2019

XI International Symposium on Protected Cultivation in Mild Winter Climates
&
I International Symposium on Nettings and Screens in Horticulture

Tenerife, Spain | January 27-31, 2019

MILDWINTER 2019

PROGRAMME AND BOOK OF ABSTRACTS

ORGANIZATION:

ISHS

Universidad Politécnica de Cartagena

imida
Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario

Agricultural Research Organization
Volcani Center

LOCAL ORGANIZATION:

ICIA
INSTITUTO CANARIO DE INVESTIGACIONES AGRARIAS

Gobierno de Canarias

CABILDO TENERIFE

WELCOME

Dear colleagues,

Welcome to the XI International Symposium on Protected Cultivation in Mild Winter Climates and the first International Symposium on Nettings. It is our pleasure to invite you to share your work and ideas to promote research and other activities related to technologies, management tools and plant production and responses in protected agriculture.

Our challenging world has to face the new environmental and technological era, where food production systems need urgent and revolutionary improvement for sustainable development. Competition for key resources, as global population increases, and changing climatic conditions will encourage public and private sectors to invest in improving resilience of crop production worldwide, and especially in our mild winter climates areas.

These international symposia are an excellent opportunity to bring together researchers, academics, technicians, and other experts from public and private sectors involved in the field of protected cultivation. The symposia are comprised of plenary sessions and poster display sessions, offering a high-quality interesting program with renowned keynote speakers, as well as an attractive social program. One day field trip to visit some noteworthy horticultural companies is also planned. We hope in this symposium you can show and exchange your most recent research work, ideas and innovations, while enjoying the attractive location of Tenerife, full of a great variety of scenery which varies through the island.

We are looking forward to welcome you to Tenerife, The Canaries, Spain.

The Conveners

Prof. Dr. Juan A. Fernandez, Dr. Francisco Moisés Del Amor, Dr. Avi Sadka

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Sunday
January, 27 2019

17:30-18:30 **Registration**

18:30-20:30 **Welcome Reception, Sol Costa Atlantis Hotel**

Monday
January, 28 2019

08:00-09:00 **Registration**

09:00-09:45 **Opening Ceremony**

SESSION I: Innovative strategies for irrigation, nutrition and management

Chairs: **Yosepha Shahak & Francesco Orsini**

09:45-10:30 **Keynote lecture**
Dimitrios Savvas, Agricultural University of Athens, Greece
Current knowledge and recent technological developments in nutrition and irrigation of greenhouse crops

10:30-10:50 Youssef Rouphael, University of Naples, Italy
Implications of microbial and non-microbial biostimulatory action on the quality of leafy and fruit vegetables

10:50-11:10 Dana Charuvi, The Volcani Center, Israel
Daytime LED-interlighting for improving photosynthesis and productivity in bell pepper grown in high tunnels

11:10-11:30 **Coffee break**

11:30-11:50 Erik Van Os, Wageningen University, Netherlands
An investment order tool to facilitate coordinated development of greenhouse horticulture

11:50-12:10 Thomas Bartzanas, CERTH, Greece
Assessing the sustainability of greenhouse crops using life cycle analysis tools

12:10-12:30 Esteban Baeza, Wageningen University, Netherlands
Exploring the Boundaries of the Passive Greenhouse in Jordan: a Modelling Approach

12:30-12:50 Georgia Ntatsi, Hellenic Agricultural Organization, Greece
Metabolic profile of two different *Cichorium spinosum* L. ecotypes as influenced by nitrogen form and supply levels

12:50-13:10 Alexander Boedijn, Wageningen University, Netherlands
Modelling and dimensioning of circular food production systems fed by geothermal energy: aquaponics

13:10-13:30 Erik Van Os, Wageningen University, Netherlands
Application of the adaptive greenhouse concept in Lebanon

13:30-15:00 Lunch

SESSION II: Abiotic stresses and environmental impacts

Chairs: **Dimitrios Savvas & David Ben-Yakir**

15:00-15:45 **Keynote lecture**
Rodney Thompson, University of Almeria, Spain
Reducing nitrate leaching losses from vegetable production in Mediterranean greenhouses

15:45-16:05 Dimitrios Savvas, Agricultural University of Athens, Greece
Can grafting onto suitable rootstocks contribute to less discharge of drainage water in semi-closed soilless cultivations of tomato?

16:05-16:25 Lidia López-Serrano, Inst. Valenciano de Investigaciones Agrarias, Spain
Physiological mechanisms of tolerance of grafted pepper under salt stress

16:25-16:45 Giuseppina Pennisi, University of Bologna, Italy
Salt stress in hydroponically grown lettuce is alleviated by greenhouse white plastic covering film and exogenous proline application

16:45-17:05 Hagai Yasuor, Gilat, The Volcani Center, Israel
Plant nutrition as a tool for improving greenhouses vegetable crop performance and quality under heat stress condition

17:05-17:15 Mirella Sorrentino, PSI Photon Systems Instruments, Czech Republic;
Lettuce reaction to drought stress: high-throughput automated phenotyping of growth and photosynthetic performance

17:15-18:15 **Poster session & coffee break**

Tuesday
January 29, 2019

SESSION III: Sustainable systems and pest management

Chairs: **Esteban Baeza & Salvador Lopez-Galarza**

08:30-09:15 **Keynote lecture, Carlo Leifert, Southern Cross University, Australia**
Integrating the use of resistant rootstocks/varieties, suppressive composts and elicitors to improve yields and quality in protected organic cultivation systems

09:15-09:35 David Ben-Yakir, The Volcani Center, Israel
Means to reduce invasion and infestation of small insect pests in protected crops

09:35-09:55 Ockert Stander, University of Stellenbosch, South Africa
The influence of drape-nets on foliar spray deposition, insect pests, and important tree phenological responses of `Nadorcott´ mandarin

09:55-10:15 Gérald Chouinard, R&D Institute for Agri-Environment, Canada
Exclusion nets, a step towards pesticide-free apple growing in North America

10:15-10:35 Nikolaos Katsoulas, University of Thessaly, Greece
Development of an insect screen with silica coating for environmental friendly control of insects in greenhouses

10:35-11:00 **Coffee break**

11:00-11:45 **Keynote lecture, Jan van der Blom, COEXPHAL, Spain**
Biological control: the only sustainable basis for pest management in greenhouse horticulture

11:45-12:05 Ard Nieuwenhuizen, Wageningen University, Netherlands
Automated spider mite damage detection on tomato plant leaves in greenhouse

12:05-12:25 Juan A. Fernandez, Universidad Politécnica de Cartagena, Spain
Effect of the application of a compost tea on the production of baby leaf lettuce in a floating system

12:25-12:55 José A. Pascual Valero, CEBAS-CSIC, Spain
Soil fungicides to control soil-borne diseases of Mediterranean crops grown under greenhouse

12:55-14:30 **Lunch**

SESSION IV: Climate control

Chairs: **Jan van der Blom & Giuseppe Colla**

14:30-15:15 **Keynote lecture, Esteban Baeza, Wageningen University, Netherland**
Smart greenhouse covers: a Look into the future

15:15-15:35 Shabtai Cohen, The Volcani Center, Israel
Exploiting dynamic changes in internal screenhouse climate to inform irrigation in bananas

15:35-15:55 Maayan Friman Peretz, The Volcani Center and Ben-Gurion University, Israel
Organic Photovoltaic Modules as a Greenhouse cover: Determination of the Spectral and Thermal Properties and the Electricity Production Efficiency

15:55-16:15 Thomas Bartzanas, CERTH, Greece
Numerical evaluation of greenhouse's covering materials

16:15-16:25 Meir Teitel, the Volcani Center, Israel
Light intensity and distribution in screenhouses with different roof shape

16:25-16:55 Josef Tanny, The Volcani Center, Israel
Microclimate, evapotranspiration and water use efficiency of pepper in high-tunnel greenhouses and screenhouses in semi-arid regions

16:55-17:15 Hanna Schwartz, Kafrit Group, Israel
Method for evaluation of heat buildup reduction efficiency of various solutions

17:15-18:15 **Posters & Coffee**

18:15-19:15 **Working Group Business Meeting**
Chairs: Youssef Rouphael & Juan A. Fernandez

20:30 **Farewell dinner (buses leave for dinner)**

Wednesday
January 30, 2019

SESSION V: Semi protected horticulture

Chairs: **Carlo Leifert & Meir Teitel**

08:30-09:15 **Keynote lecture, Yosepha Shahak, The Volcani Center, Israel**
Netting and photoselective netting: friendly solutions for high-quality production together with crop protection.

09:15-09:35 Avi Sadka, the Volcani Center, Israel
Top netting as a practical tool to mitigate the effect of climate change and induce productivity in citrus

09:35-09:55 Graham Barry, University of Stellenbosch, South Africa
Microclimate and tree physiology of 'Nadorcott' mandarin are affected by shade netting

09:55-10:15 Yishai Netzer, Eastern R&D, Israel
Shading table grapes-effect on water consumption, physiology and yield parameters

10:15-10:35 Maanea L Ramphinwa, University of Venda, South Africa
Effect of net shading and season on plant growth, productivity and quality of bush tea (*Athrixia phylicoides* dc)

10:35-11:00 Coffee break

11:00-11:20 Paul J.R. Cronje, University of Stellenbosch, South Africa
The influence of 20 % white shade nets on fruit quality of `Nadorcott´ mandarin

11:20-11:40 Fernando José Hawerroth, Est. Exper. de Fruticultura de Clima Temp., Brazil
Anti-hail nets in apple orchards in Southern Brazil: current situation and perspectives to improve fruit production and quality

11:40-12:00 Mike Nichols, Massey University, New Zealand
Recent changes in berry fruit production in New Zealand

12:00-12:20 Juan Carlos Diaz-Perez, University of Georgia, GA, USA
Bell Pepper (Capsicum annum L.) Plant Growth and Fruit Yield Under Colored Shade Nets

12:20-12:40 Mirella Aoun, American University of Beirut, Lebanon
Assessment of a netting system for apple production in a Mediterranean semi-arid climate

12:40-13:00 Leonardo Soldatelli Paim, Federal University of Rio Grande Do Sul, Brazil
Sequential application of budbreak promoters in 'Baigent' apple trees under anti-hail nets in orchards of Southern Brazil

13:00-13:30 Closing ceremony

13:30-15:00 Lunch

SESSION VI: Industry perspective of protected and semi protected agriculture

16:00 - 16:15 Presentación

16:15 - 16:45 Secretos, verdades y mentiras de los textiles destinados a la protección de cultivos contra plagas.
Antonio J. Álvarez. Universidad de Almería (CRIADO & LÓPEZ)

16:45 - 17:15 Uso de pantallas y mallas anti-insecto en la producción bajo invernadero.
Nelson Pérez. SVENSSON

17:15 - 17:45 Plásticos inteligentes para aumentar rendimientos.
Celeste Savio. POLITÍV EUROPA

17:45 - 18:00 Innovative solutions for Agricultural films with Kafrit Masterbathes.
Hanna Schwartz. KAFRIT

18:00 - 18:30 Descanso

18:30 - 19:00 Manejo Integrado de Microorganismos en cultivos protegidos. Experiencias y resultados
Manuel Pérez Escobar. ASM de SYMBORG (Andalucía Oriental y Canarias)

19:00 - 19:15 Desarrollo de difusores de feromona para el control de *Tuta absoluta* en tomate y de *Cosmopolites sordidus* en platanera
Fernando Pinacho. ECOBERTURA

19:15 - 19:30 Experiencias de suelta de *Trichogramma* sp. en el control de *Chrysodeixus chalcites* en platanera en invernadero de malla y en aire libre
Tomás Martín. BIOAGROLÓGICA

19:30 - 19:45 La importancia de la información para un fertirriego eficiente
Antonia Felices. WISE-AGROTECNOLOGÍA

19:45 - 20:00 Efecto de NOVIHUM® sobre la producción y calidad de cultivos de pimiento y tomate en invernadero
Carmen García. IFAPA La Mojonera (NOVIUM TECHNOLOGIES, S.L.)

Thursday
January 31, 2019

08:00	Departure (Hotel Sol Costa Atlantis, Puerto de la Cruz)
09:30 - 11:00	**Pitaya Farm (PITABER http://www.pitaber.com)**
11:00 - 11:30	Coffee at the facilities of PITABER
12:00 - 13:30	**Strawberry Farm (SAT IZAÑA http://www.izaña.com)**
14:00 – 16:00	Lunch in San Cristóbal de La Laguna
CULTURAL VISIT	
16:00 - 18:00	San Cristóbal de la Laguna

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POSTERS

SESSION I: Innovative strategies for irrigation, nutrition and management

Current knowledge and recent technological developments in nutrition and irrigation of greenhouse crops

Dimitrios Savvas

Agricultural University of Athens, Laboratory of Vegetable Production, Lera Odos 75, 11855 Athens, Greece

The greenhouse production of vegetables and cut flowers is increasingly based on modern technologies to minimize resource use efficiency, while maximizing yield, produce quality, and environmental sustainability. This trend applies also in regions with mild winter climate such as the Mediterranean basin, although the majority of greenhouses in these areas are simple constructions aiming to minimize the investment and operational cost and profit from the low requirements for heating. Plant nutrition and irrigation are two crucial factors for yield, produce quality, and environmental sustainability in protected cultivation, and this applies in both high-tech and simple greenhouse constructions. In recent years, many new developments related to plant nutrition and irrigation of greenhouse crops have appeared. In the current presentation, a short overview of new technologies and developments is provided, focusing mainly on new products and application methods, alternative greenhouse cropping systems, issues related to nutrient and water use efficiency in greenhouses, and environmental sustainability in protected cultivation. One of the issues addressed in this keynote lecture is the use of biostimulants in greenhouse crops and their impact on plant nutrition, fertilization and irrigation. Furthermore, some special aspects of plant nutrition and irrigation in organic and soilless greenhouse production systems are reported. In this respect, some information about organic soilless culture systems is provided. Grafting of fruit vegetables and its impact on nutrient and water use efficiency is also a topic of this presentation. The need to develop more resilient plants to multiple (i.e. nutrient & water) stress in view of the upcoming climate change by breeding new cultivars and hybrids and developing new crop management strategies is also highlighted. In this respect, the serious constraints imposed to protected cultivation by the shortage of good quality irrigation water and the concomitant problem of irrigation water salinity are discussed. Finally, new technologies to automatically control nutrient and water supply in greenhouse crops such as modern decision support systems (DSS) are also presented.

Keywords:

Fertilization, protected cultivation, hydroponics, greenhouse crops, irrigation, biostimulants

Implications of microbial and non-microbial biostimulatory action on the quality of leafy and fruit vegetables

Youssef Rouphael[1], Mariateresa Cardarelli[2], Paolo Bonini[3], Giuseppe Colla[4]

[1]University of Naples, Via Università 100, 80055 Portici(Napoli), Italy [2]CREA Pontecagnano, Pontecagnano, Italy [3]NGA Laboratory, 43762 Riera De Gaia, Tarragona, Spain [4]University of Tuscia, Viterbo, Italy

The difficulty in coining a universal definition of quality in reference to horticultural products stems to an extent from the multiple stakeholders partaking to the horticultural supply chain, each acting essentially as a consumer in relation to the preceding chain member. Recently the quality of fresh vegetables has been defined as 'a dynamic composite of physicochemical properties and evolving consumer perception, which embraces organoleptic, nutritional and bioactive components'. The use of natural organic non-microbial and microbial plant biostimulants (PBs) has been proposed as one of the most promising and innovative approach to address the challenges to sustainable agriculture, to ensure optimal nutrient uptake and crop yield. Very limited information are available concerning the effect of PBs on compositional and bioactive compounds of vegetables. Accordingly, it is in the best interest of growers, extension specialists and scientists to elucidate how biostimulant applications can modulate quality of leafy and fruit vegetables. In the current paper, the results of several experiments on fruit and leafy vegetables (e.g. lettuce, tomato, spinach, zucchini, cucumber, pepper) will be presented, in order to elucidate the differences in physicochemical and organoleptic quality characteristics between non-treated control, PBs-treated plants (with arbuscular mycorrhizal fungi, protein hydrolysates, seaweed extracts). The results of the various experiments on several vegetable crops, demonstrated that PBs application and microbial inoculants increase yield and yield components but differentially modulate quality of product. To obtain a broad view on the quality changes that occurred in biostimulant-treated and untreated plants the whole data set was subjected to Principal Component Analysis (PCA), to explore relationships among variables and treatments and to determine which quality traits were the most effective in discriminating between biostimulant application treatments. The PCA conducted in the present study was able to provide the basis for a more in-depth approach to elucidate the mode of action of biostimulant treatments/method/time/rate of application/species on the quality traits of vegetables.

