



**PROGRAM AND ABSTRACTS  
COST863 WG2 + WG3 Joint Meeting**

**Biotic and abiotic stress prevention in integrated  
berry fruit production**

**Sofia – Bulgaria**

**9<sup>th</sup> - 11<sup>th</sup> March 2009**

**Organised by AgroBioInstitute Sofia  
and  
the COST-Action 863**

**“Euroberry Research: from Genomics to Sustainable Production, Quality and  
Health”**

**Organising committee**

**Dr. Violeta Kondakova, National Centre for Agricultura Science, Plant Genetic  
Resources, Sofia, Bulgaria**

**Ms. Päivi Parikka, MTT Agrifood Research, Plant Protection, Jokioinen, Finland**

**Dr. Rolf Nestby, Bioforsk, Stjørdal, Norway**

**Mr. Gijs van Kruistum, Applied Plant Research, Lelystad, The Netherlands**



# Program

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**Monday, March 9<sup>th</sup>**

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## ***Opening of the workshop and welcome***

- 14.00 **V. Kondakova**, local organiser  
**J.F. Hausman**, Action rapporter  
**A. Maggio**, COST Scientific Officer

## ***Session 1 – Abiotic stress***

**Moderator: Rolf Nestby**, Norwegian Institute for Agricultural and Environmental Research, Grasland and Landscape Division, Kvithamar, Stjørdal, Norway.

- 14:15 **Privé Jean-Pierre**, Agriculture and Agri-Food, Boctouche, New Brunswick, Canada  
*Understanding and reducing environmental stress in sustainable berry fruit production*

## 15.15 ***Break***

- 15.30 **Ercesli Sezai et al.**, Department of Horticulture, Ataturk University, Erzurum, Turkey  
*The use of PGPR (Plant Growth Promoting Rhizobacteria) as biological control of Botrytis cinerea and biofertilizer agents in raspberry cv. Heritage*

- 16.00 **Neri Davide**, Department of Environmental and Crop Science – Polytechnics University of Ancona, Ancona, Italy.  
*Abiotic stress in strawberry tray-plant production*

- 16.30 **Karhu Saila**, Agrifood Research Finland, Horticulture Toivonlinnantie, Piikkio, Finland.  
*Abiotic environmental factors can stress strawberry in modern production systems.*

- 17.00 **Dénes Ferenc**, Research Institute for Fruit Growing, Fertőd, Hungary  
*Influence of climate change on small fruit species in Hungary.*

- 17.30 **Nestby Rolf et al.**, Norwegian Institute for Agricultural and Environmental Research, Grasland and Landscape Division, Kvithamar, Stjørdal, Norway.  
*Low temperature stress and freezing injury of strawberry plants.*

- 18.00 **End of the first day**

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**Tuesday March 10<sup>th</sup>**

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09.00 **Kondakova Violeta**, National Centre for Agricultura Science, Plant Genetic Resources, Sofia, Bulgaria.  
*Visit to AgroBioInstitute Sofia*

13.00 **Lunch & Poster Session at AgroBioInstitute**

**Session 2 – Insect pests, viruses and residue management**

**Moderator: Gijs van Kruistum**, Applied Plant Research, Wageningen University and Research Centre, Lelystad, The Netherlands

15.00 **Baroffio Catherine A**, Agroscope Changins-Wädenswil ACW, Centre de Recherche Conthey, 1964 Conthey, Switzerland  
*Flight monitoring of *Resseliella theobaldi* and *Byturus tomentosus* in Swiss raspberry cultures*

15.30 **Tuovinen Tuomo & Lindqvist Isa**, MTT Agrifood Research Finland, Jokioinen, Finland  
*Experiences in biological pest control in remontant strawberry*

16.00 **Palha, M. G. et al.**, Portugal  
*The effects of monoculture practice on strawberry crop protection and plant growth*

16.30 **Van Kruistum Gijs et al.**, Applied Plant Research, Wageningen University and Research Centre, Lelystad, The Netherlands  
*Modified Atmosphere Treatment as Alternative for Methyl Bromide to Control Strawberry Tarsonemid Mites*

20.00 Joint Dinner

22.00 **End of the second day**

**Session 3 – Fungal diseases**

**Moderator: Päivi Parikka**, MTT Agrifood Research, Plant Protection, Jokioinen, Finland

09.00 **Evenhuis Bert et al.**, Applied Plant Research, Wageningen University and Research Centre, Lelystad, The Netherlands  
*Biological control of Botrytis cinerea in strawberries: distant fact or fiction?*

09.30 **Romanazzi Gianfranco et al.**, Department of Environmental and Crop Sciences, Marche Polytechnic University, Ancona, Italy  
*Induction of resistance as a tool to control postharvest decay of strawberry*

10.00 **Michel Vincent et al.**, Agroscope Changins Wädenswil, Centre de Recherche Conthey, Switzerland  
*Interactions between green manure plants and soil type to control Verticillium wilt of strawberry*

10.30 **Parikka Päivi et al.**, MTT Agrifood Research, Plant Protection, Jokioinen, Finland  
*Phytophthora cactorum on strawberry: control by resistance and suppressiveness*

