

## IHC2018-Symposium 16

### International Symposium on Tropical and Subtropical Vegetable Production: Tackling Present and Future Global Biotic and Abiotic Stressors

#### ORAL PRESENTATIONS

#### KEYNOTE 1

#### MODIFICATIONS OF SOURCE-SINK RELATIONSHIPS AND STRESS TOLERANCE IN CROP PLANTS

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Abiotic stress (water deficit, salinity, heat, etc.) is the most prominent threat to agricultural production worldwide. In most crops, stress accelerates leaf senescence, leading to a decrease in canopy size, loss in photosynthesis and reduced yields. We hypothesized that it may be possible to enhance drought tolerance by altering sink/source relationships in the plant, delaying stress-induced senescence. We generated a number of strategies, aimed at altering hormone homeostasis for the delay of leaf senescence and the increased chloroplast stability. Our results also showed that the stress-induced cytokinin production had a positive effect on nitrate uptake as well as on the expression of genes associated with primary N assimilation and N re-assimilation, enhanced higher protein synthesis and the strengthening of the transgenic plants sink capacity. We applied a System Biology approach to identify genes and gene networks mediating the stress-response of crops to abiotic stress. A number of genes have been identified, and their expression has been modified in a number of crop species. We also identified a novel pathway for the degradation of chloroplast proteins and the mobilization of nitrogen from source tissues to sinks. The earliest detectable event during the senescence process is the loss of photosynthetic activity and degradation of the chloroplasts that contain up to 70% of the total leaf proteins. Most of the nitrogen resulting from chloroplast degradation at the source leaves is recycled and supplied to the sink organs. The protein CV (Chloroplast Vesiculation) targets the chloroplast, promoting the formation of vesicles (containing stroma and thylakoid proteins) that are released from the chloroplast and transported into the vacuole through an autophagy-independent pathway. The overexpression of *AtCV* induced leaf senescence and chloroplast degradation in *Arabidopsis*. On the other hand, *AtCV* silencing resulted in delayed chloroplast degradation and abiotic stress-induced senescence. Our results support the notion of an interaction between *AtCV* and the photosystem subunits mediating their incorporation into vesicles and facilitating their traffic to the vacuole for protease-mediated degradation. From a biotechnological perspective, CV silencing offers a suitable strategy for the generation of stress-tolerant transgenic crops.

Keywords: abiotic stress, source/sink relationships, photosynthesis, chloroplast turnover, CV, chloroplast vesiculation gene, stress-induced-senescence

#### SESSION I: Salt Stress

##### OS 1-1:

#### EXOGENOUS MELATONIN IN ALLEVIATION OF SALT STRESS OF TOMATO SEEDLINGS

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As a medium salt-tolerant crop, tomato (*Solanum lycopersicum* L.) were serious affected by soil salinization. Alleviation effects of exogenous melatonin on salt stress of tomato were found in our previous study, but its mechanism is still unknown. To evaluate salt resistance, 37 tomato lines were selected as materials to investigate their electrolyte leakage, chlorophyll content, malondialdehyde content, plant height, stem diameter, dry weight, fresh weigh, and root cap ratio. Principal component analysis, subordinate function and cluster analysis were performed to analysis their salt resistance base on their comprehensive evaluation value. Eight salt resistance,



nine moderate salt tolerance, 14 weak salt resistance, and six salt sensitive resistance tomato lines were identified. The salt resistant tomato genotype ('Lenmon Boy' and 'super sweet 100') and salt sensitive tomato genotype ('LA1627' and 'LA1698') were selected to detect their photosynthetic characteristics, chloroplast ultrastructure and antioxidant system under treatment of water, 200mM NaCl, 100µM melatonin, 200mM NaCl + 100µM melatonin. The result found that the gas exchange parameters of Pn, Gs, Ci and Tr, activity of PS II, and the content of photosynthetic pigments reduced under salt stress. By spraying melatonin on seedlings under salt stress, the plants recovered by decreasing the damage of chloroplast, increasing content of photosynthetic pigments and Pn, reducing the intercellular CO<sub>2</sub> concentration, enhancing the activity of PS II. Besides, ROS and electrolyte leakage decreased, the antioxidant enzyme activities and AsA-GSH recycle system increased after treatment with melatonin.

Keywords: tomato, salt resistance, melatonin, antioxidant system, photosynthetic system

## OS 1-2:

### GROWTH AND NUTRIENT ELEMENT CONTENT IN MYCORRHIZAE COLONIZED MINT PLANTS UNDER SALINE CONDITIONS

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Saline areas of the world has increased rapidly as a result of the wrong soil and plant management. The remediation of saline soils is an expensive and difficult method. Instead, the use of resistant varieties to saline conditions or some measures such as mycorrhiza use which increases the plant's resistance are more rational in stress conditions. In the experiment, peppermint plants grown in saline conditions were investigated on plant growth effects of mycorrhizal inoculation to roots. As a pot experiment, we was used mint plants (*Mentha piperita* cv. Sewiss) and three different mycorrhizal species (Cocktail, *Glomus macrocarpum*, *Glomus fasciculatum*). Salt applications were initiated 10 days after transplanting. The measurements have been done after 60 days from transplanting. The number of branches and leaves of plants, plant height, root length, fresh and dry shoot and root weight were measured. At the end of the experiment, nutrient content in leaves and colonization of mycorrhizae in roots were determined. Use of mycorrhizae on mint plants were determined positive effects in saline conditions

Keywords: salt stress, mint, *mentha piperita*, mycorrhizae, plant growth, nutrient uptake

## OS 1-3:

### DETERMINATION OF THE EFFECTS OF SALT STRESS IN SPINACH BY MRI AND CT IMAGING TECHNIQUES

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The research was carried out to determine the changes occurred on the spinach leaf tissues as a result of salt stress by using MRI (Magnetic Resonance Imaging) and CT (Computer Tomography). In study which were used the Meridyen F1 and San Moreno F1 as plant material, plants were grown in hydroponic system including Hoagland nutrient solutions under controlled conditions. For this purpose, the varieties were grown in a climate chamber at 22/18 °C (day/night) temperature, 70% humidity, 10/14 hours (light/night) photoperiod and 400 micromole m<sup>-2</sup>s<sup>-1</sup> light intensity conditions. Salt applications have been started at the period which plants have 4-5 true leaves and continued to harvested time. The salinity of the nutrient solution in the pot was set up with NaCl. Trial randomized plots were established with 3 replications and at each repetition including 2 varieties (Meridyen F1 and San Moreno F1) and 4 different salt concentrations [(EC = control (2), 6, 8 and 10 dSm<sup>-1</sup>)]



were applied. Imaging studies were performed with MRI (Magnetic Resonance Imaging) and CT (Computer Tomography) devices located in the Radiology Department of Namık Kemal University Faculty of Medicine Application and Research Hospital. MRI images were obtained by taking coronal and axial reference planes of the leaves in T1 weighted (T1W) C + and Proton Weighted (PDW) sequences in GE Healthcare Brand (General Electric, UK) 1.5 Tesla MR device. In CT imaging, General Electric (UK) the Bright Speed Model with 16 detectors device was used. Sections taken at 0.625mm in diameter, 80 kV and 10 mA values following the angio protocol were examined and then with the help of postprocess multiplanar and volume rendering observations, the images were obtained. According to the observations of MRI and CT images, it was determined that the leaf texture of Meridian F1 against salt stress was less deformed than the leaf texture of San Moreno F1 and at the same time, the water transmission of Meridian F1 was more proper than San Moreno. So, the damages caused by the salt stress on the leaves could be determined early by using MRI and CT imaging.

Keywords: *Spinacia oleracea* L., NaCl, Imaging techniques

## SESSION II: Salt, Water and Nutrient Stress

### OS 2-1:

#### SALT INCREASE THE NUTRITIONAL CONTENT OF CAULIFLOWER

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It is known that intermediate salt stress may increase the taste and nutritional content of some horticultural crops. Some vitamins, carotenoids, mineral content and total soluble solids of edible part of the crops can be increased. In this study, we have searched the effects of 50 mM NaCl on brix, dry matter and mineral nutritional contents of cauliflower. Plants were grown in cocopeat slabs and 50 mM NaCl was applied by the nutrient solution during the autumn and winter growing season by using an open soilless system in the greenhouse. Cauliflower samples were analyzed for water soluble dry matter (brix), pH, EC, total dry matter and concentration and some minerals. The salt increased the cauliflower total dry matter (9%), water soluble dry matter (1.3%), EC (43%), N (6%), K (17%), Mg (9%), Cu (281%), Cl (17%) and Na (120%). However, the salt decreased Fe (7%), Zn (1.5%) contents and mean cauliflower weight (4.8%). While the small decreases in the cauliflower weight and size, 50mM NaCl salt enhanced eating taste, dry matter and mineral properties.

Keywords: *Brassica oleracea* var. botrytis, NaCl, minerals, brix, cauliflower size

### OS 2-2:

#### ESTABLISHMENT OF QUANTITATIVE PHENOTYPING PLATFORMS TOWARDS MAPPING LOCI ASSOCIATED WITH FLOODING TOLERANCE IN CABBAGE (*Brassica oleracea* var. capitata)

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Cabbage (*Brassica oleracea* var. capitata), one of the most abundant vegetables, exist a huge market gap in summer production at lowland area in Taiwan, because high temperature and heavy rainfalls are two critical obstacles for cabbage production. Taiwan requires new cultivars that adapt climate changes to fill the gap of year-round production at lowland. However, cabbage breeding without molecular assisting costs at least 10 years for a single cultivar. To establish the basis for mapping quantitative trait loci (QTL), we firstly focused on flooding and developed quantitative phenotyping measurements to describe flooding tolerance. Multiple measurements have been utilized, including survival, leaf injury, regeneration of new leaves, recovery time of apical growth, chlorophyll fluorescence (Fv/Fm), degree of hyponasty, and elongation of petiole. Notably, 'Fuyodori' showed lowest leaf damage, and '228' have highest survival in apical meristem after flooding, suggesting that protection



of leaf cells and apical meristems are two separated mechanisms of flooding tolerance in tested cabbage cultivars. Expression profiling of glycolytic genes and transcription factors were also used to describe flooding responses. Taken together, this study not only dissects underlying mechanisms of flooding tolerance in cabbage, but also provides a basis for further mapping QTL associated with flooding tolerance.

Keywords: flooding, hypoxia, phenotyping

## OS 2-3:

### RESPONSE OF FLUTED PUMPKIN (*Telfairia occidentalis* Hook F) TO DRY SEASON IRRIGATION

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Fluted pumpkin (*Telfairia occidentalis* Hook. F) is an indigenous leaf vegetable with immense health benefits. In response to increased demand for it by health conscious consumers demand it is grown in the assortment of intensively managed urban and peri-urban gardens in the humid parts of Nigeria. However, during the dry season production is limited to the few wetlands due to soil moisture stress. Consequently, supply is severely curtailed and fluted pumpkin becomes scarce and expensive. To redress this problem, between October 2013 and March 2014 a study was undertaken at the Federal University of Agriculture, Abeokuta Nigeria to determine the response of fluted pumpkin to dry season irrigation. Seedlings spaced 0.5m x 1.0m on a moderately fertile sandy soil were trained on 1.5 m high bamboo trellis. Each seedling received 0.5, 1.0, 1.5 and 3.0 L water/week. The irrigation rates were assigned following a randomised complete block replicated four times. Crop response was monitored weekly. Plants irrigated with 3.0 L water/plant/week produced significantly ( $p < 0.05$ ) longer vines, larger leaf area, more branches and higher dry matter yield at first harvest than other irrigation rates. The effects of 0.5, 1.0 and 1.5 litres on these parameters were often not significantly different from one another. Number of leaves produced, and foliar N, P, K, Mg, Ca, Fe and Vitamin A content, number of fruits and weight of fruits produced were not significantly influenced by irrigation rates. To augment supply of fluted pumpkin during the dry season in south-western Nigeria, irrigation with 3.0 L water /plant/week is recommended for plants grown on sandy soils.

Keywords: indigenous vegetables, intensification, out-of season production, southwest Nigeria

## OS 2-4:

### NITROGEN UPTAKE AND METABOLISM OF *Brassica campestris* ssp. *Chinensis* L. IN RESPONSE TO WATER DEFICIENT

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Tighter water restrictions and competition with other sectors of society is increasing pressure to diminish the share of fresh water for irrigation, thus resulting in the decrease in water diverted for agriculture. Pakchoi (*Brassica campestris* ssp. *Chinensis* L.) is one of the most popular leafy vegetables cultivated over a large northern to southern range in China. The aim of this study was to assess the effects of water deficiency on nitrogen nutrition of pakchoi. The experiment was conducted under hydroponic culture conditions. The water deficiency was manipulated by adding polyethylene glycol (PEG) 6000. In experiment 1, pakchoi seedlings were exposed to nitrogen free nutrient solution with different osmotic potential (by adding 0, 3%, 6%, 9% and 12% PEG 6000) for 48 h. Then the seedlings were transferred to the standard nutrient solution to recover and the nitrogen consumption was investigated. The nitrogen consumption of pakchoi treated by PEG6000 was significantly higher than that of in control (0 PEG6000) after 6 hours of recovery, indicating that moderate drought accelerated the nitrogen absorption of pakchoi. In experiment 2, seedlings were exposed to modified nutrient solution with different nitrogen concentration (2, 9 and 18mM NaNO<sub>3</sub>) and osmotic potential (0, 6% and 12% PEG 6000) in a full factorial, replicated randomized block design, and the changes in nitrogen accumulation and enzyme activities involved in nitrogen assimilation were investigated. Drought stress





promoted root nitrogen concentration, but it decreased the leaf nitrogen concentration. Additionally nitrogen concentration and the activities of nitrate reductase (NR) and glutamine synthetase (GS) in the roots were increased when the nitrogen supply was increased under drought condition (12% PEG 6000). The results suggested that drought restricted the accumulation of leaf nitrogen, whereas the increased nitrogen supply contributed to nitrogen assimilation ability of roots under water deficiency

Keywords: pakchoi, drought, nitrogen concentration, enzyme activities, leafy vegetable

## OS 2-5:

### ENERGY USE EFFICIENCY, AGRONOMIC EFFICIENCY, ECONOMIC ANALYSIS, RESIDUE DEPOSIT, NUTRIENT TOLERANCE AND YIELD OF TOMATOES UNDER LIMITED AND OPTIMAL FERTILIZER

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Nine tomato cultivars comprising Tropimech (T1), Carl J (T2), Peto 86 (T3), Roma (T4), UC82B (T5), Chibli (T6), Heinz (T7), NI (T8) and RIO (T9) were evaluated for energy use efficiency, economic analysis, residue deposits, agronomic efficiency, nutrient tolerance and yield performance under four fertilizer rates. The trial was conducted at the Kadawa irrigation site of Kano State altitude 476.2m, Lat.11.550N and Long. 8.380E. Nursery sowing and transplanting were carried out on 10 November, 2015 at a minimum temperature of 160C and on 22 December 2015 at a minimum temperature of 13.40C. Fertilizer treatment was applied at 0,30,60,90, and 120 kg/ha-1(20-10-10) respectively under the basin size of 25 m<sup>2</sup> and 0.5 m x 0.5 m spacing. Irrigation water was applied uniformly at the flow rate of 11 m<sup>3</sup>hr<sup>-1</sup> using 3" diameter pressurized rubber tube at an average discharge rate of 10.87 m<sup>3</sup>-hr. Results obtained indicated that the total energy budget for the production of the nine cultivars was 112,180.55 MJ/ha-1 with fertilizer accounting for about 41.2% of the energy input. Energy use efficiency was however low showing inefficient use of energy in tomato production typical of Nigerian system. T2, T4, T5, T6 and T7 recorded agronomic efficiency of 8.05, 14.10, 2.38, 4.53, and 13.96 with a corresponding yield performance of 20.6, 24.8, 19.4, 20.1 and 24.4 tha<sup>-1</sup> respectively. Residue deposits were significantly more pronounced with T4, T7, T9, T3, and T2 suggesting cultivars with higher concentration of ethanol than others at 7.88 tha<sup>-1</sup>, 5.99 tha<sup>-1</sup>, 4.85 tha<sup>-1</sup>, 4.75 tha<sup>-1</sup>, and 4.62 tha<sup>-1</sup> respectively. The highest TOLN was observed in T4 followed by T7, T6 and T5, revealing the cultivars with the possibility of early segregation, although displaying the characteristics of initial better yield performance in contrast to T2 with more stable traits as observed in low TOLN with higher yield at both optimal and limited fertilizer rates. However, due to low yield performance associated with T5 under limited fertilizer rates, T2, T4, T6 and T7 were found to be more desirable for production and further improvement. Benefit-Cost ratio, was found to be 2.09 with corresponding returns of N1,503,168.00 per ha. This outcome was highly desirable despite the massive invasion of tomato leaf-miner (Tuta Absoluta) towards the maturity stage of the crop.

