

## Symposium 23 (S23): Issues and Advances in Seed, Transplant Production, and Stand Establishment Research

Monday · August 12

Location: Metro Toronto Convention Centre, Room 201AB

1100-1140

S23-0-1

### APPLICATIONS OF COMPUTERS IN SEED TECHNOLOGY

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Seed quality assessment has been accomplished by human interpretations of normal/abnormal seedlings in a germination test and speed and uniformity of seedling growth in a vigor test. Advances in computer technology allow rapid image capture and objective interpretations of seed and seedling growth employing appropriate software. Examples will be provided of hardware/software development for germination and vigor testing for lettuce and soybean crops.

1140-1200

S23-0-2

### NEW SUPPORT FOR THE INVOLVEMENT OF ETHYLENE IN LETTUCE GERMINATION AT SUPRAOPTIMAL TEMPERATURE

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Silver Thiosulfate (STS), an ethylene inhibitor, was reported to reduce germination of seeds of the thermotolerant genotype 'Everglades™' from 100% to 49% at 35 °C (Nascimento, 1998). It was suggested that ethylene was necessary for lettuce germination at supraoptimal temperature and that the effect of STS was due to its inhibition of ethylene action. The STS-induced reduction in germination was found to be both temperature and concentration dependent. With the increase in temperature at imbibition from 20 °C to 24 °C, 28 °C, 32 °C and 36 °C, the percentage of germinated seeds remained almost constant in water (100% at 20 °C compared to 92% at 36 °C). In STS, germination decreased from 100% at 20 °C to 99%, 79%, 39% and 22% at the respective higher temperatures. With increasing molarity of the STS solution from 1 to 5, 20 and 50 mM the percentage of germinated seeds at 35 °C was reduced from 97% to 91%, 46% and 0%. This decrease was not observed at 20 °C, except at the highest molarity at which germination was 67%. The effect of STS can be negated by simultaneous application of 1-aminocyclopropane-1-carboxylic acid (ACC). After transfer from STS to water the seeds germinated 100%. Seedlings which developed from seeds transfer from STS to water had a phenotype typical for plants treated with an ethylene inhibitor- long radicles, no root hair, and altered gravitropic response. Sensitivity of 'Everglades™' seeds to ethylene and STS was examined using a triple response assay. With the increase in ACC from 0 to 3 μM, the length of seedlings exposed only to ACC decreased from 8.7 cm to 4 cm compared to a decrease in ACC and STS exposed seedlings from 8.8 to 6.7. This study provided evidence for ethylene involvement in lettuce germination at supraoptimal temperature.

1200-1220

S23-0-3

### TRACE GAS ANALYSIS FOR RAPID NON-DESTRUCTIVE DETERMINATION OF SEED VIABILITY

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Seed viability, the most important factor in determining seed quality, is tested by destructive means that can take anywhere from 24 hours for assays for enzyme activity in the embryo to as many days as it takes for the seed to actually germinate. We used onion seeds as a model system for determining viability based on comparisons of gaseous emissions by intact control, natu-

rally- and artificially-aged seeds, both with and without imbibition. It is generally considered that seeds that have been imbibed for less than six hours can be dried and re-stored without incurring damage. Volatiles from imbibing seeds were monitored continuously or after 1 to 3 hours of accumulation. Dry seeds were sealed in vials for 10-18 hours before measurement of accumulated gases. Ethane, acetaldehyde, and ethanol were measured in pl/g by laser-based photoacoustic spectrometry, while CO<sub>2</sub> was measured in nl/g by infra-red absorption. Ethane production, a marker for lipid peroxidation of membranes, decreased in proportion to seed age and germinability, and also decreased during the first 5 hours of seed imbibition. CO<sub>2</sub> production was enhanced in aged seeds compared to non-aged controls, in both dry and imbibed seeds. Acetaldehyde production increased sharply, compared to ethanol, during initial imbibition of aged seeds, although ethanol production increased strongly after 2-3 hours of imbibition. Similar results were obtained in wheat, tomato, and chickpea seeds. Monitoring of trace gases from intact seeds appears to be a rapid and non-destructive means of determining seed viability. This work was supported by the European Community-Access to Research Infrastructures action of the Improving Human Potential Programme.

1220-1240

S23-0-4

### ELEVATED LEVELS OF ETHYLENE DURING GERMINATION REDUCES THE TIME TO RADICLE EMERGENCE IN IMPATIENS

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Hypocotyl and radicle growth rate following germination was biphasic in impatiens. There was an initial slow growth rate associated with hypocotyl emergence from the testa followed by a more rapid rate of hypocotyl and radicle elongation. The time required to initiate germination was not correlated with subsequent hypocotyl and radicle growth rates. The ethylene biosynthetic precursor 1-aminocyclopropane-1-carboxylic acid (ACC) was effectively "loaded" into impatiens seeds using an aqueous soak prior to being dried back to their original fresh weight. ACC-treated seeds showed a 10-fold increase in ethylene production following imbibition as well as reduced time for initiation of germination. We have demonstrated this phenomenon in tomato, sweet corn, tobacco, arabidopsis and impatiens. For impatiens, the time to reach 50% radicle emergence was reduced 10 hours by treating seeds with ACC. Primed seeds produced ethylene sooner and at greater levels than untreated seeds. In addition, ACC accumulated during osmotic seed priming, which may account for the increased ethylene production. The impact of treating impatiens seeds with ACC prior to sowing on seedling emergence will also be presented.

1340-1440

S23-P-5

### THERMOPERIOD AFFECTS SEED GERMINATION OF *SOLANUM TORVUM*

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Seed germination is one of the responses that has been intensively studied in thermoperiodism in plants. Alternating temperature enhances the seed germination of *Solanum* plants and is practically used to improve percent germination. Most of studies previously done have focused on temperature differences with a thermoperiod (i.e., the period of one cycle of temperature alternation) of 24 h, while few have reported the effects of thermoperiod or patterns of temperature alternation, probably because the thermoperiod of natural alternation of temperature is nearly 24 h and its pattern is analogous to a sine curve. In the present study, alternating temperature in step-wise curves with two temperatures (20.0 and 30.0 °C) was applied to clarify the effects of thermoperiod on seed germination of *Solanum torvum*. Three seeds were sown on agar media in 0.5-mL tubes and placed in Peltier thermal cyclers (PCR) (PTC-220DYAD, MJ research, Waltham, MA) for 12 days. Ten treatments of alternating temperature (AT) that had the same ratio (1:2) of periods of 20.0 and 30.0 °C but different thermoperiods ranging from 11 to 5760 min were applied. Non-alternating (i.e., constant) temperatures (NA) (20.0, 25.0, 27.7 and 30.0 °C) were also applied as control treatments. The percent germination in four NA treatments was 0%, 12 days after sowing. The percent germination was also 0% in

AT treatments of thermoperiods shorter than 22 min and longer than 5760 min (i.e., 4 days). The maximum percent germination was 97% in AT treatment of 45 min thermoperiod. Percent germination was greater in treatments of thermoperiods from 45 to 720 min than in treatment of thermoperiod of 1440 min (i.e., 1 day). Results clarified that thermoperiod affects the seed germination of *Solanum torvum*.

**1340-1440**

**S23-P-6**

**EFFECT OF LOW-LEVEL GAMMA RADIATION ON GERMINATION OF SEVERAL VEGETABLES**

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To strengthen germination performance of seeds with certain treatments is very important for successful raising of young seedlings because some species show low germination percentage of seeds by nature and the optimum condition for germination is not always maintained. It was reported that gamma radiation usually retarded seed germination, but at levels that did not cause injury, germination was stimulated. But further and detailed studies about the stimulation have not been carried out. Seeds irradiated with gamma rays to strengthen their potential might be distributed commercially. Seeds of six vegetables were exposed to 30 Gy of gamma ray (duration?) and placed in petri dishes (immediately or after some storage time?) to measure their percentage of germination at standard temperatures. The germinations of garland chrysanthemum and asparagus seeds were retarded, but those of lettuce and broccoli seeds were accelerated. The radiation did not have great influence on the germination of spinach and onion seeds. The effect of radiation on germination of lettuce seeds was more pronounced at high (30 °C) temperature than at optimum (20 °C) temperature, and was also found after three months storage. Moreover, the emergence of those seeds after sowing in pots was also stimulated and the seedlings did not show any abnormal appearance. In conclusion, effect of gamma radiation at 30 Gy on germination of seeds varied with vegetable species. The radiation of lettuce seeds was very effective to stimulate germination even under unfavorable conditions.

**1340-1440**

**S23-P-7**

**ENDOSPERM UTILIZATION EFFICIENCY—AN AID IN HEAT TOLERANCE STUDIES IN TOMATO**

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The prevalence of high day/night temperature during the late summer (i.e., mid-June onwards) in the plains of north India, particularly in Punjab, is one of the major limiting factors in the cultivation of tomato. Studies were conducted for the evaluation of thirty six F1 hybrids obtained from a diallel cross of heat tolerant lines along with parents and a check hybrid (TH-2312) during April to July 1999. The seedlings were raised at 30 plus/minus 1 degree centigrade and were tested for dry weight determination after ten days of germination. Endosperm utilization efficiency (EUE) was calculated as (Blum and Sinmena, 1994) by the ratio of seedling dry mass gain to seed dry mass loss after ten days of germination. The genotypes having high EUE at high temperature will be vigorous and heat tolerant thus facilitating their identification at an early stage. The genotypes P2-6-1-1, 246-1-5, P3-1-7-1, UC82B, EC 50534-1-2-1 and 1-7-1-1 were found to be good general combiners due to highly significant and positive effects and therefore considered heat tolerant. In twelve out of thirty six crosses the SCA effects were significant and positive ranging from 4.48(1-7-1-1xP3-3-4-5-1) to 18.51(P3-3-4-1xP3-1-7-1). Among the twelve crosses, five crosses involved both the parents with significant GCA effects. The cross 1-7-1-1xP3-3-4-5-1 was good specific combiner for EUE. Three hybrids showed positive heterosis over better parent and four over the check(TH-2312). The most heterotic hybrid (P3-3-4-1xP3-1-7-1) had 93.61 percent EUE and it showed 13.78 percent increase over the check hybrid TH-2312. There are possibilities for developing true breeding lines for higher EUE under high temperature conditions from the segregating population derived from the cross P2-6-1-1xP3-1-7-1 involving both the parents with significant positive GCA effects

**1340-1440**

**S23-P-8**

**MATERNAL CONTROL OF SEED DORMANCY BY TRANSCRIPTION FACTOR IN LETTUCE**

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The DAG1 gene of *Arabidopsis* encodes a zinc finger transcription factor of the Dof family that is shown to control seed dormancy in *Arabidopsis*. DAG1 cDNA knockout mutant, dag1-1, produces seeds that are morphologically normal, non-dormant, lack WT light requirement for germination, and maintain ABA sensitivity and GA requirement for germination. While dag1-1 mutant seeds germinate in the absence of light, exposure of the mutant to far red light inhibits germination indicating dag1-1 mutant seeds are still controlled by phytochrome-mediated pathway for germination. The expression of DAG1 is limited to the vascular tissue of the mother plant and segregation analysis results indicate that the mutant phenotype of the progeny is determined by mother plant genotype (Papi et al 2000. Genes Dev. 14:28-33). Light dormancy of lettuce is a common problem of producers that is usually alleviated by seed priming techniques. However, application of information gained in *Arabidopsis* research to lettuce may eliminate priming needs and provide useful insight to discerning the molecular mechanisms controlling seed dormancy. Because of its characterized photodormancy and economical importance as a crop, lettuce has been selected as the model system to explore the role of DAG1 regulatory mechanism in seed germination. The study uses a combination of genomic, genetic, and molecular biological approaches to identify DAG1 homologue in lettuce. Database analysis and cDNA library screen or PCR will be used to detect the homologue followed by the characterization of temporal and spatial expression patterns. The long-term goal is to use genetic manipulation to alter the level of DAG1 homologue in lettuce to determine their effect on lettuce seed germination. Results of genomic analysis will be presented.