11.00 **Break**

11.30 **Discussion and conclusions**

13.00 **Closing of WG 2&3 Joint Meeting**

## Posters

<b>First Author</b>	<b>First name</b>	<b>Institute</b>	<b>Country</b>	<b>Titel</b>
Klamkowski	Krzysztof	Research Institute of Pomology and Floriculture	Poland	Response to drought stress of two strawberry cultivars grown under greenhouse conditions
Tryngiel-Gać	Anna	Research Institute of Pomology and Floriculture	Poland	Effect of mycorrhiza on plant development and photosynthetic activity of cranberry grown under different water regimes.
Özgen (a)	Mustafa	Gaziosmanpasa Univ., Horticulture Dept	Turkey	The Effect of Tarnished Plant Bug Damage on Antioxidant Characteristics of Organically and Conventionally Grown Strawberries
Özgen (b)	Mustafa	Gaziosmanpasa Univ., Horticulture Dept	Turkey	The effect of biotic stress (arbuscular mycorrhizal) on the vegetative and generative components of strawberries applied with different phosphorus doses in soilless culture
Koron	Darinka	Agricultural Institute	Slovenia	The regulation of stress conditions in strawberries with biocidal plants
Mavric Plesko	Irena	Agricultural Institute	Slovenia	Detection of Blueberry red ringspot virus in highbush blueberry cv. Coville
Van Delm	Tom	Proefcentrum Hoogstraten	Belgium	Plant architecture of strawberry trayplants in relation to nutrient application system

### Remarks:

*Poster Tryngiel-Gać Anna will be presented by Klamkovski Krzysztof*

*Poster Özgen Mustafa (a) will be presented by Serçe Sedat*

*Poster Van Delm Tom will be presented by Neri Davide*

# Abstracts

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Monday, March 9<sup>th</sup>

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## ***Session 1 – Abiotic stress***



# UNDERSTANDING AND REDUCING ENVIRONMENTAL STRESS IN SUSTAINABLE BERRY FRUIT PRODUCTION

J.-P. PRIVÉ

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*Extenday*<sup>®</sup>, leaf photosynthesis, cold hardiness,

Reducing environmental stress for sustainable berry fruit production is particular to each growing region of the world. Working as a whole plant physiologist in Canada, I will discuss the approaches I have used for studying the effects of environmental stress on fruit crops and some of the methods/systems used to reduce this stress.

Sometimes the approach has been to look to the past, i.e., historical data, to help predict what environmental components have been responsible for losses in crop productivity and thus help breeders develop genotypes and plant physiologists develop systems that can better tolerate or avoid these stresses. Examples will include: 1) the analytical method that generates  $\chi^2$  indices of association between daily weather occurrences and annual variations in production and 2) G x E studies. The benefits of using reflective cloth in raspberry production will be discussed in “light” of these findings.

Sometimes we look to the present for technological advances that help us better assess the impacts of certain environmental stimuli such as temperature, water, and wind either when in excess or when limited. Three reliable methods will be explained for estimating different types of cold hardiness. They include: 1) a whole plant controlled freezing experiment for the assessment of low mid-winter injury, 2) electrical impedance spectroscopy (Z) for the estimation of multiple freeze-thaw cycling injury and 3) a controlled freezing protocol to facilitate the rapid screening of large populations of seedlings. A modified shift trellis system will be used to exemplify a sustainable system that helps reduce cold injury in blackberries. Additional abiotic stresses that have been evaluated include heat, drought and wind. The best methods for monitoring and predicting drought stress for ‘Heritage’ red raspberry; the importance of wind protection for optimum growth and development, the impact of a kaolin clay-based crop protectant on leaf gas exchange are a few of the topics that will be discussed. Finally, the holistic approach of evaluating both biotic and abiotic stresses will be demonstrated using an intelligent irrigation system for wild blueberries (*Vaccinium angustifolium* Ait.) and a modified polytunnel system for red raspberries (*Rubus idaeus* L.)

**THE USE OF PGPR (PLANT GROWTH PROMOTING RHIZOBACTERIA) AS BIOLOGICAL CONTROL, OF *BOTRYTIS CINEREA*, AND BIOFERTILIZER AGENTS IN RASPBERRY CV. HERITAGE**

SEZAİ ERCİSLİ AHMET ESİTKEN

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More recently we are working on use of plant growth-promoting rhizobacteria (PGPR) as biocontrol and biofertilizer agent in berry fruit production. In our studies the bacteria *Azotobacter*, *Azospirillum*, *Bacillus*, *Clostridium*, *Pseudomonas* and *Streptomyces* have been used for both purposes. The study on effects of PGPR both as biocontroller and biofertilizer agent in raspberry production, started in 2007 in Turkey. The raspberry cv. Heritage was inoculated with three microorganisms (*Bacillus subtilis* M3, *Bacillus subtilis* OSU-142 and *Pseudomonas putida* BA-8), and compared with non inoculated as control. The bacteria were used either alone or in combination, and the experiments were conducted in field conditions. The PGPR strains were found capable of IAA producing, N fixing and cytokinine producing capacity. The amounts of IAA produced by bacteria varied among bacteria. *Pseudomonas putida* BA-8 produced more IAA and had higher cytokinine producing capacity than the others. The inoculation of bacteria increased plant growth and productivity. However, the antioxidant capacity of different treatments was variable. *Pseudomonas putida* BA-8 was found more effective for control of *Botyrtis cinerea* than the other bacteria. All bacteria had effect on abiotic stresses and initiated an increased plant nutrient element uptake from the soil.

## ABIOTIC STRESS IN STRAWBERRY TRAY-PLANT PRODUCTION

DAVIDE NERI <sup>\*)</sup> AND GIANLUCA SAVINI <sup>\*\*)</sup>

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*Flower induction, plant architecture, fertilization, stolon propagation, temperature response*

Abiotic stresses play an important role to control plant growth and development in the strawberry nursery tray production, strictly interacting with the physiological processes which lead to flower induction and differentiation. As a consequence environmental stressing conditions assume a key function in determining plant quality in relation to different physiological internal factors of the plants.

The present work will discuss a few experimental and modeling approaches to control plant quality as a result of stress manipulation, trying to describe the sequence of correlated events and the conditions in different growing phases.

As case studies, time of transplanting, regulated deficit nutrient and water application, limited substrate soil volume in tray plant production are discussed. From previous physiological data (Savini et al. 2005) it emerges that the vegetative-reproductive equilibrium of the plant is principally controlled by temperature and photoperiod.