Keywords: energy use efficiency, limited and optimal fertilizer application, benefit cost ratio

## SESSION III: Nutrient, Temperature and Light stresses

### OS 3-1:

#### THE EFFECT OF LEAD STRESS ON SOME OF THE BIOCHEMICAL PROPERTIES IN EGGPLANT ROOTSTOCKS AND THEIR VARIETIES

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The effects of heavy metal stress on plants may vary depending on the type and dosage of the heavy metals, and on the genetically based physiological properties of the plants. While some species can tolerate excessive concentrations of heavy metals, lead accumulation capacities in the same plant species and their condition of lead tolerance can change. In addition to studies being carried out that investigate the usage of rootstock and grafted plants against heavy metal stress, which is an abiotic stress, these studies have also reported that grafting and using rootstocks have significantly limited the uptake of heavy metals. In this study, the application of lead and the resulting changes in MDA content and in SOD, CAT, APX, and GR enzyme activities have been investigated. For this study, which was carried out under controlled greenhouse conditions, 6 commercial eggplant rootstocks and 4 eggplant varieties were used as the plant materials. The eggplant seedlings, once they were at a 4-5 real leaf stage, were subjected to 0, 150, and 300 ppm of Pb solution ( $\text{Pb}(\text{NO}_3)_2$ ). Stress application on the plants lasted for a period of 20 days. At the end of this period, the plants were analysed in terms of physiology and biochemistry. Different reactions in rootstocks were observed in relation to the properties analysed. The application of lead, relative to the increase in dose applications, resulted in the decrease of chlorophyll content in the eggplant rootstocks. While both stem and root Pb uptake in rootstocks increased significantly, this increase occurred more in the roots than in the stems of the rootstock and genotypes. Rootstocks that were under stress conditions were found to have lower chlorophyll content, higher antioxidant enzyme activities (SOD, APX, CAT, and GR) and, especially those treated with 300 ppm lead, higher lipid peroxidation levels. Irrigation water that contained lead, had a negative effect on some of the biochemical properties in eggplants during their seedling stage.

Keywords: Pb, *Solanum melongena*, grafting, enzymes, heavy metal stress

## OS 3-2:

### EVALUATION OF TOLERANCE TO LOW TEMPERATURE IN A COLLECTION OF CUCUMBER (*Cucumis sativus* L.) ACCESSIONS UNDER DIFFERENT LIGHT INTENSITIES

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Early cultivation of cucumber (*Cucumis sativus* L.) plants is usually restricted due to its sensitivity to low temperature conditions. Discovering fast and high throughput methods for cold tolerance assessments is substantial for screening of cucumber populations. Here we used polyphasic fluorescence transient (OJIP transient) to analyse low temperature (4 °C) damage to electron transport chain in the photosynthetic apparatus of a collection of native Iranian cucumber accessions under different light intensities (0, 300 and 600  $\mu\text{mol m}^{-2} \text{s}^{-1}$ ). The results showed that negative effects of cold stress depend on the light intensity. The plants that were exposed to darkness were less negatively influenced by the low temperature stress, while those exposed to higher light intensities showed more damages to their electron transport chains. During exposure to low temperature, although accessions showed normal OJIP curve in dark conditions, exposure to light caused abnormal transient induction of chlorophyll fluorescence among cucumber accessions in a light intensity dependent manner. Our results confirm that OJIP transient can be a useful tool for investigating response of cucumber accessions to low temperature stress when the plants are simultaneously exposed to low temperatures and lighting environments. Using this protocol we can also show that where in the electron transport chain disturbances are occurred.

Keywords: chlorophyll fluorescence, cold stress, cucumber, light intensity, OJIP transient

## OS 3-3:

### SALICYLIC ACID IMPROVED THE HEAT TOLERANCE BY ENHANCING GROWTH, GAS EXCHANGE ATTRIBUTES AND CHLOROPHYLL CONTENTS OF TOMATO

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Heat stress is one of the major issues that are curtailing yield and productivity of the crops. This situation is to aggravate further under the global warming scenario. Keeping in consideration the prevailing problem, the present study was designed to investigate the role of exogenously applied salicylic acid in enhancing heat tolerance of tomato. Tomato genotypes (two heat tolerant and two heat sensitive) were exposed to controlled conditions of high temperature (40/32°C day and night) and were sprayed with salicylic acid at various concentrations. The data regarding growth related attributes, gas exchange related attributes and chlorophyll contents were recorded and analyzed statistically. The study proved that exogenously applied salicylic acid induced heat tolerance in tomato genotypes as enhanced tolerance was noted as compared to control. The results revealed that foliar application of salicylic acid with concentration of 1.5 mM was found appropriate in alleviating the drastic effects of high temperature as compared to other concentrations tested. It can be concluded that heat tolerance potential of the tomato can be enhanced by applying salicylic acid exogenously. The findings of this study will not only help in boosting yield but will also expand the growing period of tomato in summer months.

Keywords: heat tolerance, salicylic acid, tomato, gas exchange, chlorophyll

## OS 3-4:

### CAN GRAFTING ENABLE OFF-SEASON CUCUMBER PRODUCTION DURING WINTER UNDER LOW COST PROTECTED STRUCTURES IN INDIAN ARID PLAINS?

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In recent years, protected vegetables cultivation is gaining momentum even in Indian hot arid regions. It not only ensures high quality and productivity of vegetables, by minimizing the risk of external growth limiting factors but also enables efficient utilization of inputs such as water and fertilizers. Naturally ventilated polyethylene houses and shade net houses are the common protected structures in these areas. These low cost protected structures have no heating facility, hence crop like cucumber which is predominantly grown in this region is adversely affected by low temperatures during winter season, when night temperature often falls below the required low (i.e., 16-18°C) for optimum growth and production of cucumber. However, growers prefer to take the off-season winter crop by compromising with yield at some extent as it fetches premium price of produce coming during late winter or early spring (in February-March) when no produce from field grown crops available. Grafting vegetables onto suitable rootstocks are generally known to enhance the efficiency of scion under adverse (biotic or abiotic) conditions. In present study, the potential of grafting was explored to minimize the effect of low winter temperature on cucumber growth and production. The self-rooted cucumber (Infinity) and those grafted onto different cucurbit genotypes such as bottle gourd (Sharda), fig-leaf gourd, pumpkin (BSS-750), winter squash (Arka Suryamukhi) and muskmelon (Kesar) were evaluated for different growth and yield attributes under prevailing low temperature (minimum 12-14°C) under non-heated plastic house during growing season. Fig-leaf gourd (FLG) rootstock-grafted cucumber was superior to other graft combinations. Compared to non-grafted cucumber, FLG-grafted plants gave 30% higher per plant fruit yield, which was followed by bottle gourd rootstock grafted plants (10%). Biomass production, per plant fruit weight and fruit number were also highest in FLG-grafted plants. Additionally, FLG rootstock grafted plants had higher nutrients (K, Ca, Mg and Fe) accumulation in their leaves than other grafting treatments. It is concluded that grafting cucumber onto FLG can enable successful cucumber production under sub-optimal temperature condition of winter (off) season under non-heated low cost protected structures.

Keywords: grafting, cucumber, rootstock, yield, low temperature



## OS 3-5:

### THE HORTICULTURAL AND ECONOMIC CONSTRAINTS OF CULTIVATION OF EDIBLE VEGETABLE FERN (*Diplazium esculentum*) UNDER DIFFERENT SHADE REGIMES IN NORTHERN THAILAND

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Indigenous forest vegetable ferns, *Diplazium esculentum*, are a local perennial vegetable consumed throughout parts of tropical and sub-tropical Southeast Asia. Most ferns are considered a Non-Timber Forest Product (NTFP), and are typically wild collected and sold in local markets during the rainy season. Little work has been conducted on the cultivation of this niche horticultural product, the economics of the cultivation, and how it can contribute to income generation. This study explores how limiting sunlight in a horticultural situation via the use of shade cloth can alter marketable quantities of ferns. The effect of shade cloth on fern growth, marketability, frond length, and frond necrosis was studied on vegetable ferns growing in irrigated raised beds at the ECHO Asia Seed Bank in Mae Ai, Thailand. Over the course of two years, mean height and weight of marketable fronds was significantly higher in treatments receiving either 50% or 80% shade cloth compared to ferns in full sun. Additionally, total necrosis increased as the percentage of sunlight increased across treatments. This study suggests that shade (in this case in the form of shade cloth) positively impacts growth and productivity of perennial vegetable fern fronds and reduces necrosis. Market analysis conducted throughout the year suggests that creative farmers with access to markets may have the potential to create a niche horticultural product market for this crop where currently none exists for a large part of the year.

Keywords: vegetable fern, shade regime, northern Thailand, underutilized perennial vegetable, Niche market

## SESSION VI: Genes, Pest and Disease Management

## OS 4-1:

### EVALUATION OF NOVEL PHEROMONE LURES AGAINST STRIPED FLEA BEETLE (*Phyllotreta striolata* FAB.) ON BRASSICAS AND BEAN POD BORER (*Maruca vitrata* FAB.) ON YARD-LONG BEAN IN SOUTHEAST ASIA

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Striped flea beetle (*Phyllotreta striolata*) is an important pest of leafy brassicas in Southeast Asia. Bean pod borer (*Maruca vitrata*) is the most damaging pest of food legumes in tropical Asia, sub-Saharan Africa, Oceania and South America. Male-borne aggregation pheromones have been identified in *P. striolata*. Although six male-specific sesquiterpenoid compounds were identified, active component was identified as (+)-(6R,7S)-himachala-9,11-diene. Sex pheromone of *M. vitrata* consists of (E,E)-10,12-Hexadecadienal, (E,E)-10,12-hexadecadienol and (E)-10-hexadecenal. Two types of aggregation pheromone lures were evaluated against *P. striolata* on leafy brassicas in Cambodia, Lao PDR, Taiwan, Thailand and Vietnam during 2015. In Cambodia, Himachala-9,11-diene 0.3 mg attracted significantly higher *P. striolata* (188 beetles/trap) compared to check (52 beetles/trap), but the yield of pak-choi (18.45-25.25 t/ha) did not differ significantly. However, none of the lures were attractive





for *P. striolata* in other four countries. In 2016 trials, none of the lures were attractive in all the five countries. Besides Himachala-9,11-diene, a second compound, (3S,9R,9aS)-3-hydroxy-3,5,5,9-tetramethyl-5,6,7,8,9,9a-hexahydro-1H-benzo[7]annulen-2(3H)-one was recently reported. Hence, future blends should contain both these components to enhance the attraction of *P. striolata*. Four types of blends using the three pheromone compounds were evaluated against *M. vitrata* on yard-long bean in 2015. All blends were attractive (24-30 moths/trap, compared to 6 moths/trap in check) only in Cambodia, but not in Lao PDR, Taiwan, Thailand and Vietnam. Four types of blends were evaluated against *M. vitrata* in Cambodia, whereas one improved blend [Z,E-10,12-hexadecadienal; (E,E)-10,12-hexadecadienol; E-10-16OH (100:10:5)+1-Octene-3-ol (50%)] was evaluated in Lao PDR, Taiwan and Thailand during 2016. The pheromone lures were unattractive to *M. vitrata* in all countries, except Cambodia, where it consistently attracted more moths (42-53 moths/trap), with significant yield increases. Hence, pheromone lures can be incorporated into the integrated pest management strategy against *M. vitrata* in Cambodia, whereas it should be refined for other countries in the region.

Keywords: *Phyllotreta striolata*, *Maruca vitrata*, brassicas, yard-long bean, aggregation pheromone, sex pheromone, Southeast Asia

## OS 4-2:

### IDENTIFICATION OF GENES, TRICHOMES AND ACYLSUGARS ASSOCIATED WITH RESISTANCE TO TOMATO FRUITWORM (*Helicoverpa armigera* Hübner) FROM WILD TOMATO (*Solanum pimpinellifolium* L.)

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Tomato fruitworm (*Helicoverpa armigera* Hübner) is major production constraint to cultivated tomato (*Solanum lycopersicum* L.) in tropics and subtropics. Developing pest-resistant cultivars would be an alternative control approach, which could reduce the misuse of chemical pesticides in tomato production. Here, molecular markers, glandular trichomes and acylsugars associated with tomato fruitworm resistance were investigated. A total of 200 F2 plants derived from the interspecific hybridization between WorldVeg's breeding line *S. lycopersicum* CLN3682C and *S. pimpinellifolium* VI030462 were genotyped using 8 putative resistance loci previously identified for whitefly resistance on chromosomes 3, 5, 6, 7, 9 and 11. The same plants along with resistant and susceptible parents, their F1 and susceptible check tomato line were bioassayed for larval mortality, larval weight, pupal duration, and egg number using a no-choice test at 7 and 13 weeks after sowing. The results show that the mortality rate of larvae feeding on F2 populations for 10 days positively correlated with density of type IV trichome at 7 weeks old plants. Type IV trichome and acylsugars production showed recessive gene action because the F1 was skewed strongly toward the susceptible parent. A total of 12, 2, 3, 1 and 9 CAPS markers in 4 regions were significantly associated with density of type IV trichome, larval mortality, pupal duration, larval weight and acylsugars respectively. More studies are underway to confirm these markers in F3 and BC1F2 populations which would be very useful for marker assisted selection in our breeding program for insect resistance.

