Book of Abstracts

Workshop on
„Berry Production in Changing Climate Conditions and Cultivation Systems“

Geisenheim, Germany

29th to 31st of October 2008

held in the frame of the COST-Action 863 „Euroberry Research: from Genomics to Sustainable Production, Quality and Health“

Organising Committee:

Erika Krüger	Geisenheim Research Center, Germany
Christoph Carlen	Agroscope Changins-Wädenswil ACW, Switzerland
Bruno Mezzetti	Marche Polytechnic University, Ancona, Italy

Scientific Committee:

Pedro Brás de Oliviera	INRB, Portugal
Christoph Carlen	Agroscope Changins-Wädenswil ACW, Switzerland
Beatrice Denoyes-Rothan	INRA, France
Erika Krüger	Geisenheim Research Center, Germany
Margit Laimer	Boku Vienna, Austria
Bruno Mezzetti	Marche Polytechnic University, Ancona, Italy
Päivi Parikka	MTT, Finland
Anita Sønsteby	Bioforsk, Norway

Program

Wednesday, October 29th

13:00 – 14:00 Arrival of the participants, registration and small lunch

14:00 – 14:15 Welcome and short overview of the Geisenheim Research Center
M. Großmann, Vice-director Geisenheim Research Center

*Session on **Impacts on berry physiology and cultural management I***
Moderation: B. Mezzetti

14:15 – 14:45 Climate change in Europe and its impacts on fruit species phenology and production
Invited speaker: J.-M. Legave

14:45– 15:25 Modelling of climatic changes impact on the growth and fruiting of currant and strawberry in the southern part of Romania
E. Chitu, P. Mladin, M. Coman

Economic impacts of climate variability in berry fruit – a decision analysis
M. Njavro and B. Duralija

15:30 – 16:00 Coffee Break

*Session on **Impacts on berry physiology and cultural management II***
Moderation: C. Carlen

16:00 – 16:30 How climate change could influence breeding and modern production systems in berry crops
Invited speaker: A. Dale

16:30 – 17:30 Climate change effects on strawberry production
P. Palencia, F. Martinez, J.J. Medina, E. Vázquez, F. Flores and J. Lopez -Medina

Photosynthetic response of strawberry leaves to changing temperatures
C. Carlen, A.M. Potel and A. Ancay

Effects of modified air temperature and relative humidity on vegetative and generative parameters of red raspberry
G. Muster

Thursday, October 30th

*Session on **Impacts on berry physiology and cultural management III***
Moderation: A. Sønsteby

08:30 – 09:00 Possible impacts of climate change on soft fruit production: The example of winter chill in *Ribes*
Invited speaker: H.G. Jones and R. Brennan

09:00-09:40 Temperature limitations for flowering in strawberry and raspberry
A. Sønsteby and O.M. Heide

Growth control of raspberry plants with ProCa
P. Palonen, E. Pehkonen and M. Rantanen

9:40–10:10 Coffee Break

*Session on **Impacts on berry physiology and cultural management IV***
Moderation: E. Krüger

10:10–10:40 Early and late production of raspberry, blackberry and red currants
Invited speaker: F. Pitsioudis

10:40–11:40 Effect of polyethylene tunnel cultivation on fruit quality and yield of ten strawberry cultivars
P. Crespo, P. Stamp and C. Carlen

Potential of the European blueberry (*Vaccinium myrtillus*) for cultivation and industrial exploitation in Norway
R. Nestby, I. Martinussen, A. Nes, T. Krogstad, J. Rohloff and E. Joner

Attempt to identification of Qare-Qat (*Vaccinium arctostaphylos* L.) traits and introduction to Iran's Horticulture
S. Sedaghathoor

*Session on **Impacts on dynamics of diseases, pests and beneficials***
Moderation: P. Parrika

14:00-15:20 Plant diseases in changing environment
P. Parrika and A. Lemetty

Biotisation of red fruits for increasing plant stress tolerance and antioxidant activity
A. Gollotte, L. Mercy, B. Secco, J. Laurent, M. Prost, S. Gianinazzi and M.C. Lemoine

Phytopathological problems of strawberry in Erzurum, Turkey
C. Eken

Evaluation of new strawberry cultivars and of beneficials microbes to improve strawberry production in *Verticillium*-infested soils
H. Weissinger, A. Sporenberger, R. Steffek, K. Jezik, and K. Stich

15:30–16:00 Coffee Break

16:00 - 18:00 Poster Session

Friday, October 31st

*Session on **Impacts on breeding strategies***
Moderation: B. Denoyes-Rothan

8:30 -9:00 Molecular characterisation of flowering in perennial fruit trees and shrubs
Invited speaker: E. Varkonyi-Gasic

9:00 – 10:00 Variation of genetic dissection of seasonal vs recurrent flowering according to year in cultivated strawberry
A. Gaston, E. Lerceteau-Köhler, Laure Bardot, A. Petit, M. Rousseau-Gueutin, B. Denoyes-Rothan

Investigating the response of strawberry to water deficit conditions
A.W. Johnson, O.M. Grant, M.J. Davies, C.M. James, A.J. Passey and D.W. Simpson

The attempt to find out biochemical markers related to frost tolerance in red raspberry and blackberry
T. Orlikowska, D. Kucharska, M. Horbowicz and G. Hodun

10:00 – 10:30 Coffee Break

*Session on **Fruit quality and nutritional values of berry fruits***
Moderation: M. Laimer

10:30 – 11:50 The interaction of plant genotype and climate conditions affects strawberry nutritional quality
J. Diamanti, F. Capocasa, S. Tulipani, M. Battino and B. Mezzetti

Differential effect of water deficit irrigation on fruit quality of five june-bearing strawberry cultivars
J. Giné Bordonaba and L.A. Terry

Antioxidant-enhancing and understanding in strawberry fruits
D. Neocleous and M. Vasilakakis

Effect of pre-harvest temperature, photoactive radiation and fruit thinning on strawberry bioactive compounds
E. Krüger, H. Dietrich and M. Josuttis

11:50 – 12:30 Final discussion: Further research requirements
Moderation: C. Carlen and E. Krüger

Lunch

Departure

Poster

Influence of enhanced soil temperature to the pathosystem strawberry-*Verticillium*
P. Schubert, H. Schwärzel, J. Golldack, P. Lentzsch

Increasing arthropod pest attacks due to climate change in the northernmost berry production area in EU
T. Tuovinen

Assessment the resistance of *Ribes* cultivars to the Blackcurrant Reversion Virus
J. Špak, D. Kubelková, J. Pribylová and V. Spaková

Climate change and the production of small fruits in the republic of Serbia
A. Leposavić and R. Cerović

Is climate change bringing positive effects on berry production in areas with higher altitude and short vegetation period?
S. Ercisli

Influence of climate change to berry crop growing in Latvia
K. Kampuss and S. Strautina

Climate change and performance of strawberry at Geisenheim, Germany
E. Krüger

Autumn Raspberry cultivars in Belarus
L. Liohkaya

Yield and berry characteristics of some northern highbush-blueberries grown at different altitudes in Turkey
H. Celik

Study of the water stress effect on some physiological characteristics in three strawberry cultivars
N. Ghaderi and A. Siosemarde

Getting water to roots in berry production: The challenges of poor soil wettability and root proliferation
B.M. McKenzie, P.D. Hallett and S.N. Jennings

Effect of mycorrhizal inoculation on photosynthetic activity of cranberry grown under different pH and water regimes – preliminary study
K. Klamkowski, B. Borkowska, W. Tryngiel-Gać and G. Krzewińska

Effect of some nutrient application on plant properties and fruit colour in organic strawberry production
A. Atasy and N. Turemis

Growing ‘Heritage’ red raspberry in greenhouse using organic farming methods in Adana, Turkey
I. Ordu, A. Burgut and N. Turemis

Strawberry PRPs fluctuate depending on genotype and seasonal conditions
G. Marzban, A. Herndel, B. Mezzetti, S. Tulipani, M. Battino, and M. Laimer

Antioxidant-response of salt treated strawberry plants to heat-stress
D. Neocleous and M. Vasilakakis

Influence of cultivation technics on health beneficial components in strawberry
M. Josuttis, E. Krüger, H. Dietrich

CLIMATE CHANGE IN EUROPE AND ITS IMPACTS ON FRUIT SPECIES PHENOLOGY AND PRODUCTION

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Recent global warming has been found to affect phenology of annual crops and forest trees. Possible physiological effects on phenology have poorly been investigated in Europe for fruit trees, when impacts on these plants are beginning to be visible. The fruit tree sector has specific vulnerabilities like perennial plantations and a complex process to achieve fruit production, involving various temperature requirements during a biennial development cycle. In this context our studies focused on possible effects during the dormancy and flowering phases that are determining steps in the elaboration of fruit yield. Particularly, the effects of warming were investigated for two main traits, i.e. the flowering time and the physiological abortion of floral primordia. Regarding the effects on flowering time, the main species of *malus* and *prunus* genera were involved considering a network of observation sites in different European countries (Belgium, France, Italy, Switzerland). Flowering data collected in these different sites have been chosen to highlight warming impacts on flowering time over a large geographic area (50°-42°N; 12°E-0°W). The analysis of chronological series of flowering dates were done using an appropriate statistical method to rightly characterize the response to warming and a modelling of flowering dates to understand how this response has been determined. This analysis was completed by an analysis of temperature changes during the successive chilling and heating phases required to break the dormancy and ensure the active floral growth respectively. Regarding the effects on floral abortion, the studies focused on the case of apricot tree as plant model due to its relatively high susceptibility to this process. Our approach involved quantitative assessments of floral damages, relationships with bud dormancy and multiple regression analysis.
Over the last 40 years, perceptible advances in mean dates of flowering stages have been observed for all the studied sites and fruit species. The statistical analysis of the longest series clearly supports the occurrence of a significant abrupt change in the time-course variation of flowering dates at the end of the 1980s toward more frequent early dates. The coincidence between this abrupt change and marked increases in temperature recorded since this period, in France particularly, led to consider the flowering advances in fruit trees as impacts of global warming. In addition, the modelling approach suggests that global warming exerted two opposing effects simultaneously, i.e. a slower mean rate of completion for the chilling requirement and a higher mean rate of completion for the heat requirement. A more marked effect on the completion of the heat requirement may have resulted from more pronounced temperature increases during the flowering phase of active floral growth (particularly in February and March), than during the dormancy-breaking phase (October to January). In some years, the rate of the chilling completion was unusually low, which led to unusual lengthening of the flowering at tree scale or at cultivars range scale, as to unusual flowering gaps between cultivars or regions. Regarding floral abortion, no significant effect in relation to warming was recorded, but some years have been characterized by unusual high frequencies of floral damages for a large number of cultivars, following high temperatures at the end of dormancy. These unusual events since the beginning of the 2000s, relating to flowering time and floral abortion, may be considered as beginnings of future warming impacts, while advances in mean dates of flowering stages and delays in mean dates of dormancy break are impacts in course since the end of the 1980s. Such changes in flowering patterns are liable to lead to production irregularities in Europe, because of new flowering conditions producing troubles in flowering intensity (floral abortion, frost risk / flowering advance), pollination (excessive flowering gaps), fruit set (flowering advance), fruit maturity time (advance and excessive lengthening of flowering). Changes in regional specificities may be also expected at the level of the panel of adapted cultivars.

wednesday, oct 29th, 14:15-14:45

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MODELLING OF CLIMATIC CHANGES IMPACT ON THE GROWTH AND FRUITING OF CURRANT AND STRAWBERRY IN THE SOUTHERN PART OF ROMANIA

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Ribes, Fragaria, simulation, climatic factors, fruit yield