**1340-1440**

**S23-P-9**

**AN ULTRASTRUCTURAL STUDY OF SEED RESERVES IN TRIPLOID WATERMELON COTYLEDONS**

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Poor germination, inconsistent emergence and relatively high seed costs limit the interest of potential growers and market prominence of triploid watermelons. The major problems in triploid watermelon production are considered morphological, physiological and environmental, such as hard thick seed coats, small and weak embryos, dense endotesta layers, large seed cavities, moisture control, planting depth, and temperature control. The focus of our studies has been to understand the major structural and physiological events associated with lipid and starch breakdown in diploid and triploid watermelon seeds. Previously, we found that the starch content (diploids vs. triploids = 42.2% and 11.6-27.3%) was lower in triploids. Linoleic acids (C18:2) dramatically increased in triploids (diploids vs. triploids = 35.1% and 54.0-87.2%) whereas other fatty acids were lower in comparison to the fatty acid composition of diploids. Also, higher fatty acid content (high-germination lots vs. low-germination lots = 72-128 mg/g and 157-320 mg/g dry seed weight) was detected in low-germination lots of triploids. At the light microscope level, cotyledon cells were characterized by abundant protein bodies that were the most discernible organelle. At the electron microscope level, differences were found between diploids and triploids. Starch granules in triploids were smaller in diameter (0.8-1.4 µm) when compared to diploids (about 1.8 µm). The size of lipid bodies was substantially similar between diploids (about 1.7 µm) and triploids (0.7-2.0 µm). The occurrence of irregularly shaped lipid bodies was found, regardless of ploidy. In conclusion, better germination and vigor of watermelon seeds would be expected from cotyledons that have higher reserves. The differences found in cotyledon cells may indicate less availability of starch reserves in triploid watermelon seeds.

**1340-1440**

**S23-P-10**

**ONION SEED CROP POLLINATION: A MISSING DIMENSION IN MOUNTAIN HORTICULTURE**

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Onion is one of the leading exportable vegetable crops of India. It does not produce quality seed if the insects are not allowed to visit on the flowers. Insufficient availability of seed has been one of the major handicaps in increasing its productivity in the sub-temperate mountainous region of the country. Studies were conducted on an abundance of different pollinators and the effect of bee pollination on quality and quantity of the onion seed crop. *Apis dorsata* proved to be a dominant flower visitor (7.4 bees/square meter/2 min.) and efficient pollinator covering on an average 7.5 flowers per umbel during a single visit followed by *A. cerana indica*. *Apis mellifera* and *A. florea* were the least visiting (1.4 bees/square meter/2 min.) bees on the crop. Though, syrphids covered a minimum 1.6 flowers per umbel per visit, yet spent maximum time (8.8 sec.) on the flower compared to other pollinators. Induced bee pollination increased seed yield by 2.5 times and produced on an average 971 seeds per umbel with average weight of 30.3 g per 1000 seeds as compared to 406 seeds per umbel with an average weight of 28.9 g per 1000 seeds in the control. The seeds from experimental field resulted in 90 per cent germination compared to 69.5 per cent in seed from control. Though, *A. dorsata* was judged the best, *A. cerana indica* being a domesticated species, can be best utilized for efficient pollination of onion seed crop.

**1340-1440**

**S23-P-11**

**EFFICACY TESTING OF ONION SEED TREATMENTS IN THE GREENHOUSE AND FIELD**

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Fungicide seed treatments protect onion seedlings from damping-off, caused by *Pythium* species, and onion smut, caused by *Urocystis cepulae* Frost. A greenhouse screen was used to identify effective materials and rates, in order to increase the repetitions each year and reduce the number of treatments evaluated in the field. Trials were conducted in the greenhouse and field 2000 and 2001. In the greenhouse, 200 cell, black plastic trays were filled with field soil (60% organic matter, pH 6.4), naturally infested with the pathogens. Onion, cv. Gazette was seeded one per cell, with four replicate trays per treatment. Trays were held in the dark at 13–15°C until emergence, then placed in a greenhouse. Emergence and the incidence of damping-off and onion smut were recorded. Treatments were Charter (triticinazole 2.4%, 1 mg) or a new product—L0258 (5, 10, 25, 50, 100 or 200 mg)—in combination with Raxil (tebuconazole 28.3% at 100, 200 or 400 mg), and Allegiance (metalaxyl 28%, 30 mg), compared to the standard – PRO GRO (30% carboxin, 50% thiram, 2000 mg), and an untreated check. Treatments were applied with film coat; rates are ai/100g seed. Field trials, with treatments based on greenhouse performance, consisted of cv. Gazette seeded 46 seeds/m, in 5 m rows, in early May each year. A treatment of 6.6 kg ai/ha of mancozeb, applied in the seed furrow, was included. Incidence of onion smut on untreated checks was 35% to 80% in the greenhouse and 51–73% in the field. Damping-off was 11% to 16% in greenhouse trials. Charter was less effective than Raxil in greenhouse trials and was not tested further. PRO GRO was less effective in field trials than in the greenhouse. Raxil (100 or 200 mg) plus Allegiance plus or minus L0258 (5 or 50 mg) seed treatments were as effective as PRO GRO plus a furrow application of mancozeb (6.6 kg ai/ha), in the field.

**1340-1440**

**S23-P-12**

**EFFECTS OF SOLUTE LEAKAGE AND SEED SIZE CLASSES ON PRIMING EFFICIENCY OF IMPATIENS SEED**

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Priming is a presowing treatment in which seeds are soaked in an osmotic solution that allows them to imbibe water and go through the initial stages of germination, prior to radicle protrusion through the seed coat. Seeds can then be dried to their original moisture contents and stored, or planted immediately after priming. In the last two decades, seed priming has been a common seed treatment to increase the rate and uniformity of emergence in many vegetable

and flower species. Until recently, priming techniques have been developed primarily on an empirical basis and more work is needed to decide on the optimum priming conditions of different species. Impatiens (*I. wallerana*) is now the most popular bedding plant in garden centers where the crop accounts for 25 percent of sales. It has been observed that when different amounts of impatiens seeds (e.g., 0.5 g vs. 5 g) were placed in the same amount of priming solution, the greater the amount of seeds the faster germination proceeded after priming. The hypothesis of germination producing promoters from the seeds activating the induction of germination was tested by germinating fresh dry seeds by using the priming solution. No significant promotion effect was found. Our research did find that promotion effects maybe related to the water potential of the priming solution and the hydration status of the primed seeds, the drying step after priming may also affect priming efficiency. In addition, priming effects are often different among seeds with different sizes (e.g., 0.1 mm size classes from the 1.1 to 1.5 mm range) which may indicate different maturity levels. Data will also be presented on the relationship between priming and different sizes of impatiens seed.

**1340-1440**

**S23-P-13**

**SEED PRIMING AFFECT SWEET PEPPER GERMINATION BEHAVIOR AND SEEDLING GROWTH**

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Seeds of pepper (*Capsicum annum* L.) CV. Yolo Wonder were primed for 144 hours in an aerated solutions of polyethylene glycol 8000 (PEG), KNO<sub>3</sub>, CaCl<sub>2</sub> and K<sub>2</sub>HPO<sub>4</sub> as a means for improving germination behavior and seedling growth. Seed priming can slightly increase germination percentage and markedly increase germination rate of pepper. PEG and KNO<sub>3</sub>-primed Yolo Wonder seeds had higher germination percentage and rate. All seed priming treatments had positive effects in decreasing days to 50% germination (T50), mean time to germination (MTG) and mean time to emergence (MTE) PEG and CaCl<sub>2</sub> were the most superior in this regard. Osmoconditioning promoted pepper seedling growth and uniformity compared to seedlings from check treatment. The resultant seedlings from primed seeds exhibited high values of fresh and dry weight, seedling height, number of leaves and root/shoot ratio.

**1340-1440**

**S23-P-14**

**PHYSIOLOGY OF DESICCATED SEEDS OF ONION (*ALLIUM CEPA* L.) DURING STORAGE**

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Effect of extreme desiccation of onion (*Allium cepa* L. cv. Pb. Selection) seeds and various packagings was studied in order to standardize lower most safer (non-injurious) moisture level & packaging materials for long- & medium- term storage; to assess the injuries (if any) in these seeds during storage due to desiccation. The seeds were desiccated from 9 to 5 & 3.8% moisture content over calcium chloride. Desiccation of seeds from 9 to 3.8% seed moisture had no immediate injurious effect on % seed germination, root/shoot length, seedling dry weight, electrolyte leakage and % abnormal seedlings. During storage at room temperature seeds with 9% moisture showed a reduction in their germination earlier when stored in paper bags whereas seeds stored in other packagings at this moisture showed a slightly higher % germination at comparable time intervals up to 18 months of storage. Desiccated seeds at 5% and 3.8% seed moisture maintained a significantly higher % germination in polyester, aluminum and polyethylene pouches than the non-desiccated seeds (9%). Polyester and aluminum packaging materials showed better results with higher germination capacity of the seeds and seedling dry wt. Seedlings raised from seeds at 9% moisture showed a higher loss in their dry wt. as compared to those raised from seeds at 5% 3.8% seeds moisture. However, the seed desiccation had no effect on the electrical conductance. Total soluble sugar content of the seeds increased with progressive storage at all the moisture levels and packagings, however, the % increase was higher in non-desiccated seeds (9%) as compared to the desiccated seeds (5 and 3.8%). Seeds packed in aluminum and polyester showed less accumulation of soluble sugar as compared to paper and polyethylene pouches. The seeds with 5% 3.8% moisture

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showed less accumulation of the free radicals (in terms of malondialdehyde content).

**1340-1440**

**S23-P-15**

**FRUIT DEVELOPMENT AND DORMANCY BREAKING TREATMENT EFFECTS ON THE SPEED OF GERMINATION OF THE TOMATO (*LYCOPERSICON ESCULENTUM* MILL.) MUTANT DARK GREEN (DG)**

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The tomato fruit is an important source of antioxidants such as beta-carotene and lycopene. Consequently, tomato breeders are developing genotypes with higher levels of carotenoids. However, by modifying the biosynthesis of lycopene and carotenoids, other physiological processes may be affected. For instance, the tomato mutant dark green (dg) synthesizes higher levels of lycopene, but shows delayed seed germination, low seed vigor and reduced plant growth, which limits its use in commercial varieties. The cause of delayed seed germination and low vigor is poorly understood. Studies were conducted to evaluate whether harvesting in early fruit development stages and applying some dormancy breaking treatments such as GA<sub>3</sub> and stratification, improved the germination of dgT4099. Fluridone, an inhibitor of carotenoid biosynthesis, was also evaluated. Fruits of Flora-Dade (wild type) and dgT4099 (mutant) were harvested at five maturities (mature green, breaker, pink breaker, red mature and over-ripe) during 2000 and 2001. Seeds were extracted by 48h fermentation at room temperature, and quality was assayed by standard germination and germination index tests. There was a genotype by maturity interaction for final germination. In addition, the germination of dgT099 was consistently slower than that of Flora-Dade regardless of fruit maturity. However, at mature green fruit maturity dgT4099 had better final germination than did Flora-Dade. Seeds treated with fluridone showed faster germination than untreated ones, especially when treatment was applied under dark conditions. The synthesis of ABA in seeds of Flora-Dade and dgT4099 is being investigated when dry and during the imbibition process.

**1340-1440**

**S23-P-16**

**NONDESTRUCTIVE GERMINABILITY ASSESSMENT OF SOME VEGETABLE SEEDS BY NIR SPECTROSCOPY**

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NIR spectroscopy is widely used today as a quantitative analytical technique for predicting the chemical composition of various agricultural products. However there exist few application for seed quality assessment, especially for seed germinability. This study was to show the possibilities of a nondestructive estimation of germinability in some vegetable seeds, such as radish, watermelon and cucurbitaceae. NIR spectral measurements were carried out on the seeds surface by single seed base and planted on blotters individually to observe germination. The seeds were characterized to nongermination and germination group, which in turn grouped to normal and abnormal germination and compared with the NIR spectra. The result suggested that NIR spectra could be applicable to determine the seeds germinability.

**1340-1440**

**S23-P-17**

**EFFECTS OF OSMOPRIMING TREATMENTS ON SEED GERMINATION OF TWO TYPES OF RADICCHIO (*CICORIUM INTYBUS* L. VAR. *SILVESTRE* BISCH.)**

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Seed osmopriming was evaluated as a means to improve germination performance of two types of radicchio ('Rosso di Chioggia Precoce' and 'Bianco di Chioggia'). Seeds were soaked in only deionised water or primed in aerated solutions of polyethylene glycol (PEG) 6000 (140, 180 or 240 g·L<sup>-1</sup>) or KNO<sub>3</sub> (2.5, 5.0 or 12.0 g·L<sup>-1</sup>), and compared with no-soaked controls. Seeds were soaked in water or priming solutions for 2, 4, 6 or 8 hours; then they were rinsed and placed in petri-dishes at 20 or 27 C germination temperature. Seeds were considered

germinated when cotyledons were completely unfolded. Germinated seeds were counted and removed every day for 10 days. Pre-sowing treatments affected more the germination percentage than the mean time of germination, and the effects were more evident when 20 °C germination temperature was applied. The higher germination percentage was obtained with medium-lasting treatments (4–6 hrs.) in only water and with short-lasting treatment (2 hrs.) in PEG solution (180 g·L<sup>-1</sup>). Long-lasting priming treatments (8 hrs.) proved to be detrimental for seed germination (especially for 'Bianco di Chioggia'). Seed germination was either unaffected or reduced by using KNO<sub>3</sub>.