Keywords: *Solanum lycopersicum*, insect resistance, *Helicoverpa armigera*, cleaved amplified polymorphic sequence, marker-assisted selection

## OS 4-3:

### MANAGEMENT OF PHYTOPHTHORA BLIGHT (INCITED BY *Phytophthora capsici*) OF PEPPERS

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*Phytophthora blight*, caused by *Phytophthora capsici*, is an important disease of peppers. Crop losses of 100% to *P. capsici* have been recorded in commercial pepper fields in Illinois. *P. capsici* can infect pepper plants at all growth stages, causing root rot, crown rot, seedling death, stem blight, leaf spot, and fruit rot. In some cultivars, only fruit are infected. Four approaches were evaluated for management of *Phytophthora* blight in peppers, which included: (i) using resistant cultivars, (ii) induction of resistance in plants by red-light treatment, (iii) crop



rotation, and (iv) fungicide application. To identify resistant pepper cultivars to *P. capsici*, accessions/cultivars of bell pepper were tested in the greenhouse and field, and several cultivars were found resistant/tolerant to *P. capsici*. Pepper seedlings grown under red light (600-700 nm) for four weeks reduced *P. capsici*-infection by 74% in the greenhouse. To establish effective crop rotation for management of *P. capsici*, host-range of the pathogen was determined and survival of the pathogen in soil was investigated. A 4-year crop rotation with nonhost plants and effective weed control are recommended for management of Phytophthora blight of peppers. More than 50 fungicides with potential effects have been evaluated for their efficacy for control of *P. capsici*. Ametoctradin + dimethomorph (Zampro 525F), captan (Maestro 80DF), cyazofamid (Ranman 400SC), famoxadone + cymoxanil (Tanos 50WDG), fluazinam (Omega 500F), fluopicolide (Presidio 4SC), mandipropamid (Revus 2.09SC), mefenoxam (Ridomil Gold Copper 65WP, Ridomil Gold EC 4SC), and oxathiapiprolin (Orondis) fungicides were effective in controlling *P. capsici* in peppers.

Keywords: *Phytophthora blight*, *Phytophthora capsici*, pepper, disease management, resistance induction, fungicide control

## OS 4-4:

### IDENTIFICATION, EXPRESSION AND DIVERSITY ANALYSIS OF PHEROMONE BIOSYNTHESIS ACTIVATING NEUROPEPTIDE (PBAN) IN THE CABBAGE BUTTERFLY, *Pieris rapae* (LINNAEUS) (LEPIDOPTERA: PIERIDAE)

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Cabbage butterfly, *Pieris rapae* is one of the serious pests of brassicas and it is present in Europe, Asia, North Africa, North America and Oceania. While only very few butterflies are agricultural pests, *P. rapae* is one of the economically importance pests, known for reducing productivity of cabbage and other mustard family members. The male butterflies of *Pieris* spp. release aphrodisiac pheromones, but these have not yet been exploited in pest management. Understanding the population structure and genetic differences of *P. rapae* in different geographical locations is imperative to develop most effective pheromone lures. Pheromone biosynthesis activating neuropeptide (PBAN) is one of the most important in insect physiology regulation. It is a member of the PBAN/Pyrokinin neuropeptide family, which has the similarity at the C-terminal end by an amino acid sequence FXPRLamide motif produced by neuroendocrine cells of the sub-esophageal ganglion (SEG). The motifs include DH (diapause hormone),  $\alpha$ SGNP (sub-esophageal ganglion neuropeptide),  $\beta$ SGNP, PBAN and  $\gamma$ SGNP. This study was carried out to understand the population structure of *P. rapae* based on the PBAN gene obtained from a de novo transcriptome assembly. We found that *P. rapae* PBAN is composed of 4,650 bp genomic DNA sequence with six exons and five introns. The open reading frame (ORF) contains 564 nucleotides, encoding 188 amino acids. Real-time quantitative PCR assays indicated the PBAN expression is higher in virgin male wings. It continued to increase as the virgin adult male finds the mate and drastically reduced after mating. The genetic diversity of PBAN however showed no significant difference among the insect populations from Lao PDR, Taiwan, Thailand and Vietnam and USA. Thus, the *P. rapae* population seems to be genetically similar in Southeast Asia and USA. Hence, there is a potential to use same or similar pheromone blends for managing various populations of *P. rapae* on brassicas in these regions.

Keywords: Lepidoptera, Pheromone Biosynthesis Activating Neuropeptide (PBAN), Pieridae, *Pieris rapae*, Southeast Asia

## KEYNOTE 2

### ASPECTS IN TOBAMOVIRUS MANAGEMENT IN MODERN AGRICULTURE

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In the recent decade, new disease outbreaks of old and new tobamoviruses occurred worldwide. The disease caused by Cucumber green mottle mosaic virus (CGMMV) in the cucurbits melon watermelon and cucumber was reported in Israel, North-Europe, Canada, USA, Australia and the Far-east. Recently, the tobamovirus Tomato mottle mosaic virus (ToMMV) was discovered in tomatoes grown in Central America. In the Middle East, in Jordan and Israel, a new Tobamovirus isolate, Tomato brown rugose fruit virus (ToBRFV), that infects tomato plants harboring Tm-22 resistance gene was identified. A tobamovirus that breaks both L3 resistance in pepper plants and Tm-22 resistance in tomatoes, Paprika mild mottle virus (PaMMV), was recently identified as well. The tobamoviruses are highly stable viruses that are mechanically transmitted. Studies of disease management in contaminated greenhouses revealed new strategies for disease control including the use of specific disinfectants that can minimize the primary infectious inoculum from contaminated soil and trellising ropes. Epidemiology of the tobamovirus disease was also studied and the role of beneficial pollinator insects: honey bees for CGMMV spread and bumble bees for ToBRFV spread, was proven. Importantly, possible cooperativity between tobamoviruses, such as the co-inoculation of Tm-22 resistant tomatoes with ToBRFV and PaMMV was also studied, implicating the possible involvement of each tobamovirus in the developing disease of another. Growers in large-scale fields adopted the outcomes of these extensive studies. Recently, the manouvers applied to CGMMV disease management in cucurbits was rapidly adopted to ToBRFV disease management in tomatoes grown trellised in protected structures (greenhouses, walk-in tunnels etc.).

Keywords: CGMMV, ToBRFV, TMV, ToMV

## SESSION V: Virus stress

### OS 5-1:

#### SURVEY OF VIRUS DISEASES AFFECTING SQUASH (*Cucurbita moschata*) IN TAIWAN

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Virus disease is a major constraint to squash (*Cucurbita moschata*) production worldwide. To assess what were the predominant and emerging virus diseases of squash in Taiwan, a field survey was conducted in 2016 and 2017. More than 600 samples from different squash plants with virus-like symptom were collected from 15 counties of Taiwan and the virus(es) present in each was diagnosed by ELISA and PCR. Across all the samples, the predominant viruses were from the genera Begomovirus and Potyvirus. Further testing showed that Squash leaf curl Philippines virus (SLCuPV; Begomovirus) and Papaya ringspot virus type-watermelon (PRSV-W; Potyvirus) were the main viruses present being detected in nearly 50% and more than 43% of samples, respectively. The distribution of the two viruses was different in the different regions of Taiwan, with SLCuPV predominant in the south and east of Taiwan, while PRSV-W was more prevalent in the northern and central counties of Taiwan. Zucchini yellow mosaic virus (ZYMV; Potyvirus) was identified as the second most important virus in north and east of Taiwan while it was the third most important in the Central and southern parts of Taiwan. Watermelon mosaic virus (WMV; Potyvirus) was only identified in samples collected in northern and central Taiwan, while Cucurbit chlorotic yellows virus (CCYV; Crinivirus) was mostly identified in the south and east of Taiwan. These results suggest that in order to reduce the production losses of squash caused by virus disease in Taiwan, it is essential to breed cultivars with good resistance to both SLCuPV and PRSV-W.

Keywords: *Cucurbita moschata*, Squash leaf curl Philippines virus, Papaya ringspot virus type-watermelon, Zucchini yellow mosaic virus

### OS 5-2:

#### TRANSCRIPTIONAL ANALYSIS OF TOMATO-INTERACTIONS WITH RNA VIRUSES

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Tomato is one of the most important agricultural crops in the world and Turkey. There are a number of viruses causing disease in tomato. RNA viruses cause many major diseases of tomato and adversely affect tomato production in various tomato grown regions of the world. The most effective way of controlling viral diseases is the genetic resistance. Since only limited resistant genes were identified for certain viruses and some of the resistance genes identified were broken in the field, alternative resistant strategies need to be developed. Development of alternative resistance requires understanding plant-virus interactions. Therefore, different genomics methods including SSH, microarray and RNA-seq were used for identification of virus responsive genes in RNA virus infected tomato plants. Tomato plants were infected with tomato chlorosis and tomato spotted virus by different methods such as mechanical or graft inoculation, or vector transmission based on the virus. Changes in gene expression were also effected by the time of virus infection. Therefore, gene expression was analyzed at different stages such as early, mid and late periods of RNA virus infection. Analysis showed that expression of a number of genes involved in different cellular functions and/or metabolic activities were changed by virus inoculation at different time. Expression profile of many differentially expressed genes were dependent on virus used for infection, methods of inoculation or method of gene expression. However, some differentially expressed genes were the same regardless of the virus, methods of inoculation and expression analysis. This suggested that they were involved in disease development process of different viruses. These genes could be used or targeted for developing alternative broad-spectrum resistance strategies against RNA viruses in tomato or other plants.

Keywords: tomato, RNA viruses, transcriptome, resistance, microarray, RNA-Seq

## OS 5-3:

### MULTI-LOCATION PRELIMINARY FIELD SCREENING OF WORLD VEGETABLE CENTER BITTER GOURD BREEDING LINES FOR REACTION TO TOMATO LEAF CURL NEW DELHI VIRUS IN SELECTED HOTSPOTS IN INDIA

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Bitter gourd (*Momordica charantia* L.) is an economically and nutritionally important vegetable in Asia where approximately 340,000 ha are devoted to its cultivation annually. The Tomato leaf curl New Delhi virus (ToLCNDV) (genus Begomovirus, family Geminiviridae) is a significant biotic constraint to bitter gourd production throughout South Asia. Natural epidemics of ToLCNDV regularly occur on bitter gourd during certain periods in three locations in India: Guntur in Andhra Pradesh state (February-April), Jagdalpur in Chhattisgarh state (December-February) and Bangalore in Karnataka state (January-March). Bitter gourd breeding lines bred at World Vegetable Center were evaluated in Guntur (200 lines), Jagdalpur (118 lines) and Bangalore (200 lines), using single plot of 20 plants (Guntur; transplanting 4 March 2017) and 5 plants (Jagdalpur – transplanting 8 December 2016 and Bangalore – transplanting 28 January 2017). Plants were rated 60-days after transplanting for ToLCNDV severity using 0-2 scale: 0 = no visible symptoms; 1 = mild symptoms and 2 = very severe symptoms. Plants rated 0, 1 and 2 were considered resistant, moderately resistant and susceptible, respectively. Phylogenetic analysis of the nucleotide sequences of the begomovirus DNA-A components amplified by PCR from infected bitter gourd leaf samples collected from the test fields confirmed infection by strains of ToLCNDV. A single bitter gourd breeding line, AVBG1655, remained consistently free of disease symptoms at each location and considered resistant or highly tolerant to ToLCNDV. However, ToLCNDV DNA-A could be detected in AVBG1655 plants by PCR. Lines AVBG1651, AVBG1652 and AVBG1656 segregated for resistance at each location and the other tested lines were ToLCNDV susceptible. Lines AVBG1651, AVBG1652, AVBG1655 and AVBG1656 are sister lines originating from a landrace population collected in Bangladesh. Line AVBG1655 will be further tested at multi-locations across South Asia and crosses will be made to understand the genetics of resistance to ToLCNDV.





Keywords: *Momordica charantia*, tomato leaf curl New Delhi virus, resistance, germplasm

## OS 5-4:

### THE BENEFIT OF COMBINING DIFFERENT TY-GENES FOR RESISTANCE TO TOMATO LEAF CURL BEGOMOVIRUSES

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Leaf curl caused by whitefly-transmitted geminiviruses (begomoviruses) constraints tomato production in many production areas, and so breeding for durable resistance is an important target. Four of the leaf curl resistance genes (Ty-1/3, Ty-2, Ty-5, and Ty-6) identified from tomato wild relatives have been extensively studied, but each of these alone generally provides only tolerance to leaf curl. Marker assisted selection was used at The World Vegetable Center to stack different combinations of these Ty genes into new tomato breeding lines. A set of 15 of these lines carrying different combinations of the Ty genes was screened in the field in Taiwan where Tomato yellow leaf curl Thailand virus (TYLCTHV) and Tomato leaf curl Taiwan virus (ToLCTV) were confirmed as the predominant tomato-infecting begomoviruses, in Thailand where TYLCTHV and Tomato yellow leaf curl Kanchanaburi virus (TYLCKaV) predominated, and in Vietnam where Tomato leaf curl Hainan virus (ToLCHaV) predominated. The same set of lines was also screened in the net-house in the Philippines with an isolate of Tomato leaf curl Philippines virus (ToLCPV), and in Vietnam with an isolate of Pepper yellow leaf curl Vietnam virus (PepYLCVnV). The tomato lines reacted slightly differently when challenged with the different begomoviruses in the different countries, though generally the lines carrying two Ty genes presented milder leaf curl symptoms than those carrying only one Ty gene. However, none of the combinations of Ty genes provided complete resistance (immunity) to any of the challenging viruses.

Keywords: tomato, begomovirus; Ty-genes; pyramiding

## SESSION VI: Pests and Disease Tolerance

### OS 6-1:

#### PRELIMINARY FIELD SCREENING OF NEWLY DEVELOPED BITTER GOURD BREEDING LINES AGAINST CUCURBIT POWDERY MILDEW AND FOR KEY FRUIT TRAITS

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Bitter melon (*Momordica charantia* L.) is a major cucurbitaceous crop in Asia that is important for both its economical and for nutritional importance. Cucurbit powdery mildew (CPM) caused by *Podosphaera xanthii* (Px) is a serious disease of bitter melon that results in defoliation and high yield losses. Five bitter melon breeding lines resistant to CPM were developed in 2014 at the World Vegetable Center (WorldVeg) and seed was made available to interested stakeholders in private seed sector and public institutions. In addition, we developed additional 23 CPM-resistant bitter melon S6 lines by selecting within segregating populations of 23 landraces originating from India (4), Bangladesh (8), Philippines (9) and Vietnam (2). The 23 lines were evaluated for resistance to CPM in the field and for key fruit traits (fruit weight, length, breadth, color, shape and bitterness) during May-August 2017 when CPM is epidemic in bitter melon fields at the Research and Training Station of the World Vegetable Center, East and Southeast Asia, Kamphaeng Saen, Thailand; lines were grown in single plot of 10 plants per entry. WorldVeg line 'THMC 144' develops 100% CPM disease in the field during this period and rows of this susceptible check were grown on both sides of each entry. Each plant was rated 60-



days after transplanting for CPM reaction using 0 (no evidence of infection) to 5 (>75% infection evident on individual leaves) disease severity scale. The 23 lines were resistant (score 0) to the local isolate of Px and the susceptible check was 100% susceptible to Px (score 5). Three distinct fruit skin colors green, light green, and dark green. Average fruit weights ranged from 10 to 193 g. These 23 lines will be tested against local isolate of Px in multi-location trials in Asia.