Nevertheless, it was found that similar conditions of growth are interpreted in different ways by the various organs (inflorescence, leaves, shoots and meristems) and also in different positions along the crown, inducing diverse morphological changes of the different organs.

The result is a significant modification of plant architecture influencing when forcing should be started, the timing of chilling and the effect of short days. This will have an impact on the possibility to predict the production by only analysing the real architecture of tray plants at the moment in which the plants are forced or chilled.

For instance smaller pot volume stimulates early flower induction when the plant is forming its root system, but if the growing period in the tray is too prolonged the roots are stressed and the inflorescence quality is reduced. As well low temperatures can be flower inducing when the plant is still vegetative, but when the plant is flower initiated a high temperature is needed to increase the number of flowers per single inflorescence.

## ABIOTIC ENVIRONMENTAL FACTORS CAN STRESS STRAWBERRY IN MODERN PRODUCTION SYSTEMS

S.T. KARHU

MTT Agrifood Research Finland, Horticulture, Toivonlinnantie 518, FI-21500 Piikkiö, Finland

*cultivation under protection, Fragaria, fruit quality, polyethylene mulch, small fruit production*

Plastic tunnels and mulches are often used in strawberry (*Fragaria* × *ananassa*) growing systems to increase production efficiency, to extend the harvest period, and to improve fruit crop and its quality. Although these means are used to modify the environment to be beneficial to strawberry production, the modern growing techniques can also affect the plant and fruit quality of strawberry by increasing some environmental stress factors.

By comparing production in the open and production in the growing system where plants were grown periodically under polyethylene cover, we found differences in fruit quality parameters that were correlated to abiotic environmental factors: The concentration of soluble solids (“sugar content”), firmness, and dry matter% were negatively correlated to temperature, and pH was inversely related to the daily global radiation. In some cultivars temperature and total water input affected fruit colour.

Even polyethylene mulch can affect strawberry. Lower carbohydrate reserves and decreased chlorophyll content of leaves were observed in plants with black mulch compared with white mulch. Black mulch decreased fruit size in the first harvest year and also decreased the concentration of soluble solids of fruits in both trial years. In our northern conditions even the north-east position within the double-row bed decreased plant growth as compared to south-west position in an unheated walk-in tunnel covered with polyethylene.

# INFLUENCE OF CLIMATE CHANGE ON SMALL FRUIT SPECIES IN HUNGARY

F. DÉNES

Research Institute for Fruit Growing

*climate change, raspberry, blackberry, black currant*

It is difficult to analyse climate change processes using statistical data, as there may be little or no change in temperature means or rainfall quantities. One clearly discernible change is the more frequent occurrence of extreme events – an increase in the number of very hot days, changes in the distribution and intensity of rainfall, the repeated occurrence of unusually warm winters, etc. Hungary is situated between latitudes 46 and 48 °N. It has a continental climate, but due to its location in the Carpathian Basin it is excessively exposed to climatic factors.

Damage caused by abiotic effects was regularly observed in berry fruits. Almost every year, frost caused damage to currant varieties and strawberries at flowering. Every 3–5 years blackberry varieties were frozen right down to ground level by long periods of temperatures as low as –20°C. Nevertheless, in the long term ecological anomalies did not endanger economical production. Over the last 6–8 years, however, extreme climate events have seriously endangered profitability.

As the result of mild winters, the chilling requirements of berry fruits have not been fulfilled, so plantations of raspberry and currants have only partially sprouted, if at all. Pathogens in the buds have continued to multiply during dormancy, causing considerably more damage in spring.

Damage suffered during the vegetation period can now be regarded as regular. Although blackcurrant flowers are no longer damaged by frost, extremely hot weather during fruit formation causes the green berries to drop.

Raspberries and blackberries exposed to the sun suffer sunburn, making them suitable only for juice production. Blackberries with a long, late ripening period (Thornfree) shrivel up despite constant irrigation.

Due to the intensive solar radiation, sunburn symptoms appear on the leaves of blackcurrant, inducing early leaf abscission and thus reducing the efficiency of flower bud differentiation.

The intensive warming of the soil inhibits root growth and nutrient uptake, thus spoiling the quality of nursery reproductive stocks (the length of raspberry canes is reduced by 30–35%).

To avoid all these unfavourable effects, expensive interventions are required (irrigation, shading, etc.), together with the selection of plants with better resistance to environmental stress factors.

## **LOW TEMPERATURE STRESS (LT) AND FREEZING INJURY OF STRAWBERRY PLANTS.**

R. NESTBY.

Bioforsk, Grasland and Landscape Division, Kvithamar, Stjoerdal, Norway.

*low temperature, alternating temperature, wintercover, location, strawberry*

Freezing injury is a recognized problem in the berry industry. The magnitude of the problem depend on geographical area, and it has to be considered when addressing cultivation management and recommending cultivars. The type of injury experienced may be caused by extreme low temperatures (LT) occurring during the winter while plants are still dormant, or by late frosts when plants are resuming growth in the spring, or occasionally in late autumn before plants are dormant. The typical injury is caused by forming of extracellular ice outside the cytoplasm and subsequent injury of the plasma membran.

During freezing of strawberries stored at 0 °C before freezing, the temperature was lowered by 2 °C h<sup>-1</sup> and kept at the desired temperature for 2 hours before the temperature was raised to zero °C at the same speed. After storage at zero the plants were set to grow. The cvs showed a danger point for mortality close to -8 °C. However, 'Senga Sengana' and 'Korona' showed a significant increase in freezing injury, demonstrated by reduction in fruit yield, at a warmer freezing temperature than 'Bounty', but survived a lower temperature. Cutting the crown longitudinally demonstrated tissue browning of injured tissues. Since the flower primordia rarely seems to be injured, the observed reduction in yield probably is caused by problems of the plant to transport water and nutrients out to the developing peduncles and flowers, at resumption of growth in the spring.