Under the climatic conditions when severe changes and the global heating are foreseen, it is more and more difficult to spread the small fruits and strawberry crops in countries with a continental temperate climate, such as Romania. Most of these species are adapted to a cooler weather, higher relative air humidity and milder winters. In order to avoid negative influences of climatic factors by proper zoning and specific control methods, scientists have developed climate-based models. Models using cumulative heat or chilling units to predict spring growth and phenology and findings on the influence of climatic factors on growth and fruit bearing caused by natural variation in weather, belong to this category (Goldwin, 1992; Stopar, 1998; Chitu, 2000; Lakso et al., 2001; Bustan et al., 1996; Denes and Porpaczy, 2005; Honjo, et al. 2006; Rea et al., 2006 and Legave et al., 2008). The aims of this work were: a) to find climatic preferences for the black currant and strawberry cultivars, b) to determine critical periods for fruit formation processes, c) to evaluate a climate rating model in the region investigated, and d) develop an improved methodology and model to process primary weather data using computers in order to estimate the potential fruit yield under specific climatic conditions. A database of phenological observations for green tip, early blossom as well as petal fall, biological small berry parameters such as fruit yield, fruit number per bush, number of flower buds per bush, average fruit weight and percentage of harvested fruit number from the total number of flowers were used in 56 cv. of black currant (*Ribes nigrum L.*) and 30 cv. of strawberry (*Fragaria x ananassa*, Duch.) for a 29 (1980-2008) year period. The effects of climate variables including air temperature, sunshine hours relative air humidity, precipitation, Penman-Monteith reference evapotranspiration and precipitation deficit on small fruit crop production were examined using a weather database consisting of 40 years (1969–2008). Link strengths for the probabilities of weather data and biological parameters were evaluated. The climate rating estimation model was based on the identification of time intervals that produced strong correlations between major climatic and phenological dynamics. In the south region of Romania, an increasing trend in mean air temperature for the February through April period was apparent over the last 40 years. The trend of increasing mean air temperature is attributed rather to the maximum temperature growth than to the dynamics of minimum temperature which seem to stagnate. Over months, the minimum air temperature has shown a decreasing trend for February and of a slight increase for the March, April and May months. The standard deviation of the minimum monthly air temperatures has also increased during the last 40 years, specifically for April and much weaker for February, March and May, in a correlation between SD and time. In the past 29 years, the buds breaking occurred increasingly earlier, for instance 20 days earlier in the case of black currant (from March 28 to March 8). That was due to a continuous increase in the maximum temperatures during February and March. The beginning of blooming started also earlier because of the increase in the mean, but especially in the maximum temperatures (instead of April 17, it was on March 28). At the same time the fruit yield was negatively influenced both by an early buds breaking (R^2=0,673*), and also by an earlier blooming (R^2=0,723*).

wednesday, oct 29th, 14:45-15:05

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ECONOMIC IMPACTS OF CLIMATE VARIABILITY IN BERRY FRUIT – A DECISION ANALYSIS APPROACH

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Climate change, risk, simulation model, economics, berry fruits

The risk environment for agribusiness is constantly changing. Weather risks are a major source of uncertainty. The occurrence of adverse weather events increased in the last decade is likely to continue increasing due to climate change. However, producers should also take account of the economic instability likely to occur and this will manifest itself through price changes, changes in supply networks, employment and insurance availability.

Assessments of climate change on Croatian agriculture suggest that climate change will have positive effects on the increase in yields and quality of agricultural crops in continental part of Croatia. Nevertheless, crops will be threatened by higher air temperatures and the shortage of water during summer period. Researches on berry production have not been conduced yet.

The objective of the paper is to assess economic impact of climate variability on berry production, namely strawberry and blackberry in the continental part of Croatia. The factors that will be taken in consideration are increase in mean temperatures, changes in precipitation, increase in frequency and intensity of extreme weather events and greater weather variability (change in start and end of growing seasons).

In achieving mentioned goals quantitative and qualitative decision management methods will be used. Approach will be based on the steps in risk management: 1) Identify risk, 2) Risk Assessment and 3) Select risk management strategies. Stochastic budgets will encompass uncertain factors like yields, growing/harvesting season, irrigation cost and prices. In the scarcity of data sources, base for budgeting will be founded on empirical results from previous projects ran by Department of pomology (ten years period).

The paper aims to help berry producers to cope with increasing uncertainty related to climate risk by establishing a process of efficient risk management.

wednesday, oct 29th, 15:05-15:25

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HOW CLIMATE CHANGE COULD INFLUENCE BREEDING AND MODERN PRODUCTION SYSTEMS IN BERRY CROPS

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climate variability, salt-tolerance, everbearing, winter-hardiness, cool-season

Over the next century, the temperate regions of the world are projected to get hotter, rainfall patterns are expected to change, and the weather become much more variable. Of these, the increased variability will have the greatest impact on how we breed berry crops, and how we modify the production systems.

To ameliorate these changes, cultivars will need to be able to withstand rapid fluctuations in the cold weather in winter, be able to grow with little chilling, and be able to initiate flower buds in most environmental conditions. As rainfall and water-use patterns change, more plants will be raised in containers and grown in protected cultivation, which will increase soil salinity. Also, increased heat will stress plants and negatively affect pollination and fruit development.

With the existing berry crop germplasm, we should be able to develop everbearing cultivars that are salt-tolerant, extremely winter hardy, and grow in cool-season environments, except perhaps for everbearing *Ribes*.

At present, breeders tend to create new cultivars adapted to one environment, region or production system. However, to cope with extremely variable weather at single locations, breeders will need to develop new cultivars which are adapted to multiple environments and multiple cropping systems. To do this, breeders and crop physiologists must cooperate and design breeding systems which will create cultivars with the required heterozygosity.

wednesday, oct 29th, 16:00-16:30

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CLIMATE CHANGE EFFECTS ON STRAWBERRY PRODUCTION

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Fragaria, fruit yield, radiation, temperature

The impacts that future climatic conditions on agricultural productivity depend of sensitivity to each environmental factor and the relative changes in temperature, precipitation, EV-B radiation, atmospheric CO_2 concentration (Olesen and Bindi, 2002). Strawberry (*Fragaria x ananassa* L. Duch.) is a microclimatic crop almost worldwide cultivated. Spain is the world's second largest strawberry producer after the USA. Huelva is Spain's leading agricultural region, with about 6.800 ha of strawberry production, yielding 312.065 t of strawberries per year, of these 80% was exported (MAPA, 2006). The climatic conditions can vary considerable along the crop season. In this regard, there are two different periods into the crop season, a cold early crop season (low temperature and high relative humidity) between January and March (early production) and a warmer late crop season (high temperature and low relative humidity) between April and May. Temperature is limiting factor in crop productivity and a considerable amount research has been conducted on the individual effects of this factor on crop yield.

The aim of this work was to assess the possible effects of increased temperature on the strawberry production and crop cycle duration.

The assay was carried out in commercial strawberry fruit production fields on the Huelva (Southwest coast). Planting material of cv. 'Camarosa', fresh-plant, were planted between 8 and 26 October, under plastic tunnels, mulched with black polyethylene and drip-irrigated. Assay was repeated three times (between 2003 and 2006), winter-cultivation system was implemented every year.

The following crop was recorded weekly in production fields: Early and total strawberry production, in g per plant was recorded from January until March and from January until May, respectively.

There was a quadratic relationship between early production and temperature ($R^2 = 0,86$); and between total production and temperature ($R^2 = 0,69$).

Our estimates suggest that strawberry production can be affect by climate change. Due to the relationship between the rate of production and temperature, climate change scenarios will result in reductions in crop cycle duration.

wednesday, oct 29th, 16:30-16:50

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PHOTOSYNTHETIC RESPONSE OF STRAWBERRY LEAVES TO CHANGING TEMPERATURES

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cultivar, Fragaria x ananassa, harvest period, leaf age, photosythesis

Carbon fixation by photosynthesis is an important process for crop productivity. The photosynthesis of leaves is mainly influenced by genetic, physiological and growing conditions. For the future, large-scale simulations of climate change are predicting increasing temperatures. In addition, increasing temperatures are achieved by changing cultivation systems, such as cultivation under plastic tunnels. Little is known on the consequences of higher temperatures on photosynthetic activity of the strawberry leaves.

The photosynthetic activity of leaves of strawberry plants grown in the field under plastic tunnels was measured and related to leaf temperature. The response of net photosynthesis (P_{net}) of the leaves to temperature was carried out for different cultivars and differently aged leaves.

Light saturation of strawberry leaves was reached at a photon flux density of about 1400 μmol m^{-2} s^{-1}. At light saturation, P_{net} of the leaves increased with increasing temperatures and was highest at about 30°C within a range of 15 to 18 μmol CO_2 m^{-2} s^{-1}. With further increasing temperatures P_{net} decreased. However, at 40°C, P_{net} was still considerable with about 8 to 12 μmol CO_2 m^{-2} s^{-1} indicating that strawberry leaves seemed to be adapted to hot conditions.

Leaf age had a considerable influence on P_{net}. The youngest fully developed leaf of a plant was compared to 10, 20, 30 or 40 days older leaves. The youngest leaf has in average a significantly lower P_{net} than older leaves. However, leaf age had no significant influence on the P_{net} response to temperature.

In conclusion, increasing temperatures induced by climate change and/or cultivation under plastic tunnels seem not to be a limiting factor for photosynthesis of strawberry leaves.

wednesday, oct 29th, 16:50-17:10

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EFFECTS OF MODIFIED AIR TEMPERATURE AND RELATIVE HUMIDITY ON VEGETATIVE AND GENERATIVE PARAMETERS ON RED RASPBERRY

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raspberry, increasing temperature, relative humidity, cooling, plastic cover

The trial plots of the research station in Weinsberg are situated in South-West Germany on a plateau (200 m above sea) between the rivers Jagst and Kocher. The climate may be characterized as continental with relatively dry and warm summer months. Especially there are seldom thunderstorms with heavy rain during summer. The raspberry plant is understood to be a plant of the light forest preferring mild winter and warm but not hot summer with sufficient humidity.

With this background there were two trials put through in the end of the 1990ies. A temperature increase was caused by a permanent plastic cover. Various watering methods for cooling were used to decrease air and foliage temperature. Also an increase of humidity was expected. The raspberry varieties ‘Meeker’ and ‘Schönemann’ were planted.

According the plastic shelter it was found that in average of a year the air temperature was increased by 0,6 to 1,0° C. On hot summer days with high radiation the temperature was up to 8° C higher. But the temperature of the leaf area (canopy) did not increase that much. During the observation period there was an increase of vegetative growth, a decrease of number of canes and an increase of yield - in comparison to the open field. There was less non-marketable fruit because of grey mould (*Botrytis cinerea*) or sunburn. There were positive effects on the fruit quality. In conclusion the higher temperature did not effect the plants negatively.
The other trial was a comparison of three different water application systems for cooling on summer days. Variant 1 (control) was the drip irrigation, variant 2 spraying in between the plants and variant 3 overhead spraying above the planting. The water gifts started at a temperature of 25° C for two minutes. There was no effect of all methods on the air temperature. But there was an effect on to the leaf temperature in all variants. It could be dropped most in the overhead spraying variant (8 - 10° C). There was no difference found according the yield. In the overhead variant the amount of non-marketable fruit increased. There were also differences between the two varieties ‘Meeker’ and ‘Schönemann’. The growth, especially the cane length, increased enormously.

Actually there is no doubt, that the global temperature increased during the last 30 years and it is expected to increase further on.

As a result of the Weinsberg trials, it is shown that the favourite conditions for a raspberry are mild temperature and an optimal humidity - these conditions do especially support the vegetative elements. Among the forced changes of the climatic conditions there were no plant damaging effects.
In fact other climatic aspects as wind and rain seem to become more important.

wednesday, oct 29th, 17:10-17:30

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POSSIBLE IMPACTS OF CLIMATE CHANGE ON SOFT FRUIT PRODUCTION: THE EXAMPLE OF WINTER CHILL IN *RIBES*

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Climate change, weather, Ribes, chilling, flowering

This paper will initially review the ways in which climate change may be expected to influence soft fruit production in the coming years. This will include an analysis of the sensitivity of cropping to climatic variables including both water supply and temperature at different times of year, together with an analysis of evidence for historical and future climatic changes, concentrating on evidence from the UK. Implications of changes in summer growing conditions and of conditions, especially temperature, during the winter dormant phase will be assessed. Analysis of historical meteorological data confirms a trend towards warmer winters; this has led to increasing concern in parts of Europe that cropping of soft fruit species and cultivars may be adversely affected by mild winters, leading to insufficient winter chill and poor bud development in the subsequent year. Because of these concerns we will present a case study for blackcurrant *(Ribes nigrum*) from our research on understanding the chilling responses of different crops. Breeders need an accurate and high-throughput method for the phenotyping for winter chilling requirement, so that more environmentally adaptable cultivars can be developed for the future. Unfortunately there is still considerable uncertainty as to the basis of chilling with a wide range of chill-units having been adopted. For soft fruit, the commonest chill units include the accumulation of time below 7.2°C, the time between 0 and 7.2°C, and a model with increasing response to lower temperatures (Lantin, 1966). More sophisticated weighting schemes (Richardson et al., 1974) have also been tried. Sunley et al. (2006) showed that none of these are very successful at describing flowering in soft fruit, while there is evidence for varying sensitivity to cold in different cultivars.

