence of pests (insects and mites) and predators was recorded. Parts of the plant infested by pests were collected and brought to the laboratory where the precise identification of the species and any predator species found was carried out. Parasitized insects were reared in the laboratory until adult emergence before species identification. Specimens of some predators and parasitoids were sent to specialists for correct identification.

## Results

The presence of pest species was found in 80 different plant species in the sampled areas. The number of plant-pest associations recorded was 196 and 173 in 2001 and 2002, respectively.

The plant-pest associations were distributed to the different pest groups as is shown in Table 1. The most abundant pests were Homoptera and the highest plant-pest associations corresponded to Aphididae, which were 50 % of the total records, followed by Coccoidea at 20% of the total records (ranging from 15 to 25%) and other homopterans like leafhoppers, psyllids or triozids. Mites represented 7% of the associations with plants, whereas caterpillars and bugs represented around 4%. Some plants were attacked by hymenopterans (3%), mainly gall wasps. The different species of phytophagous Coleoptera and Diptera showed a lower incidence.

**Tab. 1** Main groups of pests recorded on ornamental plants in Lleida (Spain) during 2001 and 2002 and main plant genera affected.

| Pest group | Number of plant-pest associations (percentage in brackets) | | | Plant genera |
|---|---|---|---|---|
| | 2001 | 2002 | Two years period | |
| Heteroptera | 6 (3.1) | 8 (4.6) | 14 (3.7) | *Platanus, Populus* |
| Hom. Aphididae | 98 (50.0) | 95 (54.9) | 193 (50.9) | *Robinia, Sophora, Acer, Hibiscus, Prunus, Quercus, Tilia, Populus, Catalpa, Cedrus, Lagestroemia* |
| Hom. Coccoidea | 48 (24.5) | 26 (15.0) | 74 (19.5) | |
| Coccidae | 16 (8.2) | 9 (5.2) | 25 (6.6) | *Acer, Ulmus, Prunus, Albizzia* |
| Diaspididae | 8 (4.1) | 10 (5.8) | 18 (4.7) | *Morus, Sophora, Firmiana, Catalpa, Melia* |
| Margarodidae | 16 (8.2) | 4 (2.3) | 20 (5.3) | *Pinus, Aesculus* |
| Pseudococcidae | 8 (4.1) | 3 (1.7) | 11 (2.9) | *Cupressus, Albizzia* |
| Other Homoptera | 9 (4.6) | 16 (9.2) | 25 (6.6) | |
| Cicadellidae | 5 (2.6) | 6 (3.5) | 11 (2.9) | *Quercus, Populus, Ulmus* |
| Psyllidae | 2 (1.0) | 3 (1.7) | 5 (1.3) | *Cercis, Fraxinus* |
| Triozidae | 1 (0.5) | 1 (0.6) | 2 (0.5) | *Laurus* |
| Others | 1 (0.5) | 6 (3.5) | 7 (1.8) | |
| Thysanoptera | 1 (0.5) | 1 (0.6) | 2 (0.5) | *Fraxinus* |
| Coleoptera | 5 (2.6) | 2 (1.2) | 7 (1.8) | *Ulmus, Populus* |
| Lepidoptera | 8 (4.1) | 7 (4.0) | 15 (4.0) | *Pinus, Populus* |
| Diptera | 1 (0.5) | 2 (1.2) | 3 (0.8) | *Quercus* |
| Hymenoptera | 5 (2.6) | 4 (2.3) | 9 (2.4) | *Rosa, Salix, Quercus* |
| Acari | 15 (7.7) | 12 (6.9) | 27 (7.1) | *Tilia, Fraxinus, Salix, Quercus* |

The most important features for each pest group are summarized in the following paragraphs.

## Aphididae (aphids)

The total number of aphid species determined in the two years sampling was 58. The most frequent associations, with the greatest incidence of aphids, are shown in Table 2.

Because of the presence of aphids on these plants, insecticide treatments were applied mainly due to the honeydew produced. Despite these treatments, high aphid densities in all of these plant-aphid associations were recorded in 2002, especially *C. populialbae* on poplars, *H. pictus* on evergreen oaks and *E. tiliae* on lime-trees, producing large amounts of honeydew, aesthetic damage and an annoying nuisance.

**Tab. 2** Main plant-aphid associations in Lleida during 2001-2002

| Plant | Aphid species |
|---|---|
| *Acer campestre* | *Periphyllus hirticornis* |
| *Hibiscus syriacus* | *Aphis gossypii* |
| *Populus alba* | *Chaitophorus populialbae*<br>*Chaitophorus populeti* |
| *Prunus cerasifera pisardii* | *Phorodon humuli* |
| *Quercus ilex* | *Thelaxes suberi*<br>*Hoplocallis pictus*<br>*Tuberculatus (tuberculoides) eggleri* |
| *Robinia x Casque Rouge* | *Aphis craccivora* |
| *Sophora japonica* | *Aphis craccivora* |
| *Tilia* sp. | *Eucallipterus tiliae* |

A number of natural enemies, predators and parasitoids, were also recorded on the associations. Coccinellidae (*Oenopia conglobata*, *Scymnus* spp., *Adalia decempunctata*, *Propylea quatuordecimpunctata*, *Adonia variegata*, *Coccinela septempunctata*), Chrysopidae (*Chysoperla carnea*), Syrphidae, Cecidomyidae (*Aphidoletes aphydimiza*), Anthocoridae and Miridae were the most abundant predators. Most aphid species were parasitized by one or several parasitoids, the most common being *Lysiphlebus testaceipes* (for details see Lumbierres et al. in this volume).

## Coccoidea (margarodids and scales)

Two species were found at high densities: the margarodid *Palaeococcus fuscipennis* (Margarodidae), and the armoured scale *Pseudaulacaspis pentagona* (Diaspididae).

A severe outbreak of *P. fuscipennis* on *Pinus halepensis* and, to a lesser extent, *Pinus pinea* occurred during the spring and summer of 2001, with large production of waxen wool, honeydew and sooty mould, which caused aesthetic damage. A lower incidence was recorded in 2002. The coccinellid predator *Rodolia cardinalis* and the parasitoid *Chryptochaetum jorgepastori* (Diptera, Chryptochetidae) were associated with *P. fuscipennis*.

In 2002, *P. pentagona* heavily infested branches and trunks of several ornamental trees: mulberries, pagoda-trees, Indian been-trees and firmianas and, to a lesser extent Persian lilacs. In 2001, the number of trees infested and the intensity of damage were much lower. A hymenopteran species of the family Encyrtidae (not determined) was found parasitizing the scale.

## Acari (mites)

The main problem due to mites was the attack of *Eotetranychus tiliarum* on lime-trees. Heavy attacks occurred on mature trees of *Tilia platyphyllos*. The coccinellid *Stethorus punctillum* was the most abundant predator species predating on the mite. The presence of phytoseid mites of the genera *Typhlodromus* occurred at low levels.

## Other pests

There was some aesthetic damage on Judas-trees (*Cercis siliquastrum*) caused by *Psylla pulchella*, on bays caused by *Tryoza alacris* and on evergreen oaks caused by the gall midge *Dryomyia lichtensteini*.

Other pests that occasionally caused damages were the bark beetle *Scolytus multiestriatus* on elms, the lace bug *Corythuca ciliata* on planes and the pine processionary moth *Thaumetopoea pityocampa* on pines.

## Discussion

Public concern about the use of pesticides as a main pest control system in urban areas has greatly increased in the last few years [2] and IPM is the alternative strategy that best responds to the plant health care [3]. The accurate identification of pest problems and natural enemies is essential for the development and implementation of IPM programmes, in determining key pests and key plants and in the decision-making processes. In Spain there are few studies on pests affecting ornamental plants in urban areas. Most of them deal with a single pest in a particular environment and there is very little information about the pest status in different localities.

The results of our study show that the main pests in Lleida were aphids, as is usual in many urban areas [1,4,5]. However, local characteristics such as plant composition [1] may lead to the prevalence of different aphid species in localities not too far from each other, as can be seen by comparing the data of the present work with those of a coastal locality only 75 km from Lleida [6]. In Lleida, due to the densities reached on the respective host-plants and the abundance of the latter, the associations shown in Table 2 can be considered as aphid-plant k-associations. To control these aphids several treatments are regularly applied each year. However, recent studies conducted in Lleida show that some of these treatments are unnecessary or are applied at the wrong time (authors' unpublished data). Moreover, the role of natural enemies, whose variety and abundance has been described above, may be limited.

The biology and natural enemies of *P. fuscipennis* in conventionally treated and untreated pines were studied in Lleida [7], and it was concluded that the predator *R. cardinalis* and the parasitoid *C. jorgepastori* were able to reduce the *P. fuscipennis* populations in non-treated trees. However, the lower abundance recorded in 2002 cannot be explained only by the action of natural enemies.

*P. pentagona* is an increasing pest problem in Lleida. It was introduced in Catalonia in the mid- seventies and produced economic damages to peach trees. It has been pointed out that in areas where the insecticide pressure is high the pest population develops as a consequence of the destruction of the natural enemies [8]. The outbreak recorded in 2002 in the urban trees of Lleida could be due to the great number of treatments applied.

The mite *Eotetranychus tiliarum* and the lime aphid (*Eucallipterus tiliae*) are the main pests of lime trees in Lleida. Both pests have been mainly recorded on *Tilia platyphyllos* and *T. cordata*, and small populations were found on *T. tomentosa*. This species sensitivity should be taken into account when plantations are done.

The plant composition of urban green areas of Lleida and the diverse origin of the material planted allows the establishment of some new species that can become pests. In Europe, several new pests species appear every decade for different reasons. Lleida is no exception. For example, *P. pentagona*, the lace bug *C. ciliata* and the geranium bronze *Cacyreus marshalli* can be considered recently-introduced pests. The polyphagous flatid planthopper *Metcalfa pruinosa* and the horse chestnut leafminer *Cameraria ohridella* are two new pests that have been recorded recently in Europe in urban green areas [9,10] that can cause severe damage. *M. pruinosa* has been regularly recorded in the north-east of the Iberian Peninsula on more than 100 different host-plants [11], though Lleida remains free of this pest. On the other hand, so far there are no records of *C. ohridella* in the Iberian Peninsula.

## Abstract

The occurrence of pests and natural enemies on trees and shrubs was recorded in Lleida (NE of the Iberian Peninsula) during the period 2001-2002. Aphididae were the most abundant pest group, reaching half of the total plant-pest associations recorded. Due to their high populations and honeydew production, aphids caused aesthetic damages on trees of the genera *Acer*, *Catalpa*, *Cedrus*, *Hibiscus*, *Lagestroemia*, *Populus*, *Prunus*, *Quercus*, *Robinia*, *Sophora* and *Tilia*. Coccinellids were the most abundant aphid predators and the parasitoid *Lysiphlebus testaceipes* the most common parasitoid species. Coccoidea held about 20 % of the plant-pest associations. The margarodid *Palaeococcus fuscipennis* heavily damaged *Pinus* sp. during 2001, but the occurrence of natural enemies was very high and a possible cause of the pest decline in 2002. The armoured scale *Pseudaulacaspis pentagona* is an emerging pest in Lleida that infests the genera *Morus*, *Sophora*, *Firmiana*, *Catalpa* and *Melia*. The main problem with mites was due to *Eotetranychus tiliarum* but damage varied according to the *Tilia* species.

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## Literature

1 RAUPP, M.J., KOEHLER, C.S., DAVIDSON, J.A., 1992. Advances in implementing integrated pest management for woody landscape plants. Annu. Rev. Entomol. 37, 561-585.

2 JOHNSON, W.T, LYON, H.H., 1991. Insects that feed on trees and shrubs. 2nd ed. Cornell University Press, Ithaca, New York. 560 pp.

3 NIELSEN, D.G., 1989. Integrated pest management in arboriculture: from theory to practice. Journal of Arboriculture 15, 25-30.

4 ALFORD, D.V., 2000. Pests of ornamental plants in urban streets, parks and gardens in the UK. Mitt. Biol. Bundesanst. Land-Forstwirtsch. 370, 59-62.

5 WU, Z., JAMIESON, S., KILEBASO, J., 1991. Urban forest pest management. Journal of Arboriculture 17, 150-158.

6 PONS, X, LUMBIERRES, B., 2003. Aphids on ornamental trees and shrubs in an urban area of the Catalan coast: bases for an IPM programme. In Aphids in a new millennium. J.C. Simon, C.A. Dedryver, C. Rispe and M. Hullé (eds.). Editions INRA. (In press).

7 EIZAGUIRRE, M., ARENAS, N., LUMBIERRES, B., PONS, X., 2002. Daños de *Palaeococcus fuscipennis* Burm (Homoptera: Margarodidae) en pinos y cipreses de los parques de Lleida. Bol. San. Veg. Plagas 28, 199-205.

8 PALOUKIS, S.S., NAVROZIDIS, E.I., KUKURYANIS, V.H., 1997. Contribution to the integrated control of *Pseudaulacaspis pentagona* Targ.-Toz. (Homoptera: Diaspididae) on kiwifruit trees (*Actinidia chinensis*). Acta Hort. 444, 797-802.

9 GIROLAMI, V., MASON, L., ALMA, A., 2002. Il flatide *Metcalfa pruinosa* (Say) in Europa vent'anni doppo. Informatore Fitopatologico 7-8, 10-13.

10 REYNAUD, P., 2001. La mineuse du marronnier *Cameraria ohridella*. Phytoma, 539: 32-34.

11 PONS, X., LUMBIERRES, B., GARCÍA, S., MANETTI, P.L., 2002. *Metcalfa pruinosa* (Say) (Homoptera: Flatidae), ¿una plaga potencial de las plantas ornamentales en espacios verdes urbanos de Cataluña? Bol. San. Veg. Plagas 28, 217-222.

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# The species composition of the beetles (*Coleoptera*) on the poplars in Minsk

The green plantations have important climate-regulating, soil-erosive, water-protecting and wind-protecting value. By virtue of it, the process of planting of greenery in large administrative - industrial centres recently develops very intensively. In cities new species of plants are introduced from various regions of the country, as well as from foreign countries, that constantly enriches the composition of a adventive fraction of flora. One of such genus widely used in planting of greenery, is the poplar (*Populus* L.) - extremely composite in the systematic respect group of wood plants.

In territory of Belarus 3 species and 1 hybrid of poplars are aboriginal. All other species and hybrids (and more than 20 of them are indicated) are introduced species, delivered from various regions of the planet. With the development of a ecology and actualization of ecological aspects in all other sciences it became apparent, that it is impossible to study comprehensively alive organisms in a separation from each other and from their habitat. When cultivating introduced species there are many difficulties, connected with harmful activity of phyllophagous insects. Some of them are frequently delivered together with untroduced plants, with which they have evolutionary fixed connections. Besides on the delivered plants some aboriginal species begin to parasitize or to eat them. Therefore the researches on the species composition of phytophagous (phyllophagous first of all ) insects, connected with various species and hybrids of poplars, degree of their harmfulness, features of biology, establishment of natural enemies and parasites, and development of measures of reduction of their number become pressing.

The present research is supported by the grant of BRFFR Б02М-031. The results of examinations of consortiums are adduced in it, as unities of biocenosis as an example of consorts of the first order from Coleoptera order, is immediately bound with a determinant - species of a *Populis* genus.

During the research work (2002-2003 years) 48 species of the bugs relevant to 6 families were registered. The samplings were carried out on model trees various age of 6 species of a Populis genus (*P. alba* L., *P. bolleana* Lauche, *P. tremula* L., *P. balsamifera* L., *P. nigra* L.) and 1 autotriploid form (*P. tremula* f. *gigas* Nilsson-Ehle).

The greatest harm to poplars within the city of Minsk caused by phyllophagous (table 1), which cause their oppression, breaking normal entering of nutritious substances, exercise of respiratory processes, reducing rates of a photosynthesis because of destruction of chlorophyll-bearing tissues. Most massive and eating up practically on all species of poplars are *Melolontha melolontha*, *Amphimallon solstitialis*, *Chrysomela lapponica*, *Ch. populi*, *Phyllobius arborator*. Among caylophagoes 9 species are registered. To the rizophagoes at a larva stage 12 species are included. Among antophagoes 6 species are marked, and *Otiorhynchus ovatus*, *Phyllobius arborator* and *Ph. oblongus* damage the plants greater in the spring with the additional feeding supply after coming out of hibernation The analysis of trophic links has shown, that from the assembled species the share of polyphages is 62,5% (30 species), a share of oligophagous - 35,4% (17 species). The monophagoes are represented by one species - *Zeugophora flavicollis*, that makes 2,1%. This species was found out on *Populis alba*, *P. tremula*, *P. nigra*.

The majority of phitophagoes were registered on *Populis tremula* – 39 species, *P. alba* - 21 species. Sufficiently enough number of species was marked on *P. nigra*- 16 species, *P. bolleana* - 15 species and *P. simonii* - 12 species. *P. tremula* f. *gigas* and *P. balsamifera* were exposed least of all, where 5 species were registered on each of them.

The living conditions of poplars, is also important for the firmness to the influence of the consorts of the first order. The old trees when strongly damaged by philophagoes are frequently exposed of an attack of the secondary pests. In this way on old *Populis* besides philophagoes 8 species of *Cerambicidae* and 1 species of *Buprestidae* were marked. The young trees were damaged mainly by representatives of *Scarabaeidae*, *Chrysomelidae*, *Atellabidae*, *Curculionidae* families. The only species of *Lucanidae* was marked on young plantings of an aspen.

Solitary growing trees are damaged mainly by monophages and oligophagous, while poplar growing on a neighbourhood with other hardwood – by polyphagous. In polydominant phitosenosises the negative effect of phitophagoes become apparent to a lesser degree, that is probably connected with a large quantity of entomophagoes in them.

**Table** Coleoptera species registered on poplars and types of damages superimposed by them.*1– nibbling and gnawing of holes in leaves; 2 – skeletonizationof leaves; 3 – miniring of leaves; 4 – damage of generative bodies; 5 – damage of a cortex and wood; 6 – damage of roots (** I- imago; L - larva)

| **Phitophago** | **superimposed damages** | | | | | | **a Populus species** |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | |
| *Agrilus viridis* L. | I | | | | L | | *P. alba, P. simonii* |
| *Anomala dubia* Deg. | I | | | | | L | *P. alba, P. tremula, P. simonii* |
| *Melolontha melolontha* L. | I | | | | | L | *P. alba, P. bolleana, P. tremula, P. tremula* f. *gigas, P. simonii, P. balsamifera, P. nigra* |
| *Amphimallon solstitialis* L. | I | | | | | L | *P. alba, P. bolleana, P. tremula, P. tremula* f. *gigas, P. simonii, P. balsamifera, P. nigra* |
| *Serica brunnea* L. | I | | | | | L? | *P. alba, P. tremula,* |
| *Phyllopertha hortycola* L. | I | | | | | L | *P. alba, P. bolleana, P. simonii* |
| *Rhagium mordax* Deg. | | | | | L | | *P. tremula* |
| *Strangalia quadrifasciata* L. | | | | | L | | *P. bolleana, P. tremula* |
| *Aromia moschata* L. | I | | | | L | | *P. tremula* |
| *Xylotrechus rusticus* L. | I | | | | L | | *P. alba, P. bolleana* |
| *Saperda carcharias* L. | I | | | | L | | *P. bolleana, P. tremula* |
| *S. populnea* L. | I | | | | L | | *P. alba, P. bolleana* |
| *Lamia textor* L. | I | | | | I, L | | *P. tremula* |
| *Oberea oculata* L. | I | | | | L | | *P. tremula* |
| *Platycerus caraboides* L. | I | | | | | | *P. tremula* |
| *Zeugophora flavicollis* Mrsh. | | I | L | | | | *P. alba, P. tremula, P. nigra* |
| *Clytra quadripunctata* L. | I | | | | | | *P. alba, P. tremula, P. nigra* |
| *Cryptocephalus. bipunctatus* L. | I | | | | | | *P. tremula* |
| *Chrysomela lapponica* L. | I | | | | | | *P. alba, P. tremula* |
| *Ch. populi* L. | I | | | | | | *P. alba, P. bolleana, P. tremula, P. tremula* f. *gigas, P. simonii, P. balsamifera, P. nigra* |
| *Ch. tremula* Fabricius | | I, L | | | | | *P. alba, P. bolleana, P. tremula, P. tremula* f. *gigas, P. simonii, P. balsamifera* |
| *Ch. vigintpunctata* Scopoli | | I, L | | | | | *P. tremula* |
| *Gonioctena. viminalis* L. | I | | | | | | *P. tremula* |
| *Agelastica alni* L. | I | | | | | | *P. alba* |
| *Lochmaea caprea* L. | I, L | | | | | | *P. tremula* |
| *Altica brevicollis* Foudras | I | L | | | | | *P. tremula* |
| *Apoderus coryli* L. | I, L | | | | | | *P. tremula* |
| *Byctiscus betulae* L. | I, L | | | | | | *P. tremula* |
| *B. populi* L. | I, L | | | | | | *P. bolleana, P. tremula, P. nigra* |

| **Phitophago** | **superimposed damages** | | | | | | **a Populus species** |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | |
| *Deporaus betulae* L | I, L | | | | | | *P. tremula* |
| *Otiorhynchus ovatus* L. | I | | | I | | L | *P. alba, P. bolleana, P. tremula, P. nigra* |
| *Ot. repletus* Boh. | I | | | | | L | *P. tremula* |
| *Ot. tristis* Scop. | I | | | | | L | *P. alba, P. tremula* |
| *Phyllobius arborator* Hbst. | I | | | I | | L | *P. alba, P. bolleana, P. tremula, P. tremula* f. *gigas, P. simonii, P. nigra* |
| *Ph. argentatus* L. | I | | | | | L | *P. bolleana, P. tremula, P. nigra* |
| *Ph. maculicornis* Germ. | I | | | | | | *P. bolleana, P. tremula, P. simonii, P. nigra* |
| *Ph. oblongus* L. | I | | | I | | | *P. alba, P. tremula* |
| *Ph. scutellaris* Redtb. | I | | | | | L | *P. alba, P. tremula, P. simonii, P. nigra* |
| *Polydrusus cervinus* L. | I | | | | | | *P. tremula, P. nigra, P. balsamifera* |
| *P. undatus* F. | I | | | | | L | *P. tremula* |
| *Tanymecus palliatus* F. | I | | | | | | *P. nigra* |
| *Chlorophanus viridis* L. | I | | | | | | *P. nigra* |
| *Dorytomus longimanus* Forst. | I | | | I, L | | | *P. alba, P. bolleana* |
| *D. nebulosus* Gyll. | I | | | I, L | | | *P. alba, P. bolleana, P. nigra* |
| *D. tremulae* F. | I | | | I, L | | | *P. bolleana, P. tremula, P. simonii, P. nigra* |
| *Rhynchaenus decoratus* Germ. | | I | L | | | | *P. tremula, P. simonii, P. nigra* |
| *Rh. populicola* Silfverberg | | I | L | | | | *P. tremula* |
| *Rh. stigma* Germ. | | I | L | | | | *P. tremula* |

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# *Tomostethus nigritus* F. (Hym., Tenthredinidae) – a serious pest on ornamental ash trees in Zagreb

## Introduction

Zagreb, the capital of Croatia has a long tradition of urban horticulture. Tree lined avenues, parks and urban forests are one of Zagreb landmarks.

Ash is, among other species (plane, horse chestnut, lime, maple), one of the regularly planted species in tree avenues, especially in newer parts of Zagreb.

Three ash species are native to Croatia. *F. excelsior* L. grows in forests on mountaintops, *F. angustifolia* Vahl. is very important species in lowland common oak (*Quercus robur* L.) ecosystems and *F. ornus* L. grows in Mediterranean forests. *Fraxinus excelsior* (common ash) and non-native *F. pennsylvanica* Marshall (red ash) grow quickly and make excellent shade trees and are therefore often planted in avenues.

## *Tomostethus nigritus* – occurrence and damage

The larvae of *Tomostethus nigritus F.* (Hym.: Tenthredinidae) began causing severe defoliation on ash along avenues and tree lines in Zagreb, Croatia since 1997. The phenomenon of population outbreaks of this pest in periurban and urban environments is known but poorly documented in the literature [1, 4]; the fact that it has not yet been recorded in Croatian forests has spurred authors to investigate further into this natural event. Populations achieved outbreak levels in the second year after defoliation was first recorded and since 1998 the population shows no signs of coming into latent phase. This was first known outbreak of this pest in Croatia but this ash sawfly is on the checklist of Croatian Hymenoptera [5]. Periodic outbreaks of common forest pests are well monitored in the area so the first dramatic signs of ash defoliation caused by *T. nigritus* initiated interest among forest entomologists who were concerned about the threat it could pose to these valuable tree species.

The insect makes serious damage to ash avenues. At the time of swarming the whole ash avenues are full of sawfly adults flying from crown to crown, being a nuisance to inhabitants and passerbies. Defoliation dynamics is dramatic because in a few days trees with no visual damage are left without leaves. Larvae completely defoliate ash trees and only leaf midveins are left. It is impossible to sit or stand under these trees because of masses of excrement that fall to the ground like a rain. Because of lack of food larvae fall to the ground in masses. Since 1998. the insect is slowly spreading to other ash avenues in Zagreb.

Lack of newer data, toughness of the local outbreaks, occurrence of new outbreak loci (only in urban areas) and reports of similar pest causing serious damage on ash species in forest and periurban stands in northern Italy (Stergulc, pers. comm.) lead us to further investigate *T. nigritus*.

We have researched detailed biology and population dynamics of *T. nigritus*, conducted palatability test on three ash species (*Fraxinus excelsior, F. pennsylvanica and F. angustifolia*), tested laboratory level of parasitism and looked behind reasons for outbreaks in avenues only and not in forest.

## Biology of *Tomostethus nigritus*

T. nigritus is univoltine and it is monophagous pest on ash. The ash sawfly spends a winter as eonymph or pronymph within cocoon in soil around the base of previously infested ash trees. Pupation occurs in early spring. Adults are small, black, nonstinging wasps that emerge in April. Date of emergence depends strongly on weather (in the 2002 the emergence started on 3$^{rd}$ April, in the 2003 on 20$^{th}$ April). During warm days swarms of wasps appear around ash trees as they mate and lay eggs. In heavy infested avenues swarms are nuisance for inhabitants. Females insert eggs into the edge of expanding leaves. This

usually results in a slight distortion of the leaves. This pest has a prolonged emergence and egg laying so at the same time adults, eggs, first, second and third larval instars can be found. Young larvae emerge after 10-14 days, in warm weather development is much quicker. During most years the larvae are active by the end of April and during first two weeks in May when they become full-grown. *T. nigritus* has five distinct instars. The colour of the larva changes through its development. It starts as small hyaline egg larva, the second instar has greenish cast because of the gut filled with chloroplast. Third and fourth instar are bright green with green head. The fourth larval instar which is making the most damage, moults into non-feeding olive green instar which descends the tree trunk and burrows itself in the earth where it starts making an earthen cocoon. During their development papery larval skin (exuvia) can be found attached to the leaf. After the final larval stage (olive green and non-feeding) they crawl to the soil where they form protective cocoons. The larvae remain in the cocoons, as pronymphs until the following season, or as eonymph until the second spring (diapause).

## The reasons behind outbreaks in avenues only and not in forests

We have noticed that in avenues larvae attack *F. excelsior* trees only and *F. pennsylvanica* trees are left almost intact. The results of palatability test showed that *T. nigritus* larvae can fully develop on three ash species (*F. excelsior, F. pennsylvanica and F. angustifolia*). This indicates that *T. nigritus* could pose a serious threat to our native ash forests and it also indicates that the palatibility of ash leaves is not a limiting factor for choosing the ash species. Phenology is one of the key factors influencing intensity of defoliation on individual ash trees of the same species (*F. excelsior*) and intensity of defoliation of different ash species (*F. excelsior* and *F. pennsylvanica).* Females lay eggs on the margins of ash leaves that have just started to emerge from buds. Ashes that have been in the right stage of leaf development at the time of mass swarming have been completely defoliated. Ashes that had fully developed leaves or that had only buds on their branches have not been attacked or have been moderately attacked. *F. pennsylvanica* comes into leaf later than *F. excelsior* so its leaves are not in the optimal developmental phase for egg laying.

Although *T. nigritus* is considered as a forest pest, there must be limiting factors in forests that determine its occurrence there. *T. nigritus* is present in natural oak and ash forests and it is regarded as forest pest. Lowland oak and ash forest are stabile ecosystems which are regularly flooded and which have natural regulating mechanisms (predators and parasitoids). It is also known that the floods can have a negative impact on some populations of forest arthropods that occur in the soil or litter including some serious forest pests [6]. Excessive moisture in the soil during a portion of the year could heighten the impact of pathogenic fungi thus enhancing the mortality of arthropod populations. Presumably, the high levels of flood water during adult emergence in spring could also cause mortality; all of these parameters might have a significant role in regulating some other pest populations in these forests [3].

In natural habitats herbivorous insects seldom outbreak whereas in disturbed or highly managed habitats, where ecological processes are disrupted, insects frequently outbreak [7]. Compared to the forest, avenues can be regarded as very simple or disturbed habitats where there are only trees without understory layer. In these simple ecosystems natural regulating mechanisms are absent or are present in a number that can not efficiently influence the pest population.

Parasitoids of *T. nigritus* have been observed in the field, searching for and attacking larvae. In laboratory tests parasitoids have also been reared. But despite the presence of parasitoids the population of *T. nigritus* shows no sign of coming down.

It was expected from investigation of the parasitoid community to reveal some clues into the regulation of *T. nigritus* particularly the causes of the decline in population. However the parasitism rates were not as high as was reported by Mrkva [4]. He reported parasitism rates as high as 80% and stated that even a 20% rate was considered as adequate to cause the population decline and eliminate the need for control measures. The parasitism rate obtained in our monitored population was less than 50% and this level did not seem to have any effect on sawfly populations. It’s very possible that repetitive chemical treatments had detrimental effects on the parasitoid community. At the same time, ineffective treatments only partially reduced *T. nigritus* populations which might have contributed to the continuation of the outbreak itself [2, 8].

## Control of *T. nigritus*

There are several considerations when deciding whether to control ash sawfly. Established, healthy trees tolerate defoliation fairly well, particularly if it occurs infrequently. Trees that are repeatedly heavy defoliated are in marginal health particularly if they are suffering from other stress. Ash trees in avenues in Zagreb have been heavy defoliated since 1997 and in 2000, 2001, 2002 have been under stress because of serious drought in spring. This situation has caused alarm and concern among inhabitants and specialists in tree health care. It was therefore decided to treat the outbreak sites with insecticides. In the period of several years IGR (DIMILIN) were used. The results were satisfactory but one critical moment was observed. Defoliation progresses very quickly and treatments are most useful if applied early in the infestation when young larvae make pinhole injuries on leaves. If this stage is missed defoliation progresses very quickly and tress can be defoliated in two to three days. At this stage treatment has only partial beneficial effect because larvae have already defoliated the majority of the crown.

Regarding the spatial and temporal distribution of larval stages and post embryonic development, it is of practical interest to note that it is quite common to have almost all larval instars present at the same locality at the same time. This is due to the intraspecies diversity in tree phenology. This complicates the timing of application of suppression tactics and is the most important factor that contributes to inconsistent results of the treatments. Early appearance of the egg laying females and insufficient leaf area available for spray deposits also contribute to application problems.

Good population prognosis is very valuable when planning a treatment. The number of eonymphs diapausing in the soil is very important for prognosing the population densities of *T. nigritus*. If the treatment of larvae has been successful there is always certain number of eonimphs in the soil which can cause the build up of population the following spring.

Laboratory and field trials were conducted in order to determine the best possible way of suppressing *T. nigritus* populations with chemical pesticides. All tests conduced under laboratory conditions gave satisfactory results and results differed only in the time lag between the application of the products and first symptoms of larval intoxication. Four commercially available chemicals were tested: NOMOLT SC (a.s. teflubenzuron 150 g/l), BONUS SC (a.s. alphacypermethrin/teflubenzuron 40/120 g/l), SOxJA (neem oil) and FASTAC SC (a.s. alphacypermethrin 100g/l) which was used as the control. Based on operational success, market availability, and legislative restrictions on the use of chemical treatments in urban areas, we selected NOMOLT SC and DIMILIN for field use and since 1998 it has been applied annually. The success of the applications has varied and, depending on the efficiency of the equipment used to provide good coverage and droplet distribution, and timing of application. In the context of this research the applications are considered as additional impact factors which obscured the otherwise more natural dynamics of the population.

## Conclusion

*Tomostethus nigritus* is a serious pest of ash trees which can cause complete defoliation. We regard it as a potential threat to nurseries, avenues and forests where ash trees especially *Fraxinus excelsior* and *F. angustifolia* is grown. After several years of studying its biology and population dynamics the following conclusions can be made:

Floods are natural regulating mechanisms in natural oak and ash forests. These forests are regularly flooded in spring. There are no floods in avenues so nymphs have much better conditions for overwintering and nothing prevents adults from emerging from the ground.

In avenues, parasitoids are present but not in sufficient number to reduce the population. In very simple urban ecosystem (only trees without shrubs or any other undergrowth) there are not enough hiding places for predators and there are no secondary host for parasitoids.

The avenues with severe outbreaks of *T. nigritus* have been treated with insecticides annually. Untimely, low quality and unselective treatments influence also the parasitoid population and it could be possible that they have prolonged the outbreak and made it more severe than the initial outbreak.

Combination of all these factors has caused severe outbreaks of *T. nigritus* in ash avenues in Zagreb. More investigations are necessary to understand all the influencing factors on outbreak triggering and population regulating mechanisms of *T. nigritus*.

This is important because the use of pesticides for a pest control in urban environment will be more limited in the coming years.

## Literature


1 AUSTARA, O., 1991. Severe outbreaks of the ash sawfly *Tomostethus nigritus* F. (Hymenoptera, Tehthredinidae) on ornamental trees in Oslo. Anzeiger für Schädlingskunde, Pflanzenschutz und Umweltschutz 64 (4): 70-72.

2 BERRYMAN, A., 1986. Forest insects. Principles and Practice of Population Mangement. Plenum Press. New York and London, 279 pp.

3 HRAŠOVEC, B., 1993. Prilog poznavanju bioekologije iz roda Balaninus Germ., štetnika žira hrasta lužnjaka (*Quercus robur* L.). Glasnik za šumske pokuse 29, 1-38.

4 MRKVA, R. 1965: Prispevek k morfologii, bionomii a poznani parazitu pilatky jasanove (*Tomostethus nigritus* Fabr.). Vyzkumny ustav lesniho hospodarstvi a myslivosti, Zbraslav-Strnady, 35-59.

5 PEROVIĆ, F., LEINER, S., 1996. Index of the Sawflies Sensu lato (Hymenoptera, Symphyta) of Croatia. Natura Croatica 5(4): 359-381.

6 SCHOWALTER, T.D., 2000. Insect Ecology – an Ecosystem Approach. Academic Press. San Diego.

7 SHREWSBURY, P., RAUPP, M.J., 2000. Crating landscapes that suppress insect pest outbreaks. Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft. Int. Symp. Plant Health in Urban Horticulture, Braunschweig, 256-261.

8 SPEIGHT, M.R., WAINHOUSE, D., 1989. Ecology and Management of Forest Insects. Clarendon Press, Oxford.

# Special - *Cameraria ohridella*

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## *Cameraria, Gugnardia* or drought, how much of an impact ?

### Introduction

Quite astonishing appearance and dramatic spread of the newly recorded leaf miner on horse chestnut trees lured attention and much of the research focus on the problem of its management, suppression and many other fundamental and practical aspects in natural sciences. *Cameraria ohridella* Deschka et Dimić conquered the larger part of the European territory in less than two decades and justifiably earned a reputation of becoming one of the most severe and damaging defoliators on urban trees in this part of the continent [1, 2, 3, 5, 6, 7, 10, 11, 12]. Dramatic population buildups, both in the years following the first appearance, as well as during the development of the multiple generations in a single year period resulted with obvious leaf damage, premature leaf fall and abnormal autumn sprouting and leafing. Due to the heavy damage extent a tree mortality induced by this severe defoliation was expected to appear. The phenomenon is known from similar cases of defoliator attack, the difference here being in the relative late seasonal culmination of the leaf tissue destruction. The fact that serious leaf damage due to the mine development appears later in the season, after a significant portion of the leaf physiology has been performed, led some researchers to a hypothesis that moth itself is not really that much important and has been given too much emphasis in the light of other noxious factors involved in the destruction of urban trees [9, 13, 14]. On the basis of new monitoring activities targeted to an infamous moth and the fact that more attention has been drawn on other harmful impacts involved [4, 8], we made an effort trying to quantify the impact of most important biotic and non biotic precursors on the trees in the city of Zagreb. The quest for the most important ones, with the readily available and defined method, led us to the most dominant three: *C. ohridella*, *Guignardia aesculi* (Peck.) Stew. and drought with combination of the high temperatures.

### Materials and methods

For the monitoring purposes we selected the typical and largest horse chestnut tree lanes in the city, trying to cover the variable site characteristics that might have influenced the health status of the monitored trees. Nearly all monitored trees had bad to extremely bad conditions in the pedosphere, based on the area of open soil area and its compaction. One location had a better conditions regarding the winter salting issues since it had a raised stone circumsphere guarding the trunks from the mechanical injuries from parked vehicles.

For the two years in a row (2000–2001) during July, every tree was visually analyzed and tested against previously defined parameters. They were grouped under the two categories. First, the visible part of the trunk was checked against possible scars and signs of internal damages. Three damage classes were defined: undamaged, damaged up to 1/3 of the circumference and damaged more than 1/3 of the circumference. On the basis of the visible soil cover, three classes describing the pedosphere situation were described: good, medium and poor. Secondly, the crowns received the most of our attention. General appearance was classified into three classes: natural-full, reduced and significantly reduced (due to extensive pruning). Leaf color was the main topic on which we based our screening. In order to be as objective as possible we reduced the number of classes to three as follows: green, yellowish-brown and fallen (sometimes with first signs of new leafing). The last monitored character was the assessment of the cause for the leaf color change. Being acquainted with the already known factors we could easily distinct between three different classes: predominantly drought, predominantly leaf miner and predominantly leaf fungus. Aerial ortophoto images of the monitored tree lanes were used as helpful tool for the easier

identification of the trees in the field. Meteorological data from the research period were taken from the local measuring stations through the national climatic monitoring network.

## Results

The results of the conducted two-year analyses are both tabulated and presented graphically. A total of 470 (468 respectively) trees has been analyzed in both of the consecutive years. Number of trees varied both in the three tree lanes as well as in the two consecutive years. Minor differences in total tree numbers were caused by the removal of dead or almost dead ones or addition of new young trees. All of the tree lanes had an east-west orientation. We expected to find some differences in north and south facing trees. The reasoning was that the variable amount of insolation they receive, especially the amount of sun hitting the ground should cause excessive evaporation on the already small area of open soil.

**Tab. 1** Results of the screening in the year 2000

| **Tree lane** | **Orien-tation** | **Leaf color** | | | **Harmful agent** | | | | **Crown status** | | | **Total trees** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **G** | **Y** | **B** | **D** | **Co** | **Gu** | **A** | **F** | **R** | **SR** | |
| 1. Deželićev prilaz | north | 88 | 15 | 1 | 16 | 87 | 0 | 1 | 33 | 66 | 5 | 204 |
| | south | 85 | 15 | 0 | 6 | 94 | 0 | 0 | 24 | 71 | 5 | |
| 2. Maksimirska | north | 33 | 79 | 15 | 74 | 40 | 0 | 13 | 46 | 75 | 6 | 127 |
| | south | - | - | - | - | - | - | - | - | - | - | |
| 3. Zvonimirova | north | 5 | 49 | 11 | 29 | 28 | 0 | 7 | 6 | 47 | 11 | 139 |
| | south | 3 | 53 | 19 | 41 | 28 | 0 | 6 | 13 | 51 | 11 | |
| Total | | 164 | 211 | 46 | 166 | 277 | 0 | 27 | 122 | 310 | 38 | 470 |

**Tab. 2** Results of the screening in the year 2001

| **Tree lane** | **Orien-tation** | **Leaf color** | | | **Harmful agent** | | | | **Total trees** |
|---|---|---|---|---|---|---|---|---|---|
| | | **G** | **Y** | **B** | **D** | **Co** | **Gu** | **A** | |
| 1. Deželićev prilaz | north | 86 | 19 | 0 | 18 | 79 | 8 | 0 | 206 |
| | south | 91 | 10 | 0 | 12 | 77 | 12 | 0 | |
| 2. Maksimirska | north | 71 | 44 | 11 | 82 | 28 | 11 | 5 | 126 |
| | south | - | - | - | - | - | - | - | |
| 3. Zvonimirova | north | 23 | 35 | 2 | 35 | 22 | 2 | 1 | 136 |
| | south | 34 | 40 | 2 | 36 | 38 | 1 | 1 | |
| Total | | 305 | 148 | 15 | 183 | 244 | 34 | 7 | 468 |

**Leaf color** = **G** (green), **Y** (yellow), **B** (brown); **Harmful agent** = **D** (drought), **Co** (*C. ohridella*), **Gu** (*G. aesculi*), **A** (no leaves); **Crown status** = **F** (normal-full), **R** (reduced), **SR** (significantly reduced)

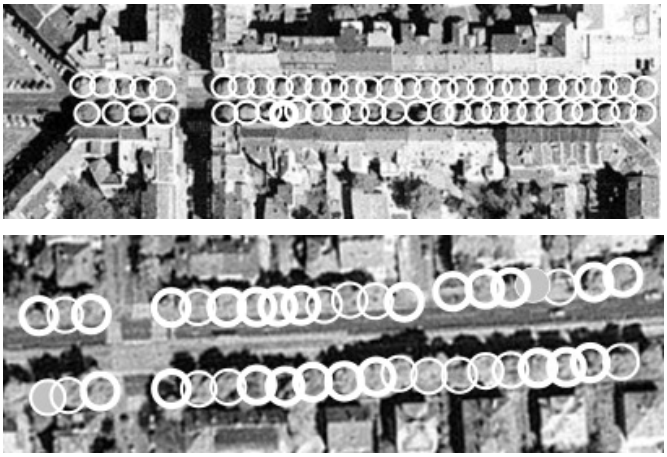

**Fig. 1** Example of the different ratio of harmful impacts in two of the monitored tree lanes (thin circles – *C. ohridella*, thick circles – drought, shaded circle – no leaves). Both pictures reflect the situation in 2000 (further explanation in the text).

Crown status was only determined in the first screening in 2000, since no major changes occurred in that aspect of tree morphology. Climatic data (Figure 2, 3) confirmed the obvious sensation of high spring and early summer temperatures and lack of precipitation in the same period. Both temperature and precipitation in the two consecutive years have shifted significantly from the 30-year averages. Shortly, the research area has been hit by abnormally high daily temperatures as well as quite serious drought. *G. aesculi* impact was almost negligible due to the fact that the atmospheric circumstances were not preferable for the fungal growth. Small change is still visible when comparing the results for two consecutive years.

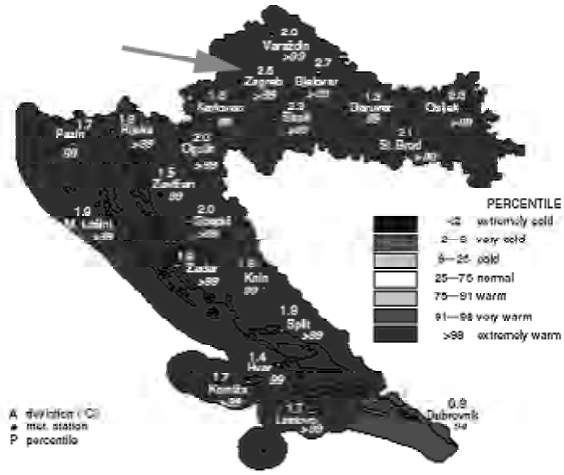


**Fig. 2** Seasonal air temperature anomalies for Croatia for summer 2000 (June August) from normal values (1961–1990).

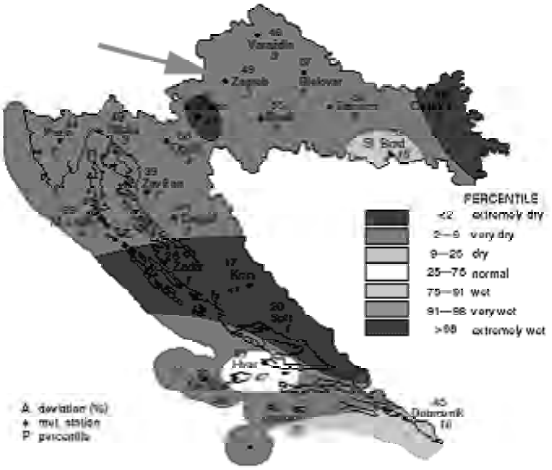


**Fig. 3** Seasonal precipitation amounts in Croatia for summer 2000 (June August) expressed as percentages from normals (1961–1990).

## Discussion

According to the biannual visual assessment, the trees in Zagreb were quite widely been attacked by the *C. ohridella* moth. It should be noticed that in all of the screened tree lanes, as well as the rest of the city trees, repressive actions have been applied regularly for more than 5 years backwards. Removal of the leaf litter and spraying with the IGR chemicals against the first generation moths has become a practice in the city. It is still of no surprise that the moth is widely distributed and easily found in all blocks and tree lanes. This is especially true later in the summer when refugiums that are not treated at all (private backyards and gardens inside blocks of houses) start contributing significantly to the moths dispersal. Second most encountered factor were the symptoms of drought. In some instances, such as tree lane number three, drought was encountered even more important than all other factors. *G. aesculi* was definitively the least important and most rarely encountered factor. This might be explained by the climatic circumstances that govern its dispersal and growth. They were unfavorable in both of the consecutive years. Also the crown densities were low and those tree lanes are normally not that heavily attacked by this fungus. More problems with it occur in shady and humid places like city parks and nurseries where dense and interwoven crowns pose ideal growing substrate for the fungus. Numerical relations suggest that *C. ohridella* was actually the most commonly encountered factor, followed by drought and *G. aesculi* (Figure 4, 5). This might lead to a conclusion that it is also the most important noxious factor regarding the health condition of the trees and this obviously was not the case in our study.

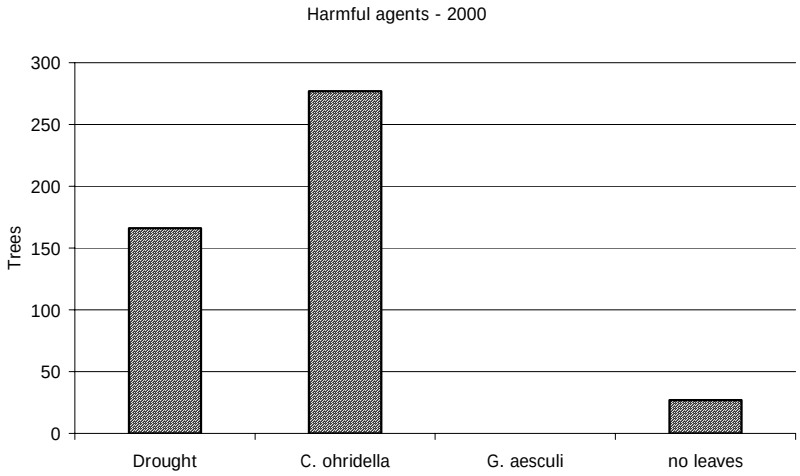


**Fig. 4** Frequency of the three most important detrimental factors in the year 2000.

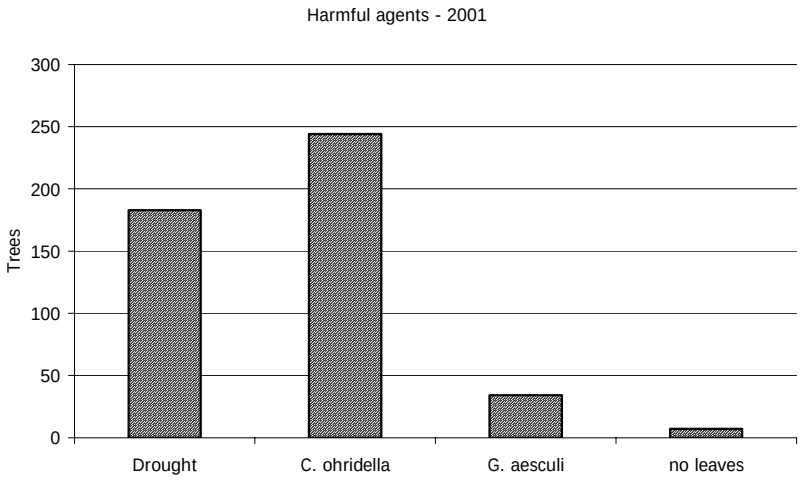


**Fig. 5** Frequency of the three most important detrimental factors in the year 2001.

Comparative analysis of two tree lanes with different site conditions can support this statement. Observed leaf color, which generally reflects the condition of the tree attack status irrelevant of the causal agent, between trees in plot number one and three show striking differences in the distribution of the leaf color classes (Figure 6).

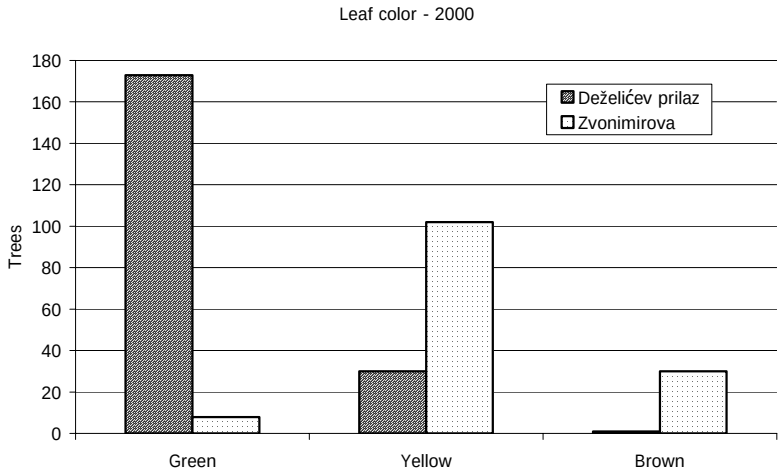


**Fig. 6** Condition of the tree crowns assessed through the leaf color in the year 2000 in two contrasting tree lanes.

The only plausible reason for this are the site conditions which were obviously more favorable in the tree lane number one. Those trees had significantly more shade (narrower street bordered with three or four story house blocks) and less sun insolation respectively. Amount of available aerated soil was also larger. Finally, the trees in the location one have been pruned in such a way that they retained their natural crown shape. The whole tree lane can be described as well looking, well hidden from the sun and in certain extent protected from the mechanical injuries. Not less importantly, for a longer period of time there have been no reconstruction works in this area. And yet the moth predominance was the highest in these trees ! Actually the moths presence was probably underestimated in the other two tree lanes due to the fact that summer scorched leaves could not be precisely observed from the ground (or for that matter even if taken a closer look). This is one of the inaccuracies that we could not overcome with the methodology that we used. Still, it is more than visible, from the numerical data accompanied with site descriptors, that the most heavily struck trees were those hit both by drought and high temperatures (evapotranspiration) and not by the impact of moth or fungus *per se*. Quite seriously attacked trees in the first location remained green and retained most of the physiological and aesthetical role of its crowns. On the other hand, equally or less attacked trees in the other two locations showed obvious symptoms of serious leaf damage and even complete leaf fall as well as more instances of dying or completely dead individuals.

A conclusion that we draw from all these data is that *C. ohridella* and *G. aesculi* cannot be blamed for being the one and only detrimental factor involved in the physiological and aesthetical problems affecting horse chestnut trees. Urban environment, with its negative abiotic and anthropogenic impacts has much more significant and visible influence on these trees. However, it should be underlined that the tree lines in this study have received regular suppression measures against *C. ohridella*. This obviously had a positive impact on reducing the moth population to acceptable levels. These "acceptable levels" obviously are variable and very tightly dependant on general physiological status of the tree. In our study, it turned out to be the drought and high spring and summer temperatures that act as predisposing and even main detrimental factors determining the crown status of horse chestnut trees in urban environment.

Practical impact of the above conclusion is that not only moth suppression will be needed in efforts to minimize the damages but more emphasis should (and could) be targeted on improvement of site conditions, especially soil and microclimate, in order to enable the trees to heighten their resistance levels and "learn to live" with the new pest.

## Literature


1 DAUTBAŠIĆ, M., DIMIĆ, N., 1999. Occurrence of *Cameraria ohridella* Deschka & Dimić in Bosnia-Herzegovina. Works of the Faculty of Forestry University of Sarajevo 1, 11−14.

2 DE PRINS, W., PUPLESIENE, J., 2000. *Cameraria ohridella*, een nieuw soort voor de Belgische fauna (Lepidoptera: Gracillariidae). Phegea 28 (1), 1–6.

3 GUICHARD, S., AUGUSTIN, S., 2002. Acute spread in France of an invasive pest, the horse chestnut leafminer *Cameraria ohridella* Deschka & Dimić (Lep., Gracillariidae). J. of Pest Science 75 (6), 145–149.

4 HARAPIN, M., 1999. The horse-chestnut miner (*Cameraria ohridella* Deschka et Dimić), a dangerous pest in Europe. Šum. list 123 (3–4), 129–132.

5 HEITLAND, W., FREISE J., 2001. Verbreitung der Roßkastanien-Miniermotte, *Cameraria ohridella* (Lep., Gracillariidae) in Deutschland. Mitt. Dtsch. Ges. Allg. Angew. Ent. 13, 131–134.

6 HELLRIGL, K., 1998. Zum Auftreten der Robinien-Motte, *Phyllonorycter robiniella* (Clem.) und der Roßkastanien-Miniermotte, *Cameraria ohridella* Desch. & Dim. (Lep., Gracillariidae) in Südtirol. J. of Pest Science 71, 65–68.

7 HELLRIGL, K., AMBROSI, P., 2000. Die Verbreitung der Roßkastanien-Miniermotte *Cameraria ohridella* Desch. & Dimic (Lepid., Gracillariidae) in der Region Südtirol-Trentino. J. of Pest Science 73, 25–32.

8 HRASOVEC, B., DIMINIC, D., 2000. Pests and diseases of trees in continental urban areas in Croatia – surrent status and future trends. Mitt. Biol. Bundesanst. Land-Forstwirtsch. 370, 63–68.

9 JURC, M., 1997. Besides the Leaf Blotch of Horse Chestnut (*Guignardia aesculi* /Peck./Stev.) the Horse Chestnut in Slovenia is threatened by the Horse Chestnut Leafminer (*Cameraria ohridella* Deschka et Dimić). Gozdarski vestnik 55 (9), 428–434.

[10] KENIS, M., FORSTER, B. 1998. Die Rosskastanien-Miniermotte: neu in der Schweiz. Der Gartenbau 39, 16–17.

11 LABONOWSKI, G., SOIKA, G., 1998. The horse chestnut leafminer infesting chestnut in Poland. Ochrona Roslin 42 (12), 12.

12 MACELJSKI, M., BERTIĆ, D., 1996. Kestenov moljac miner - *Cameraria ohridella* Deschka & Dimić (Lep.: Lithocolletidae) – novi opasni štetnik u Hrvatskoj. Fragmenta Phytomedica et Herbolologica 23 (2), 9–18.

13 OVEN, P., 2000. Poškodbe mestnega drevja zaradi soli. Proteus 63 (4), 177–178.

14 OVEN, P., LEVANIČ, T., 2001. Jahrringanalytische und holzanatomsiche Untersuchungen an unterschiedlich belaubten Rosskastanien (*Aesculus hippocastanum* L.) in Ljubljana, der Haupstadt Sloweniens. Jahrbuch der Baumpflege 2001, 34–39.

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## Management and monitoring of the horse chestnut leafminer, *Cameraria ohridella* with an attract and kill formulation, LASTCALL

Infestations of horse chestnut leafminer are devastating tree-lined avenues in many European cities. An efficient high-yield, high-purity pheromone synthesis was developed. Attract and kill formulations of the pheromone were tested in a commercial tree nursery and for protection of street trees. In this first year of trials, 2003, LastCall Attract and Kill shows considerable efficacy in suppression of *Cameraria ohridella*.

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# Thermal treatment of *Cameraria ohridella*

Since several years people have been looking for possible and feasible methods for a sustainable control of *Cameraria ohridella*, a pest of the white flowering horse-chestnut trees, *Aesculus hippocastanum*, which nowadays is present in many parts of Europe. So far neither biotechnological (e.g. using pheromone baited sticky traps) nor permitted chemical approaches (e.g. using insecticides) resulted in any success. Experience showed that the only recommendable method is the area-wide complete removal of the the horse-chestnut autumn foliage because it is in this that the pupae of *C. ohridella* hibernate (GILBERT ET AL 2003, KEHRLI & BACHER 2003).

The Waipuna Hot Foam System was originally designed for weed control. The system consists of a mobile diesel-powered, computer controlled boiler that delivers a mixture of corn and coconut sugars added to boiling hot water (0.9 litre sugar mixture / 182 litre water) through a supply hose. The system generates a biodegradable foam at 98°C (compare QUARLES 2001), with a thin film that prevents the heat from immediately dissipating as the hot water is released. In first field tests the suitability for a control of *C. ohridella* by treatment of the autumn leaf litter containing the hibernating pupae was tested in spring 2003. Leaf litter of different height (10, 20, and 30 cm) in bottom- and topless round wire baskets (diameter: 0.6 m) and, in addition, different parts of the garden were treated with the organic foam. Samples of the the treated leaf litter and of controls were transferred into a climatic chamber the following day and adults of *C. ohridella* were reared.

The foam kept up temperatures of 30- 40°C in the leaf litter for several hours. In general, the organic hot foam led to a significant reduction of living pupae inside of the leaf litter with more then 90% of the pupae killed.

While the Waipuna System still has to prove its feasibility and effectiveness in large scale trials, it might be one additional method to reduce the leaf damage caused by the horse chestnut leafminer at least at certain locations, especially in combination with other control methods (e.g. pheromone trapping techniques).

## Literature

1 Gilbert et. al, 2003.

2 Kehrli, P. & S. Bacher (2003): Date of leaf litter removal to prevent emergence of *Cameraria ohridella* in the following spring. Entomologia Experimentalis et Applicata 107: 159-162.

3 Quarles , W. (2001): Improved hot water weed control system. IPM Practitioner XXIII (1): 1-4.

4 Quarles , W. (2001): Improved hot water weed control system. IPM Practitioner XXIII (1): 1-4.

5 Dr. J. F. Freise, Fachbereich Schädlingsbekämpfung, Niedersächsisches Landesamt für Verbraucherschutz und Lebensmittelsicherheit, Birkenweg 1, D-26127 Oldenburg – JonaFreise@laves.Niedersachsen.de.

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# Possibilities of *Cameraria*-control under urban conditions

The horse chestnut leaf mining moth, *Cameraria ohridella* DESCHKA AND DIMIC (Lepidoptera, Gracillariidae) was first noticed in Berlin in 1998. Ever since effective solutions were demanded to reduce the population in order to conserve the city-image and the chestnut-vitality. There are no simple options for *Cameraria*-control under urban conditions as there are many occurrences of the chestnuts in the city and the trees are spread over all boroughs. Possible methods were evaluated in detailed pre-analyses with the aim to be applicable for the usage in public as well as in private green. Criteria for the official registration of the pesticides in Germany by the state authorities are equivalent to the effectiveness of the products, but also the acceptance in the public and the suitable application technologie are important.

## Chestnut trees in urban areas

The chestnut has been a popular tree-type in the urban area for over 200 years both in public as well as in private greens. They are almost the only tree widely known by local residents. This type of trees blossoms in spring with nice flowers and in autumn with fruits. There are multiple arrangements of the chestnut trees in the whole urban area. In public parks and squares they are either planted as singles-trees, in view-axes or as group-plants. Thus chestnuts were used as a view-element in historical parks. Big trees grow in backyards of tenements in Berlin. In some Berlin districts many house-gardens are characterised by the chestnut tree. Individual chestnuts exist also in the Berlin forests. As street-tree-type the chestnut is only the fifth most common tree. A typical chestnut-avenue impress especially because of the height of the trees. Its prominence is decreased since the late 1970's because of acute problems with the de-icing salt application in the winter-service [1]. Actually there are nearly 60 000 chestnut trees in Berlin.

## Possibilities of control of *C. ohridella* at different areas

Mechanical methods

At present the complete defoliagtion is one of the most popular and efficient methods for reduction of *Cameraria*. This goes for the small-flat foliage-elimination as well as for concentrated foliage-actions in the city. The problems of the foliage-actions in Berlin and their effects on the population-development of *C. ohridella* were clearly demonstrated [2].

Chemical methods

In Europe the population-regulation of *C. ohridella* with insecticides was tested since their first appearance. Nowadays many insecticides made of different active substance-groups are available. Additionally application-methods and application-time of the different insecticides can be altered. Chemical pesticides must be registrated in Germany specific for the control of *C. ohridella*. Most of chestnuts are on private properties, therefore extended registrations for the house- and small-garden of the products are necessary. Chemical applications are:

- Leaf-spraying over the entire crown
- Leaf-spraying as patch-treatments of the crown
- Spraying of the trunk during the fly of the first generation of *C. ohridella* in the spring
- Paint-procedures of the bark with systemic substances
- Trunk-infusion or -injection with systemic substances
- Ground-treatments (pours and injection) with systemic substances

Since four years the trunk-infusions and -injections and different ground-treatments like pours and injection were tested against *C. ohridella* with a systemic insecticide at old chestnut-trees. Four big-trees were treated with individual variations. These uniform and equally old (ca. 50 years old) trees stood at a street. The findings after one year application are shown in figure 1. The effect of the product could be proven in the comparison to the control. It is recognisable that the ground-treatments are the best control for this pest. Trunk-infusions and -injections had a smaller effects and in addition caused mechanical wounds.

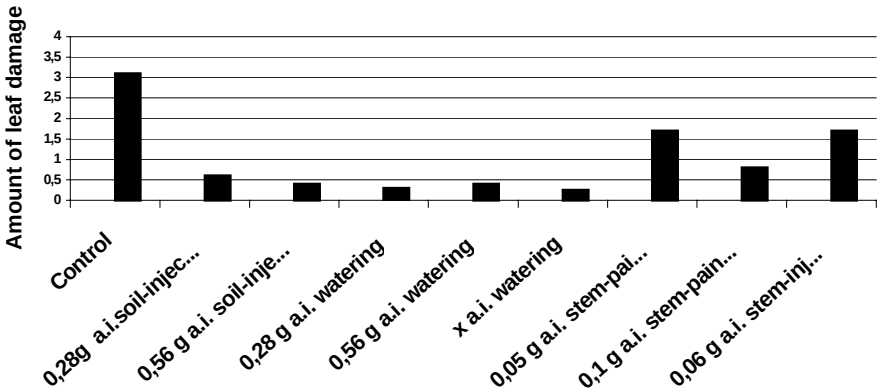


**Fig. 1** Effect of a systemic insecticide against *Cameraria ohridella* depended on the application-technology in the second year (0=no attack until 4=very strongly damage of leaf-case [3, changed]

Other than those systemic active substances also other substances can be applied to control, *Cydia pomonella* L. Especially growth-regulators or contact insecticides should be reviewed. It is necessary to determine the exact time for application for these product-groups. The use of specific pheromones can help to regulate in an optimal way the cameraria-population. In contrast to other countries in Europe the leaf-application of the crowns of big trees in Berlin's streets is unacceptable. Therefore tests with partial applications of the crown and trunk-applications must be performed. The results of the trunk-applications with contact-insecticides are shown in figure 2. The trunks were sprayed in the tests three meters high at the beginning of the first flight of the moth in spring. The effect of dimethoate (BI 58) was the best possible.

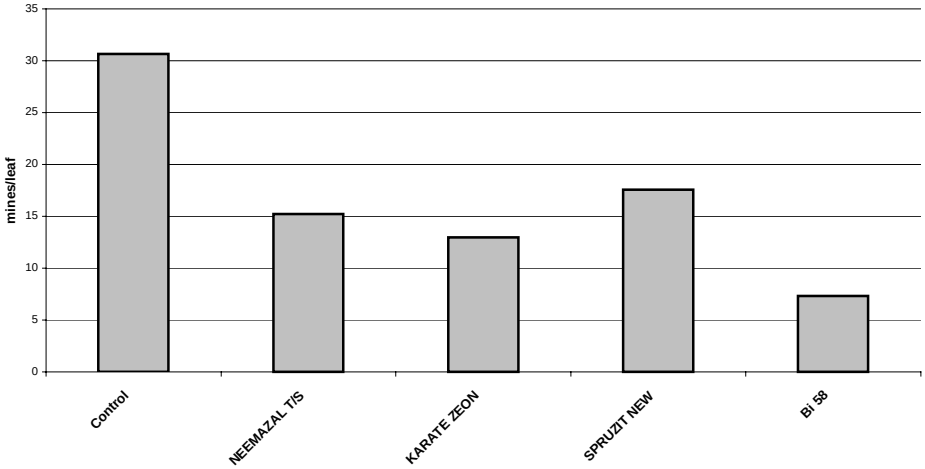


**Fig. 2** Results of a trunk-spraying during flowering of chestnut with different insecticides to the control of *Cameraria ohridella*

Attract-Kill-method

Like in the apple crops the use of biotechnical procedures is theoretically possible to reduce Lepidoptera and offers essential advantages in the urban area in comparison with spray-treatments. For two years we are testing the Attract and Kill-method (APPEAL) for the regulation of *C. ohridella*. After laboratory tests with small-trees field experiments are carried out with different aims in practice. The findings are encouraging (figure 3), however essential factors have to be optimised. For a further utilisation industry-partners, who can apply for the official registration of the product, are the most important prerequisite. The possibilities of further biotechnical control-methods like sterilisation, mating disruption-methods or mass-catching are discussed at present.

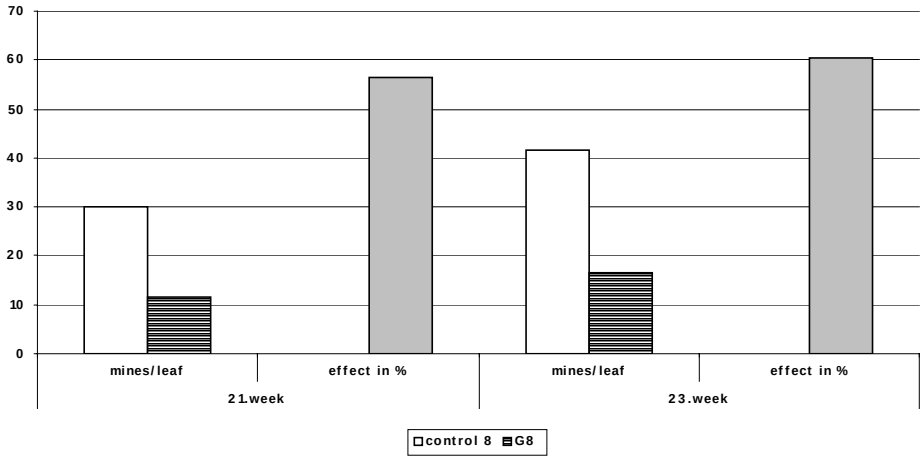


**Fig. 3** Effect of "attract and kill" (G8=APPEAL and the dispenser with the specific pheromone of *Cameraria ohridella*) against *C. ohridella* on old trees

Biological methods

Biological methods for the regulation of *C. ohridella* may have substantial advantages in the urban area. Plant-tonics and microbiological products as well as the support and the targeted use of antagonists are possible solutions. First usability studies were started. In greenhouses different plant-tonics and microbiological products were tested on young chestnuts plant. The products were sprayed on the leafs for prevention. Best results were achieved by a product on the basis of *Bacillus thuringiensis* and a plant-tonic-product (figure 4). Some products have already shown good results in outdoor conditions in large-scale trials.

Natural antagonists of *C. ohridella* should be applied directly [4,6,7,8]. Pre-analyses are currently underway. First examinations with the Institute for Biological Pest Control of Federal Biological Research Centre for Agriculture and Forestry have proofed that parasitiods of eggs of the type *Trichogramma* are not suitable. For reduction of the hibernation-stages of the moth in the foliage different nematodes, predators and insects pathogenes are tested at present.

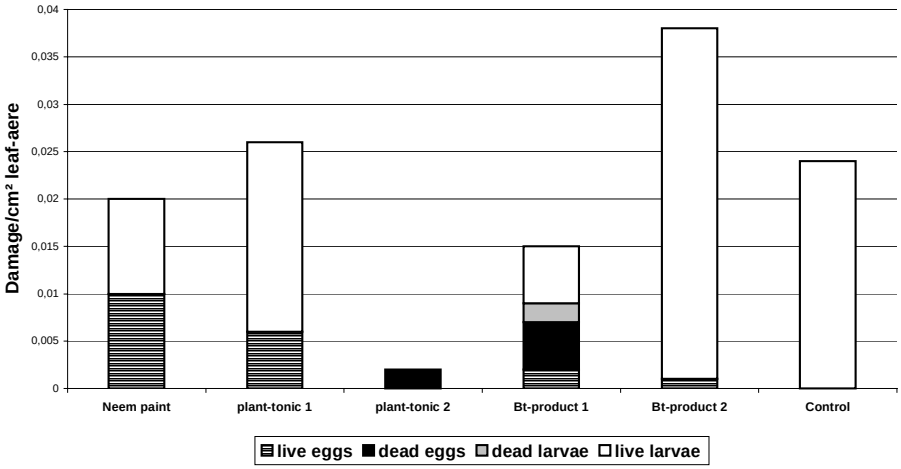


**Fig. 4** Effect of different biological products on the development of *Cameraria ohridella* at young-trees in the greenhouse (Bt-product = product based of *Bacillus thuringiensis)*

## Evaluation of the procedures and discussion

The findings outlined above are only the very first results at present. It is necessary to continue those tests with big-trees to revise the possibility to transposition those methods in the city. Not only the criteria of the effect are in discussion but in contrast to applications in the producing plant-cultivation, further important variables must be taken into account for the urban area. They came from the immediate proximity to public and to local characteristics, like acceptance of the public, location in the residential-surroundings, schoolyards, hospitals etc. The owners of the trees are not all equally qualified to apply the pesticide. Most chestnuts in public spaces are looked after by professional gardeners, trees on private properties are serviced by professional gardeners too, but many by their untrained individual owner. This, as well as different application-technologies and application-times, are taken into account as an important criteria in the public registration of chemical pesticides. It must be heeded in the organisation of plant-protection-methods (logistics) that chestnuts are distributed in all parts of a city. In the table important criteria were composed in order to compare practicable control methods considered during an application in the urban area. A possible result is that chemical methods show the lowest advantages in urban areas. Special possibilities for chemical application (e.g. patch-treatments, injections) are not

considered in this analysis. Nevertheless the official registration allowing also the application in house- and small-gardens is always necessary. For the future it is necessary to develop optimal technology for the application. In contrast other methods offer essential advantages in terms of acceptance of the application in sensitive urban areas and also of the registration process. With this over-view the main focus should be on the project “Berlin-Cam" [5].

**Table** Compare of advantage (V) of different plant-protection-methods in the urban area at the control of *Cameraria ohridella*

| | **Methods** | | | |
|---|---|---|---|---|
| | **Biological** | **Attract and Kill** | **Chemical** | **Mechanical** |
| Application on sensitive areas | V | (V) | - | V |
| Extended application-time | | V | - | V |
| Application-technology on old trees | V | V | - | (V) |
| Registration | (V) | | - | - |
| Acceptance | V | (V) | - | V |
| Logistics at expanse application | (V) | V | - | (V) |
| Specialists for application | V | (V) | - | - |

## Literature


1 BALDER, H.; BECKER, W., BREITENKAMP, M., 2003. Reduction of the damage of de-icing salt on trees by a different winter service. In Balder, H.; Strauch, K.-H.; Backhaus, G., 2003: 2. International Symposium on Plant Health in Urban Horticulture. Mitt.Biol.Bundesanst.Land-Forstwirtsch. 394 (in press).

2 BALDER, H., FEILHABER, I., JÄCKEL, B., 2003. Effect of organised leaf collections in the control of *Cameraria ohridella* in the city of Berlin. In Balder, H.; Strauch, K.-H.; Backhaus, G., 2003: 2. International Symposium on Plant Health in Urban Horticulture. Mitt.Biol.Bundesanst.Land-Forstwirtsch. 394 (in press).

3 BALDER, H., JÄCKEL, B., 2003. Die Kastanienminiermotte und mögliche Gegenmaßnahmen. In Stadt und Grün 52, S. 44-49.

4 GRABENWEGER, G., 2002. Die Parasitierung der Rosskastanienminiermotte *Cameraria ohridella* durch heimische Erzwespen in Europa. In Mitt.Biol.Bundesanst.Land-Forstwirtsch. 390, 315-316.

5 HENDRICH, L., BALDER, H., JÄCKEL, B., 2003. Berlincam-Practical strategies to control *Cameraria ohridella* in different urban areas of Berlin. In Balder, H.; Strauch, K.-H.; Backhaus, G., 2003: 2. International Symposium on Plant Health in Urban Horticulture.Mitt.Biol.Bundesanst.Land-Forstwirtsch. 394 (in press).

6 KEHRLI, P., BACHER, S., 2003 Massenschlupfanlagen für Parasitoide: Eine Biocontrolstrategie gegen die Rosskastanien-Miniermotte, *Cameraria ohridella*? In Tagungsbericht-Entomologische Tagung, 2003, Halle S. 211.

7 LETHMAYER, C., 2000. Control measures against the horse chestnut leafminer, *Cameraria ohridella*. In Mitt.Biol.Bundesanst.Land-Forstwirtsch. 370, 253-255.

8 MORETH, L., BAUR, H., SCHÖNITZER,K., DILLER, E., 2000. Zum Parasitoid-Komplex der Rosskastanienminiermotte in Bayern *Cameraria ohridella*. In Mitt.Dtsch.Ges. Allg.Angew.Ent.12, 489-492.

# Session 3 - Abiotic disease factors of plants in urban stands

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## New results about necroses at the stem of young trees

### Introduction

Since some years in many cities and communities in Germany and Austria a new damage on young trees are observed. On the south west side of the stem the bark and the cambium die. New investigations came to the results, that these damages are necroses and often occur at *Acer, Tilia* and *Aesculus*, but also on other genera (Schneidewind 1998, Lesnino 2001, Dujesiefken and Stobbe 2002). Trees with this defect can be found in cities, along highways and also in the free landscape. The damage becomes first remarkable, when the dead parts of the bark dries out and falls down. The appearance of these necroses on young trees is increasing, and in some cities almost hundreds of new planted trees were damaged in this way.

### Symptoms and causes

The necroses occur on young trees being planted in the last 10 to 20 years. The common symptoms of the damaged trees are areas of dead bark, in form of longitudinal stripes from up to several decimetres in length and some centimetres wide. Often the necrotic bark tissue remains on the stem, so that the dimension of the damage can only be seen after the removal of the dead bark (Figure 1 and 2). The damages are mostly oval shaped and the wood in this area show longitudinal cracks.

**Fig. 1** Unobtrusive damage on horse chestnut

**Fig. 2** After taking off dead bark the extension of the necroses can be clearly seen (same tree as in Figure 1)

With regard to the compartmentalisation of the damages in the trunk, differences according to tree genera are obvious. Lime trees often have a discoloration of one to three tree-rings (Figure 3). Horse-chestnut shows a weaker compartmentalisation with beginning decay up to the middle of the stem (Figure 4). Necroses on maple often lead to vast discoloration and decay almost of the whole stem tissue (Figure 5); only the wood formed after wounding is not discoloured. According to the ability of a tree to compartmentalise, necroses can cause severe damages to trees which may result to the breaking-off of the stem (Figure 6).

**Fig. 3** Lime with narrow discoloration

**Fig. 4** Horse chestnut with beginning decay up o the middle of the trunk

**Fig. 5** Maple often has vast discoloration of almost the whole stem tissue, only the wood formed after wounding is not discoloured

**Fig. 6** Necroses can led to the breaking-off of the stem

**Fig. 7** Reed mats can protect young trees effectively

The occurrence of the described damages on the south west side of the stems indicates that a possible cause for necroses could be the overheating of the exposed stem by the sun. This argument can be underlined by the observation, that trees being shaded from buildings or other trees do not have such necroses (Dujesiefken and Stobbe 2002). Thermal defects appear also on other plants and occupy gardeners and foresters in the same way since over hundred years (Wartenberg 1933, Schwerdtfeger 1949, Jahnel 1959, Peace 1962, Shirazi and Fuchigami 1993, Fink 1999).

In the German literature this phenomena is called “Sonnenbrand” or “Forstplatten” and both were initiated by extreme temperature differences, e.g. from plus 20°C at daytime to some degrees minus during the night. Because of the influence of the sun and the fact that the damages are necroses they were called “Sonnennekrosen”, in English “sun necroses”. They can be formed during the vegetation period and also in the winter season (Dujesiefken and Stobbe 2002).

## Protection

To protect new planted trees for being damages by the sun, stems can be shaded with reed mats, which are proved as a good and inexpensive protection material (Figure 7; Schneidewind 2002). Trees with little damages can be protected in the same way, to hinder new necroses and to promote wound closure in this way. If young trees show big necroses, they should be investigated first, to evaluate the extension of discoloration and decay in the stem. Severe damaged trees with widespread decay only can be substituted.

## Literatur

1 SCHNEIDEWIND, A., 1998. Frostschäden an jungen Straßen- und Alleebäumen in der Region um Quedlinburg. Neue Landschaft 1/98, 29-34.

2 LESNINO, G., 2001. Stammschäden an jungen Straßen- und Alleebäumen. In: Dujesiefken, D.; Kockerbeck, P. (Hrsg.): Jahrbuch der Baumpflege 2001. Verlag Thalacker Medien, Braunschweig, 247-251.

3 DUJESIEFKEN, D.; STOBBE, H., 2002. Neuartige Stammschäden an Jungbäumen. In: Dujesiefken, D.; Kockerbeck, P.: Jahrbuch der Baumpflege 2002, Thalacker Medien, Braunschweig, 73-80.

4 WARTENBERG, H., 1933. Kälte und Hitze als Todesursache der Pflanze und als Ursache für Pflanzenkrankheiten. In: Handbuch der Pflanzenkrankheiten, Erster Band. Die nicht-parasitären und Virus-Krankheiten. Erster Teil. 6., neubearb. Aufl., herausgeg. v. O. APPEL, Verlag Paul Parey, Hamburg und Berlin, 475-592.

5 SCHWERDTFEGER, F., 1949: Grundriss der Forstpathologie. Verlag Paul Parey, Berlin und Hamburg, 197 S.

6 JAHNEL, H., 1959. Über Frostresistenz bei Waldbäumen. Archiv für Forstwesen 8, 697-725.

7 PEACE, T.R., 1962. Pathology of Trees and Shrubs - With Special Reference to Britain. Oxford University Press, 723 S.

8 SHIRAZI, A.M.; FUCHIGAMI, L.H., 1995. Effects of „near-lethal“ stress on bud dormancy and stem cold hardiness in red-osier dogwood. Tree physiology 15, 275-279.

9 FINK, S., 1999. Pathological and Regenerative Plant Anatomy. Verlag Gebrüder Borntraeger, Berlin 1095 S.

10 SCHNEIDEWIND, A., 2002. Stamm- und Rindenschutzmaterialien für Baumpflanzungen an der Straße und im Siedlungsraum. In: Dujesiefken, D.; Kockerbeck, P. (Hrsg.): Jahrbuch der Baumpflege 2002. Verlag Thalacker Medien, Braunschweig, 81-91

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# The epidemiology of canker stain of Plane tree and its spread from urban plantings to spontaneous groves and natural forests

## The first isolation and identification of the agent of canker stain: a difficult task

More than thirty years have passed since it was reported that some Plane trees (*P.* x *acerifolia*) at Forte dei Marmi, along the Tuscan coast in north-central Italy, had suddenly started to wither. It took some months to isolate the parasite, *Ceratocystis fimbriata* Ell. et Hallst f.sp. *platani* Walter (*Cfp*), establish that it was indeed the causal agent and identify it [14]. The numerous mycetes that were initially also isolated from the diseased plane wood (*Pestalotiopsis* sp., *Fusarium* sp., *Asterosporium* sp., *Sphaeropsis* sp. and *Trichotecium roseum)* caused not a few problems in identifying the real cause of the damage in question. The prevalently saprophytic tendency shown by those other fungi *in vitro* masked the true causal agent by overgrowing it and hindering its development in isolations initially carried out on the browned plane wood. This pronounced saprophytic tendency of those other mycetes, which utilised the tissues killed by *Cfp,* enabled them to grow faster on the culture media (PDA, malt-agar, carrot-agar, oat meal, etc.) normally used to isolate mycetes. Nevertheless, all attempts to infect trees artificially with those other mycetes proved consistently unsuccessful. These inconclusive findings continued until the disease attacked young plane trees with a trunk diameter of some 25 cm. Only when these trees were felled and cut up, and isolations were taken from all the dark areas in the inner and outer parts of the trunks, was it noticed that while all samples from darkened wood mainly contained those other mycetes, samplings from the inner margins of the cankers, which were bluish in colour, always revealed *Cfp* [15]. Artificial infections carried out with mycelium of this fungus gave rise to cankers and withering of mature plane tree similar to those found in nature. Here it was noticed that in the first stages of these artificial infections the bark tissue killed by *Cfp* on the cambium was immediately colonised and covered on the outside with various reproductive structures of those other mycetes, confirming the findings of the first isolations. At a later date the wood tissue of the sapwood and the heartwood was invaded and degraded by a succession of micro-organisms (*Auricularia auricula-judae, Stereum purpureum, Fomes fomentarius, Coryolus* sp., etc.), causing wood rot that eventually made the trees unstable.

Not only the isolation of *Cfp* but also its identification were not without their difficulties, which had already been encountered by earlier researchers [4, 24]. The structure that developed after about a week (25°C) on culture medium or on infected sapwood in a humidity chamber was initially taken to be a pycnidium with a long neck but later turned out to be a perithecium with deliquescent asci. The shape of this perithecium, the hat-shaped ascospores with their characteristic gelatinous sheath, and the three types of endoconidia of the genus *Chalara* enabled the mycete isolated to be positively identified as *C. fimbriata.* This species was first reported along the east coast of the United States before the Second World War [1, 8] and was the cause of a serious disease of plane tree called canker stain. Research reports also indicated that other parasitic fungi morphologically identical to the fungus isolated from plane in the present study cause serious damage to other trees and shrubs. We have found that *C. fimbriata* isolated at Forte dei Marmi was not pathogenic on sweet potato (*Ipomoea batatas*), aspen (*Populus tremuloides*), or various fruit trees (*Prunus armeniaca, P. persica, P. amygdalus, P. domestica*), nor, conversely, was *C. fimbriata* from any of these plants pathogenic to plane tree. The Forte dei Marmi isolate was therefore a *forma specialis, Ceratocystis fimbriata* f.sp. *platani,* which exclusively attacked plane trees. Other tree species in *Cfp*-infected areas therefore do not run any risk of becoming infected with this strain.

## Infection biology and potential for spread

To understand the danger of *Cfp* and the very serious threat posed by its epidemic spread it is necessary to consider briefly some of its biological characteristics and its behaviour inside and outside the tree.