The plants develop winter hardiness in response to short day lengths and low temperature in the autumn. At alternate periods of mild and freezing temperatures, which are often experienced in a coastal climate, the plants lose winter hardiness during the mild periods and may be freeze injured at a warmer freezing temperature than if the temperature stayed low the whole winter, as in a continental climate. It was also shown that plants grown in a continental climate, were more injured at alternate winter temperatures ( $\pm 0^{\circ}\text{C}$ ) than plants grown in a coastal climate, and vice versa. Suggesting that some factor in the growing season, signaled the type of stress that could be expected in the winter. Probably because of the large difference in day and night temperature between the climate zones.

There are several possibilities of protecting the strawberry plants from LT stress when there is no snow cover, like covering the plants with grain straw, hay or poly-foam mulches. These covers are helpful also in a situation with snow cover. In Norwegian experiments it was shown that covering with e.g. fleece reduced the winter injury, but more in a coastal than in a continental climate. The reason of this is that the fleece reduced the maximum day temperature and made the minimum temperatures higher. By this the dehardening effect of mild temperatures was decreased as well as the low temperature stress, resulting in reduced LT injury.

# Abstracts

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Tuesday, March 10<sup>th</sup>

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## ***Session 2 – Insect pests, viruses and residue management***



## FLIGHT MONITORING OF *RESSELIELLA THEOBALDI* AND *BYTURUS TOMENTOSUS* IN SWISS RASPBERRY CULTURES

C.A. BAROFFIO

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*Soft fruits, raspberry, monitoring, Resseliella theobaldi, Byturus tomentosus*

The raspberry cane midge *Resseliella theobaldi* is a major pest of Swiss raspberries. The midge population dynamics have been studied for three years in the Valais region using a sex pheromone identified and synthesised by EMR and NRI. Four to five generations were observed in the low altitude and three to four in the mountains. Based on these observations and in order to find a substitute to diazinon, the only registered insecticide, an efficacy trial was conducted in 2008. Beside diazinon, two insecticides were tested. Only thiacloprid and diazinon showed a significant difference compared to control. The trial will be completed in 2009. This pheromone trap allows to estimate the midge populations and to decide if it is necessary to use an insecticide and at which moment

The raspberry beetle, *Byturus tomentosus* is a major pest of Swiss raspberries. In 2008, in the frame of an international cooperation with UK, Norway and France the flight of the raspberry beetle has been monitored for the first time in the Swiss Alps with the semiochemical trap (floral attractant) developed in Scotland by SCRI. Early results show an irregular attractiveness of the trap. The traps were installed before flowering at the beginning of June and were immediately attractive for 2 weeks. Then the caught decreased till end of July. A second important flight was observed at the end of July and at the beginning of August. Fruit analysis showed that at the end of August 14% of the fruits was damaged in the control plot and less than 5% in the trial plot. Neighbouring woods with wild *Rubus* sp. near the plot could explain high beetle populations. This monitoring will continue for two years. This semiochemical trap allows to estimate and to kill the beetle population.

Pheromone and semiochemical traps are useful in a strategy using biological control and / or pesticide residue management.

## EXPERIENCES IN BIOLOGICAL PEST CONTROL IN REMONTANT STRAWBERRY

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*Two-spotted spider mite, thrips, aphids, Phytoseiidae, Orius majusculus*

Strawberry production in Finland is aimed for fresh market. Only short-day cultivars are used, and the harvesting time usually lasts only a few weeks. This is risky as almost all production is in the open. There is a market niche for everbearer cultivars but very little is known about their suitability for production in Finland. A project was started in 2007 at MTT Horticulture and Plant Protection to investigate the everbearer cultivars and to increase profitability of strawberry production. Plant protection studies are aimed to select and develop monitoring methods and efficient control methods against pests even during the flowering and harvesting periods.

For detailed plant protection studies three everbearer strawberry cultivars, 'Malling Opal', 'Rita' and 'Rondo', were planted in Jokioinen (60°48' N, 23°28' E) in a walk-in polythene tunnel and in an out of doors field in 2008. Another tunnel for other investigations was situated in Piikkiö (60°23' N, 22°33' E), and biological control of pests was practised also there. Fruits were inspected for injuries and sorted out as marketable and non-marketable yield by quality and size. Several methods were used to observe insect and mite pests: leaf sampling, folded leaf sampling, banking from leaves and flower trusses, and yellow and blue sticky traps. Thrips were sampled also from adjacent plants to compare the species composition in strawberry and common weeds nearby.

Arthropod pests for which biological control was aimed in tunnels both at Jokioinen and Piikkiö were the two-spotted spider mite (*Tetranychus urticae*), thrips and aphids. In tunnels, the two-spotted spider mite was controlled by releases of *Phytoseiulus persimilis*, *Amblyseius californicus*, *Neoseiulus cucumeris* and *Neoseiulus barkeri*, thrips were controlled by *Orius majusculus*, *N. cucumeris* and *N. barkeri*, and aphids were controlled by *Chrysoperla carnea* and *Aphidius ervi*. In the open field, pests were controlled by one release of *N. cucumeris*, *N. barkeri* and *O. majusculus*. Pests accounted for 16% and 22%, grey mould 2% and 10%, and other factors 10% and 21% of the injuries of berries in the tunnel and open field, respectively.

The results and experiences of the first year will be used for planning biological control in 2009. Monitoring methods will be selected for convenient and reliable observation of pests to ensure proper timing of the introductions of biocontrol agents and required pesticide treatments.