Keywords:

Principal component analysis, protein hydrolysate, seaweed extracts, arbuscular mycorrhizal fungi, phytochemicals, metabolomics, physiological mechanism

Daytime LED-interlighting for improving photosynthesis and productivity in bell pepper grown in high tunnels

Dana Charuvi[1], Ms. Kira Ratner[1], Naveen Joshi[1], Ms. Orly Eidelman[1], Dominika Bednarczyk[1], Yair Many[1], Yosepha Shahak[1], Achiam Meir[2], Ms. Ziva Gilad[2],

[1]Inst. of Plant Sciences, ARO Volcani Center, 68 HaMacabbim Road, Rishon LeZion, Israel [2]Jordan Valley Research and Development, Mobile Post 91906, Israel

Owing to their many advantages, light-emitting diodes (LEDs) have been gradually replacing most other types of light sources in recent years. The relative low heat output and small sizes of LEDs allows using them as light sources within plant canopies. This emerging use is termed 'LED-interlighting' or 'intra-canopy illumination'. Interlighting has been developed and utilized mostly for high-wire vegetable cultivation in northern latitude countries, typically in the context of environmentally-controlled greenhouses with added overhead illumination. In crops such as tomato, cucumber and sweet pepper, interlighting has been shown to result in higher yields and/or improved fruit quality. In this study, we applied daytime intra-canopy LED lighting for bell pepper grown in high-density 'Spanish' trellis systems in high tunnels in the Jordan Valley, Israel (latitude ~32°N). At these conditions, a large fraction of the inner canopy is greatly shaded, while the outer exposed canopy is mostly not light-limited. We found that the supplemental intra-canopy illumination, which enhanced the photosynthetic rates of the inner canopy foliage, resulted in a significant increase in fruit production during spring. Higher fruit numbers accounted for the increase in yield, with no changes in fruit size or weight. Our results thus present the potential of LED-interlighting to become a useful tool for improving fruit production at variable conditions and in areas with sufficient sunlight .

Keywords:

Light emitting diodes (LEDs), LED-interlighting, bell pepper, photosynthesis, fruit yield

An investment order tool to facilitate coordinated development of greenhouse horticulture

Chris Blok, Esteban Baeza-Romero, Erik van Os, Caroline van der Salm

Wageningen UR Greenhouse Horticulture, Violierenweg 1, 2665 MV, Bleiswijk, Netherlands

Growers world-wide, faced with alternative investments, often lack means to find the most economically sound order of investing i.e. rank alternative investments. Authorities face similar problems when deciding which developments to stimulate. For Dutch greenhouse horticulture models for production and climate as well as for revenue and costs allow selection of an optimal investment order. However, outcomes are only valid for a specific economic climatic region and running the models requires expert skills. Our goal was to deliver a simplified software tool which would allow horticultural suppliers, researchers and growers to autonomously rank alternative investments in a particular region, for a specific greenhouse design and a given crop. The tool was developed in cooperation with selected horticultural supply companies for the regions Almeria in south Spain, the Jordan Valley and Jordan Highlands. In Spain the flat roofed parral greenhouse was compared to a multispan greenhouse. In Jordan the single tunnel greenhouse was compared a high multispan greenhouse with passive crop based cooling. The tool uses a one-time model run with the local standard system for yield level, prices and climate. This evaluation serves as a tabulated data set. All adaptions in greenhouse construction and cultivation system are defined as relative changes from the local standard. The adaptations are provided with their specific costs and benefits. The investments compared include: reverse osmosis switch to substrates fertilisers and nutrient units climate adapted varieties recirculation of drainage water ventilation capacity shading screens thermal screens heating and carbon dioxide. Results showed chances and limits of developing parral and single tunnel systems compared to multi tunnel greenhouses. It also showed recirculation is not always feasible. The tool informed growers on the investment order with the highest return on investment and the investment order with the lowest demand for capital. Flexibility was realised by defining yield and market price level per month and by defining a first and second class for product quality. The tool illustrates the results of different investment orders. It is hoped the tool will serve to guide investments by growers and local authorities .

Keywords:

Economics, decision support, cultivation system, greenhouse type, Mediterranean

Application of the adaptive greenhouse concept in Lebanon

Erik Van Os[1], Esteban Baeza Romero[1], Caroline van der Salm[1], Ihab Jomaa[2], Ilias Tsafaras[1], Chris Blok[1]

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Goal of the research is to improve the horticultural development in Lebanon by improving the presently used tunnels and to increase the water and fertiliser use efficiency by comparing traditional tunnels with newly constructed improved tunnels, affordable for local growers. The Lebanese agricultural sector is the largest water user (60-70% of all renewable water resources), and faces challenges to increase its production and productivity (agricultural production per unit of inputs) with less water. The sector has to anticipate the impacts of the global climate change. Simple tunnels are common and widely spread, crop production is mainly in soil and limited to spring and autumn. The water use per unit crop is relatively high because of the lower yields and higher drainage emissions. The Bekaa valley was chosen to construct improved tunnels at the LARI site in Tal Amara, to compare them with the traditional ones while cultivating tomato in soil and in substrate and to exchange knowledge with local growers. For the Bekaa valley (600 m altitude) a climate analysis was executed showing that temperatures in summer are not extremely high and that with more ventilation continuous production should be possible, precipitation is moderate but mainly in winter. In early spring a few cheap measures could be taken to extend the growing season (earlier planting) and to come to the market earlier. Improving the water use efficiency was introduced by simple soilless growing methods and rainwater harvesting from the tunnels. Four tunnels were constructed (2x2 traditional and improved, soil and substrate). In the traditional tunnel (8x41 m) soil cultivation took place according the local methods, in the other traditional tunnel coir cultivation was introduced, rainwater was collected from the roofs. In the improved tunnels of the chapel type gutter height was 3.5 m and side-wall ventilation with insect netting was applied soil, coir and rainwater collection was applied here too. Besides passive heating with water filled sleeves between the rows and fixed foil above the crop was applied to increase the night temperature, both were removed when night temperatures arose above 15oC. In 2018 first experiments took place, local growers visited the site several times and economic evaluation took place of the investments of each measure. In this paper the first results will be presented.

Keywords:

Soilless cultivation, climate control, water use efficiency, fertilizer, substrate, coir, tomato

Exploring the Boundaries of the Passive Greenhouse in Jordan: a Modelling Approach

Esteban Baeza, Chris Blok, Erik van Os, Ilias Tsafaras, Caroline van der Salm

Wageningen UR Greenhouse Horticulture, Violierenweg 1, 2665 MV, Bleiswijk, Netherlands

Greenhouses are expanding fast in arid and semi-arid regions, amongst other reasons, because of the water savings that can be realised compared to open field cultivation. However, it is difficult for growers to recognize the optimum greenhouse design. Many competing aspects must be weighed against each other such as the structure, the cover and the climate control equipment. Obviously, the optimum design must be tailored for each specific crop and growing cycle and availability of resources (land, water, energy, labour, etc.). Simulation models can assist in this process, saving time and money. Wageningen University & Research, BU Greenhouse Horticulture has developed the Adaptive Greenhouse Methodology, which combines the use of greenhouse climate and resources simulation models, with crop growth models and economic models, to solve the problem of designing the optimum greenhouse for each specific scenario in the world. In the present work we present the results of the application of this methodology to the specific case of the production of greenhouse soilless tomato in two regions in Jordan in the mid tech range: the highlands and the Jordan Valley. Results show that the optimum mid tech design improves the performance of the locally used simple tunnels by a large extent. The final design is very similar in the two locations, although some differences could be found in the type of internal mobile screens. Some technological options can only be applied with profit if market prices are much higher than the local market available prices i.e. require export and thus export quality of the product. The economical case is also improved by extending the growing cycle.

Keywords:

Cooling, whitewash, fogging, tomato, water use efficiency

Metabolic profile of two different Cichorium spinosum L. ecotypes as influenced by nitrogen form and supply levels

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Cichorium spinosum L., commonly known in Greek as “Stamnagathi”, is used as a health promoting vegetable. Although Stamnagathi is a native species that is being harvested for private consumption, it has been developed as a commercially cultivated species in the last two decades in Greece and especially in Crete. In the present study, seeds collected from wild plants in two different regions of Crete, namely the coastal area Stavros in Akrotiri and the mountainous site Tavri on Lefka Ori, were propagated and grown hydroponically. Plants were supplemented with nutrient solutions differing in the total-N level (4 or 16 mmol L–1) and the N source (NH4-N/total-N: 0.05, 0.25 or 0.50). Due to its high nutritional value, we have undertaken the task of mining the effects of the different N sources and N supply levels on the metabolism of the abovementioned two contrasting ecotypes. For this purpose, comparative GC/EI/MS metabolomics combined with bioinformatics analyses were performed using the top five fully expanded leaves of each plant. Results showed that the genotypic composition was the predominant factor for the observed discrimination followed by the N treatments. More than 180 metabolic features were recorded with the absolutely or tentatively identified metabolites to correspond quantitatively to more than 80% of the recorded metabolite profiles. Many of the recorded metabolites play important roles in plants’ physiology (e.g., trehalose, a-linolenate) and also are important for their nutritional value (e.g., carbohydrates, amino acids, fatty acids). Differences in both total-N and NH4-N/total-N levels imposed clear effects on various metabolites belonging to several biosynthetic pathways. The two ecotypes responded differently to the treatments the mountainous ecotype exhibited, among others, substantially lower carbohydrate levels (monosaccharides) and higher disaccharide and a-a-trehalose levels compared to that originating from a seaside location when both were treated with high N levels. Results confirmed the applicability of GC/EI/MS metabolomics for the assessment of the effect of different N supplementation regimes on Stamnagathi metabolic composition. The obtained information could be further exploited towards the improvement of cultivation techniques for the hydroponic production of superior quality products.

Keywords:

local landraces, metabolomics, N stress, Stamnagathi, carbohydrates

Modelling and dimensioning of circular food production systems fed by geothermal energy: aquaponics

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There is an increasing interest in many countries to increase the economic viability of geothermal heat infrastructure using circular food production systems, such as aquaponics systems, which combine the greenhouse hydroponic cultivation of vegetables with that of fish. The Geofood project focuses on circular agricultural production processes, water treatment and waste recovery processes - operating in synergy as circular food production systems - which can be operated in series as a thermal treatment train which extracts as much heat as possible from geothermal well installations. Specifically, this thermal treatment train will be comprised by sequence of horticultural greenhouses, fish farming systems and wastewater treatment and nutrient recovery systems which will have a variety of heating requirements through the year and that are able to use the waste heat from each previous step in the treatment train. The main outcome of such setup will be an increased utilization of existing geothermal well capacity with a concomitant decrease in its operating costs. In this project a predictive model to design thermal treatment trains based on aquaponics circular food production systems to maximize heat extraction from geothermal heat installations has been generated. For this model, the inputs include the most relevant climate parameters of the location, size of the greenhouse and the fish farm facility, type greenhouse/building for both facilities including climate control equipment and crop/fish species to be grown in the greenhouse/fish farming system. The model calculates the total hourly energy and nutrient needs for running both facilities year-round as well as more detailed energy and mass flows of all independent processes. From there, a calculation can be made of the dimensions of the geothermal required pumping facility. The model has been used to run different possible scenarios including different crops and fish species and robustness of the model output has been analysed. This project has been subsidized through the ERANET Cofund GEOTHERMICA (Project no. 731117), from the European Commission

Keywords:

Greenhouse, heating, fish, cooling, thermal train

Assessing the sustainability of greenhouse crops using life cycle analysis tools

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There is evidence that the greenhouse tomato industry is moving towards a future where larger, technically advanced growers, producing fresh, environmentally sustainable products. However, during greenhouse tomato production, large amounts of waste are produced, which can potentially cause environmental issues. Moreover, the intensity of fertiliser use has implications for agricultural production and environmental impacts of nutrient run-off from farmland. Increased use of fertilisers concern nutrient volatilization and GHG emissions on one hand and nutrient and heavy metal leaching on the other, leading to various environmental impacts, such as climate change, air, soil and water pollution. Fosil fuels used still in large amount for heating are also increase GHG emissions to the environment. The sustainability of the greenhouse sector will depend on how it copes with the environmental regulations imposed by legislation for production and how it manages its waste as well the rising costs for fossil fuels. Sustainability has somehow to be assessed and quantified. Many tools and indicators for assessing and benchmarking environmental impacts of different systems have been developed. Life cycle assessment (LCA) is a constructive tool that can be used to evaluate the environmental load of a product, process, or activity throughout its life cycle. In other words, LCA analyzes the ecological impacts that stem from raw material acquisition, production, use/maintenance, and recycle/waste. Life cycle assessment can not only help guide changes in systems to reduce environmental impacts, but also make them more energy, carbon, water, and therefore cost efficient. The paper presents a comprehensive LCA analysis of a typical Mediterranean greenhouse tomato crop. The results help to identify hot spots in relation to environmental pollution and based on these, mitigation strategies are proposed.

Acknowledgments: The research is supported by the Greek NEXUS project funder under the KRHPIS II action from the General Secretariat for Research and Technology of Greece

Keywords:

Environment, footprint, greenhouse, waste, LCA

SESSION II: Abiotic stresses and environmental impacts

Reducing nitrate leaching losses from vegetable production in Mediterranean greenhouses

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Vegetable production in simple plastic greenhouses has contributed substantially to the rapid recent economic development of south-eastern Spain. Of the approximately 40,000 ha of greenhouses in this region 30,000 ha are located in the province of Almeria, the rest in the nearby provinces of Murcia, Granada and Malaga. Approximately 90% of cropping is in soil. Very few of the substrate-grown crops collect and recycle drainage. The shallow aquifer of the Campo de Dalías region of Almería, with 20,000 ha of greenhouses, is heavily contaminated with nitrate. Nearly all of the areas in Almeria where the greenhouses are located, and many of those in the nearby provinces, have been declared Nitrate Vulnerable Zones in accordance with EU legislation, and are required to adopt management practices that reduce contamination of water bodies. In the region of Murcia, considerable public concern over eutrophication of the salt water lagoon “Mar Menor” will likely lead to strict controls on nutrient management in greenhouse and open field crops. Nitrate leaching is the sole cause of nitrate contamination of aquifers and a major contributing factor to eutrophication of saline waters. Data of the large nitrate leaching losses from soil- and substrate-grown greenhouse crops will be presented both from research and commercial crops. Results of surveys of grower practice will show practices and attitudes that contribute to excessive applications of irrigation and N that cause nitrate leaching. Data from regional studies will be presented to demonstrate the cumulative effect of excessive irrigation and N applications from the high concentrations of greenhouses. The reduction of nitrate leaching loss requires that excessive application of irrigation and N be appreciably reduced, that is that both water and N be used more efficiently. As N is often applied in all or most irrigations through fertigation, improved management of both irrigation and N has to be integrated. Information will be presented on improved irrigation and N management practices and on how these can be integrated. Additionally, more efficient management of irrigation and N, will require the integration of 1) planning approaches whereby crop requirements are estimated e.g. that consider all sources of N, and of 2) monitoring approaches that assess either the immediately available supply of water and N, and/or or the crop water and N status. The available and most promising tools and technologies will be described and examples of their use presented.

Keywords:

Nitrogen management, Irrigation management, Nitrate contamination, Eutrophication, Fertigation

Can grafting onto suitable rootstocks contribute to less discharge of drainage water in semi-closed soilless cultivations of tomato?

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Two commercial hybrids of tomato (Solanum lycoperiscum), particularly 'Merillia' and 'Belladonna' either self-grafted or grafted onto the rootstock 'Armstrong' (S. lycopersium L.x S. habrochaites) were cultivated in a closed soilless system with continuous recirculation of nutrient solution (NS). The NaCl concentration in the new NS supplied to the system to compensate for plant uptake (SNS) was either low (0.6 mM) or high (5 mM). Grafting tomato onto the rootstock "Armstrong" changed appreciably the partitioning of Na+ and Cl- in shoot and roots, particularly at the high NaCl level in the SNS. Thus, the hetero-grafted plants contained much more Na+ and Cl- in the roots and much less Na+ and Cl- in the leaves compared to the self-grafted plants. The much more extensive retention of Na+ and Cl- in the roots of both 'Merilia' and "Belladona' plants when grafted onto "Armstrong", compared to self-rooted plants, resulted in similar or slightly reduced rates of Na+ and Cl- accumulation in the recirculating NS. This is ascribed to the increased deposition of Na+ and Cl- to the roots of hetero-grafted plants which compensated for the appreciable reduction of Na+ and Cl- translocation to the leaves. Nevertheless, the appreciable reduction of Na+ and Cl- transport to the leaves of plants grafted onto 'Armstrong' enables growers to recycle the DW for longer times before discharging it, when irrigation water salinity is a constraint in semi-closed hydroponic tomato crops. Further research is needed to select new tomato rootstocks with even higher ability to retain Na+ and Cl- in the roots, while restricting even more efficiently their translocation to the leaves. The availability of such rootstocks can increase the acceptable concentrations of Na+ and Cl- in irrigation water used in closed or semi-closed hydroponic tomato crops, and restrict or even eliminate the need to discharge DW.

Keywords:

Hydroponics, NaCl, salinity, salt accumulation, nutrient solution, recycling

Physiological mechanisms of tolerance of grafted pepper under salt stress

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Sweet pepper is one of the most important vegetable crops in arid and semiarid regions where salinity is one of the major restricting problems for this crop, as it is considered sensitive to salinity, even though salt tolerance can vary between pepper genotypes. Grafting commercial plants onto tolerant rootstocks is a friendly-environmental technique which could improve several abiotic stresses, including salinity. Therefore, the objective of this experiment was the study of mechanisms of tolerance and the behaviour of roots (rootstock) and leaves (scion) of a new hybrid rootstock, 'Niber' (formerly H2), previously demonstrated as tolerant to salinity in terms of productivity. To reach this objective the commercial variety 'Adige' (A), A grafted onto itself (A/A), A grafted onto H2 rootstock (A/H2) and H2 grafted onto A (H2/A) were evaluated for salinity tolerance in hydroponics conditions. Physiological measurements were taken 24 h and 10 days after the exposure to 90 mM NaCl. The photosynthesis was maintained until the end of the experiment in A/H2 plants respect to the other combinations in the salt treatment. The A/H2, and H2/A combinations reduced Na+ net uptake in the roots and, consequently, their leaves had a lower Na+ concentration. With respect to the parameters related to the antioxidant activities, at the end of the experiment under salt conditions, a high concentration of both phenols and H2O2 were observed in A/H2 plants compared to the other plant combinations, meaning a higher capacity of plants to tolerate salinity. On the other side, the A plants had more lipid peroxidation, increasing the instability of the membranes. In conclusion, grafting plants may be a good solution to solve salinity, especially if it is grafted onto a tolerant rootstock, for instance onto H2, although H2/A and A/A plants showed a certain degree tolerance to salt stress indicating a positive effect of graft itself. This work has been financed by INIA (Spain) through the project RTA2017-00030-C02-00 and the European Regional Development Fund (ERDF). López-Serrano L. is beneficiary of a doctoral fellowship (FPI-INIA).