Keywords: *Momodica charantia*, cucurbit powdery mildew, resistance, germplasm

## OS 6-2:

### ALTERNARIA FOLIAR DISEASES OF SOLANACEOUS CROPS IN ALGERIA: A MULTI-SPECIES THREAT?

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Northwestern regions of Algeria are characterized by a warm Mediterranean climate where tomato constitutes a very important crop that can be cultivated throughout the year. In these regions, other solanaceous cultivated plants, i.e. potato, eggplant, pepper, are often found in the near vicinity of tomato fields or even used as crop rotation with tomato. Climatic conditions and agricultural practices are therefore highly favorable for the development of epidemics and the appearance of new virulences. *Alternaria* foliar diseases (early blight, leaf and brown spot) are important factors that decrease yield in solanaceous crops worldwide. In fact, surveys carried out since 2010 in different areas revealed that early blight occurs every year in Algeria and could be considered as a major threat for tomato production. Thus, the composition of *Alternaria* species associated with tomato foliar diseases is probably rapidly evolving in Algeria and may be more complex than previously recognized. We present here the characterization of *Alternaria* species isolated from diseased tomato and neighboring wild and cultivated Solanaceae collected during surveys carried out between 2011 and 2017. As a preliminary step, morphological analyses allowed the separation of large-spored and small-spored *Alternaria* isolates. Then multilocus sequence analyses were carried out to identify representative isolates at the section and/or species level. A high inter-specific diversity was observed and isolates belonging to at least six different sections and eleven different species were identified. These results will be discussed with respect to their implication for the management of *Alternaria* leaf diseases in Algeria.

Keywords: *Alternaria*, leaf spot, tomato, Algeria, species diversity

## OS 6-3:

### DEVELOPMENT OF NEMATODE RESISTANT PURE PEPPER LINES VIA ANTHR CULTURE METHOD

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This study was carried out in the laboratories and greenhouses of Cukurova University, Alata Horticultural Research Institute and a seed company between 2015 and 2016 to obtain nematode resistant pure pepper lines. The pure lines were obtained from F1 plants via anther culture method. F1 plants were obtained via crossing of three nematode resistant pepper genitors in F6 level (N-269: green long-N gen, N-8: green long-N gen and N-6: bell-N gen) which were obtained from the studies carried out at the Alata Horticultural Research Institute with breeding pepper lines of a seed company selected in terms of high fruit quality and desired agronomic characters in F3 level (5 green long, 5 bell, 5 charleston and 5 capia). Murashige and Skoog (MS) nutrient medium contained 30 g L<sup>-1</sup> sucrose, 0.25% activated charcoal, 15 mg L<sup>-1</sup> silver nitrate (AgNO<sub>3</sub>), 4 mg L<sup>-1</sup> naphthaleneacetic acid (NAA) and 0.5 mg L<sup>-1</sup> 6-benzylaminopurine (BAP) was used. The cultivated anthers were transferred hormone free MS nutrient medium after 35 days. As a result of the study; it was observed that different parameters were changed according to genotypes. The highest embryo yield was obtained from the genotype numbered Z-tad 87 (nematode resistance x bell hybrid). Among crossing between nematode resistance





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and different pepper types; bell pepper type gave the highest embryo yield and this was followed by capia, charleston and green long types. The highest rate of embryos produced plants was observed in green long pepper type. The highest haploid plant percentage was observed in capia pepper type and this was followed by charleston. As a result, all genotypes tested reacted to anther culture and the number of embryo and haploid plants obtained were varied. In the study, three homozygote pure lines contained Me1, Me3, N and Me7 resistance genes were recorded. Also, one homozygote pure lines contained Me1 was noted. These nematode resistant genotypes obtained can also be used in breeding studies.

**Keywords:** *Capsicum annum*, pepper, anther culture, nematode resistant



## IHC2018-Symposium 16

### International Symposium on Tropical and Subtropical Vegetable Production: Tackling Present and Future Global Biotic and Abiotic Stressors

#### POSTER PRESENTATIONS

##### S16-P1

##### RESPONSE OF SOME CUCURBIT GENOTYPES TO SALINITY STRESS

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The research was conducted in order to identify the response of some cucurbit genotypes to salinity stress in an unheated PE greenhouse in the autumn season of 2013. Sixteen genotypes (*Citrullus lanatus* Thunb.: ‘Sultan F1’, ‘NosztalgiaF1’, and ‘Lentus F1’; *Cucumis melo* L.: ‘Vitalia F1’, ‘ZK1 1112 F1’, ‘Ceşme’, and ‘Kirkagaç’; *Cucurbita pepo* L. var. *giromontia*: ‘Izobilna F1’; *Cucurbita maxima* L.: ‘Plovdivski 48/4’; *Cucurbita moschata* Duch.: ‘51-17’; *Luffa cylindrica* (L.) Roem.; *Cucurbita ficifolia* Bouché; *Lagenaria siceraria* Mol.: ‘Macis’; *C. maxima* L. x *C. moschata* Duch.: ‘RS 841’, ‘TZ148’, and ‘Nun 9075’) were grown as water culture. The seeds were sown in peat on 16th of September. Two weeks later after the peat on their roots were washed, the seedlings were transplanted (4 seedlings in pot on foam board) into brown plastic lateral pots filled with complete nutrient solution. Salinity was initiated two weeks after the transplantation of seedlings. Salinity level was gradually increased up to 300 mM by adding 50 mM NaCl at 2 day interval. Plants were put at 100 and 300 mM NaCl levels for 7 days. The plants in the control were fed with normal nutrient solution during the same period. Stress severity on the leaves was scored. Also stem length and diameter, leaf number, shoot and root fresh and dry weights, electrolyte leakage (EL, %) and relative water content (RWC, %) were measured. The results demonstrated that plant growth and dry matter production differed among the tested genotypes, although plant vigour was decreased with increased salinity. The performance of some genotypes was even higher at 100 mM and 300 mM. A genotype differentiation in the response to salinity stress was revealed. On this base the studied genotypes were grouped according to their tolerance to salinity stress.

Keywords: cucurbit genotypes, salt stress, vigour

##### S16-P2

##### THE EFFECT OF SALT STRESS ON SPINACH LEAF COLOR CHARACTERISTICS

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In order to determine the adverse effects of salt stress on color of spinach leaves, plants were grown in a climate chamber set at 22/18 °C (day/night) temperature, 70% relative humidity, 10/14 hours (light/dark) photoperiod and 400 µmol m<sup>-2</sup>s<sup>-1</sup> light intensity conditions. In this research Meridian F1 and San Moreno F1 varieties and Hoagland nutrient solution as a hydroponic growing system were used. Salt applications have been started from the period which plants have 4-5 true leaves and continued to harvested time. The salinity of the nutrient solution in the containers has been set up as EC = 2 (control), 6, 8 and 10 dSm<sup>-1</sup>. Trial coincidence plots were established with 3 replications and at each repetition including 2 varieties and 4 different salt concentrations were applied. A total of 24 experimental plots in all, a total of 384 plants were grown in 16 plants in each plot and the entire trial. Spinach leaf color measurements were performed using the Hunter Lab D25LT instrument. Color parameters measured with the instrument; color (darkness-aperture) brightness (L \*) and color coordinates (a \* and b \*). The measurements were carried out in 3 replicates using 3 different plants in each plot and choosing the most developed leaf from each plant. According to obtained results; while the differences between the values of brightness (L \*) and b values of leaves of the Meridian F1 and San Moreno F1 varieties against salt stress were





found to be significant with respect to 1%, a \* values were statistically insignificant. It was determined that the mean L\* value (24,37) of the Meridian F1 leaves was closer to the dark than the one of San Moreno F1 (24,99). Leaf color of the varieties was determined as green (-a). Meridian F1 (-5,82) was found to be greener than San Moreno F1 (-5,71). The leaf color b \* value of the varieties was measured as yellow (b +) and the b + (yellow) values (6,20) of the leaves of the San Moreno F1 varieties were higher than other variety. The color brightness (L \*) and color coordinates (a \* and b \*) were statistically significant at 1% level against increasing salt addition to the control application. According to this, with respect to the control application (2 dSm-1), the increase of the salt concentration and the brightness values of the leaves (L \*) were found to be colored. With salt application, green color values (-a) of leaves were lower than control, while yellow color value (b +) was increased.

Keywords: *Spinacia oleracea* L., NaCl, leaf color, color brightness (L), color coordinates (a, b).

## S16-P3

### DETERMINATION OF SALT TOLERANCE LEVELS OF LANDRACE CLIMBING COMMON BEAN (*Phaseolus vulgaris* L.) GENOTYPES COLLECTED FROM WESTERN MEDITERRANEAN REGION

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Bean, a salt-sensitive plant, is the main food grown in many developing countries to meet its daily protein needs. Although it is possible to achieve some methods of soil salinity which causes significant loss in agricultural production, together with these measures, the introduction of resistant cultivars to salt stress and their breeding offer more permanent and effective solutions. In this study, it was aimed to determine the salt tolerance levels of landrace common bean genotypes collected from the Western Mediterranean region as an important gene source. The 84 climbing common bean genotypes collected from the Western Mediterranean region were exposed to four different salt concentrations (0.5 dsm-1, 2 dsm-1, 4 dsm-1, 6 dsm-1) during the early developmental stage. The research was terminated after flower formation in the genotypes. In order to determine the tolerance level of the genotypes during salt stress applications; 84 genotypes were measured with respect to plant weight, root length, plant fresh weight, plant dry weight, leaf width, leaf length and stem diameter. They were also evaluated in terms of lipid peroxidation, superoxide dismutase and catalase enzyme activities, total glutathione content, chlorophyll content and total protein content. The common bean genotypes gave different responses to changing salt conditions. All vegetative parameters except for the stem diameter of all plants treated with salt decreased. It is thought that thickening of the stem diameter is maybe related to the reduction of the plant height. Even at the highest level of salt applied plants, no drying or deformation of the leaves was detected. It has been determined that different salt levels have a decreasing effect on chlorophyll content. Besides, SOD, CAT and GSH values decreased depending on salt stress at low rates such as 0.08%, 0.09% in generally.

Keywords: antioxidative enzymes, common bean, landrace genotypes, *Phaseolus vulgaris* L., salt stress

## S16-P4

### COMPARISON OF ROMAINE, LOOSE LEAF AND ICEBERG LETTUCES GROWN IN SALINE

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The effects of salt on different types of lettuce were investigated. Three commercially available lettuce varieties Lital, Caipira, and Savula which were belong to romaine, loose leaf and iceberg types were used as plant material. Plants were grown in cocopeat slabs in open soilless systems and irrigated by the nutrient solution with or without 50mM NaCl. Experimental period was autumn-winter in the Mediterranean climate. Plant growth, physiological responses and yield were compared for the different lettuce types in saline and non-saline



conditions. The reduction in leaf area in romaine and iceberg lettuce was 17% and 20%, respectively while in loose lettuce was increased by 3% in salt. Stomatal conductance in salt was decreased by 8.8% and 18% in the loose and iceberg lettuces while 41% increased in the romaine lettuce. Total soluble solids (brix) in 50mM salt were increased in the romaine, loose and iceberg lettuces by 25%, 16% and 31%, respectively. Yield reduction in salt was 28%, 11% and 18% in romaine, loose and iceberg lettuces, respectively.

Keywords: *Lactuca sativa* var. longifolia, crispa, capitata, NaCl stress, growth, yield

## S16-P5

### THE EFFECTS OF HYDROGEN PEROXIDE AND NITRIC OXIDE ON ION CONTENTS AND LIPID PEROXIDATION LEVELS OF PEPPER CALLUS TISSUES UNDER SALT STRESS

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Some chemical compounds [such as calcium, hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>), abscisic acid, jasmonic acid, ethylene, salicylic acid, and nitric oxide (NO)] have been suggested to be signal molecules or messengers that are required for stimulating specific responses against various biotic and abiotic stresses. In this research, the effects of hydrogen peroxide and nitric oxide on ion contents and lipid peroxidation levels of pepper callus tissues under salt stress were investigated. Hypocotyl explants from 4 week-old pepper seedlings were cultured with 1:1 mg/L 2,4-D:kinetin to form callus. After 100 µM H<sub>2</sub>O<sub>2</sub>, 100 µM SNP (NO donor) and their combinations with 150 mM NaCl were applied for 48 hours. Changes in ions and MDA (lipid peroxidation) contents were examined in calluses. In salt treated callus, while Na<sup>+</sup> contents of tissues were induced, Ca<sup>2+</sup> and K<sup>+</sup> levels were lowered. Na<sup>+</sup> intake is less in H<sub>2</sub>O<sub>2</sub>+150 mM NaCl, SNP+150 mM NaCl and H<sub>2</sub>O<sub>2</sub>+SNP+150 mM NaCl treatments when compared with only salt treatment where there is no significant difference in K<sup>+</sup> contents. The least Na<sup>+</sup> content is found in SNP+150 mM NaCl when these 3 groups are compared with each other. The lipid peroxidation levels of pepper calli was increased under salt stress conditions. For the groups that H<sub>2</sub>O<sub>2</sub> and NO are applied one by one or in combination it is seen that lipid peroxidation level is decreased when compared to the only salt treated groups. When H<sub>2</sub>O<sub>2</sub>+150 mM NaCl, SNP+150 mM NaCl and H<sub>2</sub>O<sub>2</sub>+SNP+150 mM NaCl treatments are compared with each other, the least MDA content is found in H<sub>2</sub>O<sub>2</sub>+SNP+150 mM NaCl treatment. The derived data shows that hydrogen peroxide and nitric oxide given with salt have healing effects when applied even one by one or together.