We will present the results from a novel screening technique using a controlled environment. The approach was tested for twenty contrasting *Ribes* genotypes harvested from the field on 18th October 2007. These were then treated for periods of between 35 and 147 days at temperatures of -5°C, 0°C, 5°C or 10°C. Bud burst and flowering were then followed for each cultivar for each of the 20 treatments over 59 days after removal to 20°C. Using novel curve-fitting approaches we were able to establish chilling functions for the different genotypes. It was found that excessive chilling can actually be inhibitory, especially in some cultivars. The amount of bud burst or flowering was dependent on the cold treatment only, as long as minimal warming was provided. Different cultivars had markedly different chilling responses, so that any screening on the basis of a single chilling function is unlikely to be very useful. Notwithstanding some chill functions that are currently used we found that all cultivars had substantial response to -5°C temperatures, in some cases this temperature being more than 3 times as effective as 0°C, while 10°C was ineffective for many of the cultivars.

thursday, oct 30th, 8:30-9:00

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TEMPERATURE LIMITATIONS FOR FLOWERING IN STRAWBERRY AND RASPBERRY

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Climate, flowering, Fragaria, fruit yield, night temperature, Rubus

It is a common notion among strawberry growers that low temperature is required for short day (SD) induction of flowering in single-cropping strawberry cultivars. Because of this, many growers are concerned about the effect of the predicted and ongoing global warming on flower bud formation and yield of this crop. Therefore, the effect of night temperature on SD floral induction in three June-bearing strawberry cultivars of different geographic origin have been studied and compared with their yield performance in the cool Nordic environment. At the optimum day temperature of 18ºC, the SD flowering response of the cultivars ‘Florence’ and ‘Korona’ increased significantly with increasing night temperature from 9 to 18ºC, while an optimum was reached at 15ºC in the cultivar ‘Frida’ that is selected under cool-environment conditions in Norway. Also, while saturated flowering response was obtained with 3 weeks of SD treatment at all temperatures in ‘Frida’, several plants of ‘Florence’ and ‘Korona’ failed to initiate flowers at 9ºC night temperature even with 5 weeks of SD. The effect of extended SD was particularly pronounced in ‘Florence’. The slow SD floral induction response in ‘Florence’ was associated with a 2 week delay of anthesis in subsequent long day (LD) conditions at 21ºC. Yield performance of the same cultivars during two years under field conditions at Nes Hedmark and in North Norway also demonstrated that the yield potential of ’Florence’ was not realized under the climatic conditions prevailing at these locations. In both years, the yields varied significantly among the cultivars, ‘Frida’ having the highest yields followed by ’Korona’ with ‘Florence’ far below. It is concluded that, in the Nordic environment, autumn (September) night temperatures are obviously sub-optimal for yield performance of some June-bearing strawberry cultivars, and that the response is mediated by autumn temperature effects on flower initiation processes. Only at temperatures well above 20ºC is there an inhibitory effect on SD floral initiation in these cultivars. On the other hand, everbearing strawberry cultivars, which are LD plants, have no such high temperature inhibition of flowering under LD conditions.
In contrast, flowering and dormancy induction in biennial-fruiting raspberry cultivars have an absolute requirement for low temperature. In cultivars such as ‘Glen Ample’ neither process takes place at temperatures above 15ºC regardless of photoperiodic conditions and low temperature thus becomes of crucial regulatory importance in this crop. In annual-fruiting (primocane-fruiting) raspberry cultivars such as ’Polka’ on the other hand, flower bud initiation freely takes place at temperatures as high as 30ºC.
Implications of these contrasting temperature responses under a global warming scenario will be discussed.

thursday, oct 30th, 9:00-9:20

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GROWTH CONTROL OF RASPBERRY PLANTS WITH PROCA

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growth control, prohexadione-calcium, raspberry, Rubus idaeus

Vegetative growth of raspberry (*Rubus idaeus* L.) plants is vigorous. There is a need to control vegetative growth and establish an appropriate balance between vegetative and generative growth, i.e. to increase harvest index. Especially for year-round greenhouse production, compact plants with high cropping potential are needed. The aim of our study was to examine the use of prohexadione-calcium in growth control of raspberry plants.

Prohexadione-calcium (ProCa) has been found to control vegetative growth in many fruit species (Owens and Stover 1999, Medjoub et al. 2005, Smit et al. 2005). It also reduced vegetative growth of primocane raspberry cv. ‘Ariadne’ (Palonen and Mouhu 2008). However, ProCa did not prove useful for commercial production of primocane raspberries, since the number of flowers was decreased by the treatment. We studied the effect of ProCa on vegetative growth and cropping potential of biennial raspberry cultivars ‘Glen Ample’ and ‘Tulameen’. First year canes of plants grown in pots were sprayed with ProCa (concentration 100 ppm or 200 ppm) either once or twice in 4-week-interval during the growing season. For three weeks after the treatment, new developing internodes were shorter than in control plants. Treatments decreased primocane height by 7 to 35 % without affecting the node number. The response was stronger in cv. ‘Glen Ample’. This may be a significant growth reduction for purposes of commercial production, as handling and storage of shorter canes is easier.

As ProCa is known to increase carbohydrate content in plants (Owens and Stover 1999), carbohydrate contents of ‘Glen Ample’ canes and buds were determined at the end of the growing season. A minor effect was observed; starch and sucrose contents were slightly increased. After cold storage, canes were forced in a greenhouse. Budbreak was observed and the number of flowers was recorded to estimate crop potential. Budbreak was delayed in cv. ‘Glen Ample’ plants treated twice with ProCa. Furthermore, number of lateral shoots was reduced in plants treated twice with ProCa. However, laterals were longer and they produced more flowers than in control plants. Flowering occurred in two waves and was delayed in the plants treated twice. In cv. ‘Tulameen’ treatments had no effect on budbreak or timing of flowering. Cv. ‘Glen Ample’ produced 108 to 124 flowers per plant and cv. ‘Tulameen’ 85 to 105 flowers per plant, in different treatments. Crop potential was not affected by ProCa in either of cultivars.

As ProCa breaks down in plants in a few weeks (Evans et al. 1999), the timing and the number of treatments is critical for successful growth control. In raspberry plants treated twice, the later treatment may have interfered with flower bud initiation. ProCa seems to be an appropriate growth regulator for biennial raspberry cultivars, as it reduced vegetative growth without affecting crop potential. However, timing of treatments needs to be further optimized.

thursday, oct 30th, 9:20-9:40

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EARLY AND LATE PRODUCTION OF RASPBERRIES, BLACKBERRIES AND RED CURRANTS

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Production techniques such as early and late production of raspberries, blackberries and red currants were developed the last 2 decades and are practiced on relatively large scale. These modern cultivation systems allow to produce top quality fruit for a long period and to realise high yields. To achieve this, plants are grown in containers and under protection. Growing plants in pots maximises yield, allows two cultures a year in the same greenhouse or tunnel, has possibilities for cold storing and manipulating plants and to separate physical plant growth and fruit production. Early production is practiced in heated greenhouses and closed plastic tunnels. Late production of raspberries is done by using cold stored plants under rain shelters and in closed plastic tunnels or green houses.

The changing climate and the need for more sustainable cultural management will change the present production system and clearly demand another approach in research and development.

For the cultivation of berry crops in containers peat is mostly used as substrate. We need a renewable substrate that is stable in time, can be recycled and has comparable physical characteristics to peat. When plants in pots are fertigated drain is needed as a good cultural practice, sometimes up to 20% of the given amount of water. This water, rich in nutrients should be collected and used again. Also necessary is a better understanding of the amount and time of irrigation as it is determinant for plant quality and plant condition but also for yield and fruit quality.

In raspberries variety trials and breeding will be even more important. We need low chill cultivars with short laterals that grow well in most environmental conditions. There is a renewed interest in primocane fruiting raspberries because of new high fruit quality varieties which permit to program the picking season by cultural practices without cold storing plants. We need a better understanding how irrigation, nutritional solution, growing season and other factors influence cane length, flowering and number and size of fruiting laterals.

In blackberries ‘Loch Ness’ proved to be a very suitable variety for early and late production. There is also a possibility to double crop the canes in greenhouses by cutting back the fruiting laterals the end of June after the spring production. This gives a second crop in autumn and allows a late production without cold storing plants.

Red currants have a much higher chilling requirement compared to raspberries and blackberries and can’t successfully be cultivated in South European countries like Spain and Portugal. In Belgium and the Netherlands there is a small early production in heated greenhouses. Junifer has the lowest chilling requirement and is the only variety suited for this type of production. After soft winters bud break is uneven or poor, flower period is lengthened and the flower and fruit development uneven. Overall this leads to fruit and flower fall and thus low yields and poor fruit quality. There is a need to control the break of dormancy and the balance in flowers and flowering time.

thursday, oct 30th, 10:10-10:40

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EFFECT OF POLYETHYLENE TUNNEL CULTIVATION ON FRUIT QUALITY AND YIELD OF TEN STRAWBERRY CULTIVARS

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Fragaria x ananassa, soluble solid contents, color, temperature, antioxidant capacity

Strawberries are the most important berry crop cultivated in Europe. The production of high quality fruits is essential to enhance fresh consumption. However, the sensory quality of strawberry fruits is often criticized by the consumers. Previous studies have shown that consumer appreciation is directly related with sweetness and aroma content of the fruits. Two main factors directly influence strawberry quality: the genotype and the growing environment.
Large-scale simulations of climate change predict in general an increase of temperature in the future. The aim of this study is to evaluate the effect of increasing temperatures on plant growth, yield and fruit quality. For this purpose the environmental conditions were modified from end of winter to end of harvest through the presence or absence of polyethylene tunnels. New polyethylene plastic was used to avoid a strong reduction in photosynthetic active radiation by the tunnel. Temperature, relative humidity and photosynthetic active radiation inside and outside the tunnels were continuously monitored during flowering, ripening and harvest. The fruit yield and the leaf area per plant after harvest of ten cultivars were measured. The colour, the firmness, the soluble solid content, the titratable acidity and the antioxidant capacity of the fruit were analysed at two harvest dates: seven days and fourteen days after the beginning of harvest.
The genotype x environment interaction regarding the measured parameter will be presented and discussed.

thursday, oct 30th, 10:40-11:00

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POTENTIAL OF THE EUROPEAN BLUEBERRY (*VACCINIUM MYRTILLUS*) FOR CULTIVATION AND INDUSTRIAL EXPLOITATION IN NORWAY

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Climate, cultivation, nutrition, growth, yield, antioxidants, soil parameters

Today there are no industrial exploitations of the Norwegian wild blueberry (*Vaccinium myrtillus*), in contradiction to the highly exploited lowbush blueberry of Canada. However, because *Vaccinium myrtillus* have a higher content of biological compounds important for human health (antioxidants etc.) than the lowbush blueberry, there is an increasing demand for this berry on the market. In this new project running from 2008 to 2011, the potential for industrial exploitation of *Vaccinium myrtillu*s in Norway will be examined through a set of treatments that are based on experiences from Canadian cultivation and receiving experiences. This includes examinations of halfcultivation on forestland including; clear-cutting of forest, periodical cutting of plants, fertilization and water management and the effect of competition with weeds and under wood. The growth and development of blueberry on farmland will also be examined. All these cultural tasks will change the environmental conditions of the blueberry in addition to the effect of an ongoing climatic change. Climatic examinations will be undertaken supported by meteorological stations in forest fields, and under controlled experiments in phytothrones and experimental greenhouses.
In addition to growth and fruit yield parameters and plant growth dynamics, there will be made examinations on biological compounds like antioxidants and on soil parameters like nutrients, soil profiles and mycorrhiza. This will be undertaken on plant populations from South, Mid- and North Norway covering latitudes from 61°N to 68°N.