We have established with certainty that *Cfp* is a wound parasite because it cannot invade the tree through a sound epidermis. For infection to occur the tree must have a wound, however small; the puncture of a nail is enough. Artificial infections on the leaf blade or the veins, or on herbaceous twigs have had some degree of success but usually do not manage to penetrate into the underlying organs. But penetration occurs easily when there is a wound that lays bare well-differentiated woody tissue such as the sapwood, and this is what happens during routine pruning operations, which thus inadvertently become the main means of pathogen entry. Once infection has taken place the parasite immediately invades the conducting vessels, from where it proceeds rapidly in all directions. In a year the infection can reach a length of more than two metres along the axis. When the mycelium in its acropetal or basipetal movement encounters parenchymal bundles it colonises them very rapidly and moves through them in a radial direction both inwards and outwards. This explains the lenticular wood stains extending in a radial direction across the sapwood: an important diagnostic character that is particularly evident on cross-sections of infected trunks that have been recently killed by *Cfp.* When the fungus in its colonisation of the parenchymatic rays reaches the cambial tissue this is killed, and with it the overlying bark tissue becomes necrotised. That is why the epidermis then shows the characteristic lenticular stains, some centimetres in length, arranged along the axis. These stains are easily identified on *P. occidentalis* and on many *P. x acerifolia* individuals which have a smooth bark, but are less conspicuous on *P. orientalis,* whose rhytidome is thick, rough and do not flake off, at least not in the older organs. The lenticular stains arranged along the axis are an important diagnostic sign of canker stain at its first appearance on the rhytidome, especially when the fungus invades from the root system and spreads through the neck inside the tree, without visible symptoms on the outside. The early identification of canker stain symptoms in a stand is vital since on it depend how successful will be the control measures taken and the disease management programmes adopted.

Colonisation of the sapwood is also rapid along the circumference of the tree. In 2-3 years a single infection can girdle and kill a *P.* x *acerifolia* tree with a diameter of 30-40 cm. and the same has been noted on *P. orientalis* although here tests were carried out only on trees with a diameter of 15-20 cm.

During its colonisation of woody tissue, *Cfp* mycelium produces thick or double-walled brown endoconidia inside the vessels and the cells of the parenchymatic rays. The function of these endoconidia is to preserve the species since they remain unaltered even in the presence of other, succeeding micro-organisms. The endoconidia can remain alive and vital even for some years after the infected tree has died, and are an additional risk-factor in the epidemic spread of canker stain [7]. This characteristic assumes diagnostic importance since even after a tree has been dead for some years it is still possible to establish from the woody tissues whether its death was from *Cfp.* When the infection invades through the upper part of the crown, and an epigeous part dies, there is regrowth below the dead part of the tree but this regrowth also shortly dies as the infection proceeds. Since while this is going on the roots still remain live and functional for some time, even when the tree dies, the parasite mycelium continues to live in the roots and has an opportunity to move toward the root tip until it meets, if there is one, a root-contact (anastomosis) with a neighbouring tree, which thereby also becomes infected [13]. The spread of canker stain by root anastomosis is particularly dangerous in the case of street trees arranged in rows or in stands where the trees grow very close together.

## Colonisation of wounds and production of inoculum

During the first phases of wound colonisation, *Cfp* produces cylindrical endoconidia (ameroconidia) on the exposed tissue and the underlying vessels. If weather conditions are favourable (temp. 20-25°C, high humidity) the whole wound surface may be colonised by the mycelium whose conidiophores immediately form an ash-grey pruinescence consisting of a bloom of endoconidiophores and cylindrical ameroconidia whose function is to spread the fungus. These endoconidia form quickly and disintegrate equally quickly if they become dehydrated or washed off or touch the soil. Inside the woody tissues we never observed doliform or barrel-shaped endoconidia which usually accompany the perithecia, and which form only on the outer surface.*Cfp*-infected wounds of a certain size are distinguished from other wounds by the fact that in the former the damaged bark tissue is not, or only partially scarred over.

When the bark of infected trees becomes dehydrated and separates from the cambium, mature perithecia may develop in the cracks exposing the underlying wood; these perithecia are accompanied by the barrel-

shaped conidia plus the two other types of conidia that *Cfp* produces. However, perithecia that form in this way are very rare. Much more frequent and abundant, especially in spring, when the weather is more humid, is the formation of cylindrical ameroconidia, which are washed down by the rains and accumulate at the base of the tree together with wood debris produced by wood-dwelling scolitids that infest dead and infected parts of the tree.

It is these spores and conidia that accumulate between cracks in the bark or at the base of the trees, as well as the debris produced by some insects (nitidulids, wood-dwelling scolitids, etc.) that are the main source of canker stain inoculum. This inoculum is then spread, mainly by insects, small rodents, birds, etc., that may have an active role, wounding the tree and transporting inoculum, or a passive one, only wounding the tree, and leaving infection to chance. A particular type of naturally occurring infection is when trees growing on the banks of streams are wounded at the base or upper roots by sharp floating objects or pebbles rolled along when the stream is in spate, and are then infected by conidia also borne along in the water [6].

## The anthropogenic effect on canker stain spread

While even the natural spread of canker stain is not as limited as was initially thought, its spread in urban areas, where anthropogenic factors are at work, can become a major problem. In large natural forests where the anthropogenic effect is absent, canker stain is not very common, even though some groups of trees killed by canker stain have recently been found in some forests in Arkansas [10] and also in riparian forests in the Province of Syracuse (Sicily, southern Italy). The presence of man favours both the production and the spread of inoculum for the following reasons: man causes most of the wounds permitting inoculum entry; man causes inoculum spread directly by pruning as yet uninfected trees with *Cfp*-infected tools; when wounds are made inadvertently on wood already infected, they lead to the production of enormous amounts of inoculum; and large quantities of infected sawdust are produced when infected plane trees are treated without the proper precautions being taken. Experimental studies have shown that canker stain becomes epidemic only in those areas where the plane trees require human tending. In towns and cities such tending is necessary to enable the trees to grow in spaces that are becoming ever more constricted and unsuited for their natural growth. A solution to the space problem is found by frequent pruning. Pruning necessarily involves making a great number of sometimes quite extensive wounds, which become the main mode of entry for the parasite. Other types of wounds to which street trees are subject are those to the roots. Roots are cut during the construction of pavements, power lines, gas lines, water mains etc., not to mention wounds caused to the base of the trunk by motor traffic and mechanical weed-removal.

The position of the wound on the tree is very important since once it has become infected with *Cfp* and the first symptoms have appeared, on this depends whether surgery is feasible to remove the infection. The pruning of mature urban trees is today unavoidable in all cases, but the pruning intervals vary depending on the type of planting and the vicinity of adjacent buildings. If the pruning interval is very short (2 years) the pruning cuts can be smaller and farther away from the main branches and the trunk, and in that case the wounded tissue is younger and heals over more quickly, so that the time during which the wounds are liable to infection is shorter. Moreover, since the mycelium must traverse a longer distance to reach the critical areas of the larger branches and the trunk, the sanitation of these more distal cankers can be undertaken. On the other hand, when because of financial constraints pruning intervals must be more widely spaced (every 4-5 years or more), pruning cuts must also be made to the larger branches that are nearer the trunk, leading to larger wounds that take longer to heal and become impervious to infection, and the parasite can rapidly invade these branches and even the trunk; and in those cases any attempt at surgical sanitation must be ruled out.

If the branch of an infected tree is accidentally wounded or pruned at a place above that which the mycelium has reached, nothing will happen -- because of their size *Cfp* conidia produced in the vessels cannot be transported upward by the lymph vessels to higher parts of the tree, as occurs, for example, with *Ophiostoma ulmi*. If infected tissue is cut or pruned, on the other hand, an ash-grey bloom will form on the wound site in 24-48 hours, depending on the temperature and humidity; this bloom consists mainly of cylindrical ameroconidia, and of smaller amounts of the other two types of endoconidia produced by *Cfp*. Some 7-10 days later the mature perithecia with a long neck form, with little masses of

ascospores arranged on the ostiolar hyphae. The conidia and ascospores are washed down by rain water to the base of the trees where they accumulate. These propagules can also contaminate occasional vectors (insects, small rodents, birds) by which they can be transported, sometimes over considerable distances. The ascospore masses can survive for about two months, being embedded in a gelatinous matrix [3]. They are well-adapted for vector-spread for this reason and because they are located high on the perithecial neck, so that they touch and adhere more readily to their vector. Pruning cuts or accidental wounds of whatever kind will give the parasite a means of entry into sound tissue, or a chance to reproduce in already infected tissue, and should therefore be avoided; if they occur, the wound area must be carefully disinfected [16].

When infected tree parts are cut off, sawdust with the parasite on it may fall to earth or remain attached to the pruning tools (saws or chainsaws). If these tools are then used on other trees, these trees may also become infected. For this reason the disinfection of pruning tools and of wounds is very important, even more so if work is being carried out in an area where *Cfp* foci are known to occur. In Italy the pruning of plane trees and the felling of dead or infected trees are governed by a Decree law of 17/04/1998 and the circular giving it force**,** and may be carried out only under the supervision of the local authorities. Such activities must not be undertaken on windy days or without taking special precautions such as using canvas sheeting to collect the waste material, blocking vehicular traffic, etc. since the sawdust from infected trees that are felled and cut up may be carried over very considerable distances. During these operations the parts most at risk are any exposed roots on which infected sawdust may settle. Infected sawdust and conidia may play an important role in spreading canker stain to wounds made on roots as a result of digging carried out in connection with building works. When the earth dug up and containing conidia or fragments of infected roots and sawdust is replaced into the excavated hole, infectious parts of the replaced soil may come in contact with damaged roots of nearby trees and infect them.

## Spread of canker stain: from the USA to Europe and Asia

As has already been mentioned, canker stain was first recorded in the suburbs of Philadelphia, Pennsylvania, USA, in 1935. Walter [22] postulated that at that time the parasite had infected the trees of this city for more than a decade. The first tree to be affected was *P.* x *acerifolia* (London plane), an introduced species that was grown exclusively in large cities where it was preferred to the native sycamore (*P. occidentalis*) because of its fast growth and resistance to pollutants and anthracnose (*Apiognomonia platani*). To have an idea of how serious the disease was, some canker stain data for Gloucester (NJ) can be given, one of the oldest foci of the disease: here from 1940 to 1943 72% of all planes became infected and died. In Philadelphia, by the end of the Second World war, some 10,000 trees were dead out of an inventory of 150,000. In subsequent years the disease spread to almost all states of the Atlantic seaboard, from New York to Louisiana. Initially it affected only city plantings of *P.* x *acerifolia* but subsequently infection foci appeared also in plantations [9, 11, 18] and in natural forests of *P. occidentalis* in Arkansas [10]. The reason for the slow spread of *Cfp* to *P. occidentalis* is that this species is more resistant than the hybrid. This resistance has made it possible to select clones for resistance in breeding programmes. Some researchers postulate that this greater resistance is due to a selection pressure exerted by *Cfp* on *P. occidentalis* in the past, which conferred resistance to this host. Individuals of *P. occidentalis* resistant to *Cfp* are now being used also in Europe (France) in genetic improvement programmes to create resistant hybrids [21]. The use of *P. occidentalis* itself in Europe is not feasible because of the slow growth of this species and its greater susceptibility to anthracnose [19].

During the war and its aftermath therefore canker stain was raging in the main cities of the east coast of the US. It is likely that the wood from the many *Cfp*-killed trees was used without particular precautions (sterilisation) to make crating materials for the transport of war material or catering supplies to areas of conflict. In this way wood still containing resistant thick-walled endoconidia may have found its way from the USA to the coasts of Europe. This hypothesis is buttressed by the fact that in Europe canker stain first appeared in the coastal ports of the Mediterranean (Livorno, Naples, Marseilles, Syracuse), which were centres of intense activity during and after the war. From these ports it spread to many of the countries now affected, causing serious damage to Italy, France, Spain and Switzerland, and also in a less degree to Spain, Asia and Armenia [20]. At present the disease is still spreading rapidly and poses a serious threat to plane tree plantings in northern and southern Europe and in Asia [12].

Although canker stain was first reported in Italy at Forte dei Marmi in 1972 [14], as has been mentioned, the occurrence of dead trees in plane tree plantings at Caserta in southern Italy had already been reported in the 1960s [2]. It may not be a coincidence that the avenue where the disease was first noted was precisely the place where during the war American lorries carrying cases of ammunition used to park. Since the time the disease was first reported until today it has spread with devastating effect to almost all the provinces of northern Italy and to some areas in the centre. It has not been detected in Liguria, some parts of central Italy, which in any case does not count many planes, and Sardinia. In Sicily it is found not only in Palermo, but also in some coastal areas of Ibleo territory (Syracuse) where there are spontaneous growths of *P. orientalis* [5]. Here it appears that a careless use of the riparian forests as coppice has enabled canker stain to spring up at an epidemic level.

In Italy, as in the USA, damage caused by *Cfp* has been enormous. At Forte dei Marmi, one of the oldest infection centres, in the twenty-year period from 1972 to 1991 90% of all plane trees died of the disease. It is the municipal governments that have had to bear the considerable costs of felling the many plane trees that died of canker stain, in accordance with regulations laid down by the decree law already mentioned. These costs are often too onerous to be borne, especially for smaller localities, and this has led to serious delays in the felling of trees, which has in turn served significantly to worsen the epidemiological development of the disease.

## Comments and conclusions

The foregoing brief description of the dispersal capacity of *Cfp* propagules and on how the disease has spread through the countries where it now occurs makes clear both the aggressiveness of the fungus and its enormous capacity for epidemic spread, as was indeed already stated by some authors [17, 23]. These two characteristics become even more evident if events in the USA over last 70 years are considered. During that time canker stain spread from its original focus in Philadelphia, Pennsylvania to much of the US east coast. In its advance northwards and southwards it caused particularly heavy damage in the large cities where anthropogenic conditioning and the sensitivity of London plane produced a synergy that enabled canker stain to assume epidemic proportions. This process has unfortunately not yet run its course since new infection centres have now been reported from some natural *P. occidentalis* forests in Arkansas. Since *P. occidentalis* is more resistant than its hybrid, this spread of *Cfp* to those natural forests requires to be explained. One possible explanation is that the virulence of *Cfp* has changed. The many specialised forms that have arisen, and that attack a wide range of new hosts such as sweet potato, cacao (*Theobroma cacao),* aspen, cotton (*Gossypium hirsutum),* coffee (*Coffea arabica),* etc., show that the pathogen has a high capacity for variation (through mutation or other genetic mechanisms). A second explanation is that the high inoculum pressure developed on *P.* x *acerifolia* trees growing in areas bordering spontaneous stands and natural forests of *P. occidentalis* led to canker stain infiltrating into those forests, a process that may have been facilitated by some vectors, especially birds and insects. A third explanation is that only a very few individuals in the *P. occidentalis* populations actually possess any great degree of resistance to *Cfp.* A weakness of *P.* x *acerifolia,* on the other hand, is that it does not have behind it a large natural population that can be exploited for selection purposes in case of parasite attack. The low variability of *P.* x *acerifolia* genotypes, in part due to preponderant clonal reproduction, is one of the reasons why canker stain spread epidemically through urban tree plantings.

History therefore seems to be repeating itself: what is happening in Europe now is the same as what happened in the USA before. After the first recorded appearance of *Cfp* in Italy in 1972, it spread to neighbouring states (France, 1974, Spain, 1977, Switzerland, 1986). In Italy the disease spread especially northwards but also to the south, severely affecting street trees, particularly those in the larger cities. In 1986, as we had feared, there was a first report of *Cfp* having invaded a natural forest of *P. orientalis,* in Sicily, Italy. At the moment, therefore, *Cfp* is a serious threat to *P.* x *acerifolia* trees in all countries to the north and the north-east of Italy.

The appearance of the parasite on *P. orientalis* in Sicily and the infection centre reported from Erevan (Armenia) in 1982 [20] presages unfortunately that it may also spread in an east-south-easterly direction, all the more in view of the sensitivity that *P. orientalis* has shown to *Cfp.*

It seems obvious by now that one of the main reasons for the epidemic spread of canker stain was the failure to diagnose it in the early phases after its initial appearance. This is to be ascribed on the one hand

to insufficient knowledge about the biology of the fungus, and on the other to the ignorance, compounded by negligence and carelessness, of the personnel in charge of plant sanitation. Ever more stringent legislation at the regional, national and municipal level to prevent, limit or control the introduction or spread of dangerous plant disease agents -- and *Cfp* is certainly one of those -- is a clear indication that the health of urban trees is now an important matter.

With the advent of molecular diagnosis new opportunities are opening up to researchers in the field of plant protection. Sophisticated molecular diagnostic techniques (such as the PCR with all its applications and variants, to name but one) identify pathogens by detecting their nucleic acids and represent the most promising means to test urban trees for the presence of disease agents. If we wish to save the urban plane trees in Europe it is now urgently necessary to develop molecular diagnostic protocols with which *Cfp* can be detected accurately and rapidly in symptomatic as well as asymptomatic tissues of infected trees. Diagnostic tests can be of great benefit both in programmes monitoring trees for canker stain, and in the nursery. The success of 'pest management', which aims to control plant health in the nursery and to eradicate early infection centres in the field, depends very largely on the speed and accuracy with which the causal agent can be identified.

But the information supplied by molecular tests will not only save some street trees and avoid the cost -- economic, aesthetic and scenic -- arising from their loss, but will also give the molecular characterisation of a pathogen, and this will reveal the genetic diversity of its populations, which is vital if we wish to know its evolutionary and pathogenic potential. Broadening our understanding of the biology of *Cfp* will improve our understanding of the dynamics and the epidemiology of the parasite and the effect of human activity on its preservation and spread.

Such information will also make it possible to take ever more effective control measures against canker stain and will furnish valuable support for legislative action, which, particularly in the case of canker stain, may be of decisive importance.

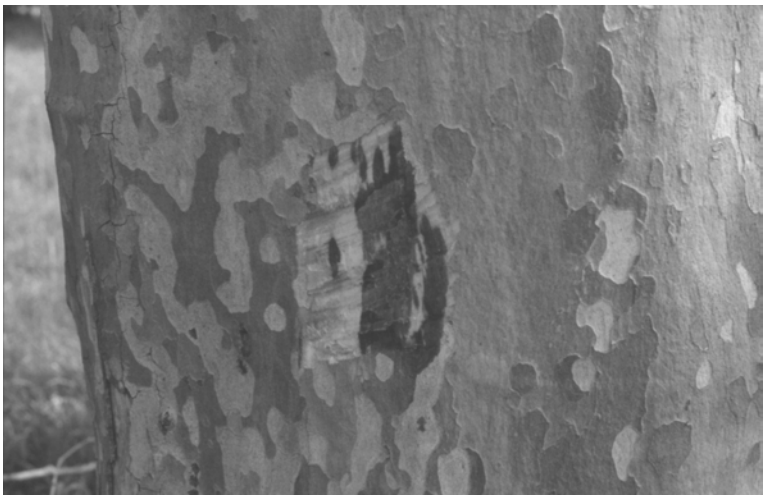

**Fig. 1** Characteristic brown areas elongated along the axis and on the underlying tissues of a Plane tree individual.

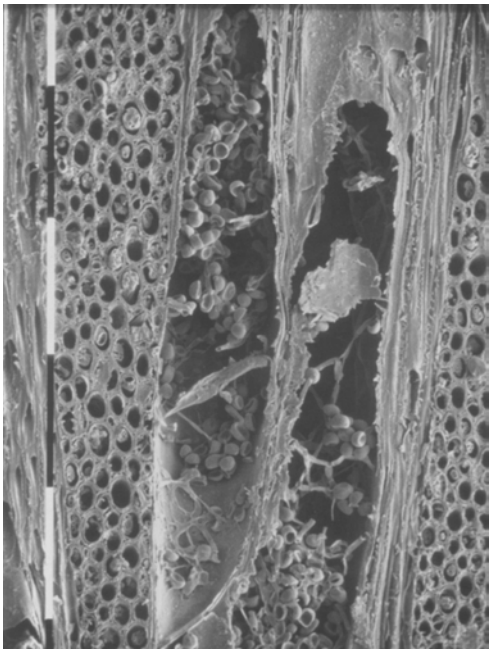

**Fig. 2** Typical aleuroconidia produced by *Ceratocystis fimbriata* f.sp. *platani* in the xylem vessels of a Plane tree.


## Summary

This article examines some biological and epidemiological characteristics of canker stain of plane trees caused by the fungus *Ceratocystis fimbriata* f.sp. *platani*, focussing on how the inoculum is formed and preserved, and how it spreads. It is explained how these characteristics, together with the host response and the environmental conditions, are the factors that determine its capacity for epidemic spread. Some key aspects of isolation in culture, and the main morphological characters of the reproductive forms of the fungus necessary for its identification, are also elucidated. The way in which this pathogen can be expected to behave in natural forests of *Platanus occidentalis* is stressed. Since the disease appeared in Asia some decades ago, and has now also appeared in Italy on *P. orientalis*, an attempt is made to identify potential vectors and to establish how canker stain may spread in natural *P. orientalis* forests. The importance of the early diagnosis of the pathogen by using molecular detection tools in order to prevent its further spread in Europe is also discussed.


## Literature


1 CRANDALL, B.S., 1935. *Endoconidiophora fimbriata* on sycamore. Plant Disease Reporter (supplement), 98 (Abstract).

2 CRISTINZIO, M., MARZIANO, F., VERNEAU, R., 1973. La moria del Platano in Campania. Riv. Pat. Veg., S. V, IX, 189-214.

3 CRONE, L.J., 1962. Symptoms, spread and control of canker stain of plane trees. Ph. D. Thesis, Rutgers University. New Brunswick, New Jersey.

4 ELLIOT, J.A., 1923. The ascigerous stage of the sweet potato black-rot fungus. Phytopathology Abstr., 13, 56.

5 GRANATA, G.A., GUASTELLA G., 1986. Grave moria di platani lungo i corsi d'acqua del territorio ibleo. Sviluppo Agricolo, 20 (9), 5-8.

6 GROSCLAUDE, C., OLIVIER, R., PIZZUTO, J.C., ROMITI, C., 1991. Etude expérimentale du transport de l'inoculum de *Ceratocistis fimbriata* par l'eau d'une riviere. Eur. J. For. Path., 21, 168-171.

7 GROSCLAUDE, C., OLIVIER, R., ROMITI, C., 1993. Chancre coloré du platane. Trasmission et survie hypogeés de l'agent responsable. Phytoma- La Defense du Végétaux, 455, 5759.

8 JACKSON, L.W.R., SLEETH, B., 1935. A new disease affecting *Platanus orientalis* in the eastern United States. Phytopathology Abstr., 25, 22.

9 Mcalpine, R.G., Brown, C.L., Herrick, A.M., Ruark, H.E., 1996. "Silage" Sycamore. Forest Farmer, 26 (1): 6-7, 16.

10 MCCRACKEN, F.I., BURKHARDT, E.C., 1977. Destruction of sycamore by canker stain in the midsouth. Pl. Dis. Reptr., 61, 984-986.

11 MCCRACKEN, F.I., FILER, T.H., 1971. Sycamore anthracnose epidemic in Mississipi-Yazoo delta. Pl. Dis. Reptr., 55, 93-94.

12 MORICCA, S., PANCONESI, A., 2000. Canker stain of plane-trees: a serious threat for North-European urban plantations. Plant health in urban horticulture, Int. Symp. Braunschweig, May 22-24, 97-101.

13 MUTTO ACCORDI, S., 1986. Diffusione di *Ceratocystis fimbriata* attraverso le anastomosi radicali. Inf.tore fitopatol., 36, 11, 53-58.

14 PANCONESI, A., 1972. I nostri platani sono in pericolo. Inf.tore fitopatol., 22 (3), 10-13.

15 PANCONESI, A., 1973. Il rinvenimento della *Ceratocystis fimbriata* (Ell. and Halst.) Davidson f. platani Walter su platano. Riv. Pat. Veg., 4, 9, 167-188.

16 PANCONESI, A., 1976. La pericolosità della *Ceratocystis fimbriata* (Ell. and Halst.) Davidson f. *platani* Walter in rapporto alle operazioni di potatura. Riv. Pat. Veg., 12 (1-2), 21-23.

17 PANCONESI, A., 1999. Canker stain of plane trees: A serious danger to urban plantings in Europe. Journal of Plant Pathology, 81(1), 3-15.

18 ROSS, E.W., 1971. *Diplodia theobromae* and *Ceratocystis fimbriata* f. *platani* found in silage sycamore plantings. Pl. Dis. Reptr., 55, 741-743.

19 SANTAMOUR JR., F.S., 1976. Resistance to sycamore anthracnose disease in hybrid *Platanus*. Plant Dis. Reptr., 60, 161-162.

20 SIMONIAN, S.A., MAMYKONIAN, T.O., 1982. Disease of plane-tree. Zashchita-Rastenii , 8, 23-24.

21 VIGOUROUX, A., 1992. Preliminary results for obtaining a plane tree resistant to canker stain and adapted to european conditions. Acta Horticulturae, 320, 91-98.

22 WALTER, J.M., 1946. Canker stain of plane trees. U.S. Dept. Agric. Cir., 742.

23 WALTER, J.M., REX, E.G., SCHREIBER, R., 1952. The rate of progress and destructiveness of canker stain of plane-trees. Phytopathology 42, 236-239.

24 WRIGHT, E.F., CAIN, R.F., 1961. New species of the genus *Ceratocystis*. Can. J. Bot., 39, 1215-1230.

# Session 4 - Procedures for Diagnosis and monitoring

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## Tree stability survey in big urban populations - The experience of Milano: 30 000 trees assessed during a triennium in relation with a standard settled protocol

### Introduction

The city of Milan counts more then 160.000 trees spread on a surface of about 1.810.000 $m^2$. A big amount of this population should have more then one century but bombardments of $2^{nd}$ world war, excavation for underground railways and infrastructures (as gas pipelines, telephone networks etc…) heavily influenced survival and healthy condition of many ancient big urban trees. This situation so common in most big cities all over the world, requires a deep knowledge as far the pathological, physiological and biomechanical conditions of trees is regarding, in order to highlight potential immediate risk situations, to plan corrective actions and to prevent any dangerous situation potentially linked to a bad tree management.

### Material and methods

The total amount of trees in Milano is described in the following table (Table 1).

Tree populations rooted in Public gardens and Row plantations cover practically the 80% of the total amount.

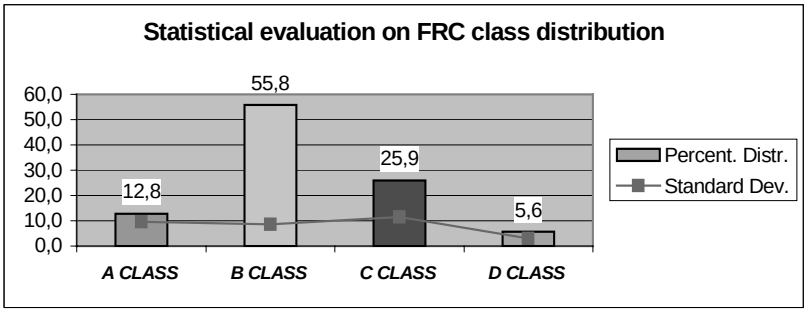
| SITE | NR. | % |
|---|---|---|
| Public gardens | 100.731 | 61% |
| Linear plantations | 28.656 | 17% |
| Schools | 19.831 | 12% |
| Cemeteries | 7.017 | 4% |
| Historical Parcs | 6.407 | 4% |
| Parcs | 2.502 | 2% |
| TOTAL | 165.144 | 100% |

Tree assessment history starts, using Vta method, on 1998 with small “pilot project”; a little bit later in comparison with other Italian cities, but in five year the Council planned and performed biomechanical check for more then 30 thousand trees as described in (Table 2)

| O | SITE | Total Assessed Trees | | A CLASS | B CLASS | C CLASS | D CLASS |
|---|---|---|---|---|---|---|---|
| | | | | % | % | % | % |
| 1998 | Foro Buonaparte | 231 | 231 | 1,3 | 67,1 | 25,1 | 6,5 |
| 1999 | Monumental Cemetery | 835 | 1066 | 17 | 53 | 25 | 5 |
| 1999 | Major Cemetry A | 1782 | 2848 | 25 | 53 | 20 | 2 |
| 1999 | Major Cemetry B | 1677 | 4525 | 24,4 | 67,3 | 6,3 | 2 |
| 2000 | Row Population A | 10000 | 14525 | 12 | 50 | 27,3 | 10,7 |
| 2001 | Row Population B | 11716 | 26241 | 5,7 | 44,1 | 43 | 7,2 |
| 2002 | Row Population C | 11700 | 37941 | 3,9 | 55,8 | 34,6 | 5,8 |
| | Average | | | **12,8** | **55,8** | **25,9** | **5,6** |
| | Standard deviation | | | 9,7 | 8,6 | 11,5 | 3,0 |

It is evident that growing curve of assessed trees rises very steeply in the last triennium. The statistical data evaluation underline that there is much more fluctuations around the average value in the lower risk class then in the highest.

The percentage of D (very dangerous trees) is quite constant showing an average value of about 5,6 % and a standard deviation value three times lower than the others.

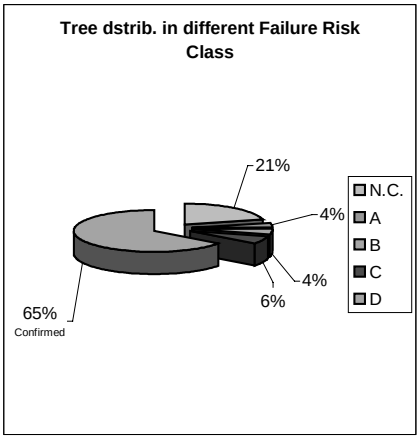



Comparing data in D column with the other columns, we can see that in year 2000, the valour flare up and there were almost double D class than in the normal situation. This high percentage of D class was judged by the Council really strange. Survey, performed by our office, had the aim to re-assess 670 trees attributed in D class, by previous staff of professionals and to verify if mentioned trees were really classable in the maximum risk class .

## Results and considerations

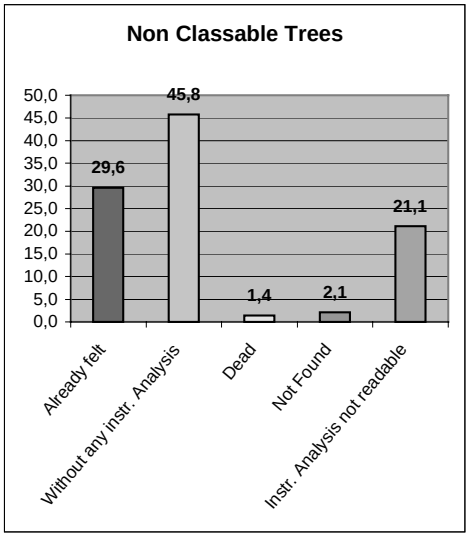
Our staff worked during the months of November and December 2001. All the technical reports have been take in consideration as well as the trees rooted inside Milan's parks and lines.

The same method of the previous professionals has been used. The GLSA protocol has been applied in order to settle a fixed procedure.




The 14 % of the analysed trees were not confirmed by us; such amount of tree has been grouped in the lower hazard class (A;B;C). Such discordance has been considered not so significant in comparison with the 21% of trees, that was not possible to be classified, that is for various reasons, it was not possible to understand if our predecessors was right or not.

The unclassified trees are following plotted:

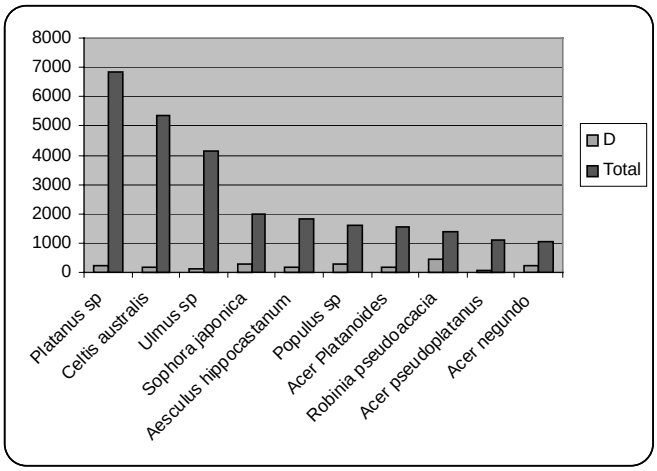



In 46,8% of the unclassified trees we found reports without a right instrumental support.

Obviously trees with an evident damage and decay could be fell down with only visual analysis, but sometimes we found judgement too drastic (sometimes was enough to prune a bit to reduce the risk) without any instrumental support. In 24,4 % the instrumental analysis was made, in confused way, for example (from the report) was impossible to determine with care where the drilling or the electronic

hammer tests have been carried out. In 2,1 % was not possible find the trees. In order to identify every trees without any doubt is necessary to use a simple labelling or cartographic system if not Transponder or more sophisticated methods.

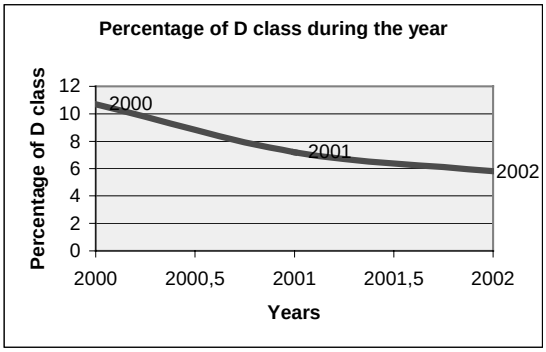
Speaking about species the following graph (M. Carra) shows the final distribution of trees related to the D class




It is evident that the dangerous tree rate ranges between 3 to 30%; fortunately it is lower in the more represented trees i.e. 205 D class (3%) versus 6828 planes and higher in the less represented 431 D class (31,9%) versus a total number of Robinia pseudoacacia of 1353 trees

## Conclusions

These data have been successfully discussed between the parts, and finally more precise procedures were defined and agreed. Most of these procedures were already described on the GLSA protocol. It was confirmed that it is important to have a standard official method (VTA in this case) but also to have standard settled operative procedures in order to “speak the same language”.




The average D value has been confirmed in the following years not only in Milano but also in other big Italian cities with parity conditions.

## Literature

1 CARRA, M., SAVOCA, B., CRESPI, G., STERGAR, D., 2002. Monitoraggio e verifica della stabilità delle alberature con VTA nel Comune di Milano. *Giornate Tecniche ISA-San Remo Italy -December 2002.*

2 GIANNI, F., 1987. Via per via gli alberi di Milano *Ed. Il Mondo Positivo Milano Italy 1987*

3 PESTALOZZA, A., 2002. State of the Art of Tree Stability in Italy *5th ISA European Congress Oslo Norway - June 2002*

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# The protocol of tree stability edited by GLSA of ISA Italy chapter

## Introduction

The tree stability science started to be practiced in Italy from the end of ’80. Also in our country the studies elaborated by A. Shigo, T.A. Tattar and later C. Matteck in this period, drastically changed the approach with the arboriculture and the urban tree. The first important surveys in bio mechanical assessment have been carried out in the city of Torino, the other big cities started years later a real and systematic city tree monitoring. Clearly, VTA method gave a big contribution in this field, it has been fundamental to have inserted concepts as “minimum stress”, “adaptive growth” and “optimum design” and as a consequence edit a list of external symptom correlated with internal defect. As far instrumental analysis is regarding, a very big step has been done with the new devices introduction, as electronic hammer and the new micro-drillers, in order to report the tests and evaluate the defects. The introduction of safety factor based on the residual healthy wood have been important too. Nevertheless, could be that some approach kept deep different, and could create misunderstandings. Could be that some technician spoke about the same thing without understand themselves. It was necessary to fix some simple operative procedures.

During the first period of the year 2001 a Working Group of ISA members (20 people), with a good knowledge in this specific topic and coming from different site of Italy, meet together for the following purposes:

1. To make a survey finalized to have some marketing information about the tree stability assessment. In other words be able to answer at the following questions:
   How many trees have been assessed in italy during the past triennium ?
   How much in the North Area ?
   How much in South Area ?
   Which is the growing trend ?
   Which is the method the most reliable and used ?
   Which the inspecting tools or instrument ?
   How many customers have been served ?

2. To Write a document (protocol) suitable to detail some important guidelines as.

## The Protocol

In this part of the paper the original version of the document is reported.

**1. Purpose of tree stability evaluation**

- This study includes individual trees rooted at any site (Parks, gardens, roadsides, etc.). The purpose of an evaluation regarding stability is to describe the biomechanical situation of a tree in relation to its various apparatus, in qualitative and quantitative terms, in particular as far as regards risk of any given tree falling or collapsing. Such verification, is based on notions of plant pathology, botany, mechanics, wood technology etc. and which is based on theories fundamentally elaborated by Shigo and Mattheck is designed to consent singling out operative procedures aimed at restoring a situation of static plant stability for those plants under study (operative arboricultural notes).

- It is good practice to define and evaluate all arboricultural techniques possible aimed at reducing risks so as to avoid the idea of the verification aimed solely at establishing whether or not to fell the tree.

- It is furthermore necessary that each tree be assigned a predefined risk category in order to be able to rapidly and unequivocally single out trees that are stable or unstable and which must be rechecked.

- This subdivision also serves to collect data which consider and underline the "dynamic situation" and "presumed evolution" of possible tree damage.

## 2. General procedures of visual analysis

- The tree must be clearly and unequivocally identifiable by different systems ( labeling, planimetric positioning, etc.)
- Visual analysis takes the entire tree apparatus into consideration. All references will be made to a Glossary (see enclosed) which clearly defines terminology such as collar???, castello??? etc. in an unambiguous manner.
- It is opportune to describe the characteristics of an area and environment where a tree is located and destined to grow.
- If available and objective in nature, even historical data can be useful concerning past situations, thus providing a more complete picture.
- For tree populations subject to verification, visual screening serves to single out which plants need further instrumental study.
- Visual screening of individual trees research, describe and evaluate symptoms, damage and anomalies in order to pinpoint "critical factors" which may have direct or indirect repercussions regarding the stability of a tree or any of its parts. Such procedures, which can be carried out with simple tools such as rubber mallets, chisels, measuring sticks, binoculars etc. all may contribute to help determine points on which to carry out further studies.

## 3. General procedures of instrumental analysis

- On trees upon which "critical factors" have been determined further instrumental studies must be carried out with the purpose of describing damage or lesions on a quantitative level.
- Analysis should be carried out at the discretion of the technician as often as necessary to obtain a complete and accurate documented diagnosis relative plant stability. The criteria must be that of guaranteeing minimum tree damage.
- The instruments utilized must furnish repeatable data and be directly or indirectly correlated to physical-mechanical characteristics of the anatomical parts taken in consideration.

  To cite a few of the most common measurement parameters utilized.

  1. Identifying the discontinuity of ligneous tissues by way of sonic or ultrasonic systems
  2. Measuring density of wood by way of penetrometric systems.
  3. Evaluation of mechanical characteristics of wood through destructive tests on ligneous samples measuring strength and angle of fracture under noted conditions.

## 4. Consignment of data to customer

The technical report relative to stability enquiries must contain:

- A description of methodologies utilized and operative procedures
- A plant data sheet (signed and dated by the technician) which permits understanding the biomechanical situation of the tree (underlining the critical factors) and to visualize and localize possible testing points (if a tree has been verified by instrument). The plant data sheet will also contain a synthetic evaluation concerning the conditions of stability of the plant.
- Any instrumental report produced will be enclosed in each plant data sheet in order to safeguard the customer's interests as well as those of the technician responsible for carrying out verifications.
- The technical operative notes (if entered below the bio-mechanical description of the tree) must contain detailed instructions aimed at reducing risk of deterioration and to support the natural tendency of restoring a situation of stability within a reasonable period of time.

## 5. Duration of analysis and risk classification

- FRC classes will be considered valid (see enclosed)
- Only take bio-mechanical characteristics of the tree into consideration independently of the target, which must be considered separately (if possible).
- Re-control procedures are independent of class risk and will be evaluated separately case by case. Such procedures will be assimilated with operative technical notes and "personalized" for each tree.
- The validity of the analyses will be made clear in every report.

## 6. Operative notes concerning plant safety measures

- If such notes must be indicated , will be established with the customer beforehand. If descriptions of operative notes are agreed to be unnecessary, it goes without saying that corrective actions will be deduced by the customer on the basis of the biomechanical stability diagnosis.
- Corrective actions must not modify or distort the tree and be carried out, as far as possible, so as not to alter its natural features.
- Corrective actions must be documented and motivated by known modern arboricultural criteria.
- The notes must be operatively translatable in qualitative and quantitative terms.
- It is desirable that the notes also contain guidelines regarding overall future maintenance operation management in relation to tree stability.
- In as far as regards consolidation systems it is necessary to refer to previously documented and experimented techniques and material. (To this extent the person responsible for carrying out proposed work should await complete documentation and EAC technical norms etc.).

## 7. Application limits

- All inspection methodology is to be considered limited and dynamic, in the sense that it can be updated and is renewable on the basis of continuously evolving scientific, technical and technological knowledge.
- It is not possible to predict if an examined tree (or part thereof) will fall or not, but it is possible to establish if it has or does not have the biomechanical and structural characteristics suitable in order to guarantee stability based on current know how.
- At present stability studies can examine a tree or its parts directly visible or at least that can be inspected by techniques aimed at revealing defects or anomalies (hypogeal apparatus or hidden for other reasons).
- Small branches or ramifications of modest importance are not subject to enquiry. The so called physiological drying out of branches may give rise to detachment and minor structural damage which may in itself prove risky or dangerous, however this falls into the category of simple tree maintenance operations.
- Evaluations based on esthetic criteria, landscaping, environmental ecology or relative to ornamental value perhaps based on historical value of urban trees are not part of the study regarding stability. It is possible to advise felling a tree simply due to its insignificance or scarce importance as long as such opinion is expressed separately with associated motivations.
- At the moment VTA is the most reliable universally known experimented technology available.

## Conclusions

A number of about 100 000 trees has been checked in the last triennium and the trend is largely increasing.

Micro - drillers and impulse hammers are the most utilized inspecting tools at the moment.

The document (protocol) has been written, and presented at the National Italian ISA Congress on June 2001, at the 5 th ISA European Congress ( Oslo – Norway June 2002) and published by the most important Italian Magazine specialized on green keeping and arboriculture. The results of this work will be the basis for possible further development of the Working Group in a matter so quickly in evolution.

## New perspectives

The GLSA is still living in order to be an "observatorium" for this specific matter. For the medium terms it is scheduled in cooperation with the Milano University a study finalized at the evaluation of new techniques and methodologies. As far is regarding the instrument. GLSA effort will be concentrated finding and testing non intrusive devices (tomography) and dynamic method.

The definition of a new technical glossary will be performed in order to edit in univocal way, all the technical, physiological and anatomical words (similar to German ZTV).

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# A study of root response to cutting and foaming treatment

## Introduction

Chemical foaming and root cutting are commonly used to keep sewer pipes free from tree roots. The objective of this study was to test the herbicides dichlobenil and diquat for their potential to limit root growth in sewer lines. These chemicals were tested on roots which had been recently severed and roots which had been left intact.

## Experimental Procedure

Six tree species, *Melaleuca styphelioides*, *Cupressus torulosa*, *Acmena smithii*, *Corymbia maculata*, *Salix viminalis*, and *Liquidambar styraciflua* ,were selected for the study based on the following criteria: their reputation for being present where blockages have occurred; literature on species with vigorous root growth; their tolerance of compacted sites; and a survey of root blockages in metropolitan Melbourne. The herbicides that were examined were dichlobenil at two different rates (2.34 g dichlobenil/L of solution and 0.70 g dichlobenil/L of solution) and diquat (2 g of diquat dibromide (a.i.)/L). A group of plants were left untreated.

Each plant was grown in a pine bark potting mix in 170 mm squat pots. To simulate sewer line conditions these pots were placed into 140 mm standard pots, and then in plastic tubs. The tubs had a drainage outlet approximately 30-40 mm above their base, therefore there was 30-40 mm of water always sitting within the tub and thus the bottom of the lower pots (see Figure 1). Irrigation was via an overhead fixed sprinkler system.

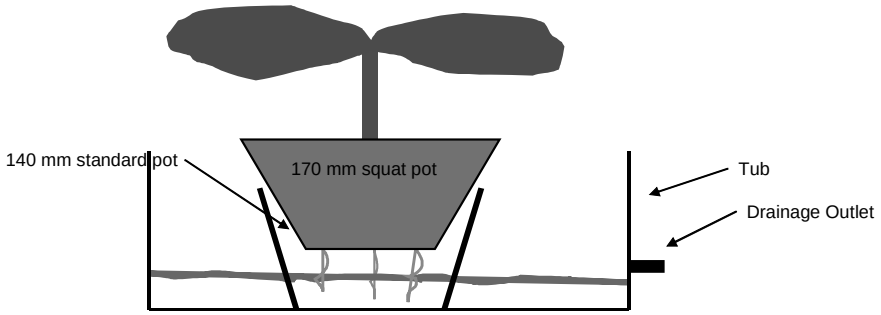


**Fig. 1** Diagram of plant, base pot and tub

Plants were grown for approximately 14 weeks in the tubs prior to the application of the chemical foams. Plants that were selected for the cut treatment had their roots cut approximately 15 mm-20 mm from the base of the pots. Blunt secateurs were used to simulate roots being cut by a sewer root cutter.

Figure 2 shows a representative of each species prior to foaming. A visual estimation of root production from highest to lowest was: Salix > Corymbia > Liquidambar > Acmena > Cupressus > Melaleuca

***Melaleuca styphelioides***

***Cupressus torulosa***

***Acmena smithii***

***Corymbia maculata***

***Salix viminalis***

***Liquidambar styraciflua***

**Fig. 2** Overall representation of amount of roots of species prior to treatments

Foam was introduced into new 140mm standard pots to approximately 50mm below the brim. Plants were then placed in this foam for 2 hours. Figure 3 shows foam being placed in the containers prior to treatment.

**Fig. 3** Application of foam

Root growth was harvested approximately 6 weeks after the treatments were applied.

Roots were harvested by cutting all roots at the base of each of the pots. Dead roots were identified by their browning and soft texture and separation of cortex from stele when lightly pulled [3]. The live roots were separated from dead roots, placed in water and then stored in a refrigerator. The root lengths measured were the sum of untreated roots emerging from the base of the pots and any live roots growing outside the pots after treatment.

## Results

Cut roots

Figure 3 displays the mean new root length for each species by chemical treatment for the cut root treatment.

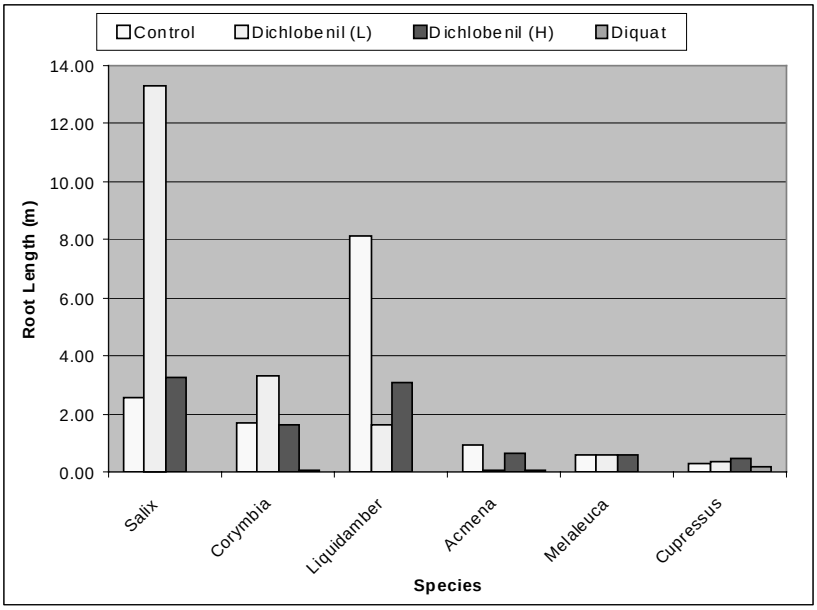


**Fig. 4** Mean root length (m) of species by chemical treatment (cut root treatment)

A GLM using transformed data indicated that there were significant effects due to chemical (P-value < 0.05) and species (P-value < 0.05). There was no interaction between chemical and species (P-value > 0.05), that is, the chemicals had similar effects on the root growth of all species.

When considering pairwise comparisons between species, while the back transformed data appears to show large differences between species none were significantly different from each other. This is probably due to a number of factors such as the broad variation of root lengths among the individual plants within a species, the small number of replicates and the removal of the interaction factor in the model.

Figure 5 shows the mean root lengths and standard error bars. The data is sorted by decreasing order of the means.

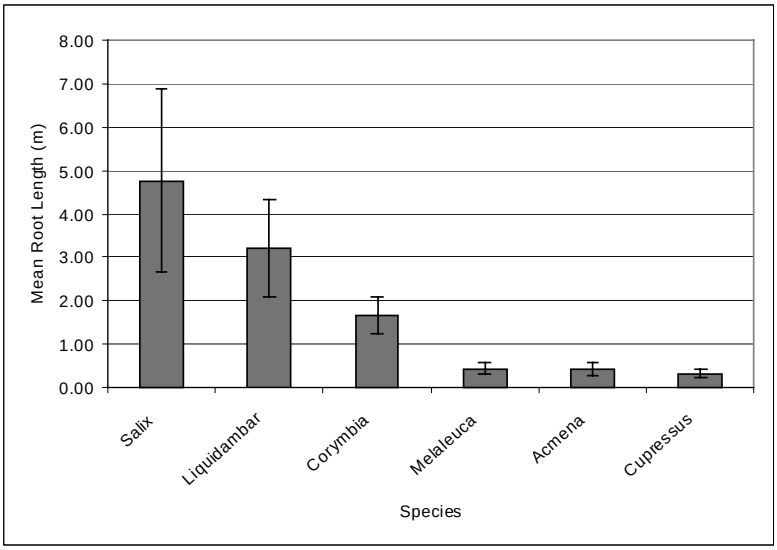


**Fig. 5** Mean root length (m) plus standard error bars for species- (cut root tratments)

Another test for pairwise comparisons was made but with confidence intervals set at 90.0%. Figure 6 illustrates that the genera *Salix, Corymbia* and *Liquidambar* had significantly more root growth than *Melaleuca. Salix, Corymbia, Liquidambar, Acmena* and *Cupressus* were not significantly different from each other and *Acmena, Cupressus* and *Melaleuca* were not significantly different in terms of root growth after treatment.

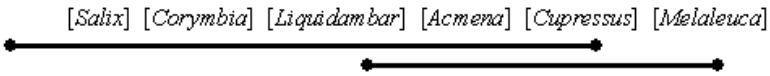


**Fig. 6** Species deemed having significantly different and similar root lengths-cut roots (based on transformed values)

Lines are drawn under species that are not significantly different using Tukey 90.0% C.L. (P-value 0.10).

Figure 7 shows the means and standard error bars of each chemical treatment. The data is sorted by decreasing order of means.

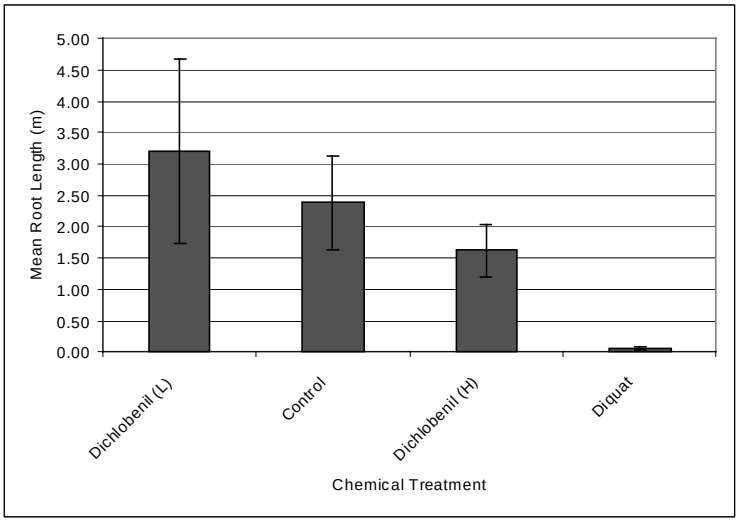


**Fig. 7** Mean root length (m) & standard error bars for chemical treatment- (cut root treatments).

A Tukey's test for pairwise comparisons was made but with Confidence limits (C.L.) set at 99.0% to examine if there were significant differences. Figure 8 illustrates that root growth was not different for dichlobenil at both high and low rates and the control. They all resulted in significantly more root growth than the diquat treatment.

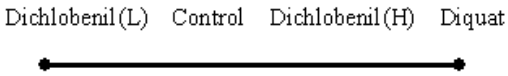


**Fig. 8** Chemical treatments that are deemed having significantly different and similar root lengths-cut roots. (based on transformed data)

Lines are drawn under treatments that are not significantly different using Tukey 99.0% C.L. (P-value 0.01).

## Uncut root treatment

The measure of root lengths for uncut roots is like that for cut roots, that is it is the sum of living roots growing from the base of the plant pot of a replicate. Figure 9 displays the mean root lengths of species by chemical for the uncut root treatments.

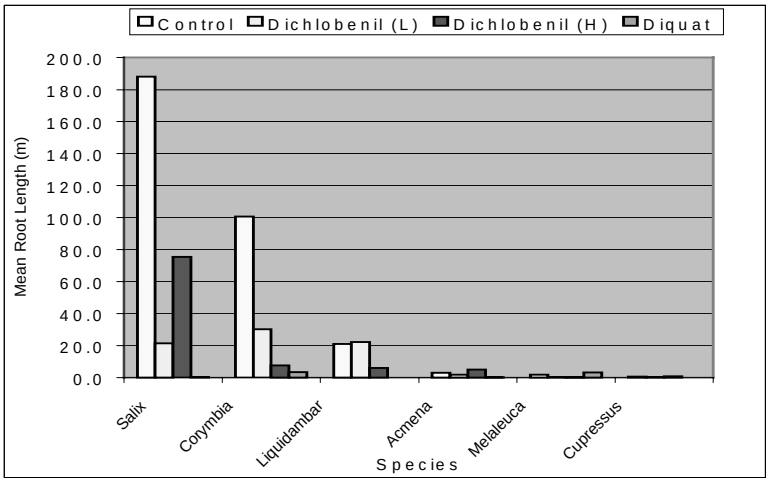


**Fig. 9** Mean root lengths (m) depending of species by chemical treatment- (uncut root treatments).

A GLM using this transformed data indicated that there were significant effects of chemicals (P-value < 0.001) and species (P-value < 0.001). There was a significant interaction between chemical and species (P-value < 0.05) meaning that the effect of the chemical treatments was different on different species. Figure 10 highlights that there is interaction, as the lines of the separate treatments are distinctly non-parallel.

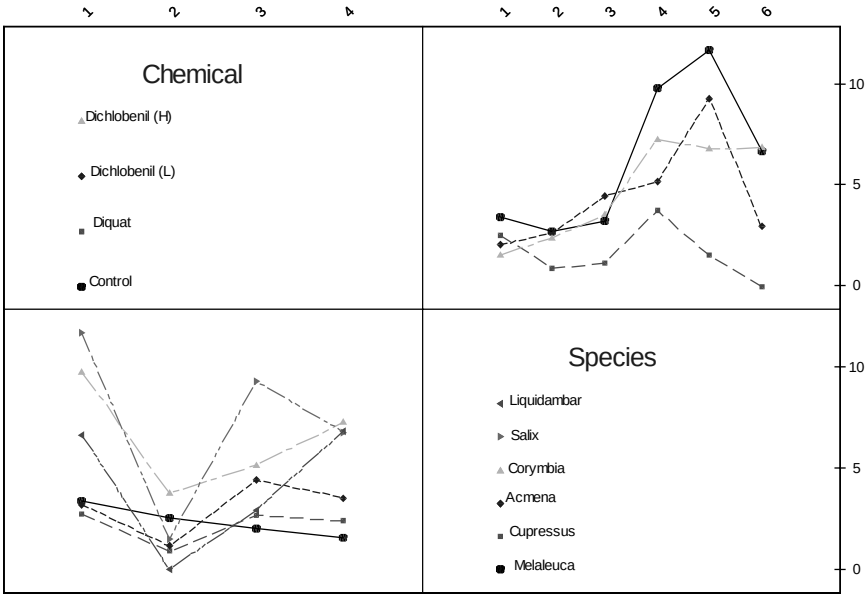


**Fig. 10** Interaction plot of means of (root length)$^{0.25}$ of species versus chemical- (uncut root treatment).

Due to the interaction, it is not possible to examine in any detail the main effects of chemical treatment or of species, however to assist the interpretation of the data, graphical comparisons were made among the species and chemicals separately as if an interaction did not exist.

Figure 11 is a graphical representation of mean root growth with standard error bars. The data is sorted by decreasing order of the means.

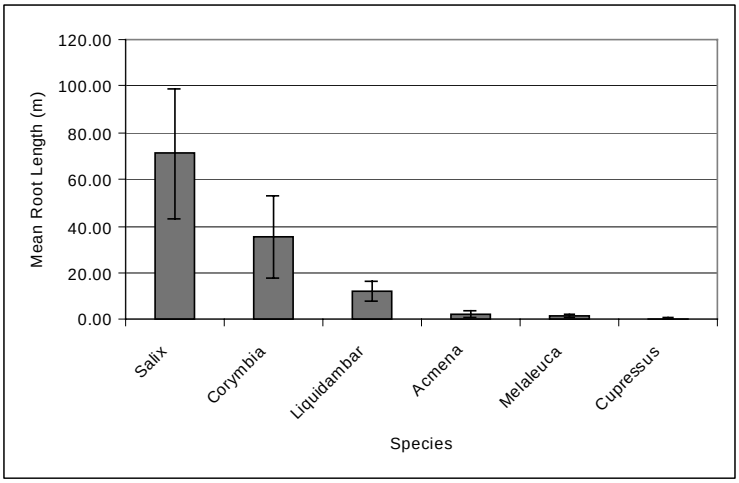


**Fig. 11** Mean root length (m) plus standard error bars for species-(uncut root treatments).

Figure 12 shows the means and standard error bars for each chemical treatment. The data is sorted by decreasing order of means.

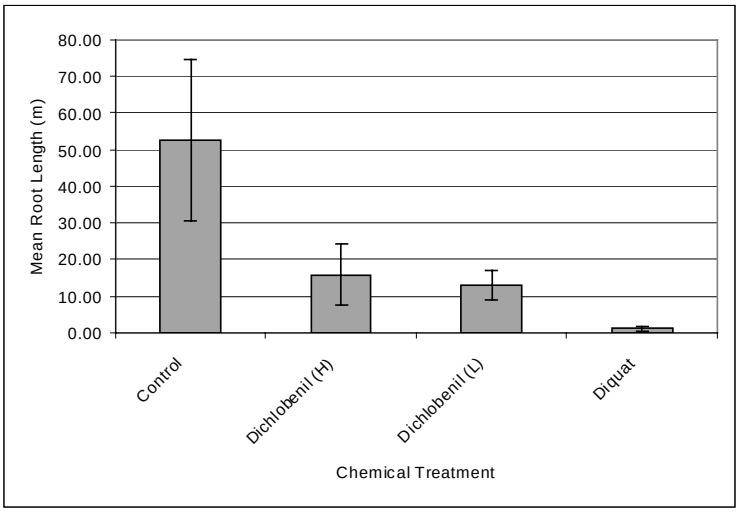


**Fig. 12** Mean root length (m) plus standard error bars for each chemical treatment (uncut root treatment).

## Discussion

Cut root treatment

When roots from a tree are growing within a pipe there will normally be a significant root mass growing outside the pipe. Untreated roots outside the pipe may eventually grow back through the openings of the pipe if they are not sealed. In this experiment, the root length measured was the sum of live root growth from treated roots outside the 170 mm squat pots and from untreated roots emerging from the base of the 170 mm squat pots. Therefore, the measure of root growth is a combination of the effect of the chemical on the treated roots plus growth of roots from untreated roots after treatments were applied.

Six weeks after treatment, the mean length of roots of the test species, from highest to lowest was: *Salix viminalis* > *Corymbia maculata* > *Liquidambar styraciflua* > *Acmena smithii* > *Cupressus torulosa* > *Melaleuca styphelioide* . This order was the same as the pre-treatment ranking. The chemical treatments did not change root growth vigour. The GLM showed that there was no interaction between chemical and species, highlighting that each chemical had a similar effect on each species.

That a particular species had more root growth than others does not strictly indicate that the species was more tolerant or resistant to a chemical than another species. Because untreated roots were included in the total root lengths, the comparison of species is in past a reflection of the vigour of untreated root growth. However, if continued vigour is considered as a tolerance or at least a resistance mechanism then, *Salix viminalis*, *Corymbia maculata* and *Liquidambar styraciflua* may be considered more tolerant of the chemicals. The literature and survey data describes *Salix viminalis* and *Eucalyptus* spp. (*Corymbia maculata*) as belonging to genera that have reputations for causing frequent damage to pipes and buildings and that have high water demands [1]. The time between blockages reoccurring at sites may be dependent on the genera that are present. It may also be due to age, cultural, site and climatic differences that affect vigour and therefore may change as the tree reaches maturity [2,6].

There were no visual signs of necrosis or foliage death caused by root pruning or chemical treatments. This suggests that at the concentrations used, the herbicides were not translocated past a certain point in the roots. Neither chemical is strongly translocated in plant tissues.

Chemical treatments from highest to lowest mean root lengths were; dichlobenil (low), control, dichlobenil (high) and diquat. Dichlobenil at both concentrations and the control all resulted in similar amounts of root growth and all were significantly greater than diquat. Previous work completed on the use of chemicals to kill roots in sewers found that diquat was ineffective in killing roots that were soaked for an hour at concentrations of 10 mg and 100 mg per L of water [7]. The differences in outcomes between that experiment and this one may be the result of differences in experimental procedures, climate and plant materials. On the basis of the experiment reported here, diquat shows considerable promise for reducing root growth after pipe clearing. A major issue to resolve however, is the high toxicity of the chemical.

Table 1 shows the different levels of dichlobenil concentrations recommended by the manufacturer and those used by Leonard and Townley and in this experiment. The rates quoted are based on the amount used to treat a volume of 1 L of pipe and the type of application i.e. line soaking or foaming.

**Tab. 1** Comparison of dichlobenil concentrations (g) per L of pipe.

| Manufacturer Rate | (Leonard and Townley 1971) | Low Rate | High Rate |
|---|---|---|---|
| 0.12 g (foam & soak) | 0.10 g (soak) | 0.035 g (foam & soak) | 0.12 g (foam & soak) |

This foam experiment used dichlobenil at 0.12 g and 0.035 g. The higher rate resulted in less root growth than the control and the lower rate of dichlobenil but there was no significant difference between these three treatments. The Leonard and Townley experimental set up was similar to the one used in this experiment except that roots were soaked rather than foamed. Leonard and Townley (1971) state that dichlobenil had killed roots of many species but not all, and that the tissue death did not extend much further than the point of treatment (see Table 2).

**Tab. 2** Effect of dichlobenil on kill of *Eucalyptus* & *Prunus* roots.

| Genus | Kill of root above point treated | Root regrowth into lower pot |
|---|---|---|
| *Eucalyptus* | 30 mm | none |
| *Prunus* | Only small roots dead | - |

From [7] (Leonard and Townley 1971) pg 14

The experiment reported here found that at the same rate as that used by Leonard and Townley, dichlobenil did not prevent root growth in any of the species tested. The differences in results between this experiment and Leonard and Townley's with dichlobenil and diquat could be the difference between the application techniques of soaking and foaming.

Diquat clearly had a greater effect on root growth than the other three treatments. An interesting point is that there was no recovery root growth in twelve of the eighteen replicates. The diquat may have actually been absorbed or bonded to the potting mix at the base of the pot and still have been active enough to prevent further root growth. Diquat bonds quite readily to organic matter [5]. Another factor that could be involved is that the chemical may have been translocated far enough within the root system, extending the distance that roots would need to travel to reach the base of the pot in the time allocated.

Uncut roots

The GLM for uncut roots showed that there was a significant interaction between chemicals and species indicating that a particular chemical had a different effect on different species. A problem with interpreting that there was an interaction is that some plants of certain species had developed relatively little root growth prior to treatments (e.g. *Melaleuca styphelioides*). The effect of a chemical may not have been as dramatic on a plant with one or two roots on to a plant with twenty long roots. As was the case with the cut treatments, some root length measurements could actually be an indication of the vigour of the root system that was not treated. Because of the limited number of replicates, it is difficult to determine if the interaction in the GLM is a reliable representation that the various chemical treatments had different effects on the different species. The orders from highest to lowest of species and chemical treatments are shown below.

The order from highest to lowest mean new root growth from uncut roots was very similar to the results found with cut roots: S*alix viminalis* > *Corymbia maculata* > *Liquidambar styraciflua* > *Acmena smithii* > *Melaleuca styphelioides* > *Cupressus torulosa*.

The order of root length, after chemical treatment, from highest to lowest mean root lengths was different for uncut roots than with cut roots (Control > Dichlobenil (high) > Dichlobenil (low) > Diquat). The control and both dichlobenil treatments had similar amounts of root growth, and all three had significantly more than diquat. As was the case with cut roots, diquat treatment of uncut roots resulted in a relatively larger number of replicates (50%) with zero root growth, indicating that diquat treatment inhibits new root growth. This result does not accord with Kerruish (1990) who states that diquat kills foliage but does not kill roots[4].

If interaction is considered then treatment combinations that had the highest and significantly similar mean new root growth lengths were:

- Control/(*Salix, Corymbia, Liquidambar*)
- Dichlobenil (Low)/(*Salix, Corymbia, Liquidambar*)
- Dichlobenil (High)/ (*Salix, Corymbia*)

As was the case with cut treatments, *Salix viminalis, Corymbia maculata* and *Liquidambar styraciflua* displayed signs of tolerance or resistance to dichlobenil. Lateral root growth was initiated from roots treated with dichlobenil in the majority of species but especially with *Salix viminalis*.

Treatment combinations of diquat/ (*Liquidambar*, *Acmena*, *Cupressus*, and *Salix*) had mean new root growth lengths within the lowest four. Diquat/(*Corymbia* and *Melaleuca*) treatments had significantly similar new root lengths as the other diquat treatment combinations mentioned. All the measured new root growth from the diquat treatments was the roots that emerged from the pots containing the plants. Most likely they grew from roots in the potting mix that had not been treated with the chemical. Again diquat does show promise for reducing root growth after pipe clearance, but to only those roots that are treated. Any roots growing outside the pipe that have not been treated will enter the pipe through the openings.

Dichlobenil treatments at both concentrations had statistically as much root growth as the control with uncut roots, and greater root growth with cut roots. This could place some doubt on the capacity of dichlobenil to inhibit root growth and it seems likely that if drains are being cleared by root cutting, dichlobenil foaming may not have any benefit in terms of extending the interval until the next clearance is required.

A reason that the dichlobenil was not very effective in killing roots was that it did not seem to completely dissolve. The ability to mix the dichlobenil product thoroughly is very difficult even when small volumes are used. The chemical cocktail was shaken vigorously before application and still some chemical sediment settled on the bottom of the container. These sediments could be either dichlobenil or Kaolin (china clay) or a mixture of both. It would be even more difficult to mix the larger volumes that would be used in the field (e.g. 900 L tank).

## Literature


1 BIDDLE, P.G., 1998. *Tree Root Damage to Buildings*. Willowmead Publishing Ltd, Wantage, London.

2 GILMAN, E.F., 1990. Tree root growth and development. I. form, spread, depth and periodicity. *Journal of Environmental Horticulture* 8: 215-220.

3 GRONINGER, J.W., ZEDAKER, S.M., SEILER, J.R., 1997. Herbicides to control tree roots in sewer lines. *Journal of Arboriculture* 23: 169-172.

4 KERRUISH, M.R., 1990. *Plant Protection 2*. Rootrot Press, Canberra.

5 KHAN, U.S. 1980. *Pesticides in the Soil Environment*. Elsevier Scientific Publishing Company, Amsterdam.

6 KOZLOWSKI, T.T., 1971. Physiological Ecology: A Series of Monographs, Texts and Treatises. Academic Press Incorporated, New York.

7 LEONARD, O.A., TOWNLEY, N.R., 1971. Control of tree roots in sewers and drains. *California Agriculture* 25: 13-15.

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# Hyperspectral remote sensing for urban areas monitoring: Techniques and methods

## The objectives for monitoring green urban areas

The collection of data to use for manegement of the urban areas is the first step for the organisation and programming of the maintenance. Until recently the manegement of the area did not correspond neither to the archives where the data was stored and therefore to analyse the relevant data. The next step was to compare the variety and record the characteristics of the green urban areas. They were classified in different areas; the parks, gardens, open spaces and also the single tree, and their necessary maintenance. The limits of the first records were those which were noted in a situation which contained data difficult to upgrade. By utilising the appropriate software the data in a short time could be elaborated and expanded by using the relevant applications.

With the application of G.I.S. the data collected became directly associated with the specific area characterised by geographic co-ordinates.

The basic phases are acquiring the data and the relative upgrades. A potentially effective methological system, dependent on the precision, flexibilty and speed is the hyperspectral remote sensing.

## Hyperspectral data acquisition by new optical systems

The high spatial and spectral resolution of the imagery provided by many today new remote sensors is of growing importance for thematic mapping , above all for the urban areas.

As part of the project “Hyperspectral Data Exploitation for Urban Land Cover Analysis” promoted by the

Universities of Ancona, Pavia, Iceland and Kingston on the benefit and application of new high-resolution imagery, some DAIS 7915 scenes, for a predominantly urban space (Pavia city area) were processed in view to examine how it could assist in planning urban inventories and keeping them up to date.

The hyperspectral images have been recently acquired by two types of sensors: DAIS 7915 and ROSIS, being the ground resolution three meters for the first and just one meter for the second.

At the present only four image lines of the DAIS 7915 (recording date 8 July 2002, from 9.44 a.m. to 10.19 a.m. local time, Alt. 1890 meters) are available (Figure 1, Figure 2).

**Fig. 1** The image data line1 and line2

**Fig. 2** The image data line3 and line4

The main characteristics of the DAIS 7915 are listed in Figure 3. They refer to the "Specification of the Airborne Spectrometer" as well as to the "Digital Airborne Imaging Spectrometer DAIS 7915 Requirement Document (IRD)" both agreed by the DLR - Institute of Optoelectronics, Oberpfaffenhofen, Germany and the Geophysical & Environmental Research Corporation (GER) [1].

**The Imaging Spectrometer DAIS 7915**

| | |
|---|---|
| Field of View | 52° |
| Inst. Field of View | 3.3 mrad |
| o. Of Channels | 79 |
| o. Of Pixels | 512 |
| Scan Principle | Kennedy |
| Scan Frequency | 6 - 24 Hz |
| Ground Resolut. | 5 - 20 m |
| Rad. Resolution | 15 bit |
| Weight | 170 kg |

| Wavelength | Channels | Resolution | Detector |
|---|---|---|---|
| 400 – 1000 nm | 32 | 20 nm | Si |
| 1500 - 1800 nm | 8 | 45 nm | InSb |
| 2000 - 2500 nm | 32 | 20 nm | InSb |
| 3000 - 5000 nm | 1 | 2.0 µm | InSb |
| 8000 -12600 nm | 6 | 0.9 µm | MCT |

**Fig. 3** The main characteristics of DAIS 7915

This new sensor covers, with its 79 channels, the spectral range from the visible to the thermal infrared wavelengths at variable spatial resolution from 3 to 20 meters depending on the carrier aircraft flight altitude.

## Hyperspectral data pre-processing

Due to the optomechanical and electronical characteristics of the instrument, all data have been submitted on a special pre-processing and calibration procedure before any quantitative analysis.

The system correction procedure first detects and removes bad scanning lines. Thereafter the calibration coefficients may be applied as the last step of the radiometric pre-processing. The atmospheric correction was based on the MODTRAN radiative transfer code [2]. Therefore image data in the reflective channels of the DAIS sensor has been converted to ground reflectance. From the thermal channels, emittances and surface temperatures, were derived.

The geometric properties of raw images deviate essentially from the geometric integrity of maps. Deviations are caused, among other things, by sensor projection characteristics, internal deficiencies such as lens distortion and non-linear scanning speed. External factors may also be involved, including variations in the attitude and position of the sensor, terrain relief, and atmospheric refraction.

Several levels of rectifications are available, such as corrections for distortions introduced by the rotation and curvature of the earth. At the highest level, the images are even corrected for relief distortions, resulting in orthoimages, to link the analysis result to other maps and to the earth surface and to allow the transfer of the image to the most popular map projections. So it is necessary also the interactive acquisition of Ground Control Points (GCP) from topographic maps and images. Using a redundant number of GCPs, the system should provide the root mean square error as a measure of how well the rectification has been carried out. Since any geometric transformation leads to resampling, which is essentially an interpolation process involving reflectance values, it should enable nearest neighbour.

To obtain the geocoded hyperspectral images, different tools have been experimented in order to correct the geometry, to realize a visual analysis and to obtain a good radiometric interpretation and classification. For the raster data image processing and their geometric correction, DEM information have been collected and organized. These last ones (DEM information) have been generated by using LIDAR data acquired some years ago. We used also, like reference for rectification, the vector Topographic Map at scale 1:2000, the same in WGS84 (UTM32) reference system. Furthermore GPS measurements recently have been obtained by the permanent GPS receiving station.

Geometric accuracy investigation, polynomial geometric corrections were carried out using Er-Mapper™ software. We determined the actual geometric accuracy by ground control points (GCPs) selected manually from 1:2000 vector Topographic Maps and a polynomial cubic function. The results regard both. At the first one for the line2 we used 33 GCPs, distributed over all the area (Figure 4), and the resulted average RMS error 1.5 pixel, demonstrated that the distortion was too big for the large-scale mapping.

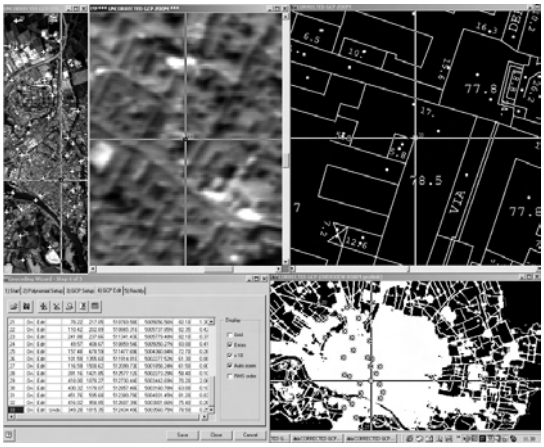

**Fig. 4** The procedure of GCPs localization to perform the geocoding

So we rejected some bad points and we obtained a good result: accuracy within 1 pixel using only 28 GCPs.

The same procedure has been followed for the line3 by 36 GCPs resulting an average RMS error 0.91 pixel. The rectified images (line2 and line3) were resampled using nearest neighbours so as to retain the spectral scale values for subsequent multispectral classification .

To improve the accuracy another method was tested. The software PCI OrthoEngine™ 8.2 Satellite Project was used to carry out geometric corrections based on rational functions. Rational polynomials functions are based on the relation between ground points and corresponding image points defined as ratios of polynomials [3]. No sensor data is needed.

We realize the geocoding of the image line2 measuring 33 GCPs, resulting an average RMS error in X pixel coordinate about 0.26 and Y pixel coordinate about 0.27 (Figure 5).

The ortho(rectified) image line2 shows the correct procedure and the capability of the rational functions to model some deformations using only the ground control points (Figure 5).

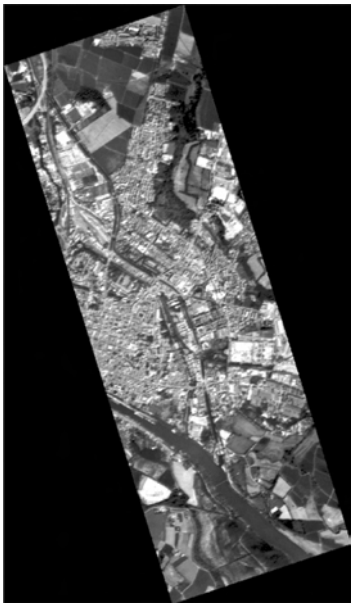

**Fig. 5** The rectified image line2 by rational functions

## Image classification

In this first stage of the project, a traditional procedure to extract thematic layers information from hyperspectral images DAIS 7915, was followed.

First, taking advantage of high spectral resolution of the sensor, both single bands and RGB composition visual interpretation were executed. That drives the operator, working with the photo-interpretation techniques, throughout a sort of self-training steps. The operator is then lead to connect his own acquaintances on the territory resumed on the image with targets on earth spectral behaviours, using like reading key the specific technical-cultural references of its professional formation (in this case agronomist). Through this analysis the following has been characterized: *1)* the spectral bands characterized from a low signal/noise relationship (from 41 to 46 and 62 to 72) that they will not have to be used in the numerical classification; *2)* main features referred to vegetated covers and leaf canopy

(analysis of RGB that takes advantage of the "red edge", as an example RGB 17-11-5) and main features referred to artificial covers (artefacts in several materials: asphalt, concrete, tiles, etc.); *3)* the urban planning structure of the city of Pavia that conserves references to its roman origin (as it reveals from its increase and organization around to the original centre of the city, middle way between the "cardo maximo" and the "decumano").

At this stage of the project, the objective is to identify the greatest number of vegetated and not vegetated covers. On the other side, the state of the covers has not been momentary taken into account. Such analyses are being developed and they will be reported on another paper. Integrating the visual analysis of some RGB compositions with a ground data set, collected during the flight of the sensor, a training set of 18 different cover typologies has been selected. They characterize: the city system properly said (road system and buildings), the system of the urban green (herbaceous vegetation and arboreal vegetation inner to the city), the urban fringe of agricultural system (crops and meadows), the hydrographical network (rivers and channels). Using the same method, it has been also selected a set of "ground truth" referring to the same 18 classes.

By means of the software ENVI ™, the end-members have been extracted from the training set. The end-members are the spectral behaviours of reference, which will be used by the selected classification algorithm (Spectral Angle Mapper, acronym SAM) in order to classify the entire image (image line3 of the DAIS 7915).

The Spectral Angle Mapper is a classification algorithm that discriminates the pixel of the image based on the likeness degree between their spectral behaviour and the spectral curve of reference, gained from the training set or obtainable from a spectral library [4,5]. The spectral likeness between objects of the scene and spectral curves of reference is calculated based on the *n*-dimensional angle that separates them, as vectors, in an *n*-dimensions space, where *n* is the number of bands utilized for the classification.

SAM classifier compares the angle between the collected training set vectors and every image single pixel vector. The pixel class of allocation is the one demonstrating a minor angular distance. Pixels, which do not reach the value of a priori established likeness, as minimal threshold for the classifier, they are not attributed to any class, remaining therefore unclassified.

Given two *n*-dimension vectors, e.g. vector *a* (1) and vector *b* (2):

$$a = a_1 + \mathrm{K} + a_n \qquad (1)$$

$$b = b_1 + \mathrm{K} + b_n \qquad (2)$$

Then (3):

$$a = \cos^{-1}\left[\left(\sum_n a_i b_i\right) \Big/ \left(\sum_n a_i^2\right)^{1/2} \left(\sum_n b_i^2\right)^{1/2}\right] \qquad (3)$$

Where $\alpha$ is the angular distance (expressed in radian and fixed by the operator) and *n* is the number of spectral bands.

The SAM classifier has been applied to the selected set of bands for the image classification, (in all n.61 bands, of which n.32 inside VIS-NIR from the spectrometer I, n. 8 bands inside SWIR from the spectrometer II, n.15 bands inside SWIR from the spectrometer III and n. 6 inside TIR from the spectrometer IV of DAIS 7915).

Some different angular distances $\alpha$ were used, and then every thematic map obtained from the classifier was tested by accuracy analysis. We obtained the most interesting results with the angular distance $\alpha$ = 0.01 radian (Figure 6), but the 18 classes from SAM classification, as the Table shows, did not give us full satisfaction.

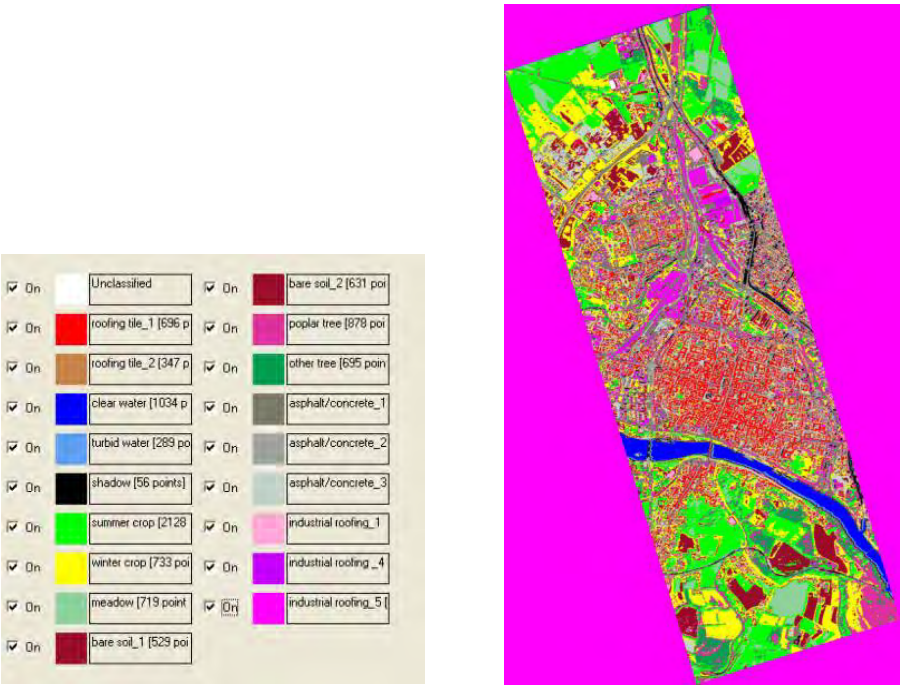


**Fig. 6** Legend and classification results for the image line 2

**Table** Accuracy evaluation of classification results

| Class name | Commission (percent) | Omission (Percent) | User Acc. (Percent) | Prod. Acc. Percent) |
|---|---|---|---|---|
| roofing tile_1 | 11.55 | 6.76 | 93.24 | 88.98 |
| roofing tile_2 | 0.82 | 20.90 | 79.10 | 98.97 |
| clear water | 5.72 | 0.00 | 100.00 | 94.59 |
| turbid water | 35.00 | 16.25 | 83.75 | 70.53 |
| shadow | 5.80 | 5.65 | 54.35 | 90.36 |
| Summer crop | 17.38 | 22.62 | 77.38 | 81.66 |
| Winter crop | 12.23 | 10.04 | 89.96 | 88.03 |
| meadow | 3.95 | 5.14 | 94.86 | 96.00 |
| bare soil_1 | 10.08 | 13.03 | 86.97 | 89.61 |
| bare soil_2 | 50.00 | 1.75 | 98.25 | 66.27 |
| poplar tree | 97.55 | 4.49 | 95.51 | 49.47 |
| other tree | 16.39 | 72.05 | 27.95 | 63.04 |
| asphalt/concrete_1 | 15.38 | 17.00 | 83.00 | 84.36 |
| asphalt/concrete_2 | 28.67 | 12.59 | 87.41 | 75.30 |
| asphalt/concrete_3 | 27.59 | 12.07 | 87.93 | 76.12 |
| industrial roofing_1 | 1.92 | 16.35 | 83.65 | 97.75 |
| industrial roofing_4 | 7.58 | 19.70 | 80.30 | 91.38 |
| industrial roofing_5 | 6.95 | 11.76 | 88.24 | 92.70 |

## Conclusions

In questa prima fase di studio sono emerse le enormi potenzialità del metodo applicato. L'elaborazione dei dati derivanti da sensori che rilevano dati con maggior precisione consentirà una maggior accuratezza e definizione, raggiungendo risultati che confermeranno gli obiettivi già raggiunti in questa fase.