Keywords: hydrogen peroxide, nitric oxide, ion content, lipid peroxidation, pepper, in vitro

## S16-P6

### SCREENING OF OKRA GENOTYPES FOR THEIR RESISTANCE TO SALINITY AND DROUGHT

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In the study, 37 okra genotypes have been investigated for their responses against salinity stresses in 24 day old early plant growth stage. For these purposes, several morphological and physiological measurements and analysis have been done in stressed plants. Shoot and root dry weights, plant height, leaf number, leaf area, relative water content, stomatal conductance, leaf osmotic potential, leaf water potential, shoot Na, K, Ca and Cl concentrations were measured and analyzed. Salt and drought tolerant and sensitive (intolerant) genotypes have been found out according to the responses of the okra genotypes to the above mentioned morphological and physiological parameters. At the end of the study, 37 okra genotypes were classified as tolerant, mildly tolerant



or susceptible. The leaf water potential, osmotic potential, stomatal conductance, membrane injury, K, Ca, Na and Cl concentrations in shoot and root were more relevant parameter for screening studies.

Keywords: stress, saline, water, tolerance, selection, breeding

## **S16-P7**

### **EXPRESSION OF APIGENIN BIOSYNTHESIS GENES AND ACCUMULATION OF APIGENIN IN CELERY LEAVES IN RESPONSE TO DROUGHT STRESS**

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Flavonoids have various functions in growth, development, reproduction, and stress defense. Apigenin, a naturally occurring plant flavone, is recognized as a bioactive flavonoid shown to possess anti-inflammatory, antioxidant and anticancer properties. The principal flavonoid compound of celery is apigenin. However, little is known about apigenin accumulation in response to drought stress in celery. In this study, two celery cultivars Shanghai yellow heart (Chinese celery) and Ventura were chosen to analysis apigenin accumulation and expression pattern of key enzymes gene under different extent drought treatment and different time drought treatment. Then the accumulation of apigenin in celery leaves was test by high performance liquid chromatography (HPLC) and the expression pattern of apigenin biosynthesis genes in celery leaves were assayed by Quantitative real-time PCR(qRT-PCR). The apigenin content in celery leaves were increased during drought treatment under mid drought stress and cultivar Shanghai yellow heart was higher accumulation than Ventura. qRT-PCR analysis showed that there were a rapid increase in expression levels of CHS, CHI, and FSI under mid drought stress in two celery cultivars. The increase rates of genes expression were superior in Shanghai yellow heart compared to Ventura. These results suggest that mid drought stress could enhance apigenin accumulation in celery. Further, the apigenin pathway genes expression and accumulation of apigenin may be closely related to drought tolerant in celery.

Keywords: celery, apigenin, key enzymes genes, drought stress

## **S16-P8**

### **EFFECTS OF EXOGENOUS MELATONIN ON ACTIVE OXYGEN METABOLISM OF EGGPLANT SEEDLINGS UNDER HIGH TEMPERATURE STRESS**

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This paper studied the effects of of foliar application of exogenous melatonin (MT) on the active oxygen metabolism of the eggplant (Huqie '08-1') seedlings under high temperature stress. The results showed that the exogenous MT could sinificantly decrease the malonadehyd (MDA) contents, superoxide radica production rate ( $O_2^{\bullet-}$ ) and hydrogen peroxide ( $H_2O_2$ ) contents, but increase the activities of superoxide radical (SOD), perxidase (POD), catalase (CAT), ascorbate peroxidase (APX) and contents of ascorbic acid (AsA) and glutathione (GSH), proline and soluble protein contents. The above results illustrated that pretreatment with MT cold inhibit the reactive oxygen species, raise the antioxidative enzyme activities and antioxidant contents, and decrease the membrane lipid peroxidation to alleviate the damage of high temperature stress to the seedlings.

Keywords: melatonin, eggplant seedlings, high temperature stress, active oxygen metabolism

## **S16-P9**

### **EFFECTS OF PHOSPHORUS AND CALCIUM ON THE CAPABILITY OF WATER CONVULVULUS AGAINST CHILLING STRESS**

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Water convolvulus (*Ipomoea aquatic* Forsk.) is a vegetable originating from tropics, so it is sensitive to low temperature and easily damaged by chilling. Cold currents frequently come to Taiwan from winter to early spring, rendering the temperature lower than 15°C. When cold currents come, water convolvulus often exhibits chilling symptoms, which results in significant inhibition of growth, and decreases in yield and economic value. Phosphorus (P) is an essential macronutrient which plays diverse roles in controlling plant growth and development. Chilling stress results in early depletion of inorganic phosphate (Pi), and then inhibition of photosynthesis in plants. Calcium (Ca) is also an essential macronutrient and it is involved in temperature-sensing mechanism. Calcium can improve cold tolerance in many plants. Hence, the following experiments were conducted to determine the effects of phosphorus and calcium on the capability of water convolvulus against chilling stress. Water convolvulus seedlings grown in hydroponic culture for 14 days at 25°C with a modified one-half Hoagland nutrient solution which contains 250, 500, 750 or 1000 µM KH<sub>2</sub>PO<sub>4</sub> or contains 1.25, 2.5, 3.125 or 3.75 mM Ca(NO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O were transferred to 8°C for chilling treatment. The shoot fresh weight, water content, total chlorophyll concentration, hydrogen peroxide concentration and phosphorus content of the plants were measured after the plants were subjected to chilling for 18 hours and recovery for 2 days. The results showed that the chilling treatment caused the shoot fresh weight decreased more in low P (250 µM KH<sub>2</sub>PO<sub>4</sub>) and low Ca (1.25 mM Ca (NO<sub>3</sub>)<sub>2</sub>·4H<sub>2</sub>O) treated plants. The other indexes were also differentiated under different treatments, and the details thereof would be showed and discussed in this study. In conclusion, a nutrient solution with adequate levels of phosphorus and calcium can improve the capability of water convolvulus against chilling stress.

Keywords: water convolvulus, chilling, phosphorus, calcium

## S16-P10

### EVALUATION OF CHILLING TOLERANCE POTENTIAL OF TOMATO (*Solanum Lycopersicum* L.) GENOTYPES UNDER THE AGRO-CLIMATIC CONDITIONS OF BAHAWALPUR

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*Solanum lycopersicum* L. is a chilling sensitive crop and shows limited growth at temperature below 12 °C. In the focus area of this study, tomato is exposed to low temperature from December to February which causes significant losses in growth and productivity. To combat the issue, the present study was designed to investigate the effect of low temperature on 14 tomato genotypes. Various parameters like chlorophyll contents, antioxidants activity (superoxide dismutase, peroxidase, catalase and ascorbate peroxidase), number of fruits per plant, individual fruit weight, yield per plant and shelf life were recorded to estimate the potential of genotypes to withstand under adverse environmental conditions. The ranking of genotypes was done by giving highest score to varieties performing well in the attributes investigated and hence represented their chilling tolerance potential. The results of this study revealed that genotype L00525 was proved to be most tolerant followed by Rio Grande, whereas two varieties namely China and Layyah were noted the most sensitive to low temperature regime.

Keywords: chilling, tolerance, tomato, antioxidants

## S16-P11

### EVALUATION OF NATIVE CUCURBIT GENOTYPES AS ROOTSTOCKS FOR GRAFTING CUCUMBER UNDER WATER STRESS CONDITION

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Water stress is one of the major limiting factors for crop production in Indian arid and semi-arid regions. Drought tolerant cultivars play crucial role in sustainable crop production in these areas. However, the availability of commercially viable drought tolerant cultivars of many vegetables is a major bottleneck. Grafting, a faster and sustainable tool, has revolutionized vegetable production in many countries by providing rootstock induced tolerance to different biotic and abiotic stresses in commercial cultivars. Besides issues related to graft compatibility and scion's contribution, role of rootstocks is very crucial for the success of grafting. Thus, for selection of suitable rootstocks for grafting cucumber for water stress condition, twenty potentially known drought tolerant native genotypes of different cucurbit species were evaluated. Experiment was conducted in pots filled with coco-peat, and water deficit (WD) was imposed by irrigating one set of plants at 60% irrigation level of the control throughout the 45 days growth period under greenhouse. Plants scoring for tolerance to water stress was done based on different morphological and physiological traits. Compared to cucumber cv. Swarna Ageti taken as control, which produced 1.99 g and 9.51 g plant<sup>-1</sup> root and shoot dry weight (DW), the highest root and shoot DW was in Azad Pumpkin-1 (pumpkin, 48 and 72.7 %) followed by NSSQ-55 (squash, 39.2 and 68%), AHLS Long-1 (bottle gourd, 16.2 and 38.2%), Pusa Chikni (sponge gourd, 11.1 and 12%), respectively under WD condition. The genotypes Azad Pumpkin-1, AHLS Long-1, NSSQ-55, AHC-2 (long melon) and AHW-19 (water melon) reflected more resilience for relative water content of leaves, leaf transpiration, rate of photosynthesis and Fv/Fm as these parameters reflected least change under WD over normal irrigation. Thus, considering both growth and physiology, genotype AHLS Long-1 followed by NSSQ-55 and Azad Pumpkin-1 are considered as promising rootstocks for grafting cucumber under water stress condition.

Keywords: Grafting, cucumber, tolerance, rootstock, water stress

## S16-P12

### PERFORMANCE OF DIFFERENT PEPPER VARIETIES IN THE RAINY AND DRY-COOL SEASONS IN BAMAKO, MALI

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Different pepper varieties (*Capsicum annum* L.) were screened in two season in Mali to assess performance in terms of fruit yield, select disease tolerant/resistant varieties, and better understand disease distribution and dynamics across seasons. Twelve pepper varieties were planted at Samanko Research station, Bamako, Mali during the rainy and dry seasons. The experimental design was a randomized complete block design with four replications. There were no application of pest or disease control chemicals. Yield and yield components, and number of plants showing symptoms of plant diseases were recorded during both seasons and analyzed using JMP statistical software package. During the rainy season, there were significant differences in fruit yield, with accession VI031556 yielding the most (3976 kg/ha) and variety BeibeiHong the least (806 kg/ha). However, due to plant disease problems during the dry-cool season none of the varieties yielded well; variety Bafarima yielded the most (37.5 kg/ha). The types and incidences of plant diseases varied depending on seasons. During the rainy season the incidence of plants with symptoms of virus infection was very low, only variety Nisondia showed significant incidence of leaf spot (*Cercospora* spp.) and only a few fruits of some varieties had anthracnose (*Colletotrichum* spp.) lesions. However in the cool dry season, more than 90 % of the plants of each variety presented severe symptoms of viral disease(s); probably the main reason for the poor yields in this season losing an estimate of 80 – 90% of pepper production. Thus, there is urgent need to screen more local and improved pepper varieties to identify those better adapted to the cool-dry season conditions in Mali and carrying resistance/ tolerance to the major viruses and/or their vectors. Coupled with this there is also the need to develop or adapt integrated pest management practices suitable for use with pepper in the region.

Keywords: pepper, *Capsicum annum*, plant diseases, fruit yield

## S16-P13

### AVAILABILITY OF WATER RESOURCES FOR TOMATO PRODUCTION IN COLOMBIA: A BASIC MODELLING APPROACH



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Colombia is one of the most water abundant countries in the world; nevertheless, the availability of this resource is limited in some agricultural regions. As horticulture is recognized as a highly water demanding sector, this work aims to determine the monthly water supply and demand of the open field (OF) and greenhouse (GH) tomato production systems, established in contrasting catchments. The OF production area corresponded to the Fonce river basin which is the main stream of the Guanentá province (6°25'18.83''N, 73°10'03.18''W; 1370 masl). The selected GH tomato production area is located in the Monquirá river basin in the Alto Ricaurte province (5°39'37.30''N, 73°34'57.46''W; 2070 masl). The estimated tomato production areas were 320 hectares for OF and 330 hectares for GH production area. We used the soil and water assessment (SWAT) hydrological model to estimate the water supply. Required soil and weather inputs for SWAT simulations were obtained from the geological and meteorological Colombian services, respectively. Tomato water demands were determined by a series of successive growers' pilot studies at farm level. Results showed that the water supply is higher in the OF area (1.49 Mm<sup>3</sup> km<sup>-2</sup> yr<sup>-1</sup>) as compared to the GH (0.37 Mm<sup>3</sup> km<sup>-2</sup> yr<sup>-1</sup>). Water supply follows the same bimodal distribution trend as the rainfall throughout the year. During the dry season, water supply for OF and GH areas is only around 21 and 4%, respectively, from that of the rainy season. GH systems have the highest water demand (2.83 Mm<sup>3</sup> yr<sup>-1</sup>), while OF demand 0.78 Mm<sup>3</sup> yr<sup>-1</sup>. For the OF system most plantings are synchronized with the first rainy season while GH production is continuous throughout the year. El Niño-southern oscillation have highlighted the susceptibility of the GH tomato system to water scarcity.

Keywords: water supply, greenhouse tomato, SWAT model

## **S16-P14**

### **EFFECTS OF LED LIGHTING SYSTEM ON SOME GROWTH PARAMETERS: TOMATO (*Solanum lycopersicum*) PLANT CASE**

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This study was carried out on the determination of the effects of the LED lighting system on tomato (*Solanum lycopersicum*) plant. In the study, it is aimed to extend the lighting period of the tomato plant with the LED lighting system. The research was carried out in two plastic greenhouses with a total floor area of 20 m<sup>2</sup> and a total height of 3 m, located in the research and development greenhouse areas of Süleyman Demirel University. During the research, all cultural (irrigation, pruning, harvesting, etc.) facilities were carried out at the same level in both the LED lighting greenhouse. For both applications, tomato seedlings were grown in April and placed in the greenhouse at the beginning of May. At the experiment, plant dismantling took place on August 15th. The greenhouse lighting system with LED lighting was started three hours before sunrise. The closing process was again carried out three hours after sunset. At the end of the research, plant height (cm) and yield values were taken weekly during the production season in the greenhouse which does not have LED lighting and the lighting, and the effects of LED lighting on efficiency and vegetative development were investigated. Temperature and humidity values were also recorded during the cultivation period. For this purpose, two temperature and humidity sensors were installed in both the control greenhouse and the application greenhouse. As a result, it has been tried to determine the effects of the use of LED lighting in prolonging the lighting period of tomato plant. It was determined that there were differences between the experiment and control greenhouses and it was interpreted statistically

Keywords: greenhouse, LED, lighting, *Solanum lycopersicum*

## **S16-P15**

### **GROWTH AND DEVELOPMENT OF WATERMELON PLUG SEEDLINGS AS AFFECTED BY SUPPLEMENTAL LIGHT SOURCE**



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Supplemental lighting is widely used as a commercial implementation to produce high quality greenhouse crops. To study growth and development regulated by different light sources, two cultivars, 'Speed' and 'Sambok Honey', of watermelon (*Citrullus vulgaris*) grafted onto the 'RS-Dongjanggun' bottle gourd (*Lagenaria siceraria* Stanld.) rootstock were treated with or without (the control) 16 h/day of supplemental lighting at 100  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  photosynthetic photon flux density (PPFD) from high pressure sodium (HPS), metal halide (MH), far-red (FR), white LED (LED-w), and mixed (white: red: blue = 1: 2: 1) LED (LED-mix). Seedlings were grown for 10 days in a glasshouse with an average daily maximum light intensity of 490  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  PPFD coming from the sun, 32/25°C day/night temperatures, 85% relative humidity, and natural photoperiod of 14 hours. Compared with the grafted seedlings without supplemental lighting, LED-mix generated significantly increased shoot and root length, biomass, number of leaves, and chlorophyll content. The LED-mix also significantly increased formation of root ball, and contents of total protein, soluble sugar and starch followed by the LED-w, HPS, and MH. Besides, both cultivars showed no significant differences, indicating that light quality is an important environmental factor for growth and development of grafted watermelon seedlings. Overall, the LED-mix was identified as the optimal supplemental light source for growth and development of grafted watermelon seedlings.