# THE EFFECTS OF MONOCULTURE PRACTICE ON STRAWBERRY CROP PROTECTION AND PLANT GROWTH

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*Fragaria x ananassa, IPM, metam sodium, pests, diseases*

In the annual strawberry production systems the occurrence of edaphic plant pathogens, mainly nematodes and fungi, frequently constrains fruit yield. These systems rely on monoculture system that is commonly considered as not sustainable and, in general, yields typically decline. To maintain the high productivity of berry crops, soil fumigation with methyl bromide (MB) has been used before planting. The phase out of MB has intensified the search for alternatives methods. In addition, the interests in integrated control measures and combinations of different methods to reduce the use of chemical pesticides have also increased. Integrated pest management (IPM) can eliminate environmental stress caused by pesticide use, thus increasing soil biotic diversity and beneficial organisms.

This study was conducted to better understand the effects of monoculture practice on strawberry plant growth and on crop protection. Field experiments were established in soils that have been cropped with strawberries for several years. Two soil disinfection treatments (without and with soil fumigant metam sodium - MS) and two plant protection systems (IPM and the usual chemical control - CC) were compared. Before planting, plant material was analysed for diseases and pests and during the growing cycle some vegetative growth parameters were recorded. For IPM, field monitoring was done for pests, diseases and natural enemies throughout the growing season.

Plant mortality was higher in non fumigated treatments (3.1% in IPM and 2.79% in CC plots). Plants from non-fumigated soil with IPM treatment were less vigorous (less crown and inflorescence n° and less leaf area) compared with plants from other treatments. The presence of aphids (*Aphis* spp., *Pentatrichopus fragaefolii* and *Macrosiphum euphorbiae*) and mites (*Tetranychus* spp.) population was observed but with no significance (Ferreira, 2005; Valério and Cecilio, 2005). Diseased plants were detected in the plots and isolation tests confirmed *Phytophthora cactorum*, *Rhizoctonia* and *Phytium* isolates. These effects were more evident in non-fumigated treatments. Plants from fumigated soil and with IPM performed as well as plants from non fumigated and fumigated soil with CC treatments. With IPM, the number of pesticides applied was reduced. To enhance fruit yield with IPM soil disinfection with MS revealed to be essential in strawberry crop monoculture.

## **MODIFIED ATMOSPHERE TREATMENT AS ALTERNATIVE FOR METHYL BROMIDE TO CONTROL STRAWBERRY TARSONEMID MITES**

GIJS VAN KRUISTUM<sup>1</sup>, MARIAN E.T. VLASWINKEL<sup>1</sup>, CHARLES BUDDENDORF<sup>2</sup>  
AND FLORIS VAN DER ZOUWEN<sup>3</sup>

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<sup>3</sup> Ruvoma BV, Montfoort, The Netherlands

*Phytonemus pallidus*, *Fragaria x ananassa*, runner production, methyl bromide, controlled atmosphere

Strawberry tarsonemid mite (*Phytonemus pallidus*) is a severe pest in the production of strawberries (*Fragaria x ananassa*). The presence of tarsonemid mites in plant material results in a considerable loss of production. Until 2007 the Netherlands mother planting stock for runner production was treated with methyl bromide (MeBr) to eliminate tarsonemids. This chemical disinfestation method is banned from 2008.

During recent years research is carried out to replace MeBr preferably by a non-chemical method. After screening a wide range of non chemical disinfestation methods, in 2007 the choice was made to optimize the controlled atmosphere (CA) treatment. Mortality of the tarsonemid mites was over 99.5 % when CA-treatment during 48 hours was combined with a temperature of 35 °C. CA-treatment can have a slightly negative effect on plant vigour. Compared to the standard MeBr gas fumigation the CA-treatment is at the same level.

In 2008 promising results are obtained with up scaling CA-treatment. From 2009 CA-treatment is applied on a large scale by Dutch growers and is replacing MeBr for eliminating tarsonemids in planting stock.

# Abstracts

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Wednesday, March 11<sup>th</sup>

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## *Session 3 – Fungal diseases*



## **BIOLOGICAL CONTROL OF *BOTRYTIS CINEREA* IN STRAWBERRIES: DISTANT FACT OR FICTION?**

A. EVENHUIS<sup>1</sup>, J. KÖHL<sup>2</sup>, WILMA MOLHOEK<sup>2</sup>, C.H. LOMBAERS<sup>2</sup>, H.M. VAN DE GEIJN<sup>2</sup> & J.A.M. WILMS<sup>1</sup>

1 Applied Plant Research , PO BOX 430, 8200 AK Lelystad

2 Plant Research International, PO BOX 69, 6700 AB Wageningen

*Fragaria, Ulocladium*

Fruit rot of strawberries can cause severe yield loss, and therefore is controlled with fungicides extensively. By request of the Dutch Ministry of Agriculture, Nature and Food Quality alternative methods to control grey mould were investigated. The aim was to reduce fungicidal burden to the environment and at the same time to guarantee economic benefit of strawberry cultivation

*Botrytis cinerea* is causing fruit rot of strawberry after infection of flowers and fruits by airborne conidia. Conidia of *B. cinerea* can be produced on necrotic tissues. Spray application of *Ulocladium atrum* results in partial control of grey mould compared to chemical treatments.

Optimum timing and targeting of *U. atrum* is a big challenge. The results of field experiments demonstrated that intervals between antagonist applications during flowering must be short to guarantee that newly opened flowers are reached by the antagonist. Field experiments were carried out using a decision support system (DSS) to optimise timing of antagonist applications and to avoid applications under conditions not favourable for disease development. In 2002, 8 applications of *U. atrum* at 3 to 4-day intervals resulted in a reduction of grey mould incidence by 50 %. When applications were timed according to DSS (at an infection chance >7.5 %), 4 applications were carried out resulting in a reduction of grey mould incidence by 30 %. In 2003, 7 applications of *U. atrum* at 3 to 4-day intervals resulted in a reduction of grey mould incidence by 24 %; 6 applications timed according to DSS resulted in a reduction of grey mould incidence by 39 %. Fungicide application timed following the same decision rules reduced grey mould incidence by 67 %.

