IHC2018-Symposium 18
II International Symposium on Soilless Culture

ORAL PRESENTATIONS

SESSION I, August 15, 2018-Wednesday 08:45-10:30
Session Chair: Erik Van OS

Integrated rootzone management (IRM) for successful soilless culture

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Soilless culture involves the production of plants using soilless growing substrates or using nutrient solution only (e.g., aeroponics). Regardless of what system is used, it is essential to create a healthy rootzone environment for the plants. A healthy rootzone environment includes, at the very least, balanced nutrients, air (e.g., oxygen), and water at a plant-specific optimal temperature. To achieve a healthy rootzone environment requires an integrated approach, coined here as 'Integrated Rootzone Management (IRM). IRM considers all of the interconnected elements and properties of the rootzone (e.g., physical, chemical and biological), and how changing any one element can affect the others. People often ask "what is the best growing substrate for my operation?" or "how often should I fertigate my plants?" To correctly answer these types of questions, all the important growing environment components (e.g., microclimate, fertigation system) must be considered and an integrated approach must be taken. Otherwise, even when using the 'best' growing substrate, a crop can be over watered, creating an oxygen-deficient rootzone leading to diseases such as pythium root rot. This paper discusses the concept of IRM, its rationale, and aspects to consider when managing rootzone in soilless production systems.

What`s in the bags of tomatoes and strawberries´ soilless growing systems?

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During the past decade, there has been an increasing demand for fruits and vegetables grown locally and available all-year round in North America. The development of protected cultivation systems such as soilless cultivation in greenhouse or tunnel allow to extend the production period or even to grow offseason fruits and vegetables. Moreover, the soilless greenhouse production in grow bags gives more space for plants growth, facilitates the picking of fruits and vegetables, reduces water consumption and is cleaner than in soil productions. The aim of this study is to evaluate the performances of grow bags filled with selected substrate mixes made of peat, coir or bark and the natural active ingredients Bacillus pumilus (PTB180) and Glomus intraradices (PTB297). The experiments are conducted in two greenhouses, under Ohio or Arizona climates, with strawberries and large tomatoes on the vine (TOV), respectively. The strawberry trial runs from October 2017 to April 2018, while the TOV are grown to maturity for a 10 months period with seedlings starting in October, 2017. Both trials are made during the

offseason production. All experiments follow a complete randomized block design. Irrigation and fertilisation follow standard procedures and are automated for each of the treatments. During the crop production, plant performances and characteristics, electrical conductivity (EC), pH and nutrients analyses of the drip and drainage solutions are monitored. Both trials involve measurements of soluble solids concentration (Brix), harvest quantity and quality of full ripeness fruits. For TOV, lycopene is measured while the total acidity is quantified periodically for the strawberry trial.

Description and characterization of some North American and European wood substrates

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There has been a tremendous amount of research conducted on wood substrates and substrate components over the past decade. The data and observations generated from those trials has been the foundation to all that we know today about the uses and potential of these substrate materials. Over the past several years many different wood components have been designed, engineered/processed, and evaluated which has led to greatly furthering the potential of these materials in present-day growing media formulations. At NC State University, researchers in the Horticultural Substrates Laboratory are currently characterizing nearly two dozen wood substrate materials from around the world while also conducting research in areas including 1) Engineering practices which are looking at the different types of machinery used to make wood components and the many variables associated with making consistent, reproducible, and reliable products on a commercial level; 2) Characterizing the many different wood components that are being made by assessing particle shape and size, surface area, and degradation rates; 3) Physical and hydrological properties of wood components and substrate blends containing wood which include total porosity, air space, water holding capacity, bulk density, wettability, hydrophobicity, initial hydration, available and unavailable water, water flow and drainage, packing, settling, etc.; 4) Chemical properties including pH, pH buffering capacity, cation and anion exchange capacities, phytochemical toxicities, PGR efficacy and tie-up, etc.; and 5) Biological properties including microbial populations, nutrient tie-up, degradation and shrinkage rates, pest and disease interactions, etc. Any one of these measured properties could be different with different wood components that have different shapes, sizes, origination from different tree species, have been aged/stored, dried or not dried, etc. It is also important to remember and consider that the properties of the substrate components by themselves is not as important as the properties that are achieved after blending various components together into the final substrate.

Coconut fiber: evaluation of physicochemical properties and enzymatic activity in soilless culture during three cycles of organic cultivation

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In recent years, the use of organic substrates has increased due to the urgent need to find new sustainable and environmentally friendly media alternatives for soilless containers. The main objective of this research was to evaluate the impact of three continuous cycles of organic cultivation (*Solanum lycopersicum* L.; *Cucumis melo* L.; *Lactuca sativa* L.) on the physicochemical and biological properties of coconut fiber. The crops were grown in a multi-tunnel greenhouse in 27 L containers under automated irrigation. Vermicompost tea applied through the irrigation system was the main source of nutrients. Physical (organic matter, carbon/nitrogen ratio, dry bulk density, porosity, air volume, and readily available water), chemical (pH, electrical conductivity, and cations and anions) and biological (dehydrogenase, acid phosphatase, and β-glucosidase activities) properties were evaluated. The results showed differences in properties for each of the three cultivation cycles. Physical and biological properties maintained optimal ranges throughout the three crop cycles. However, chemical properties showed limitations in the availability of nutrients after one crop cycle. Therefore, it is recommended the use coconut fiber in mixture with another organic substrate to improve some characteristics.

Potential use of biochar in growing media for quality production of *Syngonium podophyllum*

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The main sustainability barrier in growing media (GM) industry is obtaining the best quality, readily available, low cost and environment friendly components. Biochar (BC) is a carbonaceous material produced from the pyrolysis of biomass. It is widely explored for its potential in agriculture, environmental safety and energy production sector but focus towards its amendment in growing media for replacing nonrenewable components such as peat is very limited. A field study was planned with the objective to compare the potential of waste material and waste material with wheat straw-BC amended GM mixes on the growth of *Syngonium podophyllum.* The BC and waste material based GM mixes were characterized for their chemical properties. A nutrient holding capacity comparison was also made among the waste material based and BC amended waste material leaching experiment. The BC amended leaf compost growing media showed the superiority among all the media mixes tested. BC increases pH and the cation-exchange capacity (CEC), and it also depicted 10 % reduction in nutrient leaching. BC also affected the particle-size distribution (PSD) of the GM. Except it benefits, BC is not considered a standardized product owing to dynamic nature of the source biomass. However, the commercial production of GM demands highly consistent, excellent quality and homogenous nature components to meet industry demands on long term basis. There must be a suitable

standardized program put in place for defining the properties of BC products in GM industry. From economics point of view, BC presents a good potential towards replacing conventional costly GM such as peat.

Particle density of substrate components measure by gas pycnometer

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The particle density (ρs) of a porous medium represents one of its basic physical properties. The ρs of substrate components can be derived from indirect measurements such as the North Carolina State University Porometer Method or assumed to be 1.55 g/cm3. However, direct ρs measurements of organic and inorganic substrate components could generate more accurate and realistic values. The ρs of coir, peat, perlite, pine bark, and wood fiber were determined by a gas pycnometer using helium (He), nitrogen (N), and purified air. Perlite, an expanded silicate-based rock, yielded the lowest ρs at 0.60-0.70 g/cm3, presumably due to the large amount inaccessible, internal pore spaces which occur during manufacturing. The average ρs of wood, peat, and coir differed slightly for each gas. The ρs of wood, peat, and coir measured with He, for example, were 1.40 g/cm3, 1.44 g/cm3, and 1.49 g/cm3, respectively. Air containing high concentrations of nitrogen resulted in a lower pine bark ρs, 1.08 g/cm3, than He, 1.20 g/cm3. These measurements coupled with the understanding of the variability in the ρs of organic/inorganic substrate components could generate more accurate values of calculated parameters including total porosity and volumetric water content.

Evaluation of two fertigation systems based on substrate moisture and timer system in soilless crop

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Fertigation systems are the main method of nutrition for vegetable production in greenhouses; they allow an efficient and homogeneous distribution of water and nutrients. In most cases, when using substrates, it is necessary to apply dissolved nutrients in a large number of low volume fertigations. There are numerous fertigation systems based on the contribution needed in each physiological stage of the crop, volumetric moisture content of the soil substrate at a given time according to the farmer's criteria, solar radiation, evapotranspiration, and the demand tray. In all cases, those variables must be controlled by evaluating the drainage volume, electrical conductivity and pH of the drainage throughout the crop cycle. In this research, a qualitative comparison was made between two fertigation systems: time schedule system, as this is the most common system used in Mediterranean vegetable production, and the volumetric moisture method. For this purpose, a long-cycle tomato crop established in coconut fiber substrate was used. The evaluated variables were: aerial and radical biomass, crop nutritional status, yield, quality and efficiency of water and fertilizers. The same nutrient solution was used for both systems; the difference was the frequency and number of irrigations applied. The management of the fertigation system based on time schedule was determined by

climatic demand by checking the drainage percentage and EC of the drainages. However, the fertigation system based on moisture was conducted by using a dielectric probe installed in the substrate that conditioned the demand for fertigation to maintain volumetric moisture in a range between 20-28% throughout the production cycle. The results of this experiment show significant differences between the two systems in the total water used. The volumetric moisture system showed a lower consumption of water and fertilizer than the timed system; this represented a lower production cost and a decrease in the loss of nutrients by leaching.

SESSION II August 15, 2018-Wednesday 14:00-15-30
Session Chair: Dimitrios SAVVAS

KEYNOTE 1
Organic soilless production and hydroponics: a new sustainable paradigm

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Organic greenhouse production systems are often seen as a 'conventionalized' organic farming system, where off-farm synthetic inputs are replaced by off-farm organic inputs that are permitted under country-specific organic standards. This perception is partly explained by the fact that protected crop cultivation is a highly intensive production system with yields up to 10 times higher than those produced in open fields. Consequently, minimization of off-farm inputs is difficult, given that up to 85% of the fresh crop biomass is exported off-farm. Furthermore, one of the main challenges for organic greenhouse fruiting vegetables is to synchronize soil nutrient release with plant nutrient uptake, without any leaching or emissions into the environment. Although soilless organic greenhouse production, also known as raised/ demarcated beds or bag/container growing systems, is not allowed in the European Union, it may be considered a sustainable organic growing system that adheres to the organic principles of limited farm inputs if waste biomass and crop effluents are recycled to the production system. Growing out of soil that is connected to the earth's surface offer the advantages of (1) cultivating in area that would normally be unproductive due to poor soil structure and quality, soil contaminants and persistent pests; (2) minimizing risks related to infection by soilborne diseases, nematodes, weeds and other soilborne pests; (3) reducing nutrient run-off to groundwater by collecting crop effluent and reusing it on the farm; (4) achieving optimal crop nutrient management by fine-tuning the water and fertilization regime; and (5) achieving similar yields to conventional crops, producing fruits with high-quality attributes. In addition, these organic growing systems may be used for urban vertical or rooftop farming systems where space is limited at ground level, contributing to food security in urban areas and to food safety by stringently controlling physical, chemical and biological hazards to the produce. During that presentation, an overview of the actual worldwide situation and research performed during the last years on organic growing out of the soil and under controlled environment will be presented as well as the constraints observed at the commercial scale. For example, the impact of the soil/growing medium, irrigation, nutrient management and biostimulants on the physico-

chemical properties, microbial soil diversity and composition, and product quality of organic fruits will be discussed. Consumer perception of the organic hydroponics and its acceptability will also be discussed.