**1440-1500**

**S23-O-17-A**

**FILM COATING TECHNOLOGIES FOR SEED TREATMENT APPLICATION**

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Film coating is a method that consists of applying an aqueous formulation that results in an uniform coating film on the seed surface (Taylor et al., 2001 HortScience 36: 199-205). This technology was originally developed for the pharmaceutical and confectionery industries, and now adapted to seeds. Commercial film coating polymer formulations have been developed and available for seed coating. Laboratory equipment is illustrated to coat small quantities (100 g) of seeds using a tumbling drum, and external air atomization nozzle with controlled metering. Drying is performed concurrently with the application of the coating formulation. The film coating formulation produces an excellent delivery system for plant protectants (seed treatments). New chemistry insecticide seed treatments will be reviewed. Efficacy of seed treatments on selected vegetable crop-pest combinations will be highlighted. Seed treatments are shown to reduce pesticide usage per hectare by >90% compared to conventional in-furrow applications.

**1500-1520**

**S23-O-17-B**

**INTERACTIVE IDENTIFICATION TO GENUS OF LEGUME (FABACEAE) SEEDS VIA THE INTERNET**

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A comprehensive database for the interactive identification of legume fruits and seeds to genus was developed and is now available via the Internet (<http://nt.ars-grin.gov>). Retrieval of information on fruits, seeds, and distribution of legume genera can be customized according to the needs of individual users. The legume family (Fabaceae or Leguminosae) includes 687 genera distributed among three subfamilies: Caesalpinioideae, Mimosoideae, and Faboideae. Caesalpinioideae has 23% of the genera, Mimosoideae 11%, and Faboideae 66%. For each genus the following characters were recorded in a DELTA-formatted database: 9 classification characters, 157 for fruits, 127 for seeds, 7 for distribution, 1 for notes, and 3 for metadata. There were approximately 1,360 images attached to the genera and 205 to the characters, for verification of identifications and interpretation of character states. Some interesting results for legume fruits and seeds are: The shortest legume fruit is in the genus *Trifolium* and is 0.1 cm long, and the longest legume fruit is in the genus *Entada* and is 200 cm long. The smallest legume seed is in the genus *Ononis* and is 0.5 mm long, and the largest legume seed is in the genus *Mora* and is 180 mm long. Twelve genera have seeds lacking a testa of which seven have all species lacking a testa and five have a few species lacking a testa and the majority with a testa. The subfamily Faboideae has relatively smaller seeds, with an average length of 9.1 mm, than the seeds of subfamilies Caesalpinioideae and Mimosoideae, with average lengths of 14 and 18 mm, respectively.

**1520-1540**

**S23-O-17-C**

**WATER SORPTION ISOTHERMS OF VEGETABLE SEEDS AS INFLUENCED BY SEED SPECIES AND STORAGE TEMPERATURE**

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The water sorption isotherms of seeds of four vegetable species; carrot, cucumber, onion, and tomato were determined using the static method of eight saturated salt solutions (relative humidity range from 11 to 98%) at four storage temperatures; 5, 15, 25, and 35 °C. The water sorption isotherms of each crop exhibited a reverse sigmoid shape. When seeds were stored at low relative humidity (RH), their equilibrium moisture contents (EMC) were relatively low. At 5 °C, no major changes in moisture sorption up to 80% RH. Beyond this point, a sharp increase in EMC occurred. In general, the increase in storage temperature increased the water activity ( $a_w$ ) of seeds. At 97% RH, seeds held at 25 and 35 °C deteriorated before reaching equilibrium. The experimental data were fitted well with GAB and Henderson equations. Equilibrium moisture content varied from a minimum of 0.00236 (g water/g dry matter) for tomato to a maximum of 0.0388 for carrot. The correlation coefficient (0.968 to 0.999 for GAB model and 0.922 to 0.961 for Henderson model) indicated a good fit to experimental data. The GAB model fits experimental data better than Henderson model as indicated by the higher correlation coefficient values.

1540-1600

S23-0-17-D

### COMPARISON OF THREE PRIMING TECHNIQUES FOR ONION SEED LOTS DIFFERING IN INITIAL SEED QUALITY

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Priming is a technique that can improve seed performance by reducing the time to germination and seedling emergence, and also by increasing the tolerance of seeds to stress conditions. Priming involves controlled seed hydration into the second stage of imbibition, where various metabolic processes are activated, but without permitting radicle protrusion. Research to date has provided several priming procedures which can lead to different results. The objective of this study was to compare the effect of hydropriming (germination paper moistened with water), drum priming and osmopriming (aerated PEG 8000 solution) on germination speed and percentage using six lots of onion (*Allium cepa*) seeds. In the drum priming technique, seeds were hydrated in several cycles. The optimal amount of water added and treatment duration varied among seed lots, which had a wide variation of germination and vigor. In the hydropriming method, seeds were exposed to 2, 4 or 6 layers of moistened germination paper, for 2 or 4 d. For the osmopriming method, osmotic potentials of -0.5 MPa and -1.0 MPa and imbibition periods of 1 and 2 d were used. All treatments were carried out at 15 °C and 25 °C. The response to priming methods varied among lots. For lot 1, all priming methods improved both percentage and speed of germination. On the other hand, there was no germination response to priming method for lot 2. However, the speed of germination was increased by nearly all priming treatments. The treatment that provided higher speed of germination values for lots 1 and 2 was hydropriming using 6 layers of moistened paper for 4 d. The most practical technique was drum priming, which allowed efficient seed hydration without the labor costs and disposal concerns associated with the hydropriming and osmopriming techniques.

1600-1620

S23-0-17-E

### ADVANCES IN SEED RESEARCH ON EMBRYO DORMANCY IN AFRICAN EGGPLANT (*SOLANUM AETHIOPICUM* L., SSP. KUMBA)

Abdoulaye Seck\*

BP: 26 130 P. Assainies, Dakar, West Africa

Embryo dormancy is a major constraint in garden egg (*Solanum aethiopicum* L.) of which new seeds cannot germinate correctly unless they are conserved for 4-5 months, which requires suitable facilities. Since 1990, seed research in Senegal has dealt with artificial breaking through physical and chemical processes, but until now, only GA<sub>3</sub> resulted in good and reproducible rates. However, this regulator is very expensive with seed cost increasing up to 2-3 folds. From 1992 to 2000, research was oriented to genetic solution through gene transfer with interesting findings summarized as follows. 1) Genetic variability assessed on 11 accessions with non treated seeds produced under high temperatures (harvest in August, 1992) was very important (germination ranging between 36 and 100%); in particular, the low rates of check varieties (Soxna, Keur Mbir Ndao) were confirmed. 2) further studies with the same varieties

multiplied under low temperatures (harvest in December-January, 1999-2000), have resulted in totally different findings: both treated and non treated seeds germinated quite well for parents (90 and 95.6%) and F<sub>1</sub> hybrids as well (97.7 and 96.3%). These results seem to indicate a favorable effect of heterosis and of low temperatures during seed formation. In addition, environmental effect was better expressed by Soxna with the highest rate difference between cold and hot seasons (58%) as compared to the other varieties (50 and 17.5%). 3) several F<sub>1</sub> hybrids from crosses between dormant and non dormant cvs produced seeds in hot and cold seasons which germinated quite well without GA<sub>3</sub> (respective rates = 86 and 94.7%); this gives evidence that dormancy could be recessive; however, treated seeds germinated better with means up to 90 and 94% according to the GA<sub>3</sub> concentration. Based on these results, future research is suggested.

1620-1640

S23-0-18

### ADVANCES IN SEED RESEARCH ON EMBRYO DORMANCY IN AFRICAN EGGPLANT (*SOLANUM AETHIOPICUM* L., SSP. KUMBA)

Abdoulaye Seck\*

BP: 26 130 P. Assainies, Dakar, Senegal, West Africa, BP 26130

Embryo dormancy is a major constraint in garden egg (*Solanum aethiopicum* L.) of which new seeds cannot germinate correctly unless they are conserved for 4-5 months, which requires suitable facilities. Since 1990, seed research in Senegal has dealt with artificial breaking through physical and chemical processes, but until now, only GA<sub>3</sub> resulted in good and reproducible rates. However, this regulator is very expensive with seed cost increasing up to 2-3 folds. From 1992 to 2000, research was oriented to genetic solution through gene transfer with interesting findings summarized as follows. 1) Genetic variability assessed on 11 accessions with non treated seeds produced under high temperatures (harvest in August, 1992) was very important (germination ranging between 36 and 100%); in particular, the low rates of check varieties (Soxna, Keur Mbir Ndao) were confirmed. 2) further studies with the same varieties multiplied under low temperatures (harvest in December-January, 1999-2000), have resulted in totally different findings: both treated and non treated seeds germinated quite well for parents (90 and 95.6%) and F<sub>1</sub> hybrids as well (97.7 and 96.3%). These results seem to indicate a favorable effect of heterosis and of low temperatures during seed formation. In addition, environmental effect was better expressed by Soxna with the highest rate difference between cold and hot seasons (58%) as compared to the other varieties (50 and 17.5%). 3) several F<sub>1</sub> hybrids from crosses between dormant and non dormant cvs produced seeds in hot and cold seasons which germinated quite well without GA<sub>3</sub> (respective rates = 86 and 94.7%); this gives evidence that dormancy could be recessive; however, treated seeds germinated better with means up to 90 and 94% according to the GA<sub>3</sub> concentration. Based on these results, future research is suggested.

1640-1700

S23-0-18-A

TO BE ANNOUNCED

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**Tuesday · August 13**


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1100-1140

S23-0-19

### STAND ESTABLISHMENT TECHNOLOGIES IN PROCESSING CARROTS: PROBLEMS AND PROSPECTS

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Soil crusting, cooler soil temperatures and low moisture availability reduce crop stand and contribute to poor yields and lower root grades in the Canadian Maritimes. In a series of experiments, primed seeds of variety 'Ildiana' improved early emergence. Amongst several soil conditioners, humic acid promoted early emergence. Germination rates and early seedling vigor was re-

duced as temperatures and soil moisture declined. Among several thermogenic compounds, ASA showed the greatest promotion of germination at 5 °C. Embryo preconditioning, using natural and synthetic anti-stress, anti-oxidant compounds, e.g., AMBIOL and GERMPRO 2 and 3, promoted emergence when soil moisture was limiting (e.g., at 25% FC). Amongst several endophytic beneficial bacteria isolate, *Pseudomonas fluorescens* provided the greatest enhancement of seedling growth in vivo. Optimal carrot under low, limiting soil temperatures and moisture conditions can be achieved by: 1: preventing soil crusting, 2. embryo preconditioning, with thermogenic, anti-stress and anti-oxidant compounds, and, 3: Biotization with endophytic plant growth promoting bacteria.

**1140-1200**

**S23-O-20**

**STAND ESTABLISHMENT OF PROCESSING TOMATO UNDER TROPICAL CONDITIONS**

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The production of processing tomato in Brazil in 2001 was approximately 1.000.000 ton in 16.000 ha. About 77% of all processing tomato production are located in savanna (cerrado) area in Minas Gerais and Goias states. In recent years, it has been observed some important changes in tomato production, including the utilization of hybrids. High cost of hybrid seeds has changed the way of stand establishment for this crop. In contrast to the last decade, where most of growers used direct seeding (need of 2 kg of seeds/ha), nowadays, the use of transplants (need of 0.2 kg of seeds/ha) is a reality. The growing of transplants in plug cell trays is the major method of producing tomato transplants in Brazil. In generally, transplant industry has used 288-cell-trays and a mixture of vermiculite, pinus husk and peat as substrate. The time required for tomato transplant production in these conditions has been 21 to 25 days. Mechanization for transplanting is highly favored under savanna topography. The transplanter used in these areas has an average capacity of planting 120.000 transplants per day, corresponding to 4 ha. In some areas, transplant industry has delivered the transplants already transplanted in the tomato field. Some results of research in transplant production and stand establishment of processing tomato under tropical conditions will be discussed.