thursday, oct 30th, 11:00-11:20

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ATTEMPT TO IDENTIFICATION OF QARE-QAT (*VACCINIUM ARCTOSTAPHYLOS* L.) TRAITS AND INTRODUCTION TO IRAN'S HORTICULTURE

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Qare-Qat, Vaccinium arctostaphylos, Botanical and Chemical traits

To remove of doubt about fruit named Qare-Qat, two wild small fruits were studied and finally it be distinguished that Qare-Qat is the same *Vaccinium arctostaphylos* L., which is erroneously said to another wild berry in *Ribes* genus. Qare-Qat that called Siahgileh or Siahdar in some regions of Iran is a member of *Ericaceae* (or *Vacciniaceae*) family and Ericals order. It grows in northern mountains of Iran including Talesh, Asalem, Fuman, Kalardasht and Ardebil forests (Amin, 1991, Sabeti, 1994, Akhondzadeh, 2000). Study of Qare-Qat habitats climate indicated the plant grows in cold forest climate, which is special for highlands. These areas are located up to 1100 to 1900 meters above sea level and have acidic soil with high organic matter content. Qare-Qat habitats have cloudy days in growing seasons. Botanical study of Qare-Qat showed that it grows at shrub or woody bush form up to 2.5 meters high in Fagus forests. The stems are mostly thin, without thorn and green to brown colors. The alternifolius leaves of the plant are ovate or elliptical shape, up to 10 cm in length, with entire margin and very short petiole, which open in spring. Its hermaphrodite flowers appear in raceme inflorescence with pinkish red to white color petals. They start to open at June. Qare-Qat has many shallow roots. Globular fruits of it are many seeded and are borne on young shoots on the lateral or terminal buds. Seeds in clued mostly 5.9% of berries weight. Each seed and berry weighs 0.31 milligrams and 270 milligrams respectively. Average diameter of Qare-Qat berries is 9.47mm that seems smaller than other cultivated *Vaccinium* berries. Anatomy of leaf and stem of this plant studied using light microscope. In the cross-section of stem can be seen cuticle, epidermis, collenchyma, spongy parenchyma, vascular bundle (phloem and xylem) and pith. Electron micrographs obtained by scanning electron microscope (SEM) showed that Qare-Qat seeds are ovate or elliptical in shape and seed coat is reticular. Essential oil of Qare-Qat shoots obtained by water distillation in a Clevenger type apparatus and the compounds identified by GC-MS. Results revealed that the major volatiles present in Qare-Qat shoots are Hexadecanoic acid (27.0%) and Vitispirane (6.5%). This experiment showed that the ripe fresh fruit of V.arctostaphylos L. have 6.8 % sugars, 3.4% protein, 0.32% fat, 0.7% tannin, 77.75% water, 362ppm potassium, 51 ppm magnesium and 7.9 ppm iron. In study of horticultural traits, chilling requirement of Qare-Qat seeds is assessed and the best condition for seed germination is studied ANOVA of data at 60th days after transferring of seeds to germination condition indicated a significant difference between two levels of first factor (A: number of chilling days) at 5%, and between two levels of second factor (B: dry or wet chilling) at 1%. The results showed that dry chilling of seeds for 15 to 90 days can be removed Qare-Qat seeds dormancy. An experiment was conducted for assessment propagation of Qare-Qat by stem cutting using IBA and NAA, but it did not obtain good results. So that nothing of hormone treatments (500, 1000 and 2000 ppm) caused rooting of cuttings.

thursday, oct 30th, 11:20-11:40

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PLANT DISEASES IN CHANGING ENVIRONMENT

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Plant diseases, temperature, rainfall, plant resistance

Climate change has recently been discussed widely. According to the IPCC Panel documents, the changes in temperatures are expected to be greatest in northern latitudes. Expected changes in temperatures and rainfall will make it more likely than now for some diseases to spread and survive over the winter season in northern areas. Pathogens favored by changing climate include powdery mildews, *Phytophthora* species and bacterial pathogens. *Colletotrichum* species may also increase with changing host cultivation and viruses can benefit from increasing vector populations.

Powdery mildew has recently become an increasing problem in Finland on red and white currant even in cultivars where it has not previously been detected. In these species, widespread fruit infection can reduce crop yield and quality. Black currant is also infected by the fungus *Podosphaera mors-uvae*, but it does not affect fruit quality.
Colletotrichum species have not been common in nordic small fruit cultivation. *C. acutatum* has been a quarantine disease on strawberry and has not been able to establish in strawberry cultivation. It has, however, been detected on sweet cherry in Norway. In future, the status of *C. acutatum* will change. To estimate the risk of disease spread and the potential for its survival in production fields, some alternate hosts have been investigated for their ability to transfer infection to strawberry in Finnish conditions. Blueberry cultivation is increasing in Finland and *C. gloeosporioides* was detected in 2003 on fruit in the field and storage. Infection is favored by high temperatures and rainfall. *Colletotrichum* species are easily transported with planting material, but severe infections require high humidity and high temperatures. With increasing plant trade the risk for these diseases capable of surviving in nordic conditions has increased.
Phytophthora diseases, especially *P. cactorum*, have spread widely with plant trade. Increased use of frigo and waiting bed plants has brought more infected plants to farms and, consequently, increased fungicide use to avoid plant losses. Soil-borne pathogens like *Phytophthora* species are favored by heavy rainfall and high temperatures. To be able to avoid disease problems, plant resistance to *P. cactorum* has been evaluated of the cultivars introduced for cultivation in Finland since 1993. Crown rot resistance is also evaluated in the Finnish strawberry breeding programme. Quarantine pathogens among *Phytophthora* species, *P. fragariae var fragariae* and *P. fragariae var rubi*, have not yet been detected in Finland. Once recovered in planting material, increased rainfall, especially during prolonged autumn periods, can promote infection of these diseases which can infect at lower temperatures.

thursday, oct 30th, 14:00-14:20

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BIOTISATION OF RED FRUITS FOR INCREASING PLANT STRESS TOLERANCE AND ANTIOXIDANT ACTIVITY

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Plant breeding, mycorrhization, Phytophthora fragariae var. rubi, antioxidant activity, PCR diagnostics

Chemical inputs used in red fruit production can be detrimental to the environment and pesticides are not always efficient in controlling plant diseases. In addition, it is suspected that conventional agricultural practices have a negative impact on antioxidant activities in red fruits. Therefore new cultural approaches are required in order to produce red fruits of high quality. This involves an integrated programme of plant breeding and development of sustainable agricultural practices.
In the case of raspberry, a plant breeding programme is under way for the selection of varieties which produce higher quantities of antioxidant molecules, are more tolerant to *Phytophthora fragariae var. rubi* and which are not dependent on large quantities of mineral fertilisers for optimal growth. For this purpose, the KRL test (Prost 1990) is being used for assessing antioxidant activity in leaves and berries of different raspberry varieties. In addition, an in vitro tolerance test to *P. fragariae var. rubi* is being developed for screening hybrids.
Biotisation is a new complementary biotechnological approach which consists in inoculating young plants with beneficial microorganisms such as bacteria and mycorrhizal fungi for improving plant growth and tolerance to biotic and abiotic stresses (Gianinazzi et al., 2003). The aim of our work is therefore to optimise biotisation of raspberry, strawberry and blackcurrant for its use in real plant production systems. Biotisation was shown to be most efficient at the step of acclimatisation of in vitro produced plants. When used in combination with appropriate growth substrates and fertilisers, it could improve plant growth and enhance antioxidant activity in leaves. In addition, it was shown to increase water content in plant leaves, suggesting that biotised plants would have a greater ability to resist to water stress, which is an important aspect in the context of climatic changes. Finally, in order to ensure raspberry plant phytosanitary status, a PCR-based diagnostic test has been developed for checking the presence of inoculated mycorrhizal fungi and the absence of *P. fragariae var. rubi* in plant roots.

References

Gianinazzi S, Oubaha L, Chahbandar M, Blal B, Lemoine MC (2003): Biotization of microplants for improved performance. ISHS, Acta Horticulturae, Belgium, 625: 165-172.
Prost M. (1990): Process for the determination by means of free radicals of the antioxidant properties of a living organism or potentially aggressive agents. US patent 5, 135, 850.

thursday, oct 30th, 14:20-14:40

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PHYTOPATHOLOGICAL PROBLEMS OF STRAWBERRY IN ERZURUM, TURKEY

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Strawberry, Fragaria, disease, Turkey

Strawberry (*Fragaria x ananassa Duchenne, Rosaceae*) is one of the most popular fruits cultivated and consumed worldwide including Turkey. Strawberries have a unique, highly desirable taste and flavor and are one of the most popular edible spring and summer fruits. During the last decade strawberry production has spread throughout almost all parts of Turkey. In 2004 Turkey produced 155,000 t of strawberries on 10,400 ha. The strawberry is increasing importance in the Erzurum (1850 m above mean sea level), Eastern Anatolia, Turkey. The general climate of the Erzurum is terrestrial climate with cold winters and dry summers. According to record of 2007, 8.5 t organic strawberries were produced in Erzurum. Strawberries are produced on black polyethylene-mulched beds in Erzurum.

High yields of quality strawberries require vigorous growth and healthy plants. Growth can be affected by many different factors such as soil fertility, lack of moisture, weeds, insects, and diseases. Growers can control all of these factors, while certain factors, such as weather conditions, cannot be controlled. Diseases are major factors limiting production of strawberries in Turkey. The most important disease of strawberry in Erzurum has been grey mould (*Botrytis cinerea)*, and soil borne diseases (*Rhizoctonia spp., Fusarium spp., and Verticillium sp.*).

thursday, oct 30th, 14:40-15:00

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EVALUATION OF NEW STRAWBERRY CULTIVARS AND OF BENEFICIALS MICROBES TO IMPROVE STRAWBERRY PRODUCTION IN *VERTICILLIUM*-INFESTED SOILS

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Fragaria, cultivar, Verticillium, beneficial microbes, fruit quality

Soil-borne pathogens, all above *Verticillium sp*., cause plant loss and yield decrease in many Austrian strawberry regions. A reduction through wide crop rotation is not possible because of long-living spores. The use of soil fumigants is forbidden and other methods of reducing soil-borne pathogens effectively are not found yet. ‘Elsanta’, the main early-mid season strawberry cultivar in parts of Europe, though convincing because of good fruit characteristics and high yield, is highly susceptible to soil-borne pathogens (Barth et al. 2002, Spornberger et al. 2005). Aims of this project were, on the one hand, to test new strawberry cultivars in different Austrian strawberry regions regarding their robustness regarding soil-borne and fruit diseases to serve as alternative to ‘Elsanta’, and on the other hand, to test the application of beneficial microbes to ‘Elsanta’ to increase the resistance of the plants.

13 cultivars were planted in 2005 at 11 sites in 5 different regions. Infestation with *V. dahliae* was evaluated in 2005 and 2006 at 7 sites and in 2007 at 3 sites. Moreover marketable yield, percentage of different categories of unmarketable fruits, plant vigour, and incidence of chlorosis and of leaf spot diseases were assessed on 2 of the sites in 2006 and 2007.

‘Elsanta’ showed the highest infestation with *V. dahliae* whereas ‘Salsa’ and ‘Daroyal’ were most tolerant. ‘Daroyal’, ‘Queen Elisa’, ‘Eva’ and ‘Dora’ showed very high plant vigour. Highest marketable yield per plant had the late ripening cultivars, particularly ‘Salsa’ and ‘Sonata’. Of all early ripening cultivars tested, ‘Darselect’ showed the highest yield, followed by ‘Elsanta’, ‘Daroyal’ and ‘Alba’. In conclusion, the early ripening cultivars ‘Alba’, ‘Clery’, ‘Daroyal’ and ‘Queen Elisa’ can be used as new alternatives to ‘Elsanta’, though ‘Alba’ and ‘Clery’ are only partially tolerant to *V. dahliae*.