Attualmente sono i corso approfondimenti per poter applicare il sistema anche ad analisi fitosanitarie. Seguendo questa strada sarà possibile in tempi brevi definire il territorio, classificare le diverse situazioni e programmare interventi mirati, ottenendo quindi una maggiore efficienza a costi contenuti.

During the first phase of the study this method of data collection has shown great potential. The expansion and the extension of the data gained from sensors with more precision, will allow a greater accuracy and definition. This has been displayed in the confirmation of the aims during this prelimary phase.

Actually at the moment a preliminary study is being made to verify the system to tree pathologies assesment.

Following this model it would be possible in a short time to define the landscape quality, classify the diverse areas and to establish a maintenance programme to enable maximum efficiency with minimum cost.

## Literature


1 BERK, A., BERNSTEIN, L.S., ROBERTSON, D., 1989. "MODTRAN: A moderate resolution model for LOWTRAN 7", GL-TR-89-0122, Geophys. Lab., Bedford, MA.

2 CHANG, S.,. WESTFIELD, M.J, LEHMANN, F., OERTEL, D., RICHTER, R., 1993. "A 79 - Channel Airborne Imaging Spectrometer", in SPIE Proc., vol. 1937 pp. 164 - 172.

3 CHIUSOLI, A., ADVERSI, R.,.BORIANI, M.L,.BUFFERLI, E, MINELLI, A. 1996. "Il recupero di superfici a verde nella città. Il piano del verde di un ospedale a Bologna". Atti Convegno nazionale "Pianta e Ambiente" 25 ottobre, pp 21-26.

4 DELLOSTE, L.,.MINELLI, A., MINELLI, M., 1996. "Gestione computerizzata del censimento di alberature: l'utilizzo di indici progressivi". Atti Convegno nazionale "Pianta e Ambiente" 25 ottobre, pp 37-43

5 DOWMAN, I., DOLLOFF, J.T., 2000. "An evaluation of rational functions for photogrammetric restitution", in IAPRS, vol. XXXIII, Amsterdam.

6 GALLI, A., MARINO, C.M., MENIN, A., PANIGADA, C., 2000. "Hyperspectral Remote Sensing in environmental monitoring: detailed mapping of asbestos concrete in sheeting and in illegal stocking area", SEG/Calgary, Society of Exploration Geophysicists International Exposition, Seventieth Annual Meeting, 6-11 August 2000, Calgary, U.S.A.

7 MINELLI A. et al. "La qualità del verde; disciplinare per la migliore gestione dell'ambiente". Il Divulgatore, anno XXI, n°9/10.

8 WANG, Z., ZHU, Z., WANG, H., LIU, Q., 1999. "Application of the Method of Imaging Spectral Angle Mapping base on laboratory spectral analysis", Applied Geologic Remote Sensing, Vancouver, BC, Canada- 1-3 March 1999, 300-307.

# Session 5 - Tree biology and tree care

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## Treatment of tree wounds caused by traffic accidents

### Introduction

Wounds set by removing the bark tissue from the trunk totally but leaving the cambium or the outermost differentiating xylem mechanically unaffected may lead to the formation of a callus tissue on the wound surface (Zhengli and Keming, 1988; McDougall and Blanchette, 1996; Dujesiefken et al., 2001). This type of wounding may be caused by traffic accidents along streets or careless logging in forests. This phenomenon of large-scale reactions at the wound surface is known for about 200 years and has been studied at both macroscopic and tissue levels. It has been variously described as “reproduction of new bark and wood tissue” (Hartig, 1844), “surface or superficial callus growth” (Sharples and Gunnery, 1933), ”direct cambium to bark development” (Fenner, 1949), ”Wundbekleidung” (Fink, 1999), or just ”surface callus” (Dujesiefken et al., 2001). In the following description the term surface callus is used for this type of wound response.

In Germany wounds on roadside trees caused by traffic accidents lead to vast damages of several million Euros. The formation of surface callus is an effective reaction helping the tree to counteract against wounding, which could be promoted by wound treatment. Wounds covered by opaque plastic wraps can develop surface callus tissue more frequently than those treated with wound dressing or those being left untreated (Stobbe et al. 2002c). Deciduous tree species are generally capable of surface callus formation after plastic wrap treatment all year around (Stobbe et al., 2003). Recommendations for the treatment of fresh wounds caused by traffic accidents were given in the new German rules and regulations for arboricultural practice (ZTV-Baumpflege 2001).

This paper focuses on the biological details of surface callus formation on stem wounds for a better understanding of this new method using opaque plastic wrap for wound treatment in arboricultural practice.

### Materials and methods

The investigations were carried out using three lime trees (*Tilia* sp.), each approximately 50 years old, growing in a forest near Hamburg, Germany. The trees were wounded during a four-week period in June 1999. Wounds were made in a helical pattern at stem heights between 40 and 200 cm. These wounds, measuring 10 cm², were produced using first a saw to cut the bark up to the cambium and then removing it from the trunk by tapping with a hammer. Thereafter, the wounds were covered by 0.5 mm thick, black polyethylene plastic wraps. These wraps were pinned using steal-needles to healthy bark along the edges of the wounds.

Microscopy was carried out on the samples taken after response periods ranging from one to four, eight to eleven and thirteen to sixteen weeks. A detailed description of methods for microscopy is given by Stobbe et al. (2002a).

### Results

In June the bark was easy to remove mechanically from the wood, leaving a whitish, moist, and sometimes fibrous tissue on the wound surface (Figure 1a). The wounds, which were regularly covered with plastic wraps immediately after wounding, rapidly showed reactions on most parts of their surface. They became visible even with the naked eye and showed different discoloration as early as one week after wounding. Some parts were greenish to brownish, while other parts remained white. These colour

differences increases over time and nine weeks after wounding areas with callus formation could be easily distinguished from the dark, stained areas of the wound without callus growth (Figure 1b).

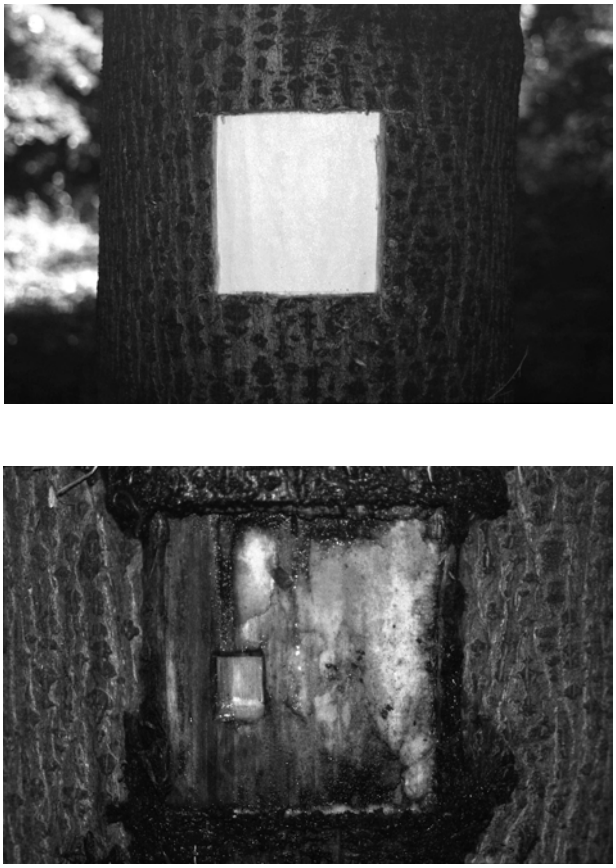

**Fig. 1** Lime, macroscopic view on the wound surface: **a:** fresh wound; **b:** after nine weeks nearly half of the wound is covered with bright surface callus tissue

After response periods of a few days, those wounds with the cambium and innermost phloem remaining attached to the xylem showed a few rows of collapsed cells on their surface. More detailed analyses clearly revealed that these rows consisted of collapsed innermost phloem and cambium. Inside of this zone, undifferentiated xylem cells without secondary walls proliferated through mitotic activities. Also, ray parenchyma cells divided and proliferated thus actively contributing to the callus formation, as the light microscopy of transverse sections revealed (Figure 2a).

By continued cell divisions and enlargement of daughter cells, this tissue with its isodiametric cells rapidly expanded in both radial and tangential directions. It became evident that nearly all the undifferentiated xylem cells were involved in callus formation. As a consequence, an exclusively parenchymatic tissue without vessels, fibres and ray structures developed directly adjoining the latewood of the previous year tree ring (Figure 2b) or to current year earlywood laid down prior to wounding and already with secondary walls. The cells of the collapsed zone did not actively participate in the callus formation, but obviously provided protection onto the underlying tissue. Bacteria often colonised this zone, but were not found in the living tissues.

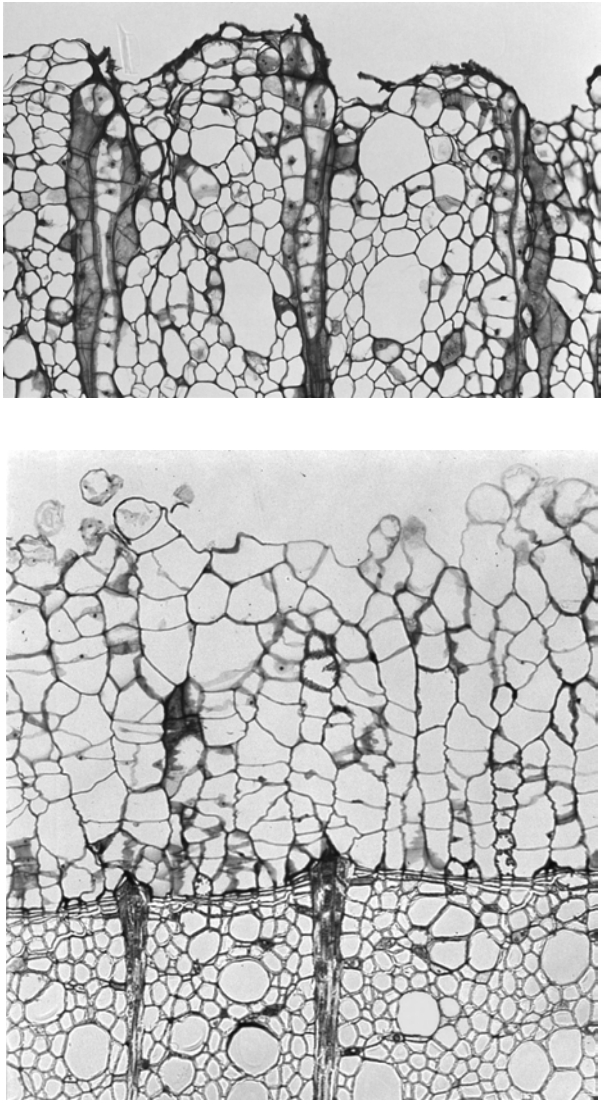

**Fig. 2** Lime, early stage of surface callus development: **a:** proliferation and cell division of the ray parenchyma cell; **b:** complete layer of surface callus cells directly attached to previous year latewood

Another series of samples was taken after response periods of four and eight weeks from white surface regions. Parenchyma cells just inside of the collapse zone have started to deposit a thin suberin-like layer onto their primary walls. Additionally, dark-staining phenolic compounds were regularly observed in the vacuoles of these cells (Figure 3). A few rows further inside simultaneous cell divisions were observed in some cells, and the newly formed walls were strictly tangential. Also the shape of these cells changed from isodiametric to radially flatten. This process of differentiation could be first observed four to eight weeks after wounding only in some tissue portions, later on extending tangentially, until a continuous band was formed. This band could be clearly identified as the phellogen of a developing wound periderm

on the basis of its structure and position. Wound periderm formation was completed in the following weeks by the deposition of a phellem to the outside and a phelloderm to the inside of the phellogen.

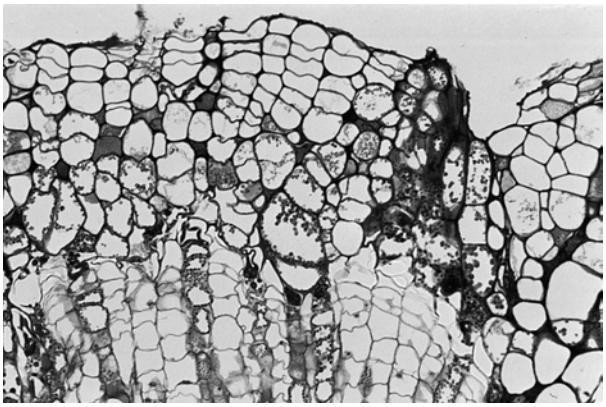

**Fig. 3** Lime, formation of wound periderm; a phellogen develops inside the outer callus tissue, some cells insert tangential walls, later on a complete tangential layer of flattened phellogen cells is formed

Just after the completion of the wound periderm, a new meristematic tissue at inner callus portions began to form (Figure 4). Initially, a few callus cells divided by producing radial and tangential walls, leading to a reduction in the cell size and also in shape changes. Thereafter, these modified cells appeared tangentially flattened. No intercellular spaces occurred in this tissue portion. In addition, longitudinal sections showed a distinct axial elongation of these cells. Again, this process was initiated in a few regions, later on extending tangentially to build up a closed layer of wound cambium.

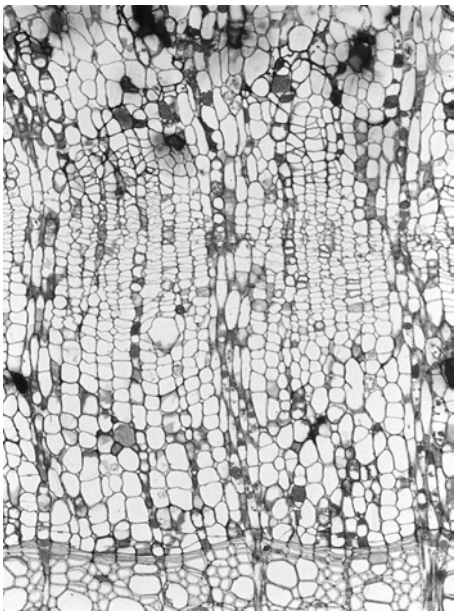

**Fig. 4** Lime, a new wound cambium develops close to previous year xylem

As a consequence of numerous cell divisions as well as differentiation of wound periderm and wound cambium a pronounced surface callus with structural and functional subdivision covered the large-scale wounds. During the vegetation period this entire response process lasted eight to eleven weeks until completion of the wound cambium.

Samples taken after response periods of 13-16 weeks typically showed wound xylem and wound phloem lay down by the wound cambium. The wound xylem characteristically contained fewer and smaller vessels and also a larger amount of axial parenchyma cells as compared to regular xylem. Additionally, stages in ray reconstitution were observable. A zone of cells with thin secondary walls and without vessels was regularly located as a kind of scar between the wound xylem and the regular xylem laid down prior to wounding, representing the callus tissue initially developed at the wound surface. At the outside, the surface callus then contained a fully differentiated periderm characterised by several rows of phellem cells with a thick suberised inner wall layer.

In conclusion, the entire surface callus was well developed within a response period of up to altogether four months during which three developmental stages could be clearly identified:

1. formation of parenchymatic tissue on the wound surface,
2. formation of a wound periderm at the outer callus tissue, and
3. formation of a wound cambium in the inner callus tissue.

## Discussion

Formation of a surface callus is a tree's response to large-scale superficial wounding. This phenomenon, known as a botanical peculiarity for more than 200 years (Dujesiefken et al., 2001), has been observed for various broad-leaved tree species in climatically different areas (e.g. Trécul, 1853; Noel, 1968; Novitskaya, 1998). However, the fine structural processes and the developmental stages have not previously been described.

If debarking occurs during the vegetation period, mostly undifferentiated young xylem cells remain on the wound surface and start to proliferate and divide, signalling the onset of surface callus formation on the entire wound area, or parts of it. In cases where only cells that have already started forming secondary walls remain on the surface, a callus tissue can not form. There are a few examples where completely differentiated axial and ray parenchyma cells are reported to have proliferated (Sharples and Gunnery, 1933). The cambium is often removed together with the bark, but when retained it forms a layer of collapsed cells protecting the undifferentiated xylem cells underneath. Hence the cambium is not directly involved in the surface callus formation if the wounding occurs during the vegetative period. The wound depth and the number of the cells that remain on the wound surface and that are able to divide are related to the growth of a surface callus.

During callus growth, some remarkable changes in the tissue take place three to four weeks after wounding: the outer cells form suberised wall layers and phenolic depositions in vacuoles. The subsequent callus tissue inward is altered into a tangentially oriented belt of flattened cells, the initiation of a phellogen. After eight weeks a fully functional wound periderm has formed, consisting of a complete phellogen forming phellem externally and phelloderm internally. The phellem is clearly suberised and contains phenolic substances in its vacuoles. Brown and Sax (1962) have observed such a reorganisation with poplar already after two to three weeks of response.

The restructuring of the outer surface callus cells can be compared with the formation of a ligno-suberised layer in the bark built after wounding (Oven et al., 1999). A necrophylactic periderm develops (Biggs, 1985) which later merges into the original periderm at the rim of the wound. According to Oven et al. (1999), the formation of such a ligno-suberised layer in the bark is a precondition for the growth of a wound periderm. Therefore, restructuring of the outer surface callus as well as the formation of a wound periderm are necessary for continuing surface callus development.

Following establishment of the wound periderm, a wound cambium is formed by the inner surface callus tissue, i.e. close to the regular xylem. This was also shown earlier for poplar and pine as well as for two tropical tree species (Brown and Sax, 1962; Noel, 1968). However, in some subtropical tree species in Asia, the wound periderm and the wound cambium was formed nearly simultaneously (Zhengli and Keming, 1988). The wound cambium develops by inserting radial and tangential walls into parenchymatic callus cells in the course of several cell divisions. This often occurs simultaneously at several places, merging into a continuous cambium band. If a tree does not rapidly succeed in forming such a continuous cambium band, bundle like structures of cambial cells are visible from where a tangentially extending cambium later originates until a continuous band is formed (Noel, 1968). The present study shows that the fusiform initials of the wound cambium are distinctly shorter than those in the regular cambium (Larson 1994). They are, at first only able to form xylem cells similar to wound xylem (Rademacher et al., 1984); only after two weeks functioning phloem cells are produced (Brown and Sax, 1962).

To conclude, the development of a surface callus is usually clearly and generally divided into three stages: an initial stage of parenchyma cell formation (1$^{st}$ stage) and two stages of restructuring, namely the formation of a wound periderm in the outer callus (2$^{nd}$ stage) and the subsequent formation of a wound cambium in the inner tissue (3$^{rd}$ stage). The surface callus is only completely developed when this wound cambium has formed. Then, a fully functioning tissue of bark, cambium and wood will develop on the surface from which bark and most of the cambium had previously been removed.

Investigations of roadside trees with wounds caused by traffic accidents and treated with opaque plastic wrap have shown, that surface callus can be developed on almost every deciduous tree species. Also old trees can react in this way. Recommendations for the practical use of this new method are given in a guideline (Stobbe et al, 2002b). However, all investigations have shown that opaque plastic wrap leads to more surface callus tissue and a better wound reaction than other treatments (Stobbe et al, 2002c).

## Literature


1 ZHENGLI, L., KEMING, C., 1988. Differentiation of secondary xylem after girdling. IAWA Bulletin n.s. 9: 375-383.

2 MCDOUGALL, D.N., BLANCHETTE, RA., 1996. Polyethylene plastic wrap for tree wounds: a promotor of wound closure on fresh wounds. Journal of Arboriculture 22: 205-210.

3 DUJESIEFKEN, D., STOBBE, H., KOWOL, T., 2001. Der Flächenkallus – eine Wundreaktion von Bäumen nach Rücke- und Anfahrschäden. Forstwissenschaftliches Centralblatt 120: 80-89.

4 HARTIG, T., 1844. Bericht über gelungene Versuche zur Reproduktion neuer Holz- und Rindenschichten aus dem Holzkörper der Bäume. Verhandlungen des Vereins zur Beförderung des Gartenbaus in den königlich preussischen Staaten 17: 329-331.

5 FENNER, 1949. Shade method of direct cambium-to-bark development. National Shade Tree Conference, Proceedings 18: 131-138.

6 FINK, S., 1999. Pathological and regenerative plant anatomy. Berlin, Stuttgart: Gebrueder Borntraeger.

7 STOBBE, H., DUJESIEFKEN, D., ECKSTEIN, D., SCHMITT, U., 2002c. Vergleich der Wundreaktionen an Stammverletzungen von Laubgehölzen nach Behandlung mit Wundverschlussmitteln und Kunststofffolie. Nachrichtenblatt des Deutschen Pflanzenschutzdienstes 54: 312-318.

8 STOBBE, H., DUJESIEFKEN, D., SCHMITT, U., ECKSTEIN, D., 2003. Wundbehandlung von frischen Anfahrschäden an Bäumen. Ist auch in der Vegetationsruhe eine Flächenkallus-Bildung möglich? Stadt und Grün 52: 39-43.

9 ZTV – BAUMPFLEGE, 2001. Zusätzliche Technische Vertragsbedingungen und Richtlinien für Baumpflege. Schriftenreihe der Forschungsgesellschaft Landschaftsentwicklung - Landschaftsbau e.V. (FLL), 68 p.

10 STOBBE, H., SCHMITT, U., ECKSTEIN, D., DUJESIEFKEN, D., 2002a. Developmental stages and fine structure of surface callus formed after debarking of living lime trees. Annals of Botany 89: 773-782.

11 TRÉCUL, A., 1853. Acroissement des végéteaux dicotylédonés ligneux, reproduction du bois et de l'écorce par le bois décortiqué. Annal de Science Naturel, 3. Série Botanique 19: 157-192 + 6 pl.

12 NOEL ARA. 1968. Callus formation and differentiation at an exposed cambial surface. Annals of Botany 32: 347-359 + 2 pl.

13 NOVITSKAJA, L.L., 1998. Regeneration of bark and formation of abnormal birch wood. Trees 13: 74-79.

14 SHARPLES, A., GUNNERY, H., 1933. Callus formation in Hibiscus rosa-sinensis L. and Hevea brasiliensis Müll. Arg. Annals of Botany 47: 827-839 + 5 pl.

15 BROWN, C.L., SAX K., 1962. The influence of pressure on the differentiation of secondary tissues. American Journal of Botany 49: 683-691.

16 OVEN, P., TORELLI, N., SHORTLE, W.C., ZUPANCIC, M., 1999. The formation of ligno-suberized layer and necrophylactic periderm in beech bark (Fagus sylvatica L.). Flora 194: 137-144.

17 BIGGS, A.R., 1985. Suberized boundary zones and the chronology of wound response in tree bark. Physiopathology. 75: 1191-1195.

18 LARSON, P.R., 1994. The vascular cambium. Development and structure. Berlin, Heidelberg, New York: Springer-Verlag.

19 RADEMACHER, P., BAUCH, J., SHIGO, A.L., 1984. Characteristics of xylem formed after wounding in Acer, Betula and Fagus. IAWA Bulletin n.s. 5: 141-151.

20 STOBBE H, DUJESIEFKEN D, ECKSTEIN D, SCHMITT U. 2002b. Behandlungsmöglichkeiten von frischen Anfahrschäden an Alleebäumen. In: Dujesiefken D, Kockerbeck P: Jahrbuch der Baumpflege 2002, Thalacker Medien, Braunschweig, 43-55.

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# Towards a better understanding of tree failure: Investigations into bending stresses of branch junctions and reiterates of European Filbert (*Corylus avellana L.*) as a model organism.

## Introduction

Heavy storms use to be rare events; this is why trees are not prepared for them. Trees will fail when winds too strong for their mechanical possibilities bend their crowns. The question is how a tree fails in a storm. An uprooted tree and a tree that breaks at its base bring down a heavy mass causing large damage. A tree that fails more politely to its surrounding will break the terminal branches. So small masses will fall down and when the storm is over the tree owner can decide whether to keep his storm shaped bonsai or to replace it by a new plant.

When investigating a mixed forest stand after a hurricane, some trees will be felled (uprooted or broken at their base) other trees will have suffered with crown damages; either large beams have broken from the trunk or smaller branches from the crown periphery are left off. Similar effects can be observed in urban parks. Especially Lindens and Beeches from open stands usually loose no more than peripheral branches which do not cause valuable damage. Our goal is to better understand how static forces like wet snow and dynamic forces like wind loads affect on beams, which effect tapered and non tapered beams bring and which crown architecture allows a less dangerous failure.

## Materials and methods

For our investigations we used European Filbert (*Corylus avellana L.*) as a model organism. The woody plant develops according to Rauh's Model, one of the most popular Architectures in temperate climate (Hallé 1970, Pfisterer 1998, 1999). Wood density of Filbert is similar to common trees (Table 1.) and so is its flexibility (Table 2). On the other hand European Filbert is a weed in our forests; this is why no forest ranger will be angry if we collect some branches from a Filbert shrub. In a second step the results on Filbert will be proved on different tree varieties more popular in our parks.

**Tab. 1** Wood density of some popular forest trees compared with European Filbert, our test organism. (after Schuett et al, since 1995).

| Wood Density [g / cm³] of several, common woody plants | |
|---|---|
| Norway Maple (*Acer platanoides L.)* | $\rho$ = 0,59 g/cm |
| European Filbert (*Corylus avellana L.*) | $\rho$ = 0,60 g/cm |
| European Ash (*Fraxinus excelsior L.*) | $\rho$ = 0,65 g/cm |
| European Beech (*Fagus sylvatica L.*) | $\rho$ = 0,68 g/cm |

**Tab. 2** Maximum bending stress of some trees (Schroeder 1998) in comparison to European Filbert (-> Tab. 4).

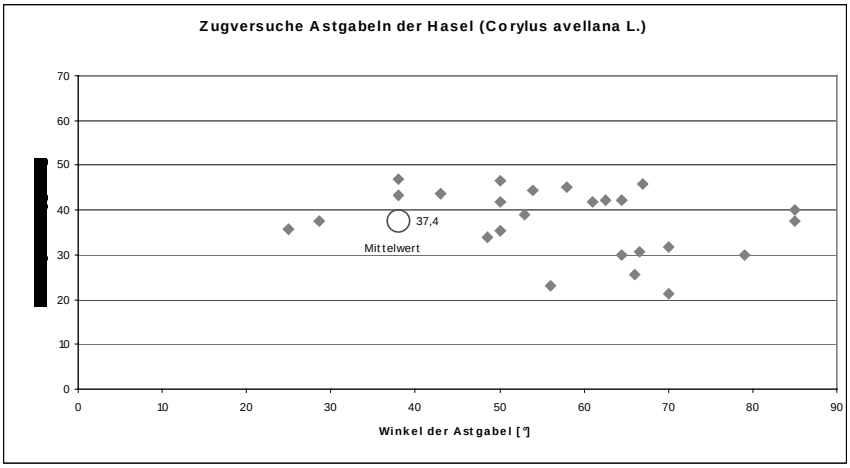
| Maximum Bending Stress [MPa] | |
|---|---|
| European Filbert (*Corylus avellana L.*) | $\delta_B$ = 41 – 65 MPa |
| English Oak (*Quercus robur* L.) | $\delta_B$ = 59 – 72 MPa |
| European Beech (*Fagus sylvatica L.*) | $\delta_B$ = 65 MPa |
| London Plane (*Platanus x hispanica Münchh*) | $\delta_B$ = 54 MPa |
| Carolina Poplar (*Populus x canadensis Moench*) | $\delta_B$ = 41 - 44 MPa |

Under mechanical view a branch junction is a weak point. Above a fork the diameter of the axis is reduced and the distal axes grow in an angle giving more power to bending forces.

## Measuring of bending forces

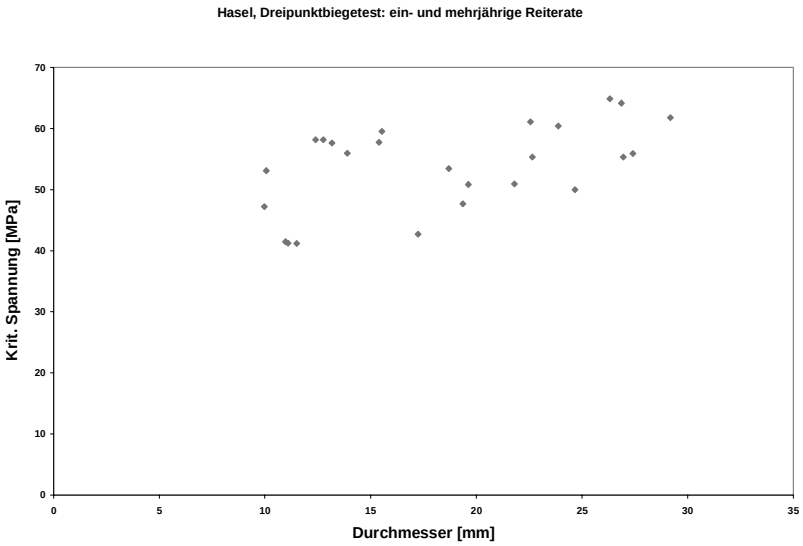
Fresh forks of Filbert beams were measured in a universal tensile testing machine INSTRON 4466. The maximal forces and the forces applied during the process were measured (Table 3). In order to compare the forces of forks of different size and different angles diameters, angles and distances between axilla and fixing points were calculated with the forces applied to the material.

**Tab. 3** Forks of European Filbert: Maximum strain [MPa] dependent on the fork's angle. The angle has no influence, narrow forks are as strong as open forks with wide angles.




In order to compare the strength of branch junction to normal wood strength in a second measuring fresh Filbert reiterates were put under three point pressure (Table 4).

**Tab. 4** Reiterates of European Filbert, 3-point-measuring with INSTRON 4466: Critical strain [MPa] dependent on the reiterate's cross section.



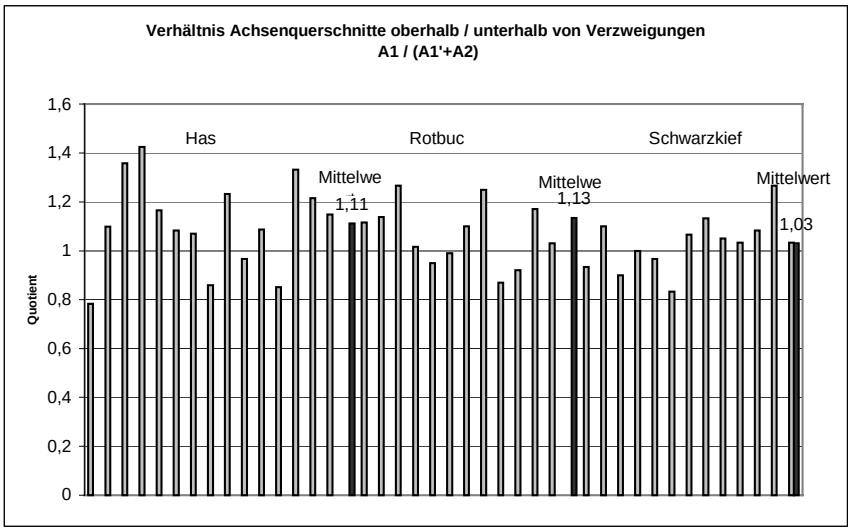
## Bending behavior relative to a beam's taper

Branches of different taper were bent under static load. The points of maximum stress were measured.

## Morphology

On branch junctions of Filbert, Beech and Pine the diameters were measured under and above a fork (Table 5). Cross section areas were set in relation to each other.

**Tab. 5** Relations of cross sections at forks of different woody plants: European Filbert ('Hasel'), European Beech ('Buche') and Austrian Black Pine ('Schwarzkiefer'). The cross section under a fork ($A_1$) has the same dimension as the total of the two cross sections above the fork ($A_1$' + $A_2$). The equation is: $A_1$ / ($A_1$' + $A_2$) = 1.




We made cross sections of forks. The open wood was stained with several dyes reactive to lignin (e.g. Fe $Cl_3$, Astra Blue, Malachite Green) to make the axillary wood visible. The dimension of axillary wood was related to the fork's angle.

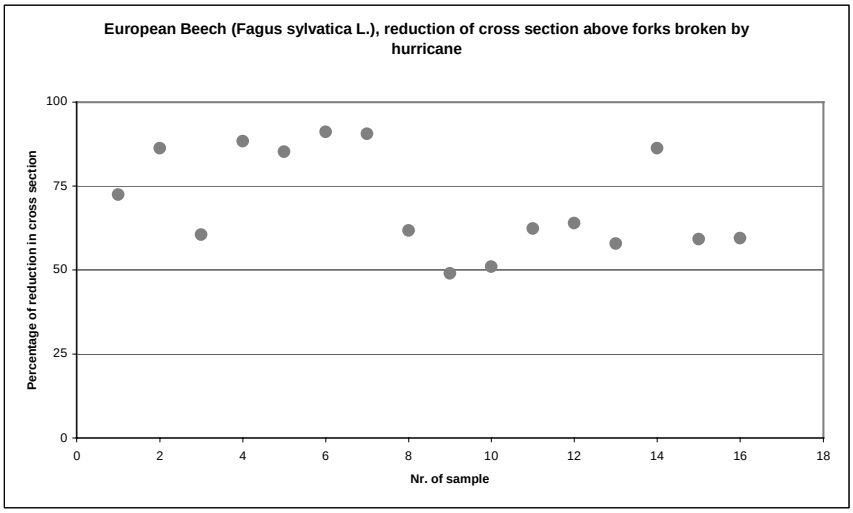
## Anatomy of axillary wood

We made cross sections of axilllary and of normal wood. Cell walls were measured. The dimensions of normal cell walls were compared with the cell walls of axillary wood.

## Mechanical failure

In a field study we took photos of branch junctions broken by a hurricane. On the photos diameters relative to the distance between fracture point and axilla were measured (Table 6).

**Tab. 6** European Beech: Limbs broken by a hurricane near a fork. Remarkable reduction in cross section at a fork (> 50%) makes the structure break at a peripheral point.




Several years old and well branched reiterates of Filbert were set in a vise and bent until the axis was broken. Bending force was applied into a right angle. Fractures near a junction were brought in relation to diameter and distance to the fixing point.

For a first approach models of similar length but different taper were shaped from foam rubber. To show the affect of branching one model was shaped as a branched beam. All models were bent under identical force.

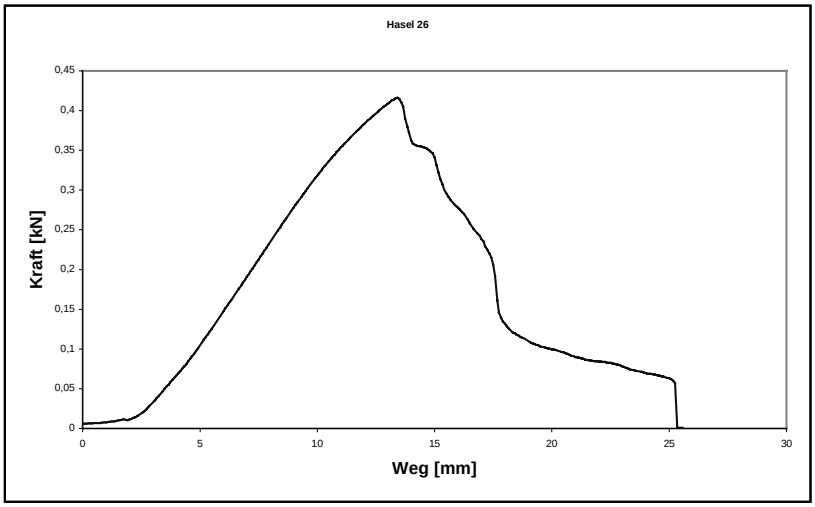
## Results

Bending forces

Under bending stress forks of European Filbert appeared about 20 % weaker compared to normal wood. The angle of the fork had no influence on a fork's strength. Maximum stress was similar in all forks tested (Table 3).

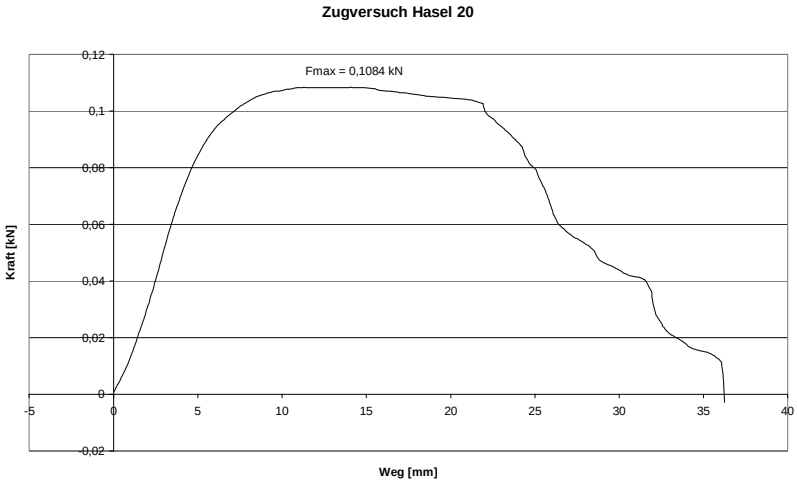
Reverse to the maximum stress the behavior of failure appeared strictly correlated to a fork's angle. Broad forks failed with a sharp and sudden break, our graphs showed sharp peaks. In contradiction to this narrow forks with embedded bark opened gradually with no peak at the graph (Table 7).

**Tab. 7** European filbert, fork with a wide angle ($\alpha$ = 70°), graph of tension test with (INSTRON 4466). The fork breaks suddenly because of a short cone of axillary wood.




Narrow forks with no embedded bark opened slowly as well, at the graphs a tiny peak used to be expressed (Table 8).

**Tab. 8** European filbert, narrow fork ($\alpha$ = 28,5°) with embedded bark. Graph of tension test with (INSTRON 4466). The fork opens gradually because of a long cone of axillary wood.




Bending behavior relative to a beam's taper

We found a strict correlation between taper and point of maximum stress. The better the taper the more terminal the region for the heaviest stress is to be found. Sufficient taper existed in well branched beams only. In unbranched beams the point of maximum bending stress used to be at its base.

Morphology

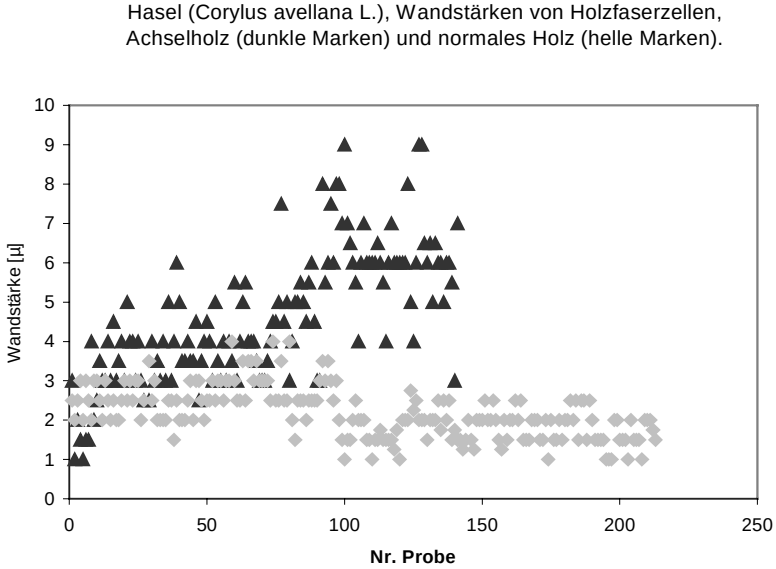
On branch junctions we found a strict correlation between the cross section below and above a fork. The sum of the 2 cross sections above a fork appeared to be equal to the cross section below. All tested tree varieties had similar results [$A_0 = A_0' + A_1$]. The correlation illustrates that within a fork the cross section of a beam will be reduced according to the dimension of the side branch. The better a beam is branched the better is its taper.

The form of axillary wood appeared to be well correlated to a fork's angle. In broad forks axillary wood represented as a broad and short cone. The narrower a fork is the smaller and longer is the cone of axillary wood. This is why a broad fork breaks suddenly and a narrow fork usually opens slowly.

Anatomy

In axillary wood the average diameter of cell walls was 100% larger than in normal wood cells. As a maximum we found 300% larger cell walls in axillary wood in comparison to the average of normal wood cells (Table 9). The reinforced cell walls compensate the higher strain applied on a beam at a junction. Similar results were found on different tree varieties (e.g. Beech, Common Maple, Lime Tree).

**Tab. 9** European Filbert, cell walls of wood cells. Diameters of the cell walls of axillary wood (dark colored marks) are up to three times larger as the cell walls of normal wood (light colored marks).




Mechanical failure

Beams in tree crowns broken by a hurricane used to fail in a short distance distal from a fork. Branched Filbert reiterates when broken by hand did the same. Unbranched reiterates failed at their base. Narrow forks of codominant stems with embedded bark used to fail under strong wind. We found such forks split, but not broken by heavy snow loads. Thick layers of new wood at their corners enabled that the split forks kept standing for at least several years – without any cabling.

## Discussion

Forks even when narrow and with embedded bark are not that weak as expected by experts (e.g. Mattheck & Breloer 1994, Pessler 1999, Shigo 1990, Siewniak & Kusche 1994, Wessolly & Erb 1998). The reinforcement by axillary wood is normally withstanding sufficiently to usual forces. For that case we are pleased to confirm the Model of Constant Stress (Mattheck 1992). A distinct difference is to be observed between static and dynamic loads (Spatz 2003). The point of maximum bending stress, where a

beam under lateral force usually breaks, is depending on its taper. Only well tapered axes will break near their tip. Unbranched axes fail at their base. Not tapered columns do the same. Sufficient tapering depends on the amount and size of side branches.

## Conclusion

Urban trees growing in a place exposed to wind, should have well branched crowns and a well tapered trunk. A dense canopy lets inner branches die from a lack of irradiation. So the main branches underneath a dense canopy will become less tapered – and may break at their base destroying the trunk. Trees with open crowns (e.g. Birch, Beech, Lime Tree) should be preferred. Trees in open stands usually have less dense canopies than trees of the same variety when they grow close together. This is why new plantings should be undertaken in a less expensive way, i.e. with more distance between neighboring trees. Adult trees which risk to develop dense canopies should be pruned in time. In open crowns inner branches will be able to survive and help the main limbs to keep well tapered. In order to keep a trunk well tapered the crown should not be lifted too early after transplanting a tree at a street side. Small crowns do not allow the cambium to produce new wood along the whole stem. This is why after a crown lifting only the upper part of the trunk may increase in diameter. Then the trunk will get a column's shape (Metzger 1893).

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## Literature

1 MATTHECK, C., 1992. Design in der Natur. Freiburg (Rombach), 242 S.

2 MATTHECK, C., Breloer H., 1994. Schadenskunde von Baeumen. Freiburg (Rombach), 349 S.

3 METZGER, K., 1893. Der Wind als massgebender Faktor fuer das Wachstum der Baeume. In: Weise W. (Hrsg.): Muendener forstliche Hefte, 3; 3 - 86.

4 PESSLER, K., 1999. Statische Sicherung und Stabilisierung, In: Malek J.v., Molitor, W., Pessler, K., Wawrik, H: Der Baumpfleger; Stuttgart (Ulmer), 417-438.

5 PFISTERER, J.A., SPATZ, H.-CHR., ERFORTH, D., HEINZ, M., 2003. Untersuchungen zur Biegebruchfestigkeit von Astgabeln und Reiteraten der Hasel (Corylus avellana L.), In: Dujesiefken, D., Kockerbeck, P. (Hrsg.), Jahrbuch der Baumpflege 2003; Braunschweig (Thalacker), 255 – 268.

6 SCHROEDER, K., 1998. Kronensicherung mit dem, Doppelgurtsystem Osnabrueck' – Entwicklungen und Erfahrungen seit 1990. In: Dujesiefken D., Kockerbeck P. (Hrsg.), Jahrbuch der Baumpflege 1998; Braunschweig (Thalacker), 170 – 183.

7 SCHUETT, P., WEISGERBER, H., SCHUCK, H.-J., LANG, U.M., ROLOFF, A., 1995. Enzyklopaedie der Holzgewaechse. Landsberg / Lech (ecomed), since.

8 SHIGO, A.L., 1990. Die neue Baumbiologie. Braunschweig (Thalacker), 789 S.

9 SIEWNIAK, M., KUSCHE, D., 1994. Baumpflege heute (3rd ed.). Berlin (Patzer), 268 S.

10 SPATZ, H.-CHR., 2003. Kronensicherung & Auffangsicherung Stadt & Gruen, Jun. 2003, 43-45

11 WESSOLLY L., ERB, M., 1998. Handbuch der Baumstatik & Baumkontrolle. Berlin (Patzer), 270 S.

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# Root Growth under Pavements – Results of a Field Study

## Introduction

Tree roots growing below road surfaces can cause damage to pavements and kerbs. This affects mainly areas built for low traffic, such as pavements, cycle tracks, pedestrian zones, squares and parking lots. Expensive and usually little durable repair is necessary in terms of maintenance and road safety, often leading to root loss and thus harming the tree. Although being a common problem, it had neither been discussed nor been scientifically examined in Germany. A research project at the institute for open space planning at the University of Hannover was performed between 1998 and 2002 to reveal more information about the situation in German city streets [1].

## Concept

The aim of the research project was a systematic analysis of the subject as a first step towards the development of solutions. Main steps were

- to reveal the dimension of the problem,
- to analyze root development below pavements and the reasons why roots raise pavements,
- to typify forms of damage and
- to draw conclusions for methods of repair and prevention which take more care of the tree.

The examinations included a statistic survey of street trees and exemplary excavations of root systems. This article introduces some main results of the project, focussing root growth below pavements and its significance for tree health.

## Statistic results

The survey of 2881 street trees in surfaced areas in the city of Hannover indicates, that pavement damage appears in remarkable dimensions: About one half of paved surfaces around tree pits showed symptoms of damage (52%). Obviously tree roots are able to grow below a great part of pavements even though soil conditions are unfavourable. The tree size, which is related to growth rates, turned out to be the most important influence on damage rate and size. Frequency and size of damage increase with tree size, measured as trunk diameter (dbh), as could be expected. It can be assumed, that almost every tree growing within paved areas will sooner or later develop roots below the surrounding pavement and thus cause damage (Table 1).

**Tab. 1** Frequency of damage to pavements and kerbs depending on tree size

| Category of diameter - dbh | up to 10 | 11 to 20 | 21 to 35 | 36 to 50 | 50 and more | average damage rate |
|---|---|---|---|---|---|---|
| Frequency of damage [%] | 3 | 34 | 67 | 81 | 84 | 52 |

Comparing tree species, gene-related specific root growth seems to exceed less influence on damage rates than is usually assumed. Even though differences can be noticed, neither extremely “serious” nor “safe” species have been found in this examination. With one exception damage rates correlate approximately with average dbh. Only *Acer* shows higher damage rates than would be expected. It seems, that tree size and growth rates are the decisive factors and not tree species itself. (Table 2).

**Tab. 2** Frequency of damage to pavements and kerbs depending on tree species*

| **Species** | ***Robinia*** | ***Platanus*** | ***Acer*** | ***Aesculus*** | ***Quercus*** | ***Corylus*** | ***Tilia*** | ***Crataegus*** | ***Sorbus*** | **Average** |
|---|---|---|---|---|---|---|---|---|---|---|
| Average dbh | 30 | 30 | 23 | 30 | 24 | 26 | 21 | 16 | 19 | 24 |
| Frequency of damage [%] | 66 | 65 | 64 | 62 | 47 | 42 | 41 | 35 | 29 | 52 |

* ranking according to damage rates

Another important factor is the existence and the construction of kerbs. For locations without kerbs, above-average rates were recorded for frequency and size of damage. Kerbs being constructed above street level showed less damage than others. It is obvious, that kerbs influence root growth below pavements without totally impeding it (Table 3).

**Tab. 3** Frequency of damage to pavements and kerbs depending on type of kerb*

| **Type of kerb** | **missing** | **even** | **elevated** | **wall, tray** | **average*** |
|---|---|---|---|---|---|
| Frequency of damage [%] | 63 | 47 | 35 | 38 | 48 |

* pavement damage only; the data was revealed separately for pavements and curbs

Also the distance between tree and pavement exceeds an influence on damage rates. Frequency and size of damage decrease with greater distance between tree and pavement, as one would expect (Table 4).

**Tab. 4** Frequency of damage to pavements and kerbs depending on size of unsealed area around tree*

| **Size of unsealed area around tree [m²]** | **(max. 1)*** | **> 1 – 4** | **>4 – 9** | **average** |
|---|---|---|---|---|
| Frequency of damage [%] | (75) | 60 | 34 | 52 |

* little data for this category

Asphalt surfaces show less damage than those with pavers or slabs. Further examinations and research of other authors suggest, that asphalt surfaces do not inhibit root development [2,3]. Lower damage rates can possibly be traced to a retardation of visibility due to the material's elasticity (Table 5).

**Tab. 5** Frequency of damage to pavements and kerbs depending on type of pavement

| Type of pavement | asphalt | slabs | pavers | average* |
|---|---|---|---|---|
| Frequency of damage [%] | 38 | 51 | 49 | 48 |

* pavement damage only

## Characteristics of root growth below pavements

For nine street trees, root systems were partially excavated where pavement damage had occurred. Root patterns were documented by photographs. If useful, roots were painted white for better visibility.

## Soil conditions below pavements are sufficiently favourable to enable root growth

Even if favourable soil conditions can be found in deeper soil layers or adjacent areas, tree roots grow below pavements. This observation differs from common opinions which believe unfavourable soil conditions to be the main cause for root-pavement problems. Tree roots take any occasion to exploit soil areas. They are not "aggressive" but simply ensure the tree's survival. Street trees often find poor, but sufficiently favourable soil conditions, including road foundation material and joints or gaps in solid constructions. Sometimes pavements are regarded to be the cause of shallow root systems, but this must be seen in perspective: Most roots, even in natural stands, grow in the upper decimeters of soil and this is also the critical zone for pavement damage (Figure 1).

**Fig. 1** *Acer* roots growing under pavements despite finding better soil conditions in the adjacent area:
**Fig. 1a**: Roots grow radially away from the stem, infiltrating the sand below pave stones and slabs. **Fig. 1b**: Intensive root development indicates favourable soil conditions below pavement.

## Wide pore space as most important factor for root growth is often available below pavements

It is well known that below roads and pavements there are often highly compacted soils with little wide pore space, not permitting any root growth and evoking the so called "flower pot effect". But also controverse conditions can be found: Many road foundation materials contain enough wide pore space to allow an intensive root development, such as gravel wich can be highly compacted and still have wide spaces. Other characteristics of physical soil conditions which were analyzed, such as soil texture, seem to play a minor role for root growth than density and wide pore space. Typical locations for root growth are sandy setting beds for pave stones and slabs and sandy gap fillings between pave stones as well as zones of low penetration resistance between road foundation and surface. This zone deserves attention, since it explains why roots grow preferably adjacent to solid construction and in contact zones of different materials. Between road foundation and surfaces as pavers, slaps or asphalt as well as between solid constructions and pavement subbase, zones of low penetration resistance are caused by thermic extension and the influence of frost. It is also known, that increased soil moisture contents resulting from condensation below surfaces amplify root growth (Figure 2)[4].

**Fig. 2** Roots grow in quite different layers below pavements on condition that wide pore space is available.
**Fig. 2a**: *Sophora* root is growing in gravel subbase.
**Fig. 2b**: *Robinia* root is growing in zone of low penetration resistance between highly compacted subbase and asphalt surface.

## Genetic disposition exceeds little influence on rooting patterns below pavements

Roots generally tend to grow horizontally and radially away from the stem. The root tip itself is being directed by the local soil conditions, thus permitting optimal exploitation of the sources of life. Under pavements with inhomogene soil conditions, this behaviour induces bizarre root patterns. The genetic disposition for the three main root types tap, sinker or striker and heart root system [5] seems to be little relevant for root patterns of street trees. The excavations reveal differences in shape and branching, but in terms of root depth and the occurrence of pavement damage no significant influence could be detected. Also it can be concluded, that the distinction between so called "deep rooted" tree species on the one hand and "shallow rooted" on the other hand, which are suspected to cause most damage makes no sense for street trees. This observation confirms other authors who doubt the existence of naturally deep or shallow rooted tree species [6]. The often assumed damage potential of certain species due to their genetic root type should be questioned.

## Shape of tree roots and root patterns adapt to growing conditions below pavements

Root patterns below pavements develop as a response to the local soil conditions. Kerbs function as barrier and influence growth direction. The excavations show, how roots are led downwards when being inhibited by kerbs. Due to building techniques, peripheral areas of road foundations next to kerbs are often less compacted and roots frequently grow upwards again. Also the joints between kerbstones allow admittance to layers below the road surface. Growing through gaps, roots adapt their shape to the restricted space and show more or less distinct deformation if not being able to move the construction. After growing under or through barriers, root growth is being continued as could be expected without a kerb. Tree roots raise pavements and constructions by thickening. Depending on root size and the construction's weight, even kerbs with deep concrete foundation can be raised. If pressure is directly exceeded upon roots, root swellings occur as reaction, sometimes amplifying pavement damage (Figure 3).

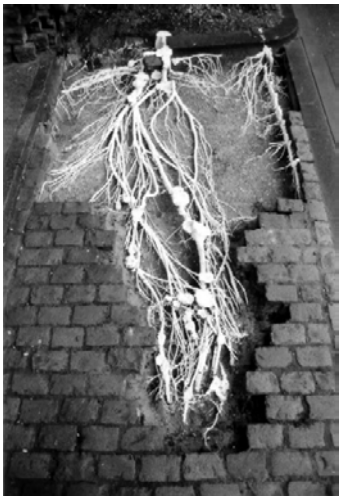

**Fig. 3** Root shape and pattern respond to local conditions. *Robinia* root growing in setting bed (sand) between concrete foundation and paving stones. Swollen root sections result from pressure.
**Fig. 3a**: Roots spread from a gap between the kerb stones. Behind the bottleneck, the root system develops as would be expected without.
**Fig. 3b**: Deformed roots in the gap, swellings before and behind.

## Roots under pavements spread far beyond canopy

The excavations indicate clearly that convenient tree pits and tree lawns are not sufficient to support street trees even for a medium term. Roots spread far beyond canopy, even with large diameters (see fig. 3a). Poor soil conditions require more root mass, exploiting a higher range and shifting root-shoot ratio towards more root mass [7]. This suggests, that the unfavourable soil conditions below pavements amplify the problem and more should be done to realize larger minimum sizes for root spaces and progressive constructions for street tree planting.

The excavations show, how trees cope with soil conditions below pavements. Root growth below pavements should not only be regarded as a source of pavement damage but also as a sign of vitality. Banning reliable street tree species such as *Platanus x acerifolia* or *Robinia pseudoacacia*, which often are suspected to cause severe pavement damage, makes little sense. On the other hand tree roots cause pavement damage, that has to be repaired to prevent accidents and claims against city administrations. The most common method of repair is root removal. Especially roots growing right below the surface are harmful to pavements. The deeper roots grow, the lower is their potential to cause damage. Unfortunately, shallow roots are often regarded as being less important than deeper roots [8]. When repair is necessary, roots are often rather thick and go beyond German standards' demand for a maximum average of 2 cm for root removal [9, 10]. Additionally, often little care is taken in terms of arboriculture, resulting in root damage. Solving the problem is therefore also important in regard of tree health.

## Conclusions

For repair of pavement damage compromises have to be found between the demand of road safety, building techniques and tree health. Even though often shortly lasting, root preserving methods should be applied and reoccurring repair should be tolerated. Considering the difficulties of repair, the prevention of damage plays an important role, but reliable methods do not exist yet. The immense adaptability of tree roots which is revealed by the excavations calls into question, if a complete prevention of damage can be achieved in practice, or, if it is rather a noticeable reduction of damage that should be achieved. Until now there is no scientific justification for the exclusion of tree species that prove to be reliable for plantings in city streets. E xcept for a sensible adjustment of tree size and available space the solutions should be searched in progressive building methods for street tree plantings and the technical construction of the surrounding area.

The key to less pavement damage and better tree health seems to be the construction of larger root spaces combined with protective means for the upper layers of pavement construction. Roots should be led into deeper soil layers where they are unlikely to cause pavement damage. An approach to keep tree roots out of sensitive areas below pavements could be to use highly compacted material with little wide pore space for the upper layer of road foundation or pavement base. For protection of the surface layer, kerbs with tight joints or without any joints, should be constructed. Root space can be extended below these upper layers by using so called compactable or structural tree soils that allow adequate soil volumes despite of restricted space above ground. The application of means of ventilation can ensure sufficient oxygen contents. With large defined root spaces allowing root growth also in deeper soil layers, also root removal in case of repair is expected to be less serious for tree health.

Prejudices against both, trees and pavements, should belong to the past: Tree roots are the cause of pavement damage, but it is not their "fault". Too little attention is paid to the trees' needs for root space and to root growth characteristics. Healthy street trees in intact paved areas require a shift in thinking in design and building techniques of street tree planting as well as an effective cooperation between the involved disciplines.

## Literature


1 REICHWEIN, S., 2002. Baumwurzeln unter Verkehrsflächen. Untersuchungen zu Schäden an Verkehrsflächen und Ansätze zur Schadensbehebung und Schadensvermeidung. Institut für Grünplanung und Gartenarchitektur. Beiträge zur räumlichen Planung Heft 66. Schriftenreihe des Fachbereichs Landschaftsarchitektur und Umweltentwicklung. Hannover

2 WONG, T.W., GOOD, J.E.G., DENNE, M.P., 1988. Tree Root Damage to Pavements and Kerbs in the City of Manchester. Arboricultural Journal Vol. 12 1988, 17-34.

3 KOPINGA, J., 1994. Aspects of the Damage to Asphalt Road Paving Caused by Tree Roots. In: Watson, Gary W. 1994. The Landscape Below Ground. Proceedings of an International Workshop on Tree Root Development in Urban soils. International Society of Arboriculture. Sayoy, Illinois.

4 KOPINGA, J., 1994, 165-178.

5 KÖSTLER, J.N., BRÜCKNER, E., BIEBELRIETHER, H., 1968. Die Wurzeln der Waldbäume. Untersuchungen zur Morphologie der Waldbäume in Mitteleuropa. Hamburg, Berlin, 25-29.

6 PERRY, T.O., 1982. The Ecology of Tree Roots and the Practical Significance thereof. In: Journal of Arboriculture Vol. 8, No. 8 August 1982, 197-211.

7 HARRIS, R., 1992. Arboriculture. Integrated Management of Landscape Trees, Shrubs and Vines. New Jersey, 48.

8 CRAUL, P.J., 1992. Urban Soil in Landscape Design. New York, 137.

9 DIN – DEUTSCHES INSTITUT FÜR NORMUNG E.V., 2002. DIN 18920 Vegetationstechnik im Landschaftsbau – Schutz von Bäumen, Pflanzenbeständen und Vegetationsflächen bei Baumaßnahmen. Berlin.

10 FLL – FORSCHUNGSGESELLSCHAFT LANDSCHAFTSENTWICKLUNG LANDSCHAFTSBAU, 2001. Zusätzliche Technische Vertragsbedingungen und Richtlinien für Baumpflege (ZTV Baumpflege). Bonn.

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# Results of mycorrhiza inoculation of trees and bushes at roadsides

## Introduction

About 80 % of all plant species live in symbiosis with a great number of soil fungi. This symbiosis is called mycorrhiza. It can be subdivided into 2 types according to the kind of partnership:

- Ectomycorrhiza
  The fungi hyphen encase the roots of the wooded plants (pseudoparentic coat)
- Endomycorrhiza
  The fungi hyphen intrude upon the bark structure of the plant root causing proceeding infection of the bark cells. Thereby the sub-species of the vesicular-arbuscular mycorrhiza (VA-mycorrhiza) grows tree-like branched hyphen endings in the bark cells. These hyphen endings are organs through which the symbiotic metabolism fungus - plant takes place.

Ecto- and endomycorrhiza are important for the plant growth. That applies especially to locations where the important factors of growth are far below the optimum for the plant development (sand dunes, extreme sites, poluted areas). But also for cultural plants under comparable good conditions significantly positive effects were proven. So you find highly improved provision of nutrients in case of relative or absolute absence (especially phosphorus), an improved tolerance of the plant against drystress, unfavourable pH values and saltyness of the soil, and a modified attitude of the plants in resisting the attacks of the pathogens.

The use of vesicular - arbuscular mycorrhizal fungi in the production of crop plants has already been tested and described by many authors. Under normal or tropical conditions (poor soils, extreme temperatures, high humidity or drought, presence of pathogens) the use of vesicular-arbuscular mycorrhizal fungi can be especially beneficial to perennial crops. These fungi not only give improved growth of different crops, but also show the potential to increase resistance of the host to root pathogens and to reduce the severity of foliar disease.

Most crops are propagated from seeds or cuttings in nurseries before they are transferred to the planting sites. These crops are normally hosts for vesicular-arbuscular mycorrhizal fungi. In Colombia, Brazil and other countries vesicular-arbuscular mycorrhizal fungi are already in some cases an important factor in commercial cultivation systems, diminishing the cost of plant production not only because the plants can be produced using smaller amounts of fertilizers, but also because there are fewer losses during production. In general mycorrhizal plants are of better quality than non-mycorrhizal ones. They are more resistant to many stress factors when they are transferred to the planting sites [1,2 ].

Why is the use of vesicular-arbuscular mycorrhizal fungi in plant production systems not yet a common procedure? Probably the most important reason for their current lack of use is that potential users of vesicular-arbuscular mycorrhizal fungi are not able to handle the inoculum production themselves and there are no producers of inoculum who can guarantee a standard quality and low cost of production and transport to the users. These problems we have solved by the use of an inorganic material as a carrier for the infection units of the vesicular-arbuscular mycorrhizal fungi - so-called „foamclay“.

With foamclay as the carrier for propagules of vesicular-arbuscular mycorrhizal fungi it is possible to produce an inoculum of high quality on a large scale. High quality means first that the inoculum causes a rapid colonization of the plant root system by the vesicular-arbuscular mycorrhizal fungi. This is guaranteed by an inoculum of high infectivity.

The second very important characteristic of an inoculum of high quality is that it should be uncontaminated or contain only small quantities of plant pathogenic microorganisms. Depending on the purpose for which the inoculum is produced, a low level of contamination can be ignored. If, for

example, it is to be used for the inoculation of young cuttings for seedlings in nurseries, it has to be pure because these plants are in most cases extremely susceptible to pathogenic fungi during the first weeks of growth. The use of foamclay as a carrier for infection units of vesicular-arbuscular mycorrhizal fungi makes it possible to avoid contamination of the substrate by pathogens during inoculum production and to decontaminate it selectively if contamination has taken place during production.

Our biological soil supporting component is a

- pure natural product
- suited for long-term storage
- selective desinfection possible
- variable with respect to colonization
- easy dosage
- easy application
- machine placement possible
- light (350 kg/m$^3$) thus, there are no problems with transport and distribution.

Our product is extremely cost effective. It is compatible with other biological and IPM systems. It is non-toxic, no crop residue and is completely safe to user and consumer.

Our product is a free flowing granular formulation containing specially selected strains of naturally occurring mycorrhizal fungi. Treating with it could not be easier - apply either by planting out or during the growth period. Roots are rapidly colonised and protected by the fungi - producing healthier, higher yielding plants.

The following practical planting experiments with the product MYKOPLANT®BT (endogenous mycorrhiza) at the sides of a road brigde building is a contribution in the field of mycorrhiza application research.

## Materials and methods

Technical data of the applied material MYKOPLANT®BT

The material is commercially available expanded clay biologically activated by immobilizing propagules of naturally occuring AM-fungi on it. The biological activation is carried out by a procedure developed by the ITA Institute of innovative Technologies Ltd. (Pty.) at Koethen. The material is no fertilizer but an inoculum. It can be disinfected and will be free of nematodes.

Components: Propagules of VA-mycorrhiza concentrated at an inorganic carrier:

The mean degree of activity of the usual material is about 50,000 propagules per liter material.

The expanded clay as the carrier (basic component) is specified by the following parameters:

Physical Data: non-conducting mineralic substance

- grain size 2 – 10 mm (fractionation variable)
- apparent density about 250 kg/m³
- water content about 13 - 17 %
- pore volume > 80 Vol-%

## Chemical Data of water eluent

- soluble salt 1.1 g/kg
- CaO 460 mg/kg
- $Na_2O$ 50 mg/kg
- $Mg^{++}$ 30 mg/kg
- $SO_4^{--}$ <2000 mg/kg
- $Cl^-$ 10mg/kg

## Plant species

**Tab. 1** Description of planted trees und bushes

| | Species | Common name | Description | Total number |
|---|---|---|---|---|
| | **Trees** | | | |
| 1 | *Acer campestre* | field maple | Hei2xv 100-125 | 60 |
| 2 | *Carpinus betulus* | grove beech | Hei2xv 100-125 | 43 |
| 3 | *Prunus avium* | wild cherry | Hei2xv 125-150 | 26 |
| 4 | *Prunus padus* | grape cherry | Str 2xv 60-100 | 62 |
| 5 | *Pyrus communis (pyraster*) | game pear | Str 2xv 100-150 | 16 |
| 6 | *Sorbus aucuparia* | mountain ash | Hei2xv 125-150 | 47 |
| | **Bushes** | | | |
| 7 | *Cornus sanguinea* | dogwood | Str 2xv 60-100 | 219 |
| 8 | *Corylus avellana* | hazelnut | Str 2xv 60-100 | 93 |
| 9 | *Crataegus monogyna* | hawthorn | Str 2xv 60-100 | 29 |
| 10 | *Crataegus oxyacantha (leavigata)* | pink hawthorn | Str 2xv 60-100 | 143 |
| 11 | *Ligustrum vulgare* | liguster | Str 2xv 60-100 | 289 |
| 12 | *Malus communis (sylvestris)* | game apple | Str 2xv 60-100 | 15 |
| 13 | *Salix caprea* | pussy willow | Str 2xv 60-100 | 104 |
| | **Small bushes** | | | |
| 14 | *Lonicera xylosteum* | hedge cherry | Str 2xv 60-100 | 106 |
| 15 | *Rosa canina* | dogrose | Str 2xv 60-100 | 184 |
| 16 | *Rosa pimpinelli folia* | Bibernellrose | Str 40-60 3-4 Tr | 41 |
| 17 | *Rosa rubiginosa* | scottish fence rose | Str 2xv 60-100 | 43 |
| 18 | *Rubus fruticosa* | blackberry | Ju 2j 60-100 | 65 |
| 19 | *Rubus idaeus* | raspberry | Ju 2j 60-100 | 3 |
| 20 | *Salix purpurea* | crimson pasture | Str 2xv 60-100 | 48 |
| | Total | | | 1636 |

Date of Outplanting: 06/12/2000, 1st Analysis: 31/07/ and 02/08/2001

**Table 2** Characterisation of particular experimental test areas:

| **Test areas (cf. plan NTW [3] )** | **A,B,G,H** | **C,D,J,K** | **E,F,L,M** |
|---|---|---|---|
| Application area | Mycorrhiza only | Mycorrhiza and reduced fertilizer | control |
| Description of treatment | Planting with MYKOPLANT® BT only<br>(per plant about 0,2 l inoculum at the roots of the plant) | Planting with 50% fertilizer and MYKOPLANT® BT | Planting with fertilizer (100% common method)<br>Fertilizer type:<br>PROFI-FERT Typ 6-6 with horn-meal and bone-dust<br>NP-fertilizer 6-6 |

## Climate and soil conditions

Climate data (temperature, precipitation, humidity) for the experimental area were taken from an official station. The conditions at the end of the year 2000 allowed the unusual late planting of wood at the 6th of December. During the main growing period in the spring of 2001 only a low amount of rain occured detrimentally for the plant grow and additionally to the low field capacity of the soil. The stony soil of middle loamy sand hindered the intensive rooting and water storage. Increased and more intensive rain fall from June 2001 improved the water situation for the plants significantly. Simultaneously the fine soil particles were rinsed to deeper soil layers of the stony soil deteriorating the growing conditions for the fine roots of the plants in the upper soil layers.

## Results of planting experiments

**Table 3** Summary of results of the test areas

| **Test area** | **number of plants** | **Growing** | **Failure** | **Growing rate (%)** | **Failure rate (%)** | **Description** |
|---|---|---|---|---|---|---|
| A | 136 | 65 | 71 | 48 | 52 | Only Mycorrhiza |
| B | 142 | 89 | 53 | 63 | 37 | Only Mycorrhiza |
| C | 131 | 89 | 42 | 68 | 32 | Mycorrh. and fertilizer |
| D | 142 | 90 | 52 | 63 | 37 | Mykorrh. and fertilizer |
| E | 141 | 75 | 66 | 53 | 47 | Control (only fertilizer) |
| F | 173 | 95 | 78 | 55 | 45 | Control (only fertilizer) |
| G | 97 | 78 | 19 | 80 | 20 | Only Mycorrhiza |
| H | 143 | 108 | 35 | 76 | 24 | Only Mycorrhiza |
| J | 111 | 82 | 29 | 74 | 26 | Mycorrh. and fertilzer |
| K | 118 | 83 | 35 | 70 | 30 | Mycorrh. and fertilzer |
| L | 152 | 80 | 72 | 53 | 47 | Control (only fertilizer) |
| M | 148 | 56 | 92 | 38 | 62 | Control (only fertilizer) |

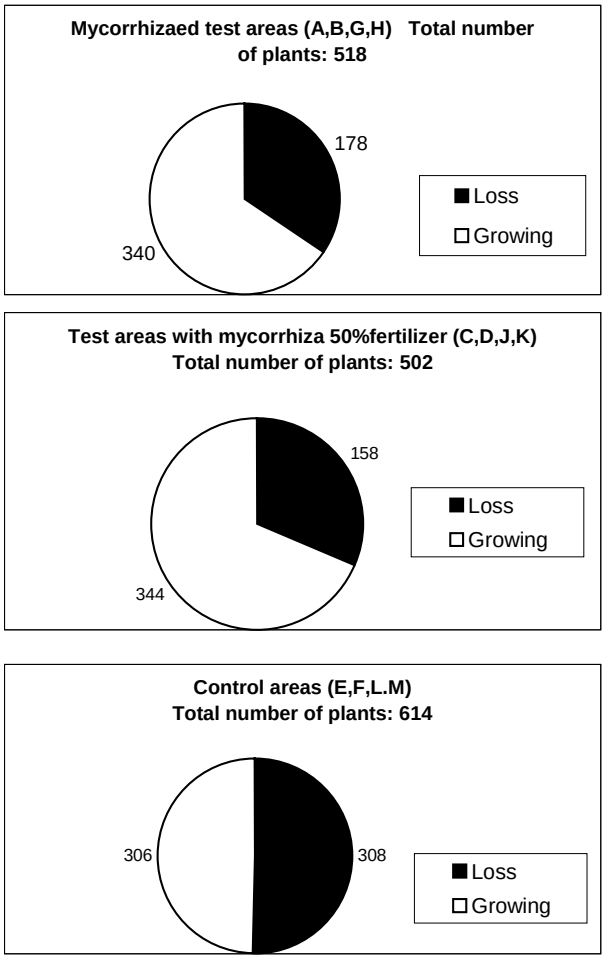



**Fig. 1 – 3** Overview about the planting results at the different test locations

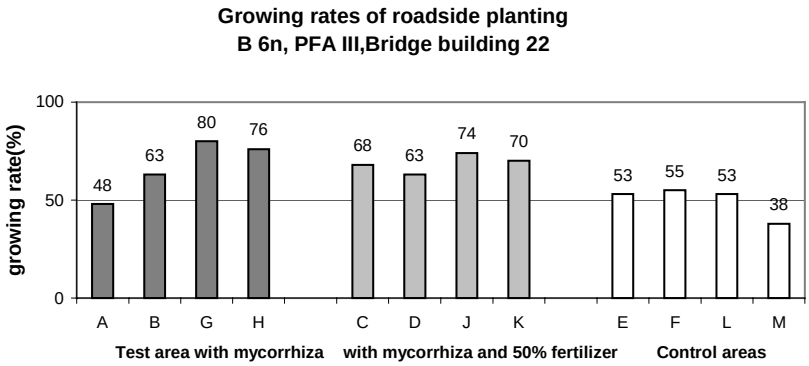



**Fig 4** Growing rates in dependece on the treatment procedure at the different locations

## Evaluation of the particular experimental areas:

At the particular experimental areas both the loss rates and the development and growth of the plants differ considerably. Site conditions and the plant species play an important role.

Better planting results i.e. lower loss rates, were achieved on the slope rounded hilltop and in the slope middle since the soil conditions are better than at the slope foot. The stony part of the soil material predominates at the slope foot so that the soil volume necessary for deep rooting plants is strongly reduced limiting the plant development.

This reduction in the soil volume is also the cause for the predominant mortality rate of deep rooting plants (results of the control report NTW such as dogwood (*Cornus sanguinea*), hedge cherry *Lonicera xylosteum*) as well as dogrose (*Rosa Canina*); Mr. Wirth, cf.literature).

## Influence of mycorrhization

Because an uniform planting of one plant species only was not intended according to the plant project, the evaluation must include the total number of plants. The results of the growing rates in dependence on the various treatment procedures at the different locations at the experimental area are shown in figure 4.

Averaging the growing rates of the different locations at the experimental area for reducing the influence of the varying soil conditions and the inhomogenous planting the mean growing rates for the various treatment procedures result as will be given in figure 5.

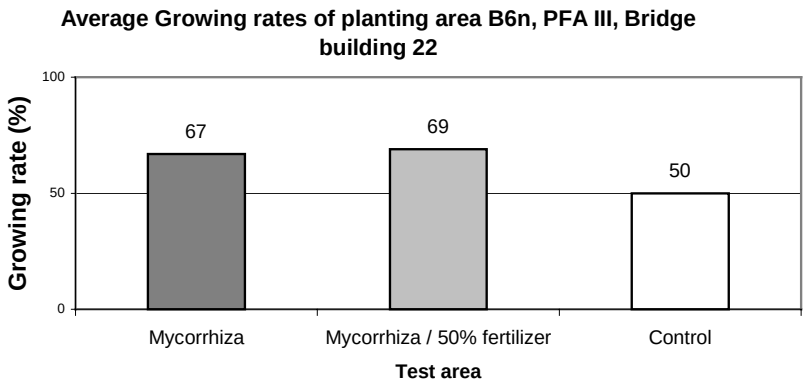



**Fig. 5** Average growing rates in dependence on the treatment procedure

Evaluating the growing rate the result at all at the test area is not satisfactory because of the poor site conditions. But a clear indication for improved results by the mycorrhiza treatment can be derived. The growing rates of mycorrhiza treated locations are between 67% (mycorrhiza inoculum only) and 69% (mycorrhiza inoculum and 50% reduced fertilizer), whereas the usual planting with fertilizer has a growing rate of about 50% only.

## Dependence on the location at the slope

**Table 4** Growing rates in dependence on the location at the slope

| Test area | Number of plants | Loss | Growing | Growing rate % | Description |
|---|---|---|---|---|---|
| B | 136 | 71 | 65 | 48 | My |
| A | 142 | 53 | 89 | 63 | My |
| G | 97 | 19 | 78 | 80 | My |
| H | 143 | 35 | 108 | 76 | My |
| | | | | | |
| C | 131 | 42 | 89 | 68 | My/f |
| D | 142 | 52 | 90 | 63 | My/f |
| J | 111 | 29 | 82 | 74 | My/f |
| K | 118 | 35 | 83 | 70 | My/f |
| | | | | | |
| E | 141 | 66 | 75 | 53 | c |
| F | 173 | 78 | 95 | 55 | c |
| L | 152 | 72 | 80 | 53 | c |
| M | 148 | 92 | 56 | 38 | c |

| | Growing rate % | Test area |
|---|---|---|
| Hilltop control | 54 | E,F |
| Hilltop mycorrhiza | 78 | G,H |
| Slope middle my/fertilizer | 69 | C,D,J,K |
| Slope foot mycorrhiza | 55 | A,B |
| Slope foot control | 45 | L,M |

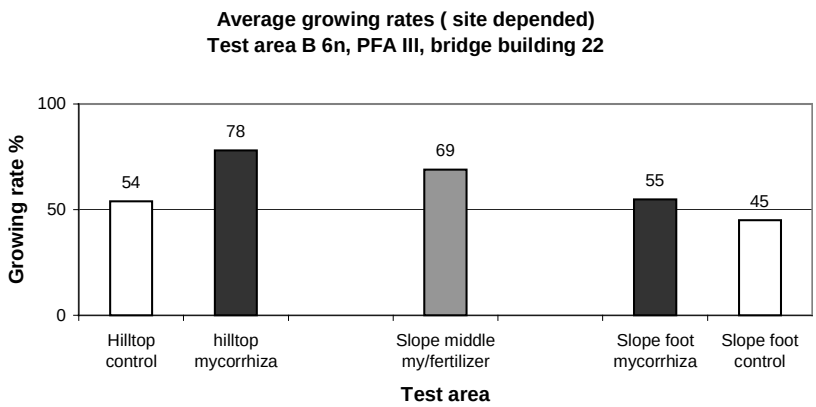



**Fig. 6** Average growing rates in dependence on the location at the slope

## Mycorrhiza-Infection

Selected plants at random of the MYKOPLANT®BT treated locations have been investigated on the degree of root infection by mycorrhiza. For the time of experiment a weak to medium infection was found in the contact area of the roots with the inoculum corresponding to a 30 % infection of the root mass.

## Summary

Experimental area B 6 n, PFA III, bridge building 22

The planting of bushes and trees at roadsides of the bridge building 22 was carried out in December 2000. The deposited soil was already overgrown with grass. The soil material was unfavourable for growing the plants (many stones, little humus). Furthermore the steep slope situation and the wind exposed location represent an extreme planting site. The influence of the mycorrhiza inoculation of the plant development was examined under these extreme site conditions.

The growing rate altogether were unsatisfactory because of these unfavourable conditions.

But the application of mycorrhiza inoculum showed a significant improved growing rate of the plants at the various locations than the plants at the corresponding locations without mycorrhiza inoculum (only fertilized).

The increase in the growing rates of the mycorrhiza treated locations in comparison to non-mycorrhized locations (E,F,L,M) are in average:

| | | |
|---|---|---|
| Mycorrhiza experimental areas | A, B, G, H | 17% |
| Mycorrhiza and fertilizer areas | C, D, J, K | 19% |

If one compares the particular locations at the slope the increased growing rate of the mycorrhized experimental areas in comparison to the non-mycorrhized ones are:

| | | |
|---|---|---|
| **rounded hilltop** ( G, H compared with E,F) | on average | **24%** |
| **slope foot** ( A,B compared with L,M) | on average | **10%** |

## Recommendation

Due to the positive results of using the mycorrhiza-inoculum MYKOPLANT® BT in combination with a reduced standard fertilizer it is to recommend this application for bushes and trees at locations of road sides to reduce the mortality rate and increase the resistance of the plants against stress factors additionally.

**Fig. 7** View of experimental areas

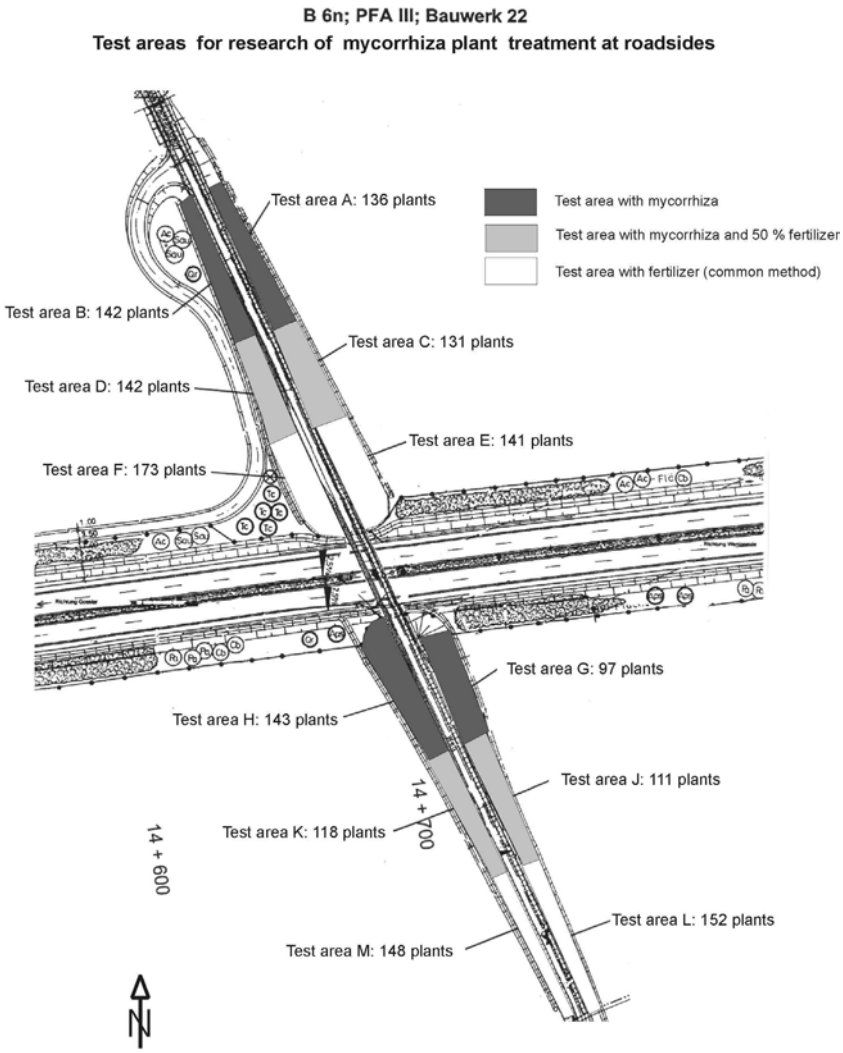
## Literature


1 BACKHAUS, G.F., 1984. Untersuchungen zur Nutzung der endotrophen Mykorrhiza in der gärtnerischen Pflanzenproduktion, Dissertation Universität Hannover.

2 FELDMANN, F., 1998. Symbiontentechnologie in der Praxis – Arbuskuläre Mykorrhiza im Gartenbau. Thalacker Medien, Braunschweig.

3 WIRT, M., 2001. Kontrollbericht Anwachsuntersuchung B6n , NTW Neubert Thiede Wirth Landschafts- und Freilandplanung.


## Appendix



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# The Use of Organic Waste Streams in the Production and Maintenance of Amenity Trees

## Abstract

Biosolids have been used for many years as soil conditioners and organic fertilisers in both farming and reclamation of ex-industrial and brownfield sites. However, there has been little attempt to introduce biosolids into urban landscaping practices. Trials with *Lolium perenne* (Perennial Ryegrass) and *Betula pendula* (Silver Birch) demonstrated the nutrient value and soil conditioning properties of biosolids. In addition to organic matter they also provide substantial amounts of plant available nitrogen (N), phosphate (P), sulphur (S) and micronutrients. Composted biosolids also contain significant amounts of potassium (K).

Where there is public access immediately following application, enhanced treated biosolids are preferred to conventionally treated materials to avoid public health issues. Horticultural operatives have also shown a preference for composted products or granules produced by thermally drying sludge because they have no unpleasant odours and are easy to measure and spread. Where large-scale applications are needed, most enhanced treated biosolids including liquids can be used. Liquids have an advantage over solids in that they can be injected into existing landscapes. This facilitates applications at higher rates without smothering grass and other plants. Composts can also be included in soil mixes for urban trees planted in large containers, but care must be taken not to create a growth media with an unacceptably high conductivity. It is unlikely that biosolids are suitable as fertilisers in containerised tree production because of the high degree of control of nutrient balance and conductivity that is needed in modern production systems. However, there is scope for a partial peat replacement with composted biosolids.