**1200-1220**

**S23-O-21**

**TOMATO TRANSPLANT GROWTH AS AFFECTED BY ROOT-ZONE TEMPERATURE UNDER COLORED PLASTIC MULCHES**

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Soil warming is one of the benefits associated with use of plastic film mulches. However, under high temperature conditions, mulches warm the soil to temperatures that might negatively affect plant growth. Greenhouse-grown tomato seedlings were transplanted to the field and exposed to a range of root-zone temperatures (RZTs), resulting from growing the plants in different seasons and by utilizing colored mulches that differed in their soil-warming ability. The objective was to determine the relationship of mean RZT with plant growth during the first 28 days after transplanting (DAT). The study consisted of experiments carried out in Fall 1999, Spring 2000, and Fall 2000. Mulches used were black (n = 2), gray, red, silver (n = 3), and white (n = 2), and bare soil. RZT under mulch was measured hourly with copper-constantan thermocouples placed 10 cm below the soil surface and connected to a data logger. Irrespective of the season, the highest mean RZT (from planting to 28 DAT) occurred under black mulch, and the lowest under white mulch. The mean RZT under black mulch was 4 C higher than under white mulch. In the spring season, vegetative top dry weight (DW) at 28 DAT was higher with increasing mean RZTs. In the fall seasons, vegetative top DW at 28 DAT was lower with increasing mean RZTs. Pooling data from fall and spring seasons, vegetative top DW at 28 DAT was found to fit a quadratic relationship with RZT. From this relationship, optimal RZT for vegetative top growth was calculated. Vegetative top growth during the first 28 DAT was correlated with subsequent vegetative top growth and fruit yield. In conclusion, RZT under colored mulches determined, at least partially, tomato plant growth after transplanting.

**1220-1240**

**S23-O-22**

**COLORED MULCHES VARY IN THEIR EFFECT ON ANNUAL ARTICHOKE PRODUCTION**

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Annual production of globe artichokes (*Cynara scolymus* L.) requires vernalization of the plants, either through cold treatment of transplants or from natural temperature conditions in the spring. These plants can be prone to devernalization, however, under high temperature conditions, delaying both bud production and total yield potential. Studies were conducted in upstate New York and New Jersey, to determine if vernalization treatments or plastic mulch color would affect the earliness and yield of annual artichokes. Mulch color has been previously shown to affect soil temperatures and may affect vernalization of artichoke under different environmental conditions. Four mulch treatments included black, highly reflective metallized silver, and white plastic mulch, and a straw mulch control. Both sites used the cultivar 'Imperial Star,' which has performed well in previous field experiments in New York. Transplants were set in the field with or without a vernalizing cool treatment on these colored mulch treatments. Vernalization treatment consistently increased the number of plants producing buds, the marketable yields, and the number of buds harvested per plant, across all mulch colors and at both sites. No significant interactions were noted between mulch and vernalization treatments. Average bud sizes did not vary with vernalization treatment. In New York, all mulch treatments increased the yield of artichokes over the straw mulch control, but there were no significant differences in yield among the three mulch colors. In New Jersey, under warmer average temperatures than the New York site, silver mulch supported higher yields compared to black mulch or the control. These results supported the need for site by site verification of the effects of colored mulches on crop development and productivity.

**1340-1440**

**S23-P-23**

**SUBSTRATES AND BORON FERTILIZATION AFFECT THE PRODUCTION OF PAPAYA TRANSPLANTS**

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A study was performed in San Cristobal, Dominican Republic, to determine the effect of substrates and boron supply on the growth of papaya seedlings in nursery. Papaya transplants were grown directly from seed in a 1:1 mixture of loamy soil and manure, a commercial substrate based on sphagnum moss, and a 1:1:1 mixture of manure, loamy soil and cured cachaza (sugarcane fiber cake). Boron was supplied to the soil at rates 0, 0.13, 0.39, and 0.52 mg/plant. Treatments were established in a randomized block design with factorial arrangement. The variables measured were plant height, leaf number, and shoot dry matter. Analysis of variance and regression were performed on the data. Results indicate that the boron rates of 0.39 and 0.52 mg significantly impaired the growth of papaya seedlings in all the substrates. Plants grown in the sphagnum moss-based substrate attained the lowest values for the variables studied. At 35 days after emergence, the best transplants were obtained from papaya seedlings fertilized with up to 0.13 mg B and grown either in the substrates of 1:1 mixture of loamy soil and manure, or in the 1:1:1 mixture of manure, loamy soil and cured cachaza.

**1340-1440**

**S23-P-24**

**NONCYCLIC ALTERNATION OF PHOTO- AND DARK PERIODS AFFECTED GROWTH AND DEVELOPMENT OF TOMATO SEEDLINGS**

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Plant growth and development are assumed to be greater under constant photo- and dark periods that provide cyclic alternation of photo- and dark periods (CA) than under random photo- and dark periods that generate noncyclic alternation of photo- and dark periods (NA). The objective of the present study was to examine

the above hypothesis. Tomato (cv. Momotaro) seedlings were grown under two NA (NA-1 and NA-2) treatments and under a CA treatment (photo-/dark periods: 12 h/12 h) as a control. All treatments had 14 repetitions of alternation of photo- and dark periods and the sum of each photoperiod and the following dark period was 24 h, and the average photoperiod was 12 h. Under NA treatments, one of 14 integers randomly generated in the range of 6 to 18 (NA-1) or in the range of 1 to [23] (NA-2) was allotted to each photoperiod, resulting in the standard deviation of photoperiod as 0, 4 and 6 h in CA, NA-1 and NA-2, respectively. Air temperature, relative humidity and photosynthetic photon flux in photoperiod were set at 24°C, 75% and 300  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ . After 14-d treatment, stem length of the seedlings was [lowest] in CA, followed by NA-1 and NA-2. Flower-bud differentiation was [delayed] the most in CA, followed by NA-1 and NA-2. On the other hand, dry mass and leaf area were [lower] in NA-1 or NA-2 than in CA. The results showed that stem elongation and flower-bud differentiation were greater under NA than CA; however, increases of dry mass and leaf area were greater under CA than NA. In the present study, plant growth and development were not necessarily promoted under cyclic alternation of photo- and dark periods as compared with those under noncyclic alternation of photo- and dark periods.

**1340-1440****S23-P-25****PACLOBUTRAZOL SOAKED ORNAMENTAL KALE SEEDS PRODUCE SHORTER SEEDLINGS**

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To control early growth of plugs, some producers spray the seedlings very early or spray the soil of the trays after sowing with a growth regulator solution. An alternative would be to use the seeds as carriers of a growth regulator. The objective of this study was to compare germination, seedling survival and height of ornamental kale after soaking the seeds in varying paclobutrazol solutions at 3 different soaking times. Ornamental kale (*Brassica oleracea*) 'Nagoya Red' seeds were soaked in water or paclobutrazol solutions at 0, 50, 200, 500 or 1000  $\text{mg}\cdot\text{L}^{-1}$  for 5, 45 and 180 minutes. After soaking, seeds were dried for 16 h at 25 °C. Seeds were sown one per cell in 288 plug trays filled with a plug mix. Trays were then moved to a greenhouse bench (22 °C) and irrigated as needed. Plugs were fertilized with a 20N-8.7P-16.7K liquid fertilizer at a rate of 200  $\text{mg}\cdot\text{L}^{-1}$  N, 3 times a week. The experiments were conducted in a completely randomized design using 20 seeds per replication and 4 replications per treatment. Seedling height and % usable plugs were measured 13 and 20 days after sowing. On day 27 only seedling height was measured. Paclobutrazol soaking solutions had a significant effect on % usable transplants. As long as growth regulator concentrations were not larger than 200  $\text{mg}\cdot\text{L}^{-1}$  N and times of soaking were not larger than 45 minutes, % usable transplants were not significantly reduced. Significant trends in plug height reduction were measured with increasing concentrations of paclobutrazol for all 3 dates. Forty-two days after sowing, plant height was reduced significantly with increasing paclobutrazol concentrations. This effect was not observed on mature plants 116 days after planting. No significant trends were noticed for plant diameter or dry weight.

**1340-1440****S23-P-26****GROWTH AND DEVELOPMENT OF SUMMER SQUASH FROM TRANSPLANTS OF DIFFERENT AGE**

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Influence of transplants' age on growth and development of summer squash (*Cucurbita pepo* L. convar. *giromontii* Gerb.) grown in north-western Croatia was researched during three years. The two-factors field trial was organized according to random block design in four repetitions with four different starting plants' age: transplants (10, 20, 30 days) and direct sowing of two cultivars: hybrid Acceste and allogamous Vegetable Marrow. The aim of the research was to establish the difference in the dynamics of growth and development between cultivars with plants of different age and to single out the treatments that will ensure the earliest harvest time and the highest yield. Vegetative increase of plants was determined every 10, 20 and 30 days after planting/sowing by measurement of fresh weight of both underground and aboveground

parts of the plants and by determining the leaf area with non-destructive method. The dynamics of generative development was monitored two times a week by determining the flower's sex and number of flowers as well as age, weight, diameter and length of fruits. Vegetable Marrow had significantly more male flowers per plant and Acceste had more fruits in all three years. The bigger leaf area and fresh vegetable weight suggest the fastest growth of plants from 10 and 20 days old transplants, that also achieved the biggest, but similar yields in the same period. The earliest harvest time achieved plants from 20 and 30 days old transplants. The results show that an acceptable transplant's age is 10 days, because of possible postponement of planting up to 10 days without the risk of yield decrease and with more rational use of greenhouse and easier transport manipulation. Transplant age of 20 days can also be recommended because of combination of earlier harvest time and high yield.

**1340-1440****S23-P-27****GROWTH AND YIELD OF TRANSPLANTED ONION AT INCREASED SEEDLING DENSITY**

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In south Buenos Aires, Argentina, farmers usually established onion crops by direct seeding, or occasionally, by bareroot transplants. The objective of this study was to determine and compare growth and yield of transplanted onion cv. 'Valcatorce INTA' produced with one, two or three seedlings per cell of 10  $\text{cm}^3$  on a 228-cell flats. Treatments were one (TC1), two (TC2) or three (TC3) seedlings/cell, and single plants separated at transplanting from those grown with two (TC2-1) or three (TC3-1) seedlings/cell. Direct seeding (DS) and bareroot field-grown transplants (BR) were used as controls. Direct seeding was done on 10 September 1999 on four lines per bed, with seeds spaced 3.5 cm. Transplants were established on 12 Nov. 1999 on two lines per bed at 5 cm spacing (BR, TC-1, TC2-1, TC3-1), 10 cm (TC2) and 15 cm (TC3). The initial plant population for DS and transplants was 1,632,653 and 571,429 pl/ha. Root, shoot and bulb growth were monitored throughout development. At harvest, bulbs were sorted by diameter into four commercial size classes: small (35-50 mm), medium (50-60 mm), large (60-70 mm) and jumbo (>70 mm). Root number and root dry weight was higher for TC1 compared to BR at 30 days after transplanting (DAT). Transplant leaf mass peaked between 64 and 80 DAT. Early bulbing occurred for DS followed by BR, but most containerized transplants exhibited a faster bulbing rate after 60 DAT. Overall, containerized transplants had 15 % higher total yields than DS, with a significant increase in larger bulb sizes (>60 mm) for TC1 (122%) and TC2 (60%). Containerized transplants growing at increased seedling density can reduce the cost per plant, with the potential for higher profits compared to direct-seeding.