Integration of the use of fungicides and antagonist in a control strategy based upon a DSS was tested from 2004-2006. Spraying a fungicide at high infection risk and *U. atrum* at moderate infection risk resulted in the same level of grey mould control than spraying with only fungicides. Therefore accordingly *U. atrum* can be implemented in daily horticultural practise. Main obstacle is registration of the antagonist involved. Another draw back is that *U. atrum* does not perform as well as fungicides under high infection risks. Therefore to apply the antagonist safely, the farmer must have knowledge on the expected infection risk to choose the control strategy. This kind of information is available, but requires an active approach of the farmer in his control strategy.

## INDUCTION OF RESISTANCE AS A TOOL TO CONTROL POSTHARVEST DECAY OF STRAWBERRY

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*Chitosan, hypobaric treatment, hyperbaric treatment, resistance inducers*

Strawberry (*Fragaria × ananassa* Duch.) is a perishable fruit, mainly after the harvest, because it is susceptible to mechanical injury, desiccation, decay and physiological disorders. Gray mold, caused by *Botrytis cinerea* Pers., and Rhizopus rot, which is induced by *Rhizopus stolonifer* (Ehrenb.) Vuill. are the most important postharvest diseases of strawberries (Maas, 1998). Both diseases can induce severe losses of fruit both in the field and during long-distance transport and storage. *B. cinerea* is an eurithermic pathogen, which can develop at 0°C, while *R. stolonifer* requires at least 4-5°C. They are very dangerous after cold storage, during shelf life at room temperature, they can cause nesting, as spreading from a single infected berries to the other close fruit.

Request from consumers for fruit free of chemical preservatives and the appearance of fungal isolates that are resistant to fungicides, together with the lack of registered compounds that are allowed for use on harvested strawberries have stimulated the search for safer alternatives. These have included the use of short hypobaric treatments and the application of resistance inducers.

A 4 h hypobaric treatment at 0.25 atm (190 mm Hg) or 0.50 atm carried out on fruit soon after harvest decreased gray mold and Rhizopus rot incidence (Romanazzi et al., 2001). Short hyperbaric treatments have proven to be effective to reduce storage decay on sweet cherry and table grapes but not on strawberry (Romanazzi et al., 2008).

The use of natural biopolymers as chitosan is known to control postharvest diseases of strawberry (El Ghaouth et al., 1992). This biopolymer can form a film on the surface of treated fruit and increase plant resistance triggering the activity of enzymes (e.g. phenylalanine ammonia-lyase – PAL, chitinase,  $\beta$ -1,3 glucanase) involved in the disease response. It has been effective both when applied after the harvest and with application in the field (Reddy et al., 2000; Romanazzi et al., 2000). Such treatments are effective in the control of gray mold and Rhizopus rot during storage. In preharvest application, the best results have been obtained by treatments at full bloom and whitening fruit. Moreover, several other commercial and experimental resistance inducers have been effective in the control of gray mold and Rhizopus rot, included a chitosan formulation easy to dissolve in water (Romanazzi et al., 2007). The application of these treatments represents a very interesting approach for conventional agriculture, and one of the few possibilities that are permitted for the management of postharvest decay of organic strawberries.

## INTERACTIONS BETWEEN GREEN MANURE PLANTS AND SOIL TYPE TO CONTROL *VERTICILLIUM* WILT OF STRAWBERRY

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*Brown mustard, green manure, rye, strawberry, Verticillium dahliae*

*Verticillium* wilt is a major soil-borne disease of strawberry. Incorporating green manure crops to control this disease is a promising method. Its efficacy can be measured by counting the number of microsclerotia of *Verticillium dahliae*, one of the agents of *Verticillium* wilt.

During the last years several field and pot trials were conducted to test the efficacy of brown mustard (*Brassica juncea*) and rye (*Secale cereale*) to control *Verticillium* wilt. In pot trials, a significant reduction of the number of microsclerotia was observed with both green manures, but their efficacy depended on the soil type. Brown mustard cultivars specifically selected for a high glucosinolate content were most efficient in a loamy soil. In contrast, rye was more efficient in a sandy soil.

As an alternative to the use of glucosinolate-containing plants, pellets of defatted seedmeal of Ethiopian mustard (*Brassica carinata*) were also tested. In both soil types, they did not decrease the number of living microsclerotia of *Verticillium dahliae*.

The findings in the pot trials were confirmed by on-farm field trials. On-station field trials will be conducted in the next two years to study the impact of these green manures not only on the *Verticillium dahliae* but also on *Trichoderma* spp. and other non-target micro-organisms.

## **PHYTOPHTHORA CACTORUM ON STRAWBERRY: CONTROL BY RESISTANCE AND SUPPRESSIVENESS**

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*Fragaria*, cultivar resistance, crown rot, composts

*Phytophthora cactorum* is one of the most important diseases of strawberry. It can injure and kill plants and reduce the quality of harvested fruit. Most strawberry cultivars are susceptible to the pathogen, but the severity of *Phytophthora* attack is highly dependent on environmental conditions. The pathogen attacks plants under stress: under crop formation, high temperatures and high demand of water. Also photoperiod affects pathogen attack and defence mechanisms. When resistance of strawberry cultivars to *P. cactorum* was tested in greenhouse, seasonal fluctuation was clearly visible in the results. Most cultivars are more susceptible to infection during a long photoperiod. Even cultivars considered resistant can show symptoms during the long summer day. However, some cultivars do not react at all to day-length. Disease susceptibility during long photoperiod can cause problems in June-bearing cultivars and when planting is made in spring.