Keywords:

Pepper, grafting, rootstock, salt stress, tolerance

Salt stress in hydroponically grown lettuce is alleviated by greenhouse white plastic covering film and exogenous proline application

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In the Mediterranean environment, greenhouse vegetable crops are often affected by abiotic stresses, including salinity associated with both intensive fertilization and irrigation management, altogether with the elevate temperatures and radiation fluxes experienced during summer. As a consequence, combined effects of salt, heat and light stresses often occur, with detrimental effects on plants growth and agronomic performances. In the hereby presented study, the potential for alleviating salt stress in two hydroponically grown lettuce cultivars (Lactuca sativa, cv. Teide and Impulsion) was addressed by comparing their morphological performances upon salinity (0 vs 15 mM NaCl), when grown inside a traditional greenhouse covered with transparent plastic film or inside an identical greenhouse covered with a white cover, with reduced permeability to the incident radiation. Dedicated experiments also studied the benefits associated with exogenous application of proline (0, 5, 10, and 15 microM). The adoption of white covering film modified the composition of the light spectrum and overall decreased Photosynthetically Active Radiation (PAR), resulting in delayed plant growth and reduced leaf chlorophyll content. However, while salinity stress caused a limitation in plant photosynthesis and consistent yield reduction, the adoption of the white cover alleviated the influence of 15 mM NaCl in the heat sensitive cultivar Teide. Furthermore, exogenous proline application (up to 5 microM) allowed to increase plant yield under control conditions and improved the plant response to salinity. Accordingly, when only saline water is available, summer cultivation of lettuce cv. Teide may benefit from a combination of greenhouse white covering film and foliar proline spray application.

Keywords:

Sodium chloride Greenhouse covering film osmolytes Lactuca sativa

Plant nutrition as a tool for improving greenhouses vegetable crop performance and quality under heat stress conditions

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High temperature stress results in poor fruit set and fruit quality reduction in bell pepper and tomato grown under protective structure in arid and semi-arid areas worldwide. To overcome fruit set problem, pepper growers deplete the nitrogen (N) fertilization and doing so improve fruit set. The goal of this research was to elucidate the mechanism in which N recession improves fruit set in pepper during the autumn in the Arava Valley with temperature climbing above 40/26°C (day/night). Nitrogen recession results in alterations in primary and secondary metabolic pathways, these metabolic changes correlated with parallel fruit set improvement and yield. To overcome the reduction in fruit quality, mainly the appearance of heat pale spots in fruit pericarp, we explore the ability of manganese (Mn) and calcium (Ca) applications via the irrigation system to reduce heat damages in pepper fruits. When Mn applied to pepper plant throughout the growing season fruit accumulates one order magnitude less Mn compare to its accumulation in pepper leaves. However, Mn was able to reduce fruit damage intensity this response was cultivar dependent manner. The exact mechanisms, which Mn is affecting fruit response to heat damages, is still need to be explore. On the other hand, increase in Ca content results in increase in heat pale spots appearance. We are currently focuses on the understanding the fruit pericarp cellular, enzymatical and biochemical alteration in order to better understanding the heat damages mechanisms and maybe the cultivar tolerance mechanisms and the role of nutritional elements and these mechanisms. These will allow us to improve our ability to cope with heat stress and will assist developing better breeding program in pepper. In summary, we show that by using different plant nutrition approaches we improved crop performance under abiotic stress such as heat stress.

Keywords:

Pepper, nitrogen, manganese, calcium

SESSION III: Sustainable systems and pest management

Integrating the use of resistant rootstocks/varieties, suppressive composts and elicitors to improve yields and quality in protected organic cultivation systems

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EU organic crop production standards prohibit the use of synthetic chemical crop protection products and mineral N and P and KCl based fertilisers and prescribe that crop plants are grown in soil.
As a result, the control of soil borne and to a lesser extent foliar and seed-borne diseases is a major challenge in organic protected crop production systems, especially since the use of crop rotation is usually not an economically feasible and/or efficient approach for disease control (Dafermos et al 2012 Giotis et al 2009, 2012a&b, Kasselaki et al. 2008, 2011 Markellou et al. 2009).
In contrast, pest control is not usually considered a major challenge by organic producers because (a) sulphur fungicides and the insecticides pyrethrum and in some countries also spinosat being permitted for use in organic systems and (b) the availability of efficient biological pest control products for protected production systems. However, the introduction of new pests (e.g. Tuta absoluta) usually has devastating effects in both organic and conventional systems (Terzidis et al 2014).
Here we present results from an EU, Greek-government and industry supported R&D programme to develop integrated control strategies for the control of major soil borne (e.g. corky root rot, Verticillium and nematodes) and foliar diseases (e.g. powdery mildew) in organic protected cropping systems. All field trials were carried out in the background of commercial organic production facilities and growing protocols.
Integrating the use of (a) resistant varieties/rootstocks, (b) disease suppressive composts can provide long-term and reliable control of soil borne disease without regular soil steaming/solarisation. However, application of microbial antagonists or biological control products did not provide significant levels of soil borne disease control in commercial greenhouse environments (Georgakopoulos et al 2002 Giotis et al 2009, 2012a&b). Replacing chicken pellets and supplementary plant extract or fish slurry based liquid N inputs with suppressive compost (made from mixtures of green waste, bark and cattle manure) also substantially reduced cost and improved the sustainability of production, mainly by reducing the need for expensive liquid organic fertiliser products and soil steaming. However, the use of suppressive composts required the development of plant growth stage specific irrigation systems .
Integrating the use (a) less susceptible varieties and (b) elicitors (e.g. chitin, milsana) can significantly reduce the severity of powdery mildew and other foliar diseases in protected crops (Markelou et al. 2009 Dafermos et al. 2012 Giotis 2012b). However, in protected organic tomato production the use of less susceptible varieties (which have a lower yield potential) was found to be commercially viable only in the winter growing season, when mildew disease pressure is high (Dafermos et al. 2012).

Keywords:

Organic cultivation, compost, rootstocks

Means to reduce invasion and infestation of small insect pests in protected crops

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Whiteflies and thrips are major pests and vectors of diseases of protected crops. Growers of protected crops often face a conflict between preventing the entry of these small pests and an effective ventilation. This conflict may be alleviated if ventilation openings will be designed and managed based on our knowledge of the invasion process. Roof vents are the major ports of entry for whiteflies and thrips. The risk of pests' entry through the leeward roof vent is significantly greater than through the other vents. This is due to the inflow at the leeward vent and outflow of air at the windward vents. In Israel, from spring to fall, over 90% of whiteflies and thrips fly and invade protected crops during the morning. Taking into account the prevailing winds during the morning, greenhouse vents may be designed and operated to lower the risk of pests' invasion. Optically active cladding materials also reduce pests' invasion by repelling (high sunlight reflection UV blocking) or arresting (attractive colors) them. Reflective soil cover (mulch) usually reduce the establishing of these pests inside the greenhouse. Invading pests can be lured away from the plants using attractive colored sticky sheets (mass trapping) and by spots or lines of attractive light (natural or artificial). These methods can reduce damages from whiteflies and thrips and lower the use of insecticides for their control .

Keywords:

Bemisia tabaci, Thrips tabaci, Frankliniella occidentalis, tomato, pepper, chives, roof vents, insect flight, prevailing winds, optically active cladding materials, reflective mulch, mass trapping

The influence of drape-nets on foliar spray deposition, insect pests, and important tree phenological responses of `Nadorcott´ mandarin

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The use of drape-nets in citrus (Citrus spp.) is becoming an increasingly popular practice in certain countries to protect crops against hail damage, and/or prevent cross-pollination and seed development in mandarins (C. reticulata). Drape-nets are being introduced to the South African citrus industry, with limited knowledge on their effect on fruit yield, fruit quality, and impacts on cultural practices in the orchard. This study evaluated the effects of drape-nets on the deposition of foliar sprays, insect pest prevalence, leaf mineral nutrient concentration, and fruit yield and quality. Three drape-net (AHN-55, 55 g·m-2) treatments and an untreated control were applied in a completely randomised design (n=4) at three timings: 1) from two months before full bloom (pre-bloom, Aug. 2017) until directly after physiological fruit drop (Nov. 2017) 2) from pre-bloom until before colour break (Apr. 2018) and, 3) from pre-bloom until commercial harvest (July 2018). Drape-net treatments consisted of the complete covering of 50 m -long tree rows. In Aug. 2017 and Mar. 2018, fluorescent pigment sprays were applied to treatment replicates at different commercial foliar spray water volumes (low: 4 L, medium: 8 L and high: 12 L per tree applied with a CS2000L Oscillator sprayer). Leaf and fruit samples were collected from different canopy positions to measure different deposition parameters using fluorometry. Canopy insect pest prevalence was monitored throughout the season with insect lure traps. At time of commercial harvest, the total tree fruit load (kg·tree-1) was determined for each treatment replicate, and insect damage and other fruit quality parameters were measured for fruit sampled from inside and outside the tree canopy. Certain results were compared to those obtained from separate experiments which evaluated a 20% white, permanent shade netting treatment in the same orchard. The drape-net and permanent shade net treatments significantly reduced the % sunburnt fruit. The inside-canopy deposition of low volume foliar sprays was significantly lower for drape-net treatments, and therefore possibly explains the lower concentrations of the micro-nutrients, Fe (-77%), Mn (-22%) and Zn (-44%) in leaves compared to the control (open), especially for the latter two elements which are annually applied as supplemental sprays to trees by low-volume foliar spray applications. A permanent shade net treatment had no effects on leaf micro-nutrient concentration, but leaf K concentration was lower compared to the control (1.34 vs 1.60 % leaf dry mass), possibly as a result of a larger fruit load. The results of the monitoring of insect pests and the effects of drape-nets on fruit load and quality will be presented, along with a financial budget model comparing different drape-net and permanent shade net treatments in 'Nadorcott' mandarin with an untreated control.

Keywords:

Citrus reticulata, foliar sprays, fruit set, fruit quality, fruit yield, sunburn

Exclusion nets, a step towards pesticide-free apple growing in North America

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Organic apple production is difficult in most parts of Canada and the United States because of the important number of insect and disease pests affecting the production and quality of fruit. A modified version of an efficient exclusion system developed and used in Europe against codling moth was tested from 2012 to 2017 in eastern Canada to measure its effectivenes against multiple pest species and possible adverse effects on tree growth and fruit quality . Our findings show that the system did not have a negative impact on fruit size, color, firmness, maturity, sugar content and pollination, and that it prevented fruit from being attacked by key insect species considered as pests in this area: the apple maggot Rhagoletis pomonella (Walsh), the tarnished plant bug Lygus lineolaris (Palisot de Beauvois) and the codling moth Cydia pomonella (L.). Key diseases did not flare up under netting and apple scab Venturia inaequalis (Cooke) G. Wint incidence was reduced by the netting in some occasions .

Keywords:

Orchards, fruit quality, insect pests, diseases, physiological disorders, photosynthesis, abiotic conditions

Development of an insect screen with silica coating for environmental friendly control of insects in greenhouses

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A major challenges that agricultural primary production face is to increase its production efficiency and reduce environmental impact. By tackling these challenges, one can safely anticipate significant advantages for the environment and increased competitiveness for the farmers and relative enterprises. Often greenhouses are the only form of economically sustainable agriculture that can be proposed in many marginal areas of the Mediterranean environment, where land abandonment is expanding considerably. All greenhouses are equipped with ventilation openings which account to about 30% of the covered area, to provide good microclimate conditions for plant growth. However, vents serve also as a major port of entry for pests and, as a consequence, growers are forced to cover the vents completely and permanently with fine mesh screens to prevent pest invasion. The use of insect screens in greenhouses reduces insect migration on the crop and subsequent crop damage, thus reducing the need for pesticide application. Very fine mesh screens are required to prevent the entry of very small pests (e.g. whiteflies and thrips). However, screens with fine mesh sizes imped ventilation, increase enclosure air temperature and reduce light transmission. Therefore, it is necessary to develop an agrotextile, which can provide physical active protection against all kinds of insects to ensure sustainable supply of food without chemical contamination (e.g. through pesticides) without compromising the greenhouse crop yield and quality. The aim of AgriTExSil project is to develop an insect screen which is ecofriendly and nontoxic and can actively protect plants against all kinds of insects by killing them by its sharp coating. AgriTexSil approach includes the development of nets with bigger mesh size to overcome the disadvantages of low screen porosity. A plasma coating process will be developed to cover different types of screens with nano silica particles. To produce the screens, a melt spinning process will be developed with regard to particle processing, to the build-up of a coating and to the coated yarn and textile. The screens that will be developed will be tested in pilot greenhouse conditions to study the effect on the microclimate and on harmful insects in field trials. The AgriTExSil project is co-financed by the European Union and Greek national funds through the bilateral Greece-Germany S & T Cooperation Program, Competitiveness, Entrepreneurship & Innovation (EPANEK)

(project code: T2DGE-0120) .

Keywords:

Pesticides, mesh, net porosity, ventilation

Biological control: the only sustainable basis for pest management in greenhouse horticulture

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In the last decades, biological control has been implemented as the basis for IPM in most of the greenhouse vegetable crops in S-E Spain, as well as in other Mediterranean countries. This started on a massive scale in sweet pepper, later followed by aubergine, tomato and cucurbit crops. Nevertheless, especially in tomato and cucurbits, the applications of biological control have diminished over the last years.

In some crops, it is obvious that biological control is limited with respect to certain pests, e.g. *Tuta absoluta* and *Aculops lycopersici* in tomato. In cucurbits, it is mostly the incidence of Tomato Leaf Curl New Delhi Virus (ToLCNDV) that makes growers choose for chemical solutions. Nevertheless, the decision made by the growers to abandon biocontrol is often in contrast with the practical IPM results. In tomato, biological whitefly control may create the conditions for control of *T. absoluta* by spontaneously appearing parasitoids (Crisol & Van der Blom, IOBC-Lisbon 2018). Both in tomato and cucurbits, it has been demonstrated that plantations with biological control are less affected by whitefly transmitted viruses.

Biological control will have to offer sustainable solutions, considering that the alternative, chemical control, faces severe limitations. The search for these solutions becomes particularly urgent due to the overall climate change: arthropod pests will have longer periods of activity and more generations per season, so the selection towards pesticide resistance will be speeded up. Partly, new strategies may be derived from an agro-ecological approach: The creation of selected non-crop vegetation, both inside the greenhouses and in the near surroundings, that provides shelter and food sources to beneficial fauna and acts as barrier for pest organisms.

Keywords:

Biological control, tomato, *Nesidiocoris tenuis*, cucurbit crops, *Amblyseius*, agro-ecology

Automated spider mite damage detection on tomato plant leaves in greenhouse

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Spider mites are one of the most challenging pests in the greenhouse, and their management is more and more challenging due to resistance to pesticides. Spider mites prefer young leaves at the outer canopy, stay at the bottom of leaves, and can crawl to nearby plants. Typical symptoms are small yellow and white spots on the upper side of the leaf due to chlorophyll depletion, leading to bronzing of the leaves. The challenge is to detect the spider mite damage in an early stage, as it is hardly possible to detect the actual spider mites underneath the leaves. Based on a structured requirement list, the following camera systems were identified as detection system candidates. Three multispectral cameras and one RGB camera were further investigated in the research. A lab study with hyperspectral imaging was performed that identified discriminating wavebands between healthy and diseased leaves. The wavebands 700, 716 and 747 nm were selected and used in the multispectral systems. Using Fisher LDA, accuracies up to 0.88 could be reached at pixel level with these multispectral cameras. However none of the setups could meet the spatial resolution to detect spider mite damage at early stage on the leaves. Second step was to perform colour image analysis. An identical accuracy of 0.88 with sufficient spatial resolution was reached. Based on these results, a high resolution RGB camera was mounted on a measurement cart. Experiments were performed in a greenhouse compartment with an ongoing spider mite damage infestation in a tomato crop. The results show the automated pipeline for spider mite damage detection in a time series of six recordings over three months. Heat maps of the infestation rate are presented to the grower and are used for input in models for integrated pest management and for the release of beneficial insects

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Keywords:

Spider mite, detection techniques, machine vision

Effect of the application of a compost tea on the production of baby leaf lettuce in a floating system

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The residues of the agroindustry through composting produce high quality compost being used in agriculture. The compost derived products, such as compost teas are used as a source of nutrients, improving crop production and allowing a more sustainable production system. The objective of this work was to analyse the effect of a compost tea application (added to the nutrient solution and by microsprinkler) composed of organic residues from the agroindustry, in two growing cycles (spring and autumn) on the production and quality of baby leaf lettuce grown in a floating system. To that end, a cultivar of baby leaf red lettuce `Antoria´ was grown in a floating system using styrofloat trays. The compost tea was applied 72 hours after sowing, maintaining its application until harvest. The plants were harvested 30 and 25 days after sowing in spring and autumn, respectively. The aerial and radical growth of the plant and the nutritional content in the leaves was assessed. The leaf height, root total length and diameter were affected by the growing cycle and by the compost tea application type. The application of compost tea to the nutrient solution had the highest yield in both growing cycles. On the other hand, the application of compost tea by microsprinkler decreased the nitrate content and increased the total phenols content and the antioxidant capacity in both growing cycles. The results of this investigation show that the application of compost tea to the nutrient solution increase lettuce growth while the application by microsprinkler improve lettuce quality.