**1340-1440****S23-P-28****CONTAINERIZED ONION TRANSPLANTS: A NEW STRATEGY TO ENHANCE ONION YIELD AND QUALITY**

D.I. Leskovar\*, K.S. Yoo, K. Kolenda, L.M. Pike

Texas Agr. Exp. Station, Texas A&amp;M Univ., 1619 Garner Field Rd., Uvalde, TX, USA, 78801

Dry bulb onion (*Allium cepa* L.) is an important vegetable crop worldwide, with 15,400 ha grown in the U.S. A 2-year field study was conducted to determine growth, yield and bulb quality when established with containerized transplants or direct seeding and irrigated with subsurface drip placed at 5- or 15-cm depth at water application rates of 1.0 and 0.5 ET. Two yellow cvs, 'TG 1015Y' and the newly developed 'Legend', and one white cv. 'Texas Early White' (TEW) were used. The initial plant population for direct seeding and transplants was 387,500 and 182,400 pl/ha, respectively. Root and shoot growth, bulb pungency (pyruvic acid level), soluble solids (brix %), and flavonoid quercetin were monitored during bulb development. At harvest, bulbs were sorted by commercial size classes. By mid development, transplants had larger bulbs with more number of leaves and roots than direct-seeded plants. After the onset of bulbing, minimal differences in bulb quality were measured in response to stand establishment and irrigation. At harvest, pungency was lower and brix was higher for transplants than direct seeding in both years. Pungency level ranges were 2.8-3.9 moles/ml (Legend), 3.4-4.1 (TG1015Y) and 5.3-5.7 (TEW).

Transplants had 37% (1999) and 42% (2000) higher total yields than direct seeding. The yield increase was greatest for the cv. 'Legend'. Transplants also had larger bulb sizes and higher water use efficiency than direct-seeded plants. Containerized transplants are more costly, but can provide an immediate and complete field establishment. This work demonstrated that transplanting with efficient subsurface drip systems and superior cultivars can enhance onion flavor attributes and produce uniform high-value bulb sizes, thus increasing profit potential.

**1340-1440**

**S23-P-29**

**HYDROPHILIC POLYMERS IN PEPPER (*CAPSICUM ANNUM* L.) TRANSPLANTS PRODUCTION UNDER DIFFERENT IRRIGATION FREQUENCY**

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Water-storing synthetic polymers—soil additives designed to improve plant establishment and growth in arid environments—had been shown as bringing benefits to horticultural plants grown under conditions of much lower water stress. Seedling emergency speed, uniformity and initial growth rate determine the seedling quality. There are different kinds of polymers used in these applications, some of them added with nutrients and growth starters. A propenamide-propeonate co-polymer was added to different substrates to evaluate its effects in pepper seedlings production under three irrigation frequency: a) each two days, b) once a day and c) twice a day. A peat-based substrate added with composted plant material: mix I (60% peat + 40% perlite) and mix II (45% peat + 30% perlite + 25% compost), with or without polymer addition. Growth patterns and quality traits of pepper seedlings were evaluated. Fresh and dry weight of shoot and roots, shoot height and stem base diameter, leaf area and net assimilation rate were measured. Dry matter content, shoot:root ratio and growth rate were calculated. Earliness, uniformity and size seedlings were improved by polymer addition, specially without compost substrates. Shoot:root ratio was not affected neither by polymer addition nor irrigation frequency though depending on substrate characteristics. When the irrigation level decreased, dry matter percentage was increased in those traits without polymer addition, specially those without compost. Significant interaction between irrigation frequency and substrate was found for parameters related to leaf area. Growth rate was more dependent on leaf area development than on assimilation rate. Seedling quality was improved by polymer addition even with lower irrigation frequency specially in growing media without compost. Polymer-treated substrate performance seems to be that nutrients held within the matrix of the polymer are less prone to leaching.

**1340-1440**

**S23-P-30**

**A BRUSHING AUTOMATIC SYSTEM TO CONTROL PLANT HEIGHT IN COMMERCIAL GREENHOUSES**

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Stem elongation in commercial greenhouse production is controlled mainly by using synthetic plant growth retardants. However, concern over the impact of these compounds on human health and environment may limit their future availability. Mechanical conditioning represents a possible way to control stem elongation in commercial greenhouse production. The aims of the research were to design, build, test and introduce the use of an automated apparatus to mechanically control plant height in commercial greenhouses of a large growing area in North of Italy, with a Mediterranean climate, but with low-light periods during winter time. The system consisted of a simple machine (Metalserra, Terzorio, IM) that moves over the benches. The machine was built with an horizontal plane, resting over two vertical brackets, which are laying on the edges of the bench by mean of two wheels each side. Beneath the horizontal plane, an adjustable bar was mounted, connected to the horizontal plane by two vertical sliding brackets. The bar distance from the plants can be adjusted according to plant species and to plant growth, to obtain the brushing treatment of the plant canopy. The apparatus movement is due to a low-voltage electrical connection that is mounted on the system. A small engine is located on the horizontal plane. At the beginning and at the end of the bench a direction-inverter catch of

the machine is located. The machine is regulated by a timer device which controls the timing and the duration of the brushing treatment. The main characteristics that the equipment was designed for are: it is easy to be used, the height of the moving bar can be modified according to plant growth, the brushing is unvarying on all treated plants, the apparatus does not reduce light interception by plants when it is in the steady position.

**1340-1440**

**S23-P-31**

**MECHANICAL CONDITIONING TO CONTROL STEM ELONGATION IN COMMERCIAL GREENHOUSE PLANT PRODUCTION**

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Growth control of seedlings and ornamental bedding plants is important to reach a high quality of the marketable products. Stem elongation in commercial greenhouse production is controlled mainly using chemical growth regulators, but their future availability may be limited because of their impact on human health and environment. Studies of alternative techniques to control stem elongation are necessary to reduce the use of chemical growth regulators in controlled environment. Mechanical conditioning represents a possible way to control stem elongation in commercial greenhouse production. Many studies have proven the beneficial effects of mechanical conditioning, but application in commercial greenhouses is not used, at least in Italy. The research was carried out from Jan. to Apr. in Albenga (SV-Italy), an important area of greenhouse production of ornamental bedding plants and of vegetable transplants, with a Mediterranean climate, but with low-light periods during winter time. Mechanically conditioned plants, chemically treated plants and control plants were compared, testing three different species: tomato seedlings, *Ranunculus* and *Dianthus* (4 cultivars) bedding plants. The system consisted of a machine moving over the benches by 4 wheels. An adjustable woody bar was mounted to brush plant apices. Plants under the brushing treatments were brushed every day for 30 minutes at sunrise and 30 minutes prior to sunset. Brushed tomato transplants and brushed buttercup and carnation plants significantly decreased stem length compared to their respectively non-treated controls. Stem length of brushed carnation was 6% less than stem of control plants, and 4% less than stem of chemical treated plants. Growers were positively impressed by the technique, because the environmental impact of chemical growth-regulator use might be drastically reduced by using the brushing technique for the tested species.

**1340-1440**

**S23-P-32**

**COMPARISON BETWEEN CLOSED-TYPE AND OPEN-TYPE TRANSPLANT PRODUCTION SYSTEMS WITH RESPECT TO TRANSPLANT QUALITY AND RESOURCE CONSUMPTION**

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Growth and development of tomato (cv. Momotaro) plug transplants produced in a closed-type (CTPS) and an open-type (OTPS; i.e., greenhouse) transplant production systems were compared during summer (August 11 to September 1, 2000) and autumn (October 7 to November 25, 2000) in Japan. The CTPS was a system to produce transplants under artificial light with minimal utilization of resources during production. Air temperature inside the CTPS with a sub-irrigation system was maintained at 28/19C (16 h photo-/ 8 h dark period) by using an air conditioner. Air temperature inside the OTPS with an overhead irrigation system was controlled by roof and side ventilators. The environmental conditions in the OTPS during production period varied according to the outside conditions (e.g., maximum/minimum air temperature: 43/23C during summer; 33/6C during autumn). Dry weight of transplant produced in the CTPS for 17 days was 150–160 mg/transplant. While dry weights in the OTPS during summer (for 17–21 days) and autumn (for 31–49 days) were 100–180 and 30–210 mg/transplant, respectively. Unfavorable environmental conditions in the OTPS extended the production period, resulting in 10 to 50% of the potential reduction of production period by using CTPS. The first flower clusters developed at lower nodal positions in the plants originating from the CTPS, while they developed at positions higher by 1.7–2.8 nodes in the plants



originating from the OTPS in summer. Electric energy consumption and its cost per transplant in the CTPS were 0.7 MJ (0.2 kWh) and \$0.03 US (market price per transplant in Japan: \$0.2–0.3 US). The amount of consumed water for transplant production in the CTPS was approximately 10% of that in the OTPS. These results show high-quality transplants can be produced in the CTPS with a short production period, low cost of electricity and low consumption of water.

**1340–1440**

**S23–P–33**

**QUALITY OF TRANSPLANTS AND YIELD OF EARLY LEEK IN RELATION TO SOWING DATE AND CELL VOLUME OF MULTICELL TRAYS**

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Many authors indicate a close relationship between quality of seedlings at planting and the yield of leeks. For early harvest of this crop, the seedlings raising in pots or multicell trays is recognized as the most suitable method of transplant production. In field study there was estimated the effect of using the seedlings of a different quality obtained from sowings on 20 January and 5 February into various size of cells in multicell trays (76.5, 55.4, 27.0, 21.6 and 10.2 cm<sup>3</sup>) and number of plants grown in one cell (1,2,3 plants/cell) on yield of early leek. Well hardened seedlings were planted out in the field on 10 April at 25 x 8 cm, 25 x 16 cm and 25 x 24 cm spacing in treatments with 1, 2, and 3 seedlings per cell respectively, which provided the same population 50 plants per 1 m<sup>2</sup>. Results of the study showed that the method of transplant production had a considerable effect on yield of leeks grown for early harvest at the end of June. Early seed sowing that was favourable for transplants quality provided about 20% yield increase in comparison to sowing delayed by two weeks. High differences were found in the yield of leeks obtained from transplants produced in different size of cells. The maximum marketable yield of the crop was provided by transplants raised in the cells most preferable for seedling growth (76.5 cm<sup>3</sup>). Decreasing of their volume resulted in significant reduction of marketable yield with simultaneous drop of plant weight. At the same plant population, the use of multiseeded transplants comprising 2 or 3 seedling adversely affected the yield of early leek.

**1340–1440**

**S23–P–34**

**HEIGHT SUPPRESSION OF PEPPER AND TOMATO PLUG SEEDLINGS BY AN ENVIRONMENTALLY SOUND SEED TREATMENT OF GROWTH RETARDANTS**

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Experiments were conducted to investigate appropriate concentrations of plant growth retardants (PGR) and durations of seed soaking in order to suppress hypocotyl length and plug seedling height of two cultivars each of pepper and tomato. Daminozide (B-9), uniconazole (Sumagic), and ethephon (Florel) were used as growth retardants. First, seeds were soaked in 15 mL PGR solutions in a 25 °C temperature controlled chamber for one day, three days, or five days. Then seeds were washed in tap water, and were dried in a 5 °C chamber for one day. Finally, dried seeds were used in both lab germination and greenhouse growth experiments. Cultivar and species differences in response were observed in germination and seedling growth. Although germination in petri dishes and seedling emergence in plug trays declined, suppression of hypocotyl length and seedling height was evident in uniconazole treatments in two cultivars of both species. Duration of seed soaking in PGR solutions had greater influence than the concentration. Difference in % germination and % emergence were also observed as affected by PGR. Uniconazole treatments suppressed hypocotyl length and seedling height most significantly. Uniconazole was also effective, while effect of ethephon was insignificant. Seeds soaked in PGR solutions germinated, but tended not to emerge as well. Seed soaking, which is effective in suppressing hypocotyl length and seedling height without affecting germination and seedling emergence significantly, are still sought.

**1340–1440**

**S23–P–35**

**PACLOBUTRAZOL SOAKED CUCUMBER SEEDS PRODUCE SHORT SEEDLINGS AND ALTERATION BY FOLIAR SPRAY OF GIBBERELLIN**

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Cucumber seedlings tend to stretch early after germination, especially if grown in low light condition and high density. Growers apply plant growth retardants (PGRs) or agricultural chemicals having retarding effects, stretching of the hypocotyl has already occurred and often lose their marketability as a transplant. Seedlings treated with paclobutrazol show delayed growth after transplanting in the greenhouse. The primary mode of action of paclobutrazol is by inhibition of gibberellin biosynthesis. Based on these results foliar spray of gibberellin solution may be altered the growth retarding effects of seedlings treated with paclobutrazol. Cucumber seeds (*Cucumis sativus* L. cv. Jangheungnakhab) were soaked for 6, 12, and 24 hours in paclobutrazol solutions of 0, 250, 500, 1000, 1500 and 2000 mg-L<sup>-1</sup>. Treated seeds were dried for 24 hours prior to sowing in plug trays. Plant height, hypocotyl length, fresh and dry weight and chlorophyll contents were recorded at 5, 15, 20, 25, 30 and 35 days after sowing. After 35 days GA solution was foliar sprayed to the seedlings treated with paclobutrazol. GA concentration was 0, 50, 100, 200, 400, 600 and 800 ppm. Plant height, leaf area, chlorophyll content and fresh weight were recorded at 5, 10, 15 and 20 days after treatment. The higher concentration of paclobutrazol and longer times of soaking increased the growth retardation. When seeds were imbibed in paclobutrazol solution for 6, 16, or 24 hours, growth reduction was 31%, 31% and 40%, respectively. Foliar spray of GA solution could be significantly altered the growth retardation of seedlings treated with paclobutrazol. Height control of cucumber seedlings by seed soaking in paclobutrazol solution was responded highly in 12 hours soaking in 1,000 mg-L<sup>-1</sup> paclobutrazol and foliar spray of GA for alteration in 200 mg-L<sup>-1</sup> gibberellin.