Fungi and bacteria in the growth substrate can affect soil-borne *Phytophthora* infection. Adding compost to normal growing media can suppress *Phytophthora* infection and protect plants from disease. There are, however, big differences between composts in their effect, and the mechanism of suppressiveness is not yet well known. In summer 2008, 21 commercial composts were screened for their ability to decrease strawberry crown rot symptoms caused by *P. cactorum*. The compost raw materials included municipal sewage sludge, biowaste, livestock manure, various kinds of garden wastes and waste from forest industry. The majority of these composts seemed not to affect crown rot severity on plants, but some showed certain degree of suppressiveness by decreasing wilt symptoms. Microbial profiles of ten selected composts were determined by qPCR, DGGE and subsequent DNA sequencing. The results show small differences between composts. The mechanism behind the effect of composts on plants and disease is still unknown and warrants closer investigation.

*P. cactorum* has contaminated the soils all over the strawberry growing areas. It is normally controlled by fungicides such as fosetyl-Al. Use of resistant cultivars would be the best method to control the disease. Composts can be useful when soil structure is improved and beneficial microflora has been added to strawberry production soils.

# Abstracts

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Tuesday, March 10<sup>th</sup>

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*Poster session*



# **RESPONSE TO DROUGHT STRESS OF TWO STRAWBERRY CULTIVARS GROWN UNDER GREENHOUSE CONDITIONS**

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The reaction of two strawberry cultivars to drought was examined by evaluating the yield and morphological and physiological parameters. Plants were subjected to two different water regimes: optimal irrigation (control), and reduced irrigation (drought stress). Genotypes differed in their response to water deficiency. Cultivar 'Elsanta' had high rate of net photosynthesis with high water use efficiency under water shortage conditions. Drought stress reduced leaf area in all cultivars, but root development was retarded in 'Elkat' only. Under water deficiency conditions 'Elsanta' gave the highest yield and 'Elkat' the lowest. Among examined cultivars, 'Elsanta' appeared to be the most drought tolerant, which was reflected in growth and yield parameters.

**EFFECT OF MYCORRHIZA ON PLANT DEVELOPMENT AND PHOTOSYNTHETIC ACTIVITY OF CRANBERRY GROWN UNDER DIFFERENT WATER REGIMES.**

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Cranberry plants grown under greenhouse conditions were subjected to two different water regimes: optimal irrigation (control), and reduced irrigation (drought stress). Part of plants were inoculated with ericoid mycorrhizal fungi. The response of the plants was determined morphologically and physiologically. In general, inoculation with mycorrhizal fungi enhanced photosynthetic activity of cranberry plants. No significant differences in weight of shoots and number of runners were found between inoculated and non-inoculated cranberry plants grown under different water regimes. The plants inoculated with mycorrhizal fungi produced more uprights than non-inoculated plants.

# THE EFFECT OF TARNISHED PLANT BUG DAMAGE ON ANTIOXIDANT CHARACTERISTICS OF ORGANICALLY AND CONVENTIONALLY GROWN STRAWBERRIES

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*anthocyanin, Ascorbic acid, Fragaria, Lygus lineolaris, organic*

We grew six strawberry cultivars ('Earliglow', 'Honeoye', 'Idea', 'Jewel', 'Northeaster' and 'Seneca') organically on three different composts (yard waste, dairy barn waste and vermicompost). Organic treatments were contrasted against a synthetic fertilizer standard, a conventional pesticide standard and an untreated control. Plots were rated for tarnished plant bug (*Lygus lineolaris*) damage during the growing season. At harvest, berries were examined for their ascorbic acid levels and total anthocyanin and phenolic contents. Ascorbic acid content of berries in different cultivars and treatments were similar. As expected fruit anthocyanin and phenolic contents were significantly different among the cultivars, ranged between 160 to 230 µg/g fresh weight (fw) and 1039 to 1333 µg/g fw respectively. Among treatments, anthocyanin contents of strawberries were not significant different, but berries grown on conventional pesticide standard had 8-12% lower total phenolic content than the other treatments. In organic treatments, production of phenolic compounds may have been induced in response to increased tarnished plant bug feeding. This putative biotic stress defence mechanism was seen most dramatically on tarnished plant bug-susceptible cultivars. However, as differences in phenolic levels were greater among cultivars than among treatments, cultivar choice may be a more important consideration than growing system for optimizing antioxidant levels in commercially available fruit.

# **THE EFFECT OF BIOTIC STRESS (ARBUSCULAR MYCORRHIZAL) ON THE VEGETATIVE AND GENERATIVE COMPONENTS OF STRAWBERRIES APPLIED WITH DIFFERENT PHOSPHORUS DOSES IN SOILLESS CULTURE**

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*mycorrhizal, strawberry, soilless culture*

The objective of this experiment was to determine the effect of different arbuscular mycorrhizal inocula and phosphor dose combinations on strawberries. Two strawberry cultivars (Camarosa and Maraline) grown in soilless culture were applied with two arbuscular mycorrhizal inoculation (*Glomus clarium* and *Glomus caledonium*) and three phosphor doses (10, 30 and 60 ppm). The strawberries planted in pumice were then irrigated with the nutrition solution in different interval according to the plant vegetation period. The standard plant nutrient solution applied to strawberry plants containing 210 ppm nitrogen, 200 ppm calcium, 560 ppm potassium and other micronutrients. The effects of arbuscular mycorrhiza on the vegetative and generative characteristics of strawberries were evaluated. Total yield, fruit size, stolon number, dried weight of leaves, fruit characteristics such as pH, acidity and total soluble solids were determined. Our results suggested that mycorrhizal inoculation statistically increased the yield in Maraline cultivar and had no significant effect on other vegetative characteristics. On the other hand, both phosphor and mycorrhizal inoculations resulted in significant decrease on total soluble solids and pH in the fruits of both cultivars. Our limited study suggested that mycorrhizal inoculation of the strawberry plants may cause minor biotic stress on the strawberry plant.