For the inoculation trial, following microorganisms were chosen because of their antagonistic and plant strengthening potential shown in previous experiments: *Bacillus subtilis* (FZB24), *Trichoderma harzianum* (PROMOT) and *Serratia plymuthica* (RHIZOSTAR). The effects of these products were tested in a pot culture, once using a substrate inoculated with *Verticillium dahliae* and once using a non-inoculated substrate. In 2007 and 2008, fruit yield and fruit quality parameters were assessed. After harvest in 2008, leaf and root dry weight was measured.

Plants treated with RHIZOSTAR tended to produce more fruits in 2008 and had a significantly higher leaf dry weight. Plants treated with FZB24 or PROMOT did not differ significantly from the non-treated plants regarding yield and leaf and root dry weight. There were found differences in some fruit quality parameters between the treatments.

thursday, oct 30th, 15:00-15:20

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MOLECULAR CHARACTERISATION OF FLOWERING IN PERENNIAL FRUIT TREES AND SHRUBS

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Flowering time, winter chilling, genetic regulation, fruit gene database

Flowering time and pattern determine the time, duration and intensity of fruiting. Current fruit production methods therefore revolve around control of the flowering process. Flowering initiation is a function of internal plant hormone levels and environmental conditions such as day length and temperature. This process is best understood in herbaceous model species where several major pathways exist (Mouradov et al., 2002), that lead to promotion of flowering through removal of floral repressors and promotion of floral activators (Boss et al., 2004). Some of the floral activators were recently demonstrated to fulfil the role of the flowering hormone, florigen (Corbesier et al., 2007; Tamaki et al., 2007; Lin et al., 2007). These pathways eventually converge by regulating the floral meristem and floral organ identity genes (Pineiro ad Coupland, 1998).

In perennial plants, that include fruit trees and shrubs, flowering initiation is less well understood. In addition, perennial plants go through annual cycles in which periods of active growth are interspersed with stress resistant dormancy periods. Release from dormancy and flowering are often closely coordinated and regulated by appropriate environmental signals (Horvath et al., 2003), most importantly winter chilling. Therefore, changing climate conditions are expected to have a serious impact on fruit production.

HortResearch's flowering group focuses on molecular mechanisms that control flowering in kiwifruit, apple, and other temperate fruits. One of the research areas seeks to understand the role of the environment, such as photoperiod and temperature. HortResearch has an extensive fruit gene database from apple (Newcomb et al., 2006), kiwifruit (Crowhurst et al., 2008), and blueberry. Within this database a number of candidate genes have been identified that are implicated in the regulation of flowering time and floral development. We are functionally characterising them through expression analysis, reverse and forward genetics, mapping and germplasm comparisons. We are using this knowledge for marker assisted breeding, crop management, production of rootstocks and transgenics. We are also extending this knowledge into related fruit species within the orders *Rosales* (*Fragaria, Rubus, Ribes*) and *Ericales* (*Vaccinium*). The examples of kiwifruit and blueberry will be presented to describe the genetic regulation of initiation and maintenance of floral fate in a perennial fruit crop and the impact of climate conditions.

friday, oct 31st, 8:30-9:00

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VARIATION OF GENETIC DISSECTION OF SEASONAL VS RECURRENT FLOWERING ACCORDING TO YEAR IN THE CULTIVATED STRAWBERRY

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Ciref CVFFR, Maison Jeanette, Douville, FR

everbearing, Fragaria, environment conditions

In France, among the most important agricultural productions, strawberry (*Fragaria*) is important for rural development and for maintaining an activity in rural regions. Today, this species is subjected to evolutions due to the global warming and due to modification of agronomical techniques (e.g. development of soiless culture). The new challenge for this crop is to control flowering in order to better manage fruit production. In this species, two different modes of flowering exist. These modes affect the flowering duration and therefore the period of fruit production. Flowering can occur only once a year in spring (seasonal-flowering genotypes) or can occur all along the growing period of the plant (recurrent flowering genotypes). Between these two extremes, all intermediate modes of flowering can exist. Our research aims to better characterize the molecular and genetic determinism of flowering. The applied objective of this research is to develop novel strawberry cultivars with extended production for better competitiveness and easier management of farmer work. This work is conducted in collaboration with private companies in order to give benefit to consumers as to strawberry industry.

Mapping of quantitative trait loci (QTL) controlling the flowering duration of cultivated strawberry (*Fragaria x ananassa Duch.*, 2n=8x=56) can be used to provide a better understanding of its genetic control and to develop marker assisted selection for breeders. For this purpose, a segregating population of 213 individuals of a cross between 'Capitola' and CF1116, two genotypes with contrasting flowering modes, was used for genetic mapping. In order to evaluate the seasonal vs recurrent flowering, the number of inflorescences was measured at the end of July for seven years.
A total of three significant QTLs was detected by composite interval mapping, both located on the female map. One of these QTL was detected each of the seven years of observation. Since its percentage of phenotypic variance explained was high to very high according to the year (from 20% to 88%), it can be considered as major QTL. Despite the major QTL was detected all the years of measurments, the differential expression of the other QTLs across years suggest strong impact of the environment on the recurrent flowering trait.
The identification of QTLs linked to the mode of flowering is a first step to understand genetic and molecular control of everbearing strawberry in order to better manage strawberry production in the context of climatic change.

friday, oct 31st, 9:00-9:20

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INVESTIGATING THE RESPONSE OF STRAWBERRY TO WATER-DEFICIT CONDITIONS

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Fragaria, water- use efficiency, yield potential, drought avoidance, drought stress

If climate change predictions are correct, water availability will become a major limiting factor on horticulture production. For long term sustainability, there is a substantial requirement for strawberry (*Fragaria x ananassa*) cultivars that utilise water more efficiently. However little is known about the potential tolerance of commercial cultivars and the mechanisms by which the *Fragaria* species respond to soil moisture deficits.

To gain a better understanding, we measured the response of ten commercial cultivars to water-limited conditions in 2007. Potted bare-root plants of each cultivar were subjected to 2 irrigation regimes in a randomised block design. The well-watered control plants were provided with irrigation to replace 100% of the water that had been lost through evapotranspiration, whilst the water deficit plants only received approximately 66% of the crop evapotranspiration. For each plant we measured traits associated with yield potential (photosynthesis and stomatal conductance measured by porometry and thermal imaging), drought avoidance (root dry mass), reduced water use (shoot dry mass and leaf area), osmotic adjustment and water use efficiency (carbon isotope discrimination and fruit yield). Leaf water potential, a standard indicator of plant stress, was measured at predawn and midday twice during the fruiting period.

A significant decrease in the predawn leaf water potentials of the deficit irrigated plants indicated that these plants were exposed to stress. At midday, the variation in water potential between cultivars suggested that some tolerate drought better than others which was partly due to the plants maintaining a greater stomatal conductance. Indices derived from thermal imaging of the leaves were found to be more stable than measurements using a porometer and showed more consistent and clear differences between cultivars. Carbon isotope composition of leaves, fruit and crowns showed an increase in photosynthetic water-use efficiency (WUE) in deficit-irrigated plants, with significant difference between cultivars indicating that there is variation within *F. ananassa*. Therefore carbon isotope composition and thermal imaging, which potentially relate to WUE, were found to be the most suitable screening tools for further investigations.

In 2008 the responses to soil-moisture deficits of four *F. ananassa* cultivars, that showed a relative difference in WUE in the previous experiments, were studied alongside four *F. chiloensis* accessions. Since *F. chiloensis* is frequently found colonising coastal sand dunes it should have inherent mechanisms for coping with drought stress. The accession of *F. chiloensis* that is deemed the best at tolerating drought will be crossed with a *F. x ananassa* cultivar to produce a progeny segregating for WUE. This will allow quantitative trait loci (QTL) to be mapped and molecular markers identified that can subsequently be used to develop cultivars that are capable of performing under conditions of water stress.

friday, oct 31st, 9:20-9:40

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THE ATTEMPTS TO FIND OUT BIOCHEMICAL MARKERS RELATED TO FROST TOLERANCE IN RED RASPBERRY AND BLACKBERRY

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Rubus, osmoprotectants, proline, soluble carbohydrates, hardening

The increasing demand for nutripharmaceuticals affects raspberry fruits, which are valuable dietary components in the fresh fruit market, and used in the food and cosmetics industries. Besides trying to yield high fruit quality and good shipping traits, breeding programs also focus on good environmental adaptation (Finn & Hancock, 2008). For effectivity of breeding program important is to begin selection of individual genotypes containing wanted traits in seedling or mutant populations as early as possible.

We attempted to establish biochemical markers for selection of more winter hardy genotypes, on the base of contents of osmoprotectants – proline and soluble sugars in in vitro shoot cultures. The contents of proline and sugars were measured in hardened and non-hardened shoot explants of six raspberry and two blackberry cultivars. The experiment on surviving and ability to regeneration after freezing of in vitro shoots – hardened and non-hardened in temperatures from -1 to -22°C was made. Six weeks after freezing surviving was evaluated and green shoots were subcultured to fresh multiplication medium for evaluation of regeneration ability.

Cultivars differed in proline and sugar levels in the control and after hardening. Content of osmoprotectants was higher in hardened shoots. The rate of increase in osmoprotectant levels depended on their initial content. Genotypes with higher level of proline in unhardened shoots produced relatively less proline in the result of hardening but the content of proline after hardening was highest in these genotypes Hardened shoots of blackberry survived and regenerated better than raspberry. Hardened shoots survived in higher percentage than non-hardened. Ability to survive and regenerate after freezing depended on genotype.

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friday, oct 31st, 9:40-10:00

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THE INTERACTION OF PLANT GENOTYPE AND CLIMATE CONDITIONS AFFECTS STRAWBERRY NUTRITIONAL QUALITY

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Fragaria, climatic factors, nutritional quality

Fruit possess different antioxidant properties depending on their content in antioxidant molecules, as it has been recently shown by studies demonstrating that strawberries have more antioxidant capacity (from 2 to 11 fold) than apples, peaches, pears, grapes, tomatoes, oranges or kiwifruit. Furthermore, the high nutritional value has to be combined to high fruit quality, both from an organoleptic-sensorial point of view. All these important components of the fruit nutritional quality are strongly affected by the type of fruit (species and variety within species), but they are also affected by the cultivation conditions of the plant (environmental and cultivation techniques).

The interaction of these different factors in determining strawberry nutritional quality in a specific cultivation conditions should be established to better characterize the agronomic production and information to the consumer.

For these reasons we carried out a study comparing the variation of fruit nutritional quality of 4 different varieties (Dora, Irma, Patty and Sveva) in 4 different years of production (2005-2006-2007-2008) in order to explore the relationships among them and the possible variations due to the genotype and specific annual climatic conditions.

Fruit nutritional quality was analyzed by detecting the following parameters:

Quality attributes: Fruit Colour, Firmness, Soluble Solids and Total Acidity, measured the same day of each harvest.

Nutritional attributes: Total antioxidant capacity (TAC), measured with the TEAC method, and total polyphenoles (TPH), analyzed on undamaged fruit samples (300g – 600g), including pooled fruit of the 3rd, 4th and 5th main harvests.

The results are confirming the importance of the genotype in defining the fruit nutritional quality but also the strong influence of the annual climatic conditions in changing the behaviour particularly of some genotypes. The variation detected for both quality and nutritional attributes will be analyzed by considering the annual trends of the climate parameters (mainly temperature) particularly during the ripening period.

This type of study can be considered of interest to better identify genotypes with a more stable performance in terms of fruit nutritional quality at different climatic conditions, so to gurantee higher quality standards to the consumer even at changing climatic conditions.

friday, oct 31st, 10:30-10:50

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DIFFERENTIAL EFFECT OF WATER DEFICIT IRRIGATION ON FRUIT QUALITY OF FIVE JUNE-BEARING STRAWBERRY CULTIVARS

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Berry size, Fragaria, organic acids, sugars.