Keywords:

Lactuca sativa, hydroponics, compost, sustainable agriculture

Soil fungicides to control soil-borne diseases of Mediterranean crops grown under greenhouse

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Plant-parasitic nematodes and fungal diseases entail loss of crop in Mediterranean areas. To maintain economically viable production of crops, application of treatments is mandatory. Increased environmental awareness is leading to more restrictive European policies with the use of certain fumigants due to their impact on human health and soil system.

An equilibrium must be reached between the use of nematicides and fungicides and soil quality. Microorganisms in soil are crucial in sustaining the health of natural and agricultural soil systems and significantly contribute to nutrient cycling, organic matter decomposition, plant nutrient uptake, and maintenance of soil structure. Therefore, to evaluate new biocides into soil, further to evaluate the direct impact on target microorganisms, it is necessary to evaluate their potential effects on non-target soil microbiota, by measuring soil microbial activity, abundance and community composition.

Analysis by qPCR of target microorganism as Meloidogyne spp. or soil fungal pathogens are faster and easily automated than microscopic techniques. The quantitative detection of plant pathogens facilitates the monitoring of pathogens and the study of their distribution, improving disease control and optimizing pesticide use.

Furthermore, the information obtained from high-throughput sequencing platforms allows us to evaluate the possible cause-effect relationship between fungicide application and soil community composition.

Keywords:

Pathogen, pesticide, nematode, molecular detection

SESSION IV: Climate control

Smart Greenhouse Covers: a Look into the Future

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In a greenhouse, the cover is the main element determining the amount and quality of entering and outgoing radiation, both short and longwave. The cover properties are therefore essential in determining inside climate and the amount of external resources (such as heating and water) required to maintain the greenhouse climate within the boundaries required for crop production. There is not a single “ideal” greenhouse cover for the entire world: properties that are useful in the Netherlands may not be in central Mexico. Regarding the properties of the cover, the present technology varies with the local average requirement, since requirements also vary in time none of the materials presently applied is “ideal” even for a singular location. Therefore, the development of new “smart” covering materials that would allow for the instantaneous modification of the optical properties of the cover, could potentially serve a large market worldwide. Some of these materials already exist in the market, such as the electrochromic glass or polymer dispersed liquid crystals, but they have not been optimized for their use as greenhouse covers. So, companies operating in this sector have a need to identify which properties are useful in various conditions and to quantify the advantage of [some of] them being switchable. A number of theoretical covering materials with filters transmitting selectively certain ranges of wavelength (PAR, NIR, FIR) for which the effect on greenhouse microclimate and crop growth can be simulated, have been considered for analysis. The reason for not analysing more specific wavelengths (UV, blue, green, red, far red) is that the knowledge on the effects of this very specific spectral composition on plant processes is still in its infancy. Therefore, the present work uses existing simulation models to quantify the benefit (in terms of production and reduced resource requirement) of improving the optical properties of the cover and the added value of making some of them switchable, for the greenhouses typical of various climatic zones of the world. Results indicate a large potential for improvement of yield and resource use efficiency, for different permanent and/or switchable filters (and their combinations).

Keywords:

Glass, polyethylene, PAR, NIR, FIR, photo-selectivity, thermochromics

Exploiting dynamic changes in internal screenhouse climate to inform irrigation in bananas

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In the hot and dry Jordan Valley of Northern Israel banana irrigation under screens is reduced below rates for open stands by about 20% following our previous research on average climate changes due to screens. In the Western Galilee and Carmel coastal regions reductions are about 10%. The ratio of evaporation inside to that outside decreases during the season due to the accumulation of dust on the net which reduces transmission of solar radiation and atmospheric evaporative demand.

We are exploiting these dynamic changes to inform irrigation management by monitoring climate under the screens and computing reference evapotranspiration years (and two yields) yields are best under the 10% screen and slightly reduced under the 20% screen. The reduced irrigation has not significantly affected soil salinity although at the end of the dry season a trend of increased salinity for the reduced irrigation was observed. No other detrimental results were found.

Dust accumulation reduced solar radiation transmission by an additional 10% at the end of the dry season. While for unscreened plots irrigation averaged 2250 mm a-1 for the two years of fully grown plants, below the 10% screen rates were 1775 for non-dynamic and 1465 mm for dynamic irrigation, respectively. Savings under the 20% screen were greater, but slight reductions of yield were found in that case.

Measurements included sap flow, leaf temperatures and horticultural data. The presentation will show and discuss these data and their implications for crop water relations and irrigation management under screens.

Keywords:

Evapotranspiration, screen, net, sap flow

Organic Photovoltaic Modules as a Greenhouse cover: Determination of the Spectral and Thermal Properties and the Electricity Production Efficiency

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This study examines the feasibility of using organic photovoltaic (OPV) semitransparent flexible modules as greenhouse cover material. By using such modules, it may be possible to utilize existing agricultural areas for harnessing solar energy for electricity production. In warm and mild- winter climates, such as the Mediterranean area, greenhouses are often shaded to reduce heat load. Using OPV modules to shade greenhouses and reduce the excess solar energy entering the greenhouse, mainly in the near infra-red range of the spectrum, allows reduction of heat load on one hand and electricity generation on the other hand. Thus, it appears an interesting and attractive approach in protected cultivation. Present study examines the radiometric and thermal properties of an OPV module. Transmissivity of an OPV module was measured under outdoor conditions in the wavelength range of 300 to 1100 nm using a transmittance measuring box (partially based on ASTM E 424 – 71(2015)) . Nine Li-Cor pyranometers were placed in the box that was covered by an OPV module. Adjacent to the covered box was an uncovered box with a reference pyranometer. Measurements were done at four different angles of sun incidence: 0, 21, 41 and 46 degrees. Simultaneously, in addition to the transmittance measurements at the different sun incidence angles, the current and voltage output of the OPV module were recorded to allow power and efficiency calculations of the OPV modules as function of the tilt angle. Supplementary laboratory measurements of transmissivity, reflectivity and absorptivity were done with a spectroradiometer equipped with an integrating sphere for wavelengths between 390 to 1100 nm as well. In order to comprehensively characterize the OPV modules, the overall heat transfer coefficient ((U value) of a module was determined using a standard hot box. Measurements were performed during several winter nights. The OPV panels examined in this study had about 20% transmissivity and about 15% reflectivity in the visible range. The electricity generation efficiency of the module was about 2 % and the overall heat transfer coefficient 6.5 [Wm -2K-1]

Keywords:

Agricultural; greenhouse cover; organic photovoltaic; electricity production; wavelength; radiation

Numerical evaluation of greenhouse's covering materials

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The internal microclimate of a greenhouse, and consequently plant growth and development, is defined, in large extent, by the combination of available radiation and the potential ventilation. Physiological fluxes like evaporation and transpiration are depended on the radiation levels as well as on temperature, air velocity, humidity and the variation of these parameters during the day. Cover materials with high transmittance coefficient may allow sufficient PAR during the winter but they may lead to overheating during the summer increasing the ventilation needs and the energy consumption for active cooling methods. On the contrary cover materials with low transmittance coefficient protect plants from overheating during the summer but they may prevent sufficient PAR during the winter. Consequently the choice of right cover material should consider the cover performance during the whole year period. A commercial Computational Fluid Dynamic Code and the finite volume method is used for the the simulation of transport phenomena and radiation transmittance for four wave length bands (UV, PAR, NIR and IR) inside a naturally ventilated arched greenhouse in order to compare four various cover material in different days of the year. According to the comparison results, and for day time operation, the cover material that offers satisfaction of the examined treaties for the longest period during the year is the Ethylene vinyl acetate film (EVA), followed by the Thermal polyethylene film (TPE) and the Three-layer co-extruded film (3L), while the Rose Polyvinylchloride-based fluorescent (VPVC) during the whole year prevent the entrance of sufficient amount of PAR radiation inside the greenhouse

Keywords:

CFD, microclimate, greenhouse

Light Intensity and Distribution in Greenhouses and Screenhouses with Different Roof Shape

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In warm and mild winter climates, to ventilate large, multispan gutter-connected greenhouses effectively, both side and roof openings are usually required. Since the roof openings and gutters are constructed of opaque structural elements and the openings are generally covered with dense insect-proof screens, they partially block penetration of solar radiation into the greenhouse. Experiments were carried out during summer and winter campaigns in three different multispan greenhouses, each of about 0.1 ha, to characterise the disturbance induced by the roof openings and gutters to the intensity and distribution of light reaching the plants. Results show that the mean daily photosynthetic active radiation (PAR) level directly below the cover of the greenhouses was 58 - 66% of the external PAR above the crop, the daily mean PAR level along a 10-m transect was 39 - 51% of the outside level. This further decrease of light transmission was mainly caused by structural elements, gutters and roof openings. The largest drop in radiation was measured at midday, in the region below the roof openings. Insect-proof screenhouses are much cheaper than fully climate-controlled greenhouses and enable growers achieving reasonable yield at good quality in regions with mild-warm climate. These structures are often built with different roof shape from various reasons. An experimental study was done to determine the light distribution in screenhouses with two different roof shapes: flat and zigzag. Light was measured simultaneously in two screenhouses, one with flat and the other with zigzag roof. The roofs of the screenhouses were made of a '50 mesh' screen with a porosity of about 0.36. Measurements were done in each house above canopy, with PAR sensors, across several screenhouse spans at their mid-length. The data was collected in the morning, midday and afternoon. Results show that light distribution in the transverse direction is more homogenous in the flat screenhouse than in the zigzag one. However, average light intensity across the spans was very similar in the two houses. Light intensity in the screenhouses was about 55, 60 and 52% of ambient values in the morning, midday and afternoon respectively. Although the screen in the screenhouse with the flat roof was installed two years earlier than in the screenhouse with the zigzag roof no significant effect of degradation in light transmittance was observed in that house. Finally, a comparison is made between light distribution in greenhouses and screenhouses.

Keywords:

Light, greenhouse, screenhouse, roof shape

Microclimate, evapotranspiration and water use efficiency of pepper in high-tunnel greenhouses and screenhouses in semi-arid regions

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The area of crops grown in protected environments is constantly increasing worldwide. Greenhouse tunnels are covered by an impermeable plastic roof whereas screenhouses are covered by a porous screen. However, in the agricultural practice, most growers do not consider the difference in cover type in their irrigation management. The objective was to study the effect of roof cover type, either plastic or porous screen, on microclimate, Penman-Monteith evapotranspiration (ET) models, and water use efficiency, to improve irrigation management.

A field study was carried out during the growing season 2016-2017 in two otherwise identical structures in which a pepper crop was grown. One roof was a plastic sheet (hereafter denoted as the greenhouse) and the other an insect-proof 17-mesh screen (screenhouse). In both houses, air velocity, air temperature and humidity, and solar and net radiation were measured simultaneously above the canopy. Evapotranspiration was estimated using 8 different versions of the Penman-Monteith model, differing either in the resistance terms, or in the type of meteorological data used, i.e. internal or external. Transpiration was measured using the heat-pulse technique. In 4 neighbouring houses, an irrigation trial was conducted with 3 treatments: ET calculated from internal microclimate and boundary-layer resistance, hourly ET from external conditions and control using regional irrigation recommendations. Water use efficiency was calculated as the ratio between yield and the supplied irrigation .

Linear regressions were derived between internal and external meteorological conditions, with R2 values between 0.08 and 0.99. Higher R2 values were obtained for the screenhouse because internal microclimate interacted with the outside more than in the greenhouse. Linear regressions between measured and modeled ET were derived with R2 between 0.15 and 0.86. Transpiration measurements were in highest agreement with a PM model based on internal meteorological conditions and a boundary-layer resistance. Water use efficiency for the irrigation treatment based on this model was larger by 17% (screenhouse) and 21% (greenhouse) than that obtained using regional recommended irrigation .

Keywords:

Temperature, humidity, radiation, Penman-Monteith

Greenhouses cooling Challenges Method for evaluation of heat buildup reduction efficiency of various solutions

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Reduction of inside temperature of greenhouse is highly required in areas with long days and high irradiation, especially if the greenhouse is to be operated during summer time.

Maintaining relatively low temperature is important for both the crop and the people working inside, as temperature can rise to the high levels.

Several techniques can be used to reduce heat buildup (HBU) in the agricultural facility. External techniques, such as, whitewash or shading nets, and integral techniques, such as incorporation of white or silver master batches and even more sophisticated substances, such as Nano TiO2 or interference pigment to reflect part of the light spectrum that contribute to HBU.

However, currently there is no standard method that allows evaluating the effectiveness of the different cooling systems.

In this paper, we present a method to calculate cooling parameters that determine the HBU reduction efficiency of "cooling" greenhouse films and their comparative performance .

The following data will be presented:

1. Near IR filtering as a function of "cooling system" type, concentration and film thickness

2. Total and PAR light transmission

3. Shading coefficient

4. HBU reduction efficiency

5. The influence of cooling systems on cherry tomato yield

SESSION V: Semi protected horticulture

Netting and Photoselective Netting: Friendly Solutions for High-Quality Production Together with Crop Protection

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The covering of agricultural crops by netting materials is becoming a common practice, widespread in many parts of the world. The initial incentive typically comes from the necessity to protect crops against environmental hazards (e.g. excessive radiation, flying pests, hail, wind, frost), which are becoming more and more extreme due to global climate changes. Protecting crops by netting is more affordable than greenhouses, thanks to the lower cost of covering materials, lighter construction, and no need for active climate control. Moreover, netting can provide additional benefits, beyond the mere protection. Once covered, the plants find themselves in a new light and microclimate environment, and respond accordingly. Thus, by manipulating various properties of the netting materials, time of application, design of the net-house, and other elements, we can greatly improve the horticultural performance of many crops. Netting improvements include enhancing the productivity and fruit quality, reducing the use of chemicals and water, and reducing the dependency on the surrounding climate. Netting research carried during the last few decades has greatly advanced our understanding of plant responses to netting, and led to innovative technological applications.

Photoselective netting is one such innovation. It is based on specific chromatic attributes that are added to the netting materials, enabling us to selectively screen out undesired parts of sunlight spectrum, while allowing the productive spectral bands pass through, in a diffused form. The spectral manipulation is targeted at promoting desired physiological responses, while the scattering improves the penetration of the spectrally-modified light into the inner plant canopy, thus further empowering the photoselective effect. Growth regulation, flowering and fruit-set, fruit color, skin quality, phytonutrient and anti-oxidant content, and post-harvest durability are few of the photoselective responding traits. Comprehensive research had established the photoselective beneficial effects on plants, as well as plant pests and diseases, and led to practical applications by growers .

In view of the growing impact of netting and photoselective netting on the global agriculture, this paper is providing an overview on various aspects of the technology, the accumulated horticultural knowledge, lessons learned, and future prospects.

Keywords:

Colored nets, light quality manipulation, micro-climate, fruit crop productivity, fruit quality, photoselective pest and disease control

Top netting as a practical tool to mitigate the effect of climate change and induce productivity in citrus

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In many areas around the globe, climate change seems to result in increased number of extreme heat waves during the springs and the summers, and in warmer winters, which might overall reduce productivity in many fruit trees.

Top netting protects outdoor crops against environmental hazards. Use of photoselective (color) nets, which differentially absorb various spectral regions and enrich the relative content of scattered/diffused light, result in additional photomorphogenetic/physiological effects. In a series of experiments, we examine the effect of color nets on various parameters, including microclimate, productivity, fruit quality, physiology, morphogenesis and water consumption, of citrus trees during the various parts of plant development. By combining differential irrigation in the mature orchard, we also attempt to estimate water use efficiency for a given color net. The most significant climatic effects of the nets is wind breaking and increased relative humidity. Reduced temperature under the net is detected not only during the summer, but also during the winter. Physiological measurements show that the physiological performance of the tree is induced, especially under light color nets. Improved physiology results in improved productivity (flowering, fruit set, yield) and fruit quality (taste, peal color). Moreover, all the nets significantly reduce water consumption, while inducing stomata opening. Overall, some of the beneficial effects might be attributed to mitigated microclimate, and are color-independent, while others are color-dependent. These results demonstrate the unique potential of photoselective, light-dispersive netting in citriculture.