## Introduction

Biosolids, are the solid residues of wastewater treatment and have been used by farmers as organic fertilisers for many years. Biosolids, in particular those composted with municipal green waste, have also been used successfully in the reclamation of ex-industrial and brownfield sites [1] where there is a need to introduce substantial amounts of organic matter and plant nutrients to improve soil conditions. However, to date there has been little attempt to introduce biosolids into urban landscaping practices. Biosolids provide a readily available source of organic matter for general soil conditioning but also contain nitrogen (N), phosphate (P), sulphur (S) and micronutrients. The treatment of biosolids falls into two categories based on the level of pathogen reduction. Conventional treatment e.g. mesophilic anaerobic digestion significantly reduces the pathogen content, demonstrated by a 2 $\log_{10}$ reduction in the number of indicator bacteria present in dry solids. The new category of enhanced treatment has also been introduced by methods such as thermal drying; composting and alkali stabilisation that produce biosolids where pathogens have been effectively eliminated [2]. Enhanced treatments may also remove more of the volatile components from sludge therefore reducing the potential risk of odour problems. In addition to the two classes of treatment, nutrients, in particular P, are removed from wastewater and transferred to the sludge by chemical (most commonly precipitation with iron salts) or biological removal process. This increases the P enrichment of biosolids produced.

The physical composition and nutrient content of biosolids is controlled by the generic type of treatment process used [3,4,5] and the characteristics of the catchments being treated. Importantly the changed physicochemical properties also alter the nutrient release kinetics of organic nitrogen (N) [3,4,5]. This paper summarises the nutrient content by chemical analysis and a field trial with Perennial Ryegrass (*Lolium perenne*) to determine the plant-available N. The growth responses of Silver Birch (*Betula pendula*) to conventional and enhanced treated biosolids are also evaluated as fertilisers and soil conditioners in amenity tree production and maintenance. The environmental benefits of using biosolids as alternatives to mineral fertilisers in urban horticulture are discussed.

## Materials and Methods

Chemical analysis of biosolids

Biosolids samples used in field trials were analysed for their nutrient content: N, P, potassium (K), S, magnesium (Mg), calcium (Ca), iron (Fe), zinc (Zn), copper (Cu) and nickel (Ni); using standard laboratory methods [5].

*L. perenne* field trial

A trial was set up in Spring 2001 at the Imperial College Field Centre at Silwood Park near Ascot to determine the fertiliser value of biosolids and the nutrient benefit to grass. The soil was a sandy loam the nutrient properties are shown in Table 1

**Tab. 1** Nutrient properties of soil at the field site (mg $kg^{-1}$ dry solids)

| Organic matter % | pH | $NO_3$-N | $NH_4$-N | P | K | Mg | $SO_4^{2-}$ |
|---|---|---|---|---|---|---|---|
| 2.3 | 6.5 | 19.3 | 6.5 | 30.0 | 87.7 | 48.1 | 19.8 |

Three experimental blocks each contained one replicate of 12 treatments: 10 biosolids and 2 inorganic fertilisers (prilled ammonium nitrate and granular super phosphate). The biosolids comprised 2 conventional biosolids: dewatered mesophilic anaerobic digested (dMAD) and liquid mesophilic anaerobic digested (lMAD); 2 conventional biosolids with nutrient recovery: dewatered iron dosed mesophilic anaerobic digested (Fe dMAD) and dewatered biological nutrient recovery mesophilic anaerobic digestion (BNR dMAD) and 6 enhanced treated biosolids: thermally dried measophilic anaerobic digested (ThD-MAD), thermally dried raw (ThD-R), liquid thermal hydrolysis-measophilic anaerobic digested (lTH-MAD), liquid thermophilic aerobic-measophilic anaerobic digested (lTA-MAD), alkaline stabilised raw (AlkR) and composted with greenwaste (CptGw). Dewatered biosolids were added to plots on a basis of dry solids at rates of 0 (control), 3.33, 6.66, 10 and 13.33 t $ha^{-1}$. Liquid biosolids were added at rates of 0, 33.3, 66.6, 100 and 133.3 $m^3$ $ha^{-1}$. Mineral fertilisers were added at rates of 0, 30, 60, 90 and 120 kg $ha^{-1}$ of N or 0, 25, 50, 75 and 100 kg $ha^{-1}$ of P. N and P plots were split and half the N plots received N at 50 kg $ha^{-1}$ and half the P plots received N at 60 kg $ha^{-1}$. Following application the biosolids and fertilisers were cultivated to a depth of 10 cm and *L. perenne* cv Guilford was sown at a rate of 12 kg ha $^{-1}$. Grass was harvested on three occasions during the growing season to determine the dry matter yield and the total N content was determined by Kjeldahl digestion and automated colorimetric analysis. Sub-samples of the grass were ground and digested in hot sulphuric acid for colorimetric determination of N content [6,7].

*Betula pendula* trial

A field trial was established to determine the benefits of biosolids to shoot and root growth of transplanted *Betula pendula*. Two enhanced treated biosolids, ThD-MAD and CptGw, were compared to untreated soil (as a control); mineral N and P fertiliser; a peat-based compost; and a conventionally treated biosolid, dMAD. The organic inputs were added at two rates of dry matter per hectare, an agronomic rate of 10 t/ha and a commonly used rate for land reclamation of 100 t/ha. The mineral fertilisers were added at rates that reflected the N range comparable with the predicted total plant-available N that would be expected during the first growing season at the higher rate of biosolids application. The rates were 100, 500 and 1000 kg/ha N, with each treatment receiving 75 kg/ha $P_2O_5$; and 100, 500 and 1000 kg/ha $P_2O_5$ with each treatment receiving 100 kg/ha N. The control and all organic and inorganic treatments received 150 kg/ha $K_2O$ as potassium sulphate. The biosolids, peat and mineral fertiliser were mixed with the sandy loam soil used in the grass trial. The soil mixtures were transferred to 1 m lengths of 11 cm diameter drainpipe submerged in the soil to a depth of 80 cm in the field. A single 80 cm tall *B. pendula* was planted on the 5/3/02 in each pipe with four replicate for each treatment. Trees were watered regularly to avoid drought stress. Lateral extension was measured at intervals of two weeks as an estimate of shoot growth and rooting depth was measured destructively at the end of the trial as an estimate of root growth.

## Results

Chemical characteristics of biosolids

The nutrient concentrations of biosolids produced by different treatment processes are shown in Tables 2a –c, however there will also be variability based due to differences in the catchment of each works. All the biosolids have relatively high N and P contents but the amount of Olsen extractable P [6] varies between biosolids types. Both the N content and extractable P are highest in liquid biosolids as was the K content. However, their high water contents (>96 %) reduce the amount supplied at equivalent rates to dewatered biosolids. The AlkR had reduced levels of most nutrients due to the bulking out caused by lime additions during treatment and consequently this also raised the Ca content substantially. The total P content is increased (Table 2b) through chemical precipitation of nutrients by iron dosing (Fe dMAD) and biological recovery (BNR-dMAD) but the proportion of Olsen extractable P in the Fe dosed dMAD was half that in the BNR-dMAD. With the exception of biosolids composted with green waste (CptGw), the K content of solid biosolids was too low to be considered a significant input constituting only supply 20 kg $ha^{-1}$ at 10 t $ha^{-1}$ dry solids, CptGw greenwaste can supply around 60 kg $ha^{-1}$. This is a consequence of the high K content of the greenwaste used as the bulking agent. With the exception of K, the major nutrient content of CptGw is generally lower than other biosolids due to bulking out with greenwaste but Mg and micronutrient contents are comparable with other biosolids.

Tab. 2 a, b, c

Typical nitrogen (a), other major nutrients (b) and micronutrient (c) content of conventional biosolids: dewatered mesophilic anaerobic digested (dMAD), dewatered iron dosed mesophilic anaerobic digested (Fe dMAD), dewatered biological nutrient recovery mesophilic anaerobic digestion (BNR dMAD) and liquid mesophilic anaerobic digested (lMAD); and enhanced treated biosolids: thermally dried measophilic anaerobic digested (ThD-MAD), thermally dried raw (ThD-R), liquid thermal hydrolysis - measophilic anaerobic digested (lTH-MAD), liquid thermophilic aerobic-measophilic anaerobic digested (lTA-MAD), alkaline stabilised raw (AlkR) and composted with greenwaste (CptGw) biosolids used in field trials.

**Tab 2a** Nitrogen content of biosolids.

| **Biosolids** | **TN (% ds)** | **$NH_4$-N (mg $kg^{-1}$ ds)** | **$NO_3$-N (mg $kg^{-1}$ ds)** | **Org-N (% ds)** | **Mineral N (% TN)** |
|---|---|---|---|---|---|
| dMAD | 5.90 | 8979 | <0.01 | 5.00 | 15.2 |
| Fe dMAD | 5.23 | 13239 | <0.01 | 3.91 | 25.3 |
| BNR dMAD | 6.51 | 13986 | <0.01 | 5.11 | 21.5 |
| lMAD | 10.5 | 49382 | <0.01 | 0.09 | 45 |
| ThD-MAD | 4.60 | 1063 | <0.01 | 3.95 | 2.3 |
| ThD-R | 4.51 | 280 | 8.69 | 4.46 | 0.64 |
| lTH-MAD | 7.3 | 25641 | <0.01 | 0.09 | 45 |
| lTA-MAD | 6.7 | 30675 | <0.01 | 0.11 | 33 |
| AlkR | 1.13 | 553 | <0.01 | 1.12 | 4.9 |
| CptGw | 1.52 | 129 | 1182 | 1.39 | 8.6 |

**Tab. 2b** Total major nutrients (excluding N) and dry solids contents of biosolids used in field trials.

| Biosolids | ds (%) | Total P (% ds) | Ext P (% ds) | Total K (% ds) | Total Mg (% ds) | Total Ca (% ds) | Total S (% ds) |
|---|---|---|---|---|---|---|---|
| dMAD | 28.8 | 2.47 | 0.125 | 0.196 | 0.333 | 5.63 | 1.89 |
| Fe dMAD | 24.3 | 3.20 | 0.078 | 0.188 | 0.303 | 6.28 | 5.33 |
| BNR dMAD | 21.2 | 3.08 | 0.188 | 0.283 | 0.464 | 5.73 | 4.00 |
| lMAD | 1.62 | 2.73 | 0.879 | 1.500 | 0.459 | 5.41 | 1.32 |
| ThD-MAD | 96.5 | 2.39 | 0.063 | 0.332 | 0.696 | 5.72 | 0.94 |
| ThD-R | 96.7 | 1.81 | 0.020 | 0.192 | 0.284 | 2.89 | 0.65 |
| lTH-MAD | 2.34 | 2.77 | 0.563 | 0.247 | 0.271 | 6.60 | 1.16 |
| lTA-MAD | 3.26 | 2.12 | 0.117 | 0.660 | 0.494 | 2.64 | 1.38 |
| AlkR | 41.6 | 0.77 | 0.162 | 0.119 | 0.161 | 19.76 | 0.22 |
| CptGw | 58.8 | 0.72 | 0.041 | 0.626 | 0.371 | 3.66 | 0.55 |

**Tab. 2c** Total concentrations of micronutrients in biosolids (mg $kg^{-1}$ ds) used in field trials

| Biosolids | Fe (% ds) | Zn (mg $kg^{-1}$ ds) | Cu (mg $kg^{-1}$ ds) | Ni (mg $kg^{-1}$ ds) |
|---|---|---|---|---|
| dMAD | 1.89 | 659 | 631 | 31.3 |
| Fe dMAD | 5.33 | 472 | 712 | 21.5 |
| BNR dMAD | 4.00 | 539 | 987 | 28.2 |
| lMAD | 1.32 | 667 | 759 | 40.2 |
| ThD-MAD | 1.27 | 990 | 387 | 28.5 |
| ThD-R | 1.18 | 519 | 333 | 20.1 |
| lTH-MAD | 2.93 | 897 | 991 | 32.8 |
| lTA-MAD | 2.24 | 488 | 279 | 130.1 |
| AlkR | 0.39 | 198 | 203 | 10.3 |
| CptGw | 2.83 | 539 | 153 | 33.9 |

Calculation of plant available N

Simple linear regression functions were fitted to the N offtake data relative to total N input and the regression coefficients for biosolids were compared to the N offtake of ryegrass with inorganic N fertiliser. The data represent the cumulative first year offtake from three consecutive harvests for the different biosolids products applied in 2001. The slopes of the various regression models are shown in Table 3 The N availabilities relative to mineral N and proportion of mineralised organic N are also given. N availability estimated from the offtake data indicated that 36 % of the N in dewatered digested biosolids was released in the first year and recovered in the harvested herbage. This was equivalent to an organic N mineralisation value of almost 20 %. Thermally dried products had similar overall N availabilities to digested cakes based on N offtake, but in this case, more-or-less all the N was derived from mineralisation of organic N. Lime stabilised sludge had a N availability of 35 %, but the product contains approximately half the total N in either dewatered or thermally dried products, so in absolute terms, the amount of N released is significantly smaller.

**Tab. 3** First year N fertiliser value as a percentage relative to mineral N fertiliser applications by comparison of regression lines of N offtake against N applied of conventional biosolids: dewatered mesophilic anaerobic digested (dMAD), dewatered iron dosed mesophilic anaerobic digested (Fe dMAD), dewatered biological nutrient recovery mesophilic anaerobic digestion (BNR dMAD) and liquid mesophilic anaerobic digested biosolids (lMAD); and enhanced treated biosolids: thermally dried measophilic anaerobic digested (Th-MAD), thermally dried raw (Th-R), liquid thermal hydrolysis - measophilic anaerobic digested (lTH-MAD), liquid thermophilic aerobic-measophilic anaerobic digested (lTA-MAD), alkaline stabilised raw (AlkR) and composted with greenwaste (CptGw). The significance of the $r^2$ values of each regession line (n = 15) is given (NS = not significant, * =p < 0.05, ** = p < 0.01 and *** = p < 0.001).

| **Sludge type** | **Slope of regression line** | **$r^2$ values** | **[(1)]N fertiliser value relative to mineral N (%)** | **Mineralised N (% organic-N)** |
|---|---|---|---|---|
| dMAD | 0.222 | 0.83*** | 39.6 | 28.8 |
| Fe dMAD | 0.161 | 0.96*** | 28.6 | 4.4 |
| BNR-dMAD | 0.223 | 0.91*** | 39.7 | 23.2 |
| **Mean** | | | **36.0** | **18.8** |
| ThD-MAD | 0.167 | 0.92*** | 29.8 | 28.2 |
| ThD-R | 0.203 | 0.91*** | 36.2 | 35.8 |
| **Mean** | | | **33.0** | **32** |
| lMAD | 0.258 | 0.68** | 46.0 | 1.9 |
| lTA-MAD | 0.324 | 0.73*** | 57.9 | 23.5 |
| lTH-MAD | 0.240 | 0.76*** | 42.8 | 15.1 |
| **Mean** | | | **48.9** | **13.5** |
| AlkR | 0.200 | 0.48* | 35.6 | 31.0 |
| CptGw | 0.036 | $0.08^{NS}$ | 6.42 | -2.4 |

[(1)]Regression slope for mineral N = 0.56*

Yield response of *L. perenne*

The fresh yields of L. perenne in response to biosolids applications (Figure 1) were comparable to the N offtake results Table 3 illustrating the close relationship between yield and plant available N for *L. perenne*. This was also shown by the lack of a significant relationship between grass yield and mineral P applications.

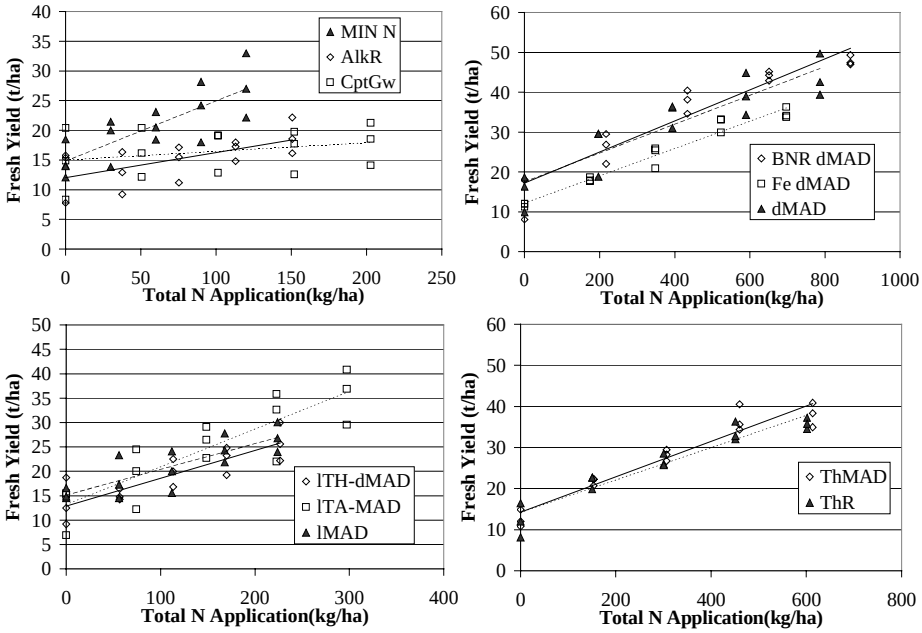


**Fig. 1** First year fresh weight yield responses of L. perenne to nitrogen (N) applications from a mineral N fertiliser with a top dressing of phosphate of 50 kg $ha^{-1}$ $P_2O_5$; conventional biosolids: dewatered mesophilic anaerobic digested (dMAD), dewatered iron dosed mesophilic anaerobic digested (Fe dMAD), dewatered biological nutrient recovery mesophilic anaerobic digestion (BNR dMAD) and liquid mesophilic anaerobic digested biosolids (lMAD); and enhanced treated biosolids: thermally dried measophilic anaerobic digested (Th-MAD), thermally dried raw (Th-R), liquid thermal hydrolysis - measophilic anaerobic digested (lTH-MAD), liquid thermophilic aerobic-measophilic anaerobic digested (lTA-MAD), alkaline stabilised raw (AlkR) and composted with greenwaste (CptGw) biosolids. Lines show linear regressions (n=15).

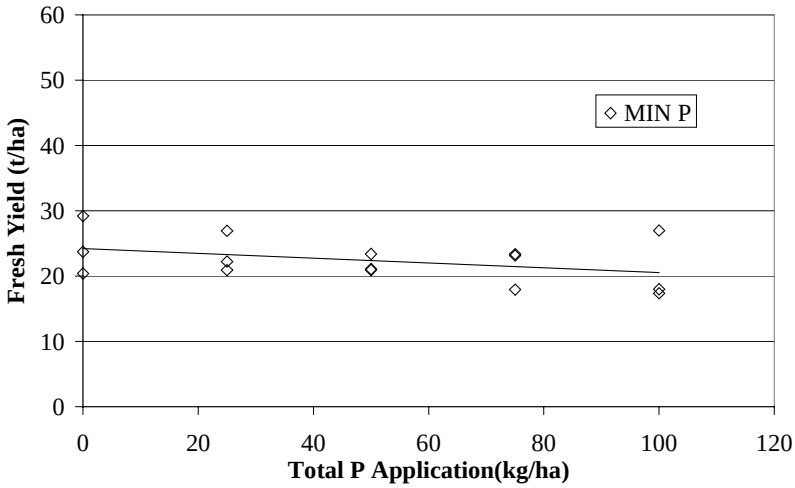


**Fig. 2** Fresh yield response of L. perenne to applications of triple super phosphate fertiliser at 25, 50, 75 and 100 kg $ha^{-1}$ with a top dressing of N at 60 kg $ha^{-1}$. Line shows a linear regression (n=15) $r^2$=0.1527.

Growth response of *B. pendula*

Lateral extension significantly increased in response to applications of mineral P and high P biosolids (ThD-MAD and dMAD) but not mineral N, (Table 4). This is in contrast to the response of L. perenne where P had no effect on shoot growth. Root growth was unaffected by N or P but applications of peat and CptGw at the higher rate (100 t $ha^{-1}$) significantly increased rooting depth (Table 4).

**Tab. 4** Average lateral extension (cm) and rooting depth (cm) in response to conventional: dewatered mesophilic anaerobic digested (dMAD), and enhanced treated: thermally dried measophilic anaerobic digested (Th-MAD) and composted with greenwaste (CptGw) biosolids applied at rates equivalent to 10 and 100 t/ha dry solids in comparison to additions of mineral N at rates equivalent to 100, 500 and 1000 kg/ha and mineral P ant rates equivalent to 100, 500 and 1000 kg/ha $P_2O_5$. Comparison of means (n=4) was performed using the standard error of differences of means (SED) (*=p<0.05, **=p<0.01 between treatments and control)

| Biosolid/Mineral fertiliser | Application rate (t/ha) | Mean lateral extension (cm) | Mean rooting depth (cm) |
|---|---|---|---|
| Control | 0 | 5.37 | 81.00 |
| MIneral N | 0.1 | 5.02 | 66.00* |
| | 0.5 | 3.82* | 84.50 |
| | 1 | 5.35 | 82.00 |
| Mineral P | 0.1 | 5.38 | 85.25 |
| | 0.5 | 7.27** | 87.25 |
| | 1 | 7.06* | 85.50 |
| Peat Compost | 10 | 4.82 | 78.67 |
| | 100 | 5.09 | 91.30* |
| dMAD | 10 | 5.94 | 82.50 |
| | 100 | 6.06* | 74.25 |
| Th-MAD | 10 | 7.06** | 85.50 |
| | 100 | 6.29* | 77.50 |
| CptGw | 10 | 5.13 | 78.75 |
| | 100 | 5.97 | 89.33* |
| SED | | 0.310 | 4.731 |

## Discussion

Biosolids provide an available source of plant nutrients in particular N and P and biosolids composted with greenwaste also supply significant amounts of K. The nutrient requirements of plants should be considered when applying any fertiliser to a specific plant group or species, this was apparent when comparing the growth response of L. perenne in comparison to those of B. pendula. However, there is little information available regarding the nutrient requirements of trees and other amenity plants in a form that can be compared to available nutrient inputs from fertilisers.

The overall nutrient balance (Table 2a-c) means that biosolids may be used as general fertilisers either in bare root stock production or for landscaping projects. In particular composted biosolids have been successfully used in this kind of application [1]. The fibrous nature of composted biosolids may also improve soil structure indicated by the increased rooting of B. pendula (Table 4), which makes them ideal as a general soil improver for impoverished urban soils. Composts can also be included in soil mixes for urban trees planted in large containers, although care must be taken not to create a growth media with an unacceptably high conductivity. It is unlikely that any of the biosolids could be used as fertilisers in containerised tree production because of the high degree of control of nutrient balance and conductivity that is needed in modern production systems. However, there is scope for partial peat replacement with composted biosolids.

Where there is public access immediately following application, enhanced treated biosolids are preferred to avoid public health issues. Horticultural operatives have also shown a preference for composted products or granular products e.g. Th-MAD because they have no unpleasant odours and are easy to measure and spread. Where large-scale applications are needed, most enhanced treated biosolids including liquids can be used. Liquids have an advantage over solids in that they can be injected into existing landscapes. This allows applications of large quantities of biosolids without smothering grass and other plants.

## Acknowledgments

The work reported here forms part of a programme of research funded by The Environment Agency, Severn Trent Water, Thames Water, Yorkshire Water, the Scottish Water Authorities and the EPSRC.

## Literature

1 NUFU, 2003. Case Note: Urban Forestry in Practice, Reclaiming derelict land using sewage sludge (Biosolids). NUFU, Wolverhampton, UK.

2 LANG, N.L., SMITH, S.R., BELLETT-TRAVERS, D.M., PIKE, E.B., ROWLANDS, C.L., 2003. Decay of *Escherichia coli* in soil following the application of biosolids to Agricultural land. *Journal of the Chartered Institution of Water and Environmental Management* **17**:23-28.

3 DUHAM, E., 1999. Effects of Thermal Treatment on the Agronomic Value of Urban Wastewater Biosolids. MSc Dissertation, Imperial College.

4 SMITH, S.R., WOODS, V., EVANS, T.D., 1998. Nitrate dynamics in biosolid-treated soils. II. Thermal-time models of the different nitrogen pools. *Bioresource Technology*. 66, 151-160.

5 BELLETT-TRAVERS, D.M., SMITH, S.R., 2001. Modelling the effects of temperature-time relationships on the mineralisation and nitrification of biosolids in soil. Proceedings of the UKWIR/Aqua Environ, 6th European Biosolids and Organic Residuals Conference, Wakefield.

6 ADAS, 1986. The Analysis of Agricultural Materials: A Manual of the Analytical Methods used by the Agricultural Development and Advisory Service. HMSO, London.

7 PETTS, K.W., BELCHER, M., 1980. An automated method for the simultaneous determination of nitrogen and phosphorus in plant material, sludge and soil. *Water Pollution Control* 399-404.

# Session 6 - Weed Control in Urban Stands

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## Economic aspects of different methods of weed control in urban areas

### Einleitung und Zielsetzung

An der Definition von Wildkraut bzw. Unkraut scheiden sich bekanntlich die Geister. Dennoch ist eine Differenzierung unumgänglich. Einerseits sollen sich Wildkräuter aus ökologischen Gesichtspunkten heraus möglichst unbeeinträchtigt entwickeln, anderseits müssen Unkräuter kontrolliert werden. Auch außerhalb pflanzenbaulich genutzter Flächen im öffentlichen Bereich (z.B. Gewerbe-, Sport- und Verkehrsflächen) gibt es zwingende Gründe gegen spontanen Pflanzenwuchs vorzugehen. Verkehrssicherheit, Arbeitsschutz und Erhaltung von Baulichkeiten verpflichten zur Vegetationskontrolle.

In der Vergangenheit erfolgte die Kontrolle von spontanem Pflanzenaufwuchs auch auf Nicht-Kulturland und im öffentlichen Grün vornehmlich mit Hilfe von Herbiziden. Mittlerweile muss hier auf Druck der Öffentlichkeit Zurückhaltung geübt werden.

Prinzipiell stehen zahlreiche alternative Verfahren zur Verfügung (Tabelle 1). Bodenabdeckung mit verschiedenen Materialien bis hin zur Versiegelung werden genutzt, um unerwünschten Pflanzenwuchs zu unterdrücken. Mechanische Verfahren wurden verfeinert und an die Bodenoberflächen angepasst. Bei den thermischen Geräten ist ein neuer Trend absehbar: weg von der Infrarottechnologie hin zu Wasser oder Dampf als Wärmeüberträger.

**Tab. 1** Alternative Verfahren zur Unkrautkontrolle im Siedlungsbereich

| | | | |
|---|---|---|---|
| **Boden-abdeckung** | gewachsener Boden | organisches Material (Rinde, Stroh, Torf, Holzhäcksel u.a.) | ▪ große Volumina<br>▪ hohe Arbeitskosten<br>▪ hohe Materialkosten<br>▪ begrenzte Haltbarkeit (ca. 3 Jahre) |
| | | Pflanzkragen | ▪ nur für Einzelpflanzen |
| | | Folien oder Vliese | ▪ lange Haltbarkeit (10 Jahre)<br>▪ hohe Materialkosten<br>▪ Probleme: Begehbarkeit<br>Entsorgung |
| | | Untersaat/-pflanzung (Vinca, mehrjährige Geranien, Cotoneaster) | ▪ positive Klimaeffekte<br>▪ zusätzliche Kosten für Anlage und Pflege |
| | | Versiegelung (Beton, Aspalt u.a.) | ▪ keine Grundwasserbildung<br>▪ Kanalanschluss erforderlich<br>▪ negative Klimaeffekte (Vereisungsgefahr) |

| | | | |
|---|---|---|---|
| **Mechanik** | gewachsener Boden | Flachschare<br>Krümelgeräte<br>Scheibengeräte<br>Freischneider | ▪ variabler Mechanisierungsgrad: von Handarbeit über Teilmechanisierung (Stihlmulcher) bis Vollmechanisierung (Unkrauthobel)<br>▪ Wirkung abhängig von:<br>Bodentyp<br>Feuchtigkeit |
| | wasser-gebundene Flächen | Spezialgeräte zur Aufarbeitung u. Rückverfestigung der Deckschicht | Beispiele: Tennenplatzpflegegeräte<br>Igelrotor<br>Krefelderegge |
| | versiegelte Flächen | Kehrgeräte | ▪ Kunststoffborsten (belagschonender, höherer Verschleiß)<br>▪ Drahtborsten (aggressiv) |
| **Thermik** | gewachsener Boden | Freischneider | ▪ Gefahr von Personen- und Sachschäden |
| | | Hochdruckreiniger | ▪ löst Fugenmaterial |
| | | Abflammgeräte | ▪ offene Flamme (hohe Brandgefahr) |
| | wassergebundene Flächen | Infrarot | ▪ Wärmestrahlung (geringere Brandgefahr) |
| | | Heißwasser | ▪ nahezu drucklos |
| | versiegelte Flächen | Heißdampf | ▪ mit Dampfdruck; ggfls mit Zuckerschaum zur Wärmeisolierung |

Im Rahmen einer Diplomarbeit wurden mechanische, thermische und chemische Verfahren auf ausgewählten Flächen im Hinblick auf Wirkung, Wirtschaftlichkeit und ökologische Aspekte miteinander verglichen, um Entscheidungskriterien für die Handhabung direkter Maßnahmen gegen spontanen Pflanzenwuchs im Siedlungsbereich zu erarbeiten.

## Material und Methoden

Versuchsflächen

Um möglichst praxisnahe Ergebnisse erzielen zu können, wurden die Freilandversuche auf Flächen mit unterschiedlicher Oberflächenbeschaffenheit und mit unterschiedlichen Pflanzendeckungsgraden durchgeführt. Es handelte sich dabei um gewerblich genutzte Anlagen mit einer Gesamtfläche von etwa 750 m². Sie setzten sich zusammen aus vier Teilstücken, zwei mit Verbundsteinoberfläche und zwei mit wassergebundener Oberflächen (Lava).

Entsprechend dem Platzbedarf der einzelnen Versuchsglieder wurde die Parzellengröße variabel an die verfügbaren Teilflächen angepasst und mit vierfacher Wiederholung durchgeführt. In den Tabellen 3 und 4 sind die Behandlungs- und Boniturtermine zusammengefasst.

Vegetation

Entsprechend der außergewöhnlich warmen und in den Monaten Juli und September extrem nassen Witterung im Versuchsjahr 2000 (Abb. 1) kann die Vegetationsentwicklung als außergewöhnlich stark angesehen werden.

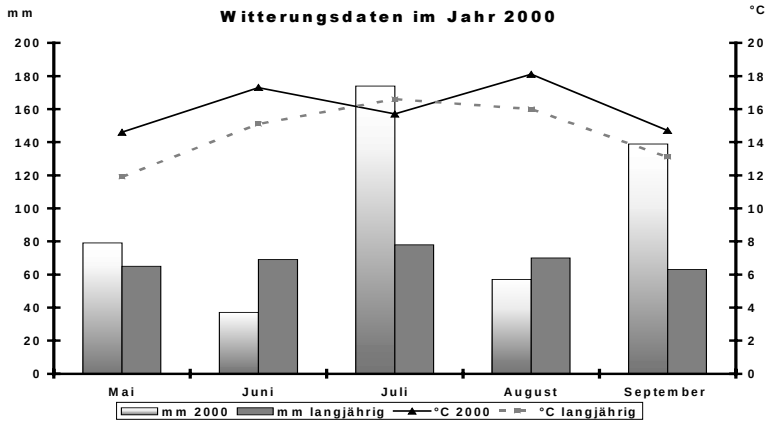


**Abb. 1** Witterungsverlauf im Jahr 2000

Während des Versuchsjahres (2000) variierte die Zusammensetzung der Pflanzengesellschaften auf den einzelnen Flächen entsprechend der Oberflächenbeschaffenheit, dem Alter und dem Nutzungsgrad (Tab. 2).

**Tab. 2** Zusammensetzung der Vegetation

| **Fläche 1** | **Fläche 2** | **Fläche 3** | **Fläche 4** |
|---|---|---|---|
| **regelmäßig vertretene Arten** | | | |
| *Erigeron annuus* | *Agrostis capillaris* | *Agrostis tenuis* | Conyza canadensis |
| *Festuca ovina agg.* | *Festuca ovina agg.* | *Cerastium holosteoides* | *Epilobium tetragonum.* |
| *Leontodon autumnalis* | *Festuca rubra* | *Ceratodon purpureus* | *Matricaria inodora* |
| *Plantago lanceolata* | *Leontodon autumnalis* | *Festuca rubra* | *Myostis arvensis* |
| *Poa annua* | *Plantugo lanceolata* | *Geranium pusillum* | *Pastinaca sativa* |
| | *Poa annua* | *Holcus lanatus* | Taraxacum officinale |
| | *Poa compressa* | *Leontodon autumnalis* | |
| | *Taraxacum officinale* | *Lolium perenne* | |
| | *Vulpia myurus* | *Medicago lupulina* | |
| | | *Phleum pratense* | |
| | | *Poa compressa* | |
| | | *Poa pratensis* | |
| **vereinzelt auftretende Arten** | | | |
| *Achillea millefolium* | *Achillea millefolium* | *Achillea millefolium* | *Arenaria serpyllifolia* |
| *Crepis capillaris* | *Cerastium holosteoides* | *Campanula rotundifolia* | *Campanula patula* |
| *Eragrostis poaeoides* | *Conyza canadensis* | *Daucus carota* | *Convolvulus arvensis* |
| *Hippocrepis comosa* | *Lotus corniculatus* | *Plantago lanceolata* | *Crepis capillaris* |
| *Kickxia elatine* | *Medicago lupulina* | *Sargina procumbens* | *Crisium vulgare* |
| *Lotus corniculatus* | *Senecio erucifolius* | *Senecio erucifolius* | *Daucus carota* |
| *Plantago major* | *Trifolium pratense* | *Taraxacum officinale* | *Galium album* |
| *Prunella vulgaris* | | *Veronica spec.* | *Holcus mollis* |
| *Sagina procumbens* | | | *Hypericum perforatum* |
| *Senecio erucifolius* | | | *Lapsana communis* |

| Fläche 1 | Fläche 2 | Fläche 3 | Fläche 4 |
|---|---|---|---|
| *Setaria viridis* | | | *Melandrium album* |
| *Taraxacum officinale* | | | *Poa annua* |
| *Trifolium repens* | | | *Polygonum aviculare* |
| *Veronica arvensis* | | | *Ranunculus repens* |
| *Veronica spp.* | | | *Rumex acetosella* |
| *Vulpia myurus* | | | *Senecio erucifolius* |
| | | | *Solanum nigrum* |
| | | | *Veronica spec.* |
| | | | *Vicia hirsuta* |

Der maximale Unkrautdeckungsgrad war auf den Verbundsteinflächen (Fäche 1 + 2) bereits Anfang Juni erreicht. Auf den Flächen mit wassergebundener Oberfläche war der Deckungsgrad dagegen über die Vegetation starken Schwankungen unterworfen (Abb. 2).

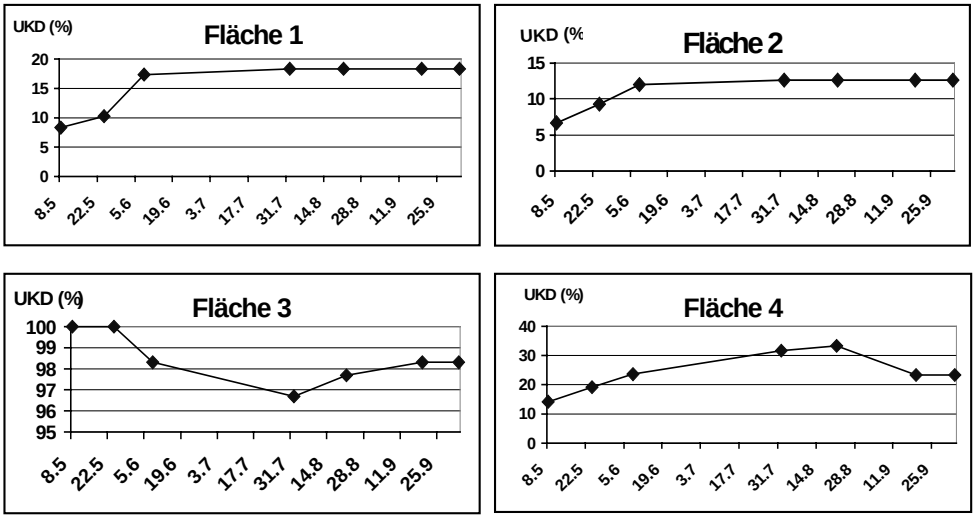


**Abb. 2** Unkrautdeckungsgrad auf den verschiedenen Versuchsflächen im Zeitverlauf.

## Verfahren

Infrarot

In den Versuchen kam ein Infrarotgerät der Firma Werner Typ IF 60/75 zum Einsatz.

Es handelt sich hierbei um ein von Hand geschobenes Gerät mit 60 cm Arbeitsbreite und Propangas-Energieversorgung.

Wasserdampf

Das Wasserdampfgerät (Fiskars-Steam) der Firma Fiskars ist als elektrisch betriebenes, tragbares Gerät zur Bearbeitung von Kleinstflächen vorgesehen.

Mechanische Unkrautbekämpfung

Die mechanische Unkrautkontrolle wurde in Handarbeit durchgeführt. Zu diesem Zwecke wurden eine handelsübliche Unkrauthacke und ein grober Stahlbesen eingesetzt. Sofern notwendig und möglich, wurden die Pflanzen auch gejätet.

Chemische Verfahren

Es kamen die derzeit bei der Unkrautbekämpfung auf Nicht-Kulturland in der Bundesrepublik häufig eingesetzten Herbizide zum Einsatz. ROUNDUP ULTRA® (Gyphosat) wurde mit 10.0 l/ha, Basta® (Glufonsinat) als Spritzfolge mit 7,5 bzw. 5,0 l/ha und Vorox G® (Glyphosat + Diuron) mit 15 kg/ha eingesetzt. Darüber hinaus wurden zwei Prüfmittel auf Fettsäurebasis mit reiner Kontaktwirkung erprobt.

Die Ausbringung erfolgte mit einem Druckspeichergerät der Firma MESTO Typ 3610. Die Querverteilung erfolgte mittels eines Spritzbalkens von 1 m Breite, bestückt mit einer Düse Lechler 12004 AD und zwei Düsen Teejet UB 8004. Ein Druckminderungsventil sorgte für einen gleichmäßigen Ausstoß (1,8 bar).

**Tab. 3** Behandlungstermine auf den Versuchsflächen 1-4

| **Fläche** | **Variante** | **Behandlungstermine** | | | |
|---|---|---|---|---|---|
| | | **08.05.00** | **08.06.00** | **01.08.00** | **19.09.00** |
| 1 Verbundstein | Basta® | x | | x | |
| | Infrarot | x | x | x | x |
| | Wasserdampf | x | x | x | x |
| | Handarbeit | x | | x | x |
| 2 Verbundstein | Basta® | x | | x | |
| | Infrarot | x | x | x | x |
| | Wasserdampf | x | x | x | x |
| | Handarbeit | x | | x | x |
| 3 Lava | Roundup® Ultra | x | | | |
| | Vorox G® | x | | | |
| | Prüfmittel 2 | x | x | x | x |
| | Roundup® Ultra | x | | | |
| 4 Lava | Basta | x | | x | |
| | Prüfmittel 1 | x | x | x | x |
| | Prüfmittel 2 | x | x | x | x |
| | Vorox G® | x | | | |
| | Wasserdampf | x | x | x | x |
| | Handarbeit | x | x | x | x |

**Tab.4** Boniturtermine auf den Versuchsflächen 1 – 4

| Fläche | Variante | 08.05.00 | 24.05.00 | 08.06.00 | 19.06.00 | 01.08.00 | 21.08.00 | 19.09.00 | 03.10.00 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | x | x | x | x | x | x | x | x |
| | 2-5 | | x | x | x | x | x | x | x |
| 2 | 1 | x | x | x | x | x | x | x | x |
| | 2-5 | | x | x | x | x | x | x | x |
| 3 | 1 | x | x | x | x | x | x | x | x |
| | 2-4 | | x | x | x | x | x | x | x |
| 4 | 1 | x | x | x | x | x | x | x | x |
| | 2-8 | | x | x | x | x | x | x | x |

## Parameter zur Ermittlung von Wirkung und Wirtschaftlichkeit

Etwa 14 Tage nach jeder Behandlung wurde der Wirkungsgrad durch visuelle Bonitur ermittelt.

Um eine Aussage über die Wirtschaftlichkeit der einzelnen Mittel/Verfahren treffen zu können, wurden die in den Versuchen ermittelten Verbrauchswerte für Primär- und Sekundärenergie, Wasserverbrauch, Arbeits- und Abschreibungskosten miteinander verglichen. Dabei wurden die in Tabelle 5 aufgeführten Kostensätze zu Grunde gelegt.

**Tab. 5** Grunddaten für die Wirtschaftlichkeitsberechnungen

| Variante | Parameter | Kosten (DM/kg, kWh, Std., m³) |
|---|---|---|
| Vorox G® | | 108,00[1)] |
| | Wasser | 6,00 |
| | Abschreibung/Jahr | 31,00 |
| Roundup Ultra® | | 23,00[1)] |
| | Wasser | 6,00 |
| | Abschreibung/Jahr | 31,00 |
| Basta® | | 58,00[1)] |
| | Wasser | 6,00 |
| | Abschreibung/Jahr | 31,00 |
| Infrarot | Gas | 2,75[2)] |
| | Abschreibung/Jahr | 500,00 |
| | Strom | 0,26[3)] |
| Wasserdampf | Wasser | 6,00 |
| | Abschreibung/Jahr | 10,00 |
| Handarbeit | Abschreibung/Jahr | 25,00 |
| Arbeitskosten | /Std. | 50,00 |

[1)] RWZ Preisliste 2000
[2)] Preise im Handel erfragt
[3)] Preisblatt für den allgemeinen Tarif 15.09.00 (RWE Energie AG)

## Ergebnisse

Auf den Verbundsteinflächen stieg das Grundwasser Ende September aufgrund der außergewöhnlich hohen Niederschläge bis in das Sandbett an. Durch den Luftmangel kam es zur vorzeitigen Beendigung der Vegetation, so dass Mitte September der letzte aussagekräftige Boniturtermin zustande kam. Basta erreichte mit zweimaliger Anwendung Wirkungsgrade zwischen 90 und 100 %. Handarbeit (3 Termine) und Wasserdampf (4 Anwendungen) erzielten Unkrautwirkungen zwischen 60 und 80 %. Trotz viermaliger Infrarotbehandlung blieb die Wirkung mit 20 bis 40 % völlig unzureichend.

Auf der wassergebundenen Fläche mit geschlossener Vegetationsdecke bewährte sich die Kombination aus Diuron und Glyphosat im Vorox G durch die Dauerwirkung. Die Wirkungsgrade von Roundup (1x) und dem Prüfmittel 2 (4x), die sich durch reine Kontaktwirkung auszeichnen, fielen die Wirkungsgrade sukzessive auf 30 %, was auf neuauflaufende Pflanzen (insbesondere Ehrenpreis) zurückzuführen war.Auf der schwächer verkrauteten Lavafläche (Fläche 4) konnte Basta, bedingt durch die zwei Anwendungstermine, die Vegetation wesentlich effektiver kontrollieren. Der einmalige Einsatz von Vorox G zeigte die bekannte Dauerwirkung. Roundup, das nur mit einer Anwendung ausgewiesen war, blieb dagegen wegen des Neuauflaufes völlig unzureichend. Während Prüfmittel 2, bedingt durch seine Gräserwirkung, eine zufriedenstellende Wirkung erreichte, blieb Mittel 1 unzureichend. Auch nach viermaliger Anwendung war mit dem Wasserdampfgerät keine ausreichende Wirkung gegen die teils schon größeren Pflanzen zu erzielen. Trotz der ungünstigen Witterung waren mit Handarbeit deutlich bessere Wirkungen zu erreichen (Abb. 3).

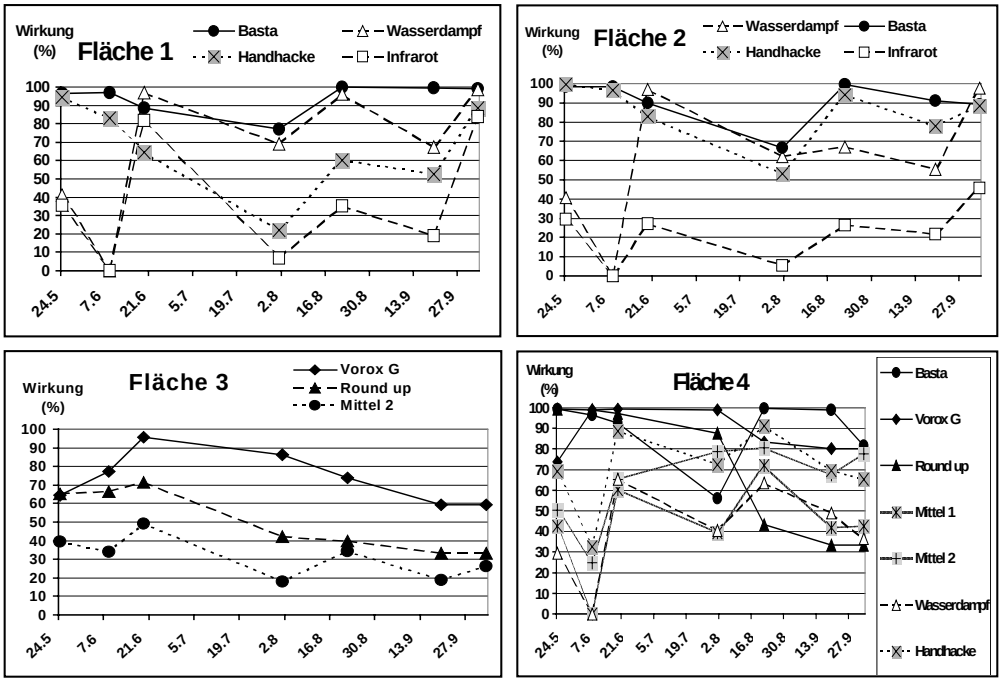


**Abb. 3** Wirkungsgrad der verschiedenen Varianten gegen die vorhandene Verunkrautung auf den einzelnen Versuchsflächen

Bei den Wirtschaftlichkeitsbetrachtungen wurde von einer Geräteabschreibung von 10 Jahren ausgegangen. Zur Ermittlung der Abschreibung wurde allen Varianten eine einheitliche Bezugsfläche von einem Hektar Behandlungsfläche/Jahr zu Grunde gelegt. Wegen der hohen Abnutzung der Handwerkzeuge (Handhacke) wurde bei ihnen eine Nutzungsdauer von nur 2 Jahren veranschlagt. Die

eingesetzten Lohnkosten beinhalten bei allen Verfahren die erforderlichen Rüstzeiten. Anhand der Verbrauchsdaten (Arbeitszeit, Energie, Verbrauchsmaterial, Abschreibung) wurde auf den einzelnen Flächen die Wirtschaftlichkeit der verschiedenen Varianten errechnet. Der Kostenbereich der einzelnen Behandlungsverfahren, der sich im Rahmen der Versuchsanstellungen in Abhängigkeit von der Oberflächenbeschaffenheit und der Verunkrautung ergeben hat, ist in Tabelle 6 zusammengefasst.

Bei der Kostenkalkulation der Behandlungsverfahren wird deutlich, dass die Flächenleistung/h eines Verfahrens und damit die Arbeitskosten entscheidend sind für die Wirtschaftlichkeit. Die günstige Kostenstruktur der chemischen Verfahren beruht auf der hohen Flächenleistung/h und der geringen Behandlungshäufigkeit/Vegetationsperiode (2x Basta, 1x Vorox G, 1x Roundup Ultra). Die geringen Flächenleistungen der übrigen Verfahren und ihre Behandlungshäufigkeit pro Vegetationsperiode (4x Infrarot, 4x Wasserdampf und 3-4x Handarbeit) verursachten hohe Arbeitskosten. Die Abschreibungs- und Energiekosten spielen hier eine untergeordnete Rolle. Dabei liegt das Infrarotverfahren, was die Gesamtkosten angeht, noch etwa um den Faktor 10 günstiger als das Wasserdampf- und Handarbeitsverfahren (Tab. 6).

**Tab 6** Kostenvergleich der geprüften Unkrautbekämpfungsverfahren (Angaben in Abhängigkeit von der Flächenbeschaffenheit in DM/m²)

| Kosten | Basta® | Roundup Ultra® | Vorox G® | Infrarot | Wasserdampf | Handarbeit |
|---|---|---|---|---|---|---|
| pro Behandlung | 0,05 | 0,04 | 0,18 | 0,15 - 0,25 | 1,23 – 2,74 | 1,36 – 2,66 |
| pro Veg. periode | 0,1 | 0,04 | 0,18 | 0,60 – 1,0 | 4,92 – 10,96 | 5,44 – 7,98 |

Aufgrund der geringen Arbeitsbreite und -geschwindigkeit sind Handarbeit oder die Heißwasser-Kleinstgeräte etwa um den Faktor 100 teurer als Herbizide (Tab. 7).

**Tab. 7** Vereinfachte Darstellung der Kostenrelationen zwischen verschiedenen Verfahren zur Unkrautkontrolle

| Herbizide → | kostengünstige Alternative → | ungünstige Alternative (Handarbeit) |
|---|---|---|
| 1 x | 5-10 x | 100 x |

Durch Verwendung größerer Geräteeinheiten (Anbaugeräte) lässt sich diese Kostenrelationen vermutlich noch verbessern. Dies dürfte allerdings zu Lasten der Handhabbarkeit gehen, weil die Geräte wesentlich größer und damit weniger wendig werden.

## Diskussion

In den letzten Jahren wurden in zunehmendem Umfang Alternativen zur chemiefreien Vegetationskontrolle am Markt angeboten.

Das Spektrum reicht von mechanischen Geräten (teilweise individuelle Lösungen für bestimmte Flächen) bis hin zu Heißwasser- oder Heißdampfgeräten.

Im Gegensatz zu den landwirtschaftlichen Nutzflächen können Siedlungsflächen sehr unterschiedlich gestaltet sein. In Abhängigkeit von der Oberflächengestaltung und –belastung entwickeln sich die Einzelpflanzen entsprechend dem Nährstoff- und Wurzelraumangebot [1]. Daraus ergeben sich die unterschiedlichsten Anforderungen an ein funktionierendes Verfahren zur Beseitigung von unerwünschtem Pflanzenwuchs. Diese Vielgestaltigkeit der betroffenen Flächen erschwert es allgemein, gültige Aussagen zu bestimmten Geräten oder Verfahren zu machen.

Die Verwendbarkeit thermischer Geräte ist im Vergleich zu mechanischen Verfahren weitgehend unabhängig von der Beschaffenheit der Oberfläche. Es können sowohl Platten- und Pflasterflächen als auch wassergebundene Flächen behandelt werden.

Infrarotgeräte entfalten ihre Wirkung nicht über die offene Flamme, sondern anhand von Wärmestrahlung. Dadurch wird die Bildung eines Luftpolsters zwischen Pflanze und Gerät vermieden. Infrarotgeräte sind daher nicht so anfällig gegenüber Störungen wie Boden- unebenheiten oder Wind. Die Brandgefahr ist deutlich niedriger im Vergleich zu den Abflammgeräten. Bei höherer und dichter

Vegetation besteht durch den niedrigen Bodenabstand allerdings die Gefahr von Sauerstoffmangel, was zum Ersticken der Gasflamme führt.

Wasser fungiert als Wärmeüberträger bei Heißwasser- bzw. Heißdampfgeräten. Es wirkt gleichzeitig als „Wärmespeicher“, d. h. die getroffenen Pflanzenteile kühlen sich langsamer ab als bei den vorgenannten Verfahren. Dadurch soll eine größere Tiefenwirkung erreicht werden, um ausdauernde Arten besser zu erfassen. Heißwassergeräte arbeiten mit Temperaturen zwischen 85 °C und 95 °C.

Bei dem Heißdampfverfahren werden die Pflanzen mit Temperaturen von 120 °C bis 140 °C behandelt. Die Dampferzeugung erfolgt bei den Kleingeräten durch Elektrizität. Größere Geräte arbeiten mit Ölbrennern.

Was Flächenbeschaffenheit und Handhabbarkeit angeht, ist die Gerätetechnik zur Ausbringung von Herbiziden am wenigsten eingeschränkt. In aller Regel werden sie mit Hilfe von Düsen unter Luftdruck ausgebracht, seltener gegossen oder als Granulat gestreut. Arbeitsbreite und –geschwindigkeit der Spritzapplikation lassen sich problemlos an die praktischen Erfordernisse anpassen (z. B. Einzeldüse, Düsenverband, Wassermenge). Schwachpunkt des Spritzverfahrens ist die Windanfälligkeit und damit verbunden die Gefahr von Abtrift. Lediglich bei der Nutzung einer Einzeldüse lässt sich die Abtrift durch Verwendung eines Spritzschirmes einschränken.

Obwohl die chemischen Varianten wirkungsmäßige Vorteile zeigten, wurde deutlich, dass unter ungünstigen Witterungsbedingungen, bei etablierter Vegetation (Fläche 2) oder hohem Samenpotential (Fläche 3 und 4) zwei Behandlungen erforderlich sein können, um über einen längeren Zeitraum eine zufriedenstellende Wirkung zu erzielen.

Die Wirkungsgrade der nicht chemischen Verfahren waren in erster Linie abhängig von der Anwendungshäufigkeit. Das Handarbeitsverfahren war naturgemäß in der Wirkung abhängig von der Oberflächenbeschaffenheit. Das Wasserdampfgerät zeigte im Vergleich zum Infrarotgerät eine nachhaltigere Wirkung, was auf die langsamere Arbeitsgeschwindigkeit zurückführbar ist.

Die Wirtschaftlichkeit der einzelnen Verfahren war in erster Linie abhängig von den Arbeitskosten. Der kostengünstige Einsatz der Herbizide beruht auf der vergleichsweise großen Arbeitsbreite und Geschwindigkeit, sowie der geringen Anwendungshäufigkeit. Bei 60 cm Arbeitsbreite und Schrittgeschwindigkeit lag das Infrarotgerät etwa um den Faktor 10 kostenmäßig höher als die Herbizide. Durch niedrige Arbeitsbreite und -geschwindigkeit lag der Kostenfaktor zwischen Herbiziden und Wasserdampf bzw. Handarbeit etwa bei 1:100. Durch Verwendung größerer Geräteeinheiten (Anbaugeräte) lässt sich dieser ungünstige Kostenfaktor vermutlich erheblich verbessern. Dies dürfte allerdings zu Lasten der Handhabbarkeit gehen, weil die Geräte wesentlich größer und damit weniger wendig werden.

Die ökologischen Risiken der Herbizidanwendung sind weitgehend bekannt. Sie bestehen in erster Linie aus Abtrift- und Abschwemmung in Oberflächengewässer. Abtrift gefährdet vor allem Nichtzielorganismen und lässt sich durch gute fachliche Praxis weitgehend reduzieren. Abschwemmungsgefahr besteht insbesondere auf versiegelten Flächen. Sie ist Wirkstoff- und Niederschlags-abhängig und kann leicht zu Belastungen der Oberflächengewässer durch direkten Zufluss oder Eintrag über die Kläranlage führen [2].

Natürlich bleiben auch die alternativen Verfahren nicht ohne Einfluss auf die Umwelt. Abgesehen von der reinen Handarbeit muss Energie aufgewendet werden.

Bei fünfmaliger Anwendung des Infrarotgerätes werden je nach Flächenbeschaffenheit auf 4 bis 10 ha Fläche eine Energiemenge verbraucht, die ausreicht, um ein durchschnittliches Einfamilienhaus mit einem Jahresverbrauch von 30.000-35.000 KW zu beheizen. Nicht unterschätzt werden darf die Brandgefahr bei vorhandenem abgestorbenen Pflanzenmaterial (z.B. Rasenschnitt).

Das verwendete Wasserdampf-Kleinstgerät verbrauchte bei fünfmaliger Anwendung ca. 4500 kWh Strom/ha+Jahr, was etwa dem Jahresverbrauch einer 4-köpfigen Familie entspricht. Darüber hinaus wurden 8-10.000 l Wasser/ha zur Dampferzeugung benötigt.

Verschiedene Untersuchungen sehen bei der Verwendung von thermischen Geräten allenfalls Gefahren für oberirdisch lebende Organismen ([3-4]). Aufgrund der geringen Tiefenwirkung sind keine Beeinflussungen von Bodenorganismen zu erwarten.

Sicherheitsaspekte machen auch zukünftig eine Vegetationskontrolle auf vielen Freilandflächen erforderlich. Grundsätzlich müssen entsprechende Maßnahmen mehr als bisher überdacht werden. Ästhetische Gesichtspunkte dürfen im Rahmen der Entscheidungsfindung keine Rolle spielen. Es gilt, den Herbizideinsatz auf das absolut notwendige Maß zu beschränken und sofern möglich, sinnvolle alternative Verfahren zu wählen.

Größere Geräteeinheiten, wie beispielsweise das Heißwassergerät „Waipuna-System“ [5] oder das mit einer Arbeitsbreite von 1 m arbeitende Heißdampfgerät „Weedstar“ müssen noch in der Praxis erprobt werden, um Handhabung und Wirtschaftlichkeit besser einstufen zu können.

Für die Anwendung von Herbiziden wurde ein abtriftarmes Verfahren erarbeitet. Es handelt sich dabei um eine Mechanisierung des so genannte „Streichverfahrens“ (Rotofix-System). Dabei wird Roundup-Ultra mit Hilfe eines Teppichbandes auf die Unkräuter gestrichen. Dadurch wird Abtrift und eine unerwünschte Kontamination des Bodenbelages vermieden [6].

## Zusammenfassung

Auf der Grundlage von Freilandversuchen auf Pflaster- und wassergebundenen Oberflächen mit unterschiedlichen Pflanzendeckungsgraden wurden verschiedene Möglichkeiten der Vegetationskontrolle auf Nicht-Kulturland im Hinblick auf Handhabbarkeit, Wirkung und Wirtschaftlichkeit miteinander verglichen. Neben verschiedenen Herbiziden (Glufosinat, Glyphosat, Glyphasat+Diuron, Prüfmittel) wurden thermische Geräte (Wasserdampf: Fiskars Steam, Infrarot: IF 60) und Handarbeit gegen den spontanen Pflanzenaufwuchs eingesetzt.

Mit den handelsüblichen Herbiziden wurden bei ein bis zweimaliger Anwendung akzeptable Behandlungsergebnisse erzielt. Allerdings konnte mit keinem dieser Mittel das Auflaufen neuer Pflanzen während der Vegetationsperiode vollständig verhindert werden. Auch mit 3 bis 4 Anwendung waren mit den alternativen Verfahren kaum vergleichbare Wirkungen zu erzielen.

Bedingt durch die hohe Flächenleistung/h und die geringe Behandlungshäufigkeit/Vegetationsperiode waren die konventionellen Herbizide mit einem Kostenrahmen von 0,1 bis 0,18 DM/m²+Jahr die wirtschaftlichsten Varianten. Das Infrarot-Verfahren lag etwa um den Faktor 10, die übrigen Verfahren ca. um den Faktor 100 über diesen Kosten.

## Possibilities of weed control in urban areas

## Summary

Different possibilities of vegetation control have been examined by means of field trials conducted on paved and gravelled urban areas covered by weeds of various densities. Herbicides (Glufosinat, Glyphosat, Glyphasat+Diuron, new substances), heat developing systems (steam: Fiskars Steam, infrared radiation: IF 60) and hand-weeding were tested against the existing vegetation. Effectivity, handling and economy of the different control measures have been compared.

Although no herbicide could completely prevent late germination of weeds, 1-2 applications of the common herbicides normally achieved acceptable results. Despite of 3-4 treatments by non chemical methods, they could hardly reach comparable results.

Speed and low frequency of chemical treatments resulted in low costs (0,1 to 0,18 DM/m²+year). The non-chemical treatments were extremely affected by costs of labour. Infrared radiation caused costs between 0,6-1,0 DM/m²+year. Because of low mechanization steam treatment and hand-weeding resulted in costs between 4,92 - 10,96 DM/m²+year.

## Literatur


1 ZWERGER, P., EGGERS, TH.; PREUSSENDORFF, G., VERSCHWELE, A., 2000. Zur Situation der Unkrautbekämpfung im urbanen Bereich. Stadt und Grün, Sonderh. 13, 54-60.

2 AUGUSTIN, B., SCHIETINGER, R., ITTEL, I. 2002. Auftreten von Pflanzenschutzmitteln in Oberflächengewässern mit landwirtschaftlich geprägten Einzugsgebieten. Z. PflKrankh. PflSchutz, Sonderh. 18**,** 1045-1052,.

3 AUGUSTIN, B., 1990. Biologische Wirkung, Wirtschaftlichkeit, Handhabung und Umweltverträglichkeit von Infrarotstrahlern zur Unkrautbekämpfung im kommunalen Bereich. Pflanzenkrankheiten Und Pflanzenschutz, Sonderheft 12,.: 447 – 453

4 HOLLNAICHER, 1989. Alternativen zum Herbizideinsatz im öffentlichen Grün. Zitiert in Koch, W. ; Döveling, J., (1990). Das Gartenamt 39: 91-93.

5 ANONYM, 1995. Heißwasser gegen Wildwuchs. DeGa Technik 32/95: 1883 – 1885.

6 HENRICHS, J.; SCHEER, E.; SEIFERT, M., 2002. Das ROTOFIX Gerät zur chemischen Unkrautbekämpfung auf ebenen, befestigten Wegen und Plätzen. Mitt. Biol. Bundesanst. 390, 541.

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# Urban areas – source of pesticide-contamination of surface water?

In the past monitoring for pesticide contamination usually concentrated on ground water rather than on surface water. Between 1985 and 1996 450 groundwater checkpoints were sampled. Only Triazins (Atrazin, Simazin) were detected to a certain extent (10 % of samples contaminated). Furthermore Bentazone and Dikegulac were detectable in well water beside the Rhine [1]. These problems were solved, because most Triazins are banned from market and the waste water treatment of pesticide production plants were significantly improved. Despite former reservations, the situation of ground water contamination seems to be relaxed.

## Pesticides in surface water

In Rhineland Palatinate numerous (14-days-mix-) samples of surface water (Mosel, Nahe, Selz) were repeatedly controlled for pesticide pollution between 1997 and 1999. Investigations focused on 35 different active ingredients [2]. Chemical analysis gave various results. Bromoxynil, Metazachlor, Pendimethalin, Propyzamid, Sulfonyl-Ureas, Strobilurines, Terbutylazin, Vinclozolin and most Azole-fungicides did not form substantial residues in the investigated surface water. More often the herbicides Atrazin, Fluroxypyr, Chloridazon, Metamitron and the fungicide Iprodion were found. Regularly present were Bentazon, Diuron, Dichlorprop, Ethofumesat, Glyphosat, IPU, MCPA, Mecoprop, Tebuconazol and Simazin. Especially Glyphosate and Bentazon were detected in all water sources and partly all over the year.

An additional investigation of a sewage disposal plant (“Hahnheim”), which drains into river Selz) clearly showed, that waste water was polluted by the same active ingredients. Pesticide concentration was about ten times as high as in the river water.

Detectable pesticides mostly formed distinct peaks during the investigation periods, which indicates a direct dependence on the application period. This was not the case for Bentazon, Diuron and Glyphosate. Runoff of Diuron from sealed urban areas is well-known, whereas there is no explanation for the unique presence of Bentazon. [3]

Up to now there are no indications for the presence of Glyphosate in drainwater of agricultural areas. Since the herbicide was detectable during the entire year, it is unlikely that it derived from application of farmland, vineyards or orchards. The fact that larger quantities are used on urban areas, let to the presumption, that there might also be runoff from sealed areas.

## Discussion

Building development in Germany is continuously growing. For that reason there is a rising demand for weed control on urban areas in order to preserve traffic and job safety. Because of economic aspects chemical treatments were preferred in the past. Especially high operation speed and working width are significant arguments facing the declining manpower [4].

Meanwhile a rising public sense for environment led to increasing legislative regulations concerning pesticide use on public areas [5,6].

In Germany only a very limited number of herbicides is registered for use on sealed areas. The application of Diuron is banned on areas connected with the sewerage system. For those reasons leaf herbicides are usually applied. Since perennial weeds are causing the major problems, Glyphosate is preferred for weed control on urban areas. Depending on site and weather conditions one to two applications/season are necessary [4].

The run-off study certainly represents a worst case scenario. Nevertheless there are comparable public and private areas treated with herbicides, where rainwater is collected and disposed as waste water. With regard to the contamination of surface water, the results indicate, that leafherbicides are of course less critical as soil herbicides like Diuron. But obviously the run-off procedure lasts longer than expected, which could be an indication of slow release of active ingredients.

Up to now it is not possible to distinguish between the exact causes of the pesticide contamination of surface water within periods without pesticide application. Further investigations must estimate the importance of inadequate handling of pesticides (treatment of roads, leaking equipment) and the relevance of agricultural use.

For those reasons herbicide use on sealed areas with the possibility of run-off in the waste water system, should be limited on non-spray-applications (i.e. Rotowiper®). Non-chemical, alternative methods (etc. Weed Cleaner® ; infrared radiators) should be preferred if possible.

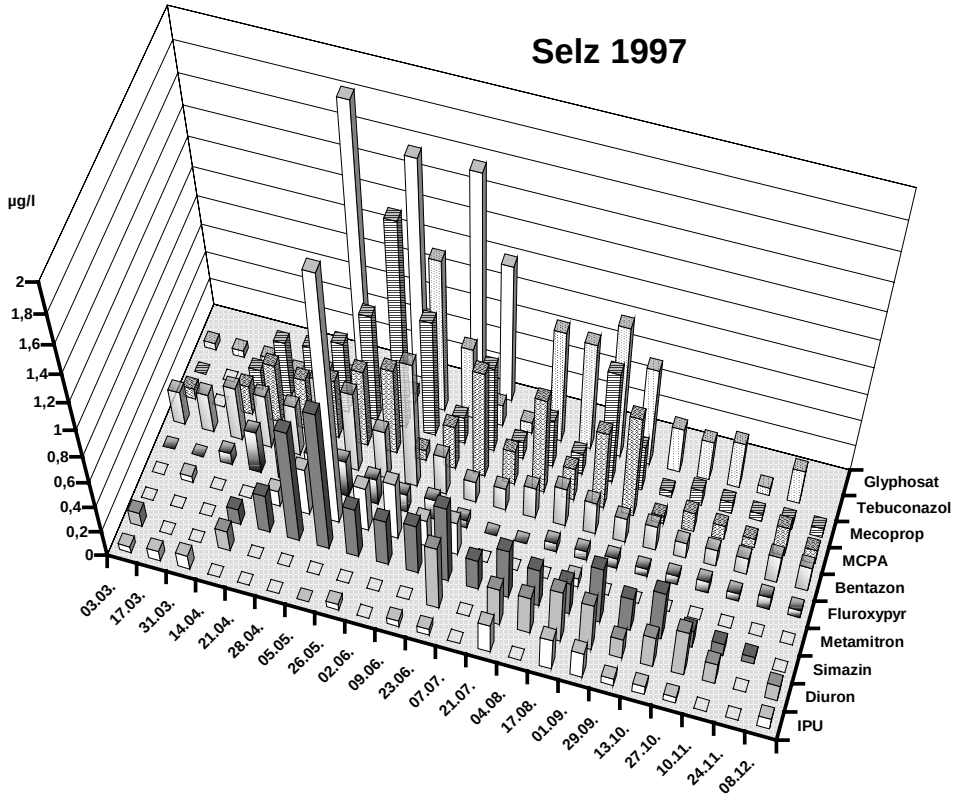


**Fig. 1** Pesticide-contamination of the river Selz (Ingelheim) 1997; analysis of 14-days-mix-samples (□ = active ingredient not detectable or not verified)

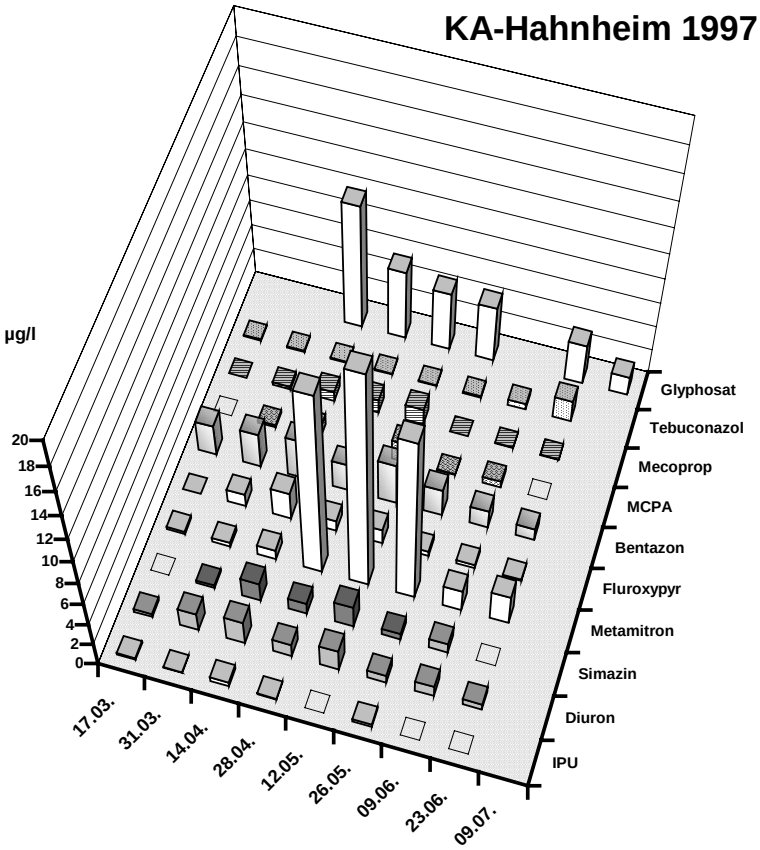


**Fig. 2** Pesticide-contamination of the wastewater treatment plant (Hahnheim) 1997; analysis of 14-days-mix-samples (□ = active ingredient not detectable or not verified)

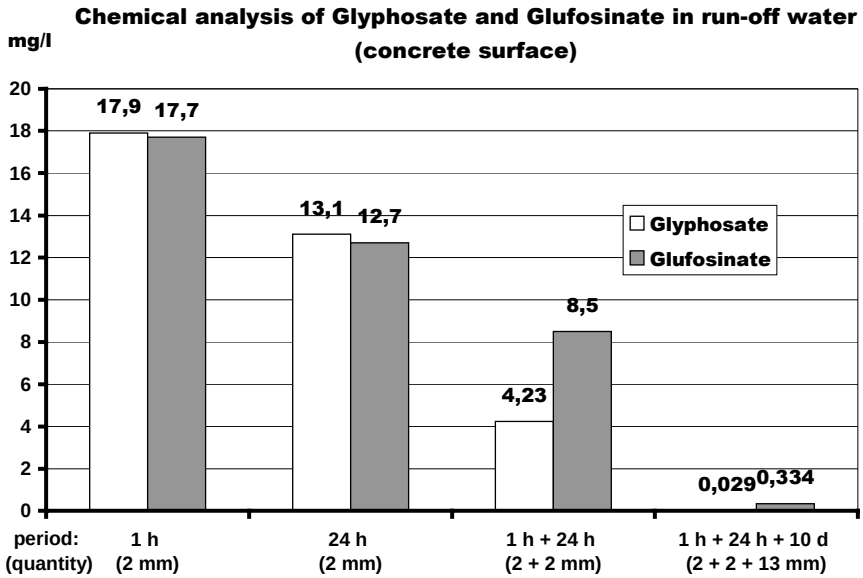


**Fig. 3** Glyphosate (10 l/ha) and Glufosinate (7,5 l/ha) analysed in run-off-water of a concrete surface in dependence of preciptation-period and -quantity.

## Literatur

[1] ANONYM, 2000. Pflanzenschutzmittelwirkstoffe. Grundwasser Bericht 2000, 84-92, Landesamt für Wasserwirtschaft Rheinland-Pfalz.

[2] AUGUSTIN, B., SCHIETINGER, R., ITTEL, I., 2002. Auftreten von Pflanzenschutzmitteln in Oberflächengewässern mit landwirtschaftlich geprägten Einzugsgebieten. Z. PflKrankh. PflSchutz, Sonderh. 18, 1045-1052.

[3] FISCHER, P., H. HARTMANN; M. BACH, J. BURHENNE, H.-G. FREDE, M. SPITELLER, 1998. Gewässerbelastung durch Pflanzenschutzmittel. Gesunde Pflanze, Nr. 5, 142-147.

[4] AUGUSTIN B., FISCHER E., SEIBEL H., 2001. Möglichkeiten der Vegetationskontrolle auf Nicht-Kulturland. Gesunde Pflanzen, 53 (6), 169-176.

[5] AUGUSTIN, B., 1990. Biologische Wirkung, Wirtschaftlichkeit, Handhabung und Umweltverträglichkeit von Infrarotstrahlern zur Unkrautbekämpfung im kommunalen Bereich: Z. PflKrankh. PflSchutz, Sonderh. 12,.: 447 – 453

[6] ZWERGER, P.; EGGERS, TH.; PREUSSENDORFF, G., VERSCHWELE, A., 2000. Zur Situation der Unkrautbekämpfung im urbanen Bereich. Stadt und Grün, Sonderh. 13, 54-60.

# Session 7 - Impact factors in urban stands

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## Occurance, importance and legal regulations of heavy metals in urban stands – an overview

### Introduction

Non-parasitic impairments of plants may be attributable to influences by weather, deficiency or excess of nutrients and noxious organic or inorganic substances in soil. The study of non-parasitic plant impairments is a prerequisite for judging symptoms of damage in plants and taking treatment measures. Plant health is impaired by both lack and excess of major nutrients, namely nitrogen, phosphorus, calcium, potassium, magnesium, and trace nutrients such as iron, copper, and zinc. Low concentrations of noxious inorganic substances effect nutrient deficiency, while higher concentrations often cause specific damage. Phytotoxic effects of chemicals on plants in urban areas are summarised at the 1. International Symposium on Plant Health in Urban Horticulture [2].

The Federal Act on Soil Protection of 17 March 1998 (*Bundes-Bodenschutzgesetz – BBodSchG*, Federal Law Gazette I p. 502) provides for protection of natural and use functions of the soil and for safeguarding its capacity under a preventive point of view. Soils have functions of regulation, production and habitat, which must be protected, and their specific chemical potentials must be secured in the long run. To that end, the Soil Protection Act has been complemented with a regulatory order (*Bundes-Bodenschutz- und Altlastenverordnung, BBodSchV*, of 12 July 1999, BGBl. I p. 1554) which lists a number of test, preventive and action-triggering values. Test values and action-triggering values have been fixed as a measure to assess risks arising with harmful changes in soil or existence of old contamination, and depend on the way the soil is used, and on the paths a noxious substance may take to finally contaminate an object which has to be protected from contamination. Such objects to be protected would be: human health, the quality of food and feed plants, and soil leaching water, that is, potential groundwater. A differentiation among these objects of protection is made when test and action-triggering limit values are set.

Assessment of the transfer of noxious substances from soil to food and feed plants, for instance, is to be based on test values according to § 8(1)2(1) of the Soil Protection Act. Total contents of heavy metals are determined by spectrometry according to standardised procedures after extraction of aqua regia of the air-dried soil sample. The noxious effect is assessed on the basis of plant-available heavy metal contents measured in an ammonium nitrate extract. Annex 1 (BBodSchV) provides a method to measure concentration in soil and other matrices for each test or action-triggering value.

Both federal and state law directly or indirectly set limits on contents of noxious elements in soil to protect water, food and feed. These regulations are called 'loads regulations'. The aim is preventive consumer protection and limitation on entries of noxious elements. Accumulation of noxious substances in soil is to be prevented or at least minimised.

Soils which have, naturally or owing to long-time colonisation, higher background contents of noxious elements are not suspicious as long as release of these substances or additional entry do not have negative effects on the distribution of noxious elements or their transport in the soil-plant system, or on soil functions, according to § 9(2 and 3) of the Federal Regulation on Soil Protection (BBodSchV).

Contents of nutrients and noxious elements in plant material, soil and soil additives, fertilisers, soil solutions and leaching water are analysed using modern analytical methods, such as atomic adsorption and emission spectrometry and polarography. Contents measured are the basis of treatment measures and adaptation of limit values for noxious substances in plants and soil set to protect consumers.

**Tab. 1** Test, action-triggering and preventive values for metals and semi-metals under Federal Soil Protection Regulation (BBodSchV)

| Path | Type of value | Elements | Specification |
|---|---|---|---|
| Soil | Preventive values | Pb, Cd, Cr, Cu, Ni, Hg, Zn | Total contents for clay soils, loam/silt, and sand, plus annual loads |
| Soil/man | Test values | As, Pb, Cd, Cr, Ni, Hg | Direct uptake; total contents in playgrounds, residential areas, park and leisure areas, industrial and business premises |
| Soil/ground-water | Test values | Sb, As, Pb, Cd, Cr, Co, Cu, Mo, Ni, Hg, Se, Zn, Sn | Leaching water; object to be protected: drinking water |
| Soil/crop plant | Test values, action-triggering values | As, Pb, Cd, Hg, Tl | Cropping and hobby gardens (Plant quality); total contents in aqua regia extract or plant-available contents in $NH_4NO_3$ extract |
| Soil/crop plant | Action-triggering values | As, Pb, Cd, Cu, Ni, Hg | Grassland (plant quality); total contents in aqua regia extract |
| Soil/crop plant | Test values | As, Cu, Ni, Zn | Grassland (growth impairment); plant-available contents in $NH_4NO_3$ - extract |

## Total contents of heavy metals in soils

Geogenic differentiation and anthropogenic input of substances lead to various levels of heavy metals in soils. Anthropogenic input comes from mining, industrial and household waste and sewage, farming and forestry, and atmospheric deposition.

In the framework of a screening study for background loads of noxious elements in urban and in rural areas, the total contents of cadmium as a representative element and of other heavy metals in the upper soil layer (0-30 cm) in BBA experimental fields in Berlin-Dahlem (Figure 1) and Dahnsdorf (Figure 2) were measured [1]. The measurements of total contents of heavy metals in soil serves to assess the potential risk emanating from heavy metals to man, animal and the natural balance.

The 7.1-ha trial field in Berlin-Dahlem is situated in a central urban area. The soil consists in loamy sand, partly with leached brown soil, over a very thick clay layer in 2 m depth. Soil quality is rated with an average 40 points.

The average content of cadmium measured in 132 sampling points is 1.36 mg Cd/kg soil in soil from 0 to 30 cm deep. The maximum level was 13.87 mg Cd/kg soil, minimum level was 0 mg Cd/kg soil. The preventive level for Cadmium according to Soil Protection Regulation is 1.5 mg/kg soil. It is exceeded in 20.3% of measurements, while 101 measurements produced levels below the preventive value of 1.5 mg/kg.

The BBA trial field at Dahnsdorf is located between the town of Belzig and the A9 motorway, some 100 km south of Berlin in a traditional rural area. Predominating soil types are leached brown soil (45%), brown soil and leached brown soil (30%), and regosol brown soil (15%). Soil quality is rated with an average 47 points.

The preventive value for cadmium levels of 1.5 mg/kg soil **is not exceeded in any case**.

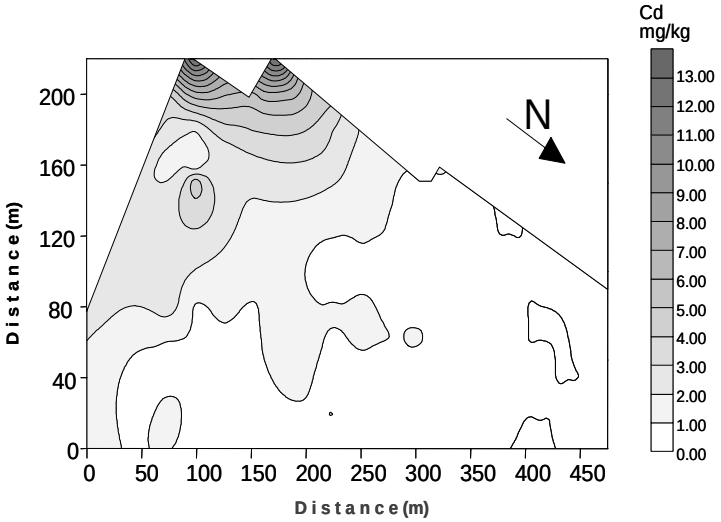


**Fig. 1** Variability of cadmium levels in urban soils (0–30 cm) on the examples of the BBA experimental field in Berlin-Dahlem

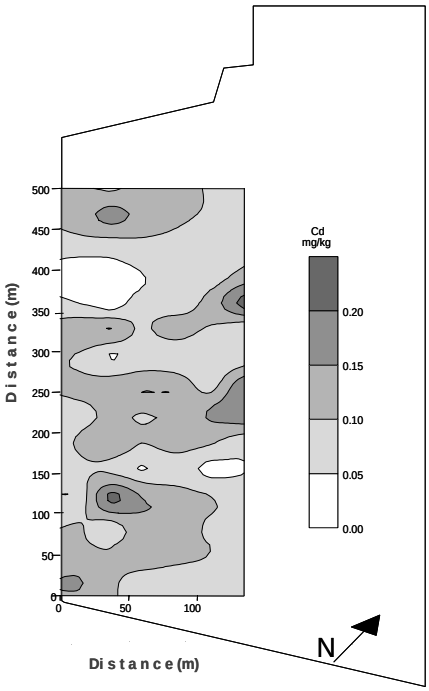


**Fig. 2** Variability of cadmium levels in rural soils (0–30 cm) on the examples of the BBA experimental field at Dahnsdorf

The picture is similar for other noxious elements (heavy metals) studied. Direct contamination stemming from industry, households and exhausts takes contaminant loads in conurbations to two to three times the levels found in rural areas.

Determination of total contents of noxious elements in soil is a basis for assessing the potential risk of heavy metals to man, animal and the natural balance. If legally fixed levels are exceeded, available portions of noxious elements must be assessed with a view to the particular objects to be protected.

## Soil-to-plant path of heavy metals

Availability of noxious elements agricultural soils

Transfer of noxious elements into the food chain via the soil-to-plant path depends on soil parameters, levels of noxious elements and their availability to plants.

Copper uptake by crop plants as a function of total copper contents in soil has been studied in a ten-year model trial [3]. The trial was made in the following soils:

Soil No. 1: Soil loaded with geogenic copper (*Schladen*, southern *Harz* mountains) in an agricultural region with a cropping history reaching back to the Middle Ages. Soil contained 183 mg Cu/kg, with high contents of organic matter (> 5%) and a clay portion of > 8%.

Soil No. 2: Contaminated loamy sand (Berlin), with Cu levels of 71 mg/kg, 2.8% organic matter and 5% clay.

Soil No. 2, cleaned: Contents of clay and organic matter were below 1% after the soil had been cleaned. Cu levels after cleaning were 25 mg/kg, that is, below the preventive levels fixed by the Federal Soil Protection Regulation for agricultural or garden soils.