Impact of grafting and different strains of plant growth promoting rhizobacteria on tomato plants grown hydroponically under combined drought and nutrient stress

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Root inoculation with plant growth promoting rhizobacteria (PGPR) can be beneficial to plants in many ways. Furthermore, grafting has proven to be an efficient practice in controlling soilborne diseases and enhancing plant tolerance to abiotic stress. The combination of the above techniques could potentially enhance plant growth under stress conditions imposed by a shortage of water and nutrient supply. In the present study, a commercial tomato hybrid (‘*Belladonna*’), self-grafted or grafted onto the rootstock M82, was hydroponically grown on perlite under non-stress or stress conditions imposed by water and nutrient (N, P) deficit. The roots of both self-grafted and hetero-grafted tomato plants were inoculated with four selected PGPR strains aiming to enhance stress tolerance in terms of crop yield and product quality. The results of this study indicated that PGPR inoculation in roots indeed enhanced plant growth but had no impact on total fruit yield. On the other hand, grafting onto M82 increased fresh biomass and total yield under both stress and non-stress conditions. In conclusion, both grafting and PGPR inoculation proved to be beneficial to tomato crops faced with limitations in water and/or nutrient supply. However, further research is needed for the appropriate selection of rootstock genotypes and PGPR strains with enhanced stress tolerance.

Effects of mycorrhiza and irrigation programs on strawberry production in substrate culture

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The study was conducted in order to determine the effects of mycorrhiza use in two irrigation programs on yield, fruit quality and water consumption of strawberry plants (cv. Kabarla) grown in perlite. The experiment was carried out during the winter season of 2016 in a PE covered bitunnel at the Department of Horticulture Faculty of Agriculture at Ege University. In mycorrhiza treatment, ERS (Endo roots soluble) was used as mycorrhizal source (0.250 g m^{-2}) and has been applied as dipping of seedling roots before the planting. The plants were irrigated according to the integrated indoor solar radiation levels of 1 MJ m^{-2} or 2 MJ m^{-2}. The amount of irrigation was based on the leaching rate of 30-40% in both treatments. Treatment without mycorrhiza and 1 MJ m^{-2} were evaluated as control. Experimental design was randomized blocks with 4 replications. Our results indicated that irrigation and mycorrhiza treatments affected total yield, some fruit quality parameters namely fruit firmness, EC of fruit juice and total soluble solids and water consumption significantly. It was concluded that mycorrhiza application increased total and marketable yields and water use efficiency especially in 2 MJ m^{-2}.

Effects of microalgae *Chlorella Vulgaris* on hydroponically grown lettuce

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Chlorella vulgaris has been used as bio-fertiliser in hydroponically grown lettuce at decreasing levels of mineral fertilizers. The nutrients and aeration in the root area of lettuce have created a suitable living condition for algae. The aim of the study was whether we can reduce mineral nutrients in hydroponic production of lettuce by using the micro-algae *Chlorella vulgaris* without reducing the yield and crop quality. The eight treatments have been applied: (1) 100% Full nutrition (control), (2) 100% Full nutrition + algae, (3) 80% nutrition, (4) 80% nutrition +algae (5) 60% nutrition (6) 60% nutrition +algae (7) 40% nutrition, (8) 40% nutrition +algae. Effects of *Chlorella vulgaris* on lettuce growth and some quality properties were investigated. The results indicated significant mineral nutrient saving in hydroponic production of lettuce. The mineral fertilizers used in the hydroponic lettuce production can be reduced up to 60% by using living *Chlorella vulgaris* in the nutrient solution. *Chlorella vulgaris* has also positively increased the quality properties of lettuce; total soluble solids (brix) and vitamin C were increased. The use of *Chlorella vulgaris* not only saved the mineral nutrients but also was environment friendly approach.

Implementation of purification equipment for removal of plant protection products from horticultural discharge water

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Surface waters in Dutch agricultural and horticultural areas do not meet the requirements of the European Water Framework Directive for good chemical and ecological water quality. Emission of nutrients and plant protection products (PPPs) from agricultural activity contributes to this. The Dutch government issued emission standards for nitrogen, evolving to zero discharge in 2027 for all greenhouse crops. However, to reduce the leaching of PPPs to surface and ground waters on the short term, additional legislation came into force January 1st 2018. This regulation obliges Dutch growers to use purification equipment for the removal of 95% plant protection products (PPPs) when discharging drain water to sewage or surface water. This stimulates growers to look critically at opportunities to reduce the amount of discharge water, thus lowering the investment and operational costs of purification equipment. In this article we describe the implementation of the obligated purification for different types of cultivation systems, including the development of an approval protocol for purification equipment. Depending on the amount of discharged water and company size, growers will choose between either applying an installation at the company level or cleaning the water cooperatively with a group of locally located companies. Another option, especially suitable for infrequent small amounts of discharge water, is rental of a mobile purification unit. In any of these three cases, the growers must use an approved installation. The installation and the applied technical specifications (for example ozone dosage) need to be tested with so-called Standardised Water following a strict protocol. An installation is approved by a governmental committee if tested correctly with a purification efficacy of 95% for each of the 11 active ingredients of PPPs in Standardised Water.

SESSION III August 15, 2018-Wednesday 16:00-18:00

Session Chair: Youbin ZHENG

Simplified soilless systems to promote and improve the production of vegetables in urban and peri-urban areas

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First experiences of soilless cultivation are reported in literature in the seventeenth century. Indeed, growing plant outside the soil was already a common practice diffused in ancient cultures, as in the Babylonian hanging gardens, or when plants were grown in floating islands over lake Titicaca in the Andes, or in the Burmese Inle Lake in South-East Asia. During the twentieth century, starting from the thirties, but more intensively from the seventies, the technology associated to soilless cultivation has been growing dramatically. High Technology Soilless Culture (HTSC) was thereafter diffused widely in intensive farming systems for the great advantages offered to growers. HTSC systems are nowadays characterized by high level of automatism with accurate climatic control in the growing environment (usually greenhouses), adjustment in plant inputs (water and nutrients) in response to the growing stage, and great mechanization of the growing process (from transplanting to harvesting). Attempts for the introduction/diffusion of HTSC in places where low-input or small-scale agriculture are predominant have often lead to failure, retarding the diffusion of soilless cultivation worldwide.

Indeed, main advantages of soilless cultivation are actually those of the independence from fertile soils, the reduced water requirements, and the high production efficiency, none of them necessarily correlated with the technological level of the system. Consistently, simplified soilless cultures (SSC, also referred to as Simplified Hydroponics, SH) are spreading in urban areas to find solutions to low fertility of the soils, low irrigation water availability, small extension of cultivated lands and environmental pollution. Successful experiences of SSC have been conducted in the last decades all over the world and nowadays a relevant number of growing solutions is available, adapting to the peculiar social and environmental conditions of the most diverse contexts. In the present study, main advantages and constrains related to the adoption of SSC in cities are presented, grouping together for the first time results from more than ten years of experimentation in developing countries from the tropics in Africa, Latin America and South East Asia.

Zero liquid discharge in soilless greenhouse horticulture: solutions to save water and the environment while ensuring an optimal production

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Zero liquid discharge (ZLD) should be the future for soilless production. In The Netherlands emission of nutrients and plant protection products to surface water is the main reason to investigate the potentials of cultivation methods without any discharge. In a few other countries water pollution issues is the main motive, but for a majority water shortage and the increasing competition for water of an acceptable quality is reason for the growing need for water efficient cultivation methods. During four years ZLD was investigated for cucumber (2014, 2017) and sweet pepper (2015, 2016). The primary goal was to reuse all drain water, while maintaining a similar yield and quality as in the traditional growing method with regular discharges. To achieve ZLD all practical reasons for growers to discharge the nutrient solution had to be anticipated before. In the ZLD trials technical and strategic solutions were jointly tested and further developed into an adapted growing strategy without any discharge. A number of factors could be mentioned as main reasons for discharge: sodium in the supply water, discharge of filter rinsing water, unbalances in the nutrient solution, no recirculation of the drainwater in the beginning of the cultivation, no disinfection equipment, too low drain storage capacity, appearance of calamities (technical failures) and the amount of remnant nutrient solution left in slabs and tanks at the end of the cultivation. The next step was demonstrating the technical and strategic solutions in a cultivation. In 2014 and 2015 we showed that ZLD-cultivation in stone wool substrate was possible without loss of yield and quality. In 2016 and 2017 the more challenging coir substrate was used to investigate the influence of buffering and sodium accumulation. It appeared that ZLD was possible without loss of production or quality. Appearing problems were more in the field of management of water flows than lack of technical equipment. Special care should come for technical failures of equipment, mostly not enough storage capacity is available.

Strategy to minimise nitrogen load to finish a zero discharge cultivation

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The Dutch authorities established a plan for the reduction of water emissions from the greenhouse sector to become zero by 2027, to enforce the European Union Water Framework Directive. At the end of the cultivation period, a considerable amount of nitrate and phosphate is still present in solution in substrate slabs and in the irrigation system. The left over nutrient solution is generally discharged into the sewage system or surface water. The end of cultivation strategy was developed to use the plant uptake to reduce this nitrate and phosphate in the last 5 weeks of the cultivation period. This reduction should be realised without affecting the production or quality of the last fruits to be harvested. The strategy consisted of a gradual decrease over the last five weeks of the cultivation of nitrate, phosphate and water quantity supplied to the plant. Chloride was used to replace nitrate in the supply water. The anion-shift allowed maintaining a sufficient quantity of cations in the root environment to meet the plant's needs and to avoid production loss. A progressive shift from nitrate-nitrogen to ammonium-nitrogen was realised. The nitrogen-shift acidified the substrate slabs to release precipitated phosphate. A double irrigation cycle at the start of the day was implemented during the strategy to anticipate nutrient accumulation in the root environment. In 2016, the strategy was applied to a sweet-pepper cultivation. The water volume in the substrate slabs was reduced from 6 l m^{-2} to 3.5 l m^{-2}. Nitrate quantity was reduced from 109 mmol m^{-2} to 55 mmol m^{-2}. Phosphate quantity was reduced from 0.5 mmol m^{-2} to 0.2 mmol m^{-2}. In 2017, the strategy was applied to a cucumber cultivation. The average water volume was reduced from 8 l m^{-2} to 5.3 l m^{-2}. Average nitrate quantity was reduced from 113 mmol m^{-2} to 45 mmol m^{-2} and average phosphate quantity from 4.5 mmol m^{-2} to 1.65 mmol m^{-2}.

Salt accumulation in soil less growing systems: the influence of rootstock, root environment and crop stage on sodium uptake of roses (*Rosa hybrid* L.) and sweet pepper (*Capsicum annuum* L.)