**1340–1440**

**S23–P–36**

**TRANSPLANTING IMPROVES YIELD AND EARLINESS OF LATE PLANTED PUMPKINS**

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Pumpkins are a highly profitable crop for the jack-o-lantern trade in most of the country. In the Northeast, pumpkins are typically direct-seeded and require 85–120 days from seeding to maturity. Varieties suitable for jack-o-lanterns generally require approximately 100 days from seeding until harvest. Planting can often be delayed due to weather (frosts, rain) which can result in a shorter growing season and missing the Halloween market. In this experiment we compared direct-seeding with transplanting of three pumpkin cultivars: Appalachian (100 days to maturity), Autumn King (105 days), Howden (110 days) grown on black plastic mulch with drip irrigation. Transplanting resulted in significantly greater numbers of fruit compared to direct-seeding for all three cultivars. Yield (kg) per plant was significantly greater from transplanted plants of Appalachian and Autumn King compared to direct-seeded plants. Howden transplants also produced greater yields than direct-seeded plants though the difference was not statistically significant. Average mature fruit size from Howden direct-seeded plants was significantly greater than the size of mature fruit produced by transplants. The mature fruit size of Appalachian and Autumn King was not significantly different between fruit from transplanted or direct-seeded treatments. However, fruit of both cultivars tended to be larger when produced by plants that were direct seeded.

**1440–1500**

**S23–O–37**

**SEED GERMINATION PERFORMANCE AND INITIAL SEEDLING DEVELOPMENT IN CONVENTIONAL AND ORGANIC SOILLESS GERMINATION MEDIA**

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Five commercially-available, soilless germination media were sown with seeds of tomato (*Lycopersicon esculentum* 'Super Beefsteak') and zinnia (*Zinnia elegans* 'California Giant Pink'). Germination rate and total germination were observed daily for 28 days until harvest. At harvest, the following were recorded: shoot length, leaf number, leaf area and shoot dry weight. Both species grown in media marketed as "organic" had lower total germination than conventional media. However, the "organic" media sustained seedling growth, resulting in greater shoot length, leaf number, leaf area and shoot dry weight when compared with conventional media, regardless of plant species.

**1500–1520**

**S23–0–38**

**FRUIT YIELD IS NOT REDUCED WHEN TOMATO TRANSPLANTS ARE PRODUCED UNDER LIGHT-FILTERING FILM**

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A study was undertaken during two growing seasons to determine the influence of light filtering plastic film (FR-) benchtop tunnels on the growth and subsequent fruit yield of tomato (*Lycopersicon esculentum* L.) plants. Seeds of determinant and indeterminate cultivars were sown into 3.61 or 6.45 cm<sup>2</sup> cells containing a commercially available soilless greenhouse medium. The seedlings were raised in a polyethylene-covered greenhouse on open benches until emergence of the first true leaves, at which time the seedlings were placed in their assigned treatment location within the house. In addition to the main treatment of FR-tunnels, seedlings were also placed under one of two control treatments: open benches or clear polyethylene tunnels similar to those made using the FR-film. Plants remained shorter when grown under FR-film than when raised on an open bench or under clear clear polyethylene tunnels. The FR-film produced darker green seedlings, with significant purpling under the leaves of all three cultivars tested. Once transplanted, shoot growth in the field appeared normal. Fruit yields and quality were not reduced by the FR-treatment, indicating that FR-films may be of significant value to growers looking for non-chemical means of controlling tomato seedling height without reducing fruit yield or quality.

**1520–1540**

**S23–0–39**

**USE OF UV TREATMENTS TO CONTROL CUCURBITS TRANSPLANTS ARCHITECTURE**

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Treatments in greenhouse of plug transplants of muskmelon, watermelon, cucumber, and squash with supplemental UV radiation were performed to control plant height and to condition them to outdoor conditions. Ultraviolet radiation was provided by UVB sources placed about 0.5 m above the seedlings. Different UV doses were obtained by changing the duration of the daily treatment (0.5–2 h). The UV treatments were repeated daily for one week and started when transplants were at the stage of open cotyledons. UV radiation was supplied in the middle of the night. UV treatments, depending on the dose, significantly lowered plant height, leaf area, and shoot dry weight in all the species investigated. Our results indicated that UV radiation could substitute completely (cucumber) or at least partially (squash and muskmelon) for chemical growth regulators.

**1540–1600**

**S23–0–40**

**EXOGENOUS TREHALOSE INHIBITS HYPOCOTYL ELONGATION AND IMPROVES DROUGHT STRESS TOLERANCE OF ALYSSUM AND MUSKMELON SEEDLINGS**

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Trehalose is a non-reducing disaccharide and is a common sugar in fungi, bacteria, and invertebrate animals. Trehalose also acts as a signal molecule in carbohydrate metabolism in higher plants. We analyzed effects of exogenous

applications of trehalose on sweet alyssum (*Lobularia maritima*), tomato (*Lycopersicon esculentum*) and muskmelon (*Cucumis melo*) seedling hypocotyl growth, root growth, and drought stress tolerance. Seedlings were growing in rolled paper towels or in a growth chamber in trays containing potting media moistened with 15, 50, 100, or 200 micromolar or 15 and 50 millimolar concentrations of trehalose. Tomato hypocotyl and root growth was generally stimulated by trehalose. Root and hypocotyl growth of alyssum and muskmelon were reduced by roughly 10% by 15 micromolar trehalose, consistent with reports of growth inhibition by trehalose in *Arabidopsis thaliana*. Muskmelon seedlings supplied with 50 millimolar trehalose showed greater wilt resistance after water was withheld when compared to seedlings supplied with equal volumes of water before drought stress was imposed. Exogenously applied trehalose may be useful as a natural growth retardant and as a drought stress protectant for some seedlings.

**1600–1620**

**S23–0–41**

**STUDIES ON IRRIGATION SYSTEMS TO GROW LETTUCE (*LACTUCA SATIVA* L.) TRANSPLANTS**

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Lettuce seedlings of high quality and vigor are produced in greenhouse for transplanting in the field. Over the last two decades a large part of the commercial horticultural growers changed from soil-based systems to artificial substrate systems, to control plant growth with small root volume investment. Therefore, different substrates have been used, like rockwool, organic substrates (peat), wood fiber, glasswool, synthetic polymers, polyester or viscose fleece, sand or coarse. Moisture and water content of the growing medium play an important role, affecting root and shoot growth, and are particularly determined by the irrigation system used during Vegetable Transplant Production (VTP). The objectives of the present research were to study the effects of different cultural techniques (substrate mixture and irrigation management) during VTP on plant growth, development and partitioning and on root architecture of lettuce (*Lactuca sativa* L.) seedlings. Containerized lettuce transplants were raised in medium prepared with peat (fixed, 30% in volume), styrofoam (variable) and rockwool (variable) and irrigated throughout the experiments with different irrigation systems. Traditional overhead irrigation systems were compared to sub-irrigation systems. Different media used created different conditions for root growth, as well as for water transport and storage. Results confirmed that in lettuce overhead irrigation increases basal root number and root:shoot ratio with respect to sub-irrigation systems. Overhead irrigation may have provided uniform moisture levels around the seedling hypocotyls, thus enhancing basal root differentiation. Cutting fertilizer costs and reducing disease occurrence are certainly the two main advantages of the sub-irrigation systems. However, transplant quality through enhancement of root mass was improved by an overhead irrigation system.

**1620–1640**

**S23–0–41–A**

**TO BE ANNOUNCED**

**1640–1700**

**S23–0–41–B**

**TO BE ANNOUNCED**

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**Thursday · August 15**

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**1100–1140**

**S23–0–42**

**RECENT ISSUES ON VEGETABLE GRAFTING**

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In vegetable industry grafting is increasingly considered a tool for facing the problems of soil born diseases and obtaining plants able to adapt to abiotic stresses. Grafting technique has improved during last decades and now, thanks to the diffusion of suitable techniques and materials, great progress have been carried out and grafted seedling are progressively adopted for crop establishment. However, although its advantages and the interests of growers, the grafting is for the moment underexploited being the percentage of grafted plants relatively low in many countries. This because the spreading of grafted vegetables poses some problems related to grafting techniques and cost, and to the effects on yield level and quality. These problems will be presented with reference to the techniques and materials adopted and to the effects on crop performance which could be related to the functional relation between scion and rootstock. The critical points which could counteract or promote further diffusion of vegetable grafted seedling will be finally presented and discussed.

**1140-1200**

**S23-0-43**

**EFFECT OF RED/BLUE PPF-D-RATIO DURING LOW LIGHT IRRADIATION STORAGE ON THE QUALITY OF GRAFTED TOMATO PLUG SEEDLINGS**

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Grafted tomato (scion: *Lycopersicon esculentum* Mill. cv. Momotaro; rootstock: cv. Kagemusya) plug seedlings were stored for 35 d at 10 °C under total photosynthetic photon flux density (PPFD) of 2  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  using mixed light from red and blue light emitting diodes (LEDs), with different red/blue PPF ratios (100/0: R100, 98/2: R98B2, 95/5: R95B5, 90/10: R90B10 and 50/50: R50B50). The stored seedlings were transplanted and then cultivated for 28 d at 27 °C and 290  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  PPF during the 12 h light period and at 18 °C during the 12 h dark period. Visual quality scores and leaf area were significantly greater in R90B10 and R50B50 than in R100 on the last day of storage (LDS). Aerial-part dry weight was significantly greater in R100 than in the other treatments except R50B50 on the LDS. Flower bud number was significantly greater in R50B50 than in R98B2 and R90B10 on the last day of cultivation (LDC). Aerial-part dry weight was significantly greater in R50B50 than in R100 and R90B10 on the LDC. Subterranean-part dry weight was significantly greater in R50B50 than in R98B2 on the LDC. There was no significant difference in the other assessed and measured items: subterranean-part dry weight, stem length, leaf number and leaf color difference value on the LDS; and stem length, leaf number and first flower truss setting node on the LDC. Although a remarkable improvement in quality was not observed by increasing the proportion of blue light, it can be concluded that the red/blue PPF-ratio of 50/50 was the best ratio among the tested ones for low light irradiation storage of grafted tomato plug seedlings at 10 °C and 2  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  PPF.

**1200-1220**

**S23-0-44**

**THE USE OF IN VITRO THERMOTHERAPY TO OBTAIN TURNIP MOSAIC VIRUS-FREE HORSERADISH PLANTS**

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Illinois is the leading producer of horseradish (*Armoracia rusticana*) and its products in the United States. The overall quality and yield of the horseradish roots has declined significantly within the past few years and is believed to be directly related to the build-up of soil and insect-borne diseases including viruses. The most detrimental virus is thought to be the turnip mosaic virus (TuMV-Marmor brassicae H.). The polymerase chain reaction (PCR) can be used to test for TuMV and is more accurate than traditional ELISA (Enzyme Linked Immuno Sorbant Assay) tests. Thermotherapy treatments were used to "clean" the horseradish plants of the TuMV. Four horseradish cultivars (9705, 9759, 7586 and Doll) growing in vitro were subjected to two different temperature treatments: 37 °C for 7, 9, 11, 14, 16, 18, 21, 23, and 25 days and 40 °C for 7, 8, 9, 10, 11, and 12 days. At each of these intervals, apical meristem ex-

plants small enough to be free of leaf primordia (<1 mm in length) were excised and grown to whole horseradish plants in vitro. To screen for the presence of TuMV, the supposedly "clean" plants were assayed using RNA reverse transcriptase and PCR amplification (RT-PCR). A primer specific to a conserved sequence in the TuMV coat protein was used to produce bands which were visualized using agarose gel electrophoresis. PCR results were then compared with traditional ELISA tests. Cultivars 9705, 9759, 7586, and Doll treated at 37 °C for up to 23 days produced viable meristems which yielded whole plants. At 40 °C, only one cultivar (Doll) yielded a single viable meristem. Thermotherapy treated horseradish cultivars 9705, 9759, 7586 and Doll were found to be TuMV-free through PCR techniques. ELISA testing supported the PCR results. Thermotherapy of in vitro horseradish plants is a useful method of removing viruses from horseradish. RT-PCR screening was found to be as accurate for these plants as ELISA.