Keywords:

Top netting, Citrus, Photo-selective nets, Climate change

Microclimate and tree physiology of 'Nadorcott' mandarin are affected by shade netting

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External and internal quality of citrus fruit determine consumer acceptance thereby driving the consumption and demand for fresh fruit. Emphasis is placed on producing a high volume of fruit of good quality, and it is known that light intensity is especially important in influencing sugar content, rind colour and blemish incidence. Extreme environmental conditions are challenging controllable factors. Therefore shade netting is used especially on fruit crops for protection against dramatic climatic events that effect the appearance of fruit, i.e. excess sunlight, wind and hail. The study was conducted on 'Nadorcott' mandarin trees planted in 2012 in a commercial orchard in Citrusdal, Western Cape province, South Africa. The aim of this study was to determine the influence of 20% white shade nets on the quality of 'Nadorcott' mandarin fruit. Monthly evaluation of fruit size, rind color, internal quality parameters (ºBrix/citric acid ratio) and the incidence of sunburn were performed. The fruit diameter was not influenced by shade net in 2016, however, in 2017 a larger fruit diameter was measured for shade net fruit. Rind colour development and internal quality were not influenced negatively by the treatment. Shade net was effective reducing the incidence of sunburn significantly in both seasons, 2016 and 2017. Moreover, postharvest fruit quality was not by the shade net treatments. In summary, our results indicate that shade-netting is a potential preventative technology ensuring unblemished and high quality in 'Nadorcott' mandarins, but further studies are required to evaluate the influence of tree age and microclimatic effect on fruit production and postharvest storage behaviour in other Citrus cultivars .

Keywords:

Fruit development, postharvest storage potential, rind condition

Shading table grapes-effect on water consumption, physiology and yield parameters

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Partial shading by nets has, at most cases, positive effects over several plant physiological characteristics. The objectives of the study were to examine in which way covering table vines affects micro-meteorological, vine water consumption, physiological parameters, and yield. For this purpose 2 sites were designated during 2008-2010 for the experiment: a commercial 1.2 hectare vineyard at Moshav Lachish and a 12 lysimeters plot at Lachish R&D center, Israel. At the commercial plot a shade net ('Polysack' Israel, 13% shadow), was overlaid above 3 plots sized 0.2 hectares each, while 3 plots remained uncovered. The environmental conditions were measured at 2 plots, approximately half a meter above the vineyard's canopy. The physiological and crop measurements were conducted in the uncovered and shaded treatments. At Lachish R&D Center, a similar net was overlaid above 12 vines growing in lysimeters, while water consumption data was compared to previous years, where no shade net was used. Our findings showed that the seasonal average of wind speed under the net was lower by 65% compared to the wind speed in the open. The 2009 annual average air temperature difference between shaded and un-shaded plots, was 1.2oC. The average photosynthetic active radiation flow (PAR) measured under the net areas, was lower by 23% The average ETo in the uncovered plot was 4.02 mm per day, compared to 3.11 mm per day in the shaded area, while major parameters that affected ETo were wind speed and net radiation. The seasonal average of mid-day stem water potential (Ψstem) was significantly lower by 0.1MPa at the uncovered vines. Average carbon fixation rate (PN) and stomatal conductance (gs) in the shaded plots were higher by 12% and 21% respectively, compared to the uncovered vines. There was no significant difference in fruit yield weight. However, the shade net had a significant positive influence on the color of the fruit, and a lower percentage of un-marketable yield. At the R&D center plot, our findings showed that during 2008-2010, when plot was shaded, LAI of the vines was higher than the LAI measured on the same vines prior installing the shading net (1999-2005) as from the end of May onwards. The Kc to LAI ratio was higher in the shaded years, compared to prior the shading. 2008-2010 Seasonal Average ETc was higher by approximately 10% compared to ETc prior the shading (1999-2005). The physiological measurements clearly indicate that growing vines under 13% shade net has few advantages. The improved physiological parameters obtained in the commercial plot in Lachish, suggesting achieving increased fruit yield could cause by thinning lesser number of clusters per vine. Despite the overlay of the net, there were a uniform fruit thinning performed in all plots, which caused no difference in the fruit yield height, but the quality of the fruit was significantly improved. To conclude, though nets reduce the wind speed and radiation and increase the relative humidity, plant evapotranspiration (ETc) and crop coefficient (Kc) not only were not reduce, but even increased. The explanation for this phenomenon is complex: the climatic conditions under the nets improved plant water status which is expressed in improved stem water potential, higher stomatal conductance, finally increasing vegetative growth -that accelerated the ETc. We assume that this could improve yields. A possible improvement in water use efficiency in the shaded areas may occur by agro-technical manipulations and not by reducing water supply. A few agro-technical manipulations that can be performed on vines can focus on the size of the vine, its design and clusters thinning. All those can, as mentioned, improve the vineyard water efficiency .

Keywords:

Shading nets, table grapes, evapotranspiration, water consumption, water relations

Effect of net shading and season on plant growth, productivity and quality of bush tea (Athrixia phylicoides dc)

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Bush tea is herbal and medicinal plant used by other traditional South Africa people for cleansing and purifying blood, treating boils, infested wounds as well as headache. In some parts of the country is used for aphrodisiac reasons. Currently, bush tea is under cultivation in small scale in South Africa. Hence, the objective of the study was to determine the effect of net shading and season on the plant growth, productivity and quality of bush tea. Treatments consisted of open field (control), black, pearl, yellow, and red shade nets with three different light intensities 40%, 50% and 80% replicated three times designed in a randomized complete block design (RCBD). Parameters recorded were photosynthetically active radiation (PAR), and stomatal conductance, biomass production as well as both primary and secondary metabolites. For the current abstract only PAR and stomatal conductance data will be discussed and presented since the study is currently underway. The other parameters require destructive sampling. Therefore the results of the recorded parameters demonstrated that PAR under controlled environment ranges from 50 to 700 µmol m-2s-1.

Keywords:

Athrixia phylicoides, net shade, phytochemicals, antioxidants .

The influence of 20% white shade nets on fruit quality of `Nadorcott´ mandarin

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The use of shade netting to change light quality and quantity is primarily focused on increasing return on investment by reducing the occurrence of damage to fruit. By installing permanent shade netting over a citrus orchard, the microclimate was expected to be modified which in turn could affect a tree's physiology. Changes in microclimate were quantified using Campbell Scientific weather stations in both netted and open situations in a 'Nadorcott' mandarin orchard planted in 2012 in Citrusdal, Western Cape Province, South Africa. Hourly logging of solar radiation (MJ.m-2), air and soil temperatures (°C), relative humidity (%), soil water content (m3.m-3) and wind speed (m.s-1) was conducted, in addition to monthly measurements of photo-assimilation, stomatal conductance and leaf gas exchange. Solar radiation was reduced by ~17% under shade netting, and mean and maximum temperatures were reduced, whereas minimum temperature was higher. However, temperature within the canopy was higher under shade netting and this led to a significant increase in effective heat units as well as relative humidity under the netting which in turn lowered the VPD. Average soil temperature was higher under shade netting resulting from less diurnal fluctuations between minimum and maximum temperatures. Soil water content was increased by ~17% over the two years. The average and maximum wind speed was reduced under shade netting which acted as an artificial windbreak. Cumulatively, the shade netting had a positive effect on carbon accumulation during the summer months. To conclude, 20% white shade netting affected the microclimate of a 'Nadorcott' mandarin orchard in Citrusdal and thereby positively affected the trees' physiology.

Keywords:

Citrus, Mandarins, Shade netting, Microclimate

Anti-hail nets in apple orchards in Southern Brazil: current situation and perspectives to improve fruit production and quality

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The southern region of Brazil, despite having important climatic characteristics for the production of apple trees, presents the occurrence of hail precipitations with a certain frequency, which implies significant losses to the growers. The use of anti-hail nets has been the main strategy used by apple growers to minimize the risk of hail damage, and despite its high cost, their use has been increased in apple orchards located in the Santa Catarina and the Rio Grande do Sul state. It is a technology of great efficiency to control the damages caused by this climatic event, but it has a significant impact on the physiology of apple trees, with reflexes in the growth/development of the plants, productive capacity, and fruit quality. Among the main implications of the use of the anti-hail in the apple orchards, it is possible to highlight the increase of the vegetative growth, insufficient budburst levels, possible problems regarding the fruit load management and less development of the fruit color, especially in years with low chilling amount during the autumn and winter season. Currently, about 20% of the apple production areas are covered with anti-hail nets. However, it is estimated that in 10 years, more than 50% of the apple production area will be covered with anti-hail nets. The increase in the proportion of orchards with anti-hail nets and the consequences on the plant metabolism caused by their use demand the measurement of the effects on the development and productive response of the plants, to subsidize the improvement of technologies that can increase the apple production under this system. The use of photoselective nets and new anti-hail nets with lower levels of shading has been one of the strategies used to improve the apple production system in southern Brazil. On the other hand, the improvement of the phytotechnical management has been studied, aiming to increase budbreak rates, adequate fruit load adjustment, control of vegetative growth and improvement in the fruit skin color. The use of plant growth regulators, taking into account the pattern of growth of the plants and the climatic variations evidenced in each phenophase, has resulted in greater productive regularity, especially when associated with management practices to increase light interception into plant canopy.

Keywords:

Malus domestica, fruit set problems, vegetative growth, fruit skin color, yield

Recent changes in berry fruit production in New Zealand

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New Zealand lies between 39S and 46S, but due to the surrounding Pacific Ocean has a mild winter climate compared with most similar Northern Hemisphere latitudes. Berry fruit has been a relatively important horticultural sector, but the risk of rain at any time has been a major constraint for rain sensitive berries such as strawberries, and cane fruit.

A dynamic field grown blackcurrant industry has been established on the South island primarily for processing, and using mechanical harvesting.

The development of relatively cheap high plastic tunnels (used mainly as rain shelters, but also to support bird netting), has resulted in recent years in the production of strawberries, raspberries and blackberries, using hydroponics. Such developments have generally not been by existing berry fruit growers, but by newcomers to the industry.

An even newer development has been the production of blueberries, primarily as a fresh export crop for Asian markets. These are grown in high tunnels using hydroponics. New Zealand has a big advantage over some other southern hemisphere countries as it is free from two fruit fly pests which (for example) prohibits fresh exports of fruit to Asia from most of Australia .

Keywords:

Berry fruit, Protected cropping, New Zealand .

Bell Pepper (Capsicum annum L.) Plant Growth and Fruit Yield Under Colored Shade Nets

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Recent research in Georgia has shown that under heat stress conditions black shading nets improve bell pepper marketable fruit yield and quality. Use of colored shading nets has shown benefits in some crops although there is little information on bell pepper responses to colored shade nets. The objective was to determine the effects of colored shade nets on plant growth and fruit yield of bell pepper ('PS 09979325'). Experimental design was a randomized complete block with four replications and five treatments [5 shade treatments (black, red, silver, white, and uncovered) (Green-tek, Janesville, Wisconsin)]. Results showed that mean and maximal air temperature and midday root zone temperature were highest in the unshaded treatment. Plant height and stem diameter were reduced in the unshaded treatment, although plant growth was unaffected by the shade net color. Chlorophyll index was lowest under the black net. The incidence of soil borne diseases was greatest in the unshaded treatment. Leaf Pnet, gs and PSII efficiency were also reduced in the unshaded treatment. PAR ranged from 1851 in the unshaded to 985 µmol·m-2·s-1 in the black treatment. Leaf temperature was highest in the white and the unshaded treatments. Marketable and total fruit number and yield and individual fruit weight were reduced under unshaded treatment compared to all shading nets. There were no differences in fruit numbers and fruit yields among colored shading nets. In conclusion, bell pepper plant growth, leaf gas exchange, and fruit yield were reduced under unshaded conditions, and there were no differences in plant growth and fruit yields among colored shading nets

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Keywords:

Plasticulture, shade house, climate change, photomorphogenesis

Assessment of a netting system for apple production in a Mediterranean semi arid climate

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A full block incomplete exclusion system using photoselective nets was used for protected apple cultivation in a semi-arid mediterranean climate in Lebanon. For two seasons, blocks of trees from an early bearing and a late bearing cultivars were covered with nets in an experimental orchard and compared to uncovered blocks of trees in the same orchard. Microclimate data were monitored throughout the seasons and pest scouting was performed weekly in both treatment. the assessment of the protective netting system covered its impact on tree physiology and production indicators, postharvest fruit quality indicators, microclimate modification and its ability to exclude major insect pests without the use of insecticides. Two years data collection and analysis seems to indicate that the netting system is a promising tool for a better quality fruit in both cultivars and an overall tree health with the opportunity of significantly reducing the need for pesticides.

Keywords:

Tree fruit production, netting systems, photoselective, apples, postharvest quality, light stress, codling moth

Sequential application of budbreak promoters in 'Baigent' apple trees under anti-hail nets in orchards of Southern Brazil

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The production of apple trees in Southern Brazil is mainly located under mild and irregular winters, leading to low breaking of lateral buds and long periods of budbreak and blooming. Thus, economical profitability of the activity is achieved through the application of budbreak promoters, chemicals that induce budbreak and blooming. It is known that climate change is enhancing hailstorms in the region and the use of hail nets has been the main and increasing strategy chosen by apple growers in order to eliminate the negative effects both in fruits and plants by hail precipitation. However, recent researches show that apple trees cultivated under anti-hail nets commonly exhibit differentiated physiology, such as the excessive vegetative growth, which can lead to reduced budbreak levels, below the threshold of sustainability, with only one application of chemicals. The objective of this study was to test sequential applications of budbreak promoters to maximize the intensity of budbreak and visualize its effects over other important reproductive parameters of 'Baigent' apples under anti-hail nets. The experiment was performed during the 2017/2018 growing season, in a commercial apple orchard growing under anti-hail nets, located in Vacaria municipality, Rio Grande do Sul State, Brazil. The treatments consisted of two applications of budbreak promoters and were arranged in randomized complete block design, with four replicates. Seven treatments were tested: (1) Control (untreated) (2) Erger® 1,5% + Assist® (mineral oil) 3,5% (3) Erger® 1,5% + Assist® 3,5% (Application 1 (AP1) and Application 2 (AP2)) (4) Erger® 3% + Calcinit® (calcium nitrate) 3% (5) Erger® 3% + Calcinit® 3% (AP1) and Erger® 1,5% + Assist® 3,5% (AP2) (6) Dormex® 0,7% + Assist® 3,5% (7) Dormex® 0,7% + Assist® 3,5% (AP1) and Erger® 1,5% + Assist® 3,5% (AP2). The second application was sprayed ten days after the first. For each treatment with chemicals, Break-thru® 0,05% was added. Influence of treatments on axillary and terminal budbreak, number of inflorescence with fruit per tree, mean number of fruits per inflorescence, number of fruits per plant, yield and average fresh fruit weight were assessed. Each evaluation was performed in two portions of the tree's canopy: upper and lower portion of canopy. There was no difference in budbreak, number of inflorescence with fruit per tree and average fresh weight of fruits between canopy portions. The highest values of number of fruits per plant, mean number of fruits per inflorescence and weight of fruits per plant were observed in the upper portion of the canopy. It was seen an increase on budbreak rate in the sequential treatments, especially in the combination of Dormex® 0,7% + Assist® 3,5% (AP1) and Erger® 1,5% + Assist® 3,5% (AP2). Budbreak promoters didn't significantly change the number of fruits per plant, yield and average fresh weight of fruits. The use of sequential applications of budbreak promoters is one important alternative to optimize the budbreak, thereby assisting in the economical profitability of apple orchards in Southern region of Brazil.

Keywords: Malus domestica B., insufficient chilling, dormancy overcoming

POSTERS

1

Can grafting improve crop performance under low calcium supplies in pepper ?

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The low availability of nutrients in the soil caused by a scenario of climate change is decreasing production and quality of crops. One of the most important macronutrients is calcium, which has multiple functions on plants. However, its mobility is very limited, especially in the phloem, so a deficiency in this nutrient may cause multiple disorders. There are multiple options to try to improve nutrient deficiencies one of them is grafting plants onto more efficient rootstock to nutrient uptake. The objective of this study was to assess the agronomical and physiological performance of pepper grafted plants under low calcium conditions. To reach this aim, two concentrations of calcium in the nutrient solution (5 mM or 0.5 mM) and four grafting combinations were evaluated: variety grafted onto itself (V/V) and grafted onto three different rootstocks (V/A8, V/A6 and V/H2). The grafting combination V/H2 exhibited the highest shoot biomass in comparison with the other ones. In addition, both the number of fruits and total marketable yield per plant was higher in V/H2 pepper plants. However, when photosynthesis was evaluated not significant changes for different plant combinations were observed at the end of the study, so we supposed that not all of them used the carbon obtained for the same purpose, being V/H2 which invested more in both aerial and fruit part. As a result, we can conclude that grafting plants onto rootstocks with a higher capacity to translocate the Ca2+ acquisition to produce fruits, as H2 does, may improve pepper production in the case of low calcium supplies.

Keywords:

Calcium, Pepper, Grafting, Production, Biomass, Photosynthesis .

2

Effects of covering inter-row orchard floor with reflecting films on light distribution, photosynthesis, coloration and quality of `Fuji´ apples

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The effect of hot and dry summers, typical of Mediterranean climates, together with inappropriate canopy management, strongly restricts apples red color development. 'Fuji' apples market demands not only for fruits with large sizes, crunchy textures and sweet flavors but also with intense and complete red coloration skin. Portuguese growers face additional difficulties by the predominance of old clones and fast-changing of market needs, requiring a different technical approach and the introduction of new technologies. The use of reflective materials between tree rows is known by its effects on enhancing red color development without reducing fruit quality and it was tested in Portuguese conditions in an orchard of 'Fuji Fubrax' apple (Malus domestica), located in Alcobaça (39º29´43,60´´N 9º00'49,66´´W). White polypropylene UV stabilized reflecting film, Reflectex (Italy), was installed 22 days before the first harvest, in alternate rows, leaving uncovered the first 50cm closer to the trunk. PAR reflection measured at 50cm height, in the middle of the rows with spontaneous vegetation increased from 9,1% to 53,6% when covered with white reflective film. Notwithstanding soil PAR reflection measured under the canopy at solar noon be low, average reflection in the first linear meter increased from 3% to 11% in west side and from 1% to 6,5% in east side, with significant gains in the first 50cm due to the effect of the film. There was also a positive effect on the side of the trees opposite to the placement of the film, verified by the reflected radiation measured at 45º in several planes inside the canopy. These differences were responsible for higher photosynthetic rates measured outside and inside the trees with the film placed laterally, being some of these results supported by chlorophyll content index and specific leaf area measurements. Covering the orchard floor with reflecting films was very effective in improving fruit coloration, showing very significant differences, and similar color between fruits harvested inside the canopy from the side with film and fruits from the outside of the canopy without film. Positive effects were also found in average fruit weight, firmness and total soluble solids. These results should be confirmed in a long-term program and others materials and provisions assessed .