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Reuse of drainage water, which is obligatory for soilless grown crops in the Netherlands, result in accumulation of residual salts (Na, Cl) if the input of these ions is higher than the uptake capacity of the crop. Rose and sweet pepper are among the lowest Na absorbers and discharge of drain water with as a result loss of nutrients and plant protection products (PPP's), is commonly carried out by growers to prevent salinity stress, which however is not in agreement with the aims within the European Waterframework Directive. In order to develop new irrigation and nutrition strategies with less (or even no) discharge, background information was needed about the process of and influences on Na uptake. Experiments were set up to obtain information on the influence of the root environment, root development, and crop stage on the Na uptake of rose and sweet pepper. Three trials were carried out with roses, in the first experiment, the Na uptake of three different rose cultivars (Pepita, Red Desire and Ruby Red) grown on rootstock and on own roots were compared in a substrate free hydroponic system. The second experiment focusses on the effect of shoot bending on Na uptake. In the third experiment, the effect of root development on the Na uptake was investigated by using different growing media: perlite, glass

balls and sand. With sweet pepper an experiment was carried out, keeping different fruit load to the plants: at two levels of Na in the nutrient solution (4 and 8 mM). Na uptake was calculated by two methods: depletion from the nutrient solution and by analysis of the produced biomass (DM). It was confirmed that both rose and sweet pepper have very low Na+ uptake rates (0.1 – 0.3 mmol/l). Although distinctive differences in Na content in different plant organs were found, consistent differences of the individual treatments could hardly be observed in both the rose and the sweet peppers experiments. In agreement with previous studies, the Na uptake seems to be quite linear with the Na concentration in the root environment. A substantial gap was found in the estimated uptake calculated by the Na depletion from root environment and derived from the biomass analysis.

Effect of calcium on Siirt saplings growth

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In Turkey, Pistachio are planted to the orchards either with potted seedlings or with grafted potted sapling. Seedlings demand of growers are generally not supplied. Preparing mixture of seedling soil without nutrient balance shows sometimes synergistic or antagonistic action to plant growth. Reaching to radial thichkness of saplings earlier is needed in nursery. This study was conducted to determine the ideal nutrient needs of cv. Siirt young plants that are widely used in Pistachio nursery. Aeroponic system is used to prevent any residue or absorption of mineral fertilizier in soil. Hoagland solution, including all nutrients for plants, is given as control. Aiming to effect of Calcium to young plant growth, including 66,7 ppm, 133,3ppm, 200ppm, 300ppm and 400ppm Calcium doses are added to Hoagland solution respectively. Effects of different Calcium contents to trunk diameter, length and weight, root weight were evaluated. Consequenty, different calcium doses were statistically correlated on parameters studied.

The effect of chelating Zn, Cu and Mn on plant Fe nutritional status of hydroponically grown tomato plants

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Common practice in Dutch horticulture is the application of Fe chelates in combination with unchelated Zn, Cu and Mn salts. Past research has shown that this unchelated Cu, Zn and Mn can compete with Fe for the DTPA molecule, resulting in a loss of available Fe. It was hypothesized that in nutrient solutions based on the Dutch Nutrient Solution Manual (Bemestingsadviesbasis), this loss of Fe can be up to 30%. In order to investigate the implications of this modelled Fe loss in a practical situation, and to investigate whether supplying Cu, Mn and Zn as chelated micronutrients would help solve this issue, a greenhouse trial was set up. In this experiment *Solanum lycopersicum* was grown on rockwool slabs using nutrient solutions based on common grower practice. Fe was supplied continuously using Fe-DTPA at two concentrations: 10 and 7 µmol L^{-1} Fe while Zn, Mn and Cu were supplied as sulfate salts or as Zn, Mn and Cu-EDTA. Throughout the growing season SPAD-index was quantified as indicator for leaf chlorophyll content. Additionally, both the fertigation solution and the drain-water were regularly analyzed for mineral nutrient content. Cumulative fruit yield was obtained upon termination; 265 days after the experiment start. On average, Fe concentration in the rockwool slab was 57% and 71% higher for respectively the 10 and 7 µmol Fe L^{-1} chelate treatments than the sulfate treatments.

On average, leaf chlorophyll content was found to be higher in the chelate treatments. Final fruit yield was also higher in the chelate treatments, with a yield of 58.4 kg/m^2 in the 7 µmol Fe L^{-1} sulfate treatment and 67.1 kg/m^2 in the 7 µmol Fe L^{-1} chelate treatment. These results show that chelating Cu, Zn and Mn is an important strategy to minimize losses of plant available Fe from the nutrient solution.

Comparing nutrient disorder symptomology of *Lactuca sativa* 'Salanova Green' and 'Salanova Red'

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Quality and consumer standards drive the fresh produce market for vegetables such as lettuce. Recognizing nutrient disorders is imperative for maintaining quality and yield, and thus, this study was conducted to induce and record the symptoms in 'Salanova Green' lettuce (*Lactuca sativa*). Plants were grown with a complete modified Hoagland's all nitrate solution: (macronutrients in mM) 15 NO_3-N, 1.0 PO_4-P, 6.0 K, 5.0 Ca, 2.0 Mg and 2.0 SO_4-S, plus µM concentrations of micronutrients, 72 Fe, 18 Mn, 3 Cu, 3 Zn, 45 B and 0.1 Mo. Reagent grade chemicals and deionized water of 18 mega ohms purity were used to formulate treatment solutions. The nutrient deficiency treatments were induced with a complete nutrient formula with a single element withheld. Boron toxicity was also induced by increasing the element 10× higher than the complete nutrient formula. Plants were automatically irrigated, and the leached solution was captured for reuse. Plants were monitored daily to document and photograph symptoms as they developed. A description of nutrient disorder symptomology and critical tissue concentrations are presented and compared with a recent study conducted on 'Salanova Red' lettuce.

Soilless cultivation of strawberry (*Fragaria sp*. cv Holibrite) with salt stress treatments in a tropical environment for improving fruit quality

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Consumer preference in Indonesia is still not satisfy with fresh strawberry (*Fragaria* sp. cv Holibrite) fruit in the market. To increase consumer satisfaction, we try to apply the salt stress treatment method in strawberry production . The strawberry fruit was cultivated using soilless culture of vermiculite and perlite in the valley of Ketep, Sawangan, Magelang, Central Java, Indonesia. Standard nutrient solution was 2 mScm^{-1} for soilless cultivation and control using soil culture. We added NaCl to increase their electric conductivity to 4 mScm^{-1} and 6 mScm^{-1}. Quality parameter of fresh strawberry which were measured include weight, size, texture of skin and flesh, color of skin, water content, soluble solid content, titratable acidity and ascorbic acid content. Sensory evaluation was also measured. Higher salt stress treatments in soilless cultivation were decreased weight and size of the strawberry fruit compare with soil culture. Texture of the skin and flesh of the strawberry were tend to be hard in the soilless condition, but highest salt stress condition in soilless culture was not significant different with the control. Color of strawberry from the soilless culture were not significant different with the control, however increasing salt stress condition was increasing red color of the strawberry skin. Soilless cultivation with salt stress treatments were increased water content, soluble solid content, titratable acidity and ascorbic acid content. Furthermore, consumer also like strawberry that produced from soilless culture based on color, texture of skin and aftertaste from sensory

testing. Soilless culture of strawberry can improve quality of strawberry fruit and they will suitable with consumer preferences.

SESSION I, August 16, 2018-Thursday 11:00-12:30

Session Chair: Michael BÖHME

Root-zone CO_2 enrichment increases biomass accumulation in lettuce and pepper grown hydroponically and aeroponically

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Enhancing CO_2 levels in commercial glasshouses is a widely used technique to increase productivity, but has high-energy costs and detrimental environmental impacts due to frequent ventilation of the glasshouse (to prevent plant diseases) releasing CO_2 into the atmosphere. Previous studies suggest that root zone (RZ) CO_2 enrichment may be a more economic and sustainable alternative to aerial CO_2 enrichment. These experiments aimed to compare the effects of RZ CO_2 enrichment by adding either bicarbonate or gaseous CO_2 into hydroponic and aeroponic systems respectively, and to determine the physiological mechanisms by which plants respond to RZ CO_2. Rootzone CO_2 enrichment (1500 ppm) of aeroponically-grown lettuce increased shoot dry weight by around 20% compared to those grown with 400 ppm RZ CO_2. Supplying hydroponically grown plants with different HCO_3^- concentrations, increasing the levels of dissolved inorganic carbon (DIC), increased biomass accumulation of lettuce (10% increase at 1 mM and 5 mM HCO_3^-) and pepper (10% increase at 1 mM HCO_3^-). Plants exposed to 1 mM $NaH^{13}CO_3$ showed a significant increase of δ13C values of leaves over time, therefore confirming the uptake of DIC by the roots. The δ13C values of roots increased significantly over time, however higher values at the beginning of $H^{13}CO_3^-$ exposure suggested root-to-shoot transport of DIC. Nutrient solution pH did not affect root carbon uptake, but shoot δ13C values were lower in those plants exposed to lower pH levels (5.8) compared to those exposed to fluctuating pH (between 6.3 and 6.7), suggesting differences in root-to-shoot transport of DIC. Thus, root carbon uptake was independent of the form in which CO_2 was provided (gaseous CO_2 at pH 5.8; HCO_3^- at higher pHs). How this additional carbon promotes plant growth is still unclear. Potential mechanisms of action such as increased rates of photosynthesis, altered amino acid concentrations and changes in phytohormone concentrations will be investigated in future studies.

Impact of nutrient solution concentration on baby leaf purslane production in floating system

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This study was conducted in a greenhouse during the winter-spring of 2016-2017 as two successive periods, and aimed to determine the effects of nutrient solution concentrations on baby leaf purslane production in floating system. Cultivation was carried out in seedling trays placed on aerated nutrient solutions and seeds were sowing into peat. Each seed was sown into each hole (17 cc) of trays having 210 cells in each (957 plant m^{-2}). Following germination in the germination chamber, seeds were moved to climate controlled greenhouse. After emergence, seedlings in trays were placed onto water culture on 07.12.2016 for 1st period and on 10.03.2017 for 2nd period. Two nutrient solution doses as (1) "full dose" (complete nutrient solution) and (2) "half dose" (50% reduced macro nutrients of full dose) and "water" (without nutrients) were applied. Plants were harvested when they reached to 12-15 cm in length, and harvested 3 times in both periods. Findings of the study showed that plant growth, yield and quality varied depending on the concentration of nutrient solution as well as the temperature during the growing period. When the temperatures were higher, yield increase and earliness were achieved. Although yield values decreased when the concentration of nutrient solution decreased, there were not significant differences between full and half dose treatments in many measured parameters. As the nutrient solution concentration decreased, vitamin C content increased and nitrate content decreased. Leaf N, P, K and Fe contents decreased with decrease in the nutrient solution concentration, whereas Ca contents increased. It was concluded that baby leaf purslane can be grown in a floating water culture resulting in a reduction in nitrate content and half-dose could be applied considering yield however growing period should be taken into account due to the higher yield and quality in spring season.