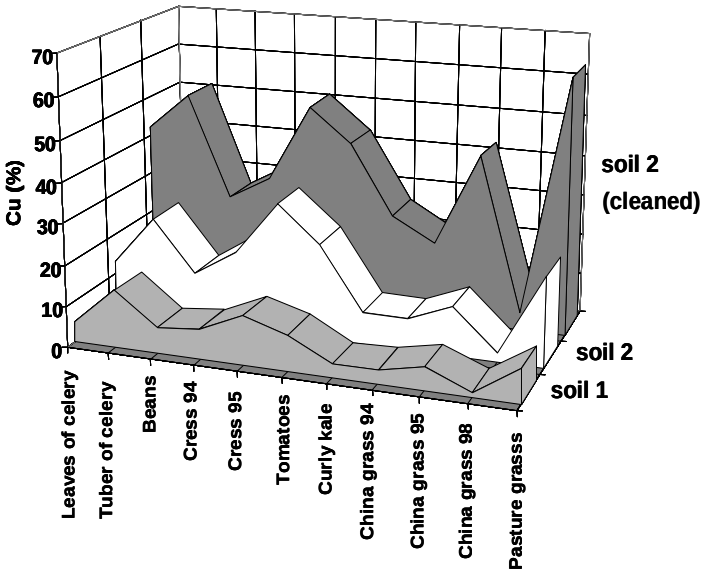


**Fig. 3** Uptake of copper by crop plants as a function of plant-available copper portions

The findings shown in Figure 3 are basically comparable with results of other studies in urban and agricultural soils. While account must be taken of the particularities of every single case, the following statements apply also to other heavy metals:

1. Crop plants accumulate noxious elements. These are accumulated to various degrees in different plant parts, for instance in tuber and leaf of celery.
2. Total contents in soil do not allow any conclusions about the loads to be expected in crops.
3. 'Old contamination' is bound to the organic matter or to clay and silt portions in the soil, and therefore only to a small degree available to plants.
4. In general, it is of little use to take measures to reduce total contents of noxious elements which may, on the other hand, destroy the soil structure and affect absorption capacity of the soil in the long run (Figure 3).

Heavy metal contents in crop plants (example: copper)

In another case, copper contents were studied with a view to the questions

- whether high levels of noxious elements in agricultural soils have negative effects on the distribution and transport of heavy metals in the plant-soil system *per se*, and
- whether one can preclude a risk to consumers under worst-case conditions such as intensive treatment crops with products containing high levels of copper, as made under the design chosen for the trial.

For the purpose of that trial, soil with high copper levels (old contamination) was chosen to simulate conditions as if with elevated geogenic copper levels, or levels found after long-time application of cooper such as in vineyards, orchards, or hops. Plot number 24 in the Berlin-Dahlem trial field was intentionally fed with large amounts of copper more than 30 years ago. Soil from that plot contained 216 mg Cu/kg dry substance. It was used in small-scale lysimeter studies and compared with uncontaminated (urban) soil from plot no. 27 (26 mg Cu/kg soil dry substance) and soil from plot no. 25 (11 mg Cu/kg soil dry substance) which had been fed with coke cinders until 40 years ago [5, 6].

**Tab. 2** Important parameters and element contents of soils used in lysimeter studies

**Soil parameters**

| Plot no. | pH | Organic matter (%) | Sand (%) 2-0.0063mm | Silt (%) 0.0063-0.002mm | Clay (%) <0.002mm |
|---|---|---|---|---|---|
| F25 | 6.3 | 1.6 | 74.8 | 20.6 | 4.7 |
| F27 | 6.7 | 3.0 | 91.6 | 8.1 | 0.3 |
| F24 | 6.6 | 3.3 | 73.1 | 19.2 | 7.8 |

**Element contents after pulping of aqua regia in mg/kg soil (dry matter)**

| Plot no. | ICP | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | As | Cd | Cu | Pb | Al | B | Ca | Fe | K | Mg | Mn | Na | P | Zn |
| F25 | 3.3 | 7.8 | 11 | 21 | 5649 | 4.5 | 1362 | 7116 | 1154 | 1090 | 510 | 12 | 511 | 43 |
| F27 | 2.4 | 0.6 | 26 | 54 | 3229 | 4.2 | 4660 | 5709 | 488 | 903 | 204 | 11 | 681 | 106 |
| F24 | 3.9 | 7.8 | 216 | 32 | 6909 | 9.1 | 2978 | 9020 | 1505 | 1399 | 398 | 17 | 894 | 83 |

The revised Feed-stuffs Regulation says, in Annex 3 (§§ 16 to 18, 21, 22 and 26), that copper-containing compounds may be added to feed-stuffs to certain maximum amounts (specified in mg/kg sole feed-stuff) related to 88 per cent of dry matter.

The question whether transfer of soil-borne copper can have implications with regard to feed law and whether elevated copper levels in the 'copper plot' impair crop plant growth was studied on the example of one monocotyledonous crop plant (maize) and a dicotyledonous crop plant (rape-seed) (Table 3). Rape-seed was chosen for the study because its high potential to accumulate heavy metal was known from earlier trials.

**Tab. 3** Test of copper availability to crop plants in soils with and without copper loads, and with characterised soil parameters. Copper contents in silage maize, maize grain, rape leaves, mill cake and oil

| | | Silage maize 16. Aug. 2000 | | Rape seed 30th week | | |
|---|---|---|---|---|---|---|
| **Soil** | **aqua regia** | **Plant** | **Grain** | **Leaves** | **Mill cake** | **Oil** |
| | **mg Cu/kg** | **mg/kg dry substance** | | **mg/kg dry substance** | | |
| F 25 | 11 | 6.9 | 3.4 | 2.3 | 4.7 | 0.12 |
| F 27 | 26 | 7.3 | 3.4 | 3.1 | 5.6 | 0.14 |
| F 24 | 216 | 13.0 | 5.4 | 22.9 | 7.4 | 0.20 |

Feed-stuffs Regulation: > 15 mg Cu/kg (related to 88 per cent of dry matter)

In maize grain, the prescribed limit value of contents in crops was found in no case exceeded, independent of total contents in soil. In spite of large differences in total contents in uncontaminated (urban) soil (plot no. F 27) and contaminated 'copper' soil (F 24), contents in harvested maize grain and rape-seed mill cake used for fodder differed only slightly and were normal in all tested variants.

In another test, field tomatoes were treated in two variants with twice the authorised dosage of copper (3.5 kg Cu/ha) and with the maximum annual amount allowed under EU Council Regulation No. 2092/91 on ecological farming of 24 June 1991, which allows 8 kg copper per hectare (Figure 4). The aim was to find out from which dosage on one would have to expect negative effects on copper distribution and transfer in the plant-soil system [5, 6].

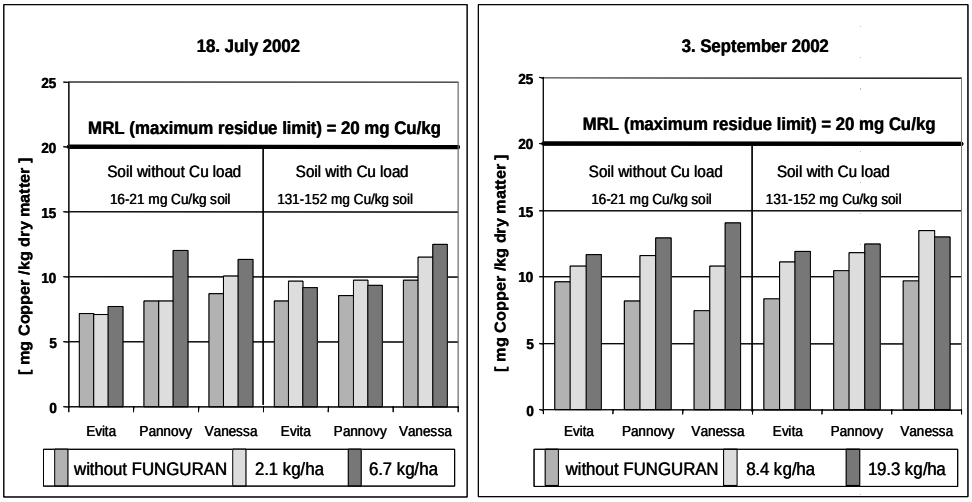


**Fig. 4** Cu contents in washed tomatoes of various varieties after deliberately overdosed treatment with FUNGURAN in the field in soils with different Cu contents at two dates of sampling

Under worst-case conditions as chosen for the trial (Cu content in soil up to ten-fold higher than normal, dosage of up to 8.0 kg per ha and year), treatment with copper chloride oxide did not have any negative effects on the distribution and transfer of copper in the plant-soil system because only minute portions of geogenic copper are actually available to plants. Even after treatment with 8 kg Cu/ha (19.3 kg FUNGURAN) and elevated background contents in soil, copper levels in samples of harvested field crop were in the normal range. This means that a risk to consumers from overdosed copper treatments can practically be excluded.

But because of the fact that overdosed copper treatments may raise total levels in soil, and because intolerable accumulation of copper in soil can only be precluded when dosage of 3.5 kg Cu/ha and year is not exceeded – that is, when input and discharge of copper are roughly in a balance – new treatment alternatives, including new copper compounds, must be developed before too long.

## The soil-water path of heavy metals

If test, action-triggering or preventive values according to the Soil Protection Regulation were exceeded, this was usually because of old loads existing in that particular place or loads stemming from general contamination in the surroundings of conurbations. Analysis of total contents of noxious elements in soil through analysis of aqua regia extract serves to assess the potential risk emanating from heavy metals to man, animal and the natural balance. If prescribed values are exceeded, plant-available portions of noxious elements must be assessed with a view to the objects to be protected (crop harvested, water), because total contents in soil alone do not allow conclusions on loads to be actually expected in crops. For a general evaluation of noxious elements in soil it is therefore of decisive importance to assess their concentration in soil solution (leached water), because both transfer into plants (and thus, the food chain) and leaching to ground water (source of drinking water) takes place by dissolution.

Transfer of copper as a function of soil parameters and crop growth after use of 4 kg Cu/ha and year was studied by analysis of leaching water from lysimeters at three sampling dates and by determination of Cu levels using ICO-OES (Fig. 5).

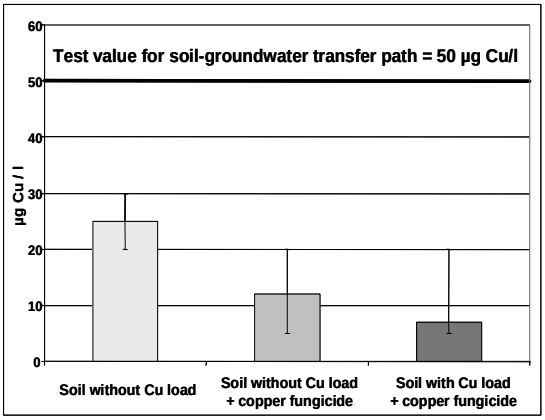


**Fig. 5** Cu levels in leaching water in urban (F 27) and in Cu-loaded soil (F 24) after six treatments with copper and without copper treatment at three sampling dates

Assessment of copper availability of in the soil-groundwater path has shown that the test value of 50 µg Cu l/L applying for soils according to § 8 (2) 1 of the Federal Soil Protection Act in conjunction with § 4 (7) of the Federal Regulation on Soil Protection, **is not reached in any case**. Small-scale lysimeter studies did not show that input of 4 kg Cu/ha would have any negative influence on Cu levels in leaching water.

On the other hand, it is not possible to make general statements on the real risk to groundwater, because prognoses about transfer into the groundwater aquifer can only be made on the basis of concrete values determined for a specific site.

## Rehabilitation measures

Plants are accumulating heavy metals to different degrees. As a rule of thumb, one can say that, the higher the transpiration rate (large leaf surface), the more intensive is transport of noxious substances by the transpiration stream into upper plant parts. Choice of adequate crops and alteration of soil parameters (applying lime, humus or clay minerals) may minimise or prevent plant damage by noxious elements such as heavy metals in soil (Figure 6).

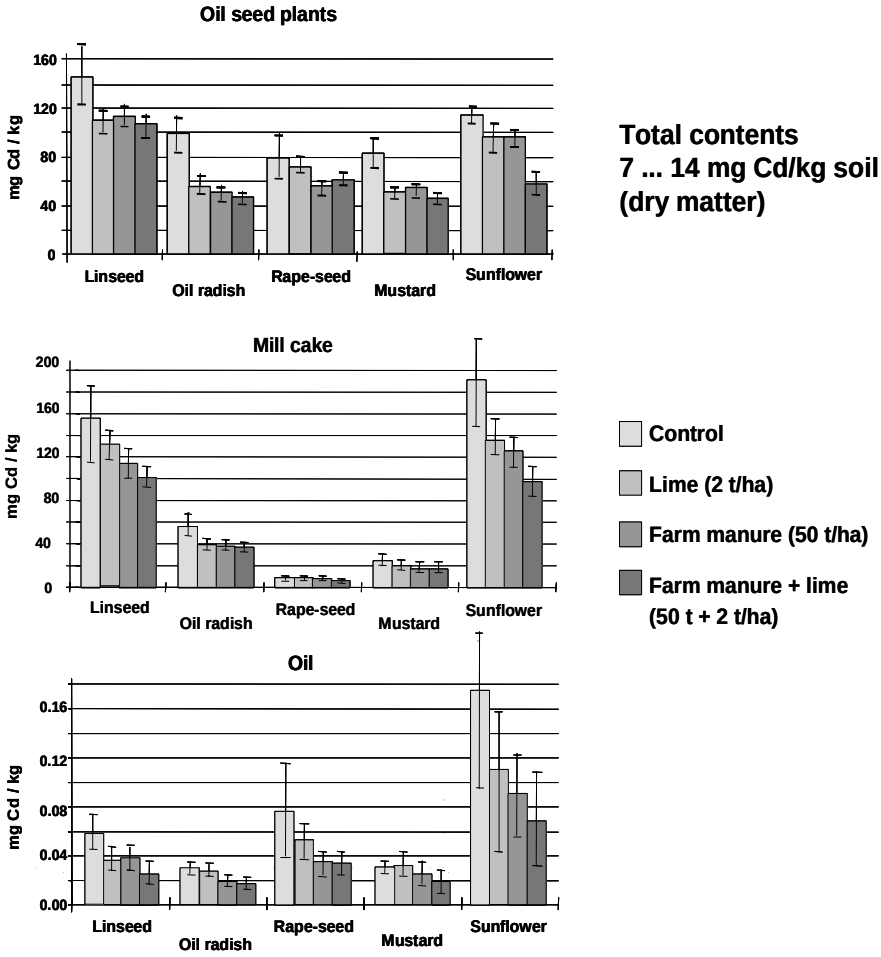


**Fig. 6** Uptake of cadmium in selected oil-seed crops, mill cake and oil as a function of various soil rehabilitation measures [limit value (feeding-stuff law) = 1 mg Cd/kg (referred to 88% dry matter)]

Careful choice of varieties (different varieties of leaf or root vegetable crops) can also help to reduce levels of noxious elements in crops grown on soils with elevated levels of such elements [4].

## Summary and Conclusion

- Contents of noxious elements are directly or indirectly limited by legal regulations ('load regulations') applying to special objects of protection (soil, water, food products, feed-stuffs).
- Determination of total contents of heavy metals in soil serves to assess the potential risk emanating from heavy metals to man, animal and the natural balance.
- Transfer of noxious elements into the food chain via the soil-plant path depends on soil parameters, levels of noxious elements in soil and their availability to plants.
- If levels are higher than limit, test, or action-triggering values prescribed in the Soil Protection Regulation, this is attributable to local 'old loads' of various origin, or to general contamination in the surroundings of conurbations. If prescribed values are exceeded, plant-available portions of noxious elements must be assessed with regard to the objects to be protected (crop harvested, water), because total contents in soil alone do not allow conclusions on the loads to be actually expected.
- Alteration of chemical and physical soil parameters (liming or adding humus or clay minerals) minimises or even prevents plant damage by noxious substances in soil.
- Heavy loads of noxious elements require action, i. e., measures of soil rehabilitation, which must be agreed with the competent authority.

## Literature


1 PESTEMER, W., KLEMENTZ, D., REESE-STÄHLER, G., SCHÖNHARD, G., TRAULSEN, B., 1996. Langzeitversuch „Integrierte Unkrautbekämpfung“ am Versuchsstandort Glaubitz der Biologischen Bundesanstalt für Land- und Forstwirtschaft. Teilthema 3: Erfassung der horizontalen Variabilität von Bodeneigenschaften, Schwermetall-, Nährstoffgehalten und der Herbizidrückstandssituation - Visualisierung in Szenariokarten des Expertensystems PEMOSYS. Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft (Berlin-Dahlem), H. 321, 228.

2 PESTEMER, W., 2000. Phytotoxic effects of chemicals on plants in urban areas – an overview. In: International Symposium on Plant Health in Urban Horticulture (Eds. G. F. Backhaus, H. Balder & E. Idczak) Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft (Berlin-Dahlem), H. 370, 118-125.

3 TRAULSEN, B.-D., SCHÖNHARD, G., PESTEMER, W., 1997. Erfassung, Beurteilung und Sanierung schadstoffbelasteter Böden in Ballungsräumen. In: Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft, no. 328, p. 193-198, Berlin 1997.

4 TRAULSEN, B.-D., STRUMPF, T., SCHÖNHARD, G., 1998. Effects of soil additives on cadmium uptake of agricultural crops. Nachrichtenblatt Dt. Pflanzenschutzdienst 50 (10), 263-267.

5 STRUMPF, T., TRAULSEN, B.-D., PESTEMER, W., 2002. Verfügbarkeit von Kupfer in landwirtschaftlich genutzten Böden mit hohen Kupfer – Gehalten. I. Eine Bestandsaufnahme. Nachrichtenblatt des Deutschen Pflanzenschutzdienstes (Braunschweig) 54 (7), 161-168.

6 STRUMPF, T., TRAULSEN, B.-D., PESTEMER, W., BODE, E., 2002. Verfügbarkeit von Kupfer in landwirtschaftlich genutzten Böden mit hohen Kupfer–Gehalten. II. Auswirkungen von Kupfereinträgen. Nachrichtenblatt des Deutschen Pflanzenschutzdienstes (Braunschweig) 54 (9), 226-232.

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# Reduction of the damage of de-icing salt on trees by a different winter-service

## Introduction

De-icing salts (primarily sodium-chloride) are used in Germany for the street-winter-service since 1960; since the seventies apathetic materials, like sand or grit, were applied alternatively. Starting from the very beginning their respective effects on the environment (phytotoxity, corrosion, health-endangering of human being and animal, impact on ground and groundwater etc) were monitored by scientists. Research is focussed to find possibilities to minimize or avoide their damaging effects [4, 5, 6, 8, 9]. Since than the legal framework for the application of de-icing salts has changed and innovative technical improvements were made:

- In many cities and communes, de-icing salt-prohibitions were enacted step-by-step for certain areas and so-called 'emergency plans' were introduced.
- Technical improvements (i.e. electronically regulated application devises) allow for a well directed output.
- Since the end of the 1980's 'moist-salt' (NaCl FS 30, which is 70% NaCl and 30% salt-solutions) is mostly used.

As a consequence on many streets no de-icing salt is applied anymore since a few years and on salt-routes the expenditure-quantity has been lowered simultaneously from previously 40 g/m² dry-salt to nowadays a maximum of 25 g/m² moist-salt per use. On German highways, where in the sixties and seventies the phytotoxic effect of de-icing salt was unknown and 15 to 50 t salt/km were used (depending on the traffic), the salt-quantities were clearly decreased in the eighties to under 10 t salt/km (Umweltbundesamt, 1980) already. Today, the consumption is reduced even further through the introduction of a winter-service in so-called operating-steps in many areas and is depending on the annual requirements in Berlin between 0,05 to 0,35 kg/m² [3]. From these facts it becomes evident that the times of an uncontrolled use of de-icing salt are gone a long time ago. The exposure to ground and vegetation in the streets has decreased clearly visibly years ago, which is backed by comparative studies of different winter-services [1, 2, 7].

As the latest development, a so-called different winter-service offers another reduction of the salt-quantities. This can be understood as the best possible compromise between roadworthiness, environmental protection and thrift. Differentiation means that the same strategy is not applied on all streets and with each weather-situation; instead it is varied locally in accordance to the requirements of restricted and adapted measures. The varied winter-service comprises also the possibility of the prelude of preventive-measures with particular weather-conditional prerequisites. These beforehand proposed low moist-salt-quantities are adherent to the carriageway and help avoiding the origination of slipperiness in case of a slipperiness-forming condition. In a three-year project in co-operation with the official bureau of plant-protection Berlin, the Berlin city-cleaning-businesses (BSR) and the ministry of urban-development the ecological consequences of this winter-service-technology were studied.

## Material and methods

A particular winter-service was operated on especially selected streets in a Berlin borough (Reinickendorf) during the winters 1999/2000, 2000/2001 and 2001/2002 :

- Street-sections which were not contaminated since 1975 with de-icing salts were the control group (tree-type: *Tilia cordata*)
- A comparable street-section was exposed to the varied winter-service (tree-type: *Acer platanoides* "Globosum").
- One street got conventional treats like years ago after operating-step 1, i.e. in the normal case use of grit, FS 30 at crossings or salt (tree-type: *Acer platanoides*).
- A street of the operating-step 1 was now treated according to the varied winter-service (tree-type: *Acer platanoides* "Globosum").
- Test-points were furnished additionally at exits of highways to pull the situation on salt-intensive street-sections as a comparison (tree-type: *Acer campestre*).

Specifically assigned personnel of the BSR enforced the winter-service on the pilot-routes (11.970 m extents) and the official bureau of plant-protection Berlin was responsible for checking the street-trees on symptoms as well as for the ground-tests at the roadside and the sampling of leaf-material (September 2001) to determine the sodium and chloride concentration. In each case three tree locations of each winter-service-variation became standardized tested, the laboratory-analyses of the ground- and plant-tests took place from a special-laboratory.

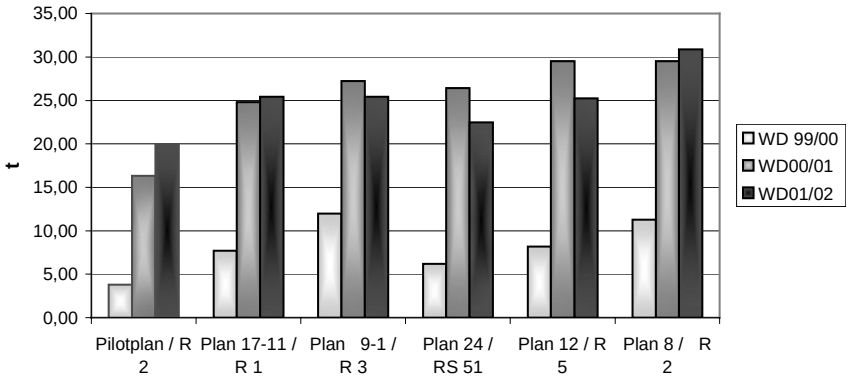
## Results

The winters in the test years were very different in respect to their frost- and ice-days as well as their precipitation-events. While only few de-icing salts had to be proposed in the mild winter 1999/2000, the following two winters necessitated a more intensive de-icing effort. This is reflected in the salt-quantities proposed in each case, the use-numbers as well as in the chloride- and sodium-concentration of ground and plant. The consequences of the different winter-service-form become therefore evident.

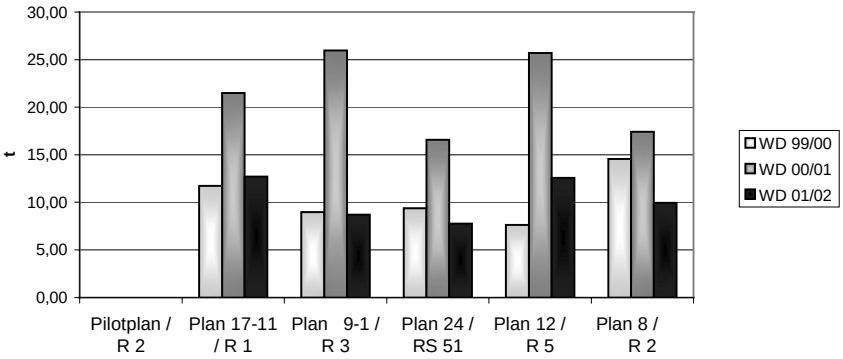
Salt-quantities in comparison of the winter-services

First it was from interest whether deviations were noticeable because of the procedure of the different winter-service in comparison to the conventional form for the proposed salt-quantities and with the operating-frequency of the vehicles. Evidence was given by the comparison of similar streets, length of the work-kilometres, number of the salt-points, area- as well as street-structure, that clearly more inferior salt-quantities were required by the varied winter-service, unrelated to the temperatures of a winter (fig. 1). The comparative routes were incriminated additionally in every winter with grit; 26 tons of grit had to be used in the most extreme case. The effort of salt-actions is usually higher in the varied winter-service however, for example in the winter 2000/2001 with approximately 50 applications versus conventionally 36 to 47. In comparison to the mild winter 1999/2000 were in the following years on the pilot-route (varied winter-service) four or five times as much salt necessary, the action-frequency was even doubled in the winter 2000/01. Salt-quantities and -actions are therefore directly dependent on the respective winter-situation.

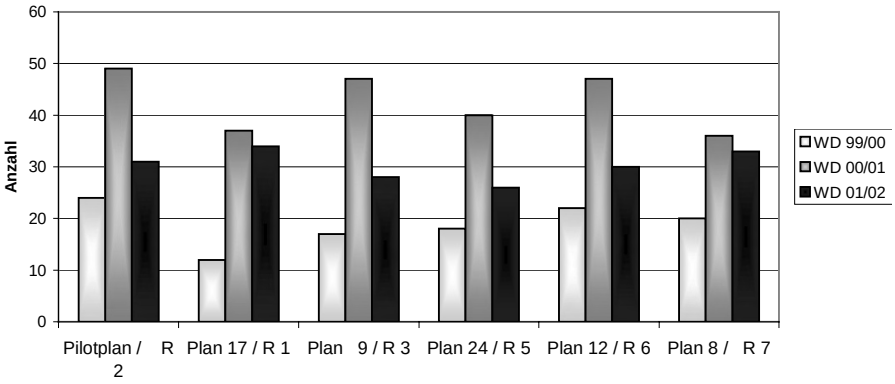
The positive effects of the varied winter-service appear also in the calculation of the average salt-quantities per m² carriageway: with an assumed middle application-width of 6m and covered on the total-route, 252 g/m² NaCl were proposed on the pilot-route in the winter 2000/2001 for example, 417 g/m² were proposed on the comparison-routes of the "normal winter-service". From this, a saving-potential of approximately 40% was achieved in this winter. The action-frequency was about 59% higher however.




a) Salt-quantities




b) Grit-quantities




c) Number of actions

**Fig. 1** Salt - and grit-quantities as well as the number of the salt-actions in the comparison of the winter-service-forms (Pilotplan=varied winter-service, left) in the winters 1999/00 until 2001/02 in Berlin

Ground-situation

The intensive de-icing-use on highways led to the known increases in the chloride- and sodium-concentration in the ground. In the hard winter 2001/2002, both elements increased in dependence on their mobility quickly in the deeper ground. Chloride reached with virtually 40 mg/100 g soil as well as sodium with over 40 mg/100 g soil a multiple of their situation to winter-beginning. Simultaneously, the potassium-concentration is reduced through the repression-process caused through the sodium, fig. 2.

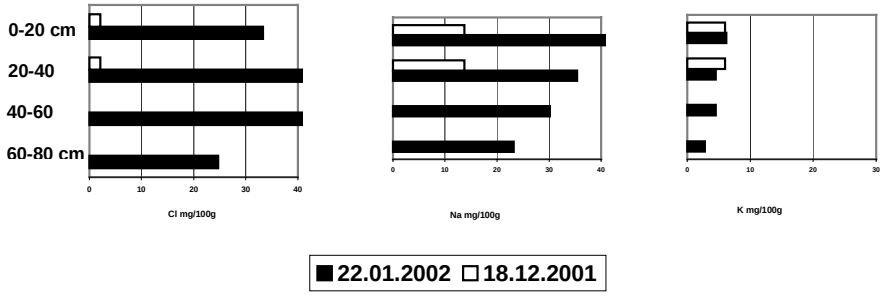



**Fig. 2** Increase of the chloride- and sodium-concentration in all ground-depths after intensive de-icing-salt use with simultaneous decrease of the potassium-concentration at the highway

On the conventional winter-service-route (E 1) moist de-icing salt was proposed predominantly in the test-area in crossing-areas and at dangerous points, so the soil in this section was analyzed well-directed. Also here was verifiable the increase of the chloride- and sodium-concentrations as consequence of the salt-input, was however essentially more inferior with in each case under 5 mg/100 g soil, fig. 3.

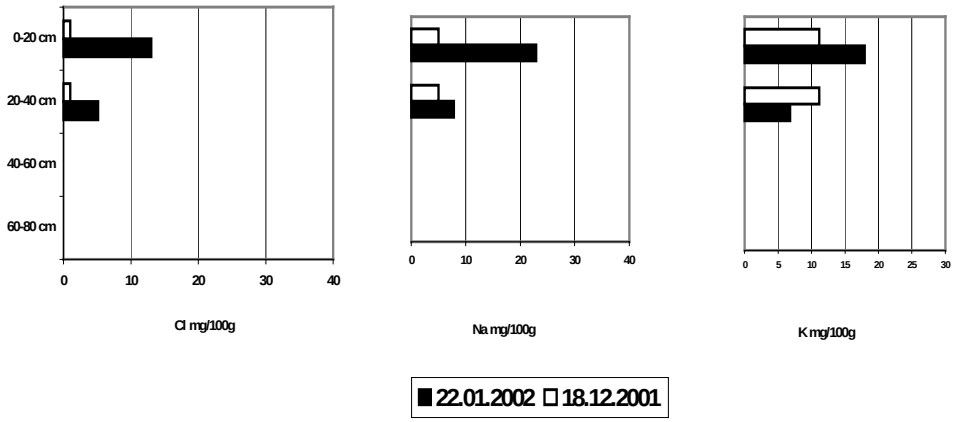



**Fig. 3** Increase of the chloride - and sodium-concentration in dependence on the ground-depth with conventional winter-service (E 1) with two test areas

The pilot-routes showed even more inferior substance-inputs. Especially the test-route, that was treated since 1975 with de-icing salt no longer (E 2), still yielded an increase in the concentration (fig. 4) in the comparison to the untreated street with chloride with the sodium neither. The potassium-values are clearly lower obvious as consequence of the long-time salt-use.

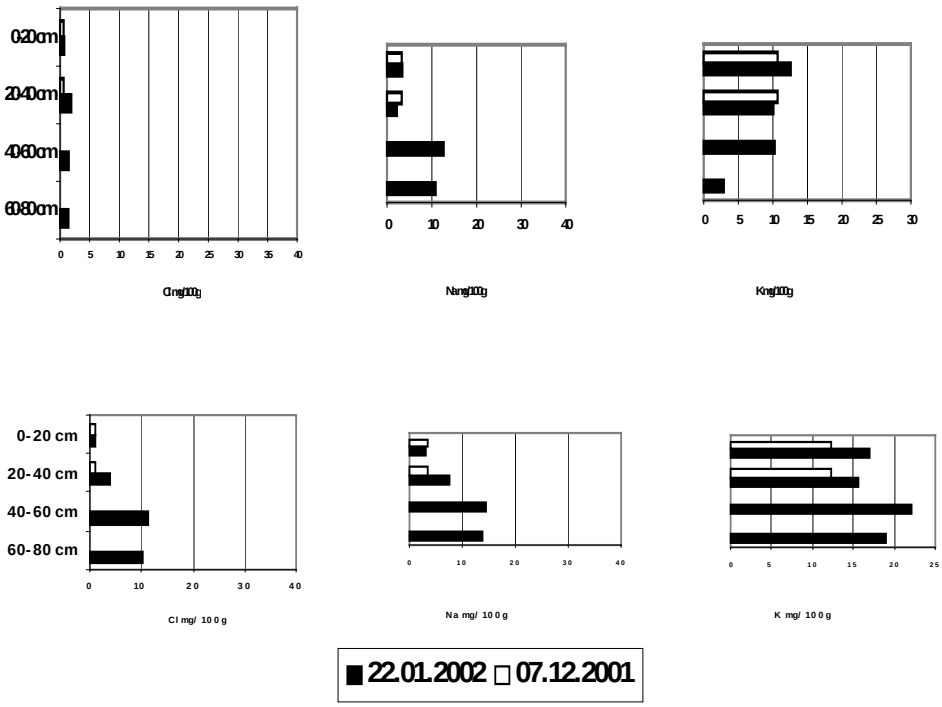



**Fig. 4** Development of the chloride-, sodium- and potassium-concentration in different ground-depths with varied winter-service (E 2) (above) in the comparison to the untreated route in the winter 2001/2002

Symptoms and leaf-concentrations

The check on leaf-damages after the winters yielded that no characteristic salt-leaf-damages were visible at all test routes in contrast to the intensive salt-routes (highway) until end of July at the trees. Only at the end of the vegetation-periods (September), small salt-symptoms could be observed at the conventional winter-service-routes (E 1) in the area of crossings and transitions, between the salt-points the trees were symptom less however. At the routes of the varied winter-service could be discovered no symptoms however up to now. These results are confirmed by the leaf-analyses, fig. 5. On the highway the chloride- and sodium-concentration is high, simultaneously the potassium-concentration is low in comparison at the vegetation of the control. Also the trees of the operating-step (E 1) treated routes were characterized through elevated values, especially the trees with salt-symptoms showed the higher chloride- and sodium-concentration. The trees in the variation "varied winter-service" showed no increases in the chloride- and sodium-concentration.

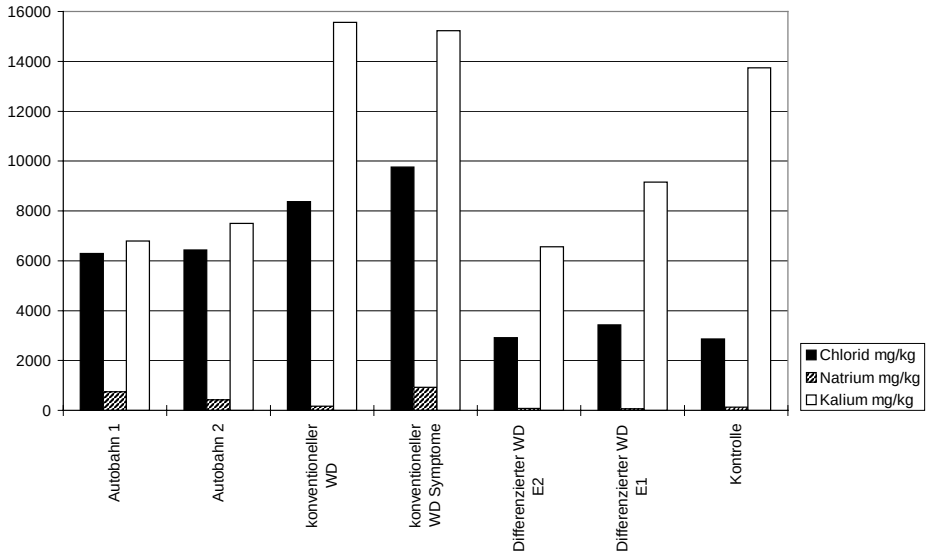



**Fig. 5** Leaf-concentrations of chloride, sodium and potassium after different winter-service (from: Balder etc. , 2002)

Altogether the application of de-icing salt didn't lead after a varied winter-service to an increase of the chloride- and sodium-concentration up to now as they were proven at the intensively treated street-sections. This covers the altogether low salt-load although accumulating effects cannot be excluded with a consequence of hard winters also in the varied winter-service.

## Discussion

The three-year studies clearly demonstrated that a different winter-service lead to reduced de-icing problems than the conventional forms. Even in a hard winter, clear reduction-potentials, that mean a lasting relief of the ecosystems consequently, can be achieved hereby. This must on the part of the operators worked for higher action-numbers however.

Also a varied winter-service is reflected in material-inputs in the area of the street-trees. The mobile and for the plants phytotoxic chloride is low in the concentration found up to now and washed out quickly at sandy grounds again. However the increase of the sodium-concentration is easily and don't reach the concentrations of former years (>20 mg/100 g soil) after a winter, accumulating effects over the years with corresponding winters are to be expected however. At loamy grounds, leaching-processes allowed to slow and adsorption-processes are reinforced.

As total reaction, the leaf-symptoms can be assessed at the trees. They had ascended after the hard winter 2001/01 in Berlin at the highways, which the demand underscores markedly after sparing procedures, disjointed. The previous winter-service (E 1) has led in Berlin to a noticeable relief of ground and vegetation already for years [1, 2], so that salt-symptoms at the E 1 - routes only at the salting-points in the cityscape after corresponding winters appears. The determined leaf-concentration is low accordingly. Since the salt-quantity through a varied winter-service even further is reduced, the more inferior load is covered for the vegetation and the ground. Even lies the leaf-concentration determined on the pilot-routes in the same concentration-area as with trees of untreated streets, so that de-icing salts obviously hardly find the way into the plant. The development of an use of several years nevertheless needs the scientific check up.

The new technology of the winter-service offers communes and cities the possibility, on the routes with salt-application through the utilization modern technology and better weather-prognosis locally adapted strategies and goal-oriented preventive measures to seize and to lower the salt-loads for vegetation, ground and groundwater markedly.

## Summary

The use of de-icing-salt on urbane streets was the cause of many visible damages on roadside trees in the seventies. Alteration in the legal framework and technical improvements led to a more environmental responsible operation of winter services in recent years. Nowadays a complex varied winter-service is suitable for a further reduced application of de-icing-salt in practise.

## Literatur

1 BALDER, H., NIERSTE, 1988.Revitalisierung streusalzgeschädigter Straßenbäume durch einen umweltfreundlichen Winterdienst. Das Gartenamt 37, 205-208

2 BALDER, H., 1990. Untersuchungen zur Revitalisierung streusalzgeschädigter Straßenbäume. Gesunde Pflanzen 42, 356-361

3 BALDER, H., BECKER, W., 2002. Untersuchungen zur Belastung von Straßenbäumen bei differenziertem Winterdienst. In: Dujesiefken, D., und Kockerbeck, P.: Jahrbuch der Baumpflege, 187-195. Thalacker Medien, Braunschweig

4 BROD, H.-G., 1993. Langzeitwirkungen von Streusalz auf die Umwelt. Berichte der Bundesanstalt für Straßenwesen. Verkehrstechnik, Heft V 2. Wirtschaftsverlag NW, Bremerhaven, 165 S.

5 ECKSTEIN, D.; FRISSE, E., LIESE, W., 1974. Holzanatomische Untersuchungen an umweltgeschädigten Straßenbäumen der Hamburger Innenstadt. Eur. J. Forest Pathol. 4, 232-244

6 LEH, H.-O., 1973. Untersuchungen über die Auswirkungen der Anwendung von Natriumchlorid als Auftaumittel auf die Straßenbäume in Berlin. Nachrichtenbl. Dt. Pflanzenschutzd. 25, 163-170

7 LEH; L.-O., 1990. Untersuchungen über die Auswirkungen des tausalzfreien Winterdienstes auf den Gesundheitszustand der Straßenbäume in Berlin. Nachrichtenbl. Dt. Pflanzenschutzd. 42, 132-142

8 RUGE, U., 1971. Erkennen und Verhindern von Auftausalzschäden an Straßenbäumen der Großstädte. Nachrichtenbl. Dt. Pflanzenschd. 23, 133-137

9 Umweltbundesamt (Hrsg.), 1980. Streusalzbericht I, Berlin

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# Effect of pollution on urban greenery and horticulture in large cities in developing countries

Introduction to problems There is rapid urbanisation in the developing countries and growth of very large cities even where level of urbanisation is low. Together with this there is increase of pollution of air, water, noise and land. Urban development is often considered as economic indicator but economic boom has often resulted in ecological doom. Urbanisation has spread with suburban sprawl destroying forests and agricultural land and filling up of waterbodies with greeneries have been lost to real estate promotion. Excessive exploitation of ground water has caused reduction in groundwater level affecting water supply and in many coastal cities intrusion of salt water has also affected water quality and supply. The plants requiring fresh water face scarcity of water. In many cities with little rainfall the trees have dried up. Historically in ancient cities like Mohenjodaro loss of vegetation due to ecological crisis led to the abandonment of the city. W. Bach mentions that trees have filtering effect on gaseous pollutants from busy highways and carbon monoxide level can be reduced by trees on the side wall (Bach, 1972). The dust collecting quality of leafy trees has been found by Bach. It was calculated that 400 poplars which are poor dust collectors spread over 2.5 acres would filter about 0.375 tons of dust during the leaf bearing session.

Dr. T.M. Das studies (Das, 1995) the dust filtering efficiency of different species of avenue trees. Total dust on both surfaces of leaf per sqm in gm. Ficus religiosa L. (Peepal) 4.25gm, Ficus infectoria Rox (Pakur) 4.09gm, Tectona grandis L.F. (Teak) 5.35m Shoree Robust Gaerin (Sal) 4.50gm, Mangilera indica (Mango) 4.05gm etc.

In the developing countries with the conflict between development and environment wood of trees is exported or sold. Deforestation is increasing and high. It is connected with international trade in timber wood and environmental degradation (Swanson, 1996). Horticulture is essential and it shaed be part of urban planning and development.

Many chemicals used in agriculture, horticulture and forestry like nitrogen and phosphorus fertilizer, pesticides, plant growth. regulators etc. Some are considered environmental pollutants and there is growing conciousness about organic fertilizer especially in urban agri-horticulture. Water and sometimes waste water is used in horticulture. Water is contaminated with fluoride, arsenic and toxic chemicals. There are various airpollutants affecting plants. The World Health Organization has provided guidelines for environmental improvement and has given the concepts of ‘no-observed-adverse-effect level (NOAEL) the concept of a tolerable daily intake (TDI) etc. (WHO, 2000).

## Lichens as indicators

The lichens, a symbiotic association of fungus with algae are good indicators in detecting the level of airpollution. The lichens are very sensitive to a number of gaseous pollutants such as sulpher dioxide, ehtylene, hydrogen fluoride, nitrogen etc. There are various types of lichens which grow on trees without any damage to host plants but sensitiveness and growth depend on pollution load.

In a study in Calcutta in 1986 it was found that in central city with heavy traffic and air pollution there is no lichen while in the outer areas and suburbs with greenery with low traffic volume and less pollution lichens are found in trees. Interestingly a new highway Eastern metropolitan by-pass built in the open area has now heavy vehicles and trees have no lichens but there are scars showing that lichens existed when the area was green (Das et al, 1996).

For the above study, three types of lichens were identified (I) Fruticose (bearing furits) most sensitive to air pollution (ii) Foliose (leafy appearance) medium sensitive and (iii) Crustose (very thin crust) the least sensitive. They grow on tree trunk as crust. It is possible for bio-monitoring of airpollution with lichens.

## Urban Agriculture

In the developing countries metropolitan area is quite large and it includes pockets of agricultural and rural land. As urban food production is being encouraged and urban horticulture together with agriculture and aquaculture is being adopted. It has come again in townplanning and future landuse planning for food security, supply of nutrition, employment to improve environment and enhance ecological sustainability. It utilises solid and liquid waste to a great extent and contributes to land greenery and waste management in the cities (UNDP, 1996).

European cities like Berlin had community gardens and horticulture was encouraged. This is being renewed and cities produce vegetables, fruit etc. City farms in London, New York etc. In Havana, urban horticulture has been accepted officially which has now 26000 self provision gardens besides community gardens (Moskow, 1999).

Urban food production is on the increase in Asian and African cities. These are helping in abating pollution. Many of the Asian cities have waterbodies and recycling of wastewater for fish production is being practiced the and aquaculture is being combined into horticulture agriculture. In one experimental station of Govt. of India in Calcutta waste water is successfully used for high production of leafy vegetables – cabbage, cauliflower, spinach etc. (Rai et al, 1995).

Calcutta has the largest recycling district in the world. In east Calcutta there are wetlands where with wastewater of the city abundant fish is produced by natural photosynthesis process and natural compost out of solid waste and sludge of waste water are producing good quanity of vegetables. Air pollution is very low in these areas.

Jamshedpur in India is a steel and industrial town. Engineering rubbish, slag, flyash and other wastes were heaped at places and there was derelict land. The Tata Steel Co, the main industry decided, a few years ago to landscaping the town. Thirty hardy flowering trees and different types of grasses were planted at these initially. Experiments were carried out at the foothills of slag dump slope; the pits were dug 600 mm x 600 mm x 600mm at interval of 2m are filled up with loamy soil and well rotten cowdung (4:1) with addition of 50 gm of Aldrindust well grown saplings were planted and 100 gm of ammonia sulphate was added at interval. The whole area became green but only hard trees like Eycalyptus hybride, Dalbergia sisso Lencaene etc. were successful. Some trees showed good growth on lime and flyash heaps. The chemical composition of the polluted soil was studied. As for example the slag is rich in micronutrients and poor in phosphate and almost devoid of potash and nitrogen (Mondal, 1995).

Among hardy pollution resistence trees in the tropical resion one may find several species like Acacia varieties in India, Azadurachia Indica (Neem) Cassia Fishela , Dalborgia, Dilomix, Bengalauses and Religiosa etc. unfortunatly, landscape architects do not follow the criteria for pollution resistant trees but their more oriented to the aesthetic aspects of plantation.

Possiblities of horticulture in urban greenery and reduction of pollution is quite promising. Vegetables can be grown in the cities at various places, in homegradens, side and back yards, roof etc. Accending to National Engineering Research Centre for vegetables, Beiing, there are 1822 species of edible vegetables, only 860 species have been cultivated and only 30 kinds of vegetables are commonly used (Chen, 1995).

Horticulture can be part of the overall greenery in the city. Vegetation changes micro climate. Most of cities in the developing countries are located in hot arid and hot humit zones. Trees and their shades lower the temperature and protects the solar radiation. Bioclimatic Design of cities with trees and vegetation will make the environment sustainable.

There are several urban design and planning concepts for future cities where urban horticulture agriaquaculture can be incorporated for functional, aesthetic and natural resources as well as for food roduction, A greening plan in a city may include (Ghosh 2000):

a. A green belt around cities where agro and aqua farms, forestry and livestock and poultry are developed.

b. Wedges of greenery and urban forests and parks developing a network of greens including waterbodies and recreational areas.

c. Avenues of trees with street design and pedestrian areas.

d. Periurban areas, derelict, abandoned and vacant sites where utilisation of solid and liquid waste can be for greening and urban agri-horticulture development.

e. Spot locations for edible landscape in industrial, governmental, institutionals areas and housing estates.

f. Private and community gardens including home gardens.

## Effective microorganism

EM (Effective Microorganisms) concept is based on the fact that crops grow healthy by nurturing the soil without using chemical fertilizers and pesticides. The concept since 1982 has been developed for wider application. Its use in urban horticulture to make its growth and becomes pollution resistant. There are many beneficial microorganisms this is being used in may Asian cities for plant growth for cleaning waste water etc. (Ecopure, 2003).

Dr. Teruo Higa, Professor of Horticulture, University of the Ryukyus, Okinawa, Japan, has done pioneering work. He has developed microbial inoculants to improve soil quality, crop growth and crop yield. It is said that a desease suppressive microflora can be developed by selecting and culturing certain types of gram-positive bacteria that produce antibiotics and have a wide range of specific functions and capabilities (Higa and Parr, 1994).

The use of biotechnology in agriculture and geneticaly produced crops is on the increase despite controversies associated with it. Control of weeds, and insects enrichment with vitamins and nutrient and increasing quantities are in favour of using generatically produced crop, fruits, etc. Its use in urban horticulture has started, though not widely practiced as safety of this fruit and vegetables from health and nutrition points of views with better environment is being discussed and the new knowledge witll allow consumers to make the best judgement (Yan and Kowew, 2002).

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## Literature

1 BACH, W., 1972. Atmospheric Pollution. McGraw Hill, New York. pp 144.

2 DAS, T.M., 1995. “A Strategy for using productive plant species for maintaining sustainable environment” Paper at International Workshop on Urban agriculture and sustainable environment, Centre for Built Environment, Calcutta, December 8-10, 1995.

3 SWANSON, T.M., 1996. The Economics of environmental degradation : UNDP. Edward Elgar, Chetencham, U.K.

4 WHO, 2000. Hazards Chemicals in human and environmental Health, Geneva WHO/PCS/00.3.

5 DAS, T.M., GUHA, N., MAJUMDAR. S., SAMIM. K.A., ROY, S., DAS, G., DAS, A.K., (1986), 'Studies on the plant responses to Air pollution I. Occurrence of lichens in relation to Traffic load of Calcutta City'. Indian Biology 18(2), 26-29, 1986.

6 UNDP, 1996. Urban Agriculture – food, jobs and sustainable Citi, written by Jac Smit et al. UNDP, New York, p 11.

7 MOSKOW, A. (1999), Havana's Self provision gardens in Environment and Urbanisation Vol II no. 2. October 1999.

8 RAI S.P., ROY, A., DUTTA, A., DAS, C.R., 1995. 'Recycling of Wastewater in Integrated Aqua-Agri-Hortifarming', Paper at the International Workshop Urban Agriculture in Calcutta December 1995.

9 MONDAL, D.P., 1994. 'Ecological improvement through landscaping of Steel town' Paper at International workshop 'Urban Agriculture' Calcutta, December 1995.

10 CHEN, H., 1995. "Vegetable for food security and healthy in Iurgen Rihter et al, edited " Vegetable productino in periurban Areas in the Tropics and subtropics Decutsche stiftungfur International. Ehtwicklong, Feldafing, Jermany.

11 GHOSH, S., 2000. Urban agricultural' and future of cities Centre for Built Environment, Calcutta.

12 HIGA, T., PARR, J.F., 1994. 'Beneficial and effective microorganisms for a sustainable agriculture and environmenta International nature Farming', Research Centre, Atami, Japan. Ecopure no. 45, March 03, EM. Labortory C. Ltd. Tykyo, Japan.

13 YAN, L., KOWEW, P., 2002. "Genetically engineered crops : Their potential use for improvement of human nutrition" in Nutrition Reviews, Vol 60, no. 5. May 2002. International Life Science Institute.

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# Acid precipitation and peach tree growth

The work of industrial enterprises, thermal electric power stations and internal combustion engines produces millions tons of technogenic emissions to the planet atmosphere. Most of them are oxides of sulfur and nitrogen which can fall at a great distance from the source of emission including agricultural areas. The maximal negative effect the acid precipitations put to air environment, and through it - flora and fauna. The woods and perennial agricultural cultures are especially strongly damaged because of influence of contamination during tens years. Fruit plants are not exception. The researches in this direction, however, are not numerous and basically concern of apple tree and grapes [3, 4, 5, and 6]. It is established, that fruit cultures are sensitive to effect of acid precipitations, and the degree of stability in many respects depends of variety. We have not met such researches of peach trees in the literature, it is known only, that its trees are middle susceptible to pollution of air by $SO_2$ [2]. Peach gets the increasing popularity in Crimea and in the south of Ukraine, since is fast-growing, high-yielding and valuable in the food relation, research of its reaction to acid precipitation are rather urgent.

In this connection the aim of our researches was to study influence of a simulated acid rain (SAR) sulfate content with various pH values on an external condition, growth and efficiency peach to establish symptoms of damages, critical concentration of acid rain, which leads to an oppression of trees and significant loss of a crop.

## Methods.

For this purpose was incorporated field experiment with two peach varieties: ‘Favorita Morettiny’ (early) and ‘Doktorskiy’ (average ripening) on almond rootstock. Age of trees is 4 years. Variants of experience were pH SAR equal to 2, 3, 4 and 5 units. Value of pH SAR set by addition of a sulfuric acid to distilled water. The control is not sprayed trees. Average pH value of atmospheric precipitation during the vegetation was equal to 6,0 is accepted for control one. The reiteration of experiment was quintuple. Frequency of spraying - once a months for the period 5 months of vegetation, from complete blossoming till autumn leaf-fall. Doze of SAR is 2 mm. Soil on a plot is chernozem southern calcareous deep ploughing, soil fertility is in optimum.

In a week after each spraying damage on the leaves was estimated measuring of its area on the one leave (the test was carried out on 100 leaves) and under the ratio of the leaves damaged to the total number of them. The length of the annual shoots and the size of the blade were measured. Fruit bearing was estimated by calculation and weighing up all the fruits on every tree. Statistical data processing of experience carried out by [1].

## Results and discussion.

The first spraying SAR, carried out during complete flowering of plants revealed that spraying of blossoming trees didn't cause visible injured on petals. SAR with pH 2 caused seen damages on leaves after second (‘Favorita Morettiny’) and subsequent (both varieties) sprayings. It were chaotically located stains and points from 1 up to 5 mm in a diameter colored as a ivory, quite often with reddish-brown edge, which revealed itself completely on 3rd-5th day after spraying. Later on tissues darkened and fell out forming holes and torn edges. Young growing leaves either were not injured, or were damaged to a lesser degree, than completely generated. In this connection, whether the greatest damages on one blade and on number of damaged leaves were observed in the beginning of August, when leaves and the runaways basically were already generated (tab. 1).

All leaves of ‘Favorita Morettiny’ in this time were with damages, which occupied about 3 % of the area of a leaf blade. Variety ‘Doktorskiy’ made only 88 % and 2,3 % accordingly. Mostly old, low leaves were injured. They soon turned yellow and fell away. In opinion of the German scientists it is connected to a strong pressure sell buffer system, which neutralizes harmful influence of an acid [2]. On September

the size of injuries on the other leaves was reducing again because of early autumn fall of injured leaves especially variety ‘Favorita Morettiny’. Probably, it is connected with early defoliation strongly damaged leaves, which began in the beginning of August caused by SAR with pH 2, and at variety ‘Favorita Morettiny’ as earlier-ripening, it began earlier.

**Tab. 1** The damage of peach leaves by SAR with pH=2.

| Date | ‘Favorita Morettiny’ | | | ‘Doktorskiy’ | | |
|---|---|---|---|---|---|---|
| | Leaves are damaged, % | Area of damages | | Leaves are damaged, % | Area of damages | |
| | | $Mm^2$ | % of blade area | | $Mm^2$ | % of blade area |
| 05.06 | 10 | 30 ± 4 | 1,00 | 0 | 0 | 0 |
| 07.07 | 64 | 47 ± 6 | 1,21 | 46 | 83 ± 17 | 2,24 |
| 06.08 | 98 | 110 ± 13 | 2,96 | 88 | 85 ± 11 | 2,27 |
| 12.09 | 100 | 27 ± 3 | 0,67 | 98 | 34 ± 3 | 0,75 |

SAR with pH 3 caused insignificant damages on 8 % leaves of ‘Favorita Morettiny’ only in July, in other terms leaves remained without damages.

SAR with pH=4 and 5 didn't cause visible injuries of leaves. The acid rain with pH equal to 2 and 3 units authentically reduced the area of a sheet plate of both variety peach during termination intensive growth of runaways on 3-6 $см^2$ that has made 7-14 % from the control. At pH SAR equal 4 and 5 the tendency to such decrease was marked only (tab. 2). Variety 'Doktorskiy' found to be more resistant to SAR than 'Favorita Morettiny'. If to take into account, that of a stain died tissue of a fabric on leaves, caused SAR with pH 2, 1-3 % of the areas of a blade make, as a whole its active photosynthesis the surface decreases on 8-17 %.

The damage of the sheet device has had the effect on intensity of synthetic processes in a plant and has resulted in an oppression of growth. At variety of a ‘‘Favorita Morettiny»’, as more fast-growing and sensitive to SAR it was appeared more strongly. So, general length of annual accretion was 2,3 and 3,3 m less then in control example under the pH of sulfate composition rain equal to 3 and 2 accordingly, and the variety ‘Doktorskiy’ on 1,2 and 0,9 м has less, than the control one.

SAR with pH 4 and 5 tended to intensification of shoot growth speaking about, the 'Favorita Morettiny' by 1,2 and 1,9 m accordingly. SAR with pH 4 affected the variety 'Doktorskiy' so, that the growth of its shoots was intensified by 2,3 m, difference to the control is not significant. At pH SAR equal to5 lengths of current growth shoots of this variety was close to control (tab. 2).

**Tab. 2** The area of a sheet plate ($см^2$) and length of current growth shoots (м) of peach tree, August 6, 1997.

| Versions | ‘Favorita Morettiny’ | | ‘Doktorskiy’ | |
|---|---|---|---|---|
| | Area of blade | Length of current growth shoots | Area of blade | Length of current growth shoots |
| Control | 42,2±1,1 | 19,2±2,0 | 42,4±1,4 | 15,6±1,0 |
| pH 2 | 37,1±1,1* | 15,9±1,2 | 37,4±1,0* | 14,7±1,6 |
| pH 3 | 36,6±1,1* | 16,9±2,5 | 39,3±1,0* | 13,4±2,1 |
| pH 4 | 40,8±1,1 | 20,4±0,6 | 41,0 ±0,9 | 17,9±2,5 |
| pH 5 | 38,2± 0,9 | 21, ±2,4 | 40,1 ±0,8 | 15,3±2,2 |

* - difference to the control is significant on the 5 % level.

SAR did not result in seen damages of peach fruits in the period from them infructescense before maturing. The crop of peach fruits by effect of SAR on a plant at variety ‘Favorita Morettiny’ was reduced more than twice at pH equal to 2 and 3 at the expense of sharp reduction of number of fruits and some - size of a fruit (tab. 3). At pH SAR equal 4 and 5 crops of this variety was close to control, exceeding it on 12-16 of relative percents, difference with the control not significant. Thus the quantity

of fruits was a little bit higher, than in the control, but they were smaller. At variety 'Doktorskiy', as steady, only SAR with pH 2 was reduced a crop of fruits on 27 % from the control at the expense of reduction of their quantity and average weight. At pH SAR equal 3 and 5 crops was close to control, and at pH 4 grew by 23 % concerning the control, at growing size of number of fruits and their weight (tab. 3).

**Tab. 3** The yield of peach fruits (average for 2 years).

| **Versions** | **'Favorita Morettiny'** | | | | **'Doktorskiy'** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Number of fruits, peace** | **Average mass of 1 fruit, g** | **Yield, g/tree** | **% to the control** | **Number of fruits, peace** | **Average mass of 1 fruit, g** | **Yield, g/tree** | **% to the control** |
| Control | 11 | 50 | 561 | 100 | 14 | 80 | 1155 | 100 |
| pH 2 | 5 | 44 | 232 | 41 | 11 | 75 | 840 | 73 |
| pH 3 | 6 | 48 | 273 | 49 | 14 | 82 | 1115 | 97 |
| pH 4 | 14 | 47 | 648 | 116 | 17 | 85 | 1415 | 123 |
| pH 5 | 14 | 45 | 628 | 112 | 16 | 85 | 1325 | 115 |

Thus, is established, that SAR with pH 2 resulted in seen damages leaves peach, which in the greater measure were shown on completely generated leaves; to reduction of the area of a sheet plate; to decrease of lengths of current growth shoots; early defoliation; to reduction of fruit crop at both peach variety. SAR with pH 3 caused seen damages leaves only in variety 'Favorita Morettiny' and resulted in all set forth above consequences, that has caused 50 % reduction of the fruit crop. SAR with pH 4 and pH 5 did not cause seen damages of a plant, at pH 4 the tendency to stimulation of growing processes and increase of a crop of fruits, especially significant at 'Doktorskiy' is marked. Probably, it connected that acidity of peach sell sap is close to 4. SAR with pH 5 on the action on a plant was close to the control. In this connection the variety have shown different sensitivity to pH SAR. For variety 'Favorita Morettiny' as more early ripening and fast-growing, where all processes of metabolism pass more intensively, critical the size pH of an acid rain influencing a plant equal to 3 is; for variety 'Doktorskiy', as more tolerant, it is equal to 2.

## Literature


1 DOSPESHOV, B., 1985. Field plot technique (with foundation of statistical analysis), 5th. Kolos. Moscow, 416.

2 Physiologie der Obstgehölze. 1978. Akademie – Verlag Berlin, 415.

3 FORSLINE, P., MUSSELMAN, R., DEE, R., KENDER, W., 1983. Effect of acid rain on grapevines. Am. J. Enol. Vitic. 34 (1), 17-22.

4 FORSLINE, P., MUSSELMAN, R., KENDER, W., DEE, R., 1983. Effect of acid rain on apple tree productivity and fruit quality. J.Amer. Soc. Hort. Sci.108 (1), 70-74.

5 ORMROD, D., 1986. Gaseous air pollution and horticultural crops production. Hort. Reviews. 8, 1-42.

6 PROCTOR, J., 1983. Effect of simulated sulfuric acid rain on apple tree foliage, nutrient content, yield and fruit quality. Environ. Exp. Bot. 23, 167-174.

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# Effect of compost-based substrates on growth and leaf physiology of *Acer campestre* and *Cornus alba* potted plants.

## Introduction

Soil-less substrates are widely used in horticulture for the production of ornamental plants in pots. The most common substrates for such cultures are prepared with peat, due to its high physical and chemical stability, and low degradation rate. It is produced by the partial decomposition of plant material under low-oxygen conditions; differences in peat are related to the climate under which they are produced and the species of plants from which it is formed [10]. In these last years, the use of peat as an ingredient for the substrates in container production has become an important environmental issue, due to the fact that it is considered a non-renewable resource to be preserved as peat bogs for wild plants and animals [9]. Increased commercial interest has therefore been directed towards developing complete or partial alternatives for peat utilized in traditional potting media within ornamental industries [12]. Waste products such as biosolids [4], wood waste [6], source-separated municipal solid waste compost [1] are considered with interest though the consistency of these products is often uncertain. As a matter of fact, physical and chemical makeup of most of the waste products may shift with time and source of the feedstock, and while slight variations in texture, particle size and mineral composition are of less consequence when the material is used as a landscape mulch, these factors may be of significant importance in the limited volume of a plant container [5]. On the other hand, waste disposal has become a concern due to the increasing population and increased cost of conventional disposal methods such as landfilling [8] and so public and private compost facilities have increased over the past decade to produce large volumes of compost that need to be reused.

The objective of this investigation was to assess the use of composted yardwaste and raw fiber as partial substitutes of peat moss for containerized perennial production.

## Materials and Methods

One-year-old uniform rooted cuttings of a tree species, *Acer campestre* “Elsrijk” and a medium sized deciduous shrub, *Cornus alba* “Elegantissima” were selected for a biennial (2001 and 2002) experiment in Pistoia (Central Italy), one of the largest nursery areas in Europe, specialized in woody ornamental plant production.

In spring 2001, a total of 400 plants (200 per each species) were planted in 3 liter (18 cm ∅) black plastic containers using a control substrate made with standard peatmoss and pumice, two different compost-based media and one which was added of uncomposted raw fiber, as reported in Table 1. All the substrates were supplemented with 3 kg/m$^3$ (15 g/pot) of a slow-release fertilizer (Osmocote Plus 5-6, 14N-14$P_2O_5$-14$K_2O$ and 18-11-10 microelements, Scotts Co., Marysville, OH). At planting, shoots were pruned to 20 cm, and at the same time, root and canopy fresh and dry weight were determined on 8 plants per species (following the procedure described later).

Plants were placed outdoors and arranged in a randomized complete block design with 8 replicates (6 plants each) per treatment. They were all placed in full sun with sprinkler irrigation, and watered four times a day in both the growing seasons. In winter all the plants were placed in a greenhouse. During the winter following the first growing season all plants were repotted in 9 liters containers with the same substrates used the previous year.

**Tab. 1** Composition of the different substrates used in the experiment

| Treatment | Pumice | Raw fiber | Green Compost | Peat moss |
|---|---|---|---|---|
| Control | 40 | | | 60 |
| Substrate 1 | 40 | | 40 | 20 |
| Substrate 2 | 30 | | 30 | 40 |
| Substrate 3 | 40 | 20 | | 40 |

Values expressed in percentage of vol.

In both growing seasons, periodically (31/05/01, 01/08/01, 17/10/01, 26/07/02, 16/09/02) five plants of each species and treatment randomly sampled were planted out, roots were washed free of media, and roots and shoots excised. Total leaf area, fresh weights of the root system and of the canopy were recorded immediately, and dry weights after the vegetative material was oven-dried at 80°C until constant weight was achieved. Shoot:root ratio as well as fresh weight:dry weight ratio was also calculated.

Relative growth rate (RGR) was calculated as: $(\ln W_2 - \ln W_1)*(t_2 - t_1)^{-1}$ where W1 and W2 are respectively the total dry matter at the beginning and at the end of the observations, t2 and t1 are the number of days between the two sampling dates. This is the most common growth index to compare stages of a plant life cycle regardless of the changing size of the plant.

Leaf area was measured with a CID CI-203 leaf area meter (CID Inc., Vancouver, WA).

Instantaneous net photosynthesis (Pn), evaporation rate (E), and water-use efficiency (WUE, calculated dividing Pn by E) were measured on three dates per year (21/06/01, 03/08/01, 12/09/01 and 03/07/02, 19/08/02, 16/09/02), using the CIRAS-1 portable infrared gas analyzer (PP Systems, Hertfordshire, U.K.).The readings were always taken between 800 and 1800 hours on the same plants (4 plants per treatment, five fully expanded leaves per plant) under conditions of light saturation (PAR > 1000 µmol $m^{-2}$ $s^{-1}$).

Chlorophyll content was determined three times (6/21/01, 7/3/02 and 9/16/02) on the same leaves with a portable chlorophyll meter (SPAD-502 Minolta Corp., Ramsey, N.J., U.S.) previous calibration curve done by measuring the absorbance at 664, 647 and 625 nm, with an Hitachi U-2000 spectrophotometer, after extraction with dimethylformamide (DMF) ($R2 = 93.3\%$, regr. eq. $-9.84 + 0.713x$) [7].

All the data were subjected to analysis of variance using SPSS (Release 8.0 for Windows). Treatment means were separated by LSD, with $p \leq 0.05$ level of significance.

## Results and Discussion

The results showed no major limitations to the use of composted yardwaste and raw fiber as an ingredient for container production of *Acer campestre* and *Cornus alba*. As a matter of fact, after two growing seasons plants of both species grown in containers filled with substrates 1, 2 and 3 showed no significant difference in total growth compared with control ones (Figure 1). More in details, *Acer* plants showed no differences in growth among different treatments in any of the sampling dates, while *Cornus* plants turned out to be more sensible to the different substrates: the plants grown in substrate 3 with uncomposted raw-fiber generally resulted in a lower growth for almost two years, which was, however, compensated by a higher growth in the last part of the second growing season. This could be due to a change in the physical and chemical characteristics of the raw fiber, which became probably more similar to a composted material in the second year than the previous one.

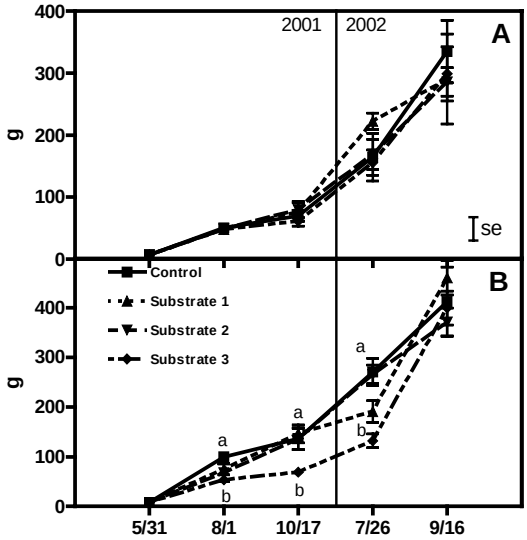


**Fig. 1** Total dry matter (g) of *Acer campestre* (A) and *Cornus alba* (B) plantsgrown for two years with different substrates. Data are mean values, n = 5.

Anyway, after two years experiment, no differences in dry mass partitioning were detected in both species, with the exception of shoot/root ratio, whose differences resulted difficult to address to the different treatments though substrate 2 had higher values in both years (Table 2, Table 3).

**Tab. 2** Effect of different compost-based substrates on dry matter (g) partitioning and dry weight/fresh weight ratio in *Acer campestre* after 2 years treatment. Data are mean values, n = 5.

| Treatment | Leaves | Stems | Roots | total | Shoot/root | dw/fw |
|---|---|---|---|---|---|---|
| Control | 52.02 ns | 107.01 ns | 175.70 ns | 334.73 ns | 1.07 b | 0.50 ns |
| Substrate 1 | 44.24 | 121.77 | 124.41 | 290.42 | 1.42 ab | 0.54 |
| Substrate 2 | 48.15 | 124.43 | 112.97 | 285.55 | 1.66 a | 0.52 |
| Substrate 3 | 50.59 | 108.04 | 140.11 | 298.73 | 1.17 ab | 0.50 |

Means among treatments with different letters are significantly different at $p \leq 0.05$.

**Tab. 3** Effect of different compost-based substrates on dry matter (g) partitioning and dry weight/fresh weight ratio in *Cornus alba* after 2 years treatment. Data are mean values, n = 5.

| Treatment | Leaves | Stems | Roots | Total | Shoot/root | dw/fw |
|---|---|---|---|---|---|---|
| Control | 58.11 ns | 81.17 ns | 273.20 ns | 412.47 ns | 0.55 ab | 0.41 ns |
| Substrate 1 | 66.05 | 79.22 | 315.27 | 460.54 | 0.46 b | 0.46 |
| Substrate 2 | 60.67 | 92.58 | 217.45 | 370.69 | 0.72 a | 0.44 |
| Substrate 3 | 71.42 | 88.98 | 239.19 | 399.58 | 0.68 a | 0.47 |

Means among treatments with different letters are significantly different at $p \leq 0.05$.

No significant differences were detected for leaf area (data not shown). The Relative Growth Rate (RGR), calculated in two successive periods of both growing season, overall showed similar growth rates among *Acer* plants from different substrates in both years, with no differences detected; *Cornus* plants, on the other hand, had a better growth efficiency with substrate 1 and 2 in the first year, while in the second growing season an increasing performance of substrate 1 and, above all, a high and constant growth efficiency of the plants grown in substrate 3 was observed (Figure 2). This last point, in particular, justifies the good total growth of the *Cornus* plants grown with uncomposted raw fiber after two years, and can be reasonably explained with an improvement of physical and chemical characteristics of the substrate 3 during the 2-years experiment.

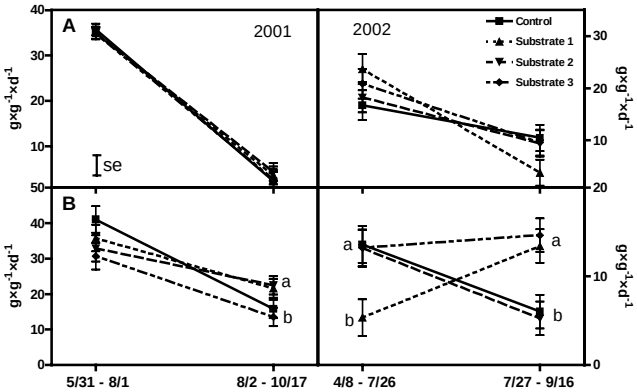


**Fig. 2** Relative Growth Rate (RGR) ($g*g^{-1}*d^{-1}$) of *Acer campestre* (A) and *Cornus alba* (B) plants grown for two years with different substrates. Data are mean values, n = 5.

Leaf gas exchanges (average data of four sampling dates in both years) in *Acer* plants were not influenced by different substrates in the first year, as a lower response (Pn and E) was obtained from plants grown in substrate 3 in the second year (Table 4). *Cornus* plants resulted to be even less sensitive to different treatments, with the only significant difference being detected in the transpiration rate (E) in the first year, with a better performance of the control plants (Table 5). Generally speaking, it seems the different substrates didn't remarkably affect leaf physiology response of both species, as confirmed by the water use efficiency, rather constant among different treatments.

**Tab. 4** Influence of different substrates on net photosynthesis (Pn) (µmol $CO_2$ $m^{-2}$ $s^{-1}$), evaporation rate (E) (mmol $H_2O$ $m^{-2}$ $s^{-1}$), water-use efficiency (WUE) (Pn/E) of *Acer campestre* plants. Average of four sampling dates in 2001 and 2002.

| | 2001 | | | 2002 | | |
|---|---|---|---|---|---|---|
| **Treatment** | **Pn** | **E** | **WUE** | **Pn** | **E** | **WUE** |
| Control | 7.03 ns | 2.63 ns | 3.15 ns | 11.87 a | 3.01 a | 4.06 ns |
| Substrate 1 | 7.36 | 3.06 | 2.85 | 10.72 a | 2.70 ab | 4.12 |
| Substrate 2 | 7.60 | 3.04 | 3.12 | 10.71 a | 2.79 ab | 3.83 |
| Substrate 3 | 7.29 | 2.72 | 3.20 | 9.54 b | 2.45 b | 3.88 |

Means among treatments with different letters are significantly different at $p \leq 0.05$.

**Tab. 5** Influence of different substrates on net photosynthesis (Pn) (µmol $CO_2$ $m^{-2}$ $s^{-1}$), evaporation rate (E) (mmol $H_2O$ $m^{-2}$ $s^{-1}$), water-use efficiency (WUE) (Pn/E) of *Cornus alba* plants. Average of four sampling dates in 2001 and 2002.

| | 2001 | | | 2002 | | |
|---|---|---|---|---|---|---|
| **Treatment** | **Pn** | **E** | **WUE** | **Pn** | **E** | **WUE** |
| Control | 7.66 ns | 2.87 a | 3.14 ns | 10.47 ns | 3.25 ns | 3.36 ns |
| Substrate 1 | 6.43 | 2.08 b | 3.35 | 9.86 | 3.08 | 3.28 |
| Substrate 2 | 7.22 | 2.47 ab | 3.06 | 10.53 | 3.39 | 3.31 |
| Substrate 3 | 7.30 | 2.65 ab | 3.14 | 9.25 | 3.01 | 3.14 |

Means among treatments with different letters are significantly different at $p \leq 0.05$.

Chlorophyll content calculated as leaf SPAD readings showed no differences among different substrates in *Acer* plants, as significant differences were detected in *Cornus* plants, with a better performance of control substrate in the first year and lower readings of substrates 1 and 3 in the second year of cultivation (Table 6). Anyway, these differences didn't affect the visual quality of the plants.

**Tab. 6** Chlorophyll content (SPAD units) in *Acer campestre* and *Cornus alba* plants grown for two years with different substrates. Data are mean values, n = 40.

| | *Acer campestre* | | | *Cornus alba* | | |
|---|---|---|---|---|---|---|
| **Treatment** | **21/6/2001** | **3/7/2002** | **16/9/2002** | **21/6/2001** | **3/7/2002** | **16/9/2002** |
| Control | 33.25 ns | 37.84 ns | 42.34 ns | 31.38 a | 37.77 ns | 40.53 ab |
| Substrate 1 | 38.85 | 38.65 | 44.21 | 29.68 ab | 38.95 | 37.71 b |
| Substrate 2 | 32.63 | 37.74 | 43.89 | 28.75 ab | 38.75 | 41.66 a |
| Substrate 3 | 36.72 | 36.23 | 44.67 | 25.30 b | 38.13 | 37.88 b |

Means among treatments with different letters are significantly different at $p \leq 0.05$.

According with other Authors [2, 5, 12], these results support the perspective of introducing compost-based media in the nursery industry. All the plants grown with different substrates appeared healthy throughout both growing season and no important differences in plant growth were observed in both species, though *Cornus alba* turned out to be more resposndent to different substrates. As a matter of fact, though the presence of uncomposted raw-fiber in the substrate didn't produce any detrimental effect in both species after two growing season, caution is advised to suggest its use in nursery cropping system, due to uncertain physical and chemical parameters of such product. On the other hand, composted yardwaste can certainly represent a valid substitute to peat, at least in the proportions used in this research (30 and 40%), that is less than 60-75% which is considered by many authors as the border line to avoid problems like greater soil compaction and/or higher soluble salts in the media [3, 11, 12]. Future research should be addressed to find the best quality for the compost produced, in order to get a peat-free substrate for nursery industry in the near future.

## Literature


1 CHONG, C., 1999. Experiences with the utilization of wastes in nursery potting mixes and as field soil amendments. Can. J. Plant Sci. 79, 139-148.

2 FITZPATRICK, G.E., 2001. Compost utilization in ornamental and nursery crop production. In: Stoffella, P.J., Kahn, B.A., (Eds.), Compost utilization in horticultural cropping systems. Lewis publishers, Boca Raton, FL, pp. 135-150.

3 GARCIA-GOMEZ, A., BERNAL, M.P., ROIG, A., 2002. Growth of ornamental plants in two composts prepared from agroindustrial wastes. Bioresource Technology, 83, 81-87.

4 GOUIN, F.R., 1993. Utilization of sewage sludge in horticulture. HorTechnology 3, 161-163.

5 HICKLENTON, P.R., RODD, V., WARMAN, P.R., 2001. The effectiveness and consistency of source-separated municipal solid waste and bark composts as components of container growing media. Scientia Horticulturae 91, 365-378.

6 LUMIS, G.P., 1976. Using wood waste compost in container production. Amer. Nurseryman 163 (11), 10-11, 58-59.

7 MORAN, 1982. Formulae for determination of chlorophyllous pigments extracted with N,N-dimethyl formamide. Plant Physiol. 69, 1376–1381.

8 OZORES-HAMPTON, M., OBREZA, T.A., HOCHMUTH, G., 1998. Using composted wastes on Florida vegetable crops. HorTechnology, 8 (2), 130-136.

9 SCOTT, M., BRAGG, N., 1993. Digging into composts. Workshop in Combined Proc. Intl. Plant Prop. Soc., Vol. 43, 150-156.

10 WILL, E., FAUST, J.E., 2003. Growing media greenhouse production. Agricultural Ext. Service, University of Tennessee, 11 pag. www.utextension.utk.edu

11 WILSON, S.B., STOFFELLA, P.J., GRAETZ, D.A., 2001. Use of compost as a media amendment for containerized production of two subtropical perennials. J. Environ. Hort. 19, 37-42.

12 WILSON, S.B., STOFFELLA, P.J., GRAETZ, D.A., 2002. Development of compost-based media for containerized perennials. Scientia Horticulturae 93, 311-320.

# Session 8 - Concept of integrated pest management

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## *Cameraria ohridella* Deschka & Dimic (Lep: Gracillariidae): A new pest on *Aesculus hippocastanum* in Greece

### Abstract

The leafminer of horse chestnut tree *Cameraria ohridella*, which was first observed in Greece in 1996, is quite often found in wild as well as ornamental horse chestnut trees.

Based on what is known so far by information obtained in 2001 and 2002 within the framework of the EC project CONTROCAM (QLK5-2000-01684), the insect was observed in 36 locations. Most of these places were part of the mountain areas in continental Greece but not in Peloponnesus, Crete and the rest of the islands while the research continues. These locations are at altitude of 520 to 1370 meters above the sea level.

Regarding the use of the *Acer* species as an occasionally host plant from the moth, there has not been found any infestation by *C. ohridella* on leaves from different *Acer* species sush as *Acer campestre*, *Acer monspessulanum*, *Acer obtusatum*, *Acer platanoides* and *Acer pseudoplatanus* from Grevena and Karitsa. The observations will continue in other areas round Greece.

Key words:*Cameraria ohridella*, existing, host plant, Greece

### Introduction

The moth *Cameraria ohridella* Deschka & Dimic was observed in the early 80's, in 1984, for the first time in the Balkan area, where *Aesculus hippocastanum* is a native tree (Krüssman 1976, Polunin 1997, Tutin 1990) On that year it was found for the first time within Europe, at the area of Ochrid Lake, on the leaves of horse chestnut trees. These leaves were attacked by a leaf miner which belongs to the Gracillariidae family. This new specie was defined by Deschka & Dimic, who named it after the area, *Cameraria ohridella* (Deschka & Dimic, 1986).

From what we know so far, the origin of *C. ohridella* could be the mountains of Balkan area and in specific of Macedonia (Grabenweger and Grill 2000).

According to Freise (2001) as the area of origination for this leaf miner could be discussed North America and South – East Asia.

In 1989 this moth was detected at the area of Linz (Austria) and by 1998 it had spread to the whole Central and Eastern Europe (Freise and Heitland 1999, Skuhravy 1998).

According to Skuhravy (1999) the spread of this leaf miner was slower in Greece rather than in other areas probably because of the limited existing of horse chestnut trees in Greece.

Within the framework of the European Community Project entitled CONTROCAM (QLK5-2000-01684) in which Greece participates through the Department of Forestry at Drama of the Technological Educational Institute of Kavala, it was attempted for the first time to study the spread as well as the bio-ecology of this particular leaf miner in Greece. Until the beginning of the CONTROCAM project, the unique information known about the status of the *C. ohridella* in Greece was a piece of information for the appearance of *C. ohridella* at Florina (1996) and on two *Aesculus hippocastanum* ornamental trees at the mountain Pelion in Central Greece as well (Skuhravy 1999).

In order to cover the needs of the project mentioned above, the systematic study of the insect started in Greece. Parts of this study, especially of their existing and host plants around Greece, are presented in that work.

## Materials and methods

Distribution

For the study of the existence of this leaf miner a net work of information was established in Greece, with the colleagues from the Greek Forestry Service. Each information was classified at the Forestry Department regarding its observation in different ornamental or wild trees, and then always followed study and observation at the location by the coordinator of the program in Greece. In this way a protocol was established about all the so far known locations of the insect. This protocol also includes the geographical data of the area, using a Garmin instrument (altitude, longitude and latitude) as well as the biological data of the host plants (wild / ornamental, age, height, diameter, intensity of the attack).

Host plants

A number of leaves were taken at the area of Grevena (Longitude: E 021$^{o}$ 12. 060, Latitude: 39$^{o}$ 58. 073, Altitude: 845 m) and Karitsa (Longitude: E 022$^{o}$ 43.367, Latitude: 39$^{o}$ 50.971, Altitude: 620 m) on a monthly basis in 2001 and 2002, in order to search for more host plants among the different Acer species. These observations are being repeated this year as well.

The search takes place close to horse chestnut trees with heavy infestation covering an area of about 300 meters (diameter) around them and the study include leaf sampling of the following *Acer* species:

1. *Acer campestre* (Grevena)
2. *Acer monspessulanum* (Grevena)
3. *Acer obtusatum* (Grevena)
4. *Acer platanoides* (Grevena)
5. *Acer pseudoplatanus* (Karitsa)

## Conclusions

The study of the spread of the leaf miner *C. ohridella* in Greece (from 2001 until today and still in progress) indicated that the problem caused by the insect is more serious than initially considered to be.

Until today this leaf miner was observed all around Greece, attacking wild as well as ornamental trees.

The insect attacks wild individual *A. hippocastanum* trees, stands and a mixed forest, as well as ornamental horse chestnut trees ın parks, gardens and across the roads in 36 different places around Greece, which were divided in 27 municipalities.

In 2001 were found in 10 places wild horse chestnut trees attacked by *C.ohridella* and 14 cases with ornamental trees which were infested by the moth. In 2002 were observed 12 new infested places (8 places with wild trees and 4 with ornamental trees).

These 36 locations (18 cases with wild trees/stands and 18 cases with ornamental trees) having an:

- Altitude from 520 till 1370 meters above the see level.
- Longitude from E 020$^{o}$ 51.100 till E 023$^{o}$ 10.444 and
- Latitude from N 38$^{o}$ 37.751 till 40$^{o}$ 50.68

These 36 locations belong mainly to the mountain area of Greece, which divided the continental Greece from north to south.

Comparing the places with infected horse chestnut trees on the 'Bioclimatic-floor' map (Mavrommatis 1980), according to the data of the observations, could be conclude that the moth appears, in the HUMIDE and SUBHUMIDE floor, where the average of the lowest air temperature during the colder month, measured in Celsius degrees, is lower than $0^0$ degrees.

So far the observations about the spread of the moth showed that:

1. No difference was observed in the intensity of attacks from *C.ohridella* between wild and ornamental trees. The infestation level after the flight of the adults of the second generation may vary from a few mines per compound leave (0-5%) up to full cover of the leaflets with mines (more than 80% of the photosynthetic area per leave).