**1220-1240**

**S23-0-45**

**EFFECT OF GROWTH REGULATORS ON HUPERZIA LUCIDULUM EXPLANTS IN VITRO**

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In tissue culture, shining club moss (*Huperzia lucidulum*) explants grow slowly and although gemmae produce roots within 4–6 weeks, apical-tip cuttings do not readily form roots. This research was designed to see if club moss shoot growth and root formation could be accelerated with the growth regulators naphthaleneacetic acid (NAA), 6-benzyladenine (6-BA) or rooting powder. During a two month period, the mean vertical growth of apical-tip cuttings in basic club moss medium was 6.2 mm. In club moss media with 0.25 mg/L NAA, cuttings grew an average of 9.5 mm. Culture in media with 0.5 mg/L 6-BA resulted in cuttings growing an average of 6.7 mm. The greatest amount of growth occurred in media containing 0.25 mg/L NAA and 0.5 mg/L 6-BA, with cuttings growing an average of 10.2 mm. The least growth occurred when explants were dipped in sterile rooting powder before culture. In this latter group, cuttings only increased in height by an average value of 3.6 mm. Statistical analysis of the growth data shows no significant difference between any of the treatments and the control group. However, the overall mean growth of gemmae cultured with and without growth regulators was significantly less than that of apical-tip cuttings, regardless of treatment and in spite of the fact that all gemmae had produced complete sporophytes with roots. Although gemmae root readily in culture, cuttings do not, and rooting was not stimulated by NAA and/or 6-BA. Of 20 *H. lucidulum* cuttings maintained in culture for one year, only 3 have spontaneously formed roots regardless of the presence or absence of growth regulators. Further work is needed to understand the factors involved in the rooting of club moss explants in culture

**1340-1440**

**S23-P-46**

**EFFECTS OF AIR TEMPERATURE ON LEAF DEVELOPMENT AND PLANT GROWTH IN VEGETATIVE PROPAGATION OF SWEETPOTATO UNDER ARTIFICIAL LIGHTING**

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For vegetative propagation of sweetpotato [*Ipomoea batatas* (L.) Lam.], single- or multi-node leafy cuttings are widely used as propagules. The objective of this study was to investigate the leaf development and plant growth of sweetpotato as affected by air temperature toward modeling vegetative propagation under artificial lighting. Single nodal cuttings, each with an unfolded leaf of sweetpotato (cv. Beniazuma), were grown for 10 days under one of five air temperature levels of 23, 26, 29, 32, and 35 °C. Photosynthetic photon flux, water vapor pressure deficit, photoperiod, and CO<sub>2</sub> concentration were maintained at 200  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ , 1.1 kPa, 16 h·d<sup>-1</sup>, and 1000  $\mu\text{mol}\cdot\text{mol}^{-1}$ . The number of newly developed leaves per plant increased linearly with time after the first leaf developed at all air temperatures except 23 °C. Days to the first leaf development decreased, and the leaf development rate increased with increasing the air temperature. When leaves with blades longer than 10 mm were considered harvestable, the number of newly developed leaves per plant 10 days

after planting increased with increasing the air temperature from 23 to 32 °C, and no significant difference was observed in the number of newly developed leaves per plant 10 days after planting between 32 and 35 °C. Days to the first leaf development increased, while the number of newly developed leaves decreased with increasing the leaf blade length considered harvestable at all air temperatures except 23 °C. The dry weight of newly developed shoot per plant increased, while the dry weight of explant per plant decreased with increasing the air temperature from 26 to 35 °C. These results are important for predicting number of sweetpotato propagules and transplants and reducing energy and other resources for transplant production under artificial lighting.

**1340-1440**

**S23-P-47**

**EXCLUSION OF END OF DAY FAR-RED LIGHT BY PHOTOSELECTIVE PLASTIC FILMS REDUCES HEIGHT OF CUCUMBER SEEDLINGS**

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The far-red light intercepting photoselective plastic greenhouse covers have been shown to be effective in producing compact vegetable transplants. However, photoselective films reduce the photosynthetic photon flux (PPF) transmission compared to conventional plastic films because of the dye contained in the film. The low PPF in greenhouses covered with photoselective film may result in decreased plant dry matter production and could especially be a problem in the season with low light level and in northern latitudes. Therefore, this study was conducted to determine if covering at the end of the day (EOD) with photoselective films was effective in controlling height of vegetable seedlings. This will allow growers to maintain a high light level during day time for optimum growth of plants. Cucumber seedlings were exposed to light transmitted through a photoselective film and a clear control film. Three exposure durations: continuous, exposure to filtered light from 3:00 pm–9:00 am, and exposure from 5:00 pm–9:00 am, were evaluated. Results show that, after 15 days of treatment, about 25% of height reduction could be achieved by exposing the plants at the EOD from 3:00 pm–9:00 am or from 5:00 pm–9:00 am. Plants grown continuously under filtered light were the shortest. Compared to plants grown in photoselective chamber continuously, EOD exposed plants had greater leaf, stem and shoot dry weights, greater leaf area and thicker stem. Specific leaf and stem dry weights were also greater in EOD exposed plants. Number of leaves was not significantly affected by any exposure periods tested. The results suggested that the EOD use of photoselective film is effective in reducing height of cucumber seedlings. The responses of other crops need to be evaluated to test the feasibility of using photoselective film as a EOD cover on wide range of crops.

**1340-1440**

**S23-P-48**

**EFFICIENT GRAFTED SEEDLING PRODUCTION BY DRY HEAT TREATMENT OF SEEDS AND ROOT-PROMOTING SUBSTANCES**

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Dry heat (DH) treatment has been widely applied to inactivate some seed-borne viruses and fungal diseases in many vegetables especially in cucurbitaceous vegetables. Virtually all the gourd seeds for watermelon grafting are treated with DH to inactivate cucumber green mottle mosaic virus and fusarium. Some commercial growers favor grafting with excised seedlings and then placing the grafted seedlings into tray cells containing ordinary substrate for healing and rooting. Even though more efficient and precise, grafting can be performed with excised rootstock seedlings. Some growers avoid this because it may require a few more days of intensive care for the rooting and seedling establishment. The purpose of this research is to reduce the duration of intensive care for rooting and healing by using root-promoting substances to the cuttings. Seeds of two commercial gourd cultivars, intact or DH treated, were sown, and the scion and rootstock seedlings were excised for grafting. Splice grafting and hole insertion grafting were made and the grafting seedlings were placed in 72-cell trays for rooting. Portions of the seedlings were treated with roton containing naphthaleneacetamide and indolebutyric acid prior to placing into cells. Roton treatment promoted rooting regardless of the cultivars,

DH treatment, and grafting methods. DH treatment alone also promoted rooting in one cultivar whereas promotion could not be observed in the other cultivar. Seedlings grafted by hole insertion grafting showed significantly faster and better rooting than splice grafting. The promotive effect of roton was more pronounced in the seedlings grafted by hole insertion grafting. Further details of the results including interesting interactions will be presented.

**1340-1440**

**S23-P-49**

**EVALUATION OF ROOTSTOCKS FOR GROWTH AND YIELD IN HOT PEPPER (*CAPSIUM ANNUUM*)**

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Grafting has been commonly practiced in cucurbitaceous and some solanaceous vegetables for decades. Recently peppers, mostly those grown under the greenhouse conditions, have been grafted and some commercial growers are supplying grafted seedlings, mainly to control the spread of soil-borne diseases, mostly *Phytophthora* disease. Several commercial hybrid rootstock cultivars have also been developed for pepper rootstocks. Two popular cultivars of hot pepper, 'Nokkwang' and 'Chungyang' were grafted onto 18 rootstocks selected for good vigor, tolerance to the *Phytophthora*, and good compatibility with the scions and grown in a greenhouse. Mature green fruits were periodically harvested and some fruit quality factors were also measured. Fruit yield, both the number and fresh weight, were markedly influenced by rootstocks in both cultivars. Highest fruit yield was obtained with Kataguruma rootstock followed by TanTan and S6 in Chungyang whereas Nokkwang showed highest yield in own-rooted (ungrafted) plants followed by Yeukkang and Keunsang rootstocks. Similar results were obtained with plant fresh weight. Fruit quality such as total soluble solids contents, chlorophyll content, and total energy value were significantly influenced by rootstocks. The interactions between scion and rootstocks were frequently significant suggesting the need for careful selection of rootstocks for scion cultivar and for food uses.

**1340-1440**

**S23-P-50**

**THICKENING AND SUGAR ACCUMULATION AT THE STEM ABOVE GRAFT UNION OF TOMATO PLANTS GRAFTED ONTO *SOLANUM* ROOTSTOCKS**

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'Momotaro' tomato (*Lycopersicon esculentum* Mill.) plants were homografted, and heterografted onto *Solanum* rootstocks: 1) *S. melongena* L. 'Daitaro', 2) *S. integrifolium* Poir. 'Akanasu', and 3) *S. torvum* Sw. 'Torvum biggor'. Two weeks after grafting, the stem diameter of scion was measured immediately above the graft union (A) and 2 cm above it (B) to calculate thickening index (A/B), which could indicate graft incompatibility. The thickening index was the greatest for *S. torvum* rootstocks, then for *S. integrifolium*, then for *S. melongena*, and it was the smallest for tomato rootstocks. Sugar concentration was higher in the scion than in the rootstock, and the highest value was found in the thickening section except for *S. torvum* rootstock, where the highest concentration was measured in the scion stem. As the value of thickening index was greater, sugar concentration in the thickening section and in the scion stem increased, but not so evidently in the rootstock. Vascular bundles bent more with heterografting than with homografting in the thickening section of the tomato plants. The results indicated that the translocation of photosynthate from leaves to roots through sieve tubes would be impaired at the graft union, therefore, in incompatible pairs sugars accumulate immediately above the graft union, resulting in the thickening of the scion stem bottom.

**1340-1440**

**S23-P-51**

**THE SEEDLING, GROWTH RELATION WITH CONTENT OF ENDOGENOUS HORMONES IN THE LEAVES ON MUTUAL GRAFTING IN SOLANACEA VEGETABLES**

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The growth of seedling content of endogenous hormones and their rates were apparently affected by mutual grafting among tomato, eggplant and ginseng-fruit. The results of analysis showed that larger changes of one or two hormone levels do not inevitably related with seedling qualities. However, proportional harmonization of various hormones plays important role in the seedling healthy and strong growth. Cytokinin amongst hormones plays a leading role in regulation control and improvement seedling qualities of tomato and eggplant/tomato (scion /rootstock). GA<sub>1+3</sub> similarly play a guiding role in seedling quality of ginseng-fruit/tomato.

**1340-1440**

**S23-P-52**

**ASEXUAL PROPAGATION OF PERSIAN WALNUT IN RELATION WITH ENDOGENOUS INHIBITING SUBSTANCES**

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Experiments were conducted to study asexual propagation of Persian walnut in relation to endogenous inhibiting substances. The research began with repeated assays in micro propagation of walnut and explants of stem cultured under greenhouse conditions. Buds of walnut were cultured on sterile media with growth regulators inside glass tubes. Then, in order to study the rooting ability of walnut stem cuttings, experiments were done in green houses of Agriculture College, Univ. of Tehran. The main work of the research was related to endogenous inhibiting substances for rooting of cutting, then by extraction, separation, chromatography and bio-assay of inhibiting substances. Advanced researches were finally done, using scanning spectrophotometer, by studying the inhibiting substances of walnut stems in relation to the rooting of cuttings.

Results of micro propagation showed difficulties. In spite of living for several months, explants of buds and tissues were finally died and cuttings at the most favorable conditions produced only the callus. Bio-assays showed the existence of inhibiting substances. Chromatography identifications were obtained and the exact positions of inhibiting substances on chromatograms were measured.