Aquaponics using Asian leafy vegetables - potential and challenge

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Aquaculture became worldwide an integral part of the food production. In the same way are widespread different hydroponic systems in many countries. Asian leafy vegetables are cultivated in particular in the water culture system 'Nutrient-Film-Technique (NFT). A combination of the two cycles in an aquaponic system seems to be reasonable. This technique becomes more and more important for the food production and has an increasing popularity, whether the system is not methodologically sound and complete scientific investigated. Therefore, three experimental series were conducted in order to investigate open and closed process water cycles, using parallel aquaculture and NFT system, as well as aquaponics, where the fish species Tilapia (*Oreochromis niloticus*) was utilised. Three leafy vegetables were used in different experiments the South-East-Asian herbaceous vegetable Water Spinach (*Ipomoea aquatica*), Leaf Mustard (*Brassica juncea integrifolia*) and Water Celery (*Oenanthe javanica*); all are suitable for waterculture systems. Plant growth and development were investigated in both systems, in the hydroponic NFT and in an Aquaponics. In the NFT system, mineral nutrient solution was used, whereas in the closed Aquaponic the plants were fertilized only with the fish water. The leafy vegetables were cultivated between four and seven month. In the end, the plant height and biomass were measured and the contents of chlorophyll a and b, ascorbic acid and carotene was analysed. In the nutrient solution respectively the process water the EC and pH-value, as well the oxygen contend were measured weekly. There were no significant differences in in plant development between the two cultivation systems, when Water Spinach was used. The yield of Leaf Mustard was much lower in the aquaponics in comparison to the NFT system. The plant development of water celery was at the beginning very slowly, later on the development of the plants were better in aquaponics. The tilapia development was better in the closed system as aquaponics in comparison to the aquaculture system. In general can be concluded the closed aquaponics system has a good potential for vegetable and fish production if suitable plants are used. Furthermore, the aquaponics should be deeper investigated in order to get stable chemical and microbiological conditions, there is a potential for optimisation.

Effect of hydroponic crop set system powered by various types of energy on the growth of green oak

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The major problems in the hydroponic crop set system are the power supply. Generally, it runs from conventional electric energy and it should continue to run all the time. This research attempted to investigate the potential and efficiency of the hydroponic crop set system powered by various types of energy .The design and construction was proposed to response the needs to reduce energy consumption and finding the cheap renewable sources of energy. The experiments were laid out in Completely Randomized Design (CRD). There is three type of energy supply for hydroponic crop set system, 1) conventional electrical energy, 2) solar energy with battery, 3) solar energy without battery. The overall sizes of a hydroponic crop set system are 1 meters width and 4 meters length. The growths of green oak on hydroponic crop set

system which are powered by various types of energy supply was tested for potential and efficiency by sow the seed of green oak for 7 days and then transfer the stems of green oak to hydroponic crop set system and observe the growth of green oak for 43 days. Collect a green oak to determine the canopy width, root length, fresh weight and dry weight of each stem. It was found that the highest canopy widths of green oak were achieved from hydroponic crop set system powered by solar energy with battery. The highest root lengths and stem fresh weight of green oak were achieved from hydroponic crop set system powered by conventional electrical energy. The highest root fresh weights of green oak were achieved from hydroponic crop set system powered by solar energy with battery. The highest stem dry weights of green oak were achieved from hydroponic crop set system powered by conventional electrical energy. The highest root dry weights of green oak were achieved from hydroponic crop set system powered by solar energy with battery.

Study of a bacterial community in the aquaponic closed-loop system of Gembloux Agro Bio-Tech

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Integrated and Urban Plant Pathology Laboratory, Gembloux Agro-Bio Tech, University of Liege, Gembloux, Belgium.

An aquaponic system comprises an aquaculture compartment and a hydroponic compartment. Its main advantages are the use of the nutrient enriched water from the aquaculture compartment to fertilise the vegetable crops instead of using chemical fertilisers and the recycling of this enriched water which avoids polluting surface and groundwater. Besides the plants and fish, microorganisms are also key players in aquaponics as they participate in processes as essential as nitrification and solubilisation of the organic matter. Herein we aim at characterising the bacteria present in the aquaponic system of Gembloux Agro Bio-Tech to better understand the composition and role of their communities in aquaponics. The studied aquaponic system is composed of one loop in which water from two Tilapia tanks is pumped through a sieve gravity filter, a microbeads biofilter and up to a greenhouse containing raft hydroponics. Bacteria were sampled from two compartments of the system, namely the sump and the biofilter. Sampling was repeated thrice in the course of three weeks to observe whether the composition of the communities would evolve. DNA was extracted and sequenced with Illumina technology. The sequences were analysed with the QIIME software. Results show that the sump and biofilter host different bacteria communities with the community of the biofilter being much more diverse. No evolution was noticed over the three weeks' test.

Assessment of different germination media for vegetable seedling production for aquaponic system

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Aquaculture system of fish rearing by peasant farmers can be sustainable, provide healthy food and income for the family when upgraded into an aquaponics scale. However, aquaponics system is relatively new in Nigeria. The importance of vegetable consumption across all ages cannot be overemphasized. Thus, precise medium for germination of vegetable seeds for aquaponics system needs to be established. The study assessed screening of different germination media that supports vegetable-aquaponics culture system for wealth creation in Nigeria. Three replicates of different media of local materials (*Luffa cylindrical*, tissue paper, cotton wool) and soil which served as the control were laid out in a 4*2 factorial design on a flat germination tray. Twenty seeds each from two selected vegetables (lettuce var. grace lakes and amaranth var. Bunchy) were grown on different media separately. The experiment was repeated two times. The seed germination rate from each medium was compared to the control. Data were analyzed using descriptive and inferential statistics. Increase in length, shoots and roots of germinated seedlings were observed at 4, 10 and 14 days after sowing. Interaction between media and crop seeds indicates that, Amaranthus + Luffa, Amaranthus + cotton wool, Amaranthus + tissue paper, lettuce + cotton wool supported 100% germination whereas; lettuce + Luffa, Lettuce + tissue paper, Amaranthus + soil supported 90% germination while Lettuce + soil gave the lowest 80.7% germination at 10 Days After Planting (DAP). Therefore, for effective and efficient seedling medium for aquaponics system in Nigeria, adoption of local materials such as *Luffa cylindrical* for future vegetable seeds germination should be encouraged.

SESSION II, August 16, 2018-Thursday 14:00-15:30
Session Chair: Vim VOOGT

KEYNOTE 2

Towards sustainable smart plant factories with LEDs, artificial intelligence and phenotyping

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In commercial plant factories with artificial lighting (PFALs) or indoor farms, it is important to find optimal set-point combinations of environmental factors at each growth stage to maximize the yield, quality and/or economic value with minimum resource consumption, waste production and cost. This complexity of environmental control provides an opportunity to develop 'smart' PFALs using light emitting diodes (LEDs), artificial intelligence (AI) with big data mining, information and communication technology (ICT), modeling of energy/mass balance and plant growth, and phenotyping using camera image sensing of plant traits. This paper proposes ideas for smart LED lighting systems, a dual (virtual and real) PFAL and a cultivation system module (CSM) for scalable PFALs, which enable commercial production, large-scale experiments and plant breeding to be conducted concurrently. 'Smart' means, in this paper, intelligent, resource-efficient with minimum waste, compact, inexpensive, easy-to-use, and so forth. Among many environmental factors, light is the most important and it has various aspects. The application of LEDs as a light source for PFALs has attracted increasing attention. LEDs are used not only to enhance plant photosynthesis and control photomorphogenesis, but also to increase secondary metabolite production, raise the disease resistance of plants and control populations of pest insects and microorganisms. The degree of such plant responses is affected by the spatial and spectral distributions of photon flux density and their integrals over time at the plant canopy level, and photo-/dark-period cycles. Plant responses are also affected by the levels of other environmental factors such as temperature, water vapor pressure deficit, CO2 concentration, composition and strength of nutrient solution, air current speed, and many other factors. Furthermore, plant responses depend on plant species, growth stage, physiological status and canopy structure. Concepts and a methodology on how to integrate the recent advanced technologies mentioned above to develop the next generation of smart PFALs are discussed.

Green light penetrates inside crisp head lettuce leading to chlorophyll and ascorbic acid content enhancement

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Increasing safe and steady food production has been approached under plant factory production. Plants are often cultivated under LED which emit blue and red light regions because photosynthetic pigments strongly absorb these regions while green light region has been considered to be less effective due to its absorptance. Crisp head lettuce is an economic crop which outer leaves have to be removed when shipping for round-shape display in a market, in spite that these removed leaves contain higher nutritional values. Effect of photosynthetic photon flux density (PPFD) of 400 μmol m^{-2} s^{-1} green light on chlorophyll and ascorbic acid content; and shoot biomass have been examined in crisp head lettuce by using a characteristic of lower light absorptance, but greater light transmittance in leaves. The contents are high inside the crisp head lettuce especially under green light irradiation because of the deeper light transmittance. The present study proposes an availability and integration of green light to improve plant quality even inside of the crisp head lettuce on its cultivation for a further novel cultivation system in plant factory.

Effects of light conditions on seed germination and greening of water spinach

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Green foods has drawn more and more attention because of their special taste and quality. Water spinach, as a kind of nutrient-rich sprouts began to attract people's attention. However, there are certain problems in the production of sprouts, and the most important problem is that the lighting system of the sprouts factory is not perfect and still uses the traditional covering material to change the sunshine. The study shows that red light can promote the phenotypic index of plants, while blue light can significantly improve the quality of sprouts. In this study, LED lamp was used to detect the effects of light intensity, photoperiod and light quality on the germination and greening of water spinach, and a series of physical indexes (shelling rate, leaf (Chlorophyll, soluble sugar, vitamin C, cellulose) as the standard, to screen out the most suitable conditions for the growth of water spinach. Light intensity is divided into three levels: 2000LX, 5000Lx, 8000Lx; photoperiod is divided into three levels: 9H, 12H, 15H; light quality is divided into three levels: red, blue and white ratio = 7:1:1, 4:1:1, 1:1:1. There are nine treatments in the study, each of which sets three samples, each sample sets three repeats. Finally, through the data analysis and comprehensive evaluation, the optimum conditions for the growth and development of water spinach were as follows: red light quality (red, blue and white ratio = 7:1:1), 8000Lx light intensity, 9 hours per day photoperiod.

Light quality and photoperiod influences crop growth, productivity and produce quality in hydroponic vegetable production

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Plant factory system, enabling continuous, enhanced and rapid crop production under precise environmental control and automation, regardless of natural environmental conditions is gaining significant global attention and popularity. Under the arid agro-climatic conditions of Kuwait, plant factory system is a prudent choice to improve indigenous vegetable production round the year, and ensure food security. Therefore, a study was conducted during 2015–2016 using a modular agricultural production system (MAPS) to investigate the effect of three light qualities and three photoperiods on growth, productivity and produce quality of hydroponic lettuce. MAPS, which is a prototype closed-plant factory system; consists of a closed, multilayer hydroponic plant growing system with advanced light emitting diode (LED) lighting, nutrient management, and Argus control, that enables food production in extreme environments. The experimental crop was grown under three light qualities (white, blue and red) and three photoperiods [8/16 Light/Dark (L/D), 16/8 L/D and 24/0 L/D]. The growing conditions during the study were uniformly maintained at 200±10 $\mu molm^{-2}s^{-1}$ photosynthetic photon flux, 21±2^{o}C ambient temperature and 65±10% relative humidity. The study revealed that the vegetative growth, yield and quality of hydroponic lettuce was significantly influenced by light quality and photoperiod. Plants grown under red lighting at 24/0 L/D photoperiod significantly excelled those exposed to blue and white light at 24/0 L/D photoperiod by 40.7% fresh biomass accumulation and 26.6% dry matter partitioning. Lettuce grown under red light at 16/8 L/D photoperiod produced comparable fresh biomass and dry matter with those grown under blue and white light at 24/0 L/D photoperiod. However, majority of the vegetative growth parameters observed were significantly higher in plants grown under blue light at 24/0 L/D photoperiod. The study revealed the influence of light quality and photoperiod on crop growth, productivity and produce quality in hydroponic vegetable production.