2. Furthermore, all over Greece, parks were found with trees not yet infected for example in Tripolis (southern Greece), Naousa and Edessa (northern Greece), Xanthi (eastern Greece).

Regarding the use of the *Acer* species as an occasionally host plant from the moth, especially after the flight of the moths of the second generation, and probably due to food shortage (Pschorn-Walcher 1997), we did not find any infestation by *C. ohridella* on leaves from Grevena and Karitsa, even if the infestation level on the closest *A. hippocastanum* trees was very high (more than 80% of the total surface of the leaves). This result is different from that of other authors, who reported development of *C. ohridella* on the leaves of *A. platanoides* and *A. pseudoplatanus* (Freise 2001, Krehan 1995, Pschorn-Walcher 1997, Skuhravy 1999), but the observations will continue in other areas round Greece during this year.

## Discussion

All the so far information regarding the existence of this moth in the Balkan area are under doubts, based on information coming from the area of Ioannina (West Greece). After interviewing employees of the municipality and the Forestry Service of this city we were informed that long before 1984 the *A. hippocastanum* trees of the park at "Xenia" Hotel were infested by an insect with symptoms like *C. ohridella*. This infestation continues to this day causing problems to the visitors of the park. Unfortunately this piece of information, which requires further research, cannot be officially proved. Yet, it was also supported by an over-aged gardener of the park.

So far *C. ohridella* creates problems very rarely because of the limited presence of *A. hippocastanum* in Greece. Yet, this situation will change soon because during the last years the horse chestnut tree seems to be one of the most favorite species for the creation of parks, gardens and avenues in many areas round Greece. To restrict this problem in the future the use most resistant species (p.e carnea) instead of *A. hippocastanum* seems to be the most appropriate action.

## Acknowledgement

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## Literature

1 KRÜSSMAN, G., 1976. Handbuch der Laubgehölze. Band I. Verlag Paul Parey. Berlin und Hamburg. 791 pages.

2 POLUNIN, O., 1997. Flowers of Greece and the Balkans. Oxford University Press. Oxford-New York- Tokyo. 592 pages.

3 TUTIN, G. T., HEYWOOD, H.V., BURGES, A.N., MOORE, M.D., VALENTINE, H.D., WALTERS, M.S., WEBB, A.D., 1990. Flora Europaea. Vol. 2. Cambridge University Press. Cambridge-New York- Port Chester- Melbourne -Sydney. 469 pages.

4 DESCHKA, G., DIMIC, N., 1986. *Cameraria ohridella* sp. n. (Lep., Lithocolletidae) aus Mezedonien, Jugoslavien. Acta Entomol. Jugosl. 22: 11-23

5 GRABENWEGER, G., GRILL, R., 2000.On the place of origin of *Camararia ohridella* Deschka & Dimic (Lepidoptera: Gracillariidae). Beiträge zur Entomofaunistik 1: 9-17.

6 FREISE, J., 2001. Untrersuchungen zur Biologie und Ökologie der Roßkastanien-Miniermote (*Cameraria ohridella* DESCH.& DIM) 1986) (Lepidoptera: Gracillariidae). Dissertation der Fakultät des Wissenschaftszentrum Weihenstephan, der T.U. München.

7 FREISE, J., HEITLAND, W., 1999. A brief note on sexual differences in pupae of the horse-chestnut leaf miner, *Cameraria ohridella* Deschka & Dimic (1986) (Lep., Gracillariidae), a new pest in Central Europe on *Aesculus hippocastanum*. J. Appl. Ent. 123: 191-192.

8 SKUHRAVY, V., 1998. Zur Kenntnis der Blattminen-Motte *Cameraria ohridella* Desch. & Dim.(Lep., Lithocolletidae) an *Aesculus hippocastanum* L. in der Tschechischen Republik. Anz. Schädlingskde., Pflanzenschutz, Umveltschutz 71: 81-84.

9 SKUHRAVY, V., 1999. Zusammenfassende Betrachtung der Kenntnisse über die Roßkastanien-miniermotte, *Cameraria ohridella* Deschka & Dimic (Lep., Gracillariidae). Anz. Schädlingskunde, 72: 95-99.

10 MAVROMATIS, G., 1980. Le bioclimat de la Grece. Relations entre le climat et la vegetation naturelle. Cartes bioclimatiques. Ministery of Agriculture. Forestry Research Institute 1, 63 pages.

11 PSCHORN-WALCHER, H., 1997: Zur Biologie und Populationsentwicklung der eingeschleppten Rosskastanien-Miniermotte, *Cameraria ohridella*. Forstschutz Aktuell. No. 21: 7-10.

12 KREHAN, H., 1995. Roßkastanienminiermote *Cameraria ohridella*. Befallssituation in Österreich. Forstschutz Aktuell No. 16:8-11.

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# Integrated plant protection management in modern architecture

## Introduce

In the formation of the human residential-surroundings the urban green is of a protruding meaning. Whether as singles-plant, shaped vegetation-society or as spontaneous-vegetation, the plants are under stress by numerous biotic and abiotc factors different from the urbane location. Appearance, lifespan and security especially the park - and street-trees is impaired therefore frequently. It must be however good technical practice to take the peculiarities of a location with the plant-selection into account and to optimize planting as well as care. The modern architecture out of glass, metall and concrete expect another plant-selection from the landscape gardeners, plants growth-conditions changed simultaneously abandoned. The care of the plants must assume therefore a new quality.

## Problems

Each time has its architecture line in form of different building-forms, construction-materials and utilizations. The status of the plant as well as their use can absolutely change outside and inside of the buildings with the time. Currently, exotic plants are used as indoor plants with frequently inadequate growth-conditions in big number and size without any informations about the specific conditions for their development. The claim of the particular alone is the motor for this procedure. That is valid also for the half-homestead or for the homestead, high design-aspects are important also here. The micro-climatic conditions are for the chosen plant-types frequently insufficiently and the ground-situation is on the basis of a high seal-degree, a restricted place and little adapted substrat of the plant-development little wholesome.

As consequence of this practice, health-problems appear at many plants and make plant-precautions necessary, because optical impairments are of course not desired. Frequently one doesn't roof in the planning-conception however that no efficient measures are available for many problems and cannot be put in especially chemical plant-precautions occasionally or finds no acceptance. The care of the plants necessitates highly qualified personnel, that doesn't usually stand to the disposal or is not put in. So many exclusive lawns already suffer after few years from optical impairments so that they must be redeveloped with high financial expenses or must be renewed.

## Resolutions

The selection of plants under new from the architecture embossed growth-conditions reveals big research-deficits. The urbane horticulture must take care with all its disciplines of suitable conzeptions, that has to the goal, to secure the health of the plants durably. Following aspects must be explored therefore absorbed:

- Optimization plant-selection in dependence on the architecture
- Preparation of the plants in the production on the later use
- Development of modern plantings
- Care-measures under integrated aspects, i.e.
- 
- Prognosis - and supervision-measures of the physiological development
- Support from beneficials to the stabilization of the plantations
- Update in the spectrum of beneficials
- Plant-protection-management

The results must become established in education and practice. Especially the green-planning is asked, itself the new challenges, to put in the sense of a good technical practice in plant-protection. This is the only way, that the architectural challenges can be mastered before the background of the financial expenditures henceforth.

## Literature

1 BALDER, H.,1999. Integrierter Pflanzenschutz in der Baumpflege. Gesunde Pflanzen 51, 182-190

2 BALDER, H., 2000. Integrierter Pflanzenschutz im Garten- und Landschaftsbau. Neue Landschaft 45, 590-598

3 BALDER, H., 2002. Pflanzenschutz im Stadtgrün – Wohin führt der Weg? Gesunde Pflanzen 54, 209-217

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# Mycorrhizal fungi as factors of integrated plant protection in urban horticulture: the state of the art

## Abstract

Most plant species of all growth form types of urban areas are able to develop symbioses with arbuscular mycorrhizal fungi (AMF, *Zygomycetes*). The partnership between these fungi and host roots can lead to an enhanced tolerance of the plants to abiotic and biotic stresses. The mycorrhizal technology developed in the last years provides horticultural practice with suitable commercial mycorrhizal inoculum for the inoculation of annual ornamentals and perennial herbs, shrubs or trees. Furthermore, inoculation methods for already established plants are now available and offer the possibility to include AMF into the design of integrated plant protection procedures. The flexibility of modern inoculum allows the inclusion of the mycorrhizal technology to integrated plant protection systems as important biological phytosanitary factors.

## Biological factors in the concept of Integrated Plant Protection

Integrated plant protection is the most promising attempt for the transformation of conventional patterns of pesticide use to more sustainable and environmentally friendly plant protection procedures in all areas of plant production (agriculture and horticulture). The German plant protection act (§2,2) defines the integrated plant protection approach as "a combination of methods in which the use of chemical plant protection products is limited to the essential minimum by paying particular attention to biological, biotechnical, plantbreeding and cultivation-related measures". Biological factors are integrated as direct protectives against disease and parasites or as plant strengtheners inducing and supporting plant defense reactions or plant disease pre-disposition. In the most of the cases arbuscular mycorrhizal fungi (AMF) are acting indirectly and are, therefore, commercialized as "soil improvers", "bio-fertilizers" or "plant strengtheners". Presently, in the most of the cases the good plant production practice in horticulture does not realise all principles of integrated plant protection, e.g. they rarely consider such biological soil improvers, which in case of symbiontal mycorrhizal fungi are known to reduce the negative effects of abiotic and biotic stresses strengthening the plant health by inducing complex physiological changes [1] in the host.

## Mycorrhizal fungi and plant pathogens

Already since decades the interrelationship between plant host, fungal symbiont and parasites are studied [2] and the phytomedicinal potential of mycorrhizal fungi recognized [3]. In the most of the cases the damage of soil borne fungal pathogens causing root rot or vascular damage (e.g. *Phytophtora parasitica* [4], *Aphanomyces euteiches* [5], *Fusarium, Verticillium, Sclerotium* [6, 7]), and of plant pathogenic nematodes causing root galls and root lesions (*Meloidogyne, Pratylenchus and Radophulus* [8]) was observed to be reduced in presence of AMF. Leaf pathogens like powdery mildew can be supported by AMF [9] or such like leaf blight fungi repressed [10]. Interactions with root pathogenic bacteria are restricted to some observations showing a protection of tomato plants against *Erwinia carotovora* and *Pseudomonas syringae* [11, 12].

The bioprotective effects are hardly understood and depend on many factors influencing the outcome of the symbiosis. The most important factors are: (i) the AMF isolate, (ii) the pathogen, concerning both virulence and inoculum potential, (iii) the host plant, (iv) the growing substrate and (v) the prevailing environmental conditions [13].

The mechanisms underlying the bioprotective effects are (i) improvement of plant nutrient status/damage compensation [14], (ii) Competition for host photosynthesis and colonisation sites [3], (iii) changes in anatomy and architecture of the root system [15], (iv) microbial changes in the rhizosphere [16], (v) activation of plant defense mechanisms [17], (vi) systemic effects of AMF colonization [4].

## Mycorrhizal fungi and abiotic stresses

Environmental conditions are influencing the host genotype and perform its phenotype. On the background of specific environmental conditions the hosts are facultative or even obligate mycotrophic, i.e. to reach their maximum fitness at a given site they depend on mycorrhiza to a different extent. Nutrient deficiency is one of the most important stresses which can be overcome by mycorrhiza [18] resulting in practical applications concerned with recultivation of marginal and degraded agricultural sites [19]. The negative influence of water logging on one hand [20] and water deficiency on the other hand [21] can be reduced by mycorrhization. Reduction of salt induced "physiological drought" [22] is another interesting effect relevant for urban horticulture, where trees at streets are often living in anthropogenic salty environments. Furthermore, the phytoremediation of heavy metal polluted areas works better with mycorrhizal plants than without [23].

## Occurrence of mycorrhizal fungi under urban conditions

Our knowledge about the occurrence of AMF under urban conditions is very scarce. One of the most important informations is that isolation between green areas, gardens or parks and long-term conservation of artificial, man-made plant sociological formations can lead to AMF communities which are patchy distributed and of low diversity and low effectiveness [24]. Substrates for roof tops and all substrates used for the production of ornamentals or other seedlings and cuttings normally are sterilized and, therefore, free from AMF. Overall, it can be stated that under urban conditions there is a latent deficiency in symbioses with the potential consequence of higher stress susceptibility of facultatively or obligately mycorrhiza dependend host plants.

## The directed inoculum production concept

Adaptation of plants to specific environments is geneticly fixed and expressed as the phenomenon of plasticity. With respect to their function AMF as obligate biotrophic organisms, of course, are highly dependend on the plant genotypes they meet in a given environment. Furthermore, all the other biological and abiotic environmetal factors influence the symbioses directly, too. As a result, for a long time the mycorrhizal technology did not find acceptance in practice because only very recent approaches overcame the very low predictability of successful mycorrhizal establishment and the high variability of mycorrhizal effectiveness.

The break-through in mycorrhizal technology was initiated by the development of the directed inoculum production process (DIPP) [25] basing on the observation that characteristics of single AMF spores in fungal populations can be selected and maintained for short time by environmental factors during the inoculum production process [26]. Nowadays, the predictability of effects arises to more than 80% probability – from 35% before DIPP.

## Adequate carrier – adequate application procedure

Use of AMF inoculum in horticultural practice is mainly defined by (i) highly diverse host genotypes, selected by criteria others than mycotropy, (ii) diverse substrates for specific uses (e.g. heterogenous soil in case of field inocultions, substrates with turf, peat or compost components, vermiculites, expanded clay or lava for hydroponic culture or roof top applications, stonewool and others) and (iii) the application procedure (by hand or machine, integration into common procedures or use of specific technological developments, mixing, surface incorporation etc.).

The different scenarios led to two different strategies of inoculum producers to adapt their inoculum to the practical demands: some are screening for "the best fungus" for special problems and specific environments and get fungal specialists for restricted use [27], others are optimizing the characteristics of a common fungal generalist by the cited DIPP and offer a very plastic inoculum for variable use [25], which in certain cases can be of lower effectiveness in comparison with specialists. Recently, the

commercialisation of AMF specialists seems not to be viable because of the high costs of inoculum, while the advantage of the latter is the lower price and flexible use in nearly all target areas (for the tested host spectrum of such generalists please refer to [28, 29]).

AMF are obligate biotrophic fungi, that means that they can be produced only on host roots. Inoculum, therefore, contains not only fungal material, but also associated microorganisms, plant roots and carrier material. For the practice it is important to know that there are already international agreements between the largest inoculum producers to control the quality of their inoculum [30], and that it is principally possible to adapt the carrier material to the demand of the user. As examples, in own experiments it could be demonstrated that natural lava was stabile enough to protect fungal structures to be blown onto roof tops by special equipment; expanded clay was suitable to inoculate old trees in compressed soil by modern on site re-ventilation methods bringing in the necessary nutrients and air together with AMF with high pressure.

Summarizing, recently there are only few limits to design adequate carriers and application procedures for AMF inoculum suitable for practice and the mycorrhizal technology is, therefore, available for all areas of horticulture.

## Compatibility of mycorrhizal technology with biological, biotechnical, plantbreeding and cultivation-related measures and chemical plant protection products

Horticultural practice, especially measures of integrated plant protection, are influencing mycorrhizal fungi, once inoculated to target plants, on one hand by favouring the fungal activity, on the other hand by handicapping the development of the symbiosis.

At horticultural sites which are often replanted by different plant species or varieties the planting sequence may negatively influence the survival of inoculated AMF if e.g. non-host like *Cruziferae* are planted for more than one year. Furthermore, permanent cultivation of a single host genotype may reduce the AMF effectiveness which can be avoided by co-cultivation with other mycorrhizal plant species [31]. The low colonization specifity of AMF can be used for inoculation purpose if e.g. old trees have to be inoculated. Co-cultivation of such trees with "donor plants" will result in higher densities of AMF structures in the soil and in a subsequent colonization of the target tree with the fungal symbiont. Whether AMF can be inoculated once and remain permanently effective in cases of such trees is not known for urban conditions in Germany. From the tropics we know, that the effectiveness of tree symbionts may be low if the tree is growing free from other hosts [32]

Plant breeding severly influences the success of inoculations. There are differences between cultivars of one species which show a genotype specific expression of fungal effectiveness and plant responsiveness [33] to inoculations. Mostly, on the level of the cultivar only the colonization behaviour but not the effectiveness of AMF is predictable.

High rates of mineral fertilizers often impede the colonization of target plants [34]; more frequently given smaller doses are recommended in certain cases. Organic material, applicated as mulch increases the quantity of mycorrhization. Certainly, the type and quantity of fertilizers are selecting AMF strains and changing AMF communities. Disturbation of the soil and tillage may select special AMF genotypes and has to be taken into account where sites are often replanted [18, 35].

There are certain pathogenic antagonists, *Trichoderma, Gliocladium, Pseudomonas, Bacillus* and PGPR which co-operate with mycorrhizal fungi in biocontrol of pathogens [36]. It seems that the phytosanitary role of mycorrhizal fungi can be made even more effective when they are combined with other plant protection measures. Internet investigations looking for commercial products mixed with AMF show that the fungi are combined with humic acids, *Trichoderma*, biostimulants, beneficial bacteria, soluble sea kelp, yucca plant extracts, amino acids, and vitamins to promote rapid and healthy root development. To reduce transplant stress and watering maintenance, and to slow release all soluble components of the formulation, water management gel is sometimes added to complete the packages.

Pesticide use often is shown to negatively influence mycorrhiza formation [35]. Nevertheless, in own tests with recently in Germany registered active substances we never found a complete destruction of mycorrhiza in test plants. Especially already established mycorrhiza is not impeded or even favoured by use of these plant protection products [37].

Overall, it is obvious that the mycorrhizal technology easily may find its place in complex mangement protocols like formulated in integrated plant protection concepts.

## Promising applications in German horticulture

The world wide production and trade with AMF inoculum increased between 1999 and 2003 to 1700% [37]. The main reason is that hobby gardeners and the professional organic farmers are descovering the possibilities of AMF applications.

In Germany, the first company selling AMF inoculum was founded already in 1989 but did not succeed in comercializing inoculum targeted to professional producers of horticultural products. Only in the last five years Germany developed several interesting projects which show promising results especially for urban horticultural aspects: as some examples, (i) a producer of high value in vitro propagated medicinal plants significantly reduced the loss of plant material using AMF and optimized the eco-balance of the plant production system [38]; (ii) Producers of ornamentals are able to provide their customers with plant material for balcony, garden or indoor use [28, 29, 39, 40] which is characterized by higher stress tolerance. Additionally, the company of such producers have a better energy-balance, because of shorter service lives and earlier selling times. (iii) On roof tops, the loss of plants was reduced and the surviving plants were more tolerant to water stress [41].

The conclusion drawn on the background of this review concerning mycorrhizal technology is that we are at the beginning of a broad introduction of the fungal symbionts to horticultural practices in Germany. Especially the consideration of AMF as plant strengtheners in integrated plant protection systems in urban horticulture and organic farming systems will promote future developments and will identify new demands and challenges for the mycorrhizal technology.

## Literature


1 VARMA, A., HOCK, B. (eds.), 1995. Mycorrhiza. Springer Berlin, ISBN 3-540-58525-7, 747pp.

2 Dehne, H.-W. 1982. Interaction between VAM-fungi and plant pathogens. Am. Phytopath. Soc. 72 (8), 1115-1119.

3 SCHÖNBECK, F., 1987. Mykorrhiza und Pflanzengesundheit. Ein Beitrag zum biologischen Pflanzenschutz. Angew. Botanik. 61, 9-13.

4 CORDIER, C., GIANINAZZI, S., GIANINAZZI-PEARSON, V., 1996. Colonisation patterns of root tissues by *Phytophtora nicotianae var parasitica* related to reduced disease in mycorrhizal tomato. Plant Soil 185, 223-232.

5 SLEZACK, S., DUMAS-GAUDOT, E., PAYNOT, M., GIANINAZZI, S., 2000. Is a fully established arbuscular mycorrhizal symbiosis required for bioprotection of Pisum sativum roots against *Aphanomyces euteiches*? Mol. Plant Microb. Interac. 13, 238-241.

6 HOOKER, J.E., JAIZME-VEGA, M., ATKINSON, D., 1994. Biocontrol of plant pathogens using arbuscular mycorrhizal fungi. In: Gianinazzi, S., Schuepp, H. (eds). Impact of arbuscular mycorrhizas on sustainable agriculture and natural ecosystems. ALS, Birkhäuser-Verlag, Basel. 191-200.

7 AZCON-AGUILAR, C., BAREA, J.M., 1996. Arbuscular mycorrhizas and biological control of soil-borne plant pathogens. Mycorrhiza. 6, 457-464.

8 PINOCHET, J., CALVET, C., CAMPRUBI, A., FERNANDEZ, C., 1996. Interactions between migratory endoparasitic nematodes and AMF in perennial crops: A review. Plant Soil. 185, 183-190.

9 SCHÖNBECK, F., DEHNE, H.-W., 1979. Untersuchungen zum Einfluß der endotrophen Mykorrhiza auf Pflanzenkrankheiten. Z. Pflanzenkrankh. Pflanzenschutz. 86(2), 103-112.

10 FELDMANN, F., JUNQUEIRA, N.T.V., LIEBEREI R. (1989): Utilization of vesicular-arbuscular mycorrhiza as a factor of integrated plant protection. Agriculture, Ecosystems and Environment. 29, 131-135.

11 GARCIA-GARRIDO, J.M., OCAMPO, J.A., 1988. Interaction between *Glomus mosseae* and *Erwinia carotovora* and its effects on the growth of tomato plants. New Phytol. 110, 551-555.

12 GARCIA-GARRIDO, J.M., OCAMPO, J.A. (1989): Effect of VA mycorrhizal infection to tomato on damage caused by *Pseudomonas syringae*. Soil Biol. Biochem. 21, 165-167.

13 AZCON-AGUILAR, C., JAIZME-VEGA, M.C., CALVET, C., 2002. The contribution of arbuscular mycorrhizal fungi to the control of soil-borne pathogens. In: Gianinazzi, S., Schuepp, H., Barea, J.M., Haselwandter, K. (eds). Mycorrhizal Technology and Agriculture. Birkhäuser-Verlag, Basel. 187-197.

14 TROTTA, A., VARESE, G.C., GNAVI, E., FUSCONI, A., SAMPO, S., BERTA, G., 1996. Interactions between the soil-borne root pathogen *Phytophtora nicotianae var. parasitica* and the arbuscular mycorrhizal fungus *Glomus mosseae* in tomato plants. Plant. 185, 199-209.

15 FORBES, P.J., ELLISON, C.H., HOOKER, J.E., 1996. The impact of AMF and temperature on root system development. Agronomie. 16, 617-620.

16 LINDERMAN, R.G., PAULITZ, T.C., 1990. Mycorrhizal-rhizobacterial interactions. In: Hornby, D., Cook, R.J., Henis Y., Ko, W.H., Rovira, A.D., Schippers, B., Scott, P.R. (eds.). Biological control of soil-borne plant pathogens. Wallingford, UK, CAB International. 261-283.

17 POZO, M.J., SLEZACK-DESCHAUMES, S., DUMAS-GAUDOT, E., GINANINAZZI, S., AZCON-AGUILAR, C., 2002. Plant defense responses induced by arbuscular mycorrhizal fungi. In: Gianinazzi, S., Schuepp, H., Barea, J.M., Haselwandter, K. (eds). Mycorrhizal Technology and Agriculture. Birkhäuser-Verlag, Basel. 103-112.

18 BETHLENFALVAY, G.J., 1992. Mycorrhizae and Crop Productivity. In: Bethlenfalvay, G.J., Linderman, R.G. (eds). Mycorrhizae in sustainable agriculture. ASA Publ. No. 54. Madison, USA. 1-28.

19 FELDMANN, F., IDCZAK, E., MARTINS, G., NUNES, J., GASPAROTTO, L., PREISINGER, H., MORAES, V.H.F., LIEBEREI, R., 1995. Recultivation of degraded, fallow lying areas in central Amazonia with equilibrated polycultures: Response of useful plants to inoculation with VA-mycorrhizal fungi. Angewandte Botanik. 69, 111-118.

20 KHAN, A.G., BELIK, M., 1995. Occurrence and ecological Significance of Mycorrhizal Symbiosis in Aquatic Plants. In: Varma, A., Hock, B. (eds.) Mycorrhiza. Springer Berlin. 627-668.

21 AUGE, R.M., STODOLA, A.J.W., 1990. An apparent increase in symplastic water contributes to greater turgor in mycorrhizal roots of droughted *Rosa* plants. New Phytol. 115, 285-295.

22 ROSENDAHL, C.N., ROSENDAHL, S., 1991. Influence of VAMF (*Glomus* spp.) on the response of Cucumber (*Cucumis sativus*) to salt stress. Environ. Exp. Bot. 31, 313-318.

23 LEYVAL, C. JONER, J., DEL VAL, C., HASELWANDTER, K., 2002. Potential of arbuscular mycorrhizal fungi for bioremidiation. In: Gianinazzi, S., Schuepp, H., Barea, J.M., Haselwandter, K. (eds). Mycorrhizal Technology and Agriculture. Birkhäuser-Verlag, Basel. 175-186.

24 FELDMANN, F., 1997. Charakterisierung des Vorkommens von arbuskulären Mykorrhiza-symbiosen in Pflanzennutzungssystemen des Braunschweiger Raumes. Braunschw. Naturkdl. Schr. 5 (2), 491-503.

25 FELDMANN, F., GROTKASS, C., 2002. Directed inoculum production – shall we be able to design populations of AMF to achieve predictable symbiotiy effectiveness? In: Gianinazzi, S., Schuepp, H., Barea, J.M., Haselwandter, K. (eds). Mycorrhizal Technology and Agriculture. Birkhäuser-Verlag, Basel. 261-280.

26 FELDMANN, F., 1998. The Strain - Inherent Variability of Arbuscular Mycorrhizal Effectiveness: II. Effectiveness of single spores. Symbiosis. 25, 131-143.

27 DODD, J.C., THOMSON, B.D., (1994. The screening and selection of inoculant arbuscular mycorrhizal and ectomycorrhizal fungi. In: Robson, A.D., Abott, L.K., Malajczuk, N. Management of mycorrhizas in agriculture, horticulture and forestry. 149-158.

28 WEISSENHORN, I., FELDMANN, F., 1999. Perspektiven der Nutzung der arbuskulären Mykorrhiza im niederländischen Gartenbau unter Glas. Mitteilungen der Biologischen Bundesanstalt. 363, 65-73.

29 FELDMANN, F., SILVA JR., J.P., JAYARATNE, A.V.R., 1999. Nutzung der arbuskulären Mykorrhiza in Baumschulen der Tropen am Beispiel des Kautschukbaumes *Hevea* spp. Mitteilungen der Biologischen Bundesanstalt. 363, 83-92.

30 VON ALTEN, H., BLAL, B., DODD, J.C., FELDMANN, F., VOSATKA, M., 2002. Quality control of arbuscular mycorrhizal fungi inoculum in Europe. In: Gianinazzi, S., Schuepp, H., Barea, J.M., Haselwandter, K. (eds). Mycorrhizal Technology and Agriculture. Birkhäuser-Verlag, Basel. 281-296.

31 FELDMANN, F., BOYLE, C., 1999. Weed mediated stability of arbuscular mycorrhizal effectiveness in maize monocultures. Angewandte Botanik. 73 (1/2), 1-5.

32 FELDMANN, F., LIEBEREI, R., 1994. Vesicular-arbuscular mycorrhiza in rubber tree monocultures. Mycorrhiza News. 5 (4), 1-6.

33 FELDMANN, F., BOYLE, C., 1998. Concurrent development of arbuscular mycorrhizal colonization and powdery mildew infection on three *Begonia hiemalis* cultivars. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz. 105 (2), 121-129.

34 ABBOTT, L.K., ROBSON, A.D., 1984. The effect of mycorrhizae on plant growth. In: Powell, C.L., Bagyaraj, D.J. (eds.) VA Mycorrhiza. CRC Press, Boca Raton, USA. 113-130.

35 JOHNSON, N.C., PFLEGER, F.L., 1992. Vesicular-arbuscular mycorrhizae and cultural stresses. In: Bethlenfalvay, G.J., Linderman, R.G. (eds). Mycorrhizae in sustainable agriculture. ASA Publ. No. 54. Madison, USA. 71-99.

36 LINDERMAN, R.G., 1992. Vesicular-arbuscular mycorrhizae and soil microbial interactions. In: Bethlenfalvay, G.J., Linderman, R.G. (eds). Mycorrhizae in sustainable agriculture. ASA Publ. No. 54. Madison, USA. 45-70.

37 FELDMANN, F., 2003. Weltweiter Handel mit Mykorrhizapilzinokulum - eine Risikoanalyse für die Bundesrepublik Deutschland. Schriftenreihe des BMVEL Angewandte Wissenschaften. In press.

38 GROTKASS, C., HUTTER, I., FELDMANN, F., 2000. Use of arbuscular mycorrhizal fungi to reduce weaning stress of micropropagated *Baptisia tinctoria* (L.) R. Br. Acta Horticulturae. 530, 305-311.

39 FELDMANN, F., HUTTER, I., NIEMANN, P., WERITZ, J. , GROTKASS, C., BOYLE, C., 1999. Einbindung der Mykorrhizatechnologie in die Heil- und Zierpflanzenproduktion sowie den Endverkauf. Mitteilungen der Biologischen Bundesanstalt. 363, 6-38.

40 FELDMANN, F., 1998. Symbiontentechnologie in der Praxis: Arbuskuläre Mykorrhiza im Gartenbau. Thalacker-Medien, Braunschweig, ISBN 3-87815-109-8.

41 BUSCH, E., LELLEY, J.I., 1997. Use of endomycorrhizal fungi for plant cultivation on buildings. Angewandte Botanik. 71 (1/2), 50-53.

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# Evaluation and risk-assessment of bio-rational pesticides for controlling crucifer pests in urban horticulture in the Philippines

## Introduction

The "UN Commission for the future" estimated that over the last 65 years the developing world's urban population has increased tenfold, and the trend is accelerating [1]. Third world cities will be crucially dependent upon the availability of reliable and reasonable priced food supplies for their burgeoning populations. Urban horticulture plays an essential role in food production and will become indispensable within these cities. The significance of urban horticulture was further emphasized at the United Nations Habitat II conference, held in Istanbul in June 1996.

It is known that the accessibility of vegetables for consumption is far from being sufficient in almost all developing countries. The importance of urban and peri-urban vegetable production to improve vitamin and micronutrient supply, especially for the urban poor, is recognized by international policy-makers and put on a high political agenda [2]. Pests are the major limitation for increased vegetable production in the tropics. Farmers react to increasing pest problems with an increased use of pesticides, often applied in mixtures. However, the control of insect pests and diseases by the use of pesticides can pose major risks in highly populated urban localities. Concerns relating to the potential contamination of surfaces, especially waters by spray drift resulted in the UK in the use of buffer or no-spray zones. Those zones are part of the conditions of approval of plant protection products having a toxicity profile that justified such protection measures. In 1997 more than 400 formulations for which the use of a buffer zone was indicated were listed [3]. Especially the concern over the use of toxic insecticides for controlling vegetable pests is increasing, since they can accumulate in the food product and pose an additional risk of toxication. Consequently more emphasis is being placed on the use of more environmental friendly pesticides as part of integrated pest management (IPM) strategies in plant health care (PHC) programs.

From 1998 to 2001 we identified three major insect pests in crucifer production systems in Nueva Ecija, Philippines. Nueva Ecija is a major vegetable production area and peri-urban to Metropolitan Manila. Those insect pests are year-round present in the Philippines. They are difficult to control due to their natural behaviour and their ability to develop resistances to insecticides. However, farmers still rely heavily on insecticides to control vegetable pests.

Materials such as horticultural oils, insecticidal soaps, secondary plant compounds, and neem extracts have been shown to be harmless on beneficial insects and human health. We evaluated such insecticides in field and laboratory experiments and focused especially on the possibility to use such materials in urban environments. All insecticides were compared with the synthetic insecticide chlorpyrifos, which is commonly used in the Philippines.

Keywords: *Plutella xylostella*, *Hellula undalis*, *Myzus persicae*, horticultural oils, insecticidal soap, neem extract, glucosinolate, plant growth, pak-choi, drift

## Material and methods

Vegetable pests identified

The three major insect pests identified in the Philippines on pak-choi, *Brassica chinensis*, were the diamondback moth (DBM), *Plutella xylostella* L., the cabbage webworm (CWW), *Hellula undalis* F., and the green peach aphid (GPA), *Myzus persicae* Sulzer.

DBM is a specialist herbivore that attacks many *Brassicaceae* species. Larvae feed voraciously with its chewing mouthparts on the undersides of leaves leaving a papery epidermis intact. In cases of severe infestation entire leaves can be consumed. Young CWW larvae mine leaves, bore stems and feed externally on leaves. Older larvae often destroy the terminal bid which results in plant death. The GPA has many host plants. These aphids have a worldwide distribution and vector many viruses.

Plant material used

Some Oriental leafy vegetables in the *Brassica* genus have become popular in western countries: pak-choi, *Brassica campestris* ssp. *chinensis* is one of those vegetables. We selected the variety Black Behi for the bio-tests, which is commonly used in the Philippines and one of the main leafy vegetables in this country. To test egg-laying behaviour on non-host plants for CWW we used the leguminous crop *Vigna sesquipedalis* (L.).

Insecticides and pathogens evaluated

Pesticides used in the experiments were based on 1) their low human toxicity and/or 2) the fact that they haven't been evaluated in the tropics against crucifer pests previously. As control we used water and the synthetic insecticide chlorpyrifos, whereby the later one is commonly used in the Philippines.

**Tab. 1** Pesticides and their active ingredients used in the experiments

| **Product name & notes** | **Active ingredient** |
|---|---|
| ULTRA-FINE® OIL | Paraffinic Oil (98.8%) |
| M-PEDE® | Potassium salts of fatty acids ($KC_{18}H_{34}O_2$) Ethanol 36% ($C_2H_6O$) |
| NEEMAZAL-T/S® | Azadirachtin (1%) and other neem ingredients (3%) |
| FOSSIL SHIELD® | Diatomaceous earth |
| AVID® 0.15 EC | Abamectin (2%) |
| BRODAN® | Chlorpyrifos |
| Microsporidia isolated from CWW | Microsporidium in the genus *Vairimorpha* |
| AGREE® | *Bacillus thuringiensis* ssp. *aizawa* |
| Glucosinolates | Glucosinolates and hydrolysis products |

In field experiments the pesticides were applied weekly starting one week after plant emergence. The dosage corresponded to the recommendation of the producers. Insecticide effectiveness to insects was tested via direct contact treatment and oral ingestions. In "contact experiments", we dipped 3rd instar larvae of both lepidopterous pests into the insecticide solution and kept them for 48 h on pak-choi leaves at 25°C and above 85 % RH in the laboratory. GPA adults obtained from the field were sprayed with the insecticide solution and kept under the same laboratory conditions as previously described. Insect mortality was assayed after 48 hours.

The infectivity and pathogenicity of the microsporidium was tested in experiments with 3rd instar larvae of CWW and DBM. Single larvae were kept in plastic containers on artificial diet (1 cm cube) at 30°±2 °C and 85±10 % RH. The artificial diet cubes for larval infection had been previously treated with the standard spore suspension extracted from infected CWW larvae, 50 µl each (about 1000 spores) [4]. In the controls water was applied on artificial diet. The test was repeated four times, 40 larvae in each repetition (20 treated and 20 untreated). The mortality and developmental stage of both insects were recorded until adult emergence. Every two days the artificial diet was replaced. Used facilities and materials were sterilized with 70 % ethanol followed by bleach. Dead larvae and abdomens of adults were examined for microsporidian stages by using phase contrast microscopy. Additionally, ovaries of female moths were examined for eggs.

Table 2 gives an overview about the laboratory and field experiments conducted to test different pesticides for their efficacy against CWW, DBM, and GPA.

**Tab. 2** Overview of pesticide application rates and dose in field and laboratory experiments

| Product name | Field / laboratory experiment | Application rate & dose |
|---|---|---|
| ULTRA-FINE® OIL | Field | 3 applications, 7 days apart beginning 7 days after plant emergence; 2 % solution, 500 l $ha^{-1}$ |
| M-PEDE® | Field | 3 applications, 7 days apart beginning 7 days after plant emergence; 2 % solution, 500 l $ha^{-1}$ |
| NEEMAZAL-T/S® | Field | 3 applications, 7 days apart beginning 7 days after plant emergence; 0.04 % solution, 500 l $ha^{-1}$ |
| FOSSIL SHIELD® | Field | 3 applications, 7 days apart beginning 7 days after plant emergence; 600 g $ha^{-1}$ |
| AVID® 0.15 EC | Laboratory | 0.6 g product $l^{-1}$ diet |
| BRODAN® | Field / Laboratory | 3 applications, 7 days apart beginning 7 days after plant emergence; 590 ppm solution, 500 l $ha^{-1}$; diet with 590 ppm conc. |
| Microsporidia | Laboratory | 1cm cube artificial diet treated with 50 µl standard spore solution |
| AGREE® | Field | 3 applications, 7 days apart beginning 7 days after plant emergence 1 kg $ha^{-1}$ |
| Glucosinolates | Laboratory | Non-host plant leaves treated with 2 glucosinolates and 2 breakdown products in a concentration of $10^{-4}$ M |
| Water as control | Field / Laboratory | 3 applications, 7 days apart beginning 7 days after plant emergence; 500 l $ha^{-1}$ |

Glucosinolate (GS) breakdown products such as isothiocyantaes (ITC) and cyanides (CN) are volatile. GS hydrolysis products have potential as biodegradable and safe insect fumigants [5]. The parent hydrolysis products of GS are not only insecticidal they are also fungicidal and bactericidal [42]. CN have been shown to be less toxic to generalist insect herbivores than ITC [6]. The action of ITC and CN is not completely understood but they may act as ingestion inhibitor and are causing respiratory distress. In laboratory choice tests with non-host-plants we investigated whether GS or their breakdown products stimulate or prevent oviposition of CWW when sprayed on the non-host-plant *V. sesquipedalis* (L.). To test if GS induce oviposition in CWW we applied the GS sinigrin and glucotropaeolin at a concentration of $10^{-4}$ M to both sides of *V. sesquipedalis* leaves. We also tested the effect of hydrolysis products of GS on oviposition behaviour. 3-Indolyl-methyl-cyanide and 5-Venyloxazoledine-2-thione, hydrolysis products of glucobrasseicin and progoitrin, respectively and previously identified in pak-choi [7] were applied as hydrolysis products to both sides of pak-choi leaves. Leaves were placed in containers, filled with water and transferred in polyethylene tubes (21 x 12 cm). Experiments were done with one compound each and water as control. Oviposition of CWW was recorded daily and leaves were replaced. The bioassay was done with 20 replications each. Insects were fed a 10 % honey solution in this experiment and in the following bioassays.

Spray drift studies

Drift field evaluation studies are designed to provide an estimate of droplet deposition away from the target site at or near the time of initial deposition. These off-site transport data are needed to evaluate the potential risk from pesticide exposure to humans, plants, fish and wildlife by products expected to be applied [8]. We used the HERBI-4® backpack sprayer from Micron Sprayers Ltd to apply insecticides in the field.

Insecticide drift was measured in 5, 10, 15, and 20 m distance respectively, from the target site. Glass plates (15 x 15 cm) were positioned on wooden sticks in 1 m height with 45° angle pointed to the target site. Insecticide residues were washed off the plates in the laboratory and analyzed.

Chemical analysis

Abamectin was analyzed using high performance liquid chromatography (HPLC) with a Partisil 10 ODS-3 column and a mobile phase of 12% water, 53% methanol, and 35% acetonitrile. The wavelength for the UV-detector was 245 nm. Chlorpyrifos was analyzed as described by Guan & Soo [9].

Sampling

In field experiments, insect densities were determined using a 1 m² bamboo-frame on five randomized selected areas in the field. In each of the five selected areas the number of plants as well as insects was counted and number of insect per plant calculated. Insect densities in the field were counted weekly three days after insecticides had been applied, beginning 10 days after plant emergence.

Statistical analysis

Data were subject to one-way-ANOVA with posthoc Tukey's HSD test for the mean comparison. Data of the experiments with microsporidia were analyzed for statistical differences among mortality of treatments by using repeated measures analyses of variance (RMANOVA). All eggs from all moths in each egg-laying experiment were analyzed with the nonparametric Sign-Test (multiple comparisons, separate test for each pair of variables). For all tests, the statistic software package SYSTAT (version 10) was utilized.

## Results

Field experiments with insecticides

The synthetic insecticide chlorpyrifos was the only material reducing pest intensities for all three species (Table 3). However, ULTRA-FINE® OIL and the BT-based product AGREE® were as effective against the two lepidopterous pests and NEEMAZAL-T/S® and M-PEDE® were equally good in controlling GPA.

**Tab. 3** Field evaluation of different insecticides evaluated

| **Treatment** | ***H. undalis*** **(larvae / m²)** | ***P. xylostella*** **(larvae / m²)** | ***M. persicae*** **(number / m²)** |
|---|---|---|---|
| neem | 4.2 $_{a*}$ | 17.0 $_{ab}$ | 42.5 $_{b}$ |
| potassium salts | 6.1 $_{a}$ | 16.0 $_{a}$ | 28.0 $_{b}$ |
| paraffinic oil | 3.4 $_{b}$ | 14.8 $_{b}$ | 67.5 $_{ab}$ |
| diatomaceous earth | 5.0 $_{a}$ | 21.1 $_{a}$ | 58.5 $_{ab}$ |
| B.t. | 1.8 $_{b}$ | 14.1 $_{b}$ | 86.0 $_{a}$ |
| chlorpyrifos | 3.0 $_{b}$ | 11.5 $_{b}$ | 22.0 $_{b}$ |
| water | 5.8 $_{a}$ | 18.4 $_{a}$ | 78.5 $_{a}$ |

(*different letters indicate significant differences between treatments within species, Tukey's HSD test, $p < 0.05$)

Laboratory evaluation of insecticides

The insecticides chlorpyrifos and abamectin were tested in direct surface contact to the three insect pests. Both insecticides increased significantly the mortality of all three species. The efficacy of the microsporidium was tested via feeding viable spores on artificial diet to the insect pests. In peroral infection experiments, the microsporidium (*Vairimorpha* sp.) was highly infectious for CWW but not for DBM (Table 4).

**Tab. 4** Laboratory evaluation of abamectin, chlorpyrifos and a microsporidium

| **Treatment** | ***H. undalis* (mortality %)** | | ***P. xylostella* (mortality %)** | | ***M. persicae* (number / m²)** |
|---|---|---|---|---|---|
| | **after 48 h#** | **diet##** | **after 48 h#** | **diet##** | **after 48 h#** |
| abamectin | 67.5 $_{b*}$ | | 67.2 $_{c}$ | | 55.2 $_{b}$ |
| chlorpyrifos | 71.2 $_{b}$ | | 31.2 $_{b}$ | | 70.0 $_{b}$ |
| microsporidium | | 80 $_{b}$ | | 21.8 $_{a}$ | |
| water | 1.2 $_{a}$ | 31.5 $_{a}$ | 2.5 $_{a}$ | 14.5 $_{a}$ | 3.5 $_{a}$ |

(#mortality evaluation 48 h after direct treatment; ##mortality during larval development after feeding treated artificial diet; *different letters indicate significant differences between treatments within species, Tukey's HSD test)

The application of the GS breakdown products 3-Indolyl-methyl-cyanide and 5-venyloxazoledine-2-thione on pak-choi leaves decreased significantly egg laying behaviour of CWW. Contrary the application of GS onto leaves of the non-host plant *V. sesquipedalis* increased significantly the mean number of eggs laid by CWW (table 5).

**Tab. 5** Evaluation of GS and GS break down products on egg laying behaviour of CWW in no-choice experiments

| **Treatment [GS = Glucosinolate] [BP = Breakdown product of GS]** | **Host plant (pak-choi) (mean nb. eggs laid within 3 days)** | **Non host plant (*V. sesquipedalis*) (mean nb. eggs laid within 3 days)** |
|---|---|---|
| GS: Sinigrin | | 12 $_{b}$ |
| GS: Glucotropaeolin | | 23 $_{c}$ |
| BP: 3-Indolyl-methyl-cyanide | 14 $_{b}$* | |
| BP: 5-Venyloxazoledine-2-thione | 17 $_{b}$ | |
| Water | 53 $_{a}$ | 3 $_{a}$ |

(*different letters indicate significant differences between treatments within plant species, $p > 0.05$ Sign-Test (separate test for each pair of variables))

Climate and drift analysis

Wind speed ranged between 2.7 and 2.9 m $s^{-1}$ during insecticide application and the RH was 80 %.

**Tab. 6** Drift of abamectin and chlorpyrifos during and subsequent application

| | **chlorpyrifos quantity* (ng/cm²)** | | **abamectin quantity* (ng/cm²)** | |
|---|---|---|---|---|
| **distance (m)** | **during application** | **subsequent application** | **during application** | **subsequent application** |
| 5 | 64.30 ± 50.3 | 51.65 ± 41.6 | 134.50 ± 97.5 | 111.00 ± 76.5 |
| 10 | 18.85 ± 10.9 | 11.05 ± 10.8 | 55.25 ± 32.0 | 33.5 ± 12.2 |
| 15 | 5.50 ± 3.1 | not detected | 25.4 ± 20.5 | 25.8 ± 22.4 |
| 20 | not detected | not detected | 22.5 ± 15.0 | not detected |

(* mean quantity resulting from two applications and two monitoring locations within the field)

There is always a drift during the application of pesticides. Especially in urban areas is the distance of insecticide drift important. Drift residues on the sample plates were higher during than subsequent application. Chlorpyrifos was detected up to the distance of 15 m from the application point and abamectin up to 20 m distance.

Risk assessment

For the risk assessment we calculated the theoretical insecticide uptake of a 70 kg person with a body-surface of 21 000 cm² [10] for abamectin and chlorpyrifos. The Acceptable Daily Intake (ADI) value for chlorpyrifos is 0.01 mg/kg/day and for abamectin 0.002 mg/kg/day [11].

**Tab. 7** Estimated pesticide exposure

| insecticide | during application | | subsequent application | |
|---|---|---|---|---|
| | 5 m distance | 15 m distance | 5 m distance | 15 m distance |
| Chlorpyrifos | | | | |
| *mg/kg | 0.0193 | 0.0016 | 0.0155 | Not detected |
| **percent ADI | 21.4 | 1.8 | 17.2 | |
| Abamectin | | | | |
| *mg/kg | 0.0404 | 0.0076 | 0.0333 | 0.0077 |
| **percent ADI | 2017 | 381 | 1650 | 387 |

(* human body: 21 000 $cm^2$ and 70 kg [10]; ** percentage of the Acceptable Daily Intake [11])

In 5 m distance we calculated for chlorpyrifos 21 % of the ADI during and of 17.2 % subsequent application. For abamectin the calculated value was in 5 m distance 20 times higher than the ADI-value during application and 3.8 times the ADI-value in 15 m distance during application. Subsequent application the residues on the glass plate were 16 times the ADI in 5 m distance and 3.8 times in 15 m distance (table 7).

## Discussion

All three major pests on pak-choi were found year-round, presenting a challenging environment to test the insecticides. DBM and CWW are the most important lepidopterous pests on crucifer crops in the tropics. Host plants include both cultivated and wild plants of the family *Brassicacea*. Both species lay their eggs singly or in small groups on the upper or underside of the leaves. They are frequently deposited in the hollows along the vein, on the young stems or on petioles. DBM larvae are surface feeders and are often found on the lower leaf surface. All the leaf tissues are consumed except the veins and the upper epidermis creating a "windowing" effect. In contrast to this the young CWW larvae begin to feed on the leaves, especially the young tender leaves and usually spin a web about themselves between two leaf surfaces [12]. On pak-choi extensive damage occur when the larvae feed on the growing points (apical meristem) and the developing leaves. Feeding damage in young plants, especially at the growing point, results frequently in plant death [7]. More often, damage to the growing point results in deformed plants and the formation of multiple growing points or heads. If the growing point is occupied by older larvae or already consumed, then CWW tend to migrate to older leaves by tunnelling into leaf petioles.

From the economic point of view, the larval stage is responsible for the damage [13]. Sole dependence on chemical controls can lead to insecticide resistance, especially in DBM [14, 15]. Both insects are difficult to control with synthetic insecticides alone. DBM because of its ability to develop quick resistances against commonly used insecticides, CWW because it is difficult to reach with insecticides when feeding inside the plant growing point. Symptoms of CWW infestations are often not detected until plants appear stunted or deformed.

DBM larvae, especially the younger stages, are very susceptible to drowning. During periods of rainy weather and high humidity when there are droplets of water in the area more than half of the first three larval stages may perish by drowning [16]. However, especially during the rainy season we found CWW more damaging than DBM. In contrast to this is DBM the dominant pest during the dry season.

Seedlings and young pak-choi plants can be stunted by the attack of large populations of GPA. GPA vectors many plant viruses and this is potentially the greatest consequence of an infestations. This pest vectors virus diseases in more than 30 plant families, including pak-choi [17]. GPA is also known to develop resistances to insecticides [18, 19].

Insecticide evaluation

Results of our laboratory experiments indicated resistance to chlorpyrifos for DBM. Abamcetin caused within 48 h a significant higher mortality in DBM than chlorpyrifos. However, both insecticides increased mortality compared with water as control. Abamectin and chlorpyrifos were both equally effective against GPA (table 4). Abamectin acts on insects by interfering with neural and neuromuscular transmission. It acts on a specific type of synapse located only within the brain and is protected by the

blood-brain barrier. Abamectin is a highly toxic material, however most formulated products containing abamectin are considered of low toxicity to mammals [20, 21]. Chlorpyrifos is one of the most-widely used active ingredients for pest control products in the world. Today, it is registered in more than 98 countries worldwide, including most developed nations. Chlorpyrifos is an organophosphate insecticide. Like other organophosphates, its insecticidal action is due to the inhibition of the enzyme acetylcholinesterase, resulting in the accumulation of the neurotransmitter, acetylcholine, at nerve endings. This results in excessive transmission of nerve impulses, which causes mortality in the target pest. Based on the results in the laboratory we would recommend the replacement of the commonly used insecticide chlorpyrifos with abamectin.

In field experiments chlorpyrifos reduced insect density significantly compared with the control. However, paraffinic oil and B.t. were as effective reducing DBM and CWW densities. The advantage of using the synthetic chlorpyrifos is that it is a systemic insecticide. It can be translocated within the plant and reach insects at their feeding place. Bacterial insecticides such as B.t. must be ingested to kill the larvae and paraffinic oil kills insects by suffocating them. Therefore, those insecticidal sprays must be applied to achieve full coverage of upper and lower leaf surfaces. The advantage of those insecticides is, that oils have few residual effects, and so their impact on beneficial insects is minimal. B.t. has been extensively studied, in over 25 years of use, no significant environmental impacts have been observed. Also B.t. kills only insects susceptible to the delta-endotoxin after they have ingested the insecticide and poses therefore a minimal risk to beneficial insects.

Since aphids are sucking insects the B.t. product had no effect on the GPA population in the field. Also ultra fine oil did not control GPA populations. In contrast aphid populations were reduced significantly through neem and the commercial soap M-PEDE®. Potassium salts of fatty acids are the active ingredients in M-PEDE®. Those ingredients act on contact by disrupting the pest's cuticle and breaking down cell membranes resulting in death of the target insects. Azadirachtin is the main active ingredient of the kernel seeds of the tropical Neem tree *Azadirachta indica* A. Juss. The active substance penetrates the leaves and is distributed partially systemic in the plant; the pest insects take it up orally upon feeding (sucking or biting). It stops the insect feeding and plant damaging activity. However, a „knock down“ effect should not be expected. After the treatment with azadirachtin insects react with feeding and moulting inhibition and mortality.

The diatomaceous earth FOSSIL SHIELD® was ineffective controlling all three insect pests in the field. Diatomaceous earths absorb fatty lipids located in the cuticle of insects, the result being that the insects lose water rapidly and die [30]. High relative humidity (more than 70 %), common in the Philippines, reduces the action of the dust [9], but high temperatures could compensate this reduction. Transpiration through the cuticle increases at higher temperatures. According to Korunic [22] the effectiveness of silica dust against insects increases with temperature. Most studies on the effectiveness of diatomaceous earth were done at 20 or 25 °C and high relative humidity. Under those conditions dusts were ineffective [23, 24]. However, new formulations of diatomaceous earths where the particles are hydrophob but still lipophil could become effective, even under tropical conditions such as in the Philippines.

The microsporidium tested in laboratory experiments against DBM and CWW was isolated from CWW larvae collected in the field and belongs to the genus *Vairimorpha* [4]. Other studies on the host range of Nosema and *Vairimorpha* microsporidia from Lepidoptera including infectivity tests to nontarget organisms strengthen the assumption of a host specifity of many terrestrial microsporidia [25, 26]. Usually the infection starts in the midgut after ingestion of spores and spreads to various tissues and organs. The infection sometimes causes tissue breakdown and septicemia. Not only vertical but also transversally transmission within a host species and transmission through a vector (e.g. predators and parasites) is reported. In our laboratory experiments mortality in CWW after infection was 80 %, but it did not increase mortality in DBM. This fact leads to the conclusion that the *Vairimorpha* sp. isolated from CWW is probably hot-specific. It is difficult to establish microsporidia as natural insecticides since they have no quick effect on yield. The identified microsporidia is transferred vertically as well as horizontally and there would be more research needed to identify the possibility to use it commercially under field conditions against CWW.

By exposing CWW adults to leaves of host plant (pak-choi) and non-host plants (*V. sesquipedalis*) treated with the GS breakdown products 3-indolyl-methyl-cyanide and 5-venyloxazoledine-2-thione and the GS sinigrin and glucotropaeolin respectively, we investigated their egg laying behaviour. Number of eggs laid by CWW was reduced on pak-choi leaves upon treatment with GS hydrolysis products. It is most likely that CWW females prefer to lay eggs on intact plant leaves, because there are only a few larvae which can successfully develop on one plant. Furthermore GS stimulates CWW adults to lay eggs on non-host plants. The breakdown products are generally relatively small molecules which make many of them volatile. It is known, that GS and their breakdown products stimulate egg laying behaviour in DBM in general. GS alone stimulates oviposition in *Pieris rapae* and *Pieris brassicae* [34]. Many of these volatiles have been shown to act as attractants for certain insects seeking food or egg laying sites rather than direct insecticidal activity [35, 36], but volatiles of damaged plants can also be repellent for ovipositing moths. Despite the many efforts that have been devoted to exploring GS and their breakdown products as naturally occurring pesticides, few products have been marketed commercially [5].

Risk of pesticide use in urban areas

Pesticide drift during application poses a risk to human health, especially in urban areas. It has been estimated that at least three million cases of pesticide poisoning occur worldwide each year, with 220,000 deaths. The majority of these poisonings occur in developing countries where less protection against exposure is applied, knowledge of health risks and safe use is limited and harmful pesticides are easily accessible. Understanding the factors influencing drift of pesticides is therefore important.

For spray nozzles it has been shown that the risk of drift is a function of the droplet size distribution, droplet velocities (speed and direction) within the spray, entrained air characteristics and the effective porosity of the spray structure [37]. Many recent nozzle developments have been specifically directed at reducing the risk of drift. The development of twin-fluid and air-induction nozzles has provided spray generation systems that create sprays that have relatively large droplet size distributions but in which the larger droplet sizes have “air-inclusions” within them [37]. Even with those developments drift can be reduced but not fully prevented.

Dermal exposure calculations: After the amount of residue on a unit area of exposure pad during a unit time of exposure has been determined, several assumptions are used to estimate the worker’s potential dermal exposure. It is necessary to extrapolate the amount of pesticide found on each unit area of pad to the amount that would have impinged on the total body region represented by the pad. Most of the literature describing pesticide exposure monitoring has recommended the use of surface areas based on the method of Berkow [38].

The most appropriate comparison points for human exposure to pesticides are the Acceptable Daily Intake (ADI) values. Although the ADI is principally based on minimizing risks of chronic effects, the relatively high acute toxicities for organophosphorous insecticides are also incorporated. The results in our study present estimates of exposure to the insecticide from typical drift scenarios based on the conservative assumption of complete absorption of deposits on the skin. However, a possible additional intake through inhalation was not implemented in the calculations.

Generally we found higher insecticide deposits on the sample glass plates during application than subsequent application. Chlorpyrifos and abamectin could be detected in 15 m and 20 m distance from the target area respectively. Wind speeds measured during application were not exceptionally high for the Philippines with 2.7 to 2.9 m $s^{-1}$. Calculating the possible body uptake through complete skin coverage [Berkow method, 38] we reached in 5 m distance during application a dose 20 times the ADI for abamectin and 0.2 times the ADI for chlorpyrifos. In 15 m distance the dose for chlorpyrifos was 0.02 times the ADI and 3.8 times the ADI for abamectin.

Abamectin is not readily absorbed through skin. Tests with monkeys show that less than 1 % of dermally applied abamectin was absorbed into the bloodstream through the skin [21]. Abamectin does not cause allergic skin reactions [20]. However, at very high doses of abamectin, the mammalian blood-brain barrier can be penetrated, causing symptoms of CNS depression such as tremors, lethargy, excitation and pupil dilation. Very high doses have caused death from respiratory failure [39]. The oral $LD_{50}$ for abamectin in rats is 11 mg $kg^{-1}$ [21] and in mice ranges from 14 to > 80 mg $kg^{-1}$ [20].

Chlorpyrifos is moderately toxic to humans [40]. Poisoning from chlorpyrifos may affect the central nervous system, the cardiovascular system, and the respiratory system. It is also a skin and eye irritant [17]. While some organophosphates are readily absorbed through the skin, studies in humans suggest that skin absorption of chlorpyrifos is limited [41]. Breakdown in soil and groundwater: Chlorpyrifos is moderately persistent in soils. The half-life of chlorpyrifos in soil is usually between 60 and 120 days, but can range from two weeks to over one year, depending on the soil type, climate, and other conditions [42, 43].

Based on the ADI and the persistence in the environment, abamectin poses a higher risk to human health in urban surroundings than the synthetic insecticide chlorpyrifos.

## Conclusions

Our results suggest, that the synthetic insecticide chlorpyrifos can be replaced by a combination of neem and B.t. to control the three important crucifer pests CWW, DBM, and GPA in the Philippines. B.t. and neem do not harm non-herbivore insects and can be used in urban areas without being dangerous to the human health. The success of the application with neem and B.t. depends on the progress of the pest infestation and adequate timing of the treatment. Therefore monitoring and pest identification is important for pest control strategies.

Abamectin can not be recommended for urban environments based on our drift studies and the ADI value for this insecticide.

The diatomaceous earth formulation tested was ineffective against the insect pests DBM, CWW, and GPA. However, new formulations where diatomaceous earths are hydrophob but lipophil might be useful under tropical conditions.

The microsporidium (genus: *Vairimorpha*) extracted form CWW caused 80 % mortality in the laboratory but was horizontally as well as vertically transferred. The pathogen had no effect on DBM populations in the field. Strategies to utilize and implement this microsporidium in control strategies for CWW need further experiments.

Windbreaks should be implemented in future pesticide drift migration strategies as they have been shown to be effective tools affecting pesticide drift [44]. Government policies, initiatives, and legislation have not included windbreaks to reduce pesticide drift in sensitive areas such as cities.

## Literature


1 BRUNDTLAND, G. H., 1987. Our Common Future. World Commission on Environment and Development, Geneva.

2 SCHNITZLER, W. H., HOLMER, R., 1999). Strategies for urban horticulture in developing countries. In: Sansavini, S., Cantliffe, D., Corelli-Grappadelli, L., Verzoni, D., Avermaete, U., Ganry, J., Robitaille, H., Janick, J. (eds.) Proceedings of the world conference on horticultural research, Rome, Italy, 17-20 June, Acta horticulturae 495, 3310-225.

3 MILLER, P.C.H., LANE, A.G., WALKLATE, P.J., RICHARDSON, G.M. 2000. The effect of plant structure on the drift of pesticides at field boundaries. Aspects of Applied Biology 57, 75-82.

4 MEWIS, I., KLEESPIES, R.G., ULRICHS, CH., 2003). First detection of a microsporidium in the crucifer pest *Hellula undalis* (F.) (Lep.: Pyralidae) – A possible control agent? Journal of Biological Control 26, 202-208.

5 TSAO, R., PETERSON, C.J., COATS, J.R., 2002. Glucosinolate breakdown products as insect fumigants and their effect on carbon dioxide emission of insects MC Ecology, 2, 5pp.

6 TIERENS, K.F.M.J., THOMMA, B.P.H.J., BROUWER, M., SCHMIDT, J., KISTNER, A. P., MAUCH-MANI, B., CAMMUE, B.P.A., BROEKAERT, W. F. 2001. Study of the role of antimicrobial glucosinolate-derived isothiocyanates in resistance of *Arabidobsis* to microbial pathogens. plant Phys. 125, 1688-1699.

7 MEWIS, I., ULRICHS, CH., SCHNITZLER, W.H., 2002. Possible role of glucosinolates and their hydrolysis products in oviposition and host-plant finding by cabbage webworm, *Hellula undalis*. Entomologia Experimentlis et Applicata 105, 129-139.

8 EPA, 1986. US Environmental Protection Agency, Standard Evaluation Procedure — Pesticide Spray Drift Evaluation: Droplet Size Spectrum Test and Drift Field Evaluation Test, EPA report number 540/9–86–131.

9 GUAN, H., TAN AND ME T. S., 2001. Multiresidue Analysis of Pesticides in Vegetables using Liquid Chromatography with Atmospheric Pressure Ionisation Mass Spectrometry (LC-API-MS) and a Heated Nebuliser. Malaysian Journal of Chemistry, 3 (1): 001-0012.

10 BERKOW, S.G., 1931. Value of surface area proportions in the prognosis of cutanous burns and scalds. American Journal of Surgery 11, 315–317.

11 BUNDESINSTITUT FÜR GESUNDHEITLICHEN VERBRAUCHERSCHUTZ UND VETERINÄRMEDIZIN (BGVV), 2001. ADI-Werte, DTA-Werte und gesundheitliche Trinkwasser-Leitwerte für Pflanzenschutzmittel-Wirkstoffe. Bundesgesundhbl. 11, 1130.

12 FULLAWAY, D. T., KRAUSS, N.L.H., 1945. *Hellula undalis* (F.). In: Common Insects of Hawaii. Tongg Publishing Company, Honolulu, Hawaii. 228 pages.

13 HARCOURT, D.G., 1957. Biology of the Diamondback Moth, *Plutella maculipennis* (Curt.) (Lepidoptera: Plutellidae), in Eastern Ontario. II. Life-History, Behavior, and Host Relationships. Can. Entomol. 89, 554-564.

14 EIGENBRODE, D.E., SHELTON, A.M., DICKSON, M.H., 1990. Two types of resistance to the diamondback moth (Lepidoptera: Plutellidae) in Cabbage. Environ. Entomol. 19 (4): 1086-1090.

15 LIU, M.Y., TZENG, Y.J., SUN, C.N., 1981. Diamondback moth resistance to several synthetic pyrethroids. J. Econ. Entomol. 74, 393-396.

16 TSAO, R., REUBER, M., JOHNSON, L., COATS, J.R., 1996. Insecticidal toxicity of glucosinolate-containing extracts from crambe seeds. J. Agric. Entomol. 13, 109-120.

17 HILL, D.S., 1983. *Myzus persicae* (Sulz.). pp. 202. In Agricultural Insect Pests of the Tropics and Their Control, 2nd Edition. Cambridge University Press. 746 pages.

18 ALABOODI, A., FFRENCH-CONSTANT, R.H., 1995. RAPD PCR con-firms absence of genetic variability between insecticide resistant variants of the green peach aphid *Myzus persicae* (Homoptera, Aphididae). Great Lakes Entomologist 28, 127–133.

19 NAUEN, R., STROBEL, J., TIETJEN, K., OTSU, Y., ERDELEN, C., ELBERT, A., 1996. Aphicidal activity of imidacloprid against a tobacco feeding strain of *Myzus persicae* (Homoptera: Aphididae) from Japan closely related to *Myzus nicotianae* and highly resistant to carbamates and organophosphates. Bulletin of Entomological Research 86, 165–171.

20 EPA, 1990. US Environmental Protection Agency. Pesticide Fact Sheet Number 89.2: Avermectin B1. US EPA, Office of Pesticide Programs, Registration Div., Washington, DC.

21 LANKAS, G.R., GORDON, L.R. 1989. Toxicology in W.C. Campbell (ed.). Ivermectin and Abamectin. Springer-Verlag, NY.

22 KORUNIC, Z., 1996. The effect of the moisture content of grain and the temperature on the efficacy of diatomaceous earths from different geographical locations against stored-products insects. Hedley Technologies Ltd.: 1-19.

23 EL-AWAMI, I.O., DENT, A., 1996. The effect of water availability, relative humidity and physical properties of Silica dust on its efficacy as a control agent for *Blattella germanica* (Dictyoptera: Blattillidae). Faculty of Agriculture 291-302.

24 MEWIS, I., 1998. Physiologische und morphologische Auswirkungen amorpher Diatomeenerden auf ausgewählte vorratsschädliche Insekten. Diploma-thesis, Free University Berlin, 175 pp.

25 SOLTER, L.F., MADDOX, J.V., 1998. Timing of an early sporulation sequence of microsporidia in the genus *Vairimorpha* (Microsporidia: Burenellidae). J. Invertebr. Pathol. 72, 323-329.

26 SOLTER, L.F., PILARSKA, D.K., VOSSBRINCK, C.F., 2000. Host specificity of microsporidia pathogenic to forest Lepidoptera. Biol. Contr. 19, 48-56.

27 CHEW, F.S., 1988. Biological effects of glucosinolates, In: Biologically Active Natural Products: Potential Use in Agriculture 156-181.

28 FENWICK, G.R., HEANEY, R.K., MULLIN, W.J., 1983. Glucosinolates and their breakdown products in food and food plants. CRC Crit. Rev. Food Sci. Nutr. 18, 123-201.

29 MACLEOD, A.J., PANESAR, S.S., GIL, V., 1981. Thermal degradation of glucosinolates in Cruciferae. Phytochem 20, 977-980.

30 MACLEOD, A.J., ROSSITER, J.T., 1986. Non-enzymic degradation of 2-hydroxybut 3-enylglucosinolate (progoitrin). Phytochem 25, 855-858.

31 DUNCON, A.J., 1991. Glucosinolates. In: Toxic Substances in Crop Plans 126-147.

32 LICHTENSTEIN, E.P., MORGAN, D.G., MUELLER, C.H., 1964. Naturally occurring insecticides in cruciferous crops. J. Agric. Food Chem. 12, 158-161.

33 BOREK, V., MORRA, M.J., BROWN, P.D., MCCAFFREY, J.P., 1994. Allelochemicals produced during sinigrin decomposition in soil. J. Agric. Food Chem. 42, 1030-1034.

34 RENWICK, J.A.A., 1996. Diversity and dynamics of crucifer defences against adults and larvae of cabbage butterflies. In: Romeo, J. T., Saunders, J. A. & Barbosa, P. (1996), Rercent Advances in Phytochemistry 30: Plenum Press, NY 57-79.

35 NAIR, K.S.S., MCEWEN, F.L., 1976. Host selection by the adult cabbage maggot, *Hylemya brassicae* (Diptera: Anthomyiidae): effect of glucosinolates and common nutrients on oviposition. Can. Entomol. 108, 1021-1030.

36 FEENY, P., PAAUWE, K.L., DEMONG, N.J., 1970. Flea beetles and mustard oils: host plant specificity of *Phyllotreta cruciferae* and *Phyllotreta striolata* adults (Coleoptera: Chrysomelidae). Ann. Entomol. Soc. Amer. 63, 832-841.

37 MILLER, P.C.H., LANE, A.G. 1999. Relationship between spray characteristics and drift risk into field boundaries of different structure. Aspects of Applied Biology 54, 45-51.

38 EPA, 1996. US Environmental Protection Agency. Occupational and Residential Exposure Test Guidelines OPPTS 875.1000 Background for Application Exposure Monitoring Test Guidelines. United States Environmental Protection Agency Prevention, Pesticides and Toxic Substances (7101) EPA 712–C–96–261.

39 HAYES, W.J., LAWS, E.R. (eds.)., 1990. Handbook of Pesticide Toxicology, Classes of Pesticides, Vol. 3. Academic Press, Inc., NY.

40 EPA, 1989. US Environmental Protection Agency. Registration standard (second round review) for the reregistration of pesticide products containing chlorpyrifos. Washington, DC, 5-44.

41 GALLO, M.A., LAWRYK, N.J., 1991. Organic phosphorus pesticides. In Handbook of Pesticide Toxicology. Hayes, W. J., Jr. & Laws, E. R., Jr. (eds.) Academic Press, New York, NY, 5-3.

42 HOWARD, P.H. (ed.), 1991. Handbook of Environmental Fate and Exposure Data for Organic Chemicals. Vol 3: Pesticides. Lewis Publishers, Chelsea, MI, 5-13.

43 WAUCHOPE, R.D., BUTTLER, T.M., HORNSBY, A.G., AUGUSTIJN-BECKERS, P.W.M., BURT, J.P., 1992. SCS/ARS/CES Pesticide properties database for environmental decisionmaking. Rev. Environ. Contam. Toxicol. 123 (1-157): 5-20.

44 UCAR, T., HALL, F.R., 2001. Windbreaks as a pesticide drift migration strategy: a review. Pest Management Science 57, 663-675.

# Film session

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## Effect of drought-stress on morphologic, phenologic and physiologic parameters of ornamental shrubs in urban areas

Urban conditions need ornamental shrubs which require only little management in irrigation and fertilisation but show good function in ecologic and ornamental value. A field trial including 17 taxa (deciduous, evergreen, strong-growing, poor-growing), 3 drought treatments (differentiated according to nutrient provision and soil cover with bark mulch) and 1 optimal treatment with additional irrigation investigated the reaction of the shrubs. Site conditions were sandy soil with few humus on pure sand of the Berlin primal river valley with a soil quality of 22. Climatic conditions were similar to those in the city centre with distinct drought periods during summer. Climatic water balance (the difference between rainfall and evaporation) was negative each year between the months of May and September. Growth, performance in flourishing, other aesthetic characteristics, symptoms of drought stress, foliar water potential as well as the variability in shrub habit and consequences of drought stress for the taxa were investigated. On drought conditions bark mulch coverage produced enough growth for some deciduous and evergreen shrubs (see Table). At the same time flourishing performance was affected only marginally. 7 taxa showed indifferent reaction, most of them were evergreen shrubs. *Deutzia scabra* was affected worst from drought damages like necrotic foliar and necrotic sprouts as well as early loss of foliage. *Callicarpa bodinieri* and *Weigela* –Hybr. also showed irreversible damages in the foliar system. During vegetation period these damages intensified also with the bark mulch coverage since the dry cover had an isolating effect and the soil below ran extremely dry. In the drought allotments *Cornus*, *Cytisus* and *Spiraea* showed an increased sensitivity to mycosis. No damages were found on the foliar system of evergreen shrubs. Drought had an extremely negative effect on flourishing intensity and duration of *Potentilla fruticosa*.

**Table** Postive effects of irrigation / bark mulch coverage on the vegetal performance of ornamental shrubs (p <0,05)

| | **Treatment** | |
|---|---|---|
| **Beginning of the positive effect on vegetal performance** | **Irrigation and bark mulch coverage** | **Bark mulch coverage** |
| From 3rd year until end of field trial | *Deutzia scabra* 'Codsall Pink' | *Kerria japonica* 'Pleniflora' |
| | *Physocarpus opulifolius* 'Diabolo' | *Symphoricarpos x doorenbosii* 'Magic Berry' |
| | *Cornus sericea* 'Kelsey's Dwarf'‘ | *Cornus sericea* 'Kelsey's Dwarf' |
| | *Cytisus nigricans* 'Cyni' | *Cytisus nigricans* 'Cyni' |
| | *Mahonia aquifolium* 'Apollo' | |
| From 5th year until end of field trial | *Callicarpa bodinieri* 'Profusion' | *Physocarpus opulifolius* 'Diabolo' |
| | *Weigela-Hybride* 'Newport Red' | *Potentilla fruticosa* 'Jolina' |
| | *Hypericum densiflorum* 'Goldball' | *Mahonia aquifolium* 'Apollo' |
| At the end of field trial after 6 years | *Spiraea cinerea* 'Grefsheim' | *Deutzia scabra* 'Codsall Pink' |
| | *Symphoricarpos x doorenbosii* 'Magic Berry' | *Syringa x chinensis* 'Saugeana' |
| | *Berberis julianae* | *Hypericum densiflorum* 'Goldball' |

| | **Treatment** | |
|---|---|---|
| No positive effect until end of field trial | *Syringa x chinensis* 'Saugeana' | *Callicarpa bodinieri* 'Profusion' |
| | *Kerria japonica* 'Pleniflora' | *Spiraea cinerea* 'Grefsheim' |
| | *Diervilla sessilifolia* 'Dise' | *Weigela*-Hybride 'Newport Red' |
| | *Potentilla fruticosa* 'Jolina' | *Diervilla sessilifolia* 'Dise' |
| | *Euonymus fortunei* 'Coloratus' | *Pyracantha*-Hybride 'Red Cushion' |
| | *Pyracantha*-Hybride 'Red Cushion' | *Berberis julianae* |
| | | *Euonymus fortunei* 'Coloratus' |

*Callicarpa* und *Hypericum* showed obvious coherence between summer drought damages and following frost damages.

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# The dangerous life of aphids

This video film, produced at the Institute of Phytopathology, University of Kiel, shows the behaviour of four aphid predators and two parasitic aphid wasps. At first a few colourful aphid species (e.g. *Megoura viciae*, *Aulacorthum circumflexum*, *Aphis nerii* are presented before the film concentrates on the main prey, the grain aphid *Sitobion avenae*. Sequences show how this aphid species gives birth to progeny, how it moults to a second stage larva and an alate female and how larval instars and adult aphids kick off honeydew droplets with their legs and cauda, respectively. A close up of the head of a large green hoverfly larva that approaches and captures an aphid then opens the series of attacks by aphid predators.

The first species illustrated in detail is the hoverfly *Episyrphus balteatus* that has just emerged from its pupa. Eggs deposited around a colony of the black bean aphid *Aphis fabae* and attacks by hatched larvae are then shown. All subsequent sequences show how different developmental stages of *S. avenae* are attacked by young larvae. Cornicle secretions released by the aphids have no effect as a defence response. The last third stage instars of *E. balteatus* cover the aphids with large amounts of slime before they scrape them out by means of their prominent mouth hooks. Final scenes show how a mature larva gradually develops into a pupa and how the adult female fly starts to emerge from it.

Sequences on the behaviour of the predatory gall midge *Aphidoletes aphidimyza* start with the emergence of a male midge from its pupa and then show a female midge in an aphid colony. The oval, orange coloured eggs are deposited close to aphids, which are then gradually sucked out by the hatched larvae. Quite often an aphid is attacked by several hatched larvae. Older larvae are able to suck out aphids within less than one hour. Emphasis is here placed on the tiny mouthparts of these larvae and how the body fluids of the aphid are continuously drawn into the pharynx by a very rapid pumping action.

Phases of the life cycle of the green lacewing *Chrysoperla carnea* show first the hatched larva, how it climbs down on the rigid egg stalk and how it attacks its first aphid prey with its prominent sucking pincers and removes the body fluids of the captured aphid. Details of the sucking mechanisms and the great skill with which prey is handled by means of these pincers are shown for the third and last larval instar. Subsequent scenes illustrate how this instar finally spins a silken cocoon for pupation, how the mobile pupa emerges from the cocoon by cutting a circular lid with its biting mouthparts and finally how the adult lacewing with now entirely different mouthparts emerges from the pupa.

The last aphid predator presented is the ladybird *Coccinella septempunctata*. Sequences show how the first instar lavae emerge from egg clusters and how they attack aphids, the contents of which are sucked out. Sequences on the moulting process of a larva precede attacks by last instar larvae, which now devour aphids completely within a very short time. Then the pupation process of the last instar larva and the emergence of the adult beetle are shown and finally how the adults feed on aphids.

The film terminates with sequences on the parasitisation behaviour of two primary aphid parasitoids: *Aphidius uzbekistanicus* and *Aphelinus abdominalis*. *Aphidius* spp. always encounter strong defence responses by aphids, such as violent jerking and kicking. In most cases cornicle secretions are released when the wasp's ovipositor pierces their cuticle during the brief oviposition attempts. Attacks are characteristically performed by a very rapid forward protrusion of the abdomen.

*A. abdominalis* females, in contrast, approach their hosts very carefully and deposit their eggs nearly unnoticed into the ventral side of the aphid. For egg production, *Aphelinus* spp. require nutrients from aphids, which they derive by host feeding, the processes of which are illustrated. The film also shows several distinctive features between the two species (and genera) during aphid mummification and the emergence of the adult wasps from the mummies.

The film lasts approximately 23 minutes and can by purchased from the Institute of Phytopathology. http://www.uni-kiel.de/phytomed/schadtiere/video/bestell1.pdf

# Postersession

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## *Gynaikothrips Ficorum* Marshal (Thysanoptera: Phlaeothripidae) and its natural enemies on *Ficus Microcarpa* in Greece

The Cuban Laurel Thrips *Gynaikothrips ficorum* Marshal, an important pest on ornamental plants of the Ficus species, especially *F. microcarpa*, was recorded for the first time in Greece in 2001. The insect feeds on young leaves making them folding. Aiming at the investigation of the insect biology, affected F. microcarpa terminal shoots (12 cm long) were collected every two weeks from trees that were found in the Agricultural University of Athens campus for the period January - December 2002.

Thrips population was found relatively low during the first three months (10 specimens per shoot in average). There was a population increase during April to July (35 specimens per shoot in average) followed by a great decline in August and September (1 specimen per shoot in average) and a new high increase during fall (150 specimens per shoot in average).

The galled leaves percentage in terminal shoots was over 30% during most of the year except in May, August and September that was 10%. The insect seemed to have developed four generations during the experimental period. The female specimen percentage in the thrips population was higher than that of the male and fluctuated between 64% and 85%. There were no differences observed between thrips populations at 2.5m and 3.5m height of the tree canopy. However, there was higher population on the east shoots compared to the other canopy sides during winter and spring.

Leaf galls were colonized by the predators *Montandoniella moraguesi* (Hemiptera: Anthocoridae), Orius sp. (Hemiptera: Anthocoridae) and Chrysoperla sp. (Neuroptera: Chrysopidae) which were feed on eggs, immature stages and adults of *Gynaikothrips ficorum. Montandoniella moraguesi* is recorded for the first time in Greece. This predator caused a great mortality in thrips population during spring and early summer. It seems that this predatory insect can effectively decrease *Gynaikothrips* ficorum population under high environmental temperature. In addition, the mite Adactylidium sp., a parasite of the thrips eggs, was found in the galled leaves, A mite of this genus is recorded for the first time in Greece and it is probably a new species to science.

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# Effect of organized foliage-collections in the control of *Cameraria ohridella* in the city of Berlin

In essential areas of the urbane green efficient biological and chemical plant protection measures don't stand by the fight of the *Cameraria ohridella* to the disposal at present. Since the pest itself in the leaf pupate and there spends the winter, the mechanical removing of the attacked foliage offers itself. The flat action in the form of organized foliage-collections is hard work and according to the local condition of the chestnuts and procedure differently successful, as the evaluation of the city-wide foliage-action has shown 2002 in Berlin.

Actions through public calls to the citizen-participation with the support of the green area-administrations is only a little successful. Only one part of the citizens will help and this cooperation is local. On places and on stands with trees without sub-growth is unproblematic the use of "laymen", at sensitive vegetation areas however frequently with damages and at dense sub-plantations with only low success connected. The green area-administrations alone doesn't manage on the basis of the low personnel-blanket to remove the entire foliage from the stands. In the street-area, that is cleaned by the Berlin city-cleaning-service, the collection is more efficient on the basis of the technical equipment.

At a city with approximately 60 000 chestnuts, big foliage-amounts come up in short time to the waste disposal. A big part of these trees is in private property, insulates usually individually on yards and in gardens. Here is removing of the foliage one of the efficient possibilities to reduce the spring-attack through the moth. Additionally, the survival of the pupa can be reduced by mechanical mastication of the foliage through chopping as well as by means of foliage-vacuum cleaners or lawnmowers on the spot. Also a covering of foliage-pile with a stratum of 10 cm or with a foil prevents the development of the pest, as well the professional composting of open foliage or from foliage-sacks. The hatch out is in every case essentially decreased.

The supervision of the spring-flight of the moth with pheromons yielded a clear reduction of the activity on evacuated tree-locations compared to few or nonevacuated stands. Also, the attack was markedly decreased, but it raised quickly again with the 2. generation and with the entry of moths through wind from attacked chestnut-locations. Nevertheless this population-decrease causes in the spring that the trees keep their chlorophyll 4 weeks longer approximately, assimilates can store and is favored the vitality of the tree with it.

Foliage-actions are an acceptable method for communes to the fight of pests, they need a mobilization of manpower and an organized logistics with the waste disposal however. Their expenses are high, appears for lack of alternatives to the salvation of valuable and cityscape-shaping chestnuts tolerable however.

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## Insect pests an ornamental trees in Croatia and some results of their control

Ornamental trees in urban areas have been attacked by an increasing number of pests that endanger the existence of those plants and are decreasing its positive influence an human beings. Many of those pests were imported in the second half of the 20''' century from other continents.

We will present some of the most important pests of ornamental trees in Croatia, especially in Zagreb.

First mines of the horse chestnut leaf miner *(Cameraria ohridella* Deschke et Dimic) were found an one tree in Zagreb in 1989. Strong infestations started in 1995 an all of more than 2000 horse chestnuts trees in Zagreb. In most years C. *ohridella* totally destroy all leaf greens, as early as in August. In some towns in Croatia, also in Zagreb, the control of this insect pest is organised. The treatments are conducted by foliar spraying diflubenzuron with knapsack mistblowers. In our three years trials the insect growth regulators diflubenzuron and hexaflumuron have shown a satisfactory efficacy. The efficacy of the naturalit spinosad and the microbiological insecticide based an *Bacillus thuringiensis kurstaki* was not satisfactory. Both used pheromones showed a very high attractiveness to male of C. *ohridellaa.* In co-operation with companies `Intus' and `Arbosan' from Italy we started trials by using different devices and insecticides for the endotherapeutical control of the horse chestnut miner.

The sycamore lace bug *Corythuca ciliata* (Say) was discovered in Zagreb in 1970. This bug can totally destroy the chlorophyll of the leaves of plane trees. The damages were stronger in the 1980's but in the last years the intensity of infestations of C. *ciliata* decreased, probably due to natural enemies. Plane trees are also attacked by the leaf miner *Phyllonorycter platani* St. Infestation with *Ph. platani is* very high this year.

Ort locust trees we have found two leaf miners: in 1983 *Parectopa robiniella* Clem. and in 2001 *Phyllonorycter robiniella* Clem.

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# Aspects of the stability of Italian stone pine (*Pinus pinea* L.) in Rome, Italy

The Italian Stone Pine, or Umbrella Pine (*Pinus pinea* L.) is widely employed as ornamental tree in parks, streets and gardens of Rome. It is well known that its distinguishing crown shape contributes to make unique and pictorial the skyline of the city.

The utilization of this species along the streets was very common during '20 -'50 [1] so that a great number of tree lines are now old or senescent. According to the data of Rome Garden Department in 2002 the Pines along the streets were 16840 (i.e. 11.5% of the total trees employed). No certain data are available for total number, that may be around 35000. Then, in the last years the maintenance and the construction of underground pipelines has been particularly increased, with frequent damages of the roots of the Pines growing along the streets. In this scenario, the risk assessment is now considered one of the most serious problem for the maintenance of Pine trees.