Keywords: Reflective materials, Malus domestica, Fruit color, Photosynthesis

3

Effect of the use of plastic mulching in the integrated management of Meloidogyne spp

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Meloidogyne is a genus of phytophagous nematodes that causes great damage in many crops around the world. Its identification and control are difficult, for that reason it is important to find viable and sustainable management tools. The soil temperature affects the duration of the Meloidogyne cycle and the expression of the Mi-1 resistance gene in tomato plants. The objective of this work was to evaluate the use of plastic mulching as a management tool in tomato crops (Solanum lycopersicum L.), which were resistant and susceptible to M. incognita, M.arenaria y M. javanica. The mulching treatments were: without cover (control), white polyethylene and black polyethylene. Two resistant (experimental) cultivars and one susceptible were evaluated. The experimental design was realized in divided plots using soil cover treatments as the main factor and tomato plant materials as a secondary factor. The test was carried out, in greenhouse, in pots with disinfected soil of sandy texture, pH: 7.1 and electrical conductivity: 2.9 dS m-1. They were inoculated with 1200 eggs-J2 of Meloidogyne javanica. The parameters measured after 60 days were: plant height, number of leaves, number of inflorescences, stem thickness at neck height, aerial and radical dry weight, number of masses of eggs root-1 (NME), and gall index (GI). The resistant cultivars showed a lower level of infestation (IA, NMH) than the susceptible one.

Keywords:

Solanum lycopersicum, nematodes, genetic resistance

4

Effect of manganese on peppermint crop reflectance

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Monoterpene produced by Mentha x piperita L. (peppermint) exhibit many ecological roles, including antimicrobial, antioxidant and anti-inflammatory, as well as anti-ulcer and insecticidal properties. The main objective of the current research was to study the effect of manganese to the antioxidant activity and monoterpenes capacity of the essential oil extracted by the peppermint plants. For this reason, cuttings peppermint were grown in pots filled with sand under greenhouse conditions and were irrigated with four different manganese doses of nutrient solution (0.0, 0.5, 1.0, and 2.0 ppm). Non-destructive measurements were carried out to determine the growth, leaf nitrogen balance index and chlorophyll content of the plants. In addition, the monoterpenes accumulation, antioxidant capacity and nutrient content of the plants were estimated using laboratory methodologies. The results were correlated with leaf spectral properties recorded by hyperspectral camera. The obtained conclusions expected to have a major effect on the peppermint production of monoterpenes and related natural products.

Keywords:

Peppermint oil, antioxidant capacity, leaf nitrogen and chlorophyll content, hyperspectral camera

5

Sustainability of Non-Cavendish Bananas Cultivars in the Subtropics of Coastal Alabama

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Bananas possess unique potential as a specialty crop to enhance sustainability of farm operations because of their global demand and the development of cultivars that are more cold tolerant and have shorter production cycles. In the global market bananas are known to require considerable inputs making their production cost prohibitive for smaller farm operations. To mitigate these demands, innovative production practices must be sought. Reflective mulches have been used to enhance lighting in production systems to improve yield and quality of fruit crops and cover crops have been used in rotations to increase crop diversity, improve soil quality, moisture retention and a source of organic matter and nutrients. Reflective mulches were selected and their effects on banana phenology were determined. White polyethylene fabric and silver reflective film panels were installed on opposing sides of a group of three banana plants to form an experimental unit. A control treatment which received no reflective mulch was included in the study. The study followed a randomized complete block design and contained six replications. Banana bunches of the white reflective mulch treatment were 27% and 15% heavier in the reflective mulch treatments compared to bananas bunches of the control and were produced on pseudostems that were 12% and 3% taller respectively than bananas of the control treatment. Leaf area of silver and white mulch treatments were increased by 8% and 16% respectively. Light radiation was enhanced in the lower canopy of banana plants of the reflective mulch treatments. Flower emergence in the white fabric mulch treatment occurred 5 d earlier than the control whereas flower emergence in the silver mulch treatment was delayed by 26 d. Our results suggest reflective mulches provided gains in increasing sustainability of niche market bananas .

Keywords:

Silver film, polyethylene fabric, flower emergence, productivity, fruit quality

6

What is the cost of increasing biodiversity in the environment of the Almeria greenhouses, southeast of Spain ?

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Since 2007, biological control has been established as a successful alternative to fight against pests affecting the main horticultural crops in the greenhouses of Almeria (SE Spain). According to the latest data, biological control technics are establish in around 26.000 hectares of the total cultivated. 100% of pepper crop surface is managed under this technic. However, many climatic factors, physical barriers etc., may affect the effectiveness in the implementation of biological control. The recent years an important effort has been made to enhance biological control by conservation in the area, with the aim offer a proper habitat to native natural enemies of pests, trying to attract them and conserve them around the greenhouses. To do so, a selection of proper shrubs species have been studied for this purpose. Hedgerows around greenhouse, established with these plants, may supply food and shelter for the beneficial insects, but should not be attractive to the pests. In these sense it is necessary to offer a staggered flowering all-year-round. One of the problems in the area is the space availability between greenhouses, so different plants combinations have been studied and proposed to design hedgerows depending on this criteria. Almeria province currently has around 31000 hectares of greenhouses, but the biological control surface by conservation is still very scarce. In this work, the costs of the hypothetical installation of this ecological infrastructures for the whole greenhouse territory has been evaluated. Likewise, an analysis of the relative importance that this cost implies in the total cost structure for the farmer has been carried out. Also the financial possibilities for this kind of environmental improvements has been carried out, both through the Agri-environmental Measures of the Rural Development Program of Andalusia, as well as the Operational Programs of the Fruit and Vegetable Producers' Organizations .

Keywords:

biological control by conservation, cost analysis, positive environmental externalities

7

Influence of the irrigation pipe color in the temperature of the irrigation water solutions within a greenhouse

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In southeaster Spain, one of the main areas for growing tomatoes in greenhouses, tomato´s seedlings transplanting usually takes place at the end of July or August, when air temperatures can reach up to 40 ºC. In this area, substrate cultivation is a common practice and the seedlings are initially placed in small blocks of rock wool or coconut fiber, where the volume of substrate is very limited. Under these conditions, high temperatures of the irrigation solution could cause the appearance of fungal diseases that cause the death of the plant or delays in growth. Some manufacturers of irrigation systems indicate that the use of white pipes can reduce the temperature of the water up to 8 ˚C even though we have not found scientific studies in the bibliography that confirm these assumptions. From April to November 2018, an experiment in a greenhouse located in Murcia was carried out to check if there would be variations in the temperature of the nutrient solution when using a white pipe compared to a conventional black one. Water solutions temperature were determined continuously using type T thermocouples placed inside the irrigation pipe with anti-drainage emitters. In April, with watering scheduled at 12:00 p.m. and mean temperatures inside the greenhouse of 30 ˚C, differences of up to 10 degrees were found three minutes after irrigation started (33 °C inside black pipe versus 23 °C inside the white one). However, in August, when the mean temperature inside the greenhouse was 35.5 ˚C, with five-minute irrigations scheduled at two-hour intervals from 8 a.m. to 5 p.m., the maximum water temperature differences found were 2.3 ˚C. The results demonstrate that the use of the plastic pipe color can significantly affect the irrigation water temperature within a greenhouse farming systems.

Keywords:

water relations; drip irrigation

8

The effect of hot summer conditions on the pollination of greenhouse tomatoes by bumblebees

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Tomato cultivation for the fresh vegetable market is performed in greenhouses and insects proof net houses where pollination is carried out by bumblebees. In Mediterranean cultivation areas, a sharp decrease in yield typically occurs during the hottest months of the summer, due to severe heat stress.This study explored the effects of heat stress as a disruptive factor in greenhouse tomatoes' fruit setting, on reproductive organ viability and on pollinator activity. Using video cameras, we recorded the bees' visitation pattern in flowers. Tomato flowers stayed open for two full days, however the majority of effective bees' visits took place only during the first day from 9:00 to13:00. On the second day of flowering, about 40% of the bees approached the flowers but eventually moved away (avoidance) without performing pollination. Despite the high occurrence of this avoiding behavior, flowers were generally visited more than 10 times, which seems as an adequate visitation frequency for proper fruit-set. The high summer temperatures led to a decrease in the viability of the reproductive organs in all flowers, while genetic variation (according to cultivars) was observed for this trait. In conclusion, its appears that pollinator activity is not a major limiting factor for tomato fruit set under hot temperature conditions, and that yield loss under heat stress is mainly mediated by a drop in the viability of the flowers' reproductive organs.

Keywords:

Tomato, pollination, greenhouse, bumblebees, flower's viability

9

Screening of pepper rootstocks for thermal stress: physiology pattern

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Nowadays, abiotic stresses, including thermal stress, are one of the main limitations for agricultural production and food security. This situation can be aggravated due to the global warming scenario, particularly in the Mediterranean region, an important area producing peppers and other vegetables in protected cultivation. A strategy of sustainable, ecological and environmentally friendly adaptation to overcome this type of abiotic stresses is the grafting technique. In this work, different genotypes were evaluated as rootstocks to cope with supra-thermal stress. To perform the study, the following physiological parameters were analyzed in three moments throughout the experiment: net photosynthesis, stomatal conductance, sub-stomatal CO2 concentration, transpiration rate, instantaneous carboxylation efficiency, fluorescence parameters, cell membrane permeability and total phenol content in leaves. According to the photosynthetic parameters, the genotypes subjected to thermal stress, obtained, in general, lower photosynthetic rates and instantaneous carboxylation efficiency, observing differences between genotypes, accompanied by a greater stomatal conductance, sub-stomatal CO2 concentration and rate of transpiration than genotypes subjected to control conditions. The fluorescence parameters and the amount of total phenolic compounds did not show clear differences between environments. Finally, an increase in cell membrane permeability was also observed in plants subjected to thermal stress, observing differences between genotypes in the last sampling time, where the stress conditions were more intense.

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Keywords:

Abiotic, grafting, genotypes, accessions, photosynthesis, fluorescence ,permeability, phenolic

10

Screening of pepper rootstocks for thermal stress: agronomic pattern

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The incidence of heat stress is currently a problem that limits the production of many crops, mainly in protected cultivation. That could even increase in the global warming scenario, especially in the Mediterranean area and in pepper crops. A solution to mitigate the effects of heat stress is the use of grafting on tolerant rootstocks, this being an environmental friendly technique. In the present work, different genotypes from germplasm banks were evaluated in conditions of heat stress and control, using them as rootstocks to see the behaviour of the grafted plants in the different environments, using the cultivar 'Maestral'. To perform the study, the quantity and quality of the production obtained in the different genotypes tested were analysed, such as yields, size or average weight, fruit density, morphological characteristics such as thickness of the pericarp, height/width ratio, soluble solids content, percentage of dry weight and a* and b* Hunter parameters. In general, the yield obtained from the genotypes under thermal stress conditions was lower than under control conditions. The incidence of apical necrosis (BER) was lower in plants with supra-thermal stress. Among the genotypes studied, it has not been possible to identify any that was clearly tolerant to supra-thermal stress, at least grafted on this cultivar. Nevertheless, some differences have been observed in the productive and qualitative parameters analysed between the two environmental conditions in some of the genotypes studied.

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Keywords:

Heat stress, genotypes, yield, accessions, grafting, quality, fruit .

11

Induction of salt stress tolerance in greenhouse-grown basil by endophytic fungi

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In many irrigated areas of the Mediterranean region, farmers are forced to use saline water to irrigate their crops due to an inadequate supply of fresh water. Overcoming salt stress problems would have a positive impact on crop yields. Numerous attempts have been made to improve the salt tolerance of crops by traditional breeding programs and by genetic transformation of plants. However, commercial success has been very limited due to the complexity of the trait. The application of endophytic fungi such as mycorrhiza and Trichoderma could be an efficient tool to mitigate the detrimental effect of salinity. A greenhouse experiment was carried out to assess the influence of co-inoculation of R. irregulare BEG72 and T. atroviride MUCL45632 on yield and quality of an important herbspecies such as basil (Ocimum basilicum L.) under non-saline, mild and severe saline conditions. Increasing the NaCl concentration in the nutrient solution in both inoculated and non inoculated plants decreased the yield and growth parameters but increased the quality traits in particular the hydrophilic and lipophilic antioxidant activities. Irrespective of the NaCl concentration in the nutrient solution the co-inoculated basil plants exhibited a higher fresh biomass and total leaf area (by 12% and 10%, respectively) compared to control plants. The better crop performance of inoculated basil has been attributed to a better nutritional status and pigment biosynthesis (i.e., higher SPAD index). On the other hand the nitrate content in inoculated plants was significantly lower by 14% compared to non-inoculated plants. Overall, the use of beneficial microorganisms could be adopted as a sustainable tool in vegetable cropping systems to mitigate the detrimental effect of saline water.

Keywords:

R. irregulare, Ocimum basilicum L., product quality, NaCl, nitrate, T. atroviride

12

Lettuce reaction to drought stress: high-throughput automated phenotyping of growth and photosynthetic performance

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The unavailability of fresh water is one of the main concerns for horticulture nowadays and it is supposed to get worse in the next years. Some crops are more vulnerable than others to drought stress: for example, leafy vegetables, such lettuce, that have high leaf water content. It is therefore essential to identify and select varieties that can overcome this kind of abiotic stress with limited or no substantial reduction in final yield, and to do it in a fast and effective way. Salanova® is a lettuce variety highly resilient to environmental stresses and fungal diseases. Drought resistance of two different Salanova® cultivars, Aquino (green butterhead) and Barlach (red butterhead), has been tested, monitoring their growth and photosynthetic performance with PlantScreenTM, a high-throughput non-invasive imaging platform developed at Photon Systems Instruments (PSI, Czech Republic). PlantScreenTM high-throughput phenotyping platform provides a powerful tool for acquisition and selection of morphological and physiological parameters, which can be used for identification of various components underlying early plant responses to various environmental conditions. A range of morpho-physiological traits was monitored every second day to verify and compare the different reactions of the two accessions to a mild drought stress. Here we show that the two cultivars perform similarly in both control (60% soil water content) and mild drought stress conditions (40% soil water content). Our results demonstrate that Aquino is growing faster in control conditions in early growth phase, while in later phase it is the red Barlach that is reaching larger area. In drought conditions growth performance of both cultivars is rapidly compromised when watering regime is reduced in mild drought treated plants. However, only after 4 weeks of mild drought stress any difference in growth of the two cultivars in drought conditions was shown, with Barlach performing slightly better. Light curve protocol was used to address light use efficiency of the two cultivars. Interestingly, we observed a rapid decline in PS II operating efficiency already 3 days upon mild drought stress initiation. Nevertheless, there was no obvious difference in the performance between the two cultivars. Our works provides quantitative insights into morpho-physiological responses associated with mild drought stress in lettuce and provides a robust protocol for high-throughput image-based analysis of different aspects associated with the early and later phase of drought response.

Keywords:

High-throughput plant phenotyping, Lactuca sativa L., chlorophyll fluorescence, morpho-physiological traits

13

Exogenous foliar application of MeJA modifies the growth response of pepper under heat shock

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Substantial deviations from the optimum temperature for plant growth can negatively influence many physiological functions in plants - affecting paramount cellular processes, provoking membrane injury, lowering plant vegetative and generative biomass, and reducing crop product quality. Climate change can exacerbate local temperature extremes by increasing the intensity and frequency of heat shock events, which forces growers to implement quick changes in management practices to ameliorate abiotic stresses. Jasmonic acid seems to play a key role in the regulation of heat stress tolerance. Thus, we have investigated the effect of thermal shock stress in different pepper (Capsicum annuum L.) cultivars and have determined the cultivar-dependent response, in southern Spain. The experiment involved three pepper cultivars, Agio (A), Loreto (L), and Guindilla Vasca (GV), which were grown in a climate chamber for 18 days (28ºC) and afterwards were submitted to a heat shock (40ºC) for 48 hours. The results indicate a cultivar-dependent response to this elevated temperature. Thus, the heat shock had only a minor impact on GV plant fresh weight, whilst A (23.3%) and L (32.5%) showed a significant increase compared with their controls (no heat shock). MeJA attenuated this effect on growth for both cultivars however, the effect of MeJA on the net assimilation rate and stomatal conductance at high temperature was not significant, neither were its effects on chlorophyll fluorescence.

Acknowledgment: This work was financed by the European Regional Development Fund 80%-Región de Murcia (FEDER 1420-07).