Sulfur fertilization enhances ajoene accumulation in hydroponically grown garlic

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Ajoene is a sulfur-containing compound in garlic, which accounts for pharmaceutical quality. The aim of this study was to investigate the influence of sulfur supply on the ajoene content of garlic and to evaluate the significance for crop quality. Garlic plants were grown hydroponically in a growth chamber under artificial lighting for two months at air temperature of $25^0/21^0$C (light/dark), relative humidity of 75%/90% (light/dark), a photosynthetic photon flux density of 450 µmol m^{-2} s^{-1}, and a photoperiod of 12 h d^{-1}. Sulfur was supplied as K_2SO_4 at 2.05, 4.1 and 8.2 mg L^{-1}. No K_2SO_4 was added to the control treatment. The fresh and dry biomass, as well as ajoene content was determined after harvest. The significantly lowest ajoene content was observed in the control treatment as compared to sulfur treatments. The present study showed that sulfur fertilization could be useful to improve phytomedicinal components in garlic plants.

SESSION III, August 16, 2018-Thursday 17:00-17:45
Session Chair: Graeme SMITH

Vertical Farms & PFAL - a perfect blueprint for growth?

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a review of current developments and emerging technologies driving innovation in global urban farming that is on course to revolutionise local fresh food supplies as a vertical farm, PFAL or containerised system could deliver a 'perfect' blueprint for growth that includes light (intensity, length, spectra) and climate (temp, rH, HD, CO2, air) with reduced labour and reduced potential for pest & diseases With the US indoor-ag market alone estimated to grow to US$3.8billion by 2020, will we see the day when consumers order online their preferred plant type (select colour, texture, vitamins, size, shape, timing) and have them automatically delivered to their personal courier box? Will breeding and systems develop to a level where other plant types than leafy greens (e.g. vine crops) can be successfully grown in a vertical farm and how disruptive can this technology become in terms of traditional food production and distribution? Will we see the demise of traditional greenhouses in favour of multi-layered vertical farms enveloped in a climate controlled 'box' with optimised 24hour plant growth? Many questions to be explored in this review of current developments and futuristic thinking around Vertical Farms & PFAL and whether they could deliver a 'perfect' blueprint for growth?

High-performance growing media for vertical agriculture in Northern environment

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High-performance growing media are needed to develop vertical farming for Northern and remote communities. The aim of this study was to evaluate the agronomic performance of three edible plants (lettuce, endive and Chinese cabbage) grown on 10 growing media (combination of conventional materials; coir and peat) combined or not with three soil amendments (biochar, worm-casting and biostimulants). A pot experiment using a randomized complete block design with four replicates was conducted in a greenhouse located at Agassiz Research and Development Centre (Canada) in collaboration with ARO, The Volcani Center (Israel). Parameters measured were the growing media physico-chemical properties as well as their biological properties and plant performance (e.g. fresh and dry plant biomass, yield, nutrient content, SPAD, Fm/Fv). Results will be discussed in terms of the most promising growing media adapted to vertical farming and practices for sustainable management of water and fertilizers. The outcomes of this study regarding the (1) fulfilment of consumers' demands for local and healthy food especially for remote community, (2) the contribution to the economic development and resource conservation in Canada and Israel, and (3) the reduction of greenhouse gas emissions and fertilizer leaching into the environment, helping to minimize the environmental footprint of food production and mitigate impacts of climate change, will be discussed.

Industrial Plant Production Center (IPPC): a fully automated industrial scale vertical farm

Thijs Van Gerrewey, Oscar Navarette, Maarten Vandecruys, Nele Ameloot, Maaike Perneel, Nico Boon, **Danny Geelen**

Threats such as increasing urbanization, climate change, water scarcity, food safety and high pesticide use increases demand for sustainable food production. Vertical farming can provide a solution through stable year-round production of fruit and vegetables regardless of climate conditions. In dense urban areas, vertical farming can bring the benefit of local qualitative production, cutting transport times and costs, while simultaneously offering pesticide free local produce. Countries with an arid climate such as those in the Middle East benefit from ample hours of sunshine but lack sufficient rainfall. Vertical farming can offer a significantly more efficient use of water and thus provide sustainable crop production. Despite increased interest in vertical farming and its many advantages, High energy and investment costs are still major obstacles. Urban Crop Solutions are dedicated to develop fully automated systems and solutions for urbanized horticulture suitable for industrial scale at maximum efficiency in terms of space, cost and energy usage (high-tech vertical urban farming). Plants are grown in a hydroponic cultivation system with closed recirculating nutrient solution and control over environmental conditions using LED technology allowing for optimal plant growth and yield. We continuously invest in R&D and optimizing the potential this technology offers. At our headquarters in Belgium the Industrial Plant Production Center (IPPC), the biggest automated vertical farm in Europe, was opened in February 2016. This proof of concept is being used for research, which is constantly focused improving the sustainable of the system, with less energy and water usage, and less pollutants into the environment. We will continue pursuing this strategy and are currently finalizing the construction of 10 new laboratories.

POSTER PRESENTATIONS

S18.P1.

Spent mushroom substrates as component of growing media for tomato seedlings

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Use of spent mushroom substrates (SMS) as a component of mixed substrate for tomato seedlings growth instead of peat was studied. SMS and peat were mixed in various ratios. Prior to sowing, the physical and chemical properties of the seedling mixed substrates and the growth of tomato seedling were determined. The results showed that with the increasing of the proportion of SMS, the total porosity, aeration porosity and water holding porosity of mixed substrate were increased, while bulk density of the mixed substrate was gradually decreased; The nutrient concentrations, pH and electrical conductivity (EC) of mixed substrate was increased. With the increasing of the proportion of SMS, nitrogen, phosphorus and potassium content of mixed substrate was increased. The plant height, and the seedling biomass of 25% SMS in mixed substrate was better than other treatments.

S18.P2

The effects of glycine betaine on pomology, yield and biochemical characteristics of strawberry plants under soilless culture

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Glycine betaine (GB) is a quaternary ammonium compound that can be found in a wide range of bacterial, plant and animal species. Exogenous GB application is a convenient and effective approach for enhancing the stress tolerance of crops and improving crop productivity. In this research, the effect of three different GB concentrations (0, 10, 20 mM) on morpho-physiological features (crown diameter, crown number, leaf number, chlorophyll index, leaf temperature and leaf area index-LAI), pomology (fruit weight, total soluble solids-TSS, pH), yield and biochemical characteristics (total phenol-TPC, total anthocyanin-TAC, antioxidant activity-EC_{50}) of 'Festival' strawberry cultivar under soilless culture were investigated. Results showed that 10 mM GB increased fruit weight and yield per unit area. Crown diameter, crown number and leaf temperature were positively affected by glycine betaine application. The highest crown diameter and crown number was obtained from 20 mM GB concentration while the highest yield and fruit weight were determined from 10 mM GB. In addition, the highest antioxidant activity was recorded on 10 mM GB application.

S18.P3

Monthly variations in fruit quality of hydroponic tomatoes grown in high technology greenhouses

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In Turkey, production of cluster tomatoes is dominant in soilless culture in high technology greenhouses. The aim of this study was to determine variations in fruit quality of different cluster type tomato varieties grown in perlite in a commercial greenhouses heated by geothermal energy. Samples were taken monthly from December up to July from four different cultivars (cvs. Bandita, Climberley, Diamentino and Soupless). Physical (fruit weight and number per truss, average fruit weight, fruit colour), chemical (total soluble solids, titratable acidity, vitamin C content, antioxidant activity, total phenols) and sensory evaluations were made. Among the tested varieties, Bandita was superior in respect to fruit quality throughout the harvest season. On the other hand, it can be concluded that Climberley and Diamentino were superior regarding to yield. Average vitamin C content changed from 7.29 to 10.36 mg 100 g^{-1} fresh weight (FW) according to harvest period. Antioxidant activity were between 2.14 and 2.84 µmol trolox equivalents g^{-1} FW. Total phenolic content was the lowest (33.54 mg gallic acid equivalent (GAE) 100 g^{-1} FW) in December and the highest (39.48 mg GAE 100 g^{-1} FW) in June.

S18.P4

Productive characterization of greenhouse cucumber (Cucumis sativus L.) variety Centauro in coconut fiber slabs

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The cucumber cultivation area under protected agriculture has had a remarkable growth in Mexico, currently it reaches 10.7% of the area of protected agriculture, only exceeded by the red tomato (37.9%) and the pepper (16%) (SAGARPA, 2009). That is why the degree in Planning for Agricultural Development of the FES Aragon-UNAM, as part of the integral training of its students and through its Center of productive practices, established the cultivation of American cucumber of indeterminate growth variety "Centauro" in coconut fiber slabs in a greenhouse. The seed was sown on June 7, 2017 in plastic trays with peat moss substrate, and on June 21, 2017, it was transplanted to coconut fiber bolls and rock wool plates with a separation between beds of 1.8 m. The seedlings were placed in a double row, with a separation between them of 0.3 m. and 0.5 m. between rows to have a density of 3.0 plants / square meter. A localized drip irrigation system was used. A modified Steiner nutrient solution with automated irrigation was used. The first 5 fruits were pruned at the beginning of the growth, pruning of leaves and lateral buds were made to have only one stem. The harvest started at 44 after the transplant and ended at 133 days later. An average yield of 124.7 t / ha and an average fruit weight of 0.498 kg were obtained. Four fruits were obtained per period and the average length of the internodes was 8.3 cm.

S18.P5

Tomato (*Solanum lycopercicum*) production under greenhouse in coconut fiber slabs

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The production of vegetables in protected agriculture, and especially in greenhouses, is constantly growing in Mexico. By 2012, SAGARPA (Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food of Mexico) estimates the area of protected agriculture in more than 20 thousand hectares, especially cultivated in shade houses and greenhouses, where predominantly the tomato with a 37.9 % of the harvested area. However, it is still necessary to find the most appropriate technology for each region and the farmer's level of knowledge about irrigation and substrate management. That is why in the Aragón-UNAM School of Higher Studies, a technological validation of the tomato production in coconut fiber slabs was carried out with the objective of knowing the management of this species in said substrate and analyzing its comparative advantages with respect to other substrates used in Mexico as the volcanic rock cultivated under the same conditions. Indeterminate growth tomato was cultivated Var. SUN 7705 in a tunnel-type greenhouse from June 2016 to March 2017. 100x15x12 cm coconut fiber slabs with a capacity of 18 liters were used, the planting density was 2.3 plants / m2 at a distance between rows of 60 cm and between plants of 35 cm and with a bed width of 2.0 m. A localized drip irrigation and a modified Steiner nutrient solution were used. A yield of 14.06 kg / m2 was obtained and there was an expenditure of irrigation water of 53.56 liters per kilogram of tomato produced, while in volcanic rock substrate are obtained 11.07 kg / m2 and 75.31 liters of water per kilogram are spent.

S18.P6

Production possibilities of green vegetables in off-season in unheated soilless greenhouses in the Mediterranean conditions

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Soilless cultivation is progressing slowly in low technology greenhouses (LTG) based on favourable natural conditions in Turkey similar most of the Mediterranean countries, and generally it has been applied in high technology greenhouses (HTG). Tomato and blocky type pepper are major crops for HTG which have central heating system, and vegetation period lasts nearly all over the year. On the other hand, in LTG covered 98% of total greenhouse area, growers prefer double season production method for fruiting vegetables in order to reduce heating costs, and between these seasons which are cold weather conditions the greenhouse is left empty. Profitability can be achieved if the crop is produced at this off-season time. This research was conducted in PE high tunnel to determine production possibilities of some green vegetables in different substrates during off-season. The tested plants were green onion, green garlic, parsley, rocket and cress. Perlite, clinoptilolite and coir were used as substrate being reused after main crop production. Substrates were filled in horizontal pots (75 x 23 x16 cm). On November 4th 2009, 30 onion shallots or 30 garlic cloves were transplanted to each pot with double line, and seeds of tested leafy vegetable species were sown (0.5 g per pot). Plants were grown until January 5th, and yield data were determined. Results showed that green vegetables can be grown in reused substrates in 2 months, and this method can be used for small scale farmers applying soilless cultivation in unheated greenhouses. Also, this method can be used for growing these vegetables at home gardens or balconies.