The aim of this paper is to collect information and results coming from different professional (around one thousand stability evaluations) and scientific experiences and direct observations in the "field" (i.e. the city of Rome) to show the peculiar aspects of maintenance and stability evaluation of this species. In fact, although the most "successful" methods for tree stability assessment are based on general principles that are suitable for all tree species (VTA and SIM-SIA) the scientific bases of the cited methods were developed studying mainly northern species of trees. For example, the data to apply the SIA method to *P. pinea* are not yet available. Moreover it is difficult to apply the methods to evaluate the root stability problems, which are the most frequent cause of failure of Italian Stone Pines, whereas trunk failure is less common.

The causes of failure are originated from two agents: root and butt rots (prevalent in parks and peri-urban forests) [2] and roots poor growth and abiotic damages (prevalent in boulevard trees and private gardens). Regarding the root and butt rot agents, the most frequent pathogens reported in Rome are: *Phaeolus schweinzii, Heterebasidion annosum, Phellinus torulosus* and *Armillaria mellea*.

Regarding the root growth problems, the suggested approach to diagnosis must include a detailed analysis of the life history of the plant, considering the peculiar characteristics of Pine root system [3]. For example, cases of root failure originated from a bad growth of roots in containers before the planting are often reported. In the poster some typical case-histories are shown.

The investigation of root stability problems includes some trials carried out in order to evaluate the strenght of trees to the extraction. Three Pines similar in dimensions were pulled out by means of a tracked tractor. Although this data are only preliminary, because both the small number of trees and the fact that only one direction of pulling was tested, the obtained data showed that some visual symptoms (i.e. girdling roots) can indicate a certain correlation with extraction resistance [4].

## Literature

1 TODARO, B., 1990. Alberate a Roma: le specie vegetali nella definizione della qualità urbana. Catalogo dalla mostra, April 20th – May 20th 1990, Palazzo Braschi, Roma. Ed. Quasar, pag. 141.

2 AMORINI, E., ANNESI, T., CUTINI, A., FARINA A., MANETTI, M.C., MOTTA, E., PUDDU, A.L., 2000. La pineta di Castel Fusano. Problematiche gestionali e patologiche del Pino Domestico. Proceedings of Conference "Applicazione e prospettive per la ricerca forestale italiana". G. Bucci, G. Minotta and M. Borghetti Eds. 45-49

3 AGRIMI, M., CIANCIO O., 1984. Le Pin Pignon (*Pinus pinea* L.). Silva mediterranea. Document provisoire monographie. FAO Ed. 116 pag.

4 BIOCCA, M., 2001. Alberi in trazione. Acer, 1, 65-67.

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# Cultivation, breeding and diagnosis of *Anoplophora glabripennis* in the Laboratory

The "Asian Longhorned Beetle" (ALB, *Anoplophora glabripennis*), a quarantine pest, was discovered in 2001 for the first time in Europe in the urban area of the community of Braunau/Inn near the border to Germany. From July 2001 to June 2003 sixty-two trees were found to be attacked by Asian Longhorned Beetles. Among them, 57 maples of *Acer saccarum* and *Acer platanoides*, 2 birches (*Betula pendula*), 2 copper beeches (*Fagus sylvatica "Purpurea"*) as well as 1 plane-tree (*Platanus platanoides*) showed typical infestation symptoms like wilting of the crown due to the feeding of the adults, saw dust of the larvae, oviposition scars, and in some cases emergence holes. To eradicate the pest infested trees were felled on plastic cover, the whole biological material (stem, branches, twigs, leaves) was chipped and burnt on the spot. So far, more than 1000 trees were felled as a safety measure to allow careful inspection and to avoid uncontrolled spread of the pest. The first occurrence in Europe gives rise to many questions of interest:

Duration of the larvae and pupa stages, favoured tree species for feeding and oviposition, number of laid eggs per female, life-span of the adults. Therefore, at the Department of Forest Protection of the Federal Office & Research Centre for Forests at Vienna, pieces of affected wood from Braunau were taken into the laboratory and stored in insect boxes for observation. There, the feeding of the larvae and the emergence of adults could take place without any danger for the environment. Emerged beetles were put together to pairs and were allowed to feed on maple twigs and leaves for maturation feeding and copulation. Branches of different tree species were offered to find out which Central European tree species will be favoured for oviposition by the female. Branches with oviposition sites were cages for larvae development.

Parallel to the development in wood pieces, larvae were cultured on artificial diet. Therefore, larvae from natural infected trees from Braunau as well as breeding larvae from the beetle pairs were prepared out of the wood and each one placed into a glass with diet. Depending on the development and the feeding activity the larvae were moved to fresh diet every six to eight weeks. From February 2002 to June 2003 altogether 30 larvae were cultured on diet so far. Forty percent of them died in the meantime due to development defects and two different unknown diseases. Nevertheless, these first cultivation experiments were successful: meanwhile two females have emerged from the diet. In one case it was possible to observe and document the whole pupal development over three weeks.

Another question of high interest is the diagnosis of *Anoplophora glabripennis* and the differentiation of ALB from other *Anoplophora* species and native longhorn beetles. Morphological features give less evidence for reliable determination done by non ALB-specialists. Also the determination of early stages like egg and larvae is nearly impossible. Molecular investigations were started with the aim to develop a non-morphological diagnostic method. Therefore, ALB from China and Austria, *A. chinensis*, *A. malasiaca*, A. *macularia*, *A. davidis*, and *A. elegans* were collected. DNA from adults, larvae and eggs was amplified with mitochondrial primers and PCR (polymerase chain reaction) products were either sequenced or digested with restriction enzymes (PCR-RFLP (restriction fragment length polymorphism)). The most common mistaken identity possibilities within the European Cerambycidae are species of the genus *Saperda*. Based on the mitochondrial PCR-RFLP method it is possible to clearly distinguish *A. glabripennis* from *A. macularia*, *A. malasiaca*, *A. chinensis*, *A. davidis*, *A. elegans* and also from *Saperda carcharias*, *S. octopunctata*, and *S. perforata* by digesting one and/or two PCR fragment(s) with five different restriction enzymes providing species specific RFLP patterns.

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# Thermography: a truly non invasive method to detect cavities and rot in trees (roots, trunk and branches) at a distance and from the ground

Thermography is a well-known investigation method that is widely used in many scientific and technical sectors. This method detects the presence of discontinuities and/or unhomogeneity in the bodies investigated, thanks to the different thermal properties between the damaged and healthy areas. Consequently, the surface temperature is generally lower in the damaged area. Investigations are performed with the use of an IR camera, that can detect the surface temperatures of bodies from a distance, provide black-and-white or pseudo-colour images in real time and store them onto a magnetic card, so that they can be later downloaded and processed on a PC. The many fields of application of this technique range from medicine to engineering, from geology to biology with an extensive bibliography that dates back to the 1960s: the use of this method to detect tree decay was introduced by Dr. Catena and co-workers in 1985.

In the case of trees an IR camera, slightly bigger than a portable camera, is pointed to the specimen to be analysed: if the surface temperature distribution of the area investigated is homogeneous, no internal decay is present, and the investigation can proceed. Any discontinuity is rendered in a shade of grey different from that of the neighbouring areas in black-and-white images, and in a colour different from that of the neighbouring areas in pseudo-colour images. If the image shows discontinuity, but no superficial damage that can modify the thermal image is seen on the plant (decortication, moss, scar of old damage etc.), then internal decay is present. That is why, this technique finds its best use within the VTA (Visual Tree Assessment), to integrate the visual tree assessment.

Thermography allows the presence of possible tree decay to be detected, localised and quantified in 1/30 sec., that is the time necessary for the camera to provide images of wide portions of the tree examined, unlike what happens with most of the instruments currently used that only give information at the height or on the point assessed. Generally, 4-5 images are enough to know the situation of the whole tree: it is possible to diagnose the condition of branches up to 20-25m of height, from the ground; for greater distances, a telephoto lens is available. The fundamental importance of this method especially and mainly in the case of healthy-looking trees can be clearly understood. At present, it is not possible to tell a cavity from damaged tissue, but an expert user can judge if the damage is serious without resorting to invasive instruments that can anyway be employed by an unexpert operator on actually damaged plants and at the very points, that provide data on the plant's stability. Consequently, the screening of urban trees is time-saving, and safety is improved, thus avoiding the dissemination of pathologies with the random use of invasive instruments to localise the extension of decay. Moreover, if the discontinuity is only present at the base, in contact with the ground, or it is particularly spread in this area, damage is certainly present at the root system level. However, this technique cannot "penetrate" the ground and give direct information on the condition and distribution of the root system.

The technique has been successfully used on thousands of plants of many different species, both broad-leaves and conifers, but also numerous palm trees. Ongoing research concerns mushrooms, of which interesting images were taken. Images of recent investigations are presented here.

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## New Trap, Intercept PT and lures for monitoring Coleopteran tree pests.

Trap efficacy in capturing economically important forest Coleoptera was measured in field trials comparing the Intercept Panel Trap (INT PT) with the Multi-Funnel Trap. The INT PT was designed to provide a better option for the monitoring of forest Coleoptera. The trap is made of corrugated plastic and is very robust under rigorous field conditions, but still lightweight, easy to carry, weather- and waterproof, and easy to install. The trap disassembles rapidly and stores flat, which uses less storage space than Funnel Traps. The INT PT also costs significantly less than the Funnel Trap.

The INT PT performed equal to or better than the Multi-Funnel Trap for Cerambycids and Scolytids. Captures of Buprestids were lower in the INT PT than the Funnel Trap. The INT PT captured more bark beetles and consistently fewer predators than the Funnel Trap. The turpentine lure (2) caught equal or fewer numbers of beetles than the standard lure (1). The ethanol lure (3) caught more bark beetles than the standard lure (1).

The Intercept Panel Trap is an effective tool for monitoring Cerambycids, as well as bark beetles, Buprestids, and other forest Coleoptera. It also captures fewer beneficial insects. The INT PT outperformed Phero Tech's Multi-Funnel Trap for most tested insect species. Higher beetle captures and increased detection capability in a less expensive trap equates to greater efficiency of forest pest monitoring programs. The Intercept Panel Trap is now commercially available.

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# Allelopathy of the invasive weed *conyza albida* with cool and warm season turfgrasses

Weeds are considered opportunistic plants and they invade man-made environments such as urban turfgrass sites. Weeds are most commonly found in turfgrasses subjected to wear and compaction that is provoked by man and/or vehicular traffic, or in cases that the turf is weakened either by adverse environmental conditions, or thatch accumulation, or diseases, or pests to the extent that the turf cannot compete for nutrients, water, or light with the invading weed species.

*Conyza* is a genus that includes many species introduced from the New World. Horseweed (*Conyza albida* Willd. ex Sprengel), is a herb originated from South America that recently has been reported to invade in urban, natural and agricultural ecosystems. The existence of *C. albida* exhibits direct and indirect effects on the structure of plant communities. In Greece, it is characterized by a rapid growth and high dispersal potential, that enables its establishment as a permanent weed of the urban landscape as well as in many other crops (Economou et al., 2002). In the recent years, *C. albida* has been contiguously been monitored in athletic fields including soccer pitches and golf courses as well as in urban parks, historical sites and monuments, cemeteries, and private gardens. Studies have indicated that the successful establishment of this introduced species depends on complex interactions between the species and its target community.

The present study was conducted to determine the allelopathic influence of horseweed on *Poa pratensis* L., *Lolium perenne* L., *Festuca arundinacea* Schreb., *Pennisetum clandestinum* Hochst ex Chiov., *and Dichondra repens* Forst. The study included in vivo as well as in vitro experiments. In the in vivo tests, leaf tissues from horseweed rosettes were incorporated in a perlite substrate and their effects on top and root growth of the selected species were evaluated. In the in vitro tests, dried leaf tissues were successively extracted with water using two temperature treatments (24 and 40$^{o}$C) in order to assess the inhibitory action of the substances that are contained within the horseweed leaves. The results showed that the extraction temperature affected the toxicity of the extracts. More specifically, the warm temperature extracts (40$^{o}$C) exhibited the greatest root growth inhibition for all species. It is speculated that warm extracts may release the allelochemicals more readily compared to the room temperature extracts (Chung and Miller, 1995).

Inhibition of growth was found to be species-specific and to significantly depend on the residue application rate. The estimated reduction of target plant root biomass and length indicated that *P. pratensis* was more sensible to inhibition by the horseweed residue application rate. In contrast, *P. clandestinum* was the most tolerant species since its root growth decreased at higher concentration rates compared to the other species under investigation.

In the in vitro test, the extracts from the dried horseweed residues significantly inhibited the root growth of all the species when they were tested in Petri dish assays. The five species exhibited differential response to the increasing extraction rates and the inhibitory estimate for 50% reduction of root length ($I_{50}$) demonstrated further the sensitivity of *P. pratensis* and the tolerance of *P. clandestinum*. In particular, the $I_{50}$ value for *P. clandestinum* root length (23g L$^{-1}$) was twice the value compared to *L. perenne* and *F. arundinacea* (11g L$^{-1}$). The inhibition estimates ($I_{50}$) for *P. pratensis* and *D. repens* were 15 and 17 g L$^{-1}$, respectively (Figure).

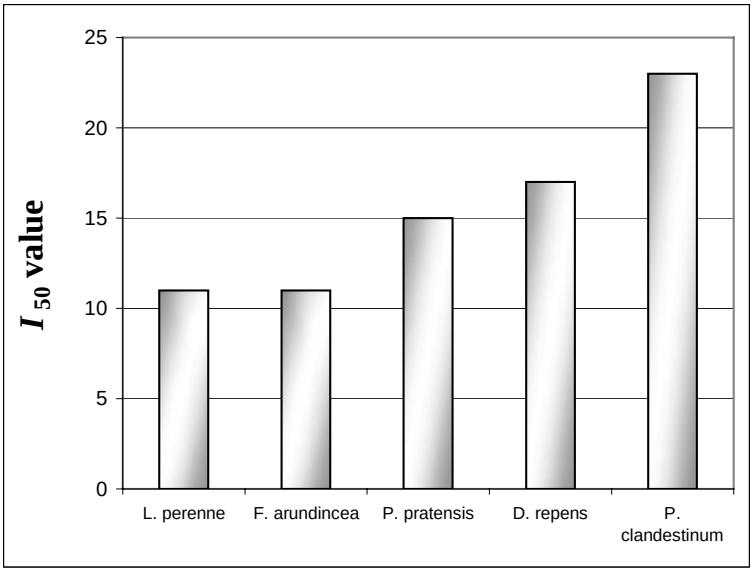


**Figure** Response of the turfgrass species *P. pratensis, P. clandestinum, L. perenne, F. arundinacea, and D. repens* to horseweed extracts. The estimated $I_{50}$ value was determined by log-probit analysis

Results suggested that horseweed residues had a contrasting effect on the selected turfgrass species growth and development due to water-soluble phytotoxic substances (allelochemicals) that were present within the residue (Rice, 1984). However, the occurrence of tolerant species should be used as a potential natural control on the dispersal of this highly invasive species.

## Literature

1 Economou, G., Tzakou, O., Gani, A., Yannitsaros, A, Bilalis, D., 2002. Journal of Agronomy and Crop Science. 188:248-253.

2 CHUNG, I-M., MILLER, D., 1995. Natural herbicidal potential of alfalfa residue on selected weed species. Agronomy Journal. 87:920-925.

3 RICE, E.L., 1984. Allelopathy. 2nd Edition, Academic Press, Orlando, FL.

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# Biodiversity of depredators and deseases of introduced species of Arkhangelsk

The number of native species for the town of Arkhangelsk makes no more than dozen plants (birch, pine, spruce, aspen, willow, alder swamp, mountain ash, honeysuckle, bird cherry and currant). However, the introduced species from different parts of the world (Far East, Siberia, Asia, Northern America and Europe) are studied for the scientific purposes (arboretum of Arkhangelsk State Technical University (ASTU), dendrological garden of Northern Research Institute of Forestry (SevNIILH) ) and used for gardening of the city. Over 200 types of wood and shrubby species grow in the arboretum of ASTU, about 600 types grow in the arboretum of Northern Research Institute of Forestry. Apparently, plants experience a stressful condition - on the one hand the given conditions are far from in what they grow in the native habitat, on the other hand - urban conditions (high content of various toxic substances and aerosols in the air, deterioration of vegetative properties of soils and so forth). As a result specific conditions are created that provide negative effect on the state of green planting and result in trees attenuation and promote its population with insects and infestants. Native species are considered to be always populated with much more insects and harvest bugs, than types of alien dendroflora.

The purpose of the first stage of our research is to determine the main pests and diseases for the given territory. In the forest stands of the Arkhangelsk region there was no serious and mass burst of pests' propagation and diseases lately. Infestations are registered only on small territories (up to 100 ha) produced by *Leucoma salicis L., Aporia crataegi L., Hyponomeuta evonymella L., Neodiprion sertifer Geoffr* and some other pests. Among fungi diseases mass epiphytoty of spruce needles rust (*Chrysomyxa abietis Wint.*) was marked in 1989. Other diseases are not widely spread. Aspen tinder fungus (*Phellinus tremulae*) makes an exception, infestation by which can reach 40 %.

Fungi causing farinose dew are most widely spread in urban plantations in arboretum and dendrological garden. They can be met on elder (*Microsphaera van Brutiana*), acacias (*Microsphaera palczewski, Trichocladia caraganae*), oak (*Microsphaera alphitoides*), sloe (*Podosphaera clanderstina*), rose (*Sphaerotheca pannosa*), hawthorn (*Podosphaera clandestina*). Honeysuckle hardly suffers from mining of leaves by larvae from the family of mining flies (*Agromyzidae spp*) and phytopathological viruses causing the formation of witch brooms at young shoots. Leaves of different kinds of mountain ash and barberries suffer differently from rust fungi (*Gumnosporangium juniperi and Puccinia graminis*). The larch needles are more often attacked in alley plantings by *Coleophora laricella*, and in shaded and unfavorable growing conditions young shoots are attacked by big larch saw-fly (*Holcocneme erichsoni*). Vegetative harvest-bugs (*Eriophyidae spp*.) and cherry ermine mole are met only on bird cherry, and on other types of bird cherry (Pennsylvanian and Maaka) such infestation was not observed. Leaves of elm smooth, are more often and intensively infested with different kinds of elm aphids (*Colopha compressa, Tetraneura ulmi, Schizoneura uimi*), than leaves of the rough one, besides elm warty harvest-bug (*Eriophyes ulmicola typicus*) and black roundish necrosis of shoots are met on elms. The necrosis cancer of branches and trunks (*Nectria cinnabarina)* is very widely spread. It is found on the apple-tree, elms, mountain ashes, hawthorn, elder and maples, however it causes the greatest damage to Bosnian maple. We observe the leaves curliness on a siren. On the linden we meet *Byctiscus betulae*, lime felt and warty harvest-bugs (*Eriophyes tetratrichus*), cream mottle (*Gloesporium tiliae* oud. var. *maculicolum*) and black (*Apiosporium tiliae*). Leaves of apple-trees of different kinds are infested by scab (*Venturia inaequalis*), and leaves of a ginnal maple by black dot mottle (*Phytisma pumctatum*). Fruit bodies of a sulfur-yellow tinder fungus (*Laetiporus sulphureus*) appear annually on 40-old ashes, and false tinder fungus (*Phellinus igniarius*) are observed on aged trees of apple-tree, elm, oak, etc Leaves of poplars are infested by rust fungi (*Melampsora spp*.) and pemphigus (*Taphrina aurea*).

The biodiversity of pests and diseases of introduced species is insignificant, and local epiphytoties are met rarely. Knowledge of specific features of growth and development of wood and shrubby species of alien cultures, and also character and features of occurrence and development of diseases and pests on them, will provide an opportunity to create highly decorative, long-living and stable park plantings with various tree species.

Here in after it is planned to determine a complete species composition of pests and illnesses of introduced plants and local ones used for gardening in the towns of the Arkhangelsk region and growing in arboretums and dendrological garden of Arkhangelsk.

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# Trees and human culture

The existence of man and the development of civilization has been, and continues to be, closely connected to the plant world, and the use of plant products, obtained through ever more organized and specialized systems, has evolved over the course of the millennia-old history of agriculture which began in embryonic form during the Neolithic period. Man has, in fact, developed increasingly more profound and vast relationships with the plant world in relation to the increase in population in various regions and to the technological progress directed at obtaining a greater range of goods necessary for the survival or well-being of humanity. However, since the most ancient forms of civilization, these relationships have also deeply involved the spiritual sphere of man, favoring his cultural activities and exerting an important influence on his psychological, mental and health conditions. These latter aspects, take on notable importance in light of the present critical situation between the environment and man's well-being, and thus deserve to be adequately studied and exploited on a practical level.

Starting in the protohistoric period, the plant world held considerable fascination for man, stimulating his fantasy and imagination, evoking emotions and feelings of admiration, amazement, fear, respect and veneration, and suggesting analogies between the biological cycles of plants and natural phenomena and the events in men's life. Thus, deep relationships between the plant world and human culture developed and evolved; relationships which changed and modified over time in close connection with political and socio-economic events in the various populations. Entire volumes would be necessary to completely and exhaustively treat the many symbolic meanings and values attributed to numerous plant species in the religious, poetic-literary and artistic fields since the beginnings of civilization. For example, it has been said that trees alone are "one of the richest and most widespread symbolic themes, and just its bibliography would fill a book" [8]; while Cattabiani [7] refers to myths, symbols and legends for more than 190 plant species, more than 100 of them herbaceous. Many primitive people of highly developed civilisations treated trees, flowers and plants with great respect. Often trees were associated with having supernatural powers, being gods, ancestors and associated with different forms of worship, whilst flowers and plants were viewed too as also having medicinal applications and miraculous healing qualities.

Trees have taken on a particular importance in cultural relationships with man. Man has been fascinated by their longevity stretching across centuries and which over time connects successive human generations, the power expressed by their massive trunks, the regal dimensions of their crowns which reach toward the heavens – home to iranic divinities – and attract lightning which bores down into the tree's members, and their roots which penetrate down into the mysterious depths of the earth – home of the chtonic gods. And in turn, especially in ancient civilizations, man gave trees sacred characteristics and imagined them as being the home of divine beings. In an old article, Quantz (1897, cited in [21]) discussed tree worship or "dendrolatry" by indigenous people and the residual of these practices in Western nations. He also suggested that a belief in tree spirits is as old as human civilization.

Sacred trees were, in fact, cultivated in the Hanging Gardens of the Mesopotamiam Ziggurats. At the bottom of the sea, Gilgamesh, the hero of the Mesopotamian epic from the third millennium B.C., found the magic plant (the grapevine) which "gives back to man his lost youth"[18]. In the Pantheon of the Egyptians, there was Sha, the god of the vineyard. In the Garden of Eden, God placed two trees, "the Tree of Life in the midst of the garden, and the Tree of Knowledge of Good and Evil" (Genesis 2:9) and its fruit was the cause of the original sin, the condemnation of Adam and Eve and the moral responsibility of man. The end of the universal flood was communicated to Noah by God with an olive branch carried by a dove (Genesis 8:11). The olive is considered a symbol of peace by many populations. The tree of Jesse (Isaiah 11:1, 10), represented in a stained-glass window in the church of Notre Dame in Chartres, is particularly rich in significance: "there will come a rod out of the broken tree of Jesse, and a branch out of his roots will give fruit (Jesus) and the spirit of the Lord will be resting on him, the spirit of

wisdom and good sense, the spirit of wise guiding and strength, the spirit of knowledge and of the fear of the Lord"; Jesus assimilates to the grapevine his relationship with the humanity: "I am the vine, you are the branches; he who abides in Me and I in him, he bears much fruit, for apart from Me you can do nothing" (John, 15,5).

The God of the Old Testament told the Jews who took possession of the Promised Land to respect their enemy's trees and to "thou shalt not destroy the trees thereof by wielding an axe against them" (Deuteronomy 20:19-20)[1].

In Greek, Roman, and Celtic mythology, as well as in other cultures, there were numerous sacred tree species or species connected in some way to divinities [1]: oak for Zeus and Pan; olive for Athens; myrtle for Aphrodite; fig for Dionysus and Mars; cypress (still today a symbol of death for many populations) for the god of the Underworld, Pluto; grapevine for Dionysus; willow for Osiris; sycamore for Hator; apple and rose, as fruits, were the sacred flower for Aphrodite; in Egypt, the rose was sacred for Isis; the apple trees with golden fruits were cultivated in the magical garden on the slopes of Mount Atlantis. It was under a pipal tree (*Ficus religiosa*) that Siddartha Gautama meditated until he attained enlightenment (Nirvana) and became the Buddha [24]. Moreover, particular significance was attributed to the cosmic tree, considered the axis of the world, which connected the center and the surface of the earth through its roots, and through its trunk and crown it connected the surface of the earth with the heavens. The cosmic tree, sometimes seen in its inverted position (the roots in the heavens and the crown toward the earth), was represented by various species: the oak by the Gauls (in the Norma by Vincenzo Bellini, the altar for druidic ceremonies is situated under an oak of the god Irminsul); the linden tree in Germany; the ash tree in Scandinavia, where it was called Yggrasill; the olive in Islam; the birch and larch in Siberia; *Ficus religiosa* in India, and also considered the cosmic tree by Buddhists. Mistletoe was the symbol of immortality for the Gauls, who called it by a name which means "that which heals all", and they used it in a complex ritual described in detail by Pliny in his 'Naturalis Historia'.

The connection between man and tree is expressed particularly by the custom of natives of the Akkaido and Sakalin islands: they plant a tree when a child is born and they believe the child's life, strength, health and vigor are tied to those of the tree through a close analogical, physical and spiritual connection (Altman, l.c.). The same author has dedicated specific research to trees with particular significance for man, dividing them into eight categories depending on their symbolic value. Sommer [21] reported that several nations had folk beliefs that passing a child trough split branches would cure certain ailments and that some trees were considered to have magical properties in the prevention of disease.

In the religion of the Greeks and Romans, forests were considered the home of minor gods such as the Nymphs, some of whom lived in particular species: the Melie in the ash tree, the Dryads in the oak. Greeks and Romans had sacred forests, objects of and sites for cults, made up of various species such as plane and ash trees, olive, and oak. Woodlands held great importance for the Celts: the Druids (according to Pliny, etymologically the "men of the oak", or according to others, "great knowers") held their sacred rites in forest clearings in a spiritual and psychological atmosphere wonderfully expressed by Bellini in the Norma, in particular with an air of "Casta Diva". The gothic cathedral of Notre Dame in Chartres may have been inspired by the tradition of druidic religious celebration in woodland clearings: the nave outlined by columns connected high above by gothic arches and overlaid by the intertwining of vaults seems to repeat the natural architecture of a path, under a canopy of branches, leading to a forest clearing where the religious rite is celebrated, represented by the apse of the church [24].

Also with regard to druidic rituals, Le Roux [15] observes that, "the Celtic world lived under the sign of the sacred wood which frequently was a support to the cult or a legendary theme: the oak in Gaul, the service-tree, the hazelnut, the ash, the birch in Ireland, and everywhere, the yew, the mortuary tree."

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[1] The sacred aspect of the oak is documented also by the fact that in Greek mythology the most ancient oracle, that of Pelagic origin, of Zeus and Dodona, was situated in an oak wood, the rustling of the branches showed divine will to the priests; a sacredness which was expressed in the poetry of the Greek lyric poet Zona (1st century B.C.).

Moreover, the hypothesis that for ancient man "the squared tree became a column" in the temple is not without basis, recalling the "original sanctuary, the sacred wood" [5]. In essence, the ancient temples of Greece had columns made from tree trunks, and from these, came stone columns with capitals which frequently portray stylized tree crowns [23].

In general, the intense and widespread sacredness of trees and woodlands for ancient peoples was abated, until its disappearance, in connection with the evolution of culture, with the spread of scientific knowledge about the morphology, biology and physiology of plants and with the solidification of the economic and ecological value of the tree and forest, which led to a vision of their practical value. Furthermore, under a specific cultural profile, the spread of the great monotheistic religions – Judaism, Christianity and Islam – led to a disappearance of earlier religious feelings connected to trees and the plant world in general. However, still today in laical culture there are displays tied to sacred sentiments, for example the nearly universal custom of surrounding cemeteries with cypress trees, the offering of flowers for the dead and their use as decoration for altars. In this regard, the presence of the so-called "Garden Cemetery" in American culture is particularly significant [6].

The plant world has exerted in all eras a profound inspiring influence in poetry, literature, figurative arts, and music. Setting aside Greek and Roman literatures for purposes of conciseness (although they are both rich in poetic references to plants and forests), in the field of poetry, significant examples can be found in every culture. It is significant that the greatest Italian poet began his divine poem (the Divine Comedy) comparing the sin into which he had fallen to a "*forest savage, rough, and stern*". Subsequently, in the XIII canto of the 'Inferno', he imprisoned the souls of the victims of suicide in trees and shrubs ("*not foliage green, but of a dusky colour, not branches smooth, but gnarled and intertangled, not apple-trees were there, but thorns with poison"*), recalling a metamorphosis present in Greek mythology[2], reported by Virgil in the 3rd book of the Aeneid and by Ariosto in the VI canto of the 'Orlando Furioso'. Dante turned again to a forest ("*the heavenly forest, dense and living-green*"), in this case diametrically opposed in aspect and atmosphere to the infernal ones, in the XXVIII canto of 'Purgatorio' to express the serenity and harmony of man, free from sin and in a state of pure innocence. As reported by Shoemaker [20], in Shakespeare's writings, over 200 plants are mentioned.

Also in contemporary times, trees, plants and flowers have continued to inspire poetic and literary works. Obviously it is not possible to cite them all or even examine them individually, however, some of the most famous examples can be mentioned: Carducci, Leopardi, Pascoli, D'Annunzio, Garcia Lorca, Eisenin, Hölderlin, ("The oak trees" – "Die Eichbäume", "The tree"- "Der Baum"), Prevert, ("Tant de forêt"). Trees and woods have also inspired famous tales and novels. Giono [11], a French author of the "Man who planted tree", wrote a novel about a humble man who single-handedly reforested a desolated area, that has long been a staple of environmental literature because of its message that individuals can make a difference. Besides, it is in the trees that elves live in the splendid and enigmatic book by Tolkien [22]. This fantastic idea evokes a strong attraction for the common man, so much so that a Scottish carpenter is doing much business with the construction of tree houses, for children and as homes for entire families. Furthermore, it is significant that Tolkien (l.c.) gives to trees that think, talk, listen, walk, love and hate the accomplishment of mighty actions which require unimaginable physical strength in other living beings. But Herman Hesse, the writer, poet and painter, is without a doubt the one who in a particularly profound way felt and expressed the dialogue with nature, and above all with trees (to which he gave a soul and human feelings) [12, 13].

It is impossible to adequately define the presence of trees, woods, and flowers in the figurative arts: from the Egyptians to the Etruscans, from the Greeks to the Romans, over the centuries until our own times. It is not an exaggeration to say that there have been few artists who have not portrayed trees, woods, flowers or other plant motifs – often with reference to particularly important religious or cultural symbols – in their works. Perhaps it is sufficient to recall the famous painting "Primavera" by Botticelli in which the sumptuous blossoms generate spontaneous awe, the paintings by the Flemish painter Justus Von Utens of the gardens of the Medici villas. However Leonardo da Vinci was probably the first artist to

[2] The nymph Daphne, to escape from Apollo who was following her, was transformed by her father, Peneo, into a laurel tree, an episode represented by Gian Lorenzo Bernini in a splendid sculpture housed in the Borghese Gallery.

truly observe Nature beyond the symbolic [19] although only a handful remain in existence today of the hundreds of sketches of plants and flowers he had made from his observations of the universal structures around him. Vincent Van Gogh was another artist who with tormented passion portrayed and painted trees, flowers, fruits and cultivated fields. In a completely different but equally fascinating way, the topic of trees was expressed by Piet Mondrian: like Leonardo da Vinci, plants, and specifically trees, were the single most important subject matter of his evolvement into abstraction [16, 19].

The cultural value tied to herbaceous and shrubby species has been equally broad, complex and widespread among various peoples of the earth, especially with regard to those used in ancient times for cut flowers or ornamental purposes [7]. While it is not possible to treat this topic in detail, it is possible to mention here, as an example, the rose, the queen of flowering plants. It is one of the richest species in terms of symbolic value [17]: etymological root for the Christian rosary; a mystical flower whose petals, in the XXXI canto of Dante's 'Paradiso' are the soul of the blessed ("in fashion then as of a snow-white rose").

The rose has been a decorative element and the object of admiration since the time of the Sumarians and the ancient civilization of Crete (in the Crosso palace we can find one of the first representations of a rose), the Egyptians, and the Jews (in the Cantico dei Cantici it is written, "I am the rose of Sharon/ lily of the Valley"). The rose is recalled by Herodotus ($5^{th}$ century B.C.), who speaks of a garden of roses belonging to Midas, king of Frigia. Arabic poets made the flower a symbol of perfection and it was adopted as a royal emblem in England after the Wars of the Roses (1455-1485)(the red rose of Lancaster and the white rose of York).

In Christianity, the rose has taken on particular symbolism: the five petals, the five wounds of Christ on the cross; the red rose, the blood of Christ; the mystic rose, the mother of Jesus.

The rose has inspired many poets, from Sappho ($7^{th}$-$6^{th}$ centuries B.C.) and Anacreonte ($6^{th}$-$5^{th}$ centuries B.C.), to Khayyam (Persian poet of the $11^{th}$-$12^{th}$ centuries)[14] whose request that his tomb be positioned so that "the wind of the north could cover it with rose petals" and authors from more modern times [17]. In addition, numerous musical compositions have been inspired by the rose, for example the ballet "Le spectre de la rose" (in "Invitation to the dance" by M.C. Von Weber), "The knight of the rose" by R. Strauss, "Scherzi musicali" by C. Monteverdi, and the "Irish melodies" by T. Moore.

Another important connection between the plant world and man, recently indicated as a parameter for the evaluation of contact or cultural communion of a people with plants, is the quantity of words and expressions present in the language [6]. While there is a lack of specific studies in this regard, it can be said that our languages is notably rich in these lexical forms [4;7].

Altman [1], in his book "Sacred trees" states : "When we leave the house each morning, how many of us truly see the trees in our midst? How many of us are aware of their beauty, their grace and their strength? By becoming more consciously aware of the many gifts we have received form trees in daily life, we begin to feel gratitude and respect, which open the door to actual communion". This communion of feeling and thought with plants, pondered and perceived by Hesse [12, 13], Borchardt [4], Brosse and Altman [5, 1], and the object of reflection by philosophers such as Cartesio, Nietzsche and Assunto [3], in what form can penetrate inside the soul of the "contemporary man, destroyer of his own world, who has placed at the top of his targets neither the wellness, nor the beauty, but the profit?"

It is certainly a duty and right to affirm the necessity to preserve, protect and appreciate the plant world. And it is also true that many recognize this need (in fact too often) more from a perspective of the economic advantages and well being for man – legitimate aims in themselves – rather than for a spontaneous and unconditional love for plants and a fascination for them, which induced ancient populations to deification. To express it in another way, to use the words of Argan [2]: "Starting from the culture of the illuminated 18th century, in a general and progressive process of secularization, the concept of nature has been clearly separated from the concept of the divine and the creation"; while, in order for man to reach a point of true respect for plants, it is necessary that he enter in communion with them motivated by a love for them and not only or exclusively for scientific speculation, technical applications or economic interest. In this regard, the writing of Gibran [10] seems significant: " 'Why are you crying, my gracious flower?' One of the flowers lifted its delicate head and whispered, 'We are

crying because a man will come and break us off and offer us for sale in the town market. And this evening, when we have wilted, he will throw us on the rubbish heap.' "

Therefore, in order to develop a meaningful relationship with plants it is necessary for man to succeed in understanding their language, to become aware that "man's supreme gift – the ability to express himself – was not given to him alone. Rather, his exclusivity is the subtle task of putting into words, into verbal language, the multiform semiotics with which extra-humans express themselves" [9]. Once again it is Tolkien [22] who expresses with great efficacy the communion between man and tree: "the wood itself, and the contact with it, gave him a joy which was different from that of the carpenter or the woodsman: it was the joy of the tree which penetrated into him"

## Literature


1 ALTMAN, N., 1994. Sacred trees. – Siera Club Book, San Francisco.

2 ARGAN, G.C., 2001. Assunto e la filosofia della natura. In "Luoghi: forma e vita di giardini e paesaggi". A cura di D. Luciani, Ed. Fondazione Benetton, Studi e ricerche, Treviso.

3 ASSUNTO, R., 2001. Bellezza e verità. – "Luoghi: forma e vita di giardini e paesaggi". A cura di D. Luciani, Ed. Fondazione Benetton, Studi e ricerche, Treviso.

4 BORCHARDT, R., 1938. Der leidenschaftliche Gärtner. F. Klett Verlag, Stuttgart.

5 BROSSE, J., 1989. Mitologie des arbres. Edition Plon.

6 BRYANT, C., 1992. Plant talk: some notes on the botanical bent of American Language. HortTechnology, 2(2):172-176.

7 CATTABIANI, A., 1996. Florario. Miti, leggende e simboli di fiori e piante. A. Mondadori, Milano.

8 CHEVALIER, G., GHEERBRANT, A., 1999. Dizionario dei simboli. Dizionari Rizzoli, XIII Ed.

9 GIANNELLI, M.T., 1990. Introduction to "Das Stume Spricht") di H. Hesse.

10 GIBRAN, K., 1992. The voice of the master. New Compton Ed., Roma.

11 GIONO, G., 1980. L'uomo che piantava gli alberi. Salani Ed., Milano. Original version "The man who planted trees".

12 HESSE, H., 1952. Bäume. Suhrkamp Verlag, Frankfurt a. Main.

13 HESSE, H., 1986. Das Summe spricht. Suhrkamp Verlag, Frankfurt a. Main.

14 KAYYAM, O., (1997). Quartine. Gioia, tristezza, misticismo nei versi di un grande poeta persiano. Traduzione a cura di H. Hajdar. Superclassici Biblioteca

15 LE ROUX, F., 1976. La religione dei Celti. In Puech H. Ch.:Storia delle religioni. T. 2, Ed. Laterza, Bari.

16 NIGRO COVRE, J., 1980. Mondrian e De Syl. Art Dossier. Giunti Ed. Firenze.

17 PATERSON, A., 1983. The History of the Rose. – H. Stephenson Publishing.

18 SANDARS, N.K., 1960. L'epopea di Gilgameš. Adelphi, Milano.

19 SHEARER, R.R., 1992. Beyond romanticism: the significance of plants as forms in the history of art. In "The role of horticulture in human well-being and social development". D. Relf (Ed.), Timber Press, Inc. ISBN 0-88192-209-9: 216-219

20 SHOEMAKER, C.A., 1994. Plants and human culture. In "People plant relationships – setting research priorities". J. Flagler e R.P. Poincelot Eds. The Haworth Press, Inc. Binghamton, NY, ISBN 1-56022-050-3:3-7.

21 SOMMER, R., 2001. Dendro-psycosis: people and trees. Arborist News, February 1:54-55

22 TOLKIEN, J.R.R., 1966. The Lord of the Rings. G. Allen and Unwin Ltd, London 1966.

23 VITRUVIUS, M.C., 27-23. a.C. De Architectura. Casa Editrice Einaudi-Torino, ISBN 8806122398, Edizione 1997

24 WITCOMBE, C.L.C.E., 1998. Sacred places. http://www.arthistory.sbc.edu/sacreedplaces/trees.html.

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## Use of slurry and compost for weed control in green areas

Increasing recycling and growing quantities of waste present possibilities for developing new products and applications. Both environmental and political goals exist to find alternative use for slurry and compost. Weed control in green areas is an option.

Excessive weed growth reduce both crop quality and the quality of green areas. By the use of different kinds of organic mulches, weed growth may be suppressed. Also mixing of slurry into the soil may decrease weed growth by the action of phytotoxic compounds.

Experiments are established in different parts of Norway in order to test the effects of different kinds of slurry and compost on growth of ornamental plants and on ability to suppress weed growth. Slurry is mixed into the soil in three different levels, relating to 50, 100, 150 kg nitrogen/ ha.

Fertilised (N-P-K) plots are used as controls. Seedlings of *Tilia cordata*, *Betula pendula*, *Aronia melanocarpa* and *Malus sargentii* are planted in the plots and plant growth will be followed for four years. Weed growth is also assessed regularly in the plots. Different kinds of compost are used as mulches in layer of 5, 10 and 15 cm in other plots. Weed growth and plant growth will be followed by regularly registration in order to identify possible differences among the composts types. Preliminary results are presented in the poster.

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# Investigations of diseased oaks (*Quercus robur* L.) grown in urban areas

## Introduction

Oaks belonging to hardwood trees are native in Germany. They are of particular importance due to economic and ecological means. Virus-suspected leaf symptoms as there are mosaic, mottling and chlorotic ringspots were observed in northern and western Germany [2]. These alterations are characteristic and may be marked off clearly to symptoms induced by abiotic factors (extreme climate, ozone), pests (*Phylloxera coccinea*) or fungal pathogens (powdery mildew, *Microsphaera alphitoides*) [1]. The aim of our studies is the mechanical transmission of the pathogen to herbaceous indicator plants and its electronmicroscopic visualization. Constructive of these data the isolates will be further characterized by applying serological and molecularbiological methods.

## Material and methods

Samples were taken from july to august at different locations covering parks and urban forest stands in Berlin, Dresden and Hamburg. Crude plants homogenates of diseased oak trees as well as partial purified extracts were used to transmit the agents to herbaceous indicator plants by mechanical inoculation. As indicator plants *Nicotiana benthamiana, N. clevelandii, N. rustica, N. tabacum* var. `Samsun`, *N. tabacum* var. `Xanthii` *a*nd *Chenopodium quinoa* were applied in a 4-5 leaves stage.

Partial purified extracts were gained by differential centrifugation of leaves of diseased oaks showing virus suspected symptoms. Extracts were prepared for negativ staining and evaluated in a Zeiss EM 10 to demonstrate virus particles electronmicroscopically. Serological testing was carried out as enzyme-linked-immunosorbent assay (DAS-ELISA). Tobamovirus-specific primer were applied in Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR) [3].

## Results and discussion

Negativ staining of partial purified oak leaf homogenates lead to the visualization of rod-shaped particles (length ~ 400 nm) in the electron microscope.

Indicator plants developed characteristic symptoms after being mechanically inoculated with partial purified leaf homogenates. *N. rustica* L., *N. tabacum* var. `Samsun` and `Xanthii` developed necrotic local lesions on the inoculated leaves whereas *Chenopodium quinoa* Willd. exhibited chlorotic local lesions. *Nicotiana clevlandii* L. and *N. benthamiana* L. showed a systemic infection with chlorosis and leaf deformation of the youngest leaves.

Applying the ELISA virus-isolates of these indicator plants react with specific antibodies to *Tomato mosaic virus* (ToMV) and *Tobacco mosaic virus* (TMV). Using specific primer the RT-PCR with two oak isolates lead to the amplification of tobamovirus-group specific PCR-products. These products were cloned and will be sequenced. A comparison with sequence data of known ToMV-isolates will lead us to characterize a known or so far unknown virus.

## Literature

1 BÜTTNER, C.; FÜHRLING, M., 1993. Beobachtungen zu virusbedingten Symptomen an erkrankten Stieleichen (*Quercus robur* L.)-eine Abgrenzung zu ähnlichen, nicht virusbedingten Krankheitsbildern. Nachrichtenbl. Deut. Pflanzenschutzdienst **45**, 110-115.

2 BÜTTNER, C.; FÜHRLING, M., 1996. Studies on virus infection of diseased *Quercus robur* (L.) from forest stands in Northern Germany. Ann. Scien. For. **53**,383-388.

3 LETSCHERT, B.; ADAM, G.; LESEMANN, D.E.; WILLINGMANN, P.; HEINZE, C., 2002.Detection and differentiation of serologically cross reacting tobamoviruses of economical importance by RT- PCR and RT-PCR-RFLP. J. of Virological Methods 106, 1-10.

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# Berlincam – Practical strategies to control *Cameraria ohridella* in different urban areas of Berlin

The Official Bureau of Plant Protection Berlin, in cooperation with the TFH Berlin, University of Applied Sciences in Berlin, is planning to develop and test new strategies to control the chestnut leaf-miner *Cameraria ohridella* DESCHKA & DIMIC, 1986 in the city of Berlin. The project is based on preliminary studies conducted by the Official Bureau of Plant Protection Berlin from 1998 to 2003, and findings from related studies among other European research institutes. Intensive field and laboratory studies are planned, spanning three vegetation periods at 27 sampling sites throughout Berlin. The Berlincam program consists of five tasks, conducted simultaneously.

## Studies of population dynamics

- Field studies examining how population dynamics of *C. ohridella* (e. g. flight activity, generation periods, mortality rate) vary among urban habitats (streets, parks, gardens) compared to a near-natural cultivated forest
- Installation of pheromone traps at all sampling sites
- Determination of species composition of beneficial insect communities (i.e., enemies of *C. ohridella*) in each habitat type
- Comprehensive laboratory studies of growth and development of beneficial insects using climate chambers

## Assessment of chestnut tree health

- Examination of the health of diseased chestnut trees at 20 different localities, focusing on the influence of tree age and on the degree of human influence (streets, parks, gardens)
- Large-scale field experiments evaluating the effect of tree health improvment measures (e.g. fertilization, irrigation) on increasing resistance to *C. ohridella*

## Mechanical control measures

- Field tests of the efficiency of leaf litter removal and treatment in varying seasons and habitat types, including the evaluation of how of leaf litter removal affects beneficial insects
- Evaluation of the efficiency of leaf litter removal and destruction for the entire city of Berlin, including private gardens
- Evaluation of the economic feasibility of different measures

## Biological control measures

- Identification of natural enemies of *C. ohridella*, establishment of breeding programs for natural enemies, and tests of their efficiency on experimental trees
- Laboratory and field tests of the effectiveness of microbiological control of *C. ohridella* (e.g., using *Bacillus thuringiensis*) and plant growth treatments in natural habitats
- Laboratory and field evaluation of efficiency of an existing control measure (Attract & Kill) in natural habitats
- Risk assessment and comparative economic assessment for each possible control measure

## Chemical control measures

- Laboratory experiments to identify the efficiency of insecticides which are selected as to be least harmful to the plants as well as the beneficial insects (in cooperation with the chemical industry)
- Testing different application techniques on their efficiency and possible utilization in public and private land, economic assessment

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# Extended pest-spectrum through modern interior plants

With the world-wide import of big-plants from other continents for the modern interior plants the danger grows for the import not known animal inhabitants at the plants.Under optimal conditions these inhabitants can develop into pests. Usually they are neither in the native country nor in our country to define as pests beforehand, but they could develop sporadically and for a short time to big problems. Despite intensive controls of the plant-quarantine it is not always possible to recognize the potential pests during the import beforehand, if they live very hidden in leaf-axes and partially under the bark in very inferior population-density. After the plantation into the areas a premature and continuous control is inalienable over a longer time period in order to discover the inhabitants early. Often an intensive diagnosis affiliates then. The control of these new pests is especially complicated in the interrior plants. After the present admission-regulation for chemical pesticides in Germany only products are allowable from the amateur-area for interiors. These pesticides don't usually have the lasting effect like profi-pesticides. Additional the application of pesticides in the rooms could be a problem. The most favorable possibility of the control of the pests are biological methods. It is not always available to get the suitable predators from commercial breeding-instituts in a short time. So it is necessary to solve the problems in plant-protection-office independently. The problem-pests and their host-plants, that have appeared in the last years in interior plants of Berlin, are composed in the table.

| **Problem-pest** | **Host-plant** |
|---|---|
| Citrus-Leaf miner (*Phyllocnistis citrella)* | Citrus |
| Bark beetles *(Xyloborus* spec.) | Ficus, palms, dracaena |
| Weevils (*Otiorrhynchus sulcatus* ) | Hedera, pittosporium |
| Boxwood psyllids *(Cacopsylla buxi)*Laurel psyllid (*Trioza alacris*)Olive psyllids (*Euphyllura olivina*) | Mediterran plants |
| Cottony cushion scale *(Icerya purchasi*) | Acacia, citrus, pittosporium |
| Cottony camellia scale(*Pulvinaria floccifera)* | Ilex, pittosporium |
| Bamboo scale (*Asterolecanium bambusae*) | Bamboo |
| Black scales (*Ceroplastes)* | Mediterran plants |
| Mealybugs *(Pseudococcus citri Pseudococcus longispinusPseudococcus affinis* ) | Differnt plants |
| *Cacoecimorpha pronubana* | Olive, laurel, citrus |
| Thrips- Types | Ficus, pepper tree |
| Bamboo aphid (*Takecallis arundiocolens)* | Bamboo |
| Spidermites and gallmites | Camphor tree, pittosporium, bamboo, pistacia |

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# Methods for the evaluation of health condition of woody K. plants in urban greenery

In der Stadtumgebung sind die Gehölze den Wirkungen vieler negativen Faktoren ausgesetzt. Von ihnen zu den wichtigsten gehören die Imissionen, die Salzerde, die Wurzelbeschädigung bei den Ausgrabungsarbeiten, die fachfremde und ungesamte Behandlung der Pflanzen (falsches Schneiden der Äste, die Hohlraumbehandlung), der verwahrlose Schutz gegen Pilzkrankheiten und Tierschädlinge.

In unserem Arbeitsort widmen wir uns langfristig dem Taxen des Gesundheitszustands der Gehölze mit Hinsicht auf das Vorkommen von parasitischen mikroskopischen Pilzen. Bis heute haben wir die Gehölze in 36 Städten der Slowakei gewertet. Die Aufmerksamkeit widmeten wir dem Gesundheitszustand der Gehölze in den Straßen, in den Parken, an den Wegen und Komunikationen, in den Siedlungen, in den Friedhofen, rundherum öffentliche und private Gebäude, bei den Schulen, bei den Industriebetrieben usw. Wir haben 396 mikroskopische Pilze an den Gehölzen in dem öffentlichen Grüne festgestellt. Am meisten sind die Blätter beschädigt (292 Arten 278 Pilze). Auf den Zweigen und auf dem Stamm haben wir 203 Pilze festgestellt. Auf den Wurzeln sind das am meisten die Pilze der Gattung Phytophthora.

In vorgelegter Arbeit stellen wir die Methoden des Taxens des Gesundheits- und Konditionzustands der Gehölze vor. Als Bestellungen für die Stadtsamten oder den Gehölzeschaffner arbeiten wir die Kompletanzeige von dem Gesundheits- und Konditionzustands der Gehölze aus. Auf jeder Gehölze stellen wir den Beschädigungsgrad mit 6-punktiger Skala (gesunde bis 5. Grad ganz trockene Bäume), den Baumzuchtswert von 1 (niedrigster Grad des Taxens) bis 5 Punkte (der höchste Grad, die Lebensfähigkeit von 0 bis über 40 Jahre) fest.

Den Beschädigungsgrad ergänzen wir mit Notizen von den Beschädigungsgründen. Die Beschädigungsgründe zeichnen wir mit Nummern von 1 bis 83 ab (z.B. Nummer 2 bedeutet, daß in der Krone des Baumes die dürre konstruktive Zweige sind, Nummer 31 bedeutet, daß auf dem taxenden Baum die Pilze der Gattung Phellinus, Trametes sind, 32 – die dürre Fäule, 33 – die Naßfäule, 35 – tracheomykotische Pilze).

Bei jedem taxenden Gehölz machen wir den Massnahmevorschlag, den wir in der Tabelle: Die Ergebnisse vom phytopatologischen Taxen mit den Nummern von 1 bis 33 feststellen (z.B. 2 – die dürre konstruktive Zweige schneiden, 13 Baumabhieb).

Zum Schluß stellen wir fest, daß die Gehölze in den Städten vor allem durch fachfremde und ärmliche Behandlung beschädigt sind. In dem öffentlichen Grün sind die Gehölze mit 4 und 5 Beschädigungsgrad beschädigt. Es gibt Bäume mit dürren konstruktiven Zweigen, mit breiten Hohlräumen, Wunden und Abschürfungen. Das baumzüchtige und phytopatologische Schneiden der Zweige macht man unzünftig, lange abgeschnittene Zweige, die sich nicht heilen können, werden an den Bäumen belassen. Sie sind dann das Eintrittstor für die Infektion der parasitischen Pilze.

Die Methoden des Taxens des Gesundheits- und Konditionszustands der Gehölze kann man vor den Rekonstruktionen des öffentlichen Grüns ausnutzen. Sie enthalten die Massnahmenvorschläge für die Steuerung der Erweiterung von Krankheitsquellen der parasitischen Pilze und der Tierschädlinge.

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# Unusual bark cankers of plane trees – symptoms and possible causes

Bark and cambium necroses on branches and trunks of plane trees (*Platanus* sp.) can be caused by a variety of abiotic and biotic agents, for instance the leaf anthracnose fungus *Apiognomonia veneta (anamorph: Discula platani*), which can also lead to necrotic bark lesions [1]. Stem cankers can also be caused by the fungus *Ceratocystis fimbriata* f. *platani*, but this serious disease is not yet present in Germany [3, 5, 6]. In Italy, bark cankers of *Platanus* associated with *Fusarium solani* have been described [2, 4]. In Germany bark and cambium necroses have been observed recently on plane trees which could not be clearly attributed to one of the known causes. In early 2002, an avenue of 70 year-old plane trees in Zweibrücken (Rheinland-Pfalz) exhibiting these „new“ symptoms was investigated by the authors in order to determine the possible cause of the damage.

Symptoms consist of annual bark and cambium necroses, most of them measuring from 2-15 cm in length and 1-2 cm in width. In subsequent years the necroses are covered by callus and woundwood tissue, leading to conspicuous longitudinal bark disturbances on the main trunk and main branches. The necroses appear to arise during the dormant period and appr. 70 % of them were initiated during the winter of 1999/2000. Mycological analysis of fresh necroses from the winter 2001/2002 showed that neither *Ceratocystis fimbriata* f. *platani* nor *Apiognomonia veneta* were present. Several representatives of the genus *Fusarium* were found, but in many cases potential secondary pathogens such as *Cylindrocarpon* sp. and *Phomopsis* sp. were also present. One of the *Fusarium* isolates had similarity to the one described for bark necroses of *Platanus* in Italy [4], but there was no convincing association between a single fungus and the symptoms.

The plane trees investigated by the authors exhibited rather poor growth and are judged to be of low vitality. Thus, they are predisposed to weak parasites and secondary pathogens of all kinds. It is assumed that several species of weak pathogens in conjunction with an abiotic factor, possibly frost damage in early winter, are responsible for the observed necroses.

## Literature

1 BUTIN, H., 1996. Krankheiten der Wald- und Parkbäume. Georg Thieme Verlag, Stuttgart, 261 pp.

2 NALLI, R., 1980. *Fusarium solani* (Mart.) Sacc. associato a cancri corticali del platano. Ann. Ist. Sper. Pat. Veg. Roma 6, 27-30.

3 PANCONESI, A., 1999. Canker stain of plane trees: a serious danger to Urban plantings in Europe. Journal of Plant Pathology 81, 3-15.

4 PILOTTI, M., PONZIO, V., MOTTA, E., 2002. Disorders of *Platanus* x *acerifolia* in Italy associated with *Fusarium solani*. Forest Pathology 32, 249-264.

5 WULF, A., 1997. Blattbräune und Krebserkrankung der Platane. Jahrbuch der Baumpflege 1997, 120-129.

6 WULF, A., BUTIN, H., 1987. Krankheiten und Schädlinge der Platane. Nachrichtenbl. deut. Pflanzenschutzd. 39, 145-148.

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# Production methods strawberries in nurseries as well as urban areas

## Abstract

Experiment was carried out with 39 cultivars of strawberry in the nursery as well as in pots in urban areas of Shimla (2000m ASL), H.P., India, during 2000-03. Significant variation with respect to fruit weight, fruit index, number of fruits per plant, runner production, yield and disease incidence were recorded in the nurseries as well as in pots in urban areas. It was found that the fruit weight, fruit size & yield are less in the nurseries than grown in pots in urban areas but the number of fruits, runner production and disease incidence (leaf spot) are more in the nurseries than in pots in urban areas. In the nursery, the average fruit weight varied from 2.10g to 15.01g, fruit length varied from 17.93mm to 30.01mm, fruit width varied from 13.20mm to 28.87mm, the number of fruits varied from 12.01 to 30.01, runner production per plant varied from 6.93 to 33.33, disease severity varied from 26 to 70 % and yield varied from 59g to 216g per plant where as, in pots, the average fruit weight varied from 5.99g to 35.01g, fruit length varied from 22.21mm to 36.81mm, fruit width varied from 15.26 mm to 35.57mm, the number of fruits varied from 10.09 to 25.03, runner production per plant varied from 4.33 to 15.33, disease severity varied from 23 to 50 % and yield varied from 150g to 460g per plant.

## Introduction

Strawberries (*Fragaria x ananassa*) are a welcome addition to any home garden. It is a delicious soft fruit and widely accepted for its characteristics aroma, attractive colour and refreshing quality. It has adapted well to highly varied climatic conditions. Its cultivation has only recently received a great impetus in India with large business houses setting up a number of agro-based establishments primarily aimed at large scale production of strawberry fruits. It has occupied a premier position in urban areas. Being a shallow rooted fruit crop, it can also be grown easily in kitchen garden, roof garden, pots etc. It is regarded as a valuable food in the diet of millions of people around the globe and is in special demand by the fruit processing industries for preparing the jams, ice cream, candy, toffee and other products.

## Material and methods

Thirty nine strawberry cultivars representing diverse fruit and plant characteristics constituted the material for the present study. The investigation was carried out at the Indian Agricultural Research Institute, Regional Station (Horticulture), Shimla during 2000-2003. The strawberry plants were planted at 30x30 cm spacing in the nursery. Ten plants were planted in a bed of 150 x 60 cm. There were three replications with five beds of each cultivar in each replicate. And there were three replications with 10 pots of each cultivar in each replicate for pot experiments. Other recommended agronomic and plant protection measures were followed for successful strawberry cultivation. The observations were recorded from randomly selected five plants from each cultivar in each replication. The data were recorded for fruit weight, fruit length, and fruit width, number of fruits, runner production, disease severity and yield per plant in both nurseries as well as in pots. The *Mcoysphaerella fragariae* leaf spot severity was recorded in nursery as well as in pots by selecting 50 leaves at random and categorizing them into 0-5 scale. All the disease ratings were further utilized for calculation of disease severity of individual genotype.

## Results and discussion

The differences in fruit characteristics, yield, runner production as well as disease reaction of suitable cultivars out of the total tested strawberry cultivars are presented in tables 1 and 2. It was found that the fruit wt., fruit size & yield are less in the nurseries than grown in pots in urban areas but the number of fruits, runner production and *Mycosphaerella fragariae* leaf spot severity were more in the nurseries than in pots in urban areas. In the nursery, the average fruit wt. varied from 2.10g to 15.01g, fruit length varied from 17.93mm to 30.01mm, fruit width varied from 13.20 mm to 28.87 mm, the number of fruits

varied from 12.01 to 30.01, runner production per plant varied from 6.93 to 33.33, *Mycosphaerella fragariae* leaf spot severity varied from 26 to 70% and yield varied from 59 gm to 216 gm per plant where as, in pots, the average fruit wt. varied from 5.99g to 35.01g, fruit length varied from 22.21mm to 36.81mm, fruit width varied from 15.26mm to 35.57mm, the number of fruits varied from 10.09 to 25.03, runner production per plant varied from 4.33 to 15.33, *Mycosphaerella fragariae* leaf spot severity varied from 23 to 50% and yield varied from 150g to 460g.

**Tab. 1** Fruit characteristics, runner production and disease reaction of strawberry cultivars in the nursery

| **Cultivars** | **Nursery** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Fruit Wt. (g)** | **Fruit Length (mm)** | **Fruit Width (mm)** | **Number of fruits/plant** | **Runner Production** | **Disease Severity (%)** | **Yield/plant (g)** |
| No.A | 2.10 | 20.21 | 13.20 | 28.01 | 10.37 | 40.0 | 58.82 |
| Etna | 15.01 | 27.58 | 28.87 | 14.09 | 11.02 | 54.0 | 211.50 |
| Belrubi | 10.66 | 25.11 | 22.94 | 20.04 | 17.33 | 70.0 | 213.63 |
| Dana | 8.50 | 24.35 | 25.10 | 20.08 | 15.03 | 54.0 | 170.68 |
| Brighton | 7.50 | 24.42 | 21.67 | 19.02 | 19.52 | 32.0 | 142.65 |
| Gorella | 6.10 | 29.81 | 18.05 | 18.08 | 17.63 | 42.0 | 110.29 |
| Chandler | 14.31 | 30.01 | 28.01 | 15.08 | 10.53 | 34.0 | 215.79 |
| Shimla Delicious | 3.81 | 28.15 | 15.05 | 30.01 | 24.92 | 26.0 | 111.34 |
| Selva | 13.51 | 29.91 | 26.85 | 12.01 | 16.27 | 48.0 | 162.26 |
| Douglas | 12.11 | 29.01 | 28.21 | 12.09 | 6.93 | 42.0 | 146.41 |
| Jutogh Special | 3.61 | 21.58 | 16.78 | 27.10 | 33.33 | 32.0 | 97.83 |
| Fairfox | 5.01 | 17.93 | 22.59 | 21.01 | 10.05 | 30.0 | 105.26 |

**Tab. 2** Fruit characteristics, runner production and disease reaction of strawberry cultivars in the pots

| **Cultivars** | **Pots** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Fruit Wt. (g)** | **Fruit Length (mm)** | **Fruit Width (mm)** | **Number of fruits/plant** | **Runner Production** | **Disease Severity (%)** | **Yield/plant (g)** |
| No.A | 5.99 | 22.21 | 15.26 | 25.03 | 09.87 | 30.5 | 149.92 |
| Etna | 35.01 | 27.58 | 35.57 | 13.14 | 09.01 | 36.5 | 460.03 |
| Belrubi | 17.71 | 33.97 | 23.94 | 18.04 | 12.01 | 50.0 | 319.48 |
| Dana | 14.51 | 27.85 | 26.80 | 17.08 | 10.51 | 35.0 | 247.83 |
| Brighton | 12.62 | 28.02 | 26.17 | 19.02 | 14.71 | 27.5 | 240.03 |
| Gorella | 12.09 | 36.50 | 22.05 | 17.08 | 12.55 | 36.0 | 206.50 |
| Chandler | 25.01 | 36.81 | 31.22 | 15.08 | 07.71 | 45.0 | 377.15 |
| Shimla Delicious | 6.81 | 30.55 | 16.09 | 24.01 | 14.81 | 23.5 | 163.51 |
| Selva | 22.54 | 35.91 | 28.98 | 11.09 | 11.32 | 39.6 | 227.46 |
| Douglas | 16.37 | 35.01 | 30.63 | 17.09 | 4.33 | 42.0 | 279.76 |
| Jutogh Special | 6.51 | 24.08 | 18.78 | 24.10 | 15.33 | 23.1 | 156.89 |
| Fairfox | 8.21 | 18.93 | 23.59 | 20.01 | 08.01 | 36.0 | 164.28 |

## Literature


1 POLING, E.B., 1993. Strawberries in the home garden. North Carolina Cooperative Extension Service. Leaf let No. 8205 pp 1-6.

2 PRAMANICK, K.K., KISHORE, D.K., SHARMA, Y.P., 2000. Effect of polyethylene on the behaviour & yield of strawberry (*Fragaria x ananassa*). J.Appl.Hort. 2(**2**),130-131.

3 Stahler, M.M., Lawrence, F.J., Martin, L.W., Moore, P.P., Daubeny,H.A., Sheets, W.A., Varseveld, G.W., 1995. Red rest strawberry. Hort. Sci. 30(**3**), 635-636.

4 WANG, S.Y., GALLETTA, G.J., MASS, J.L., 1997. Chemical characterization of 24 strawberry cultivars and selections. J.Small Fruit and Viticulture. 5(**1**), 21-36.

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# Ozone-induced foliar injury on horticultural crops

Visible injury resulting from ambient ozone pollution has been observed on a range of European crops and is usually classified as acute or chronic. While acute injury involves the death of the cells and develops within a few hours or days following exposure to high pollutant levels, chronic injury typically develops more slowly within days or weeks following exposure. Visible injury is of particular significance when the quality and value of the crop depend on the appearance of the foliage as it is the case for a number of horticultural crops. To date, however, it is not possible to recognize ozone effects in horticultural fields or in urban stands, because of a lack of information on characteristic ozone-specific visible symptoms [1]. We therefore performed an ozone fumigation study which aimed to identify characteristic visible ozone symptoms on horticultural plant species that might help farmers and home gardeners as a diagnosis reference.

Ozone exposure studies were conducted in open-top chambers with potted plants of the following species: Head lettuce, lollo rosso, lollo bionda, cornsalad, zucchini, radish, spinach, carrot, onion, leek, kohlrabi, cauliflower. Plants were exposed in repetitive experiments to two different ozone exposure treatments:

- acute ozone exposure treatment: ca. 150 ppb ozone for 4 h $day^{-1}$; 5-9 consecutive days.
- chronic ozone exposure treatment: non-filtered ambient air plus 50 ppb ozone for 8 h $day^{-1}$; 2-5 weeks.

A control treatment received charcoal-filtered air plus 25 ppb ozone.

In most of the species and cultivars studied, specific ozone-induced foliar injury was observed. Generally, acute exposure resulted in interveinal necrotic injury, developing mostly within 3 to 6 days after initiation of exposure. Interveinal chlorosis is characteristic of chronic exposure to ozone. This exposure is in the range of typical ozone episodes repeatedly recorded in Germany in recent years. The various symptoms of ozone injury on foliage of the investigated horticultural species are described in detail (colour photos) in a pictorial atlas [2] and on CD-ROM [3].

## Literature

1 BENDER, J., 2002. Luftverunreinigungen. In: Krug, H., Liebig, H.-P., Stützel, H. (Hrsg.): Gemüseproduktion, pp. 47-55, Ulmer, Stuttgart.

2 KOSTKA-RICK, R., BENDER, J., WEIGEL, H.J., GÜNDEL, L., 2002a. Sichtbare Ozonschäden bei Gemüsepflanzen. Schriftenreihe Landesanstalt für Pflanzenbau und Pflanzenschutz, Mainz, Heft Nr 12, 54 pp.

3 KOSTKA-RICK, R., BENDER, J., BERGMANN, E., WEIGEL, H.J., 2002b. Symptoms of foliar ozone injuries in horticultural crops. In: Klumpp, A., Fomin, A., Klumpp, G., Ansel, W. (eds.): Bioindication and air quality in European cities, pp 191-196. Verlag G. Heimbach, Stuttgart, (incl. CD-ROM).

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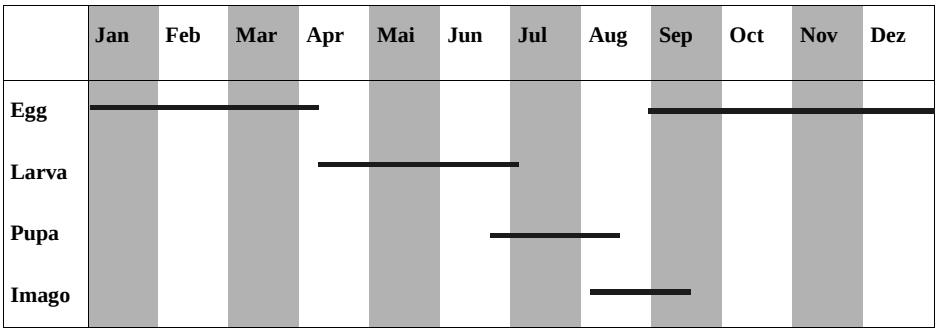
# Insecticide Treatments Against the Oak Processionary Caterpillar (*Thaumetopoea processionea* L.) in Public Green Areas

## Introduction

The oak processionary is a night-active moth of the lepidopteran family of *Thaumethopoidae*, spread in whole Europe. This species is mainly found in central and southern parts of this continent. It creates multiplication or "population explosions" in time and area limited in intervals of approximately 20 years, which are commonly lasting two or three years. Last multiplication were in Belgium, Netherlands, France and Germany in the period of 1980 to 1990.

## Development




## Topic Situation in Brandenburg

The well known southern border of presence in Brandenburg goes from Fläming-hills to Frankfurt (Oder) and was once more reached in 2002. This dispersion border continues in Poland to north-eastern direction. The recent period of detectable presence began in 1992 and contains evidences of this processionary caterpillars in five districts of the country: Ostprignitz-Ruppin, Prignitz, Havelland, Potsdam-Mittelmark and Oder-Spree.

At the same time information about similar situations at all in Sachsen-Anhalt, Mecklenburg-Vorpommern, Nordrhein-Westfalen und Baden-Württemberg arrived to the author. These so called gradations in Brandenburg have been still continuing since 1992 up to 2003, whereas in past times the population only for two or three years held the high level and broke off very soon.

## Consequence to the host plant

During mass multiplication important leaf-feeding of the caterpillars occurs on oak-species (authenticated on *Quercus robur*, *Qu. petraea*, *Qu. rubra* and surely on all *Quercus spec.*), which almost destroys the whole foliage. The caterpillars don't endanger attacked old trees, a new shooting compensates the loss of assimilation surface during summer of the same year. In the following year no damage is realisable, if no further stress factors reduce the vitality of the trees. Especially attacked are old trees inside Avenues, public places inside villages, margin of forests and increasingly new planted oak-trees.

The leaf defects are like those of *Lymantria dispar*, *Euproctis chrysorrhoea*, *Orgyia antiqua* or *Malacosoma neustria* and these caterpillars several times are socialised to them. Secondary affects may be reacted by fungi and bark-beetles.

## Economic consequences

Small stings of these caterpillars contain Thaumetopoein, an nettle-poison, even in the first stage of the caterpillars and increasingly from the end of May or beginning of June. These small hairs, dispersed in the air, at plants and soil, irritate the skin and mucous membranes of mammals. They react dermatitis, eczema and urticaria (allergic reaction) with circulation collapse. Acute symptoms of contamination to humans are skin-itching, coughing, reddening of skin parts under light covering clothes. At all passengers, owners of properties and long time exposed employees of traffic or landscape conservation suffer from this stinging attacks. The sensibility of affected person is increasing more and more after repeated contact to the stings, which accumulate in the soil covering.

Especially the tissue balls of caterpillars bear high concentration of stings. The allergic effect may last more than ten years.

In a great number moving caterpillars, so called precessions, may produce a slippery cover at streets.

## Control

Established tree stocks are not endangered. To reduce the danger to the humans is the main target of countermeasures to processionary caterpillars.

The decision about specific countermeasures have to consider following points:

- Calculation of the feeding activity of caterpillars, of procession intensity and registration of tissue balls at the trunk give an indication to the expected infestation pressure. The nests of larvae and pupae – great, strong objects made of webs, loose, larval cuticle and pupa cocoons as like as brown, spongy shaped ball – stay on or below the affected trees until the next spring.
- Prognostic calculation of the expected damage or activity is necessary. Proves from the tip of the tops (highest 2 m of top branches) must be collected during the winter latest till the end of March. The use of insecticides to control the caterpillars is useful, when more than 150 to 200 eggs at 10 running meters of branch tips are found.
- Attention: The plant protection law may require an especial permission of the official body of plant protection. Affected objects may be parts of protected areas and may contain protected species.
- Physical countermeasures are unsatisfactory and not effective. The economical expense of these methods is very high.
- The plant protection service of Land Brandenburg has long time experiences on control of processionary caterpillars

## Literature


1 BÖHM, L., FLEMMING, G., LEHMANN, M., 1996. Bedroht der Eichenprozessionsspinner Brandenburgs Alleen? Stadt und Grün 45 (2), 125 - 127

2 HEINZE, B., 1990. Warnung vor Kontakt mit Raupenhaaren (*Lep., Thaumetopoeidae*). Entomologische Nachrichten und Berichte, 34, 232

3 KEILBACH, R., 1966. Die tierischen Schädlinge Mitteleuropas. Gustav-Fischer-Verlag, Jena. 578 - 580

4 LEHMANN, M., 1996: Blattfressende Gehölzschädlinge im Land Brandenburg in den Jahren 1993 bis 1995. Gesunde Pflanzen 48 (1), 20 – 29

5 LEHMANN, M., 2003. Eichenprozessionsspinnerbekämpfung im öffentlichen Grün. Jahrbuch der Baumpflege. Thalacker Medien, Braunschweig. 200 - 204

6 ROSKAMS, P., 1996. De Eikeprocessievlinder in het Vlamse Gewest. Groenkontakt, 96/1, 19 - 24

7 WEIDNER, H., 1991. Wie lange bleibt die hautreizende Wirkung von Raupen und Imagines einiger Schmetterlingsarten bestehen? (Lep., Thaumetopoeidae, Lymantriidae, Saturnidae). Entomologische Nachrichten und Berichte, 35, 157

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# Plant-aphid-natural enemy associations in urban green areas of Lleida (Spain)

## Introduction

Aphids are the main k-pest in the urban green areas of Lleida. Up to now the control tactic of this pest has relied on insecticides, which often fail to achieve a complete control and can cause the suppression of the beneficial fauna associated.

IPM is widely accepted as the best control strategy in different environments, included urban green areas. One of the components of this strategy is the use of biological control agents such as predators and parasitoids.

There is little information in Spain about the range and relative abundance of natural enemies in urban parks and gardens. The aim of this study was to determine the species composition of natural enemies associated with aphids in order to obtain basic information for further use in biological control strategies.

## Materials and methods

Samples of aphid predators and mummified aphids were collected every two weeks from April to September and once a month from October to March on ornamental shrubs and trees in Lleida during 2001-2002. Plants were visually inspected for aphids and the observed predators and mummified aphids were collected and brought to the laboratory for identification. The mummies were reared under laboratory conditions at 25ºC until adult parasitoids emerged. After emergence the parasitoids were transferred to vials with ethanol for later identification.

## Results and Discussion

Twenty-seven of the 98 plant-aphid associations recorded in the urban green areas of Lleida were found to be parasitized. A total of 14 parasitoid species of Aphidiidae (Braconidae) were recorded from 19 aphid species collected on 22 species of ornamental plants. The two polyphagous aphid species *Aphis gossypii* and *A. craccivora* were the most frequently found parasitized.

The parasitoids reared belong to 10 genera: *Lysiphlebus* (*L. testaceipes* and *L. fabarum*), *Binodoxys* (*B. angelicae*, *B. acalephae*), *Trioxys* (*T. curvicaudus*, *T. pallidus*), *Aphidius* (*A. colemani*, *A. matricariae*, *A. salicis*), *Praon* (*P. volucre*), *Diaretiella* (*D. rapae*), *Ephedrus* (*E. chaitophori*, *E. persicae*), *Adialytus* (*A. salicaphis*), *Diaretus* (*D. leucopterus*), *Euaphidius* (*E. cingulatus*), *Pauesia* and *Aphelinus.*

*L. testaceipes* was the dominant parasitoid species observed. It was mainly found parasitizing *A. gossypii* on *Hibiscus syriacus* and *Catalpa bignonioides*, *A. craccivora* on *Robinia x Casque Rouge*, *Acer campestre* and *Sophora japonica* and *A. nerii* on *Nerium oleander*.

With regard to predators, the main aphid predators recorded were Coccinellidae, mainly *Scymnus* spp. and *Oenopia conglobata*, followed by Chrysopidae (*Crysoperla carnea*) and Syrphidae. Other predators observed include other Coccinellidae (*Coccinela septempunctata*, *Adonia variegata*, *Propylea quatuordecimpunctata*, *Myrrha octodecimguttata*), Anthocoridae (*Anthocoris* sp., *Orius* sp.), Miridae (*Daraeocoris* sp., *Pilophorus perplexus*), Trombididae (*Allothrombium* sp.), Araneae, Cecidomyiidae (*Aphidoletes aphydimiza*) and Cantharidae (*Ragonycha* sp.). These predators were related to several aphid-plant associations.

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## Ecologically Safe Plant protection Way against Fungal Infection

In recent years interest of researchers in the problems of induced phytoimmunity and induced disease resistance of plants increased. The search for safe biological preparations as an alternative to chemical ones is a basic problem in plant protection. Achievements in understanding phytoimmunity mechanisms allow development of absolutely new ecologically safe preparations, action of which against harmful organisms is realized by essential changes in host plant metabolism inducing intensification of its own protective reactions. There is a number of natural elicitors of resistance among which a compound of steroid origin—plant hormone epibrassinolide. Epibrassinolide is a high-effective growth regulator. It exhibits pronounced biological activity and has a great effect on physiologobiochemical processes of plants treated with it. This action is not strictly directed. In manifests itself in intensity of growth processes, morphogenesis and exerts an effect on reproductive ability of plants. Epibrassinolide takes up a particular place among other growth regulators stimulating other phytohormones in them—gibberellins, cytokinins and auxins. At the same time epibrassinolide shows antistress, adaptogenic properties increasing plant resistance to unfavorable environmental factors; displays mediated antifungal and antibacterial activity enabling increase in non-specific resistance of plants to some pathogens. Epibrassinolide may be attributed to the group of growth regulators with immunizing properties.

The role of epibrassinolide in formation of interrelations between host plant and pathogen in the pathosistem as well as the results of antipathogenic action of EPIN® preparation, developed on epibrassinolide basis at the Institute of Bioorganic Chemistry of National Academy of Sciences of Belarus will be considered. EPIN efficiency is within the limits of 30-40-70% depending on varietal distinctions of plants and environmental conditions. The preparation is advised to be used in alternation or in mixtures with fungicides, for by itself, particularly under epyphytoty conditions it can't protect effectively the plant. EPIN functions well at medium and low levels of disease development.

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# Alternativ plant protection means agains *Tetranychus urticae* Koch

## Abstract

The phytophagus spider mide *Tetranychus urtica* Koch is the most commonly observed mite species in rose and other flowers.

In a search for new alternativ plant protection means, the possibilites of five plant extracts for the control of this pest of rose in urban area were tested - *Ocimum basilicum* L., *Allium cepa* L., *Datura stromonium* L. - *Achillea millefolium* and *Artemisia absinthium*.

We can conclude, that the leaf extracts of the three plant species as thornapple, wormwood and basil could be a source of a pesticide of plant origin to control *Tetranychus urticae* Koch.

## Introduction

The development of resistance towords existing insecticides and acaricides, the implementation of Integrated Pest Management and a changed public opinion necessitate a continuous search for new and selective crop protection compounds in modern urban garden, worldwide, researchers are trying to understand the insecticidal properties of botanicals.

Data are found in literature giving a positive evaluation of this problem.

In this connection, the objective of the present work was to study the toxic activity of a set of plant extracts to be used for controling *Tetranychus urticae* by plantation of rose in urban area.

## Material and methods

For the purposes of the study, extracts of five plant species were prepared.

- basil - *Ocimum basilicum* L.,
- yarrow - *Achillea millefolium* L.,
- onions - *Allium cepa* L.,
- thornapple - *Datura stromonium* L.,
- wormwood - *Artemisia* L. *absinthium* L.

The foliage of the above- pointed species was gathered in the regin of Plovdiv-Bulgaria

After cleaning and washing the material was dried up on a filter paper and then 100 g of the fresh material were soaked in cold water for 24 hours. After this period, the solution was filtered and prepared for treating.

As a test material, mobile forms of Tetranychus urticae, reared as a laboratory population on rose, were used .For the purposes of the experiment, intact leaves with mobile forms of the mite were taken and placed in large petri dishes over a filter botton.

The separate plant extracts were sprayed with a handheld pulveriser. The experiments were set up several times by estimating the mite mortality until the 96 -th hour.

The effectiveness of these solutions of plant extracts has been attested by Henderson and Tilten.

## Results and discussion

The date in Figure 1 and 2 show that the different extracts from pointed plant species contain long - active toxic components against the mobile forms of *Tetranychus urticae*.

Figure 1 show that the different extracts have delayed initial activities expressed in low mortality percents. The only exception is observed in thornapple Datura stromonium.

Probably, the toxic effect of this plant species is connected with alcaloides - atropin, scolopolamin, chiosziamin and different species of essential oils.

**Fig 1. Toxic activity of plant ecstracts for controling Tetranychus urticae**

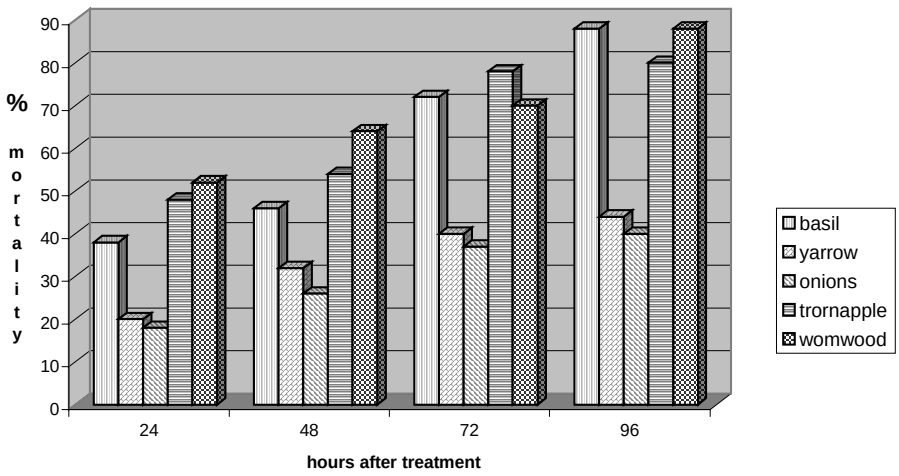
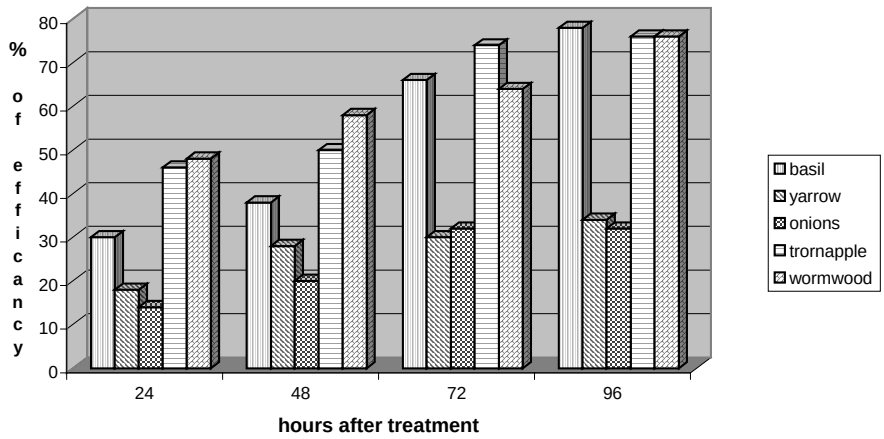



**Fig 2. Efficancy of plant extracts for controling Tetranychus urticae**



At the later estmation, the picture was signifcantly changed. Sensitive biologically active extracts proved to be those prepared from thornapple, basil and wormwood.

The toxic effect shown by these extracts was confirmed by the second investigation.

Only yarrow and onions controlled the Tetranychus urticae population insufficiently.

Nevertheless, the study made emphasized undoubtedly the capacities of natural plant species to be easily used as plant protection means.

Data were recorded in this study cleared that the Datura stromonium, *Artemisia* L. *absinthium*, *Ocimum basilicum* extracts were found to be more toxic to the active stages of *Tetranychus urtica* Koch.

Taking into acount the wide feed specialization of *Tetranychus urticae*, we consider that in many cases, pest control should be carried out with natural biologically active resources and fresh or waste plant material, in particular, which possess some insecticide of acaricide properties.