## THE REGULATION OF STRESS CONDITIONS IN STRAWBERRIES WITH BIOCIDAL PLANTS

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*crop rotation, green manure, pathogenic organisms, mycorrhiza*

Sustainable regulation of individual technological steps enables optimal growth and fertility of strawberries in integrated and biological production. The criterion for soil vitality is also a symbiotic relationship between plants and soil microorganisms. Symbiosis is possible in adequate soil, at good crop rotation, moderate fertilization and sustainable weed control and plant protection against plant pathogenic organisms. Artificial mycorrhization of plant material which reduces the consequences of biotic and abiotic stress is an expensive step. Mycorrhization can be replaced by technologies which stimulate the growth of useful microorganisms. In strawberries we tested the influence of Indian mustard (*Brassica juncea*), white mustard (*Sinapis alba*), arugula (*Eruca sativa*), buckwheat (*Fagopyrum esculentum*) and marigold (*Tagetes* spp.), which obstruct development of pathogenic fungi and have a positive influence on the structure and fertility of soil. The influence of green manure plants on mycorrhiza in our experiments was favourable or neutral.

## DETECTION OF BLUEBERRY RED RINGSPOT VIRUS IN HIGHBUSH BLUEBERRY CV. COVILLE

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### *BRRSV, Vaccinium, PCR, detection*

*Blueberry red ringspot virus* (BRRSV) is a member of genus Soymovirus in the family Caulimoviridae. It is known to infect *Vaccinium corymbosum*, *V. formosum*, *V. australe* and probably *V. macrocarpon*. Many blueberry cultivars are sensitive to BRRSV, like Blueray, Bluetta, Coville, Earlyblue and others. Cv. Bluecrop is reported to be field-resistant and cv. Jersey is field-immune. BRRSV causes red ringspots or red blotches on one year old stems or older. In mid- to late summer reddish-brown spots develop on older leaves. The spots are prominent on the upper surface of the leaf. Similar leaf symptoms can be caused by powdery mildew *Microsphaera alni* var. *vaccinii*, but the leaf spots are prominent on both sides of the leaf. In some cvs. fruit symptoms, circular areas of light colour and/or fruit deformations can be seen. The disease can significantly reduce yield.

The disease is present in USA. Paulechova (1972) has reported the occurrence of red ringspot in former Czechoslovakia on wild *Vaccinium myrtillus*. She did not detect the virus but only showed that the fungus was not present.

On one plant of highbush blueberries in introduction plantation at Brdo pri Lukovici, symptoms indicating BRRSV infection were observed. Red rings appeared on some of the stems and also red rings or spots were observed on some leaves. At the harvest time spots of light colour were observed in ripening fruits. DNA was isolated from symptomatic tissue in spring 2008. Primers RR13 and RR14 (Glasheen et al., 2002) were used in subsequent PCR. Obtained amplification product of approximately 490 bp was sequenced and the sequence confirmed the infection of blueberry plant with BRRV.

Gillett J.M. and Ramsdell D.C. 1988. Blueberry red ringspot virus. DPV No. 327. Association of Applied Biologists.

Glasheen B.M., Polashock J.J., Lawrence D.M., Gillett J.M., Ramsdell D.C., Vorsa N., Hillman B.I. 2002. Cloning, sequencing, and promoter identification of Blueberry red ringspot virus, a member of the family Caulimoviridae with similarities to the 'Soybean chlorotic mottle-like' genus. Archives of Virology 147: 2169-2186. DOI 10.1007/s00705-002-0866-7.

Ramsdell D.C., Kim K.S., Fulton J.P. 1987. Red ringspot of blueberry. In: Virus diseases of small fruits, USDA Agriculture handbook No. 631: 121-123.

## PLANT ARCHITECTURE OF STRAWBERRY TRAYPLANTS IN RELATION TO NUTRIENT APPLICATION SYSTEM

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*Fragaria x ananassa, plant propagation, flower bud development, fertilization*

Vegetative growth of strawberry plants turns to generative growth (flower induction and differentiation) under specific thermo-photoperiods, but agronomic and nutritional factors may establish which kind of growth (vegetative or reproductive) is strengthened. Therefore the adjustment of growth and development of the plant in the nursery can strongly modify the entity and the time of fruit production in the field. The aim of the present work is to describe plant architecture as a result of a few different propagation techniques in the nursery, to evaluate plant quality described as the spatial distribution of vegetative and reproductive organs and their developmental phase.

A hundred tray plants, propagated under different growing conditions in the nursery (environment, time and amount of nutrient application, planting time, pot size, etc) were dissected and observed. They represent two important varieties (Elsanta and Clery) coming from different nurseries or growing systems conducted by Italian and Belgian growers. The plants were dissected (5 replications per treatment) in December 2008, at the end of the propagation phase and/or during the cold storage. The plant architecture (number of stolons, number and position of the inflorescences along the shoot, stage of terminal flower of the different inflorescences) was determined and represented by graphic models.

Important differences in plant architecture were observed between cultivars, within the same cultivar grown in the 2 countries and between farms (growers) in the same country. Growing conditions affected plant vigour, induced the formation of a very different number of lateral flower buds and modified the ability of the plant to form new shoots along the main shoot. The developmental phase of the flowers was also affected, both in the terminal inflorescence and in the lateral ones.

It can be argued that depending on the desired production system, the plant architecture and its potential fruit production can be strongly modified, in a predictable way, by changing and modulating the growing technique in the nursery. In conclusion the architectural analysis represents a possible future application to standardize tray plant production and evaluation and seems to be a powerful tool to evaluate the quality of the plants.