S18.P7

The effects of rootstock to improve melon growth and physiological responses in salt stress

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Presented study was carried out to investigate the growth and physiological responses of melon scion which grafted on salt-tolerant and sensitive rootstock melon, in order to evaluate the potential of melon as rootstock. Two tolerant (Mln-9 and Mln-28) and one sensitive (CU-40) melon genotypes were grafted onto their own roots and reciprocally under salt and control conditions. The grafted plants were grown under 50 mM NaCl in greenhouse soilless culture. It is clearly observed that grafting improved the susceptible melon growing in salt stress. The tolerant melon rootstocks increased the plant growth, fruit weight and fruit dry matter in the susceptible melon scion in salt. The tolerant rootstocks in salt could be able to control scion stomatal openness and closure for balance between transpiration and photosynthesis. May be the susceptible rootstock in salt was not permitted on controlling of the stomatal behavior of the tolerant scions. The tolerant rootstocks were decreased the shoot Na and Cl concentrations of the susceptible melon scion. Probable potential was observed to focus on the tolerant melons to be the melon rootstock for saline conditions for future works.

S18.P8

Comparison of two nutrient blend solutions on organic lettuce varieties in vertical tower systems

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Vertical tower is an aeroponic grow tower structure that allow to grow up to 20 plants in soilless medium. Vertical tower saves land, space, water, produces no weed, pest or disease issues and ecofriendly. Leafy vegetables are tasty and nutritious source of food with a short growing season. In vertical towers, vegetables can be grown indoors and outdoors all year round in shorter time, with less effort, care and greater harvest yield. The objective of this study was to compare the effect of two nutrient blend solutions on the total yield, fresh weight and dry weight of four varieties of lettuce. The study was conducted in the summer of 2017 in grow towers in a hoop house at the Tennessee State University organic research farm. Four varieties of lettuce namely Bibb, Leaf Lettuce, Oak leaf, and Red Salad were grown per National Organic Program Standards. Organic seeds were cultivated in planting tray with organic potting mix and transplants transferred unto 2.5 cm rock wool cubes, in an indoor vertical grow towers. For comparison purposes, two levels of nutrient blend solution A and B was administered to the plants by fertigation using an inbuilt pump within the tower system spaced a few feet from each other. Lettuce plants in tower 1 received 400mL of the nutrient blend solution while lettuce plants in tower 2 were treated with 200mL of nutrient solution. Vegetables were harvested on maturity and data was gathered on the total fresh and dry per plant was recorded for each tower. The best growing concentration was found to be 200mL of the nutrient blend solution. At the 200mL concentration, the Red Salad and Oak lettuce yielded the highest and lowest while in the 400mL nutrient treatment, the highest and lowest yielders were the Red salad and Bibb lettuce respectively. It is noteworthy however, that yields for the Red Salad and Leaf lettuce did not vary significantly from one another for both nutrient blend treatments evaluated. Mostly, all Lettuce varieties were successfully grown in a grow tower at the 200mL nutrient blend solution A and B. Therefore, this study verifies that the grow tower system is a viable alternative to growing vegetables vertically on land at a recommended nutrient blend concentration of 200mL. As it uses less space while simultaneously increasing the number of vegetables produced per unit area, due to the higher number of plants obtainable per growing floor area.

S18.P9

Volcanic tuff substrate improves growth and flower quality of Asiatic lily

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Cut flower farmers use different substrates for lily production. They are always queries about which growing substrate can improve flower quality of lilies. The aim of this research was to assess the effect of different growing substrates (soil and soilless) on leaf physiology and flower quality of Asiatic lily (*Lilium ×elegans* Thunb.) cvs. 'Ercolano' and 'Fangio'. Growing substrates were clay soil, clay soil + volcanic tuff (1:1 v/v), clay soil + sandy soil (1:1 v/v), clay soil + sandy soil + volcanic tuff (1:1:1 v/v/v), and volcanic tuff (0-4 mm). The experiment was carried out in a greenhouse condition. Lily bulbs were planted in 12 L plastic pot and fertigated once a week using a full strength Hoagland solution. Both cultivars had similar chlorophyll fluorescence and relative water content across substrates. Volcanic tuff leachate had the lowest electrical conductivity (EC) and pH level compared to other substrates. Interestingly, 'Fangio' lily grown in volcanic tuff substrate had higher plant height, shoot dry weight, leaf area, flower number per plant, and flower length when compared to other tested substrates. Overall, volcanic tuff substrate hold promise for improving lily flower yield and quality.

S18.P10

Determination of cut flower performances of different growing media of some gladiolus (*Gladiolus grandiflorus*) varieties

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One of the most important problems encountered in the cultivation of cut flower gladiolus is soil-borne diseases and pests. This problem substantially reduces flower yield and quality. The characteristics of the growing media used in soilless culture either directly or indirectly affect yield and quality. Therefore, it is quite essential to determine the appropriate growing media in cultivation. Two different gladiolus varieties (Purple Flora and Ibadan) and six different growing media (peat+pumice: 1:1, v/v; peat+perlite: 1:1, v/v; rice hull+pumice: 1:2, v/v; coarse sand+peat: 2:1, v/v; soil; and cocopeat) were used in the research. Flowering time, plant height, stem length, number of florets, stem diameter, stem weight and number of leaves were investigated in the study. Among the growing media, the earliest flowering time (77.83 days) and the longest plant height (128 cm) were determined in peat+perlite, whereas the largest number of florets (15 florets/spike) and the highest stem weight (103.6 g) were recorded in peat+pumice. The plants grown in soil had low values in terms of parameters other than the number of leaves and stem weight as compared with those grown in the growing media. Regarding the varieties, Purple Flora (84.72 days) flowered earlier than Ibadan (102.78 days), while Ibadan displayed more superior characteristics in terms of the other parameters.

S18.P11

Hydroponic forcing of saffron (*Crocus sativus* L.).

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Saffron (Crocus sativus L.) is one of the most expensive plant products in horticulture and is used for various applications in the food industries, for cosmetics, and for medicine. The world production is dominated by Iran, followed by Turkey, Italy, Greece, Spain, and Morocco. Iran itself is responsible for approximately 60% of the total production with an average yield of 4.7 kg/ha. Even today, the "saffron crocus" is traditionally produced in the open field without major technology improvements and some crocus's threads are hand-picked in the wild. This research paper presents the results of Saffron cultivated in four different growing systems (organic layer of substrate, hydroponic tray and "bulbfust" pin tray, and control group) under supplemental light conditions (LED and HPS). The tests were carried out in a growth chamber at the University of Applied Sciences in Dresden in 2017 and 2018. The researchers aimed at shortening the growing period, increasing the productivity, efficiency, and finally the yield. First, the bulbs were produced in the open field (phase one) and later transferred to the growth chamber for flowering (phase two). Results included a shorter growing period known as forcing in the bulbfust pin-tray system as well as significantly yield increases in both hydroponic systems.

S18.P12

Use of microalgae (*Chlorella vulgaris*) to save mineral nutrients in soilless grown tomato

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Experiment has been carried out in early-spring growing period in the Mediterranean climate in order to investigate the effect of microalgae *Chlorella vulgaris* on nutrient saving of soilless grown greenhouse tomato. The eight treatments have been applied: (1) 100% Full nutrition (control), (2) 100% Full nutrition + algae, (3) 80% nutrition, (4) 80% nutrition +algae (5) 60% nutrition (6) 60% nutrition +algae (7) 40% nutrition, (8) 40% nutrition +algae. Effects of *Chlorella vulgaris* on tomato plant growth, yield and fruit properties were investigated. Plant growth in the reduced nutrients were not decreased when the algae was added. The results showed the significant mineral nutrient saving in soilless application of *Chlorella vulgaris*. The higher total yields were obtained by 11.3 and 11.4 kg m^{-2} from 80% nutrition+algae and 60% nutrition+algae, respectively, when the control yield with 100% nutrition was 9.8 kg m^{-2}. Yields in 80% and 60% nutrition with *Chlorella vulgaris* were increased by 15.4% and 21.7% compared to their own controls without algae. The algae has an significant increasing effect on average tomato fruit weight and fruit volume in 80% and %60 nutrition levels. The best effect of *Chlorella vulgaris* on the fruit qualityt has been to increase vitamin C content in the reduced nutrition levels. The algae can also increased some minerals content P, Na and Mg in tomato fruit. There was no significant effect of *Chlorella vulgaris* on pH at the root zone, but there was a significant lowering effect on EC.

S18.P13

Effects of boron foliar sprays on tomato cultivation

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Boron deficiency is very harmful in tomato (*Solanum lycopersicum* L.) cultivation. Boron foliar sprays can be used as a mean of prevent the occurrence fruit disorders related to B. Boron sources and polyol like surfactants can affect foliar sprays effectiveness. This work had the objective of evaluating foliar sprays of boric acid, borax and B-ethanolamine, with or without, polyol surfactant. The experiment was carried out in a 3x2+2 factorial arranged in randomized blocks with four replications. Plants of tomato cv. Tangerine F1 were fed with complete nutrient solution containing 5 µmol L^{-1} of B. These plants were sprayed with the three sources of boron, with or without a polyol like surfactant at 14 days intervals until complete the production cycle. The additional treatments were: a positive control (C+), in which the plants received 20 µmol L^{-1} B, and a negative control (C-), in which the plants received 5 µmol L^{-1} B via nutrient solution, both without supply of B via foliar sprays. We evaluated plant height, root volume, number of flowers and fruits; dry matter production; nutrient contents and accumulation, in four phenological stages, and fresh and dry matter of fruits at the harvest. The data obtained were subjected to analysis of variance and the treatments compared by mean test. Leaf sprays improved the tomato growth and production compared to the (C-) treatment, but the adequate B supply by roots (C+) was the most efficient method for nutrition of tomato plants with boron. Among the boron sources, B-ethanolamine and boric acid were those which promoted the best results in tomato production, compared to the foliar application of borax. The use of the polyol like surfactant did not result in significant improvements on growth and production of the tomato plants.