## Literature


1 AMER, S.A.A., REDA, A.S., DIMETRY, N.Z., 1988. Activity of *Abrus precatorius* L. extracts against the two-spotted spotted spider mite *Tetranychus urtica* Koch (Acari, Tetranychidae). Acarologia, t. XXX (1989).

2 BARAKAT, A.A., SHEREEF, G.M., ABDALLAH, S.A., AMER, S.A.A., 1984-1985. Toxic action of some plant extracts against *Tetranychus urtica* Koch. Bull. Ent. Sos. Egypt, Econ. Ser., 233-242, Annals of Agric. Sc. Moshtohor, vol. 27 (1), 1989.

3 DIMETRY, N.Z., EL-GENGAIHI, S., REDA, A.S., AMER, S.A.A., 1988. Toxicity of some compounds isolated from *Abrus precatorius* L. seeds towards the two-spotted spider mite *Tetranychus urtica* Koch. Bull. Zool. Soc. Egypt.

4 MATEEVA, A., 1996. One natural alternative pest control L. *decemlineata* Say on potato. First Balkan Symposium Vegetables and potatoes 4-7 June, Belgrade, Acta Horticulture. N 462, vol.1 p. 335-337.

5 MATEEVA, A., STRATIEVA, ST., ANDONOV, D., 1997. The effect of some plant extract on *Acanthoscelides obtectus* Say. Med Fac Landbouww, Univ, Gent, Belgium 62/3b. Part II, p.513-515.

6 MATEEVA, A., SERMAN, H., GEORGIEVA, T., STRATIEVA, ST., 1997. Study on the aphids effect of ethanol extracts from basil *Ocimum basilicum* and camomile *Mathricaria chamomilla*. Higher School of Agriculture. Plovdiv, Scientific Works. vol XLII, book 2.

7 MATEEVA, A. MICHOV, K., 1998. Alternativ plant protection means against *Pieris brassicae* L.50-th Union of Scintific, Plovdiv 20.XI. 1998.

8 MATEEVA, A., 2001. Biological agriculture and the protection of the planet earth. Proceeding of the International Conference Ecological protection of the Planet earth. Xanthi, Greece, 5-8 June 2001. vol. II. p. 971-973.

9 Patterson, C.G., Thurston, R., Rodrigues, J.G., 1974. Two-spotted spider mite resistance in Nicotiana species. J. Econ. Entomol., 67, 341-343.

10 Rodriquez, J.G., Dabrowski, Z.T., Stolts, L.P., Chaplin, C.E., Smith Jr., W.O., 1971. Studies on resistance of strawberries to mites, 2, Preference and non-preferanse responses of *Tetranychus urtica* and *T. Econ*. Entomol., 64,383-387.

11 SCHAUBER, M., SCHMUTTERER, H., 1981. Effect fo freshly squeezed juices and crude extract of the lebiate Ajuga remota on the two spotted spider mite *Tetranychus urtica* Koch. Z. Angew. Ent., 91, 425-433.

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## The influence of traffic on plant health in urban areas

Ornamental trees in urban areas are exposed to several abiotic stress factors. Traffic with its different means of transport directly and indirectly causes great damage to ornamental plants.

This article shows the presence and spread of pests by means of transport. We have been following the spread of some pests on horse chesnut (*Aesculus hippocastanum*), plane trees *(Platanus* spp.) and false acacia (*Robinia pseudoacacia*) especially near roads, oil stations, parking spots, cementeries etc. During our research we noticed horse chesnut miner (*Cameraria ohridella* Deschka et Dimić) on horse chesnut tree. The insect has spread considerably since it was first observed in Novo mesto in 1995. Untill now it has become common practically everywhere in Slovenia. Sycamore lace bug (*Corythuca ciliata* Say) is widely spread in Slovenia since it was first observed in 1975. Leaf miner *Phyllonorycter platani* Standiger on plane trees was first observed in 1971 and is now well established. Leaf miner *Phyllonorycter robiniella* Clemens on false acacia was first observed in 1994. It is moderately present in western part of Slovenia (Nova Gorica – Koper). It was also found near an oil station in Ljubljana. Flatid planthopper *(Metcalpha pruinosa* Say) is a serious pest of trees and shrubs, including horse chesnut, plane and false acacia. This polyphagous species was first noticed in 1991 near Koper. Now it is established in western part of Slovenia (Koper-Vipava- Nova Gorica), some specimens of *M. pruinosa* were also found along the highway in Ljubljana.

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# Diseases in sweet cherry trees in an urban orchard.

Stone and pome fruits with long standing times and short yield periods need more attention to prevent any lost from diseases and damages. Under the climatic conditions of northern and central Europe sweet cherry fruits have a higher tendency to crack (rainfall during the yield period), fact which increases the chance for disease and pest development on fruits. Subsequently an adequate fungizide application schedule is required during the vegetative period. Preventing the sweet cherries from humid weather conditions will ensure a healthy fruit status.

An experiment with sweet cherries in Berlin- Dahlem, Fruit Science section, is currently in development. Three different cultivars ( Regina, Karina, Summit) were grafted on Gisela5 rootstocks. Half of the orchard is under cover with plastic foil (FRUSTAR-BRÄNDLIN, Germany) and the rest is left open. The state of fruits and trees was monitored on a weekly basis from the beginning of april until the end of july 2002 and potential pathogens were confirmed in the laboratory. A correlation between the amount of yield and the results of the monitoring (both measurement in this case for the quality) has been carried out.

## Literature

1 CARDEI, E., ROMINGER, E., 1997. Research concerning phytosanitary protection of cherry trees plantation ant the lasi Fruit-growing Research Station. Cercetari Agronomice in Moldova, 30, 133-139.

2 BOVE, J. M., GARNIER, M., 2002. Phloem and xylem restricted plant pathogenic bacteria. Plant Science, 163, 1083-1098.

3 BOVE, J., SKAAR, E., SEKSE, L., MELAND, M., VANGDAL, E., 2003. Rain protection covered sweet cherry trees- effects of different covering methods on fruit quality and microclimate. Hortechnology Publication, 13, 143-148

4 BORVE, J., 2002. Fungal diseases causing fruit decay in sweet cherries (Prunus avium L.)- effects of rain protective covers, aborted fruits, overwintering sites and cuticular fractures. Doctor Scientiarum Theses Publication type: Ph. D Dissertations 2002, 8.

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# Occurrence of millipedes in the urban areas by example of *Spinotarsus caboverdus* on Cape Verde

The species *Spinotarsus caboverdus* has been falling into disrepute for about 30 years as a pest of many plants which are important for the food of the inhabitants of the Cape Verde.

*S. caboverdus* is an example of diplopods that was spread by people through trading. It does not only live on all kinds of vegetal waste materials, but also attacks crop plants like potato, sweet potato tubers, pumpkins, tomatoes, cassavas, melons, ripe strawberry, cabbage, germinating beans and germinating corn. The species *S. caboverdus* prefers fruits like papayas, mangos, bananas and pineapple and heavily damages them due to its massive presence.

Through laboratory breeding and field investigations we can answer some questions about millipede reproduction processes and life cycle. We were able to ascertain that the species *S. caboverdus* produces one generation per year on the Isle Santo Antao. Adults are present throughout the whole year but the maximum number of them seems to be in June, July and August. Under lab-conditions adults can live up to 8 months. In this time they are frequently changing their place to find food plants and best conditions for reproduction. During the first four phases the juveniles remain in the ground and use mainly dead organic matter as food. The later juvenile stages can also be found on plants in or on the soil' surface. The whole development of the juveniles takes 7 months.

This pest is problematic due to the high density of population. *S. caboverdus* uses very well the ecological conditions of the island to its advantage. The mountainous character of the island of Santo Antao with its humid microclimate is especially suited for the preservation of the species during the dry season. The traditional irrigation system forms optimal conditions for reproduction and early development. Thus, they reach a high reproduction rate and through the strong mobility we find a permanent spread of the species. In additional to this, Millipedes have few predators or parasites on Cape Verde which can effectively control density of their population.

These circumstances are the reason for a constant high population density across the island Santo Antao since its first detection in 1969.

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# The abiotic and biotic factor influence on *Yponomeuta padellus* population in fruit gardens of wood-steppe region of Ukraine

The fruit moth (*Yponomeuta padellus*) is one of the widespread vermin in Ukrainian wood-steppe region. The intensive reproduction this vermin has the period of 4-5 years. The caterpillars of fruit moth has the wide range of fodder plants, but nevertheless fruit moth show to monofagiae tendention. *Y. padellus* damages usually the monoculture in poly species agroecosystem that is result the evolutional differentiation to oligo- and monofagiae.

The dynamic of *Y. padellus* quantity, their possibility to injure of fruit gardens and parasite influence on them were studied. The dynamic of *Y .padellus* quantity studying for 9 years showed the population increase in years with drought and hot summer (1991, 1996) in Kyrovograd region. It was observed the considerable quantity of vermins in these years – 12-19 nests per tree. That was the result of negative effect the hydro- and thermal condition on parasite and infectional agent diseases of *Y. padellus.* The cool spring and rainy summer (1993, 1994, 1997) decreased the fruit moth population. It was shown the ruin of population (58%) on 1997, especially from *Paniscus sp.* (*Tachinidae*) (33%). These factors decreased the living potential of *Y. padellus* population and promoted their transition in depressive phase. Thus, our result confirmed that oscillation amplitude of *Y. padellus* population is quit constant. The functionally period these system is long, in spite of relative stability of agroecosystem.

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## Introduction of *Magnoliaceae* connecting with winter hardiness problem

Introduction and preservation of ornamental plant species are impossible without detailed study of their physiological reaction to climatic factors of new region of cultivation. Because *Magnoliaceae* representatives originate from subtropical country with hot climate their acclimatisation supposes the developing of coldresistanse. Therefore anatomical, morphological, physiological and biochemical coldresistanse signs of leaf shedding magnolia from collection (near 45 species, hybrids and forms) from the Acad. A. Fomin Botanical Garden of Kyiv National Taras Shevchenko University, which is the important source of conservation of rare petering varieties. The investigation of the anatomical structure of shoots showed that significant part of species studied has well formed periderm covered by cuticle 8-28 μM layer. Correlation between phellem cell density, lenses and their layer quantity with shoot ability to winter drying. It is proved that covering and mechanical tissues are the additional taxonometric sign of gender Magnolia species and it correlates with plant hardiness. According to phenologic observation, physiological and anatomic characteristics most perspective cold resistance magnolia varieties from this collection are proposed for planting in climatic condition of Europe: *Magnolia salicifolia (Sieb et Zucc) Maxim; Magnolia x loebneri Kach.; Magnolia x soulangiana Soul.Bod.; Magnolia kobus DC.*

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# The role of some physiological and biochemical parameters in integrated protection of plants against fungal infection

Phytopathosystem formation is defined by interaction between host plant metabolites and fungal pathogens among which the essential role is attributed to hormonal compounds of both organisms. Interrelation between contacting taxons is regulated owing to change in their balance that is manifested itself in activating various physiologobiocemical mechanisms providing functioning of integrated protection.

Detection of auxins, cytokins, abscisic acid and gibberellins in the composition of intercellular liquid in affected tissues of rye and barley touches upon knowledge of mechanisms causing creation of ecological niche accordingly for pathogens of brown rust (Puccinia dispersa) and net blotch (Pyrenophora teres); development of biotrophic relations at all or individual ontogenesis stages of these pathogens; processes of intracellular signalling and, finally, antioxidant function. We have shown that transduction of hormonal signals and activation of cation canals related to it stimulated the work of electrogenic pump of plasmalemma that is associated with disease resistance manifestation. The active oxygen forms/antioxidant ratio controls the intracellular state of infected cell. Its increase induces tissue necrosis of affected rye and death of obligatory pathogen. On the contrary, its decrease results in establishment of homeostasis biotrophic relations between organisms and, as a consequence, in disease resistance. This mechanisms is typical for the resistant barley variety - net blotch pathogen system, too, while necrosis development in the case of susceptible reaction favours the development of optional relations. We consider the combination of hormonal and enzymatic systems in the intercellular space a powerfull mechanism of controlling viability of fungal pathogen.

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## Strawberry cultivation in the nurseries as well as in pots for urban areas

Strawberry (*Fragaria x ananassa*) is a delicious soft fruit and widely accepted for its characteristics aroma, attractive colour and refreshing quality. It has adapted well to highly varied climatic conditions. Strawberry cultivation has only recently received a great impetus in India with large business houses setting up a number of Agro-based establishments primarily aimed at large scale production of strawberry fruits. It has occupied a premier position in urban areas. Being a shallow rooted fruit crop, it can also be grown easily in kitchen garden, roof garden, pots etc. It is regarded as a valuable food in the diet of millions of people around the globe and is in special demand by the fruit processing industries for preparing the jams, ice cream, candy, toffee and other products.

Experiment was carried out with 39 cultivars of strawberry in the nursery as well as in pots in urban areas of Shimla (2000m ASL), H.P., India, during 2000-03. Significant variation with respect to fruit weight, fruit index, number of fruits per plant, runner production, yield and disease incidence were recorded in the nurseries as well as in pots in urban areas. It was found that the fruit weight, fruit size & yield are less in the nurseries than grown in pots in urban areas but the number of fruits, runner production and disease incidence (leaf spot) are more in the nurseries than in pots in urban areas. In the nursery, the average fruit weight varied from 2.10g to 15.01g, fruit length varied from 17.93mm to 30.01mm, fruit width varied from 13.20mm to 28.87mm, the number of fruits varied from 12.09 to 30.01, runner production per plant varied from 6.93 to 33.33, disease severity varied from 30 to 70 % and yield varied from 30g to 200g per plant where as, in pots, the average fruit weight varied from 3.35g to 35.01g, fruit length varied from 22.21mm to 36.81mm, fruit width varied from 15.26mm to 35.57mm, the number of fruits varied from 10.09 to 20.01, runner production per plant varied from 4.33 to 15.33, disease severity varied from 23 to 50 % and yield varied from 50g to 260g per plant.

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# Fruit set and seed abortion of *Aesculus hippocastanum*

The large-scale abortion of flowers and immature fruits is a common phenomenon. The proportion of flowers that develop into mature fruit varies considerably among species, ranging from less than one percent to one hundred percent [1, 2, 3]. Darwin was perhaps the first to note and comment upon the significance of excess flowers produced by plants [4]. The study of causes and consequences of mortality between fertilization and seed and fruit maturation is also important in understanding the sexual strategies of plant [1]. In this work we present the results of study about fruit set and seed abortion on example *Aesculus hippocastanum* as one of the most occurred tree in urban environment.

## Material and methods

We studied the morphometric of inflorescence (length of inflorescence, number of lateral cincinnus), the production of fruits, their mortification and the spectrum of microscopic fungi which participate on seed abortion of Horsechestnut during the growing season on selected sites in Slovakia (Ivanka pri Dunaji, Rusovce, Kluknava) in 2000 and 2001. Aborted fruits were collected four weeks after fade away of inflorescence and their length was measured. Percentage of aboted seeds were detected during the stage of fruit maturing (August). The number of mature seeds and aborted seeds in inflorescence were detected.

## Results and discussion

In 2000 and 2001 European Horsechestnut started to flower in the middle of April. The length of inflorescence after fade away was from 13.5 to 30 cm (average length 23.1 cm). The number of lateral cincinnus was from 10 to 40 per inflorescence (average 25). The fruit development stated after flower pollination by insect. The horsechestnut fruits matured in last decade of August and the fruits naked in September. The horsechestnut fruit is a capsule with three septum, in every septum are present two ovule. We observed that Horsechestnut regulary produced more fruits than they mature. The majority of fruits which aborted before maturing abscised 2-5 weeks after flowering phase. None till four seeds were presented in mature fruit. We observed 61.3 % monospermous mature fruits and 5.9 % trispermous mature fruits [5].

*Aesculus hippocastanum* has a low production of seeds and number of fruits per inflorescence range between plants in population. Aborted fruits were black coloured and grew very slowly. The length of aborted fruit measured from 0.7 to 2.5 cm. The average length of mature fruit was 5 cm. In August we found 50 % aborted fruits for 27.1 % investigated inflorescences (n = 251). Inflorescences with 0 % and 100 % aborted fruits were scarce (only from 0.4 to 2 %).

Phytopathogenic fungi from the genera *Fusarium* (15 %), *Phoma* (20 %), *Phomopsis* (35 %), *Colletotrichum* (7 %) and also species *Botrytis cinerea* (20 %) and *Trichothecium roseum* (20 %) participate on abortion of Horsechestnut fruits during the phase of fruit maturing [5].

## Conclusion

The fruit abortion after pollination is a generally phenomenon for *Aesculus hippocastanum* too. *Aesculus hippocastanum* regularly initiates more fruits than it matures. Most of the fruits that fail to mature are abscised from 2 to 5 weeks after the flowering period. The length of aborted fruit varied beetwen 0.7 - 2.5 cm. The pattern of fruit abscission was examined in relation to the principal microscopic fungi.

## Literature


1 LLOYD, D.G., 1980. Sexual strategies in plants. I. An hypothesis of serial adjustment of maternal investment during one reproductive session. New Phytologist 86, 69-79.

2 LLOYD, D.C., WEBB, C.J., PRIMACK, R.B., 1980. Sexual strategies in plants. II. Data on the temporal regulation of maternal investment. New Phytologist 86, 81-92.

3 STEPHENSON, A.G., 1981. Flower and fruit abortion: Proximate causes and ultimate functions. Annual Review of Ecology and Systematics 12, 253-279.

4 DARWIN, CH., 1877. The effects of cross- and self-fertilization in the vegetable kingdom. D. Appleton and Co., New York. In: Bawa, K.S., Webb, C.J., Flower, fruit and seed abortion in tropical forest trees: Implications for the evolution of paternal and maternal reproductive patterns. American Journal of Botany, 71, 1984, 736-751.

5 PASTIRČÁK, M., ZIMMERMANNOVÁ-PASTIRČÁKOVÁ, K., 2002. Fruit production of European Horsechestnut (*Aesculus hippocastanum* L.) in urban environment. In: Proceedings from Conference "Cultivation and protection of outlandish woody plants in Slovakia", May 14 - 15th, 2002 in Nitra, IFE SAS Zvolen, pp. 198-200. (in slovak)

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# Te use of resistograph F-400 and the processing of data: a case study.

The case: 280 limes (*Tilia cordata* and *T. europea*) were drastically pruned in 1992 [1]. In 2002, experimentation was started to test the efficiency of several soil treatments in increasing vitality, but also to assess the problems of wounds and cavities. Numerous 10 years old wounds are now presenting rots and cavities. An important question is: on which objective base can we choose the sprouts to be maintained? One of the included parameters could be the width of healthy wood on which sprouts are anchored. This width can be assessed visually, but other techniques were proposed, namely the use of a resistograph to measure wood density variations.

Resistogram gives a relative measurement of wood density that is expressed as a percentage of amplitude. Apart from cavity localization, there can be doubts in the interpretation of some amplitude variations.

A first step is to compare measured signal to the mean amplitude calculated with 50 healthy limes (98 measurements without cavity). This mean curve gives a qualitative and quantitative comparison point to interpret the amplitude of each resistogram. The weakness of wood can be calculated as the relative amplitude loss (RAL) against this mean curve. Two RAL critical levels were determined as corresponding to transitions of decayed wood (RAL>20%) and cavity (RAL>80%).A second step is sometimes necessary because, an artifact occurs in the measurement of wood density when a cavity is crossed. This was illustrated by the comparison of several resistograms taken at 5 cm intervals. The wider is the cavity, the more important the apparent loss of amplitude at the end of the corresponding measurement. Nevertheless, wood is healthy at these three stages as tree has compartmentalized the rot. So, there is an artifact in the measurement of wood density related to the width of the crossed cavity. If a second measurement is not realized, corrections have to be made to the signal.RAL determination was applied on a decaying lime presenting *Ganoderma* contamination at the trunk base. Graph presents this RAL calculated from the comparison of the measured resistogram and the mean curve. The two RAL critical levels are also used to qualify the relative importance of fungal degradation. Coincidence between calculated results and the observations on wood piece are shown on the figure. Two observed limits aren't revealed by the resistograph and a RAL maximum doesn't correspond to any observable transition.RAL calculation and signal correction are combined in an example. Resistograph is there crossing a cavity formed by *Ganoderma* on the external part of the trunk. Without correction, the density of wood remaining in the central zone could be under-estimated. Similar problems could be important for risk assessment and tree management.*With the financial support of the Walloon Region (Ir. JC. Gobeaux, Director).

## Literature

1 TOUSSAINT, A., KERVYN, V., DELCROIX, B., BAUDOIN, J., 2002. Analyse de l'impact physiologique et économique de l'élagage des arbres d'alignement en port libre. Biotechnol. Agron. Soc. Environ. 6, 99-107.

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# Towards a better understanding of tree failure: Investigations into bending stresses of branch junctions and reiterates of European Filbert (*Corylus avellana L.*) as a model organism.

## Introduction

Heavy storms use to be rare events; this is why trees are not prepared for them. Trees will fail when winds too strong for their mechanical possibilities bend their crowns. The question is how a tree fails in a storm. An uprooted tree and a tree that breaks at its base bring down a heavy mass causing large damage. A tree that fails more politely to its surrounding will break the terminal branches. So small masses will fall down and when the storm is over the tree owner can decide whether to keep his storm shaped bonsai or to replace it by a new plant.

When investigating a mixed forest stand after a hurricane, some trees will be felled (uprooted or broken at their base) other trees will have suffered with crown damages; either large beams have broken from the trunk or smaller branches from the crown periphery are left off. Similar effects can be observed in urban parks. Especially Lindens and Beeches from open stands usually loose no more than peripheral branches which do not cause valuable damage. Our goal is to better understand how static forces like wet snow and dynamic forces like wind loads affect on beams, which effect tapered and non tapered beams bring and which crown architecture allows a less dangerous failure.

## Materials and methods

For our investigations we used European Filbert (*Corylus avellana L.*) as a model organism. The woody plant develops according to Rauh's Model, one of the most popular Architectures in temperate climate (Hallé 1970, Pfisterer 1998, 1999). Wood density of Filbert is similar to common trees (Table 1.) and so is its flexibility (Table 2). On the other hand European Filbert is a weed in our forests; this is why no forest ranger will be angry if we collect some branches from a Filbert shrub. In a second step the results on Filbert will be proved on different tree varieties more popular in our parks.

**Tab. 1** Wood density of some popular forest trees compared with European Filbert, our test organism. (after Schuett et al, since 1995).

| **Wood Density [g / cm³] of several, common woody plants** | |
|---|---|
| Norway Maple (*Acer platanoides L.)* | ρ = 0,59 g/cm |
| European Filbert (*Corylus avellana L.*) | ρ = 0,60 g/cm |
| European Ash (*Fraxinus excelsior L.*) | ρ = 0,65 g/cm |
| European Beech (*Fagus sylvatica L.*) | ρ = 0,68 g/cm |

**Tab. 2** Maximum bending stress of some trees (Schroeder 1998) in comparison to European Filbert (-> Tab. 4).

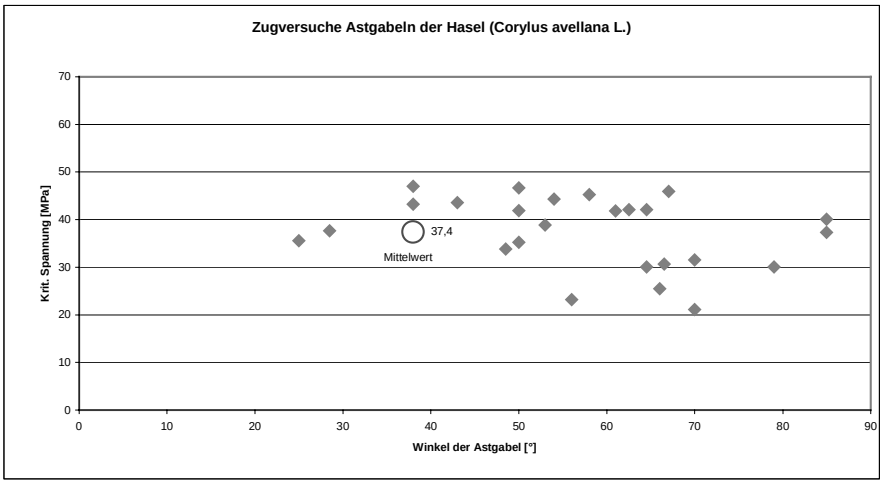
| **Maximum Bending Stress [MPa]** | |
|---|---|
| European Filbert (*Corylus avellana L.*) | $\delta_B$ = 41 – 65 MPa |
| English Oak (*Quercus robur* L.) | $\delta_B$ = 59 – 72 MPa |
| European Beech (*Fagus sylvatica L.*) | $\delta_B$ = 65 MPa |
| London Plane (*Platanus x hispanica Münchh*) | $\delta_B$ = 54 MPa |
| Carolina Poplar (*Populus x canadensis Moench*) | $\delta_B$ = 41 - 44 MPa |

Under mechanical view a branch junction is a weak point. Above a fork the diameter of the axis is reduced and the distal axes grow in an angle giving more power to bending forces.

Measuring of bending forces

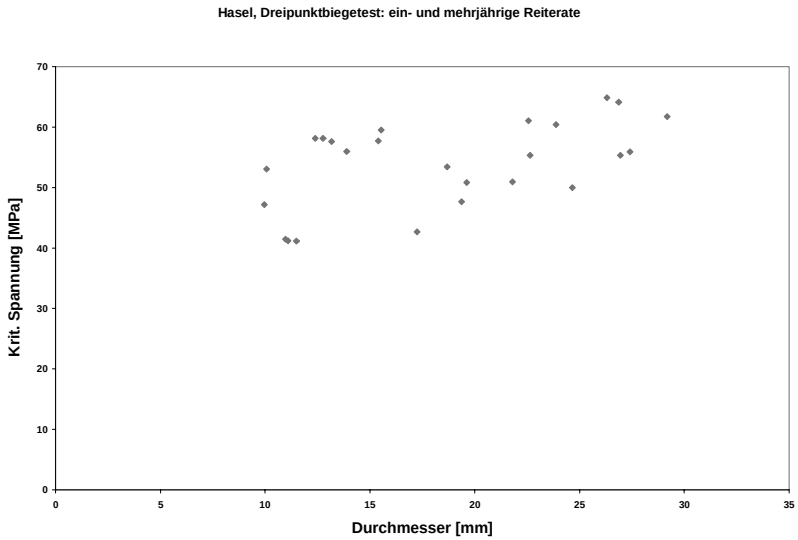
Fresh forks of Filbert beams were measured in a universal tensile testing machine INSTRON 4466. The maximal forces and the forces applied during the process were measured (Table 3). In order to compare the forces of forks of different size and different angles diameters, angles and distances between axilla and fixing points were calculated with the forces applied to the material.

**Tab. 3** Forks of European Filbert: Maximum strain [MPa] dependent on the fork's angle. The angle has no influence, narrow forks are as strong as open forks with wide angles.




In order to compare the strength of branch junction to normal wood strength in a second measuring fresh Filbert reiterates were put under three point pressure (Table 4).

**Tab. 4** Reiterates of European Filbert, 3-point-measuring with INSTRON 4466: Critical strain [MPa] dependent on the reiterate's cross section.



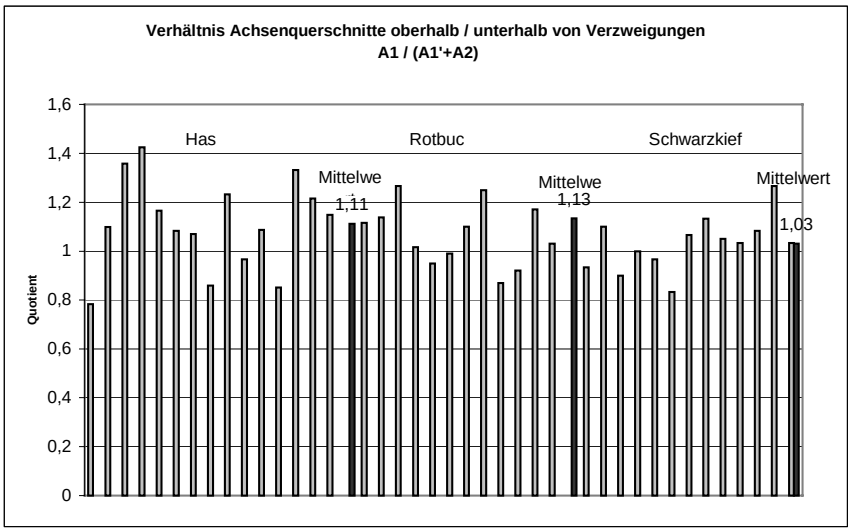

Bending behavior relative to a beam's taper

Branches of different taper were bent under static load. The points of maximum stress were measured.

Morphology

On branch junctions of Filbert, Beech and Pine the diameters were measured under and above a fork (Table 5). Cross section areas were set in relation to each other.

**Tab. 5** Relations of cross sections at forks of different woody plants: European Filbert ('Hasel'), European Beech ('Buche') and Austrian Black Pine ('Schwarzkiefer'). The cross section under a fork ($A_1$) has the same dimension as the total of the two cross sections above the fork ($A_1$' + $A_2$). The equation is: $A_1$ / ($A_1$' + $A_2$) = 1.



We made cross sections of forks. The open wood was stained with several dyes reactive to lignin (e.g. Fe $Cl_3$, Astra Blue, Malachite Green) to make the axillary wood visible. The dimension of axillary wood was related to the fork's angle.

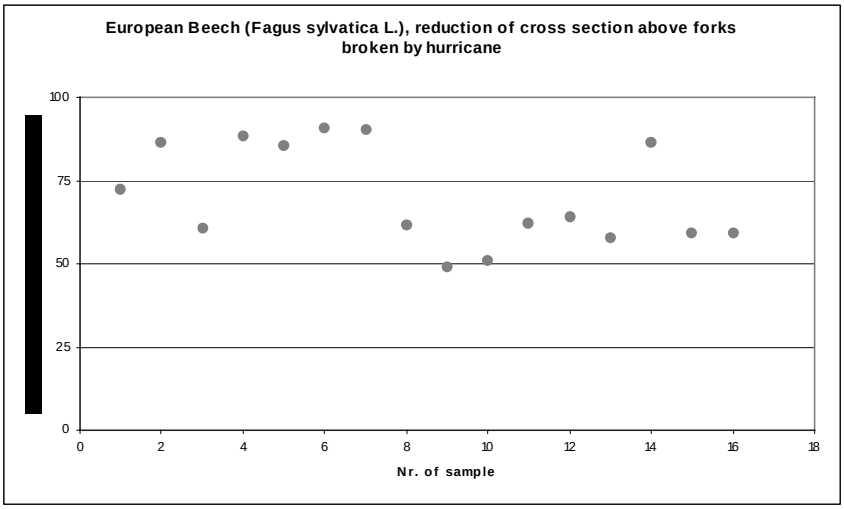
Anatomy of axillary wood

We made cross sections of axilllary and of normal wood. Cell walls were measured. The dimensions of normal cell walls were compared with the cell walls of axillary wood.

Mechanical failure

In a field study we took photos of branch junctions broken by a hurricane. On the photos diameters relative to the distance between fracture point and axilla were measured (Table 6).

**Tab. 6** European Beech: Limbs broken by a hurricane near a fork. Remarkable reduction in cross section at a fork (> 50%) makes the structure break at a peripheral point.




Several years old and well branched reiterates of Filbert were set in a vise and bent until the axis was broken. Bending force was applied into a right angle. Fractures near a junction were brought in relation to diameter and distance to the fixing point.

For a first approach models of similar length but different taper were shaped from foam rubber. To show the affect of branching one model was shaped as a branched beam. All models were bent under identical force.

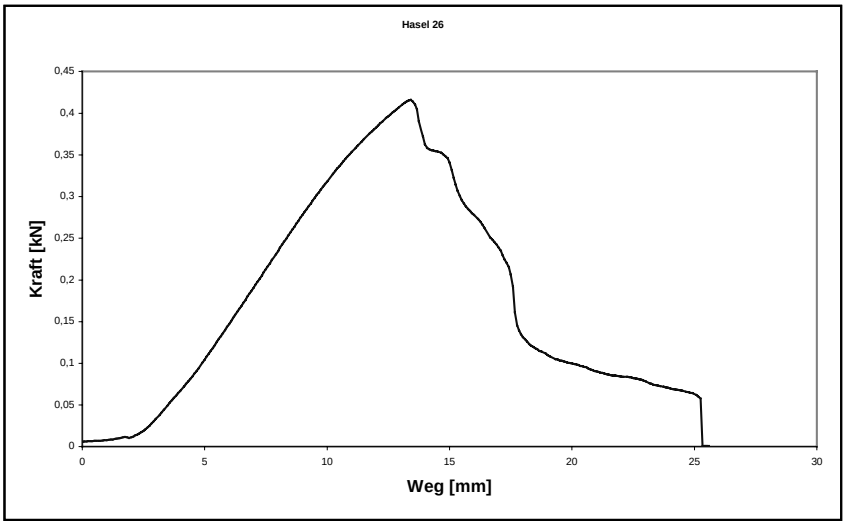
## Results:

Bending forces

Under bending stress forks of European Filbert appeared about 20 % weaker compared to normal wood. The angle of the fork had no influence on a fork's strength. Maximum stress was similar in all forks tested (Table 3).

Reverse to the maximum stress the behavior of failure appeared strictly correlated to a fork's angle. Broad forks failed with a sharp and sudden break, our graphs showed sharp peaks. In contradiction to this narrow forks with embedded bark opened gradually with no peak at the graph (Table 7).

**Tab. 7** European filbert, fork with a wide angle (α = 70°), graph of tension test with (INSTRON 4466). The fork breaks suddenly because of a short cone of axillary wood.




Narrow forks with no embedded bark opened slowly as well, at the graphs a tiny peak used to be expressed (Table 8).

**Tab. 8** European filbert, narrow fork (α = 28,5°) with embedded bark. Graph of tension test with (INSTRON 4466). The fork opens gradually because of a long cone of axillary wood.

Bending behavior relative to a beam's taper

We found a strict correlation between taper and point of maximum stress. The better the taper the more terminal the region for the heaviest stress is to be found. Sufficient taper existed in well branched beams only. In unbranched beams the point of maximum bending stress used to be at its base.

Morphology

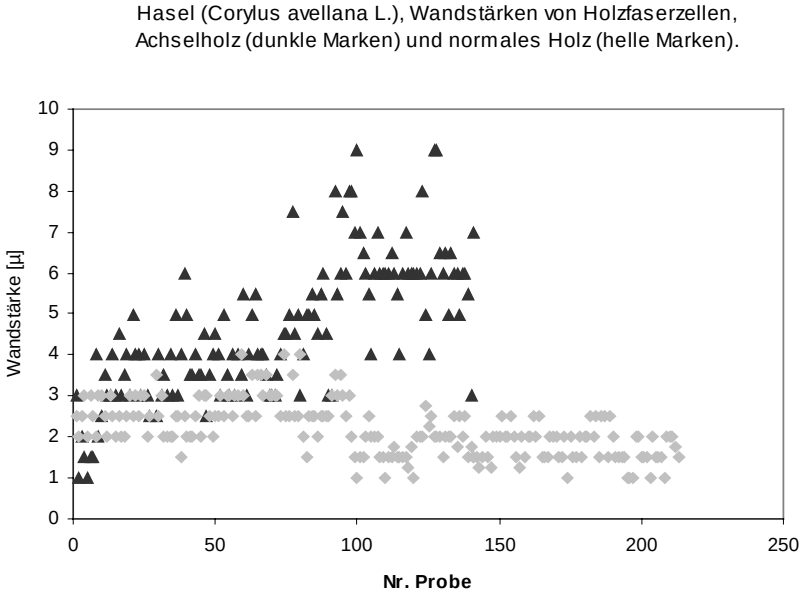
On branch junctions we found a strict correlation between the cross section below and above a fork. The sum of the 2 cross sections above a fork appeared to be equal to the cross section below. All tested tree varieties had similar results [$A_0 = A_0' + A_1$]. The correlation illustrates that within a fork the cross section of a beam will be reduced according to the dimension of the side branch. The better a beam is branched the better is its taper.

The form of axillary wood appeared to be well correlated to a fork's angle. In broad forks axillary wood represented as a broad and short cone. The narrower a fork is the smaller and longer is the cone of axillary wood. This is why a broad fork breaks suddenly and a narrow fork usually opens slowly.

Anatomy

In axillary wood the average diameter of cell walls was 100% larger than in normal wood cells. As a maximum we found 300% larger cell walls in axillary wood in comparison to the average of normal wood cells (Table 9). The reinforced cell walls compensate the higher strain applied on a beam at a junction. Similar results were found on different tree varieties (e.g. Beech, Common Maple, Lime Tree).

**Tab. 9** European Filbert, cell walls of wood cells. Diameters of the cell walls of axillary wood (dark colored marks) are up to three times larger as the cell walls of normal wood (light colored marks).



Mechanical failure

Beams in tree crowns broken by a hurricane used to fail in a short distance distal from a fork. Branched Filbert reiterates when broken by hand did the same. Unbranched reiterates failed at their base. Narrow forks of codominant stems with embedded bark used to fail under strong wind. We found such forks split, but not broken by heavy snow loads. Thick layers of new wood at their corners enabled that the split forks kept standing for at least several years – without any cabling.

## Discussion

Forks even when narrow and with embedded bark are not that weak as expected by experts (e.g. Mattheck & Breloer 1994, Pessler 1999, Shigo 1990, Siewniak & Kusche 1994, Wessolly & Erb 1998). The reinforcement by axillary wood is normally withstanding sufficiently to usual forces. For that case we are pleased to confirm the Model of Constant Stress (Mattheck 1992). A distinct difference is to be observed between static and dynamic loads (Spatz 2003). The point of maximum bending stress, where a beam under lateral force usually breaks, is depending on its taper. Only well tapered axes will break near their tip. Unbranched axes fail at their base. Not tapered columns do the same. Sufficient tapering depends on the amount and size of side branches.

## Conclusion

Urban trees growing in a place exposed to wind, should have well branched crowns and a well tapered trunk. A dense canopy lets inner branches die from a lack of irradiation. So the main branches underneath a dense canopy will become less tapered – and may break at their base destroying the trunk. Trees with open crowns (e.g. Birch, Beech, Lime Tree) should be preferred. Trees in open stands usually have less dense canopies than trees of the same variety when they grow close together. This is why new plantings should be undertaken in a less expensive way, i.e. with more distance between neighboring trees. Adult trees which risk to develop dense canopies should be pruned in time. In open crowns inner branches will be able to survive and help the main limbs to keep well tapered. In order to keep a trunk well tapered the crown should not be lifted too early after transplanting a tree at a street side. Small crowns do not allow the cambium to produce new wood along the whole stem. This is why after a crown lifting only the upper part of the trunk may increase in diameter. Then the trunk will get a column's shape (Metzger 1893).

## Acknowledgments

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## Literature

1 MATTHECK, C., 1992. Design in der Natur. Freiburg (Rombach), 242 S.

2 MATTHECK, C., Breloer H., 1994. Schadenskunde von Baeumen. Freiburg (Rombach), 349 S.

3 METZGER, K., 1893. Der Wind als massgebender Faktor fuer das Wachstum der Baeume. In: Weise W. (Hrsg.): Muendener forstliche Hefte, 3; 3 - 86.

4 PESSLER, K., 1999. Statische Sicherung und Stabilisierung, In: Malek J.v., Molitor, W., Pessler, K., Wawrik, H: Der Baumpfleger; Stuttgart (Ulmer), 417-438.

5 PFISTERER, J.A., SPATZ, H.-CHR., ERFORTH, D., HEINZ, M., 2003. Untersuchungen zur Biegebruchfestigkeit von Astgabeln und Reiteraten der Hasel (Corylus avellana L.), In: Dujesiefken, D., Kockerbeck, P. (Hrsg.), Jahrbuch der Baumpflege 2003; Braunschweig (Thalacker), 255 – 268.

6 SCHROEDER, K., 1998. Kronensicherung mit dem, Doppelgurtsystem Osnabrueck' – Entwicklungen und Erfahrungen seit 1990. In: Dujesiefken D., Kockerbeck P. (Hrsg.), Jahrbuch der Baumpflege 1998; Braunschweig (Thalacker), 170 – 183.

7 SCHUETT, P., WEISGERBER, H., SCHUCK, H.-J., LANG, U.M., ROLOFF, A., 1995. Enzyklopaedie der Holzgewaechse. Landsberg / Lech (ecomed), since.

8 SHIGO, A.L., 1990. Die neue Baumbiologie. Braunschweig (Thalacker), 789 S.

9 SIEWNIAK, M., KUSCHE, D., 1994. Baumpflege heute (3rd ed.). Berlin (Patzer), 268 S.

10 SPATZ, H.-CHR., 2003. Kronensicherung & Auffangsicherung Stadt & Gruen, Jun. 2003, 43-45

11 WESSOLLY L., ERB, M., 1998. Handbuch der Baumstatik & Baumkontrolle. Berlin (Patzer), 270 S.

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# Induction of antimicrobial compounds and Pathogenesis-Related proteins in *Alternaria solani* elicitor treated suspension cells and leaves of tomato

The early molecular events involved in the expression of defense responses in tomato against early blight (*A.solani*) were studied using tomato leaves and suspension –cultured cells. Elicitor was isolated from mycelial walls of *A.solani* and characterized as glycoprotein. The elicitor molecule induced early and had marked generation of super oxide anion and hydrogen peroxide, lipid peroxidation, lipoxygenase immediately after treatment. Two isoforms of superoxidedismutase was found in elicitor treated suspension cultured cells and leaves. Coordinated induction of phenylpropanoid metabolites *viz.*, phenylalanine ammonia lyase, polyphenoloxidase, peroxidase and phenols were also induced in a similar way. Induction of six isoforms of peroxidase and seven isoforms of polyphenoloxidase were found in elicitor treated suspension cells and leaves of tomato. Induction of Pathogenesis –Related proteins *viz.*, 35kDa chitinase and 23kDa Thaumatin-like protein were detected in elicitor treated suspension cultured cells and leaves. It was observed that induction of phenylpropanoid compounds lead to low disease incidence in tomato.

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# Distribution and characterisation of cherry leaf roll virus in woody host plants in urban areas of Germany

Cherry leaf roll virus (CLRV) has a wide natural host range including a variety of herbaceous and woody plants. It is widely distributed throughout Europe, North America and New-Zealand. CLRV is a member of the genus nepovirus and has a bipartite single-stranded positive-sense RNA genome encapsidated in isometric particles. The virus is naturally transmitted by grafting and through seeds and pollen. The symptom expression and the damage varied between host plants.

Especially in urban and periurban areas a high infection rate with CLRV was observed. In this study biological, serological and molecular properties of CLRV isolates obtained from different hosts in urban and rural areas in Germany have been compared applying host range studies, serological assays and phylogenetic analysis based on a portion of the viral genome composition.CLRV isolates were obtained from common birch (*Betula pendula* Roth.), black elderberry (*Sambucus nigra* L.), european beech (*Fagus sylvatica* L.), hornbeam (*Carpinus betulus* L.), european ash (*Fraxinus excelsior* L.), mountain ash (*Sorbus aucuparia* L.), groundelder (*Aegopodium podagraria* L.) and rhubarb (*Rheum rhaponticum* L:). Other isolates included in this study were originally recovered from walnut (*Juglans regia* L.) in Hungary (kindly provided by plant protection agency in Velence) and from cherry (*Prunus avium* L.), european ash and walnut in Germany (kindly provided by A. Hamacher, Bonn).

Cherry leaf roll virus (CLRV) isolated from various woody plants (*Betula*, *Sambucus*, *Fagus*, *Prunus*, *Juglans*, *Fraxinus)* from 14 different geographical regions in Germany showed similar symptom expression on indicator plants, except for one isolate obtained from walnut in Hungary. Part of the 3'-terminal non-coding virus genome (approximately 416 bp) was amplified from 31 CLRV isolates by Immuno-capture-RT-PCR using primer pairs designed from the consensus sequence of five German CLRV isolates from birch [1]. Sizes of PCR products varied slightly. Sequence analysis and comparison of a 280 bp stretch within these amplified fragments revealed sequence divergences between CLRV isolates ranging from 0% to 17%. Phylogenetic analysis revealed four distinct groups with a high degree of identity between isolates originating from particular host species. Most CLRV isolates clustered according to their natural host species and geographic origin in agreement with serological relationships reported for other isolates recovered from these hosts. Sequence identities and divergences observed may reflect the emergence of stable in different natural host plant variants or strains from a common viral ancestor sequence possibly due to the evolutionary selection of viral genomic nucleotide compositions adapted to persist in particular host species.

## Literature

1 WERNER, R., MÜHLBACH, H.-P., BÜTTNER, C., 1997a. Nachweis von cherry leaf roll nepovirus (CLRV) und poplar mosaic virus (PopMV) durch Immunocapture RT-PCR. Phytomedizin. 27, 14-15

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# Distribution of plum pox potyvirus in plum orchards in the Berlin area

Plum pox potyvirus (PPV) is the causal agent of the devastating sharka disease of stone fruits. In Europe, plum pox has become one of the most damaging diseases of *Prunus* species. In Germany the disease was detected for the first time in 1955. Nowadays plum pox virus occurs in all major plum-growing areas of Germany. Four strains of PPV (C, D, EA, M) exist worldwide exhibiting different degrees of aggressiveness. The D strain is considered to be the non epidemic form of PPV and is reported to be the most prevalent strain in central and western Europe.

In recent years farmers of plum orchards in the periurban area of Berlin have repeatedly observed chlorotic ringspots and chlorotic mottling on the leaves of plum trees and general insecureness about the cause were present. Therefore leaves were sampled from symptomatic and asymptomatic plum trees in four orchards in autumn 2000 and tested by bioassay, electron microsccopy, serological and molecular assays for PPV infection. Some samples were also analyzed by restriction fragment length polymorphism (RFLP) analysis of reverse transcription-polymerase chain reaction (RT-PCR) amplified DNA fragments. RFLP profiles of amplified fragments of the C-terminal part of the PPV coat protein have been shown to be useful for differentiation of PPV isolates and polymorphism is correlated with serogrouping of PPV strains according to WETZEL *et al*. [1].PPV was detected in 52% of all tested symptomatic leave samples (13 of 25) and 62% of all tested plum cultivars (10 of 16) by DAS-ELISA. The proportion of PPV infected samples and cultivars in different orchards was heterogeneous (15%-100%). The symptom expression of samples tested positive for PPV in DAS-ELISA varied strongly between cultivars. Sharka disease of plums is widely distributed in orchards tested in the Berlin area.

Electron microscopic analysis of symptomatic leaves revealed flexible, rod-shaped particles of approximately 700-800 nm typical for plum pox virus (PPV). No other viral-like particles were observed.

Two samples from different orchards in the west and north-eastern part of Berlin were analysed by RT-PCR and RFLP analysis using restriction enzyme *Rsa I*. This enzyme was previously described to be useful for strain differentiation [1]. The D strain of PPV considered to be the non epidemic form of PPV was detected in the samples analysed. The M strain which is more aggressive is considered to be the epidemic form of PPV was not detected. However, for accurate evaluation of the occurrence of different strains of PPV it is necessary to investigate a larger number of isolates obtained from plum orchards from the Berlin area.

## Literature

1 WETZEL, T., CANDRESSE, T., RAVELONANDRO, M., DUNEZ, J., 1991. A polymerase chain reaction assay adapted to plum pox virus detection. Journal of Virological methods. 33, 355-365.

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# Experiences with thermal and chemical weed control methods (WEEDCLEANER, WAIPUNA, ROTOFIX) on paved areas under practical conditions

In 2002 the Local Military Administration Münster (Standortverwaltung), the State Environmental Department Münster (Staatliches Umweltamt Münster) and the Plant Protection Service of the Chamber of Agriculture Westfalen-Lippe (Pflanzenschutzdienst der Landwirtschaftskammer) conducted extensive field trials to control vegetation on paved areas, especially on natural stone, bricks and cobble-stones.

After 15 years of exclusive mechanical weed control and its resulting problems, new possibilities and concepts of vegetation control on partly very sensitive surfaces were needed.

On the grounds of the Sportschule der Bundeswehr in Warendorf various units were examined on areas from 5000 to 6000 $m^2$. The following systems were utilized: the hot steam system of the WEEDCLEANER, the organic hot foam weedcontrol system of WAIPUNA and the wiping concept ROTOFIX, a new technique for the application of Glyphosate. Additional data in other areas (e.g. sport fields, fences) were collected.

Both thermal systems showed a considerably good effect against moss and algae (positive optical impression), the repression of the unwanted plants with a strong root system was, even after a third treatment, not satisfactory.

The weed wiper proved to be very successful on taller weeds, the smaller weeds (especially moss and algae) however could not be treated because of the mechanically limited minimum height of the roller.

After the first treatment a combination of the thermal and chemical systems were tested. The perfect combination turned out to be a thermal treatment followed by the weed wiper ROTOFIX 4 to 8 weeks later. Algae, moss and highly infested weed areas could be controlled effectively with this combination. The combination of the two systems proved to be economic, as well. This concludes, that there is a new solution for the control of vegetation on paved areas.

On account of the targeted application method of Glyphosate on established weeds and the reduced application rate, residues of the herbicide could not be found in considerable amounts in run-off-water after treatment with Rotofix. This was also confirmed by the States Environmental Department Muenster. With the first and second rain after the treatment, water samples were taken out of the sewerage and drainage system. The highest amount detected in the sewerage system beneath the treated area was 0,21 microgram of Glyphosate/liter and 0,08 microgram AMPA/liter. Regarding to the dilution, the probability of herbicide residues to be found in the surface water after ROTOFIX treatment is very low.

The trials will be continued this year. Therefore the combination of the different systems will be trialed on larger areas. In addition, water examination and cost calculations will be conducted.

The results of the trials and photos from the areas can be found on the following internet site: www.landwirtschaftskammer.com/rlp/pflsch/index.htm.

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# Retrospective identification and evaluation of mortal stand factors of trees by using tree ring and time series analysis

## Introduction

The radial growth of tree stems is influenced by many different factors. Air pollution has been shown to be important for the development of trees [1,2]. However, health of street trees seems to be mainly determined by soil conditions and other human impacts (traffic and construction work). If trees are injured or even mortally damaged, the questions of responsibility arises automatically – not only to find some one to charge the costs of replacement, but furthermore to be able to prevent repetition.

In the years after 1993 several thousand street trees in a German city showed severe damages in their crowns. After a few months many of the trees were found to be dead. The responsible authorities identified gas from underground pipes as the mortal factor: along several tree lines measurements showed unnaturally high concentrations of methane in the air.

The gas providing company looked for a method to check, which trees had really been killed by gas and ordered a corresponding expert report from us.

## Materials and methods

Two 5 mm increment cores were taken at breast height from more than 100 dead trees. The cores were fixed in wooden carriers and sanded in different stages (80-240-600) to be analysed under the microscope. Tree ring widths were measured by use of the LINTAB stage in resolution of 1/100 mm and recorded as time series by the TSAP computer program [3]. In some cases it was necessary to use special sanding equipment (up to grain 6.000) to be able to identify the tree ring borders, especially in some diffuse porous trees such as lime (Tilia) and maple (Acer).

The tree ring width time series (r(i)=growth rate curves) then mathematically treated and analysed. Increment area series a(i), derived from growth curves and then transformed into index series. Increment area curves are more suitable for such a study, because they emphasize variations of the older tree and suppresses juvenile variations.

The neighbour index values n(i) emphasize strong variations from year to year: $n(i)=(a(i)-a(i-1))^2/100$. Standard-deviation index curves s(i)=(a(i)-mean(a))/stdv(a) pronounce deviation of individual rings from the mean curve value. In addition, 11-point moving averages are calculated to visualize the mean trend of the growth rate.

All four curves are then plotted in a superposition graph (top-bottom): neighbour index, original growth rate curve with superposed 11-point moving average and standard deviation index at the bottom (Fig. 1). The four curves visualize four different properties of the increment series.

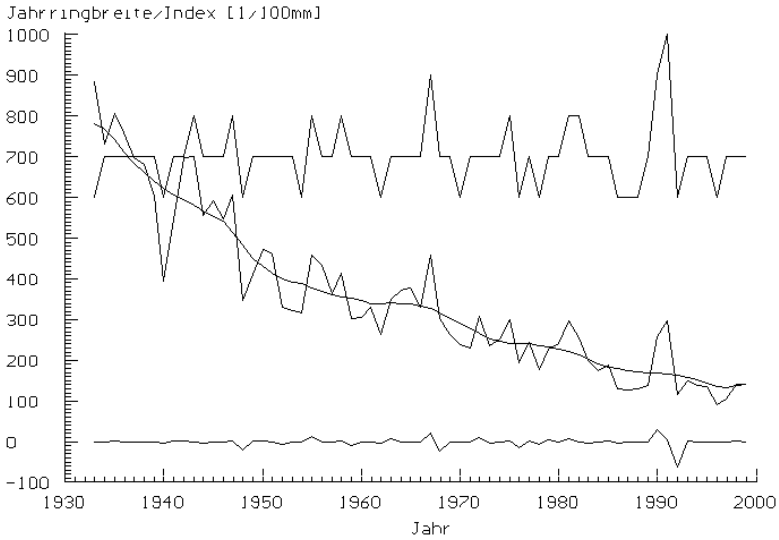


**Fig. 1** Four curves characterizing different properties of the radial growth development of a tree (x.axis= year, y-axis=ring width in 1/100 mm). The neighbour index (top) emphasize strong year-to-year variations. The original ring width curve is superposed by a 11-point moving average, showing the mean trend. The standard-deviation index (bottom) pronounces strong variations of values from the mean curve trend.

After this procedure was done for all trees, typical trends and behaviours have been found. The complete analysis required several complex mathematical and graphical steps of operations. It would need many pages to explain this procedure in detail. Some characteristic aspects of the results will be explained subsequently with the help of three typical examples.

## Results

Example graphs show typically different cases of growth behaviour found in this study.

The curves of tree no. 06 characterize a different and unbelievable development (Fig. 2): although never really having recovered this tree survived a very severe impact in the year 1900 for nearly 100 years (and died 1999). There is no clear proof that this death was caused by a gas impact in 1992 or 1993.

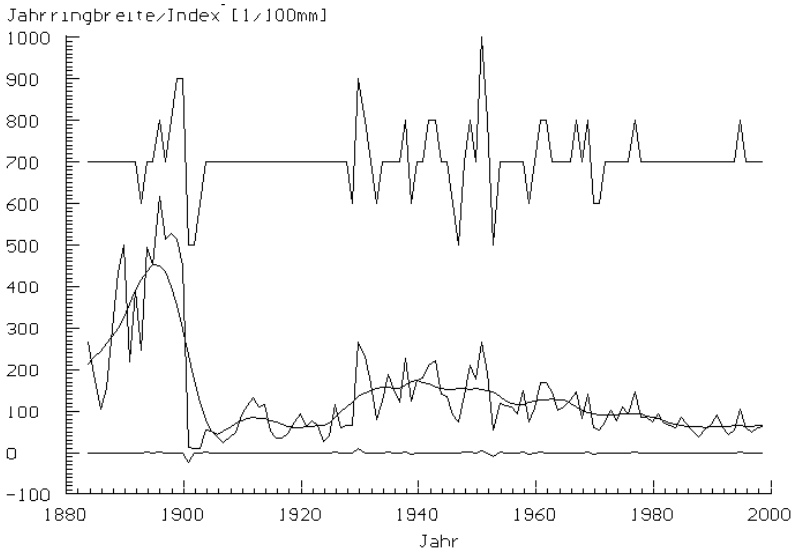


**Fig. 2** The curves of tree no. 6 do not show clear depressions from a gas impact in 1992 or 93 but a severe impact in 1900.

The series of tree no. 35 clearly show a negative impact in 1992 (Fig. 3). Index and trend curves visualize that the tree has not been able to recover from this event. Further studies verified that the gas pipe under this tree was defect in this year.

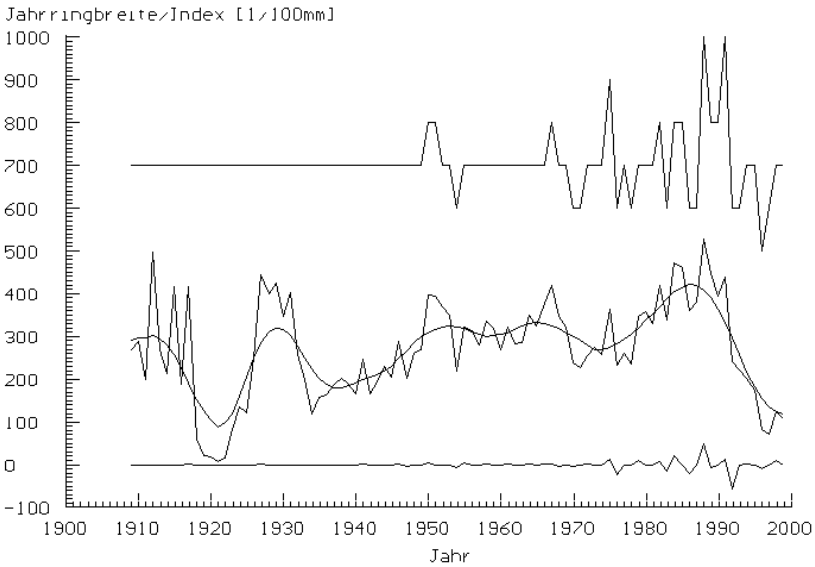


**Fig. 3** Tree no. 35 was damaged in winter 1991 or 1992. The growth rate shows a continuous negative trend until death in 1999.

Tree no. 18 (Fig. 4) recovered from the dry summer 1976 and partially from three subsequent tough years in (1981-83). Since 1989 the growth trend is constantly negative. Consequently this tree was not only killed by a potential gas in 1992/3 but by other previous stand factors.

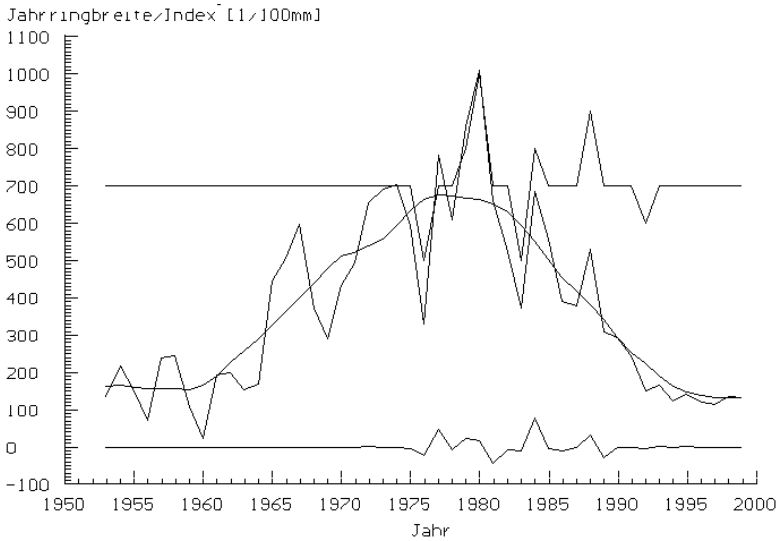


**Fig. 4** Tree no. 18 shows untypical growth rate development. The curves indicate several strong impacts, especially 1976, 1981-83, 1986-87 and 1989.

Further analysis showed that soil works for new telephone and power lines as well as water pipes have been one reason for mortal development of many trees – because the root system was destroyed in large parts. And these damages often occurred some years before the gas could harm the trees.

This way the tree ring curve analysis helped looking for other reasons of damage by showing in which years the impacts took place.

## Summary

Detailed analysis of the tree ring width time series of more than 100 trees showed that approximately 35% have been (most probably) killed by gas. The other trees died because of several different other reasons which could be identified in several cases due to signs in the index curves.

## Literature

1 ECKSTEIN, D., 1989. Dendroökologie - Arbeitsweise mit Beispielen aus der Waldschadensforschung. In: Guttenberger, H., Bermadinger, E. und D. Grill: Reaktionen von Pflanzen auf Streß. Universität Graz, Institut für Pflanzenphysiologie, 1989, S. 63-73.

2 SCHWEINGRUBER, F.H., 1986. Tree Rings. Basics and Applications of Dendrochonology. Reidel Publ. Comp., Dordercht.

3 RINN, F., 1990. LINTAB & TSAP tree ring analysis station. Measurement and mathematical analysis. Heidelberg, 1992.

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## Problems of organization system protected natural places in urban conditions

The natural territory are places for rest townspeople and realize functions of microclumate and protection. The urban vegetation is capable to absorb considerable proportion air polution and renew oxygen. At the same tame, to perform urban hygienics, plants themselves subjected to negativ impact urbanization processes. In the certain moment depression and death can be the result of it. According to the data of biologists, landscape architects, ecologists most optimal realize recriation and hygienical functions verdure massive can be in case protection and reservation in those structure natural places. The most interest in this conection present itself vallies of rivers, ravines, marshs and ather tract of low wet land, are situated within open spaces of city.These types of biogeocenoses are source biological and landscape divercity. These elements of natural complex will be present particular environmental value for city and it need to secure pricipal conditions those vital activity. The preliminary recognitions to bear witness that urban wet land until today can be place of settle down water berds, here meets rare species plants.

Unfortynately, absence needed regulations for conservation safe boundary natural places, regime of using deliver to gradual destruction it. Often we have so negativ tendency, as housing bulding, parking construction on the natural territory. Necessary to carry out extensional researches in order to discover possibility organization of sistem natural places and single particular value plots out within sistem as protection objects.

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# Total and Plant Available Contents of Nutrient and Noxious Elements in Urban Soils and their Transfer Rates to Plants

Total contents of heavy metals in soil are determined to estimate their potential risk to man, animal and the natural environment. If limit values are exceeded, available portions of noxious elements are evaluated with a view to the objects to be actually protected, because total contents alone do not allow conclusions on the actual load to be expected [1].

A colony of hobby gardens in Berlin's district Charlottenburg was established in a rather contaminated area some 80 years ago. About 15 years ago, the soil of that site was found to contain high levels of noxious elements (heavy metals) which would prompt to impose use restrictions. In the studied plots, the elements Hg, Cd, Co, Cu, Pb, Sn and Zn were present at clearly higher levels than precautionary limits set by soil protection law and higher than usual in urban centres and conurbations [3, 4].

Total contents measured and bio-available contents of noxious elements and nutrients were evaluated on the basis of physical and chemical soil parameters and present cropping pattern, using test and trigger values prescribed by the Federal Regulation on Soil Protection and Contaminant Loads (BBodSchV) with regard to the domestic garden category. The tested limit value of 1 mg Cu/kg dry mass in $NH_4NO_3$ extract – the amount which is assumed to lead to growth impairment in field and domestic garden crops when it is transferred from soil to plant – is exceeded. Yet, the pattern of uptake and distribution of heavy metals in permanent crops such as fruit shrubs and trees allows to exclude a risk to consumers with these crops.

The entry of noxious elements in the food chain via soil-plant transfer depends on soil parameters, noxious elements‘ total contents in soil and their actual availability to plants. Heavy metals have also different capacities of penetrating plant tissue into the roots. As to the very problematic elements Cd, Cu, Pb and Zn, one can roughly say that Cd and the nutrient elements Cu and Zn are taken up more easily than Pb [2].

Vegetables are accumulating heavy metals to different degrees. Careful choice of crops (such as root crops) in burdened soils will still keep the level of noxious elements in commodities low, so that limit values for noxious elements in foods will not be exceeded although precautionary limits for noxious elements in soil actually are. Plant damage by noxious elements such as heavy metals in soil can be minimised or avoided through choice of suitable crops and influencing chemical and physical soil parameters(such as by adding lime or clay minerals).

With strong loads of noxious elements in soil, the character of domestic gardens may be retained by cropping restrictions and rehabilitation measures which must be agreed with competent authorities.

## Literature

1 SOLBACH, C., BALLIN, U., KLEIN, H., 2002. Neue EU-weite Höchstgehalte für Blei und Cadmium in Lebensmitteln, Z. Umweltchem. Ökotox. 14, 73-75.

2 STRUMPF, T., TRAULSEN, B.-D., PESTEMER, W., BODE, E., 2002. Verfügbarkeit von Kupfer in landwirtschaftlich genutzten Böden mit hohen Kupfer–Gehalten. II. Auswirkungen von Kupfereinträgen. Nachrichtenblatt des Deutschen Pflanzenschutzdienstes (Braunschweig) 54 (9), 226-232.

3 TRAULSEN, B.-D., SCHÖNHARD, G., PESTEMER, W., 1997. Erfassung, Beurteilung und Sanierung schadstoffbelasteter Böden in Ballungsräumen. In: Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft, no. 328, p. 193-198, Berlin 1997.

[4] TRAULSEN, B.-D., STRUMPF, T., SCHÖNHARD, G., 1998. Effects of soil additives on cadmium uptake of agricultural crops, Nachrichtenblatt Dt. Pflanzenschutzdienst 50(10), 263-267.

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## *Phomopsis*-blight on Japanese false cypress in Norway

Japanese false cypress (*Chamaecyparis pisifera*) is commonly used as an ornamental crop (production of cut foliage for decorations) in Norway. Occasionally *C. pisifera* is used in parks and private gardens. The dominant cultivar is Squarrosa, which is an evergreen shrub with soft, featherlike, silver blue foliage composed of tight, fluffy clusters of short needles. The dense foliage creates an ideal microclimate for fungal infection and growth. During a survey in 2000, the fungus *Phomopsis* sp. was isolated from needles and bark of severely damaged plants of *C. pisifera* cv. Squarrosa from several locations along the southern coast of Norway. In some fields, the entire crop was attacked by *Phomopsis* sp. The new growth on infected foliage changes colour to pale green before it turns yellow, brown and finally ash grey as it dies. Thin branches are often girdled and die, while thicker branches develop wounds and cracks in the bark. The fungus produces two spore types (α- and ß-spores) on incubated plant material and in culture. Growth in culture and spore size and shape matched the morphological characters of *Phomopsis juniperovora*. By inoculation-tests (small pieces of agar with *Phomopsis*-growth placed on needles and thin branches) the same symptoms as seen in the fields were obtained (fulfilment of Koch's postulate). Symptoms of *Phomopsis*-blight are also often observed on *C. pisifera* cv. Filifera, but due to less dense growth, the damage is not as severe as on *C. pisifera* cv. Squarrosa. Furthermore the fungus has frequently been detected on *C. lawsoniana*, *Thujopsis dolabrata* and species of *Juniperus*, *Taxus*, *Abies* and *Picea*, both in nurseries and field plantings.

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# An improved semi-selective medium for the isolation of *Apiognomonia veneta* from diseased plane trees.

## Abstract

The isolation of the pathogenic fungal species *Apiognomonia veneta*, causal agent of the disease called "anthracnose of plane trees", from necrotic leaves, shoots, buds and wood implies the isolation of many other saprophytic fungi and bacteria that interfere in the process. In fact, this situation implies additional laboratory work to purify the main fungal isolates. Due to the antifungal feature of some antibiotic substances, an in vitro assay was performed in order to obtain a semi-selective culture medium for the isolation of *Apiognomonia veneta*. The media tested were based on PDA (potato dextrose agar) amended with two antibiotics: PENICILIN G (Sigma) and Streptomycin sulphate. These two antibiotics were tested in five different concentrations (0, 1, 2, 3 and 4 g/l). All the concentrations of Streptomycin sulphate were sufficient to avoid mycelial growth of many saprophytic fungal species but they also suppress the growth of *A. veneta*. The highest concentrations of Penicillin did inhibit the saprophytic fungal growth of several species. The lower concentrations of Penicillin did not affect significantly the miceliar growth of *A. veneta* "in vitro".

All the fungal species used in these assays had been previously isolated in PDA without antibiotics from the different necrotic tissues of diseased plane trees. The comparison between the isolations of culture media with and without antibiotics was made. The PDA medium amended with penicillin at 4g/l seems to be a suitable culture media to isolate *A. veneta* in the first steps of the isolation process, since it allows a moderate growth of the pathogen whilst significantly faster than the growth of other usual contaminants, like *Cylindrocarpon* spp. and *Trichoderma* spp. This advantage persists for at least the first 14 days of the isolation process. However, neither of the media tested was able to suppress the growth of other possible contaminants, like *Aspergillus* spp. or *Cladosporium* spp., reason why this medium cannot be considered as selective but as semi-selective.

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# Perception of plant health in public gardens – with special regards to the historical „Tiergarten“ in Berlin

City parks are important for men and animal. They raise the quality of urban living. The intensive use of parks and the interaction of men, animal and plants cause stress and damage to the environment, especially visible in the plants. Carelessness as well as willingly caused damage by park visitors add to plant stress. With time these effects multiply.

At the example of “Tiergarten” a variety of damage syndromes brought about by a variety of reasons are monitored. Big events such as the „Love Parade” as well as soccer games on the pastures, barbeques, dogs, bikes and litter damage the park. Besides anthropogen damage there are natural causes such as insects too. One visible natural stressor is *Cameraria ohridella* Deschka & Dimic, the horse-chestnut leafminer, feeding on and damaging leaves of the chestnut tree.

In scientific studies investigation of leisure and utilization behaviour of visitors are monitored in a rather generalized way. Previous investigations usually describe mainly activity structures. There are few investigations on perception considering plant health. People observe parks in a more emotional way, based on their own needs.

Polls also show that visitors often only recognize the obvious. Disturbances in a negative way like dogs running wild, faeces, litter, and damaged pastures and flower beds will be noted. Other damages caused by utilisation as well as plant damage are barely observed. Generally spoken visitors are interested in the beauty of plants but they don’t care about the background.

The importance of socioeconomic and sociodemocratic factors to the observation and usage behaviour is investigated as well as the influence of the realization of plant stress, damage and disease in the park onto its recreation and leisure value. The question is if there is any change in the behaviour of visitors dependent on plant health.

Of all visitors two different groups are filtered out and methodically questioned orally and written. The two monitored groups are men/women with children on playgrounds and passing visitors.

Pre-inquiries gave first impressions on the recognition of plant health in the Berlin “Tiergarten” by the two monitored groups. The investigation area of the park is used mainly for outdoor activities, relaxation, natural experience, sports and attendance of cultural activities. There are positive relations between higher education and experience of nature by persons questioned. People with a higher education seem to be more reflective and sensitive in their way of observing plant damage and plant stress.

Diseased plants are just realized by persons with professional competence or botanical knowledge. A high percentage of people questioned state that they wouldn’t feel at ease if the beauty of “Tiergarten” was disturbed or damaged. There is a positive correlation between the dimensions of the damages and the intention of not visiting the park under these circumstances. Anyway, the willingness to preserve the current condition of the “Tiergarten” and to prevent further damages is very poor by all persons questioned.

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# Applications of mycorrhiza inoculum for urban horticulture

The use of vesicular - arbuscular mycorrhizal fungi in the production of crop plants has already been tested and described by many authors. Under normal or tropical conditions (poor soils, extreme temperatures, high humidity or drought, presence of pathogens) the use of vesicular-arbuscular mycorrhizal fungi can be especially beneficial to perennial crops. These fungi not only give improved growth of different crops, but also show the potential to increase resistance of the host to root pathogens and to reduce the severity of foliar disease. Most crops are propagated from seeds or cuttings in nurseries before they are transferred to the plantations. These crops are normally hosts for vesicular-arbuscular mycorrhizal fungi. In Colombia, Brazil and other countries vesicular-arbuscular mycorrhizal fungi are already in some cases an important factor in commercial cultivation systems, diminishing the cost of plant production not only because the plants can be produced using smaller amounts of fertilizers, but also because there are fewer losses during production. In general mycorrhizal plants are of better quality than non-mycorrhizal ones. They are more resistant to many stress factors when they are transferred to the planting sites. With foamclay as the carrier for propagules of vesicular-arbuscular mycorrhizal fungi it is possible to produce an inoculum of high quality on a large scale. High quality means first that the inoculum causes a rapid colonization of the plant root system by the vesicular-arbuscular mycorrhizal fungi. This is guaranteed by an inoculum of high infectivity.

## Experimental area B 6 n, PFA III, bridge building 22

The planting of bushes and trees at the sides of the bridge building 22 was carried out in December 2000. The deposited soil was already overgrown with grass. The soil material was unfavourable for growing the plants (many stones, little humus). Furthermore the steep slope situation and the wind exposed location represent an extreme planting site. The influence of the mycorrhiza inoculation of the plant development was examined under these extremet site conditions. The growing rate altogether were unsatisfactory because of these unfavourable conditions.

But the application of mycorrhiza inoculum showed a significantly improved growing rate of the plants at the various locations than the plants at the corresponding locations without mycorrhiza inoculum (fertilized only).

The increase in the growing rates of the mycorrhiza treated locations in comparison to non-mycorrhized locations (E,F,L,M) are in average:

| | | |
|---|---|---|
| Mycorrhiza experimental areas | A, B, G, H | 17% |
| Mycorrhiza and fertilizer areas | C, D, J, K | 19% |

If one compares the particular locations at the slope the increased growing rate of the mycorrhized experimental areas in comparison to the non-mycorrhized ones are

| | | |
|---|---|---|
| **rounded hilltop** ( G, H compared with E,F) | on average | **24%** |
| **slope foot** | (A,B compared with L,M) | **10%** |

## Mycorrhiza-Infection

Selected plants at random of the MYKOPLANT®BT treated locations have been investigated on the degree of root infection by mycorrhiza. For the time of experiment a weak to medium infection was found in the contact area of the roots with the inoculum corresponding to a 30 % infection of the root mass.

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# Training materials for pak-choi IPM in the Philippines: an approach to guide pest management practices

In July 1998 the Asian Vegetable Research and Development Center in collaboration with its partners began a program of adaptive research and extension on leafy vegetables in the Philippines. A major objective of the partnership was to design, test, and validate production documents for leafy vegetables that, when used judiciously, would enable farmers to market year-round in urban areas, vegetables free of pesticide residue.

Pest management practices currently used by farmers in Central Luzon often lead to unacceptable levels of pesticide residue on leafy vegetables at harvest. To improve the safety of vegetables to consumers we developed and introduced a series of training documents for vegetable farmers growing pak-choi under Philippine lowland conditions. Information in the training documents was distilled from farmers who participated in scientific experiments on an IPM guidance system. All materials were translated into Tagalog, the dominant, local language in Central Luzon, Philippines.

Today, most vegetable farmers believe that insects are important constraints to high yield and therefore, that insecticides are necessary production inputs. We believe it is easier to modify the standard practice of pesticide use rather than persuade farmers to change their management practices completely. Also, pesticides are relatively inexpensive and therefore offer to poor farmers a cheap way to control pests. Farmers are aware that insects reduce quality and yield, but often do not identify the insect pest nor are they able to distinguish insect damage from symptoms/signs caused by environmental stress and plant pathogens. To assist farmers in the correct identification we created a poster and a pictorial guide with information on major insect pests and diseases. Additionally, we developed info-sheets containing information on pest morphology, monitoring procedures, and management recommendations. These were designed for farmer- teachers to give them in-depth knowledge of pests on pak-choi. To provide greater access to information on pests of pak-choi and other crops we launched in late 2000 a webpage (http://www.entomology.de). Access to and downloading of the info-sheets developed as pdf-documents can be done from this web page.

Identification of pests and diseases and the determination of intensities are important steps in IPM. However, the application of pesticides only when economic action thresholds (ETL) are exceeded, is also fundamental. Therefore, we wanted to provide farmers, with procedures to monitor pest populations and to make sound pest-management decisions based on ETLs. For this purpose we designed an action booklet to guide farmers in using appropriate pesticides if pest intensities exceed given ETL's. The ETL's we established were not based on experimental data, but on field observations and experience. To prevent losing the trust of farmer-cooperators, the threshold levels were very conservative. Action thresholds are pest-specific and increase with crop maturity.

In 2000 we trained a total of 218 farmers and technicians in four provinces. On three farms the effectiveness of the documents developed was tested and compared to standard farmer practices. Through the use of the IPM materials the mean number of pesticide application was reduced from 12.7 to 6.4 times per crop. The amount of active insecticide ingredient applied was reduced by 58 % in researcher fields compared with farmer fields. In contrast to the standard farmer practice, we applied 54 % more fungicide, but as a result, yield was 17 % higher in researcher managed fields than in fields managed by farmers. In spite of our best efforts, however, yields were generally low. We understand that synthetic insecticides, even with good monitoring practices and sound application methods do not always prevent crop loss because some insect pests cannot be controlled by insecticides available. Nevertheless, in contrast to farmer-standard practice, our system reduced the quantity of insecticides applied without

putting the crop at risk. The acceptance of training materials by farmers and their long term effect on pesticide use and yield are currently being monitored and materials continuously improved.

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# Horsechestnut leaf blotch and efficacy of foliage fungicides against *Phyllosticta sphaeropsoidea*

The most important foliage disease of Horsechestnut leaves is the leaf blotch caused by fungus *Guignardia aesculi*, anamorph *Phyllosticta sphaeropsoidea*. The striking symptoms of the leaf blotch disease are the brown or reddish-brown lesions which often involve large portions or even the entire leaf. The microconidial anamorph appears in late August. The teleomorph develops on fallen leaves of the host. *Phyllosticta* spores make appressoria and penetrate through the leaf cuticle. They did not penetrate through stomata. This fungal pathogen causes necrotization of leaf tissue, reduces assimilative area of leaf and the host has physiologicaly weakened. It cheapen a decorative characters of this woody plant. The occurrence of this fungal disease in Slovakia was presented in 2001 [1]. In this work we tested the effect of five selected fungicides against the leaf blotch in the *in vitro* and *in situ* conditions.

## Material and methods

We tested the inhibition effect of mancozeb, benomyl, iprodione, fenarimol and dodine on the growth of mycelium of the fungus *Phyllosticta sphaeropsoidea* isolated from horsechestnut leaves in the *in vitro* and *in situ* conditions.

In vitro*:* Fungicides mancozeb, benomyl, iprodione, fenarimol and dodine were added to 2 % malt extract agar (pH 5.5) of different concentrations: mancozeb 0.2 – 0.25 – 0.3 %; benomyl 0.05 – 0.07 – 0.1 %; iprodione 0.2 – 0.3 – 0.4 %; fenarimol 0.03 – 0.05 – 0.07 %; dodine 0.07 – 0.1 – 0.15 %. We inoculated the fungus *Phyllosticta sphaeropsoidea* on this toxic agar plates. The efficacy of tested fungicides was found on the strength of inhibition radial growth of mycelium.

In situ: Solutions of tested fungicides (mancozeb c = 0.2 %, benomyl 0.07 %, iprodione 0.2 %, fenarimol 0.05 %, dodine 0.1 %) were appliqued on the leaf surface of 30 three years old Horsechestnut seedlings. Control seedlings were not sprayed. On the next day we appliqued the conidial suspension of fungus *Phyllosticta sphaeropsoidea* (c = $1.25 \times 10^5$ conidia per ml) on the leaf surface. The efficacy of fungicides against the leaf blotch were evaluated six weeks after its application. The leaf surface damaged by the leaf blotch was measured by planimeter. Then we calculated percentage efficacy of fungicides against leaf blotch.

## Results and discussion

The results of testing of selected fungicides against the leaf blotch disease of Horsechestnut have shown a different sensitivity of studied pathogen to individual fungicide and its concentration. The maximal inhibition effect (100 %) on growth of mycelium of fungus Phyllosticta sphaeropsoidea had mancozeb and fenarimol of each used concentration in the in vitro conditions (table 1). The efficacy of benomyl and dodine increased with directly proportional of concentration. The smallest inhibition effect had iprodione.

The average efficacy of tested fungicides against the leaf blotch in the *in situ* conditions is presented in table 2. The most effective fungicide was fenarimol. It had 95 percentage efficacy. The smallest efficacy (to 5 percentage) had iprodione. The leaves of control seedlings were markedly damaged by the leaf blotch.

Mechanical protective measures against the occurrence of fungal diseases are not enough effective. None fungicides were used against the leaf blotch of Horsechestnut in Slovakia because this fungal infection was not epidemic wide-spread to date. We made a testing of selected fungicides just in case of a massive occurrence of the leaf blotch. We found that fenarimol was the most effective fungicide against the leaf blotch. Benomyl is also effective antifungal substance against horsechestnut leaf blotch and its efficacy is

higher after its application into the soil around the roots of tree [2, 3]. Myclobutanil, triadimenol and tetraconazole are also effective fungicides according to another authors [4]. Authors recognised that dodine and fenarimol had a small effect. Myclobutanil is also effective fungicide against Horsechestnut leaf blotch but mancozeb and bitertanol have a small efficacy [5].

**Tab. 1** The effect of fungicides against the fungus *Phyllosticta sphaeropsoidea* in the *in vitro* conditions on malt extract agar (pH 5.5), T = 25 °C ± 2 °C.

| Fungicide | c (%) | d | $d_{12}$ | $d_{24}$ |
|---|---|---|---|---|
| | 0.2 | 0 | 0 | 0 |
| mancozeb | 0.25 | 0 | 0 | 0 |
| | 0.3 | 0 | 0 | 0 |
| | 0.05 | 0.8 | 16.7 | 19.3 |
| benomyl | 0.07 | 0.7 | 14.3 | 16.9 |
| | 0.1 | 0.5 | 12.0 | 15.8 |
| | 0.2 | 1.1 | 21.1 | 26.2 |
| iprodione | 0.3 | 1.1 | 20.0 | 25.1 |
| | 0.4 | 1.1 | 20.3 | 24.9 |
| | 0.03 | 0 | 0 | 0 |
| fenarimol | 0.05 | 0 | 0 | 0 |
| | 0.07 | 0 | 0 | 0 |
| | 0.07 | 1.0 | 20.7 | 23.1 |
| dodine | 0.1 | 0.8 | 17.7 | 19.6 |
| | 0.15 | 0.7 | 14.0 | 16.2 |
| control | 0 | 1.7 | 23.0 | 39.7 |

d – average daily increase of mycelium in mm; $d_{12, 24}$ – diameter of colony after 12 and 24 days of cultivation in mm; c – concentration of solution in %

**Tab. 2** Average efficacy of tested fungicides against Horsechestnut leaf blotch in the *in situ* conditions.

| Fungicide | Concentration of solution | Average efficacy of fungicide |
|---|---|---|
| mancozeb | 0.2 % | 50 % |
| benomyl | 0.07 % | 75 % |
| iprodione | 0.2 % | 5 % |
| fenarimol | 0.05 % | 95 % |
| dodine | 0.1 % | 20 % |

## Conclusion

We observed the ontogenesis of horsechestnut leaf blotch pathogen. The most effective fungicide against the leaf blotch was fenarimol. The smallest inhibition effect on the growth of mycelium of the fungus *Phyllosticta sphaeropsoidea* had iprodione.

## Literature

1 ZIMMERMANNOVÁ, K., 2001. Fungal disease of Horsechestnut leaves (Aesculus hippocastanum L.) and its occurrence in Slovakia. Folia oecologica 28/1-2, 153-165. (in slovak)

2 NEELY, D., 1975. Treatment of foliar diseases of woody ornamentals with soil injections of benomyl. Plant Disease Reporter 59, 300-303.

3 NEELY, D., 1977. Long-term control of foliar diseases of woody ornamentals with soil injections of benomyl. Plant Disease Reporter 61, 370-372.

4 ANSELMI, N., NICOLOTTI, G., GANGEMI, D., GARIBALDI, A., 1992. Indagini sulla lotta chimica contro Guignardia aesculi (Pk) St. Atti Giornate Fitopatologiche 2, 113-120.

5 PLENK, A., 1996. Die Blattbräune der Rosskastanie- Guignardia aesculi. Biologie und Bekämpfungsmöglichkeiten. Pflanzenschutzberichte 56, 67-72.

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