Keywords: Grafted seedling, supplemental lighting, light source, light quality, seedling morphology

## S16-P16

### EFFECT OF LIGHT INTENSITY FROM HIGH PRESSURE SODIUM LAMP ON GROWTH AND DEVELOPMENT OF GRAFTED WATERMELON PLUG SEEDLINGS

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Watermelon (*Citrullus vulgaris* Schrad.) is a trailing vine crop belonging to the flowering plant family Cucurbitaceae. It is an economically important vegetable crop in South Korea. Insufficient light is one of the problems in the greenhouse cultivation in rainy summer periods in Korea, which greatly influences the yield and the quality of the watermelon seedlings. This study was carried out to assess the effect of supplemental lighting on the growth and development of two watermelon cultivars 'Speed' and 'Sambok Honey' grafted onto the 'RS-Dongjanggun' bottle gourd rootstock (*Lagenaria siceraria* Stanld.). Seedlings grown for 10 days in a glasshouse were treated without (control) or with different light intensities [120, 220 or 320  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  photosynthetic photon flux density (PPFD)] supplied from 600, 750 or 1,000 W high pressure sodium lamps (HPSL). The results showed that the seedlings grown under supplemental lighting had larger root length, and root dry and fresh weight than the control, except for the root length of 'Sambok Honey'. For 'Speed', the high light intensity (320  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  PPFD) had more benefits for root length and dry/fresh root weight in comparison with those grown under low light intensities (120 or 220  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  PPFD). However, for 'Sambok Honey' the medium light intensity (220  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  PPFD) was more suitable. Overall, the results suggest that medium and high light intensity (220 and 320  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  PPFD) may benefit the growth of grafted watermelon seedlings and can be potentially used as the level of supplemental lighting intensity in rainy summer periods in Korea.

Keywords: Grafted seedling, supplemental lighting, light intensity, seedling morphology

## S16-P17

### QUANTITATIVE ITRAQ-BASED PROTEOMIC ANALYSIS OF TOMATO FRUIT REVEALS PATHWAYS ASSOCIATED WITH RED LIGHT

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There is no doubt that light affect phytochemicals accumulation in fruits. While it is widely known that light intensity can positively affect phytochemicals accumulation, the effects of light quality are more complex and often reported with mixed results. Isobaric tags for relative and absolute quantitation (iTRAQ) is currently one of the most robust techniques that allows quantification of proteins on the basis of peptide labeling, as well as the identification and accurate quantification of proteins from multiple samples within broad dynamic ranges of protein abundance. In this study, we used iTRAQ to assess proteome changes and identify proteins that were differentially expressed in tomato fruits in response to red light. On the basis of enrichment analysis of Gene Ontology (GO) annotations and Kyoto Encyclopedia of Genes and Genomes (KEGG), the differentially expressed proteins with functions in several biologically important pathways would be identified in the response to red light. Of identified 4328 proteins totally, red light increased and decreased abundance of 742 and 847 proteins, respectively, compared to the treatments kept in the darkness. Most of these differentially regulated proteins are involved in metabolic process and cellular process. On the basis of Gene Ontology (GO) and Kyoto Encyclopedia of Genes and Genomes (KEGG) pathway enrichment analysis, we concluded that carbon metabolism and biosynthesis of amino acids were active for fruits in red light. Moreover, phenylalanine metabolism and flavonoid biosynthesis were inhibited in red light condition. Our results indicate that light quality during tomato development has significant effect on the metabolic process and also provides a comprehensive dataset on overall protein changes in red light-treated tomato fruit.

Keywords: tomato, proteome, iTRAQ, red light, metabolic process

## S16-P18

### STUDY ON OPTIMUM RELATIVE HUMIDITY FOR GRAFT HEALING OF TOMATO SEEDLINGS

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Humidity plays an important role in graft healing of seedling. This study focuses on the optimum relative humidity (RH) condition on scion and rootstock healing of grafted seedlings of tomato (*Lycopersicon esculentum* Mill.). Two tomato cultivars 'Super Sunload' and 'Super Dotaerang' grafted onto the 'B-Blocking' rootstock were subjected to one of the three RH regimes, 70-80, 80-90, or 90-100%. The results show that the scion of both cultivars showed apparent wilting phenomenon in the 70-80 and 80-90% RH treatments. On this basis, 95-96, 97-98, and 99-100% RH were subdivided. Among the subdivided RH treatments, fresh weights of the scion and rootstock were significantly increased by the treatments of 97-98 and 99-100% RH, and the graft union connection of both cultivars was also enhanced after two days of healing. Furthermore, lower levels of endogenous H<sub>2</sub>O<sub>2</sub> and less activities of antioxidant enzymes were found in both cultivars by the treatments of 95-96 or 97-98% RH, which indicated that less oxidative stress occurred. Overall, it is suggested that 97-98% is the optimal RH level for the graft healing of tomato seedlings.

Keywords: grafting, antioxidant enzymes, oxidative stress, reactive oxygen species, vascular connection

## S16-P19

### INTEGRATED PEST MANAGEMENT FOR *Bemisia tabaci* AND *Tuta absoluta* ON SOLANACEOUS VEGETABLES IN TANZANIA

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Vegetables are increasingly becoming important in urban and peri-urban areas of sub-Saharan Africa due to its nutritional and economic value. Common vegetables produced in Tanzania are solanaceous ones, particularly sweet pepper (*Capsicum annuum*) and tomato (*Solanum lycopersicum*) which enjoy high market demand.





However, cultivation of tomato and sweet pepper is constrained by pests and diseases. This study evaluated the efficacy of net houses and a biopesticide (*Metarhizium anisopliae*) against whitefly (*Bemisia tabaci*) and the tomato leafminer (*Tuta absoluta*) with small-scale farmers in Babati district, Tanzania. The study was conducted from February to June 2017. Results showed that *M. anisopliae* and net houses had a synergistic effect on control of *T. absoluta* on tomato leading to 98.8% and 63.7% marketable yield in nethouse and open field, respectively compared to 100.0% marketable yield in sweet pepper in both nethouse and open field. Integration of *M. anisopliae* and net houses against *B. tabaci* led to the marketable yield of 97.9% and 94.6% in tomato and pepper, respectively, compared to 70.6% (tomato) and 63.2% (pepper), in the open field. Generally, untreated tomato plants were more susceptible to *T. absoluta* damage while untreated pepper plants were prone to *B. tabaci* infestation. Integration of biocontrol and nethouse is therefore more effective for managing tomato leafminer than whitefly on tomato, and more effective in managing whitefly on pepper.

Keywords: *Tuta absoluta*, *Bemisia tabaci*, solanaceous, Tanzania

## S16-P20

### TISSUE SPECIFIC AND DEVELOPMENTAL REGULATION OF PHEROMONE BIOSYNTHESIS ACTIVATING NEUROPEPTIDE GENE(PBAN) AND ITS BINDING PROTEINS IN THE BEET WEBWORM, *Spoladea recurvalis* (LEPIDOPTERA: CRAMBIDAE)

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*Spoladea recurvalis* is one of the most destructive insect pests on leaf vegetables, especially amaranth in both Asia and Africa. In lepidopteran insects, the biosynthesis of sex pheromone is regulated by pheromone activating neuropeptide, which plays a significant role in insect physiology. We used Illumina sequencing library to obtain full-length cDNA for DH-PBAN of the *S. recurvalis*, which has been shown to encode a 197-amino acid protein that contains DH (diapause hormone), PBAN,  $\alpha$ -,  $\beta$ -,  $\gamma$ - neuropeptides, and shared a conserved C-terminal pentapeptide motif FXPR/KL (X=G, T or S). The genome sequence of *S. recurvalis* PBAN gene is 4,058bp in length and comprised of 6 exons interspersed by 5 introns. Full length amino acid sequence alignment and phylogenetic analysis of whole protein and each of the five neuropeptides showed high similarities to its homolog in Crambidae. To obtain full length cDNA of novel Pheromone Binding Protein (PBP) and Odorant Binding Proteins (OBPs), we employed Rapid Amplification 5'-3' end cDNA Ends (RACE-PCR) and studied the expression profiles at different developmental stages. The expression level of DH-PBAN were higher during later stage of larvae and adult stages, where it correlated with larval development and sex pheromone biosynthesis in females of *S. recurvalis*. Furthermore, differential expression profiles of PBP/OBPs were distinct, tissue and sex specific, implying that it has important function in pheromone reception and signaling. This is the first report on molecular analysis of PBAN gene and its binding proteins (PBP/OBPs) from *S. recurvalis*, which could facilitate the discovery of new functional targets for behavior, growth and development, as well as an effective target for controlling of *S. recurvalis* through novel IPM strategies.

Keywords: *Spoladea recurvalis*, insect neuropeptide, DH-PBAN, Phylogenetic tree, gene expression, integrated pest management

## S16-P21

### EVALUATION OF CUCURBIT ROOTSTOCKS AND SCREENING OF BITTER GOURD GENOTYPES FOR RESISTANCE TO *Fusarium oxysporum f.sp. momordicae*

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Fusarium wilt, caused by *Fusarium oxysporum f.sp. momordicae* (FOM), is a major constraint to bitter gourd (*Momordica charantia* L.) cultivation in Taiwan. Bitter gourd was commonly grafted to pumpkin or other cucurbit rootstocks to avoid the disease, but grafted plants are now observed wilting in the field and there is concern FOM has overcome the resistance in the rootstocks. Thus, the first objective of this study was to assess



the disease reaction of a Taiwan strain of FOM when inoculated to the bitter gourd and other cucurbit species commonly used for rootstock in Taiwan. The assessment was based on dipping the cut roots of 10-day-old seedlings in a suspension of 1X10<sup>6</sup> spores/mL. Inoculated plants were incubated for disease development in greenhouse, and then rated using a six-point disease severity scale (0-5) at 7, 13 and 20 days after inoculation. The virulent strain (FOM 6) killed almost all inoculated bitter gourd, caused some infection of bottle gourd (*Lagenaria siceraria*) and fig-leaf gourd (*Cucurbita ficifolia*), but only caused cotyledon yellowing on pumpkin (*C. moschata*). Through fungal isolation and pathogenicity tests, FOM colonization within plant stem tissue was detected, including in symptomless plants. This highlights the potential risk when inappropriate rootstocks are used for disease management. Subsequently, 90 bitter gourd genotypes, comprising 11 cultivars, 22 breeding lines, and 57 germplasm accessions, and one accession of *M. balsamina*, were screened to identify sources. Cultivar “Yueh-hua” and line “47R1S2” were included as susceptible and resistant checks respectively in each screening. Based on the area under the disease progress curve calculations, five of the 91 genotypes screened were identified as resistant, five as moderately susceptible, and the remaining as susceptible. No immune genotype was identified. However, selections from these resistance sources could be the basis for future breeding activities.

Keywords: momordica, germplasm, Cucurbita, cross-infectivity, root-dip inoculation

## S16-P22

### DETERMINATION OF RESISTANCE STATUS OF MELON LANDRACES AGAINST *Acidovorax citrulli* AND *Aphis gossypii* IN TURKEY

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Melon has an important role in agricultural production both in the world and Turkey. *Acidovorax citrulli* (Ac) and *Aphis gossypii* (Glover) are important factors that restrict protected cultivation and open field cultivation. In this study, 26 local melon genotypes were tested for *A. citrulli*. The pathogen *A. citrulli* (Ac) isolate, which was identified as 83% virulent, was used in the tests. Pathogen inoculation was performed by injecting when seedlings were 3-4 true leaves. After 15 days of inoculation, symptoms were scored according to 0-6 scale and evaluated (0: no symptoms, 1: 1-5% infected area, 2: 6-12% infected area, 3: 13-37% infected area, 4: 38-62% infected area, 5: 63-87% infected area, 6: 88-100% infected area). 11 melon genotypes, which belong to 2 scale (6-12% infected area) were found as tolerant. In the test against *A. gossypii*, 23 local melon genotypes were used. Plants were tested in the period of 7-8 leaves. Ten adults of *A. gossypii* were transferred to each test plant with a soft-tipped brush. Counts of individuals who survived for each plant were made at the end of 24 hours and 72 hours. At the end of 24 hours, 0-7 individuals per plant were considered as tolerant, and 8-10 individuals per plant as susceptible. At the end of 72 hours, 0-5 individuals per plant were evaluated as tolerant while those over 5 were as susceptible. As a result, after 72 hours; five genotypes were susceptible, two genotypes were medium tolerant and 16 genotypes were tolerant. Melon genotypes that are tolerant to both Ac and *A. gossypii* were included in the melon breeding program to develop new varieties.

Keywords: *Aphis gossypii*, *Acidovorax citrulli*, melon, resistance

## S16-P23

### BEE POLLINATION AND GRAFTING AS TOOLS TO IMPROVE PRODUCTIVE EFFICIENCY UNDER GREENHOUSE OF CUCUMBER

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Cucumber (*Cucumis sativus* L.) is an important cucurbitaceous vegetable grown extensively. However, high temperature and continuous cropping under greenhouse causing disorders and soil-borne diseases that leads low productive efficiency. Taking parthenocarpic cultivar ‘Kappa No. 11’ as experimental material for summer cultivation, the bee pollination can increase its yield and marketable fruit percentage for 1.4 and 1.5 times approximately. In addition, comparing with self-rooted treatment, grafting plants showed the resistance to



damping-off disease as well as Phytophthora rot which incidence rates were declined from 37.1% and 23.0 to 0% and 0.7%, respectively. It also performed the better plant height, shoot fresh weight, shoot dry weight, nutritional element included K, Ca, Mg, Cu, Zn, and F content. The grafted treatment also had 15.6% increasing in yield, meanwhile 25.7% increasing in marketable fruit percentage without significant difference in fruit traits. Furthermore, grafting did not enhance plant's photosynthetic efficiency but elevate transpiration rate and stomatal conductance that promoting water and nutritional uptake then improving the physiological wilting.