With increasing evidence of the effect of climate change on water resources, concerns are arising due to the high water extractions used for some horticultural purposes. In the last decade, water deficit irrigation has been seen as a potential alternative for new cultivation systems which could considerably reduce water usage in several horticultural crops. Deficit irrigation (DI) is generally associated with reduction in strawberry fruit size and yield. However, a recent study demonstrated that DI on strawberry (cv. 'Elsanta') can increase the concentration of some taste- and health-related compounds in fruit (Terry et al., 2007 J. Agric. Food Chem. 55, 10812-10819). In this context, the aim of the present study was to assess the response and variability between five different strawberry cultivars (viz. 'Christine',' Elsanta', 'Florence', 'Sonata' and 'Symphony') to imposed water-DI conditions.

Water-DI affected both fruit physiology and biochemistry. Nevertheless, the response to drought stress was different for each cultivar. Anthesis occurred significantly later in drought stressed plants for cvs. 'Elsanta', 'Florence' and 'Christine' but was not affected for cvs. 'Sonata' and 'Symphony'. Fruit ripening (i.e anthesis until full red stage) was also significantly delayed for some water-stressed cvs. ('Elsanta' and 'Florence' and Sonata). Indeed, 'Elsanta', 'Sonata' and 'Symphony' showed a greater reduction in berry size, accompanied by a significant increase in dry matter content, for fruit harvested from DI-treated plants than from plants kept at or near field capacity. Concomitant to this and where dry matter was increased the concentration of sugars and some acids were generally higher in DI-derived fruit. Fruits cv. 'Elsanta' resulted in a 1.4-fold increase in fructose content (on a fresh weight basis) when grown under DI conditions and thus was in agreement with Terry et al. (2007). However, cvs. 'Florence' and 'Christine' did not show significant variations in berry weight or any of the target analytes measured when grown under the conditions imposed in this study. The results presented herein suggest that reducing water irrigation may be a viable alternative to increase fruit quality in cvs. 'Elsanta', 'Sonata' and 'Symphony' but may not have a negative impact on fruit quality of cvs. 'Christine' and 'Florence'.

friday, oct 31st, 10:50-11:10

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ANTIOXIDANT- ENHANCING AND UNDERSTANDING IN STRAWBERRY FRUITS

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Salinity, Organic strawberries, Salicylic acid (SA), Antioxidants

Commercial frigo strawberry plants (*Fragaria x ananassa Duch*) cv. ‘Camarosa’ were cultivated in a non-heated greenhouse under soilless cultivation. The plants were planted in 3L plastic pots with peat:perlite (1:1) as the planting medium. The recorded average temperature and humidity from beginning of cultivation until end of harvest was 20 °C and 55% relative humidity. At pink fruit stage the plants were supplied with half-strength Hoagland nutrient solution (pH~6.0) containing 0, 10, 20, and 40 mM NaCl. The above salt concentrations corresponded to EC 1.4, 2.9, 3.9 and 6.7 mS cm^{-1} respectively. Fruits were picked at three consecutive harvests after salt treatment started and results are the mean values. The response of strawberry plants under salt-stress conditions, revealed that the phenylpropanoid and flavonoid pathways are still intact and functioning enabling fruit tissues to respond to external signals (abiotic stresses) for defence requirements (antioxidative molecules involved in redox reactions).

We attempted also to determine if the synthesis of phenolic compounds is influenced by the production system e.g. organic or conventional. In this experiment frigo strawberry plants cv. ‘Camarosa’ were organically and conventionally cultivated in 3L pots. The practices mainly concerned organic vs. inorganic fertilizers and pesticides. Some fruit quality attributes, the synthesis of phenolic compounds and subsequent antioxidant response of strawberry fruits were examined. Results correspond to mean values of three consecutive harvests and revealed that phenolic compounds and subsequent antioxidant capacity are higher in organically grown strawberries and this may suggest that organic strawberries are expected to benefit human health better than those from conventional production.

Finally an experiment was conducted to determine the SA’s relation to ethylene biosynthesis in strawberry fruits. This is started because SA which has been reported to act as a component of the signal transduction system important in defence mechanisms may also provide protection again certain abiotic stresses. Salicylic acid (SA) significantly affected fruit postharvest ethylene production in comparison to the control fruit. This may suggest that SA and Ethylene signalling pathways do not act individually and these signalling compounds it is possible to interact during biotic and abiotic stresses in strawberry plants

In order to facilitate the above mentioned results the following determinations were accomplished:
Evaluation of external fruit characteristics (colour assessment, flesh firmness) and evaluation of internal fruit characteristics (dry matter content, soluble solids concentration, titratable acidity, ascorbic acid (vitamin C), total anthocyanins, total phenolics, antioxidant capacity-FRAP assay, ethylene and respiration determination).

friday, oct 31st, 11:10-11:30

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EFFECT OF PRE-HARVEST TEMPERATURE, PHOTOACTIVE RADIATION AND FRUIT THINNING ON STRAWBERRY BIOACTIVE COMPOUNDS

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TEAC, total phenols, ascorbic acid, yield, fruit size

Strawberries are rich on antioxidants when compared to other fruit species. Important components of this high level of antioxidants are their content of poly-phenols, ascorbic acid and ellagacid.

Cultivar variations in the level of antioxidative capacity (AC) are well known and described in the literature. Year to year variation of AC also occur, but reasons not well understood. There are several factors which may influence the AC under field conditions such as latitude of the growing site, temperature, photoactive radiation (PAR), nutrient and water status of the plants, yield, fruit size and diverse cultivation techniques.

First results will be presented on the influence of pre-harvest temperature and photoactive radiation on the content of poly-phenols, ascorbic acid and the AC of ‘Elsanta’, grown at Geisenheim in the years 2006 and 2007. In these years, pre-harvest temperature was similar, but PAR was higher in 2006 in comparison to 2007. There were significant differences between years for total phenols and ascorbic acid and the TEAC value. Results will be discussed in the context of pre-harvest weather conditions, sampling date as an indicator of variation in fruit order, yield and fruit size.

Yield and fruit size of strawberries are different from year to year and may influence the content of bioactive compound as well as variation in temperature and photo active radiation. Therefore, in a sub-trial all inflorescences per plant except 2-3 were removed in both years. Bioactive compounds from fruits of these plants were compared to those of untreated plants.

friday, oct 31st, 11:30-11:50

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INFLUENCE OF ENHANCED SOIL TEMPERATURE TO THE PATHOSYSTEM STRAWBERRY-*VERTICILLIUM*

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Verticillium, Fragaria, osmolality, soil temperatur

In previous trials we found *Verticillium dahliae* genotypes in wilted plants of strawberry cv. ‘Elsanta’ as well as in vital plants. The results of climate chamber trails showed, that *Verticillium* wilt of strawberry is affected by enhanced temperature. Simulating the weather conditions of the extreme year 2004 resulted in an increase of damage under the warm conditions of 2004 compared to average (standard) conditions. The majority of the 21 *Verticillium* genotypes used became pathogenic under warm conditions. In contrast, only two genotypes were pathogenic at standard conditions.
The pathogenity of the *Verticillium* genotypes was classified by rating the grade of wilting of the plants. Vitality of a plant was a result of colonization with an apathogenic *Verticillium* genotype or of an adequate plant reaction against the pathogenic fungus. Therefore, leaf osmolality as a physiological plant parameter was measured. Increase of leaf osmolality is an unspecific plant reaction to stress and to infection by pathogens. Plant reaction to *Verticillium* genotypes was similar under standard and warm conditions.
At standard conditions, 5 of 18 *Verticillium* genotypes were recognised by the plant, resulting in an increased osmolality and adequate control of the fungus. The remaining 13 genotypes were not recognized by plants, resulting in slightly decreased osmolality compared to the control. These genotypes can be divided in 2 vitality subgroups: enhanced vitality reveals the fungal genotype to be apathogenic; and wilting of the plant is the reaction to pathogenic fungal genotypes.
Under warm conditions, genotypes that were not recognised by the plant are pathogenic with the exception of one genotype, which became apathogenic under warm conditions. Defence reaction of ‘Elsanta’ is not adequate to control fungi under warm conditions.
Combinations of genotypes used as inoculums resulted in two reaction schemes. Under warm conditions, the combination of genotypes, which are detected by the plant, can stimulate the reaction of the plant, preventing wilting damage. Genotypes, which are not detected by the plant, but which are apathogenic per se, will induce no damage but can fill the ecological gap for *Verticillium* and prevent the plant from colonization with pathogenic genotypes.
As was shown in a previous study, *Verticillium* genotypes are adapted to declining soil temperature conditions along a south to north gradient in the northeast German lowland. Nevertheless, warm inducible genotypes also occurred in the north. Enhanced temperatures driven by climate change would result in increasing wilt symptoms. Extreme changes in the weather between cold and warm would increase the damage by cold and warm inducible genotypes in the north.

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INCREASING ARTHROPOD PEST ATTACKS DUE TO CLIMATE CHANGE IN THE NORTHERN MOST BERRY PRODUCTION AREA IN EU

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Fragaria, Ribes, Rubus, insects, mites

Of the total acreage of ca. 6000 ha of the main berry crops, strawberry, currant, raspberry and highbush blueberry in Finland, only a few hectares are covered by plastic. Therefore the prevailing weather conditions have a straight influence on growth and yield, and especially the spring temperatures are critical for flowering and pollination. The occurrence of pests and injuries caused by them also greatly depend on temperature and rain. In Finland every season in 2000's has been warmer than the mean value in 1970-2000. The first signs of the effects of warming climate have already been noticed in the occurrence of pests.

In strawberry increasing importance of the following pests has been observed when comparing the current situation to that of 20-30 years earlier: the vine weevil *Otiorhynchus sulcatus*, the two-spotted spider mite *Tetranychus urticae*, a few aphid species (*Aphis fabae, Macrosiphum euphorbiae, Aulacorthum solani, Myzus ornatus*) and thrips. The late mild winters have helped overwintering of the two-spotted spider mite in open field raspberry. In currants special pest problems due to increasing temperature has not yet been observed. Potential species of increasing status as pest include the two-spotted spider mite, gall mites (*Cecidophyopsis ribis, Anthocoptes ribis*) and aphids in general. In raspberry the more successful overwintering of the two-spotted spider mite has been noticed as earlier emerging injuries. Lately, the raspberry leaf and bud mite (*Phyllocoptes gracilis*) has also appeared in many fields and caused increasing problems. In highbush blueberry the spreading of the vine weevil into new fields is the most serious threat related to the climate change.

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ASSESSMENT THE RESISTANCE OF RIBES CULTIVARS TO THE BLACKURRANT REVERSION VIRUS

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Currant, virus, graft, transmission

Blackcurrant reversion virus (BRV; genus Nepovirus, family *Comoviridae*) is the causal agent of the economically most important Blackcurrant Reversion Disease (BRD) in black currant cultivars. It is also associated with the Full Blossom Disease (FBD) in red and white currant. In the field, BRV is transmitted by the mite *Cecidophyopsis ribis*. Experimental assessment of the BRV resistance in *Ribes* cultivars is very difficult. BRV transmission by mechanical inoculation to *Ribes* is extremely difficult, similarly as field experiments with BRV mite transmission from infected shrubs to the cultivars tested for resistance. Those are influenced by the affinity of mites to a particular cultivar and biotic and abiotic factors. In both cases the evaluation can be done first 2-3 years after BRV transmision.

We conducted graft transmission experiments for the assessment the BRV resistance in currants. Scions from FBD infected red currants ‘Vitan’ and ’Heinemann’ and white currant ’Blanka’ were grafted on red currant cultivars ’Rondom’, ’Jonkheer van Tets’ and ’Vitan’, white currant ’Blanka’ and black currants ’Viola” and ’Öjebyn’ and on seedlings of ’Jonkheer van Tets’ and ’Baldwin’. Fifty to sixty plants of each cultivar were grafted and kept in an insect-free screenhouse at the Biology Centre. The number of symptomatic plants and symptom appearance were observed for 9 years. The presence of BRV was detected by repeated RT-PCR testing according to Přibylová et al., 2008.

The first symptoms appeared in the 2nd year after grafting. We observed high correlation between the symptoms and positive RT-PCR results. Among red cultivars the highest resistance was observed in ’Rondom’ with no BRV infection, whereas 12% and 25% of ’Jonkheer van Tets’ and ’Vitan’ plants were positive in RT-PCR, respectively. White currant cultivar ’Blanka’ was infected in 24%, black currant ’Viola ’ in 11% and ’Öjebyn’ only in 3%, the latter without any symptoms of virus infection. Seedlings of ’Jonkheer van Tets’ and ’Baldwin’ (EPPO reccommended indicator plants) were infected in 100% and 5% respectively. Although the transmission success rate may be influenced by the compatibility between the rootstock and scion, the method allows evaluation of the resistance to BRV in individual cultivars in 3 years.