S18.P14

Characterization of nutrient disorders of dieffenbachia

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To produce *Dieffenbachia* sp., growers must be equipped with cultural information, including the ability to recognize and characterize disorders. Diagnostic criteria for nutrient disorders of Dieffenbachia are absent from current literature. Therefore, Dieffenbachia plants were grown in silica-sand culture to induce, characterize, and photograph symptoms of nutritional disorders. Plants received a complete modified Hoagland's all-nitrate solution of (macronutrient concentrations in mM) 15 NO3–, 1.0 H2PO4-, 6.0 K+, 5.0 Ca2+, 2.0 Mg2+, and 2.0 SO42– plus (micronutrient concentrations in µM) 72 Fe2+, 18 Mn2+, 3 Cu2+, 3 Zn2+, 45 BO33–, and 0.1 MoO42–. Nutrient-deficient treatments were induced with a complete nutrient formula minus a single nutrient. Boron (B) toxicity was induced by increasing the element 10-fold higher than the complete nutrient formula. Plants were monitored daily to document and photograph sequential series of symptoms as they developed. Typical symptomology of nutrient disorders and critical tissue concentrations are presented. Out of 13 treatments, nine exhibited symptomologies; copper (Cu), molybdenum (Mo), manganese (Mn), and calcium (Ca) remained asymptomatic. Symptoms of nitrogen (N), iron (Fe), and sulfur (S) deficiencies, manifested early therefore, these disorders may be more likely problems encountered by growers. Unique symptoms were observed on plants grown in Zn and Mg deficient plants.

S18.P15

Dahlia foliar nutrient sufficiency ranges and growth response to fertilizer concentrations

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Two dahlia (*Dahlia xhybrida*) cultivars were grown with one of five constant liquid fertilizer concentrations (75, 100, 200, 300, or 400 mg·L^{-1} N) using a 13N–0.86P–10.8K fertilizer. The cultivars used were 'Hypnotica Cherish Pink' and 'Goldalia Scarlet'. Tissue samples were collected and analyzed for foliar nutrient concentrations at two different times. At each harvest date, plant height, plant diameter, and shoot dry mass were recorded. Dahlias achieved maximum growth when grown with 100 to 300 mg·L^{-1} N, while 400 mg·L^{-1} N was detrimental. Foliar nutrient sufficiency ranges were determined based on fertilizer concentrations resulting in maximum growth. These results provide improved dahlia fertilization recommendations and foliar sufficiency ranges.

S18.P16
Effects of salinity on ıceberg lettuce production in floating hydroponics

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The experiment was carried out in an unheated plastic tunnel in Izmir. Three different salinity levels (EC1, EC2 and EC3) were compared, 8.76 and 17.52 mM NaCl was added for EC2 and EC3, respectively into the nutrient solution used as control (EC1). NaCl application was started when leaves and roots of the plants began to develop, and continued up to harvest. Temperatures of greenhouse air and nutrient solution, changes in EC of nutrient solution, head weight, nitrate content of the leaves, consumption of nutrient solution, and element contents of the leaves were determined. Trial repeated in three different periods: from December 16 to March 13 (Experiment 1), from March 24 to May 2 (Experiment 2) and from May 18 to June 28 (Experiment 3). Plants were grown successfully during the first two trials; on the other hand, all plants died 41 days after transplanting due to the high temperatures in Experiment 3. In the first trial, head weight changed according to salinity of nutrient solution, and the highest value (464 g) was obtained at EC2 compared to EC3 (419 g) and EC1 (438 g). There were no significant differences between EC levels of nutrient solution in respect to head weight changing between 535 g and 588 g in the second trial. Nitrate content of the leaves decreased by increasing EC of nutrient solution.

S18.P17
Effect of different EC levels on rocket production in floating system

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This study aimed to determine the effects of different EC levels on rocket which have short production period and accepted as baby leaf vegetables in floating system. Experiments were carried out during the autumn and spring production seasons of 2014 – 2015 in the pools having 2.4 m length and 1.4 m width. Standard Hoagland nutrient solution [(mM) 12 $N\text{-}NO_3$, 3.8 $N\text{-}NH_4$, 2.8 P, 8.4 K, 3.5 Ca, 1.4 Mg, 9.5 Na, 8.0 Cl, 2.7 S, 0.04 Fe] was used as control treatment (1.8 mS/cm) and compared to 3 salinity levels (2.8, 3.8 ve 4.8 mS/cm) of nutrient solution. Yield, some quality parameters and leaf nutrient contents were determined in both vegetables. Total yield changed in first season growing period (P1) in rocket between 568.15-1005.31 g/m^2, respectively and in second period (P2) between 618.26-1230.92 g/m^2 for respectively. Overall results showed that, water culture as floating system could be successfully utilized in production of rocket whereas there were significant differences among the salinity levels of nutrient solution. In this respect, it was concluded that the use of nutrient solution with an EC level of 1.8 mS/cm was found more appropriate in terms of plant growth and yield.

S18.P18
Comparison of substrate, hydroponic and aeroponic cultivation systems for the production of carrot root

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In this study, possibilities of soilless grown carrot were investigated. The carrot roots have been grown in substrate culture (cocopeat, vermiculite, perlite, rockwool), hydroponic and aeroponic. Experiment was carried out during autumn-winter period in the Mediterranean climate. The better results in the experiment were obtained from vermiculite and cocopeat cultures interms of carrot root growth, yield, β-carotene, phenols, soluble solids and minerals content of the root. However, the carrot root characteristics for shape in the both substrates were still under the original characteristics of the cultivar grown in soil, especially length was shorter. Perlite used in the experiment was not successful due to the heterogene particle size. The smallest and largest perlite particles mix together was not suitable for carrot root. The tap root may have had difficulty in penetration into the rockwool slab and growth was not good too. The carrot roots in water culture not only showed decreased growth but also showed worse quality properties with the higher ratio of split and forket roots. The aeroponic system in the experiment caused the smallest, shortest carrot roots with abundant amount of thin tails presumably due to spray interval and spray time was not suitable for carrot and plant exposed to water, nutrient and humidity deficiencies.

S18.P19

Optimization of root spraying time for fresh onion cultivation in aeroponic

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Green leafy vegetables are successfully grown in the earoponic systems. The faster harvest cycles, predictable results, higher productive yield, better crop color, texture, nutrition and flavor are the advantages of the earoponic growing. We have studied optimization of nutrient spray time on roots of fresh onion. Plants were grown in glasshouse during winter and we have built own aeroponic system. The spray interval 10 minutes was constant and five different spray/misting times 7, 10, 15, 18 and 21 seconds were studied. The highest biomass yield including root and the highest edible fresh onion yield were obtained from 18 sec spray time with 10 minute spray internal. In fact, relationships between spray times and edible fresh onion yield showed that the optimal spray time was 17 sec. Remarkable effects of spray times were observed in EC of the onion and the highest was observed from 18 sec. Total phenol content was gradually decreased with the increased spray times. The 18 sec provided the highest flavanoid and the succinic acid productions in fresh onion. Ascorbic acid content not affected by the spray times. There was no meaningful relationship between the mineral content of onion and spray time. Regular increases in mineral elements in onion were not observed with increasing spray time.

S18.P20

Water use efficiency in a small scale aquaponic system in continental Europe

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Aquaponics is a cultivation system that combines hydroponic plants' cultivation and aquaculture where water is continuously recycled through an interconnected series of fish tanks and waste treatment systems. The benefits of aquaponics are the efficient use of water, limited waste due to the closed cycle system, organic management, mixed production (edible fish and plants), higher density of crop production. At a global scale, the use of water is a critical topic also because most of the water consumption for human activities occurs in the agricultural sector. The aim of this study was to assess the water use efficiency of a small-scale aquaponic system, analysing inputs and outputs of water in the aquaculture portion (3 rearing tanks, a sump tank, a trickling bio-filter and a settler sedimenter). At the same time, productivity and water use efficiency of plants' cultivation portion were assessed comparing the aquaponic system (plants grown in water provided by the aquaculture system) with several hydroponics systems characterized by different electrical conductivity of the nutrient solution (EC = 1.6, 2.0 and 3.0 dS m-1). The cultivated species were the African catfish (Clarias gariepinus) associated with lettuce (Lactuca sativa var. Salanova). Three growing cycles of plants between July 2016 and July 2017 were studied. Both productivity and water use efficiency resulted greater in the hydroponic treatment with the highest electrical conductivity. Contrariwise, aquaponics resulted in the lowest productivity and water use efficiency as compared to other hydroponic systems.

S18.P21

Effect of growing media with beneficial microorganisms on the aquaponic production of strawberries

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The aquaponic production of vegetables, done in "symbiosis" with a fish production, shows variable results, in comparison with conventional off-soil hydroponic production. There are multiple variation factors: plant species, plant density, type of medium used (inert or organic), addition of complementary nutrient solutions, fish food composition, daily ration, rearing density, quantity/quality of compensation water. The aquaponic production of strawberries (everbearing variety ''Cijosée-Anjou'') with no chemical inputs is being studied, associated with the rearing of trouts and then sturgeons, according to the growing media (Straw draining + with Glomus intraradices (PTB297) and Bacillus pumilus (PTB180) - Straw draining, 6 plants / mL) and the date of planting (fall and spring refrigerator plants). The study is conducted in a cold greenhouse at an altitude of 600 m using water with an EC of 545µS/cm (+/- 63) and irrigation water pH of 8.40 (+/-0.25). After 24 weeks, the average yield is superior by 6.4% with beneficial microorganisms (585 g/refrigerator plant and 550 g/fall plant); this superiority reaches 7.1% for refrigerator plants (591 g/ plant beneficial microorganisms and 552 g/plant beneficial microorganisms). Growing medium with beneficial microorganisms (Glomus intraradices, PTB297 and Bacillus pumilus, PTB180) shows interesting yields without chemical inputs when integrated in aquaponics. The presence of residual organic microparticles and the excretion of ammonia nitrogen by the fish contribute to the development of a complex bacterial flora within the whole aquaponic unity and especially in the grow bags, promoting the assimilation of organic mineral elements, even in an acidic environment with few minerals.

S18.P22

Effect of nitrogen and potassium on yields, pungency and enzyme activities for capsaicin synthesis in hot chili (*Capsicum annuum* L.)

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The effect of nitrogen and potassium concentrations on the yield, pungency and activities of phenylalanine amynolyase (PAL) and capsaicin synthase (CS) of hot chilli cv. Tawee 60 and Jinda were studied by using 3x3 factorials in randomized complete block design experiment with three replications. The factor A consisted of three N concentrations of 130, 230 and 330 mg L-1 and factor B consisted of three K concentrations of 200, 300 and 400 mg L-1. The study was divided in two sub-experiments for two growth stages; the vegetative growth stage using only Tewee 60 cultivar and the reproductive growth stage using both cultivars. In each sub-experiment, the chili seedlings were planted in plastic containers containing 20 L of mixed coconut husk chips and coconut-coir dust substrate placed inside a plastic-roofed net house and received Modified Resh's Tropical Dry Summer nutrient solution of which the concentrations of the N and K were modified according to the experemental design. The temperature and relative humidity during the experiments ranged between 26.45 and 30.69 ° C and 67.08 and 89.80 %, respectively. It was found that N 330 mg L-1 and K 300 mg/L gave the highest vegetative growth of 'Tawee 60' chilli plant. N 130 mg/L in combination with K 400 mg L-1 gave the highest fruit yield for CV 'Tawee60'. Chili CV. Jinda needed N 230 mg L-1 and K 330 mg L-1 in order to give the highest fruit yield. It was found both chilli cultivars had the highest oleoresin, capsaicin, dihydrocapsaicin, and capsaicinoid contents and the highest PAL activity when received N 330 mg L-1 and K between 300 and 400 mg L-1. However, the effect of N and K on CS activity was not found.