Keywords: *Cucumis sativus* L, pollination, grafting, yield, soil-borne disease

## S16-P24

### STUDY ON GREENHOUSE CULTIVATION STRATEGIES FOR FRUIT VEGETABLE PRODUCTION IN SUBTROPICAL AND TROPICAL REGION

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Taiwan located in subtropical and tropical region. Fruit vegetable production was limited by the high temperature in greenhouse. Considering construction cost, plastic house is the most popular greenhouse type for high quality cherry tomato and melon production in Taiwan. In order to extend the production season and increase the yield of greenhouse fruit vegetable, shading paint and ground cover were applied in greenhouse respectively. The result showed the inside temperature was lower than blank about 2°C under shading paint treatment during April to June, 2016. The heat tolerant melon variety 'Tainan No13' showed higher sugar content and yield with shading paint treatment but no effect on another variety 'Tainan No14'. The inside environment such as temperature and humidity did not affected by ground cover, however, the yield of cherry tomato was increased almost double with white ground cover during summer season in plastic house. In this study we also cooperated with Wageningen University, the Netherlands to establish an adaptive greenhouse for tomato production in Taiwan. Roof ventilation and fogging system were applied in tomato production greenhouse for cooling. The inside temperature was below our target inside temperature 35°C even almost equivalent to outside under the best climate control strategy. Compare to pad and fan greenhouse, fogging system with good ventilation would be better to remove the inside heat in Taiwan.

Keywords: shading paint, ground cover, fogging system, greenhouse

## S16-P25

### CHANGES OF FRESH SPROUT AND FRUIT CHARACTERISTICS BY SOWING TIMES ON CHAYOTE IN CENTRAL REGION OF KOREA

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Chayote (*Sechium edule* L.) is belonging to Cucurbitaceae vegetables, which originated in Central America and southern Mexico. It is one of the subtropical vegetables used as steamed, fried, soup and salad. Chayote is used for the cooking of fresh sprouts and fruits. Fresh sprouts was used as a seasoned vegetables by roasting or mixing with juicy spices. Fruits are used for salads, soups, stir-fries, pickles and are used similar to radish (*Raphanus sativus* L.), which is used as root vegetables in the Orient. In Indonesia, it is roasted with chili sauce and oil or boiled it. Fruits are rich in minerals such as folic acid, vitamin C, vitamin B6, copper (Cu), and magnesium (Mg), especially potassium (K). It is a perennial in the sub-tropical region, but it is treated as a annual plant in Korea. When sowing in spring, it blooms in autumn, and harvests fruit from late autumn to early winter. The purpose of this study is to develop a cultivation technique that can harvest fresh sprouts of chayote without reducing the yield of chayote fruit in the central region of Korea. It was sowed 6 times at intervals of 15 days from February 10, 2017 to April 24, 2017 at plant intervals (2×3m) and investigated germination ratio, plant height, leaf number, chlorophyll content, fruit yield, fruit sugar content and fresh sprouts yield. The first germination period in the fourth treatment (March 24) after sowing was 4.3 days and 9.9 days shorter than the first treatment (February 10). The whole germination period was 16.3 days in the fourth treatment (March 24), but whole germination period was 48.8 days in the first treatment (February 24). So, fourth treatment is 32.5 days earlier than first treatment. The fruit yield was 4,170 kg. 10a<sup>-1</sup> at the fourth sowing time, which was 8.7%



(332 kg.10a-1) higher than that of the first sowing time. But, yield of fresh sprouts were similar to that of treatments. Sugar content of fruit was similarly measured for first, third, fourth and sixth sowing time. Therefore, the optimal sowing time is considered to be most appropriate at the last of March (March 24th), considering the fruit yield, fresh sprouts and fruit sugar content.

Keywords: Chayote, subtropical vegetables, sowing time

## S16-P26

### IDENTIFICATION AND ALLELOPATHIC MECHANISM OF GREEN GARLIC VOLATILES ON CUCUMBER SEEDLINGS

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At present, the research on plant volatiles has been on the rise in the world. It has become a new trend to study the mutual response and its mechanism with neighboring plants, microorganisms and insects. Volatile route is an important way to release allelochemicals. The allelopathic effect of garlic has been widely used in the field of curtailment of crop continuous cropping obstacle. Scientists studied systematically the transformation of garlic allelopathy from bulb extract, garlic seedling volatiles, root exudates, straw extract and decomposed matter. Allelochemicals in different garlic parts were identified, but mostly extracted by solvent extraction method. The identification of natural volatile allelochemicals of green garlic has not been reported, and its allelopathic effects were relatively few. In this study, Green garlic (cv. Gailiang) volatiles was collected by headspace solid-phase microextraction method and analyzed by gas chromatography-mass spectrometry (GS/MS). The results show that diallyl disulfide (DADS) is the main compound of green garlic volatiles. Studied the allelopathic activity of green garlic volatiles and DADS on cucumber (cv. Changchunmici, CCMC) leaves. The results show that DADS is the main allelochemical of green garlic volatiles. On this basis, we further studied the allelopathic mechanism of green garlic volatiles and DADS on the growth and physiology of cucumber seedlings. Both them can promote the growth of cucumber seedlings and increase the antioxidant enzyme activities and the accumulation of active oxygen.

Keywords: allelopathy, green garlic volatiles, identification

## S16-P27

### GROWTH REGULATORS IN ESCABECHE PEPPER (*Capsicum baccatum* var. *pendulum*)

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Application of a growth regulator was evaluated in escabecche pepper (*Capsicum baccatum* var. *pendulum*) in the Cañete Valley, Perú. Treatments were 1, 2, 3, 4 and 5 applications of a growth regulator between 15 and 75 days after transplant. A completely randomized block design (DBCA) with four replications was used. Yield, number of fruits per plant and fruit set were not influenced by the application of the growth regulator. Five applications between 15 and 75 days after transplant showed fruits with the highest values in width and average weight, also had the fruits with the highest number of seeds per fruit, with statistical differences. With four applications between 15 and 60 days after transplant the longest fruit were obtained. Also this treatment showed the highest dry matter percentage in stems, with statistical differences.

Key words: sscabecche pepper, growth regulators, yield, quality

## S16-P28

### DEVELOPMENT OF PROTECTED CROPPING SYSTEMS FOR OUT-OF-SEASON VEGETABLE PRODUCTION IN THE PACIFIC ISLANDS

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At present, vegetable production in the Pacific Islands does not match local demand, with vegetable imports supplying high value hospitality and food service markets. If this demand was met by local producers, income from high value vegetable production would improve the livelihoods of producers and their communities. Protected cropping for small- and medium-scale farmers is a potentially transformational and enabling technology for vegetable production systems in the Pacific Islands that could fill this import gap. Low cost protected cropping systems have the potential to deliver year round vegetable production. Data collected from a range of simple low-cost protective structures has shown that structure height, roof venting, roof covering release systems and choice of side mesh materials are critical design features, with appropriate design delivering both suitable conditions for vegetable production and longevity in a tropical environment. Agronomic trials identified irrigation, pest management and plant manipulation strategies appropriate for protected cropping systems, and demonstrated significant crop yield increases over field production. In addition to the need for more knowledge of the production system, the research demonstrated that production capability does not ensure market access. To increase and consolidate the income-generating capacity of smallholder vegetable growers through technological innovation (especially the development of protected cropping systems), enterprise development in market oriented value chains is also required.

Keywords: greenhouse, tomato, capsicum, ventilation, irrigation, pest management

## **S16-P29**

### **PHENOLOGICAL RESPONSE TO THE CLIMATE CHANGE OF OIL-BEARING ROSE UNDER SUBTROPICAL CONDITIONS OF THE SOUTHERN COAST OF THE CRIMEA**

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Temperature is a critical cue for most rose species and some cultivars to bloom as they have an obligate vernalization requirement for flowering. Optimization of rose flower yield requires the ability to predict the response of plants to various environmental conditions, particularly air temperature. The aim of the present study was analyzed the quantitative response for the beginning of oil-bearing rose blossom to temperature. Three phenological models were examined with respect to their suitability to estimate possible shifts in the timing terms blossom of oil-bearing rose due to climate change. One of the approach was pure forcing model (F) and the remaining two models were combined parallel and sequential chilling-forcing (CF) models. The starting date of temperature accumulation, base temperature and the forcing requirements were optimized on the basis of observed data. The starting date of the models was set to 1 November (CF) and 1 January (F). Phenological observations and temperature data in the period 1968–2017 were used to fit these models. Root mean square errors (RMSE) between modelled and observed oil-bearing rose blossom data varied from 4.9 to 6.2 days. The percentages of variance explained by the flowering models were mean from 62 to 89%. The present study showed that the beginning of rose's blossom has moved forward since 1968 due to climate change slightly (average 2–3 day) however average air temperature during flowering since 2000 increased by 0.9 degrees. This study was funded by a research grant № 14-50-00079 of the Russian Science Foundation.

Keywords: oil-bearing rose, phenological modelling, climate change

## **S16-P30**

### **CLIMATIC CHANGE ADAPTATION STRATEGY UNDER URBAN AGRICULTURE RAINWATER CROPPING SYSTEMS: A CASE STUDY FROM WATERMELON (*Citrullus lanatus*) AS LIVE MULCH**

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According to UN projections, by the year 2050, at least one in four people will live in a country affected by chronic and recurring shortages of freshwater. This delicate situation will further be worsened in future rain-fed Urban Agriculture especially in the horticultural industries particularly Olericulture. Olericulture plays a key role in urban food and nutritional securities hidden hunger alleviation, especially in the off season. This investigative project therefore quantifies for policy issues strategy for easier adaptation of green technology under developing poor countries' climatic change scenarios. In-situ live mulch crops such as watermelon can improve soil moisture, reduce soil temperature, and provide additional income for income generation, poverty alleviation, nutritional/food security which hamper adoption of green technologies in sub Saharan Africa and other developing countries mixed cropping systems. The project elucidates the impact of in-situ watermelon live mulch green densities technology on yield potential, climatic change adaptation capability, income and employment generation, carbon sequestration and food/nutritional security strategies in the development of future urban greening crop productivity systems for policy makers. Imposed were 3 densities of watermelon: 1.5 x 0.45m; 1.5 x 0.90m; 1.5 x 1.50m. Grain amaranth was transplanted at 0.75 x 0.75m spacing in an RCB design. Averaged over 2 consecutive cropping's, amaranth grain and watermelon yields were significantly ( $P = 0.05$ ) highest at 1.5 x 0.90m watermelon cropping density that was optimum for yield potential, climate change adaptation, income/employment generation and food/nutritional security resilient strategy. This corresponded to the reduction cooling in maximum soil temperature of 20C by amaranth, 3.50C by watermelon, compared to the control without mulching. Soil moisture content was significantly ( $P = 0.05$ ) conserved in the live mulch treatments 18.2% compared to the bare not mulched soil control of 14%. Our findings demonstrate as well that additional income from sale of watermelon increased 300% compared to sole cropping of amaranth for income and employment generation. This research demonstrates that live mulch is useful in green urban agriculture adaptation strategy, carbon sequestration rainwater conservation agriculture and climatic change adaptation-mitigation reduced temperature; and we believe offers opportunities for urban food/nutritional security, landscape green tech restoration and carbon sequestration under rain-fed agriculture climate change scenarios for future urban organic horticultural productivity systems development.

Keywords: green-urban, rain-fed, live mulch, adaptation, employment, watermelon

## S16-P31

### FOLIAR APPLICATION OF SALICYLIC ACID INDUCES SALINITY TOLERANCE IN POTATO

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Soil salinization affects potato crop growth and yield especially under arid and semiarid climatic conditions. Salicylic acid (SA) modulates plant responses to salinity stress in a dose dependent manner. A pot experiment was conducted to optimize salicylic acid dose under salt stress (50 mM) on two potato cultivars namely N-Y LARA (tolerant) and 720-110 NARC (sensitive). Foliar spray of different SA concentrations (Control, 0.25, 0.5, 0.75, 1.0 and 1.25 mM) was done after 7 days of salinity stress. The application of 0.5 and 0.75 mM SA were found most effective doses for ameliorating salinity stress in both the potato cultivars. Higher concentration however showed negative effects when applied under salinity stress. Low SA level induced salt tolerance by enhancing antioxidant (superoxide dismutase, catalase, peroxidases) activities, improving osmoregulation (phenolic contents, proline contents), rehabilitating gaseous exchange and water relations parameters. Moreover, the K<sup>+</sup> contents in potato plants were enhanced while Na<sup>+</sup> contents were reduced in response to SA application. Tuber yield exhibited positive correlation with morphological, gaseous exchange, K<sup>+</sup>: Na<sup>+</sup>, Chl., proline, SOD, total phenolics and turgor potential attributes while negative correlation with water and osmotic potential and MDA contents. Thus, foliar spray of low SA (0.5-0.75 mM) may be employed as an environment friendly and economical alternative in inducing salinity tolerance under moderate stress, thereby sustaining potato crop productivity.

Keywords: climate change, tubers, saline agriculture, morpho-ionic attributes, plant growth



## S16-P32

### SALINITY TOLERANCE POTENTIAL IN POTATO IS ASSOCIATED WITH K<sup>+</sup> INTAKE AND RESISTANCE TO Na<sup>+</sup> ION

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Abrupt climate changes (e.g. temperature, precipitation etc.) are causing several challenges for agriculture sector like escalating salinity stress due to accumulation of soluble salts in rhizosphere. Potato crop, a part of daily diet and staple food in several countries, is particularly affected by salinity due to herbaceous nature especially in arid and semi-arid regions of the globe. Hence, salt tolerant germplasm has to be identified for sustainability of potato industry. A dedicated screening study was conducted therefore, to evaluate salinity tolerance of thirteen potato cultivars on the basis of morphological and ionic attributes in shoots and roots. Potato tubers were planted in plastic pots (9.0 L) containing fine sand with various salinity levels (0, 25, 50, 75, 100 and 125 mM). Cultivars were categorized into tolerant and sensitive ones as per their performance against various salinity levels on the basis of credit numbers given to each parameter. Resultantly, significant differences in plant emergence and growth was observed among studied cultivars under similar salinity levels. N-Y Lara was found to be the most tolerant cultivar with maximum aggregated credit numbers (109) and K<sup>+</sup> intake along-with minimum Na<sup>+</sup> intake while reciprocal results were exhibited by 720-110 NARC (30). Na<sup>+</sup> exhibited significant antagonistic correlation with potassium and studied morphological parameters i.e., mean emergence time, shoot and root lengths, shoot fresh and dry weights and root fresh and dry weights. This manuscript provides detailed account of the salinity stress investigation in potato. Conclusively, this study would help investigate physiological, biochemical, ionic and molecular mechanisms in tolerant and sensitive cultivars.