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CLIMATE CHANGE AND THE PRODUCTION OF SMALL FRUITS IN THE REPUBLIC OF SERBIA

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Small fruits, Western Serbia, production, decrease

In the total fruit production of the Republic of Serbia small fruits hold an outstanding position. In 2008, raspberry-covered acreage reached about 12,000 ha, the totall yield being 40,000 t. About 8,500 ha covered with strawberry gave a production up to 35,000 t. Similarly, blackcurrant covers about 3,450 ha, anticipated production being 28,000. The production of high-dwarf blueberry is a pioneer work as yet in Serbia. Over the past three years, some 70 ha have been established with this fruit species. The other species belonging to this fruit class (red currant, gooseberry) are currently grown on small scale, thus remaining beyond the official statistics.

The region of Western Serbia is a major small fruits production region in Serbia. The climate is temperate, the average annual temperature and precipitation rate being 11.9 °C and 714.5 mm respectively. It is also characterized by the uniform rainfall distribution both annually and over the growing season, the latter being about 50% (476.2 mm).

Aiming at monitoring the consequences of Global Warming, the paper presents the effects of rise in annual mean temperature which, over 2000 – 2007, accompanied by all the more frequent adverse weather, reached 12.3°C. Early commencement of all phenological processes of the annual cycle in all fruit species as well as frequent shortened harvest time is the most outstanding of the changes. Negative effects are reflected in lower fruit quality, which is most pronounced in blackberry (the incidence of parched fruits and high percentage of mature black fruits turning red), which doubtless affects price thereof and realisation on the market.

Noticeable arid climate offers solid ground for incidence of various diseases and pests which were not considered economically serious over earlier periods. High temperatures accompanied by low relative air humidity have brought about the incidence of damaging mites, which, due to their high population pressure and ability to rapidly develop high resistance to chemicals, are an insoluble problem for a great number of producers.

Typical example of negative effects of climate change is reflected in the drastic fall in the production of raspberry, our national agricultural product. The decrease is shown in production figures, i.e. raspberry production in 2003 amounted to 93,400 t, whereas recently the production has failed to exceed 40,000 t.

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IS CLIMATE CHANGE BRINGING POSITIVE EFFECTS ON BERRY PRODUCTION IN AREAS WITH HIGHER ALTITUTE AND SHORT VEGETATION PERIOD

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Climate changing, berry fruit production, chemical composition

Eastern Anatolia Region of Turkey is characterized by higher altitute (around 2000 m a.s.l) and very short vegetation period. For that reason, the region has the latest berry fruit production (particularly strawberries and raspberries) in Turkey. Recently there has been an increasing interest to grow berry fruits such as strawberries, raspberries and blueberries in the region, this because farmers are getting more money from the berry production. Organic production is also important in the region because of the very dry climate which is reducing pest and diseases incidences. However, berry production is limited by the low yield dues by the lower summer temperature and short vegetation period, combined with very hard winter conditions (the temperature generally drops -30 ^{0}C). Furthermore, the region is also characterized by a very interesting raspberry production in Turkey, but related only to one-year-old canes because of the frost damage during the winter months because of cold and farmers harvested berries only from.

The latest years with the global climate changing, the winter months bring warmer climate conditions in the region and a positive effect on raspberry production has been observed. At these new conditions corresponded an extended vegetation period and effected strawberry yield, mainly due to increased temperature both in night and development stage.

The aims of this study were, firstly to discuss visible results of the climate changing on berry fruit production in Eastern Anatolia region in Turkey (according to long term meteorological data) and make suggestion about berry fruit production. The field survey results on this issue will be also discussed in the paper. In this paper, the change of strawberry fruit composition (antioxidant activity, phenolic compounds, vitamin C, organic acids, sugars, total soluble solids etc.) according to years will also be discussed.

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INFLUENCE OF CLIMATE CHANGE TO BERRY CROP GROWING IN LATVIA

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Raspberries, currants, winterhardiness, frost

Berries are important crops in Latvian horticulture. Climate has always been the main factor for choosing cultivars for growing. Traditionally, winterhardiness, especially cold hardiness, is the main factor, because once in 10 – 15 years temperature can drop to -36 ºC, according to long-term observations. However, in last years adaptation to winter thaws and rapidly changing temperature is more important. In the last two years (2006 – 2007), there were warm January, but frost in February and March, when some berry cultivars has finished endodormancy. This caused serious damage for some raspberry and blackcurrant cultivars, especially for those, bred in continental climate in Russia – they are characteristic with high frost hardiness but little number of necessary chilling hours and are quite widespread in Latvia, for example, raspberries ‘Skromnitsa’ and ‘Meteor’, and blackcurrants with *Ribes nigrum sibiricum* and *R. dikusha* in their pedigrees. They lose cold hardiness and start bud break very early, often before late winter frosts, and therefore flower buds and even shoots are damaged.

Due to warmer winters, there is little or no snow cover, which increases root damage by black frost, especially in strawberries.

There is earlier flowering of berry crops (blackcurrants, red and white currants, gooseberries, strawberries) observed in the last years. At the same time, occurrence of late spring frosts has not decreased, therefore damage by spring frost is heavier even for late-flowering cultivars.

Due to warmer winters, better conditions for disease and pest spreading are formed. For example, gall mite and reversion is quickly spreading in black, red and white currant plantations, blackcurrant rust *Puccinia ribesii-caricis* infection is spreading in the last year (2008) though this was minor disease previously.

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AUTUMN RASPBERRY CULTIVARS IN BELARUS

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One of the most important decisions of raspberry grower is the selection of a proper cultivar. The grower must take into account the microclimate on farm site, including such factors as length of growing season and average heat accumulation. The physical properties of the soil, the prevalence of soil-borne pathogens, and the availability of water for irrigation may also affect cultivar selection.

The most urgent problem in raspberry growing is the cultivar winter hardiness. From this point of view an excellent alternative to the traditional system of raspberry growing is the cultivation of autumn (primocane-fruiting or remontant) raspberry. Autumn raspberry is the type of raspberry, which does not require a dormancy period with low temperature. It forms fruiting branches in the present year and yields in autumn. If all canes are removed late in autumn (or early in spring) at the ground level, next year are fruiting primocanes, which produce one abundant crop.

Traditional raspberry growing is very consuming of manual labour - mechanical operations make up only 3-5%. New technology makes autumn raspberry growing considerably simpler and cheaper. Firstly, canes do not freeze out in winter because raspberry bears fruits on primocanes. After mowing of canes it is possible to apply more efficient machinery for soil cultivation, fertilization and application of herbicides. Together with mown canes pathogens of diseases and overwintering pests are eliminated. In Belarus has been found that fruits of ‘Babje leto’ summer crop are eater by larvae of raspberry eater on 56%, ‘Zeva Herbsternte’ - 41%, while in autumn fruits are healthy. Therefore, autumn raspberry can be successfully grown on ecological farms for dietary nutrition.

In Belarus raspberry is one of leading small fruit crops. In spite of its numerous advantages the spread of this crop restrains by great labour input at cultivation. One of ways of the decision of given problem is introduction in the production of perspective technology of this culture cultivation with use primocane-fruiting varieties. The another cause of low raspberry production is the limited assortment, which does not have varieties with high winter-hardiness and resistance to the complex of pathogens. The solution of existent problem lies in breeding and introduction of new varieties of primocane-fruiting (remontant or autumn) raspberry.

The objective of our research was to investigate biological peculiarities and evaluate growing and fruiting of primocane-fruiting forms of raspberry from Russia (‘Abrikosovaya’, ‘Babje leto’, ‘Babje leto-2’, ‘Gerakl’, ‘Zolotie kupola’, ‘Elegantnaya’), Poland (‘Polana’), Switzerland (‘Zeva Herbsternte’) and Belarus (Hybrid 6-20). According to the results of investigation these varieties offer a good perspective for cultivation in the Republic of Belarus in farms of various patterns of ownership.

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YIELD AND BERRY CHARACTERISTICS OF SOME NORTHERN HIGHBUSH BLUEBERRIES GROWN AT DIFFERENT ALTITUDES IN TURKEY

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Northern highbush blueberry, Vaccinium corymbosum, adaptation, location, Turkey

Blueberries are temperate berry fruits. The cultivated blueberries are highbush (*Vaccinium corymbosum L.*), lowbush (*Vaccinium angustifolium*) and rabbiteye (*Vaccinium ashesi*). Blueberry cultivation started in USA at 1906 and continues with numerous cultivars on natural or artificial acidic soils. In Turkey, several species belongs to *Vaccinium* genus *(V. myrtillus, V. uliginosum* and *V. arctostaphyllo*s) can grow naturally on upland plateaus, forests and grasslands along Black Sea Region (Artvin, Rize, Trabzon, Ordu, Giresun, Gümüşhane, Samsun, Sinop, Kastamonu, Zonguldak, Bolu, Bartın and Düzce), Marmara (Kocaeli, Sakarya, İstanbul, Kırklareli, Bursa and Balıkesir) and East Anatolia (Erzurum-Şenkaya and Ardahan) (Celik, 2007 and 2008). This actarctive berry fruit with its waxy blue color known as blueberry around the world and we named it as “maviyemis” in Turkish. Although blueberries are easy to grow and could serve to the consumer within a short period, their cultivation could just started in the year 2000 by Dr. Huseyin CELIK. Turkey is one of the gene centers of wild blueberries and black sea habitants and local citizens consumed the wild berries which picked from forests, plateaus or grasslands as jelly, marmalade, juice, dried or jam. Wild blueberries called as “likapa, dal likapası, yer likapası, ligarba, lifos, lifor, kaskanaka, çela, motsvi, morsvi, göğen, mahabak, merhauk, ayı üzümü, çoban üzümü, çakıl çileği, çakal çileği, çalı çileği, enir or çoban üzümü” by settler (Celik, 2006) . This healthy berry fruits can retain 10 folds income than hazelnut or tea. Blueberries are an amazing crop, No other foods tastes quite like the blueberry. Not only are delicious but they also have exceptional health properties due to their high levels phenolics, anthocyanins, antioxidants, and generally high levels of vitamins and minerals that suppress certain types of cancer, prevent some infections, and enhance brain functions (Celik, 2005).
In this study, two years old potted plants of 8 highbush blueberry cultivars (Brigitta, Bluecrop, Bluejay, Earliblue, Duke, Nelson, Patriot and Spartan) planted at 4 different altitudes (690m, 440m, 175m and 140m) with 1.5*2.5 in and between rows and mulched with tea straw and pine dust during 2004-2007. Bluecrop and Patriot gave the highest crown height for all locations. In the highest altitudes (690 m) Brigitta (395 kg/da), Bluecrop (240 kg/da) and Patriot (113 kg/da) gave the highest mean yields. However Bluecrop (356 kg/da), Earliblue (231 kg/da) and Brigitta (202 kg/da) ranked in first three degree at the lowest altitudes (175 m) and Earliblue (214 kg/da), Bluecrop (142 kg/da) and Duke (138 kg/da) for the lowest altitude. Spartan gave the biggest berry (3.78g.) at the highest altitude (690m) while Brigitta was on the top at other altitudes as 3.46 g., 3.11g. and 3.32g. Brigitta (1.94 g), Nelson (2.07 g.), Nelson (2.05g.) and Bluejay (1.61g.) gave the smallest berries respectively to the altitudes.