S18.P23

Reclaiming wastewater from local food industries to produce energy and high-value urban crops

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Modern agricultural food production faces many challenges, such as an increase in water use by other economic sectors and changes in precipitation patterns which threatens the water available for agriculture in many parts of the world as well as reducing fertilizer use to protect the environment. Hydroponic crop production results in high water and fertilizer efficiency but is dependent on synthetic fertilizer and good water quality. Irrigation with municipal wastewater from food industries may be an alternative to reuse water and capture excess nutrients, but requires treatment prior to use to reduce pathogens and prevent adverse effects on the soil and groundwater. Wastewater from food industries has a high nutrient load and a reduced presence of pathogens and heavy metals, which makes it ideal for agriculture. Treating this water in a decentralized way prevents it from mixing with undesired waters. Decentralized treatment paired with urban agriculture could allow for water reuse and reclaim the nutrients for food production. This has the potential to help enhance food security while protecting the environment and creating new economic opportunities. In this project we are developing a system where wastewater from breweries is treated in situ and the effluent is used to produce leafy greens and herbs in a non-circulating hydroponic system. Wastewater first is treated using an anaerobic reactor that obtains energy as hydrogen and reduces the carbon load of the water. Treated wastewater is adjusted for the optimal pH and electrical conductivity and used for hydroponic production. Crop yields are compared to plants grown using a commercial hydroponic solution. Successful development of the model will allow for a decentralized treatment technology and promotion of soilless urban agriculture.

S18.P24

Inventory of materials with potential as substrates in San Luis Potosí State ' Mexico

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San Luis Potosi State (SLP) of Mexico have 500 hectares dedicated for vegetables greenhouse production, mainly tomatoes and peppers different varieties. SLP is the second Mexican largest producer of tomatoes growth coconut fibre. Mexico and SLP, have different residues or by-products of agricultural and agroindustry activities, as for example, tequila and mezcal obtaining waste; waste from the production of walnut, mesquite and huizache. This research was carried out an inventory the major industrial, agricultural, agroindustry and miner's residues of the State. Subsequently the most promising materials were selected and performed a physical chemical characterization of them. As a result, developed a catalogue of waste materials in the SLP State and properties of 20 materials selected as promising were obtained. Latent phytotoxicity by bioassays of germination tests were performed on these. In conclusion, there are at least 20 residues or industry by-products that could be used as substrates or substrate-mixtures for growing vegetables greenhouses production on SLP State. These 20 materials have physical and chemical properties suitable for crops or for substrates- mixtures.

S18.P25

Characterization of materials as alternative substrate for Colombia cut-flower crops

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Colombia is the second largest exporter of flowers in the world and the first supplier of carnations, cut to the United States since the early 1990s has been planted in the soil and has been transformed into a system of crops without soil, mainly due to the impact of Fusarium wilt. The more used substrate is the rice husks, partially roasted, mainly by its availability and cost. In Colombia, however, there are many local materials that are waste or by-products in agro-industrial activities, such as: sawdust or shavings, waste of mushroom or coconut fibers. Some of these materials could be used as raw material to generate a cut-flower crop medium. In this research we searched and selected available materials with potential for use as a growing media. Among the existing materials, 10 were selected for their availability and affordability. In these, a characterization was carried out chemical (pH, CIC, MO and the contents of mineral elements) and physical (total porosity, density, particle size). We conclude that most of these materials are ideal for use as substrates or of substrate-mixtures for of cut flowers crops in Colombia.

S18.P26

Fertigation management in tomato crop in a saline valley by soilless culture

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High technology agriculture is one of the keys to the development Arica and Parinacota Region in Chile. Tomato for fresh consumption is the most important crop in the region, both in terms of the area cultivated and the economic value of the production, because the mean regional tomato yields are significantly greater than the national average and the production is in off season. The installation of the seed industry in the Azapa valley, the high cost of land and the scarcity of water have made many tomato producers move to the Lluta valley, due to the greater availability of water and land.However, the poor quality of the water limits the productivity of the Lluta valley. The objective of this research was to generate new information on plant nutrition which will have an impact in the increase of production of tomato crops in the Lluta valley using natural water with high salt content, with low-cost, environmentally friendly technology, to give sustainability to vegetable farming in this valley. The agronomic evaluation of the tomato crop (cv. Poncho Negro) was carried out in a greenhouse in Lluta valley in Arica (Chile), in soilless culture with organic substrates bags of 30 L. To achieve this objective, we evaluated the effects of the physical-chemical characteristics of irrigation water on the absorption of nutrients, in three organics substrates: Coconut fiber (T0), Compost (T1) and 50% coconut fiber + 50% compost (T3). Fertigation parameters (CE, pH, water consumption), yield and quality fruit was evaluaded. Nutrient disolution was managment according to the results of the ion analysis of drainage. The results indicate that there is not significant difference between treatments. These results suggest that it is possible to obtain a sustainable production with bad quality water with the fertigation management in soilless culture systems.

S18.P27

Growth, chlorophyll content and yield of hydroponic lettuce in response to different nutrient solution formulations

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In hydroponic production systems, plant growth depends upon the composition of nutrient solution. This experiment was carried out in order to evaluate the effects of four nutrient solution formulations on growth and chlorophyll content of butterhead lettuce cv ´Ballerina´ and ´Santoro´. Thirty days following germination, lettuce seedlings were transplanted in a modified Nutrient Film Technique system at a plant density of 20 plants/m2. Lettuce plants were subjected to four different nutrient solution formulations and the number of leaves per plant, fresh and dry of leaves and roots, root length and chlorophyll content in leaves and yield were evaluated. At four weeks after the beginning of treatments, the formulation of the nutrient solution significantly affected chlorophyll a, foliar fresh and dry weights and root length. In contrast, fresh and dry weights of roots were affected by the interaction of the nutrient solution formulation and cultivar. Yield was significantly affected by the formulation of the nutrient solution.

S18.P28

Evaluation of productivity in lettuce culture with organomineral fertilizers and algae extract

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Among the vegetables that have importance in promoting health and social and economic benefits stands out lettuce. This crop presents great potential for agricultural production diversification in small and medium farms. Aiming increasing profitability by increasing productivity and optimizing the resources used, find alternative sources of nutrients provides cost reduction to farmers. This work aimed evaluate the growth, nutrient accumulation and productivity of the lettuce with the use of organomineral fertilizer and algae extract. The Regina cultivar, that have smooth and loose leaf, was used. The lettuce seedlings were produced in styrofoam trays with commercial substrate and were transplanted 30 days after sowing, at a spacing of 0.4 x 0.3. A randomized block design was used in a 3x3 factorial scheme, with three dosages of organomineral and litotan algae extract. Phytotechnical characteristics and macro and micro nutrient contents were evaluated at 35 days after transplanting. The use of lithotane up to the 150 g dose and the association of organomineral with 150 g of lithotane increased the fresh mass and the contents of macro and micro nutrients in lettuce plants

S18.P29

Influence of potassium and zinc supplement on yield and quality of greenhouse tomatoes with closed soilless cultivation system

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A greenhouse experiment was carried out in Beijing Region of China to determine the influence of potassium and zinc supplement on yield and quality of soilless tomato in Chinese solar greenhouse.The treatments included T0 (K+ 8mmol/L, Zn2+ 0.77umol/L)T1 (K+ 8mmol/L, Zn2+ 1.54umol/L), T2(K+ 16mmol/L, Zn2+ 1.54umol/L), T3 (K+ 16mmol/L, Zn2+ 0.77umol/L). Three-week old seedlings of tomato were transplanted to the pots. Adding potassium fertilizer, zinc fertilizer could increase tomato yield, potassium-zinc coupling significantly increased the soluble sugar content than other treatments, meanwhile the yield of potassium-zinc coupling was increased by 14.29%. The effect of potassium and zinc application on photosynthetic characteristics of tomato was significantly higher than other treatments, and the effect of zinc fertilizer on photosynthesis index of tomato was lower than that of potash fertilizer.

S18.P30

Effect of three supplementary nutrient solutions on growth, physiological characteristics and water consumption of basil in NFT system

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In order to reduction of environmental and economic costs in hydroponic culture systems, necessity of recirculating and reusing of nutrient solution is increasing, whereas, a little information exist about nutrient solution management in close hydroponic systems. Many growers dump out nutrient solutions and refill at weekly intervals. Other growers have recommended electrical conductivity determination and/or measuring the concentrations of individual nutrients in solution as a key to nutrient control and maintenance. With the aim of comparison of the effect of three nutrient solution replacement methods in Nutrient film technique (NFT) system on different basil varieties, a factorial experiment was conducted based on completely randomized design with 3 replicates. Factors were nutrient solution replacement method (complete replacement, partial replacement according to EC, and partial replacement according to plant demand) and variety (Green basil, Purple basil and Lettuce leaf basil). The results showed that nutrient solution replacement according to EC and plant demand reduced nutrient solution consumption to 1/3 of complete nutrient solution replacement. The highest shoot and root fresh weight was observed in treatment of partial nutrient solution replacement according to plant demand in green basil and lettuce leaf varieties, respectively. Maximum Ca and Mg concentrations were observed in the leaves of purple variety in partial nutrient solution replacement according to target EC. Iron concentration in lettuce leaf variety was higher than purple variety while Fe concentration was not affected by different nutrient solution replacing methods. The results also indicated that the highest chlorophyll a, b and carotenoids were observed in lettuce leaf variety that treated by partial nutrient solution replacement according to target EC. Therefore, considering to the reduction of nutrient consumption with acceptable growth of basil in partial fulfillment of nutrient solutions, these methods of plant nutrition is recommended for basil production in NFT system.

S18.P31

Effects of the recirculation of the nutrient solution on growth, foliar mineral content and yield of the hidroponically-grown lettuce

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The aim of this research was to evaluate the effect of the nutrient solution recirculation on growth, mineral composition of plant tissues and yield of hydroponic lettuce cv. 'Flandria'. Transplantation took place 27 days following germination on polystyrene rafts in a floating hydroponic system using three recirculating levels: without, intermittent and continuous. There was no significant difference among treatments on number of leaves per plant. Root length was higher in lettuce plants grown in recirculating solutions. Total fresh weight was not affected by the recirculation of the nutrient solution. Foliar K, Ca, Mg and P content was higher when the nutrient solution was recirculated, while NO3- and S content was favored without recirculation of the nutrient solution. In addition, lettuce plant roots grown in a continuous recirculating solution accumulated more P but less Mg. Higher Fe concentration in roots was associated with recirculating solutions. Plant yield was significantly increased when the nutrient solution was recirculated.

S18.P32

Evaluation of post-harvest quality of sweet pepper grown on compost-biochar soilless media

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An experiment was conducted to study the effect of soilless media on sweet pepper production. The objectives of the experiment were to determine the effect of the locally produced soilless media on the growth, yield and fruit quality of sweet pepper. Four treatments were formulated from locally produced sawdust compost (SC) and rice husk compost (RC) mixed separately with rice husk biochar (RB) and sawdust biochar (SB). A commercial grade soilless coir media was added as a control. The 5 treatments were set up in a completely randomized design (CRD) with four replications. the SC+RB and SC+SB produced significantly higher fruit number, fruit weight and fresh biomass. Over a period of 26 days, the coir and the SC+RB had weight losses of 36 % and 39 % respectively compared with 29 % d 28 % for SC+SB and RC+RB. After two weeks of storage, the SC+ SB maintain its green colour, however the RC+RB and SC+RB changed to breaker and the coir media changed to light red. The RC+RB produced the firmest fruit (6.3 kg/f) while the RC+SB produced the softest fruit (4.5 kg/f). Total Soluble Solids was highest in the coir media (3.1) and lowest in the RC+SB media (1.2)