Keywords:

Capsicum annuum L., temperature, plant growth regulator

14

Effect of insect proof screens on sweet pepper crop production in screenhouses

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The effects of cover optical properties and screenhouse radiative environment on sweet pepper crop development and fruit productivity were investigated in a Mediterranean climate (Eastern Greece) under three screenhouses covered by different screens: (i) a clear insect-proof screen, (ii) a white insect proof screen and (iii) a green shade-screen, with values of shading factors to solar radiation measured in the lab of about 13%, 34% and 36%, respectively. The porosity of the screens was found 0.46 for the insect proof and 0.63 for the shading screen. Sweet pepper plants (Capsicum annuum) were grown under open field (control) and under the above mentioned screens and the microclimate parameters along with crop development and fruit production characteristic were measured during a spring – autumn crop circle. The screenhouse microclimate parameters were similar to those measured outside but the radiative environment was significantly different between the three cases. The total dry matter production (DMP) of the crop inside the clear insect-proof screen and white insect proof screen was 34% and 12%, respectively, more than the total DMP of the open field crop, while the total DMP of the crop under the green shade screen was 3% less than the open field crop. The dry matter content of harvested fruits was on average 5.8% and 7.1% for the crops inside screenhouses and at the open field, respectively. The effects of screens were most pronounced on early-season-harvested fruits. Significant interactions were obtained between shading and harvest date. The results indicate that compared to open field, screens were able to induce higher pepper fruit production throughout the harvesting period, especially on early-season, where open field climate conditions (solar radiation and fruit temperature levels) induced severe crop stress conditions.

Keywords:

Radiation, shading, microclimate, dry matter, net

15

Effectiveness of Trichoderma application through drip-irrigation to reduce Sclerotinia disease incidence and improve the growth performance of lettuce

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A greenhouse experiment was carried out during the winter growing season in 2015 in Ladispoli (Central Italy) to assess the influence of Trichoderma atroviride strain AT10 on shoot fresh biomass and resistance against the soilborne pathogen Sclerotinia minor of lettuce crop (Lactuca sativa L. – cv Canasta) grown in a naturally infested field. Trichoderma atroviride strain AT10 was applied five times (0, 11, 24, 34 and 49 days after transplanting) by drip irrigation at a rate of 1 kg/ha for each application. Lettuce drop caused by Sclerotinia minor appeared at 49 days after transplanting where untreated plants (control) showed a higher mortality than plant treated with T. atroviride (4.0 vs 0.9%). The disease incidence increased significantly at 56 days after transplanting with higher value in control plots than in plots treated with T. atroviride AT10 (4.1 vs 2.4%). At the end of the trial (61 days after transplanting) the disease incidence reached 8.5% in control plot and 3.3% in treated plots. The efficacy of Trichoderma treatments in reducing the disease incidence in comparison with control treatment was calculated with the Abbott's formula and varied from 42.1 to 77.2 %. The antagonistic activity of Trichoderma atroviride strain AT10 against Sclerotinia was demonstrated through in vitro tests. At harvest, lettuce plants inoculated with Trichoderma atroviride strain AT10 had a 13% higher shoot fresh weight than untreated plants indicating a phytostimulation action of the endophytic fungus .

Keywords:

Lactuca sativa L., endophytic fungi, phytostimulation action, disease incidence

16

The effect of organic substrate and aqueous extract of vermicompost on nursery basil growth

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Organic substrates, including compost, are used in the production of commercial seedling plants. In this work, a commercial substrate (COS) was compared with a compost made from bovine manure and onion residues (CBMO) and irrigated with vermicompost of urban solid wastes tea (VT) and their effects on the growth of basil seedling (Ocimum basilicum L.) were studied. Half of these treatments were irrigated with (VT), while the other half received water (W). The experiment was conducted for two years, in a greenhouse and three replicates of each treatment were made. Seedling growing in COS irrigated with VT had the highest foliar area, height, and fresh weight in both years. Meanwhile, those growing in CBMO irrigated with VT showed no differences in these parameters compared with those which received water. Also, the treatment COS plus VT produced plants with a higher chlorophyll content than those irrigated with water, in which the color parameters of leaves (L*, C*ab, hab) changed from dark green to light yellow during the growth process. Plant growing in CBMO had no differences in color and chlorophyll content when irrigated with water or vermicompost tea. Irrigation with VT produced seedlings with the highest content of N and K in the shoots of both substrates. The use of CBMO as a substrate in the production of basil seedlings, giving rise to smaller seedlings, with an increase in the marketing period compared to those grown in the COS. The fertigation with aqueous extract of vermicompost would be promising because it increases the content of some nutrients in the aerial part and improves the commercial aspect of this aromatic plant.

Keywords:

Ocimum basilicum, compost, vermicompost tea, seedlings

17

Sustainable agri-food systems need you: the puzzle and paradox of legume-based agri-food systems in Europe

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Agricultural and (human) food-systems are interconnected. Despite this, policy- and governance measures tackle the challenges of each system using separate approaches. Additionally, legume crops are not yet recognised as essential components of sustainable agri-food syste The capacity of legumes for “biological nitrogen fixation” facilitates their own nitrogen requirements, and that of other non-fixing crops in the cropping-sequence too. Legumes also provide the most nutritious of feeds and foods, and properly managed facilitate: natural nitrogen cycling improved soil qualities lowered greenhouse gas emissions and, can help restore and conserve biodiversity. While these benefits are recognised, and European agri-food and feed systems are heavily legume dependant, it is paradoxical that this potential is forfeited while the dependency is satisfied (80 %) from imported grains.

The transition to home-grown legume-based agri-food systems demands buy-in and cooperation of all the actors spanning feed- and food-chains, and especially the awareness of consumers. Here we describe the early findings of the project, TRansition paths to sUstainable legume-based systems in Europe (TRUE, www.true-project.eu). The innovations showcased highlight a diversity of tools, from breeding and precision agriculture to European Legume Innovation Networks (ELINs), and the implementation of policies that will help place legumes in a central role to satisfy both agri-environment-, -animal- and human-health agendas.

Acknowledgements

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Keywords:

Legumes, nutrition, greenhouse gases, hydroponics, food, organic, policy, market analysis, decision support systems

18

Vegetative growth and Glomerella leaf spot (Colletotrichum sp.) in 'maxi gala' apple trees covered with photoselective anti-hail nets

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The screen cover system offers good protection against hail stor In contrast, it causes a reduction of incident light levels, which negatively affects the vegetative and reproductive growth of plants. These changes in vegetative development are closely related to the shading formed using cover systems and, depending on the color and mesh used, may increase or decrease the vigor of plants. However, these plant responses to the spectrum emitted by the screens are species specific and local climatic conditions. In order to mitigate the effects of shading caused by anti-hail netting, photoselective anti-hail nets appeared as an alternative to increase the efficiency of light dependent processes. Thus, the objective of this study was to evaluate the influence of photoselective anti-hail nets on vegetative growth and on the incidence and severity of Glomerella Leaf Spot (MFG) in 'Maxi Gala' apple trees. The experiment was carried out during the 2016/2017 growing season, in a commercial orchard located in Monte Alegre dos Campos city, Rio Grande do Sul state, Brazil. 'Maxi Gala' apple trees were used under the following treatments: 1) Full sunlight exposure (without hail net) 2) Yellow ChromatiNet® 3) Blue ChromatiNet® 4) Red ChromatiNet® 5) Black anti-hail nets 6) Pearl ChromatiNet® and 7) Mixed anti-hail nets (black and white). At the end of the productive season, before leaf fall, the incidence and severity of MFG were evaluated. Subsequently, we also evaluated the vegetative growth of the branches in the field in the upper and lower portions of the plants, obtaining the number of branches per portion of the plant and the average length of the branches (cm). The fresh mass of pruned branches (g plant-1), number of pruned branches, average length of pruned branches and average mass of pruned branches (g branch-1). Differences were observed between the anti-hail nets in the 2016/2017 season in relation to the MFG severity, with the highest disease severity indexes (ISD) being observed in the yellow chromatiNet® and the red ChromatiNet® screens. The incidence of MFG in the present study was relatively high at the end of the season of 2017, with the highest values found in the yellow and red color ChromatiNet®, respectively. The yellow and red color ChromatiNet® anti-hail nets provided an increase in the average length of the branches in the upper portion of the plants. The use of anti-hail nets did not interfere with the average length of pruned branches, total mass of pruned branches, average mass of pruned branches and average number of buds per branch pruned in 'Maxi Gala' apple trees in the year 2017. The photo-selective hail nets yellow and red color from ChromatiNet® induced vegetative growth of ‘Maxi Gala’ apple trees. These hail protection nets promoted an enhancement of the incidence and severity of Glomerella leaf spot in the season of 2016/2017.

Keywords:

Malus domestica B., plant vigor, susceptibility to pathogens.

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Sustainable management of inorganic waste in horticultural sector: new approach for implementing a bioeconomy farming system in Almería (S. Spain)

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The concept of bioeconomy has been around for the last ten years. In the European Union (EU), it emerged in 2005 and identified as a tool to address a wide range of societal challenges in the coming years: food security, climate change, sustainable resource management, private companies' competitiveness and job creation. Spain launched its own strategy on bioeconomy in January 2016 aiming at boosting a bioeconomy based on the sustainable and efficient production and use of biological resources. The targeted sectors are food, agriculture and forestry. It includes, among other challenges, the valorisation of wastes and residues reducing waste and closing the circle in the value chain. In this framework, after a brief description of the concept of bioeconomy and circular economy, the legal framework for the management of inorganic waste in rural areas is developed. After that, focusing in the Almería horticultural greenhouses system, objective of the study, the main activities in the production process and their respective inputs and waste generated were detailed, providing an overview of the main challenges and criticalities to achieve zero inorganic waste. Subsequently, a typology has been developed according to the nature and volume of waste generated. In general, about the composition of the generated waste during these activities, the plastic used as protection material represents approximately 6% of the total waste produced in intensive agriculture and the remaining 94% correspond to organic residues. The maintenance of the cover structure and the plastic for disinfection are the productive functions with a higher importance regarding the weight (42% and 23%, respectively) and volume (40% and 19%, respectively) of waste produced. Finally, framed within the REINWASTE project, some innovative practices to reduce inorganic waste is performed leading to more bioeconomy and sustainable horticultural sector in south of Spain.

Keywords:

Inorganic waste, bioeconomy

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Effect of climate conditions on growth and production of hydroponic papaya crops in the Canary Islands

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Optimal papaya production and quality in subtropical areas, such as the Canary Islands, require adequate ambient conditions. Therefore in this region, commercial papaya is cultivated inside greenhouse structures for protecting plants against pests and adverse climatic conditions. However, since these greenhouses are generally equipped with low-level, or even with no, climate control, the location of the crop on the Islands greatly affects papaya production and quality. In order to characterize this effect, experiments were conducted inside plastic greenhouses in two locations of Canary Islands, one in the north of Tenerife (TN) and the other in southeast of Gran Canaria (GS). The papaya cultivar “Sweet Mary” was grown from April 2015 to March 2017 in both locations using a hydroponic system. Crop growth measurements were taken monthly and production parameters were determined at weekly intervals, harvesting all fruits with more than 20% of yellow-orange peel colour. Air temperature, relative humidity and photosynthetic active radiation (PAR) were monitored inside both greenhouses during the study period. Although average first flower emission height was similar in both locations (77 cm in GS vs. 74 cm in TN), average first fruit emission height was higher in GS (105 cm vs. 80 cm in TN), denoting flower setting problems in relation with the TN location. This may be probably related with higher temperature events in GS location during the first cropping months. Average leaf area was above 10 m2 per plant in GS all year round. This is significantly higher than the values observed in the TN location plants during autumn and winter period, which were below 5 m2 per plant, caused by a significant plant defoliation probably associated with adverse climatic events in that area. Leaf area values together with higher PAR levels in GS with respect to TN location, led to higher fruit production in the GS plants (105 kg·plant-1 vs. 69 kg·plant-1), which may be attributed to a higher proportion of fruits with weight above 900 g. Fruit total soluble solids content were above 11 °Brix all year round, except in the winter season in TN location, with values below 10 °Brix. All these results support the recommendation of incorporating simple greenhouse modifications and crop management techniques adjusted to the limiting climatic factors of each area in order to increase papaya production and quality, especially in north-located greenhouses.

Keywords:

Plastic greenhouse, leaf area, PAR, °Brix

21

Use of plant growth regulators to increase fruit set of Gala apple orchards covered with anti-hail nets in southern Brazil

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The use of anti-hail net has been the main strategy used to minimize the damages caused by hail precipitation in apple orchards in southern Brazil. The light restriction due to the use of anti-hail nets, when combined with climatic conditions of high rainfall and cloudiness, can intensify the vegetative development in the flowering phase, having a significant effect on the reduction of effective fructification. Thus, the combined use of strategies to increase effective fruiting is necessary, especially in cultivars with a higher propensity to this problem, especially in Gala apple trees. The insufficient occurrence of chilling during autumn and winter season, characteristic of most apple growing regions in Brazil, increases apical dominance and intensifies the fruit set problem. The use of plant growth regulators with action in inhibiting the biosynthesis of gibberellins, such as prohexadione calcium, is a recently inserted tool in the production system of the apple tree in Brazil, with interesting possibilities of use in the management of orchards covered with anti-hail nets. The objective of this work was to evaluate the use of prohexadione calcium (PCa) in the fruit set increasing of 'Gala' apple trees under anti-hail nets. The experiment was carried out in commercial apple orchard of 'Galaxy' grafted on Marubakaido rootstock with interstem M9, covered with a white anti-hail net (around 15% of shading). The following treatments were evaluated: 1) control (no treated plants), 2) PCa 82.5 g ha-1 + PCa 82.5 g ha-1 at 21 days after first application (DAFA) 3) PCa 110 g ha-1 + PCa 110 g ha-1 at 30 DAFA 4) PCa 165 g ha-1 + PCa 165 g ha-1 at 30 DAFA. The first application was done when the shoots were with 5 cm in length. The evaluations of fruit set, number of floral clusters with fruit, number of fruits per floral cluster, number of fruits per plant were done. The PCa applications increased the number of fruiting points in the plant in relation to untreated plants, expressed by the increase in the number of clusters with fruit per plant. As a result, there was an increase in the average number of fruits per plant in the treatments with PCa. The use of PCa was shown to be more effective in the increase of Gala fructification in PCa treatment 82.5 g ha-1 + PCa 82.5 g ha-1 at 21 DAFA, showing an increase in the number of fruits per plant and number of floral clusters with fruit in comparison to the untreated plants. The result obtained indicated the possibility of PCa use in the fructification management in 'Gala' orchards covered with anti-hail nets.

Keywords:

Malus domestica, gbberellin biosynthesis inhibition, prohexadione calcium, vents, insect flight, prevailing winds, optically active cladding materials, reflective mulch, mass trapping

22

Effect of planting date on greenhouse strawberry production in New Zealand

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In New Zealand strawberries are normally planted in the field in May/June, as high health plants are normally only available at that time from the strawberry nurseries .

The introduction of greenhouse strawberry production has resulted mainly in an improvement in fruit quality, and that production commences a little earlier, and continues later due to the improved environment in a greenhouse.

This paper describes as study in which 4 varieties of day neutral varieties Albion, Aromas, Monterey, and San Andreas) were propagated monthly from tip runners, and grown on hydroponically in a greenhouse in a coir medium, and the fruit yield and fruit numbers recorded at each harvest.

From these data were determined the monthly yields and mean fruit weights of the different varieties and planting dates .

As expected productivity was higher during the summer months (due to higher radiation and daylength) than during the winter, but the pattern of flowering (and therefore of fruit production) was cyclic, and mean fruit weight fell significantly over time, due to the increasing number of flowers produce, without an equivalent increase in photosynthetic potential .

The relevance of this information in developing a year round greenhouse strawberry cropping strategy will be discussed .

Keywords:

Day-neutral strawberries, planting date .

23

Effect of Shade Levels on Plant Growth, Physiology, and Fruit Yield in Bell Pepper (Capsicum annuum L.)

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An experiment was conducted with bell pepper 'Bayonet' in the spring of 2016 at the Horticulture Farm, University of Georgia, Tifton, GA, to evaluate the effect of shade level on plant growth, physiology, and fruit yield. Seedlings were transplanted in the field in March and shade nets were placed in May. Plants were grown under five levels of shade (0%, 30%, 47%, 63%, and 80%) using black shade nets following the randomized block design. Shade resulted in taller plants with larger but thinner leaves. Leaf water potential increased and photosynthetically active radiation decreased as the shade levels increased. Increased net photosynthesis was observed at 30% shade level. Moderate shade levels (30% or 47%) increased the marketable fruit yield by 20% compared to the open field. Moderate shade levels also reduced the sunscald incidence significantly in comparison to the open field bell pepper production. Overall, moderate levels of shade improved plant growth, gas exchange, plant water status, and fruit yield in bell pepper compared to the open field production.