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STUDY OF THE WATER STRESS EFFECT ON SOME PHYSIOLOGICAL CHARACTERISTICS IN THREE STRAWBERRY CULTIVARS

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Strawberry, gas exchange, RWC, MSI, carbohydrate

In order to evaluate effect of different levels of drought stress on some physiological parameters in strawberry one experiment with potted strawberry cultivars 'Kurdistan', 'Selva' and 'Marak' were conducted in summer. Experiment was performed with three drought stress treatments in three replications. The experimental design was factorial on basis of randomisid complete block design. Physiological parameters such as: leaf water content (RWC), membrane stability index (MSI), net photosynthesis (A), stomatal conductance (gs), transpiration (E), water use efficiency (A/gs), chlorophylls and soluble carbohydrates were measured in leaves of strawberry subjected to different drought stress conditions and recovery of these parameters after rewatering.
This study show that RWC, MSI, A, gs, E, and chlorophyll were decreased as soil water content reduced. A/gs was higher in 'Kurdistan' and 'Marak' cultivars under mild water stress and in 'Selva' cultivar under sever water stress. 'Kurdistan' cultivar had lower photosynthesis, gs and transpiration than 'Selva' cultivar and had higher RWC than 'Selva'. Recovery of these parameters occurred faster in 'Kurdistan' and 'Marak' cultivars than 'Selva' cultivar. Chlorophyll content in 'Kurdistan' cultivar was higher than 'Selva' and 'Marak' cultivars. Chlorophyll recovery one day after dewatering didn't occurred in cultivars.

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GETTING WATER TO ROOTS IN BERRY PRODUCTION: THE CHALLENGES OF POOR SOIL WETTABILITY AND ROOT PROLIFERATION

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Soil management, Water repellency, Root distribuiton, Irrigation

Production systems for soft-fruit have changed rapidly over the last decade; with protected cropping and low intensity irrigation now standard. Changes to soil properties associated with these managment changes have not been well documented. Research on other perennial horticultural crops (Wheaton et al., 2008) has demonstrated that friable and permeable soil is crucial for water, applied as irigation, to reach crop roots. Traditional soil physics says slow water application with the soil driving water movement should result in even wetting (Fernandez-Galvez & Simmonds, 2006). We have observed for raspberry crops grown under protected cropping that water from drippers wets only localised small volumes of soil. This has been documented for many perennial crops where hydrophobic organic compounds are able to build-up over time (Hallett, 2008). The resulting water repellency causes patches of wet and dry soil to develop, creating heterogenous microbial niches in soil where pathogens may thrive and preferential flow paths of water and agrochemicals past the root-zone to groundwater.

The aim of this work is to determine soil management strategies to maximise the distribution of water and its access by roots in irrigated raspberry crops. To do this we need to quantify the extent and severity of poor soil wettability, determine the spatial extent of the root systems through the soil, and investigate management to better match water application and root distribution.

We used a row of raspberries (cv ‘Glen Ample’) grown in a Spanish style polytunnel and irrigated by drippers. We used capacitance probes to measure water content, and infiltrometers to measure soil hydraulic properties, at multiple times and distances along the row. Variation in soil repellency was quantified from hydraulic properties and related to water distribution beneath an irrigation dripper. We took multiple soil cores at defined distances along the row, into the interrow and at multiple depths around single raspberry plants. From these cores we washed out root material and determined root weights and root lengths using WinRhizo™ scanning software. Together these data sets suggest that large quantities of irrigation and agrochemicals in the irrigation water are being leached to groundwater rather than being accessed by roots. Along a row, water repellency could reduce capillary wetting rates 20-fold and the water spread beneath a dripper was typically less than 6 cm. Options to improve soil management to decrease these losses are being investigated.

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EFFECTS OF MYCORRHIZAL INOCULATION ON PHOTOSYNTHETIC ACTIVITY OF CRANBERRY GROWN UNDER DIFFERENT pH AND WATER REGIMES – PRELIMINARY STUDY

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photosynthetic rate, transpiration rate, growth, stress

Introduction. American cranberry (*Vaccinium macrocarpon* Ait.) is the only wild berry species cultivated commercially. This species grown naturally in acid soils of low to moderate fertility, rich in organic matter and water. These specialized cultivation requirements make a barrier for their commercial production. American cranberry (*Vaccinium macrocarpon* Ait.) is the only wild berry species cultivated commercially. These species grow naturally in acid soils of low to moderate fertility, rich in organic matter and water. These specialized cultivation requirements make a barrier for their commercial production. The mycorrhizal technology has been used during the last years in a number of horticultural crops. The ericoid mycorrhiza (ERM) has been regarded as highly specific, limited to hosts belonging to the *Ericaceae*. This apparent specificity has driven much of the research into this symbiosis, especially in agrosystems where growing conditions are far from demands of these plant genera in their native habitats. The function of the ERM fungi in an agriculture system is to satisfy nutrient demands of the plant growing under stress conditions and enhance tolerance to sub-optimal soil pH, limited water availability and to increase soil stability. In this study, we evaluated the physiological response of cranberry plants grown under conditions of various pH and water availability.

Plant material and evaluation. Shoot cuttings of cranberry cultivar ‘Pilgrim’ were propagated in a greenhouse of the Research Institute of Pomology & Floriculture, Skierniewice. Plants were grown in pots filled with a peat (low pH treatment) or peat-perlite medium (high pH treatment). One half of plants were inoculated with ericoid mycorrhizal fungi (ERM). The inoculum was prepared in Polish Laboratory MYKOFLOR and was applied to the roots as a water suspension of fungi filaments before planting. The pots were arranged in a factorial randomized block design with three factors: presence (or not) of mycorrhizzal fungi, pH of the growing medium (pH 4 or 8), moisture level of the growing medium (100% or 50% of container water capacity). The plants were supplied with nutrient solution on the basis of moisture readings. Physiological response of the plants was assessed by measurement of photosynthetic activity (chlorophyll fluorescence and gas exchange methods).

Results. Preliminary results indicate that the plants’ reaction to mycorrhization was the strongest when they were growing under stress conditions. Inoculation with mycorrhizal fungi enhanced photosynthetic activity (higher rates of gas exchange) of cranberry plants grown under conditions of water deficiency. No significant differences were found between inoculated and non-inoculated (optimally watered) plants grown under conditions of low (4) or high (8) substrate pH.

Measurements of photosynthetic activity will be continued together with the morphological characterization of the plants (length and number of shoots, leaf area).

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EFFECT OF SOME NUTRIENT APPLICATIONS ON PLANT PROPERTIES AND FRUIT COLOUR IN ORGANIC STRAWBERRY PRODUCTION

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Organic production, strawberry, plant properties, fruit color

This study was conducted with the Camarosa strawberry cultivar at the Egirdir Horticultural Research Institute between 2004 and 2006. In this experiment the impact of some nutrition applications upon plant development and fruit colour in conventional and organic production has been analyzed. The planting has been performed with frigo plants in the third week of July and black plastic mulch was used for mulch system and dripping method was used for watering system in the experiment. When evaluating the data of two years statistically; according to plant width, plant stem number, leaf number and root length the difference in both applications and years has given importance. According to plant height and fruit colour the difference between the years (L, Chroma and Hue^{o}) has given importance while the difference between applications has not given any importance.

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GROWING 'HERITAGE' RED RASPBERRY IN GREENHOUSE USING ORGANIC FARMING METHODS IN ADANA TURKEY

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Greenhouse, Organic Farming, Red Raspberry, Fertilization, pruning

The objective of this study was to analyze the possibility to cultivate the red raspberry cultivar 'heritage' with Organic Farming methods in the greenhouse. This experiment has been conducted in a greenhouse in Adana from 2006 to 2007. Plants of 'Heritage' have been planted into containers with a specific substrate mixture composed by bukaşi (The straw mixed with effective microorganisms), organic turf and volcanic rock.

Two topics were analysed. In the first experiment; the objective was to evaluate the effect of pruning the shoots at soil level after the first yield in 2006, on the autumn yield in 2007. In the second experiment, the objective was to compare the effect of liquid and solid farm manure, and microorganisms fertilizer, which have organic farming certificate, on phenological development, yield and quality of the fruits harvested in spring and autumn

In comparison between 2006 and 2007 pruning trial was resulted with 1816,40g/m^2 yield per plot in 2006 while it was resulted with 813,87 g/m^2 yield per plot in 2007. In autumn of 2007 pruning has not been applied. First harvest has been done in June but in both applications, the last harvest has been done in November. The fertilizer trial showed that the best results have been achieved with liquid farm manure.

In conditions of Adana, the cultivar 'Heritage' can be cultivated for a 'out of season production' with organic farming methods in greenhouse without heating and additional light.

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STRAWBERRY PRPs FLUCTUATE DEPENDING ON GENOTYPE AND SEASONAL CONDITIONS

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Fragaria, pathogenesis related proteins, allergens

To determine the effect of ripening stage on the allergen content of strawberries from different genotypes, analyses were performed on extracts from three successive ripening stages of fruits. During May 2007 and 2008, fruits at three different ripening stages were harvested from plants cultivated in open field at the experimental field for genetic improvement of Marche Polytechnic University, Italy. The ripening stages were classified as follows: stage 1, full size green fruits; stage 2, pink fruits; stage 3, ripe red fruits, easily detached from the crown (3rd and 4th main harvests specific for each clone). Two strawberry varieties (Adria, Sveva), a F1 (AN94.414.52: Don x FVG 22) and a F2 (AN00.239.55: AN94.414.52 x 91.143.5) advanced selections from inter-specific crosses of *F. x ananassa* x *F. virginiana glauca* (FVG22), were selected for the study.

Protein extraction. Since the allergen extraction method described by Björksten et al. (1980) led to very poor protein extracts, a phenol based protocol was applied which was recently shown to enrich nsLTP in apricot extracts (Marzban et al. 2008). The protein content of each sample was determined using a BCA protein determination kit (Pierce). Different amounts of protein could be extracted from different cultivars. AN00.239.55 selection contains higher protein levels than the other cultivars. The protein levels differed also within the cultivars at the different ripening stages.

Determination of Fra a 1. The strawberry allergen Fra a 1 was determined by dot blotting using purified Mal d 1, a homologous protein from apple, as a standard (Marzban et al. 2005). The cultivar ‘Sveva’ seems to contain lower amounts of Fra a 1, whereas in the selection AN94.414.52 the highest Fra a 1 could be measured. In all genotypes the allergen content was higher in the unripe fruit than in the ripe fruit. However, the values for the intermediate stages are not consistent for all cultivars.

Determination of Fra a 3. The detection of Fra a 3 was inhibited by background signals and therefore needs further method optimization.

Differences in allergen content observed between the years will be presented and discussed in the light of environmental factors.

Björksten F., Halmepuro L., Hannuksela M. and Lahti A. 1980. Extraction and properties of apple allergens, Allergy 35: 671-677.

Marzban G., Mansfeld A., Hemmer W., Stoyanova E., Katinger H. and Laimer da Câmara Machado M. 2005. Fruit cross-reactive allergens: a theme of uprising interest to consumers health. Biofactors. 23: 235 -241.

Marzban G., Herndl A., Maghuly F., Katinger H. and Laimer M. 2008. Mapping of fruit allergens by two dimensional electrophoresis and immunodetection. Expert Review of Proteomics 5: 61-75.

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ANTIOXIDANT-RESPONSE OF SALT-TREATED STRAWBERRY PLANTS TO HEAT-STRESS

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Fragaria, Antioxidants , Salinity, Hardening, Priming, Heat

Plants under field conditions often endure multiple stresses during their development but plant response to compined stresses can not be readily extrapolated based on their response to individual stresses. Some stress combinations show negative interaction, others exhibit positive interactions and others no or unknown mode of interactions (Läuchli and Grattan, 2007). Moreover, over the past decades, there has been increasing evidence that plants can be sensitized for more rapid or more intense mobilization of defense responses leading to enhanced resistance to biotic and abiotic stresses. Although this process of ‘priming’ or ‘hardening’, which involves prior exposure to a biotic or an abiotic stress factor making a plant more resistant to future exposure, has been known for years, it has been appreciated just recently (Beckers and Conrath, 2007).

The aims of this work were, firstly to determine the ability to enhance antioxitadive molecules in salt-treated strawberry plants and secondly, to observe subsequent sensitivity or resistance to heat-stress. The plants were supplied with half-strength Hoagland nutrient solution containing 0, 10, 20, and 40 mM NaCl for 15 days and then subjected for 2 days under extremely high temperatures.

Under the impact of climatic change, better information on altered strawberry stress responses would facilitate the development of ‘priming’ or ‘hardening’ techniques to enhance yields under stress conditions.

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