Keywords: Climate change, abiotic stress, vegetable, ionic uptake, germplasm, screening

## S16-P33

### HERITABILITY AND VARIATION OF SOME SALINITY STRESS CRITERIA IN MELON CULTIVARS

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Melon (*Cucumis melo* L.) is a versatile horticultural crop widely cultivated in arid and semi-arid regions. Understanding the effects of salinity stress on physiological aspects of plants growth and their genetic information is useful for both improving field management practices and enhancing our knowledge of salinity tolerance mechanisms in melon. Therefore, this experiment was conducted to evaluate the effects of field salinity stress on 17 melon cultivars including 16 native and one exotic 'Galia' in terms of physiological characters during two growing seasons 2014 and 2015. Leaf relative water content (RWC), membrane stability index (MSI), proline content (Pro), total soluble sugars content (TSC), malondialdehyde content (MDA) and hydrogen peroxide content (H<sub>2</sub>O<sub>2</sub>) were measured. Field salinity stress affected all the traits studied. The results showed that heritability estimates and phenotypic and genotypic coefficients of variation were reduced by field salinity stress. Leaf MDA had the highest phenotypic and genotypic coefficients of variation in both normal and saline conditions. Under normal condition, Pro and H<sub>2</sub>O<sub>2</sub> contents had the highest and the lowest heritability estimates while, TSC and RWC showed the highest and the lowest broad-sense heritability estimates in saline condition, respectively. In addition, because of slight differences between phenotypic and genotypic coefficients of variation, the environmental effects were low on the studied traits. These results eventually suggest that selection based on these salinity related physiological traits will result in high gain and would be effectual in melon improvement programs to confront the salinity stress.

Keywords: broad-sense heritability, *Cucumis melo* L., physiological traits, salt, sodium



## S16-P34

### EFFECT OF SALICYLIC ACID AND HUMIC ACID ON QUALITATIVE, QUANTITATIVE AND CONTENT OF MINERALS NUTRIENT IN PEPPER (*Capsicum annum*) UNDER SALT CONDITIONS

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In order to investigation the effect of salysilic acid (SA) and humic acid (HA) on qualitative and quantitative properties and absorption of mineral elements under salinity stress in greenhouse culture, a factorial experiment based on Randomize Block design was conducted in Yasooj. First factor including SA in 2 levels (1 and 2 mM), second factors HA in 2 levels (0 and 5 g/l) and third factors salinity in 3 levels (0, 50 and 100 mM). Traits such as plant height, number of leaf, number of flower, number of fruit, fruit weight, yield, fresh and dry weight of leaf and root and absorption of N, P, K, Ca, Fe and Na in leaf and root were measured. Results showed that salinity has negative effects on growth factors. Application of HA and SA reduced the negative effects of salinity stress and increased the growth parameters. So use of SA and HA is useful for improvement of qualitative and quantitative characteristics of pepper in saline condition.

Keywords: pepper, salinity, humic acid, yield

## S16-P35

### *Ziziphus jujube* Mill. AND *Feijoa sellowiana* Berg DRAUGHT RESISTANCE ASSESSMENT OF THEIR CULTIVARS AND FORMS ACCORDING TO DEGREE OF LEAVES DEHYDRATION

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Investigation of fruit-bearing crops efficiency proves that yield quantity and quality directly depend upon plants state and susceptibility to environmental factors. Lately in many regions, including the Crimea, specialists fix changes of temperature regimes. A number of extremely hot days (over 31°C) considerably has grown. In case of high temperature and moisten deficit, leaves of feijoa and jujube started wilting earlier than ever, lost turgor, slowed down growth and decreased fruiting. At the same time moisten deficit in organs and tissue causes crop capacity reduction and aggravation of fruit quality. Fruits don't gain size and taste parameters typical for a certain cultivar. Purpose of this work is to study characteristics of moisten regime and potential draught-resistance of different cultivars and forms of *Ziziphus jujube* Mill. and *Fejoa sellowiana* Berg under conditions of South Coast of the Crimea. The researches were being carried out during 2015-2017 based on collection plantations of Nikita botanical gardens - National scientific centre (NBG-NSC). Samples of domestic and foreign breeding were taken as study objects. While rating draught-resistance, capacity of water-retaining and turgor regenerating in leaf tissue were determined after wilting process during maximum high air temperature and aridity. There is a direct dependence between leaf capacity to retain moisten and degree of turgor regenerating, what makes possible to evaluate plant potential in resistance to dehydrating factors. If long-term dehydrating (30 hours), the most of jujube cultivars and forms from NBG breeding presented a high reparation capacity - from 70 to 90%. The following jujube cultivars and forms were distinguished with a high draught-resistance: Tsukerkovy, Koktebel, Pl. 5-27. Different-aged leaves of evergreen crop feijoa were investigated in this research. Close relation between water-retaining capacity and leaf adoptability to stand the dehydration was determined as a result. Wilting (48 hours) old-aged leaves output moisten slowly as possess resistance to dehydration. Cultivar Aromatnaya Fantasia and form 3/1 were distinguished according to this parameter. Turgor retaining in leaves tissues ranged from 70 to 100%. Cultivars and forms with a high water-retaining capacity during critical points of vegetation can be recommended for breeding work and founding new plantation in extra arid regions.

Keywords: jujube, feijoa, cultivar, leaves, dehydration, wilting, turgor





## S16-P36

### EFFECT OF SUPPLEMENTAL LIGHTING DURATION ON GROWTH AND DEVELOPMENT OF GRAFTED WATERMELON PLUG SEEDLINGS

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Watermelon (*Citrullus vulgaris*) is an important cucurbitaceous vegetable. It is grown worldwide and ranked sixth in world production of fruit crops. In 2011, watermelon ranked sixth highest in seed sales among vegetable crops in South Korea. One of the problems faced by the growers is the insufficient light that may result in reduced quality and longer production periods of plug seedlings in the greenhouses. One solution to this problem is supplementing artificial light to the plug seedlings. The objective of this study was to assess the effect of the duration of the supplemental lighting (DSL) on growth and development of two watermelon cultivars 'Speed' and 'Sambok Honey' grafted onto the 'RS-Dongjanggun' bottle gourd rootstock (*Lagenaria siceraria* Stanld.). Seedlings were grown for 10 days in a glasshouse with an average daily maximum light intensity of 490  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  photosynthetic photon flux density (PPFD) from 16 h per day coming from the sun with either 8, 12, or 16h per day of light supplementation with mixed LEDs (white: red: blue =1: 2: 1) at 100  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  PPFD. The culture environment had 32°C/25°C day/night temperatures, 85% relative humidity, and a natural photoperiod of 14 h. The results showed that shoot length of 'Speed' and 'Sambok Honey' showed the best results for the 12h DSL and moderate results for the 16h and 8h DSL, respectively. The best shoot fresh weight was observed in the 12h and 16h DSL for both the cultivars. The shoot dry weight in 'Speed' and 'Sambok Honey' showed best results in the 12h and 16h DSL, respectively. The shoot diameter was observed to have the best result in the 16h DSL for both cultivars. Overall, the results suggested that the 12h DSL provided the best result.

Keywords: grafted seedling, supplemental lighting, lighting duration, seedling morphology

## S16-P37

### MINING MORINGA LEAF TRANSCRIPTOMICS DATA FOR CATALOGING ABIOTIC STRESS TOLERANT GENES

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Cultivation of crop plants experiences a wide array of environmental stimuli and they cause serious damages to crop productivity. Therefore modern crop cultivar requires a set of mechanism(s) with which it recognizes and responds to abiotic stresses of many different types. Plants responses are oriented to avoid or tolerate the adverse environmental condition. The main metabolic responses of plants to abiotic stress are to cope with water loss (inducing compatible osmolyte biosynthesis) and oxidative stress (inducing biosynthesis of antioxidant compounds). Integration of environmental stimuli and adequate modulation of the physiological response is achieved by synthesizing plant hormones (such as ABA) and metabolites that act as endogenous regulators of different plant processes. Fundamental physiological and molecular information is essential to build up models and design strategies to improve or confer abiotic stress tolerance to elite crops. Moringa (*Moringa oleifera* Lam.) is a hardy crop which can thrive well even under very severe abiotic stress conditions such as drought and high temperature. Cataloging the genes that are providing tolerance to abiotic stresses will enhance the breeding efficiency of Moringa and other major crops using different strategies (induction of polyploidy and mutagenesis followed by variant selection or marker-assisted selection of genotypes using MABC, MARS or GWAS) that are used to introgress these tolerance traits into cultivated species. Therefore, whole genome transcriptomics of Moringa leaf tissue was done in this study and de novo assembly of this study has identified 25,374 validated unigenes. This data set was further used to predict 14,827 open reading frames and 14,397 of them were functionally annotated using BlatX analysis. Further, bioinformatics analysis leads to recognition of large array of abiotic stress tolerance related genes involved in synthesis of antioxidants and stress hormones. Implications of these genes in molecular breeding will be discussed during the presentation.



Keywords: moringa, abiotic stress, transcriptomics, antioxidants, stress hormones

## S16-P38

### EFFECTS OF SPECIES AND VARIETIES OF ROOTSTOCK ON THE FLOWERING OF THE GRAFTED CABBAGE

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In tropical and subtropical area, the temperature is often not low enough for the flowering of cabbage (*Brassica oleracea* L. var. capitata), which is a plant-vernalization-responsive type plant. Nowadays, grafting culture is commonly applied to vegetable for improving tolerance to biotic and abiotic stresses, increasing water and nutrient uptake, promoting plant vigor, increasing yield, and inducing or promoting flowering. Therefore, the aim of this study is to assess the effects of species and varieties of rootstock on the flowering of the grafted cabbage. 'K-Y cross' cabbage was used as scion for the grafted cabbage, while the rootstock was selected from Chinese kale, rape, leaf mustard, Chinese cabbage, broccoli, cauliflower and cabbage. The un-grafted 'K-Y cross' cabbage plant and self-grafted 'K-Y cross'/'K-Y cross' plant were used as the control. All plants were grown in greenhouse in Experimental Farm, College of Bioresources and Agriculture, National Taiwan University (Highland, 2,100 m above sea level). The results showed that the highest flowering rate of grafting combinations was found when 'Ming Hua Liu Hua Ye Suen' broccoli was used as rootstock (57.14%). Even though it was only slightly higher than the un-grafted control (50.00%), it was much higher than the self-grafted control (30.00%). However, no significant difference in days to flowering was found among different grafting combinations and the control. Despite the results indicated that the range of the promotion of 'K-Y cross' cabbage flowering by grafting was limited, this research had developed a grafting method for cabbage which is applicable to other diverse purposes in the future.

Keywords: cabbage, grafting, flowering, vernalization

## S16-P39

### PERFORMANCE OF SELECTED BITTER GOURD ACCESSIONS FOR YIELD AND RELATED TRAITS IN MALAYSIA

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Twelve bitter gourd (*Momordica charantia* L.) accessions from MARDI's collection were evaluated: Local collections (P10, P11, P13, P92, P93, P94, and PK12), Indian collections (P96, P97, P98 and P101) together with local check accession; Peria Katak (PK) were also included for comparison. The trials were carried out at Vegetable Research Plot at the Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Malaysia. The study revealed that there are significant variations among accessions in respect to yield and related traits such as a fruit weight (g), fruit length (mm), fruit circumference (mm), Fruit flesh thickness, Fruit number/plant and yield/plant. The accessions showed not much different from one and another for flowering and fruiting time. Accession P11 produced the biggest fruit with 838.60 g fruit weight, 347.20 mm fruit length, 291.20 mm fruit circumference and 16.20 mm fruit flesh thickness whereas accession P101 produced highest number of fruit (25.60). With yield of 1830.00 g per plant, P92 showed better yield performance, superseding other accessions. it is considered suitable for commercial planting and can be used as a parent for breeding purposes or directly selected as introduced variety.

Keywords: bitter gourd, *Momordica charantia* L., yield and related traits

## S16-P40

### PERFORMANCE OF NSUKKA YELLOW PEPPER IN MAIZE/MELON BASED INTERCROP UNDER MINIMUM-TILLAGE SYSTEM



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Intercropping has been reported to give higher and more stable yield as opposed to sole cropping owing to above ground and below ground potential complementarities of component plants in time and space dimensions. Crop yield in crop mixture involves the conversion of natural resources such as light, water and soil nutrients into useable products. Earlier assessment of intercropping systems have been based mainly on biological yield advantages which have been found to be more often than not misleading, particularly where monetary gain is the primary objective of the farmer. This study was therefore designed to examine the effect of intercropping on pepper yield in maize / melon based intercropping system. To assess the feasibility of raising intercrops with Nsukka yellow pepper (*Capsicum annum*) to maximize productivity and returns per unit area. Pepper was intercropped with maize and melon. The experiment has seven treatments (sole pepper, sole maize, sole melon, pepper + maize, pepper + melon, maize + melon, pepper + maize + melon) which were replicated three times. Growth and yield parameters were recorded. Intercropping advantages were estimated using Land Equivalent Ratio (LER). The yield of sole crops was higher than crop in intercrop. Intercropping pepper with maize and melon recorded the highest LER (1.39). Based on the result of this study, it is therefore recommended that crop should be planted solely for high yield. LER should be use as tools to measure profitability in intercropping system.

Keywords: growth, intercropping, Nsukka yellow pepper, tillage system, yield

## **S16-P41**

### **MANAGING NEMATODE POPULATION DENSITIES USING FERMENTED CRUDE EXTRACTS FROM POST-HARVEST LEFT-OVER TOMATO FRUITS: AN ALTERNATIVE TO SYNTHETIC NEMATOCIDES**

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Following the international withdrawal of effective fumigants and some systemic nematicides due to their environment-unfriendliness, focus on alternative management strategies for the notorious root-knot (Meloidogyne species) nematodes shifted towards the possible use of phytonematicides. Phytonematicides use allelochemicals as active ingredients, which are well-established products of secondary metabolism. Large quantities of fruits from commercially preferred indeterminate tomato cultivars are left to rot in the fields after harvest. Tomato fruits contain a wide range of secondary metabolites: lycopene,  $\beta$ -carotene, lutein, flavonoids and polyphenols. Some of these metabolites have nematocidal activities. The effects of fermented crude extracts (FCEs) from tomato fruits on nematode population densities are not documented. The objective of this study, therefore, was to determine whether FCEs from tomato fruits could suppress nematode population densities and improve growth of tomato plants under field conditions. Uniform 4-weeks-old tomato cv. 'Floradade' seedlings were transplanted to an open-field with high population densities of Meloidogyne species. Treatments, viz., 0, 50 and 100% FCEs with Nemarioc-AL 3% phytonematicide and Nematicur as positive controls, were arranged in a randomised complete block design, with eight replications. Relative to the untreated control, 50 and 100% FCEs significantly ( $P \leq 0.05$ ) reduced total nematode population densities, with 83 and 125%, respectively, and reproductive potential (juveniles + eggs/g root mass) by 136 and 89%, respectively. Although the impact of the FCEs was significantly less than those of Nematicur and Nemarioc-AL 3% phytonematicide, the FCEs from tomato left-overs after final harvest demonstrated strong nematocidal activities. All treatments had no effect on plant growth variables and on certain nutrient elements but P and S were significantly ( $P \leq 0.05$ ) higher in plants treated with Nematicur. In conclusion, FCEs from tomato fruits have the potential of serving as an alternative phytonematicide in managing root-knot nematode population densities.

Keywords: Allelopathy, botanicals, future crops, fertiliser effect, inhibition