Keywords:

Plasticulture, heat stress, shade house, climate change, crop physiology

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Hydrogen cyanamid levels and mineral oil to budbreak induction of apple trees under anti-hail nets

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The use of budbreak promoters is a usual cultural practice in the management of apple orchards in Southern Brazil, with the purpose to reduce the problems of insufficient chilling during autumn and winter season. Hydrogen cyanamide is the main substance used in the budbreak induction of 'Gala' apple trees, being the application carried out in combination with mineral oil. This combination is conventionally used for high efficiency, but in a few years the results are insufficient, especially in orchards under anti-hail nets. The microclimatic conditions of temperature and light quality in the orchard covered with anti-hail increases the vegetative growth and other physiological parameters of apple trees, modifying the plant response to the budbreak treatments, demanding the concentration adjustment of the products used in this situation. The objective of this study was to evaluate different concentration of hydrogen cyanamide in combination with mineral oil in the budbreak induction of 'Baigent/M9' apple trees under anti-hail nets, in the Southern Brazilian conditions. The experiment was performed during the 2017/2018 growing season, in a commercial apple orchard growing under anti-hail nets, located in Vacaria municipality, Rio Grande do Sul State, Brazil. The experimental design was a randomized block, with three replications of two trees per plot. Seven treatments were evaluated: 1) Control (untreated trees) 2) mineral oil 3.5% 3. mineral oil 3.5% + hydrogen cyanamide 0.17% 4) mineral oil 3.5% + hydrogen cyanamide 0.34% 5) mineral oil 3.5% + hydrogen cyanamide 0.51% 6) mineral oil 3.5% + hydrogen cyanamide 0.69% and 7) mineral oil 3.5% + hydrogen cyanamide 0.86%. The budbreak promoters application anticipated and reduced the blooming period in relation to untreated trees and increased the budbreak in axillary and terminal buds, especially in treatments with hydrogen cyanamide above 0.34%. The increase of hydrogen cyanamide concentration showed the tendency to decrease the fruit set, but with low impact in the fruit production .

Keywords:

Malus domestica, insufficient chilling, budbreak promoters

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Preliminary study of the behavior of a courgette crop grown under photoselective shade nets

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The application of new plastic shading nets with special optical properties represents a new approach to improve the use of solar radiation in agricultural crops. These nets have different percentages of transmission, absorption and reflection of light. In this work, the behaviour of a courgette (Cucurbita pepo ssp. pepo) crop grown under photoselective shade nets was evaluated. Although courgette, like watermelon and melon, is a plant that is resistant to high temperatures, this species was used here as it has been demonstrated in other species that the use of photoselective nets can improve their performance and quality. In this first trial with courgette, four walk-in tunnel-type structures were covered with photoselective screens of distinct colours (red, pearl, silver and black) and were compared to an uncovered structure. Vegetative parameters - such as the evolution of the leaf and of the growth of the plant, as well as the fresh and dry weight of the leaves, stem and whole plant - were analysed, in addition to the weight and number of fruits per plant. These first results show that with the red net the crop was more productive than the crops grown under a pearl or silver net or under control conditions in the open air, the yield being twice that of the plants grown under the black net. Regarding the number of fruits, there were no significant differences between the nets and open air, the number being lowest with the black net.

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Keywords:

Cucurbita pepo, zucchini, fruit, radiation, sunburn

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Yield of everbearing strawberries (Fragaria x ananassa Duch.) in two consequtive years depending on cultivar and row covers in winter in high tunnels in Estonia

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An open-field strawberry season in Estonia is very short, lasting from the mid-June to mid-August. The aim of the research was to prolong the season by growing everbearing strawberries 'Diamante´, `Cabrillo´, ´Harmony´ and Fresh Forward new line FF1604 in tunnels and to find out their yield, winter hardiness and consumer acceptance of fruits.

Strawberries were planted in May 2017 on tabletops in peat substrate bags (8 plants per bag, 10 bags per cultivar). The yield was harvested from 4. July until 26. September. At the end of November plastic was removed from the tunnels, plants in the substrate bags were lifted to the ground and covered with double fleece row cover or double anti-frost net. Temperature loggers were placed into the substrate at the depth of 3 cm. Row covers were removed at the beginning of April and winter damage of rhizomes was assessed. Plants were lifted to tabletops and grown until the end of August.

In the first year, the highest yield was obtained from 'Harmony' (502 g/plant), but the largest fruits from 'Diamante' (average size 22.2g). FF1604 fruits were the sweetest and were most liked by the consumers. The average and minimum substrate temperature under fleece was 0.2 and -2.2°C and under anti-frost net 0.5 and -2.7°C, respectively. On average, plants had medium winter damage (from 1.5 to 2.6 in 3-point scale) without significant difference between row covers. Overwintered plants produced very low yield (from 139 to 240 g/plant). On average, plants covered with fleece had higher yield compared to anti-frost net .

Conclusively, growing everbearing strawberries in tunnels enabled to prolong strawberry season in first year from usual 6-8 weeks to 13 weeks. However, overwintering of everbearers in substrate bags caused serious winter damage to plants despite of row covers and therefore can not be recommended.

Keywords:

Winter damage, yield, fleece, anti-frost net

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Improving fruit quality of apples growing under photoselective nets

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In recent years, apple orchards have had positive effects of using photoselective nets during the fruit growth on the quality of fruits, especially in the green varieties such as 'Granny Smith' and 'Golden Delicious'. No such information was collected on the effect of photoselctive nets during this period on the quality of the fruit in colored varieties. During an observation that was placed in Merom Golan in 2013 and have been going for 4 years, the influence of different shade ranges and colors on the development of the fruit was examined in three colorful apple varieties. The nets that were examined in the 'Gala', 'Starking' and 'Pink Lady' varieties, in 2013, were a 20% pearl leno and a 20% red leno (Ginegar). From the second year of the experiment, the nets were replaced for 'Gala' and 'Pink Lady' trees with a transparent leno 10% (Meteor). During the whole seasons we measured the percentage of shade under the various nets, the water potential of the trunk, the effect of the coverage on the air temperature below the nets, the effect of coverage on harvest and the relationship between the color of the net and the ripening state. Through the years of experiment we found significant impact of the nets on decreasing fruit sunburn. In 'pink lady' we also had a significant decrease in fruit cracking. In contrast, shading the 'Gala' and 'Pink Lady' resulted in significant decrease of fruit color. In order to overcome the decrease in fruit color, we simultaneously tried to apply different horticultural aspects such as irrigation, pre-harvest net removal, summer foliage thinning, all of which, unfortunately, didn't succeed.

Keywords:

Apple, photoselctive nets

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Kiwifruit growth under nets

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Kiwifruit (Actinidia deliciosa) is a deciduous species which its growth in Israel is restricted to the high regions of the northern areas, due to the demands of cold hours. Kiwifruit as a vine is very sensitive to the winds, especially during the time of growing young foliage. Spring winds and gusts will damage the current year shoots with flowers affecting this year yield whereas summer gusts will damage branches bearing the next year shoots. As a result we considered using net coverage to reduce wind speed and thus damage. In addition, net covering can improve the water condition by lowering the temperatures and reducing evaporation, thereby reducing water consumption in Kiwi, which is a relatively high water consumer (about 10,000 cubic meters per hectare). Consequently, bee activity that is essential for kiwi will be affected since forage under nets limit their navigation capability. An earlier attempt to grow Kiwi under nets has brought to a reduction in yields, probably due to the lack of pollinators. Recently, a method was developed to cover and fasten the nets by a zipper (Pascal-Yiron) enabling the growers to a fast and easy removal of the nets during the pollination period while at the same time enjoying the benefits of the nets during early foliage growth period and through the summer. In the first year of the experiment we found encouraging yet primary evidence for improvement in fruit size, yields and water conservation .

Keywords:

Kiwifruit, wind pollination

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Influence of different row covers on the yield of garlic (Allium sativum) in Estonia

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In Estonia the commercial production area of garlic has been about 50 hectares. The interest in garlic production has increased recently, since the local market is demanding larger amounts of garlic for fresh consumption. One of the problems for local growers is the winter damage of plants when the temperatures are below -20℃ without or with little snow cover. The aim of the present research was to study the influence of different row covers on the survival, yield and bulb quality of garlic. Experiments were carried out with winter garlic 'Ziemiai' in commercial field in southern part of Estonia in 2015-2016.

Garlic was planted in 17. October 2015 and at the end of November the field was covered with floating fleece, anti-frost net or 5 cm peat layer. Control plots were not covered. Temperature loggers were placed into the soil at the depth of 6 cm next to garlic cloves. Row covers were removed at the end of April and winter damage of garlic was assessed. The yield was harvested on 23. July 2016.

The minimum soil temperature without row covers was -8.6℃ whereas minimum air temperature at the same time was -19.1℃. The minimum soil temperature under fleece was -2.3℃, under anti-frost net -3.5°C and under peat layer -0.7°C. Plant survival in control plots was 78% row covers significantly increased plant survival, which ranged from 84 to 91%. There were no significant differences between row covers. The lowest total yield of garlic in plots without winter covers was 477 g/m2. All covering materials increased the yield, which ranged from 529 to 567 g/m2. There was no significant difference between covering materials.

Conclusively, covering of garlic fields can avoid temperature drops in soil and is decreasing winter damage.

Keywords:

Winter damage, fleece, anti-frost net, peat mulch

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Effects of Limited Irrigation on Yield and Quality of Some Vegetable Species

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The significant climate changes registered over the past few years demonstrate the vital importance of finding workable solutions allowing us to preserve our natural resources (especially vegetal genetic resources, land, and water) and ensure a steady and nutritious food supply to all people. The use of genotypes with tolerance at biotic and abiotic stress might represent an alternative solution to the current challenges. The aim of this study was to investigate the yield and qualitative performance of a plant genetic collection in water stress condition in order to (1) select and introduce in breeding programs germplasm that exhibits the tolerance to water stress (2) recommend to the farmers genotypes able to perform in water stress conditions. The experiments were conducted at the Vegetable Research and Development Station in Bacau, Romania,in the period of 2011 - 2018. The experiments were conducted at an elevation of 91 m, latitude 46.521946 N, longitude 26.910278 E., average annual temperatures during the experimental period averaged between 8 to 9 degrees Celsius. During the winter, temperatures dropped as low as -29º C, while during the summer, they reached as high as + 39º C. Average annual rainfall exceed 500 - 550 mm per m2. Daily measurements for temperature and precipitation were registered. The biological material was represented by genotypes of mung bean, tomatoes, and peppers. There were accomplished investigations related (1) to yield performance: as number of fruits per plant, number of seeds in fruit, weight of fruits, seeds and (2) to quality: as total soluble, total dry matter, proteins, content of pigments, minerals, ascorbic acid. In case of all investigated crops, yield depends mainly on soil water status throughout the growing season. There were established critical moments for each investigated species, which requires water supply. Any restriction related to water irrigation supply is likely to induce a decrease in crop yield. The impact of deficit irrigation on crop yield was correlated to specific growth stages that are more or less sensitive to moisture deficiency. More investigation that envisage the extension to other crops and cultivars, are needed in order to select appropriate germplasm for suitability in water stress condition .

Keywords:

Water stress, mung bean, tomatoes, peppers

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Physiological and agronomical response of Cantaloupe grown under different photoselective shade nets

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Photoselective nets are an emerging approach in protected agriculture. The photoselective shade nets currently available contain spectral filters with differential light-scattering properties that alter various spectral components of solar radiation (UV, PAR, and beyond) and/or transform direct light. The actual functions of colored shade nets depend on the chromatic additives and reflective elements incorporated into the netting materials. The physiological responses of plants linked to light, such as photosynthesis and photomorphogenesis, produce effects on stem growth, leaf expansion, chloroplast development, chlorophyll synthesis, secondary metabolites, and harvest time. The objective of this work was to study the behavior of a cantaloupe (Cucumis melo L) crop grown under various photoselective shading nets, placed on simple greenhouse structures. The nettings used were: silver in color with 30% shading, pearl with 30% shading, red with 30% shading, red with 40% shading, and black with 30% shading, using as a reference the crop without shading. The plants with the greatest development were those that grew under red nets with 40% shading, having a greater length, a greater number of leaves, and greater foliar area and fresh and dry weight of stems and leaves. The rate of photosynthesis was highest in plants grown under the 30% pearl and 40% red nets, as were the rates of stomatal conductance and transpiration, although they had similar values of intercellular CO2. Regarding the quality of the fruit, the soluble solids content and the maturity index were highest for the plants under the 40% shading red-colored net. The highest yield was obtained with the silver-colored net: 3.5 kg plant-1.

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Keywords:

Cucumis melo, shade netting, precocity, greenhouse tunnel, crop protection

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Photosynthetic response of 'Maxi Gala' apple trees covered with photoselective anti-hail nets

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The use of anti-hail nets increased considerably in the apple-producing region of southern Brazil, motivated by high occurrence of hail events in the last years. Most apple orchards in this region are covered with black anti-hail nets, which reduce incident light by up to 45%, affecting negatively some processes of apple tree development and production. In order to mitigate the effects of shading caused by anti-hail netting, photoselective anti-hail nets appeared as an alternative to increase the efficiency of light dependent processes. Thus, the objective of this study was to evaluate the influence of photoselective anti-hail nets on the leaf content of photosynthetic pigments and on the photosynthetic response of 'Maxi Gala' apple trees. The experiment was carried out during the 2016/2017 and 2017/2018 growing seasons, in a commercial orchard located in Monte Alegre dos Campos city, Rio Grande do Sul state, Brazil. 'Maxi Gala' apple trees from the area in full sun (uncovered) and covered with anti-hail net black (standart hail net) and photoseletive anti-hail nets (yellow ChromatiNet®, blue ChromatiNet® and red ChromatiNet®) were used to determine the levels of carotenoids and chlorophylls (g m-2), leaf area (cm2), specific leaf area (cm2 g-1) and CO2 assimilation rate curves (A, µmol CO2 m-2 s-1) in response to the increase in photosynthetic photon flux density (PPFD). The anti-hail nets were installed in August 2016, along the planting line, in the north-south orientation, using an adaptation of the 'chapel' system. Apple trees covered with anti-hail nets presented values of average leaf area below the area in full sun, but without significant differences between anti-hail nets evaluated. In contrast, the specific leaf area was higher in trees covered with ChromatiNet® yellow, as well as in the leaves of the plants uncovered. However, the ChromatiNet® blue, ChromatiNet® red and black screens had lower values of specific leaf area when related to the control treatment. The leaf contents of chlorophyll a, b and total (Chl a + b) were not affected by anti-hail netting. Plants grown under yellow ChromatiNet® and blue ChromatiNet® produced higher amounts of carotenoids in the 2016/2017 compared to the 2017/2018 growing season. A higher photosynthetic rate was observed in plants covered with ChromatiNet® red and blue ChromatiNet®. Respiration in the dark (Re) and light compensation point increased in plants covered with red ChromatiNet®. On the other hand, the apparent quantum efficiency was not influenced by anti-hail netting. The dispersion of blue and red light emitted by the red ChromatiNet® and blue ChromatiNet® photoseletive nets stimulated the maximum rate of CO2 assimilation in 'Maxi Gala' apple trees in response to the increase in PPFD, under the climatic conditions of southern Brazil, favoring a better foliar photosynthetic efficiency.

Keywords:

Malus domestica Bork., CO2 assimilation, chlorophylls

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Productivity and Quality of Pepper Crop as Affected by Cultivation Practices

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Agriculture is one environmental polluter but also the main food provider of for humans and animals. Chaotic exploitation of water and soil resources, excessive use of pesticides has led to problems with serious consequences in affecting environmental quality and human health. This study was designed in order to allow the selection of resistant material, able to perform in condition of ecological cultivation. The focus was on Capsicum annum L. var. grossum, C. annum L. var. tetragonum C. annum L. var. longum, C. annum L. var. acuminatum, cultivated in plastic tunnels in organic and conventional system .

In our study we made investigations regarding the morphological and physiological characteristics, related to crop quality and yield, in order to establish the suitability for cultivation in two different culture systems: conventional and ecological .

The biological material was represented by 10 different genotypes for each species. Our investigations were performed during the growth and development process and the investigated parameters were: the shape of the fruit, the color of the fruit (mature and immature), the size of the fruit, pericarp thickness, the pungency of the fruit, the position and the grouping of the fruit on the plant, the duration of the vegetation period, the resistance for pathological agents and also the tolerance / resistance to changing environmental conditions (drought and high temperature). We investigated also the content in water and total dry mater, the titrable acidity, the carotene and anthocyanin pigments, the ascorbic acid, the content in soluble sugar, the content in mineral elements .

The obtained ecological yield, with minimum environmental inputs demonstrates species suitability to cultivation in organic system. The results are presented in a comparative manner including both cultivation syste For each species, the best three variants were introduced in a breeding program for organic agriculture.

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Keywords:

Organic, conventional, vegetables, plastic tunnels, reflective mulches improvement

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Yield and quality of greenhouse organic pepper as affected by shading net in Mediterranean area

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In Mediterranean area the light intensity during the spring-summer season exceeds the optimal requirement of pepper plants, thus impairing production and quality of fruits. Research was carried out in Fisciano district (Salerno, Italy) on bell pepper grown in greenhouse by organic method with the purpose to identify the most effective shading net in terms of yield and fruit quality. Two black shading nets (25 % or 35 % light reduction) added to a polytunnel covered with a long life PE film and a control (unshaded polytunnel) were compared. A randomized complete block design with three replicates was arranged and the elementary plots, in which cultivars were placed, covered a 32.0 m^2 (8.0 × 4.0 m) surface area on which the plants were spaced 1.0 × 0.4 m giving a plant density of 2.5 plants per m^2. The pepper plants grown under 35% shaded gave the highest marketable yield, as a consequence of the highest number of fruits per plant and not to an increase in the fruit mean weight. Concerning the effect of shading on fruit quality traits, fruit dry matter, total soluble solids contents and total sugars, as well as the concentration of macro- and microelements (P, S Ca, Mg, K, Fe, Zn) of the fruits grown under the unshaded were highest, whereas proteins, carotenoids and vitamins were best favoured by the 35 % shaded. Our findings demonstrated, that the shading net represents a beneficial and sustainable tool in order to best fit the light and temperature conditions requirement of greenhouse pepper, thus enhancing fruit yield nutritional and functional quality.

Keywords:

Capsicum annuum L., PE film, caroteneids, mineral profile.

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