**1340-1440**

**S23-P-53**

**ROOTING ABILITY OF THREE PERSIAN WALNUT (*JUGLANS REGIA* L.) CULTIVARS IN RELATION WITH POLYPHENOL OXIDASE, PEROXIDASE AND TOTAL PHENOLICS**

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To understand the reasons for lower rooting rate of tissue culture grown shoots from three Persian walnut cultivars, the amount of total phenolics and the activity of polyphenol oxidase (PPO) and peroxidase (PO) during different stages of rooting were measured. 'Sunland', 'Chandler' and 'Vina' were used as easy- to difficult-to-root cultivars respectively. PPO activity was consistently lower in 'Sunland' during all the stages of rooting. Although 'Vina' and 'Chandler' had higher PPO activity compared to 'Sunland', but 'Chandler' had lower enzyme activity than 'Vina' in most of the time. Peroxidase was highest in 'Sunland' and activity of this enzyme was inversely related to PPO activity in these cultivars. Amount of total phenolics was lowest in 'Vina' compared to 'Chandler' and 'Sunland'. Presence of higher phenolics (lower PPO activity) and higher peroxidase activity could be related to rooting ability of walnut cultivars.

**1340-1440**

**S23-P-54**

**MICROPROPAGATION AND ESTABLISHMENT OF MITE BORNE VIRUS-FREE GARLIC (*ALLIUM SATIVUM*)**

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An increasing yellowing in field cultivations of "Serena" garlic produced by meristem-tip culture two decades ago, maintained under screenhouse and tested in ELISA by polyclonal antibodies, was recently observed. Electron microscopy observation revealed the presence of elongated virus particles in both, field and greenhouse grown, garlic plants. This indicates that the material was either reinfected over the time or it was not truly virus-free. RT-PCR tests were developed after comparison of sequences extracted from GenBank from onion yellow dwarf, garlic carla and mite-borne viruses. Degenerated primer pairs were designed for each of these virus groups to verify identity of detected virus. Only primers to mite-borne virus were able to amplify the 280 bp expected fragment from both symptomatic field-collected and greenhouse grown garlic material. New meristem-tip cultures were therefore initiated in order to produce virus free propagation material; RT-PCR test was employed to evaluate mite borne virus presence during the micropropagation process. After 18 months in micropropagation, 43 mericlones were tested and 12 (28%) resulted free from mite-borne virus. Among the 72 mericlones in micropropagation for 6 months, 17 (24%), were free from this virus. The results were substantially consistent when shoots from the same mericlone were tested in different time. The mite borne-free mericlones were employed for proliferation tests on MS culture media containing NAA 0,1 mg/L, GA<sub>3</sub> 0,5 mg/L and TDZ 0,5 mg/L. The ratio obtained ranged from 1:2 to 1:10 according to the mericlone. Proliferated shoots were induced to produce small bulbs and reestablished in insect-proof greenhouse under controlled environmental conditions. The micropropagated shoots, positive in RT-PCR tests, were processed with thermotherapy or chemotherapy with PAP-II treatment, to verify the possibility to improve the elimination rate borne virus from garlic.

**1440-1500**

**S23-O-55**

**CULTURAL TECHNIQUES TO OPTIMIZE THE THYME (*THYMUS VULGARIS* L.) PROPAGATION**

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The expansion of Medicinal and Aromatic Plant (MAP) sector and the lack of detailed information on cultural techniques require professionalism and studies to rationalize their cultivation. Propagation success represents one of the most important goal for plant producers. Vegetative propagation is more preferable than seeding propagation because MAP seed germinability is very low, sometime less 50% and plant growth can be uniform, standardized and shorten once in the field. Increasing demand for organic farming techniques also requires further research to match the needs for organic nursery material. The aims of the research were to study the cutting techniques on thyme (*Thymus vulgaris* L.), testing throughout the season natural rooting hormones for organic farming and synthetic auxins with different application procedures to increase rooting. The research has started on June 2001, at the Experimental Center of the Faculty of Agriculture of the Univ. of Turin, and will end on June 2002. Every two weeks stems were cut from the mother plants and treated with different rooting products (synthetic auxins, natural plant hormones, plus control untreated). Cell trays were used (104 cells each), filled with medium for cuttings, and located on a bench provided of irrigation for mist propagation. Starting three weeks after each cutting, weekly samplings took place, measuring the root length, fresh and dry weight, and shoot mass. Thus far, season significantly affected rooting, due to the changes of environmental factors (T, light), which had a direct influence on the physiology of the mother plants used for cutting and on the rooting capacity of the cuttings themselves. According to the results obtained, from August to October is the best period to obtain optimal rooting of cuttings, regardless of the rooting treatments. Hormones enhanced out-of-season rooting; organic products tested enhanced rooting in most of the cutting periods.

**1500-1520**

**S23-O-56**

**IMPROVEMENT OF RUNNERS FORMATION AND EARLY TRANSPLANTS PRODUCTION VIA SHADING AND GA<sub>3</sub> APPLICATION IN STRAWBERRY NURSERIES**

M.E. Ragab\*<sup>1</sup>, Kh. A. Okasha<sup>1</sup>, S.M. El-Miniawy<sup>1</sup>, A.E. Omran<sup>2</sup>

Thursday August 15

<sup>1</sup>Fac. Of Agric., Ain Shams Univ, Cairo, Egypt, 11241; <sup>2</sup>Veg. Res. Dept., Hort. Res. Inst., Agric Res. Center

This study was carried out at strawberry and Non-Traditional Experimental Farm, South Tahreer, Beheira Governorate during the two successive seasons of 1998 and 1999. The aim of this study was to investigate the effect of shading and GA<sub>3</sub> at 50 ppm applications on runner formation and production of fresh transplants used for fresh plantation as well as dormant transplants used for frigo plantation. Moreover, the study included the effect of the tested treatments on transplants quality for Camarosa (high runner productive), Carlesbad and Rosalinda (low runner productive) as short day cultivars and Seascape (low runner productive) as day neutral cultivars. Black plastic net of 63% shading was used for covering. The experimental design was split-split plot with three replicates. Obtained results indicate that there was a positive effect for shading or/and GA<sub>3</sub> spray on increasing runners formation and early fresh transplants production as well as dormant transplants in the end of the season in low and high runner productive short day and day neutral strawberry cultivars. Shading treatment decreased crown diameter, dry weight and total carbohydrates in roots and crowns of transplants. GA<sub>3</sub> application decreased dry weight of transplants and roots carbohydrates content. The study conclude that shading or/and GA<sub>3</sub> spray are preferable for low runner productive cultivars in strawberry nurseries to increase transplants production for both fresh and frigo planting systems

**1520-1540**

**S23-0-57**

**CLOSED SYSTEMS WITH LAMPS FOR PRODUCTION OF HIGH QUALITY TRANSPLANTS WITH MINIMUM RESOURCE AND WASTE**

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We need billions of high quality transplants every year to be transplanted and grown in the fields or in the greenhouses. Those high quality transplants can be produced only under carefully controlled environments because their environments affect their quality significantly. The production system should be designed to produce high quality products with minimum use of resources and minimum waste. Minimum resource associated with minimum waste is generally achieved by using a well-designed and efficiently operated "closed production system". The closed transplant production system is defined as the transplant production system covered with opaque and thermally insulated walls with minimized ventilation, using artificial light. In the closed transplant production system, water and CO<sub>2</sub> are recycled. No fertilizer is released from the system. Our recent research has shown that the closed transplant production system required considerably small amounts of electricity, water and fertilizer and no pesticide to produce high quality and value-added transplants as scheduled with minimum loss of transplants during production. With this system, photoperiod, light intensity and quality, air temperature, humidity, CO<sub>2</sub> concentration and air current speed can be controlled as desired. Using the closed transplant production system, we successfully produced tomato transplants with early flower truss setting, spinach transplants without initiation of bolting, and high quality eggplant and Chinese cabbage transplants in a reduced production period. The closed transplant production system using artificial light is cost-competitive against the open-type transplant production systems using natural light such as greenhouses, and can be widely used for production of high quality transplants at reduced costs. Our closed transplant production system has been recently commercialized in Japan and has been proving its economical and ecological values.

**1540-1600**

**S23-0-57-A**

**TO BE ANNOUNCED**

**1600-1620**

**S23-0-58**

**TO BE ANNOUNCED**

**1620-1640**

**S23-0-58-A**

**TO BE ANNOUNCED**

**1640-1700**

**S23-0-58-B**

**TO BE ANNOUNCED**

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**Friday - August 16**

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**0800-0900**

**S23-P-59**

**MYCORRHIZAL INOCULATION OF TOMATO AND ONION TRANSPLANTS IMPROVES EARLINESS**

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Field experiments were conducted near Weslaco, Texas (lat. 26°8'N) between 1999 and 2001 in order to evaluate the field performance of pre- and post-mycorrhizal-inoculated tomato and onion transplants. In 1999 'Heatmaster' tomato (*Lycopersicon esculentum* Mill.) transplants were inoculated at 17 kg/ha with Glomes interadices (Reforestation Technologies, Salinas, CA) at transplanting and exposed to two irrigation regimes; and in 2001 'Heatmaster' plants were either pre- or post-transplant inoculated and grown in a light (Hebbronville) or heavy (Raymondville) textured soil. In all years, cumulative fruit yield from mycorrhizal-treated plants were significantly greater by the second and/or third harvests, but final season yield, fruit number and average fruit weight were usually similar to controls. Marketable yield and fruit number tended to improve when plants were treated with mycorrhizae. Onion (*Allium cepa* L.) cultivars Granex 1015Y and Terlingua inoculated with mycorrhizae in a seedling mix or at transplanting and planted in Hebbronville and Raymondville soil series tended to have greater yields and accelerated maturation, but bulb soluble solids at harvest were similar when compared to uninoculated plants. Bulbs from mycorrhizal-treated plants were more uniform in diameter. Bulbs stored at 13.5 C for 120 days suffered less soluble solids and weight loss if they were from mycorrhizal-treated plants. Bulb sprouting was not affected by any treatment.

**0800-0900**

**S23-P-60**

**SENESCENCE OF HYDROPONICALLY GROWN CUCUMBER PLANT AT THE LATER STAGE OF GROWTH WAS ALTERED SIGNIFICANTLY BY THE TREATMENT OF PLANT GROWTH PROMOTING RHIZOBACTERIUM AND GLUCOSAMINE**

Soon Ju Chung\*<sup>1</sup>, Youn Tae Chi<sup>1</sup>, Jung Hyun Lee<sup>2</sup>, Hee Kyung Kim<sup>1</sup>, Kil Hwan Park

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Growth retardation or early senescence of hydroponically grown cucumber plant in the later stage of growth due to the unfavourable conditions is a severe problem in Korea. The effect of soil microorganism and Glucosamine were studied for recovering retardation and senescence of hydroponically grown cucumber plant. Growth promoting rhizobacterium, *Pseudomonas* sp. D2 was isolated from soil and Glucosamine which is known as an activator of root growth was modified the properties of material in laboratory. Cucumber seedlings were transplanted in Oxy-bed filled with perlite. Treatment were started when it is shown severe senescence at 90 days after transplanting. *Pseudomonas* sp. D2(5\_106 cfu/400g) and 7.5ppm Glucosamine solution was added into substrate. Treatments were divided into three groups, control (1), complete removal of leaves (2), complete removal of leaves and Glucosamine (3), PBG nutrient was fed during experimental period. Treatment with both plant growth promoting rhizobacterium, *Pseudomonas* sp. D2 and Glucosamine was altered significantly growth stunting and senescence of hydroponically grown cucumber plant. These results suggested that combined treatment of effective microorganism and Glucosamine could be overcome the senescence of hydroponically grown cucumber plant that is a major limiting factor to the growers in yield reduction and low fruit quality.

0800-0900

S23-P-61

**SEEDLINGS GROWTH RESPONSES TO BACTERIZATION WITH SELECTED MICROORGANISMS ISOLATED FROM SOIL**Soon Ju Chung\*<sup>1</sup>, Youn Tae Chi,<sup>1</sup> Hee Kyung Kim<sup>1</sup>, Hong Gi Jang<sup>2</sup>, Wol Soo Kim<sup>1</sup>Chonnam National Univ., Kwang-ju Buk-Ku 500-757, South Korea; Dongshin Univ., 520-180 Naju, South Korea

Recently, under the environmental pressure the application of agrochemical and synthetic growth regulators is gradually limited and efforts is focussed on the development of natural growth regulators which are nontoxic to the plants in the aspects of horticultural production. This experiment was conducted to select the effective microorganisms such as plant growth promoting rhizobacterial (PGPR) and inhibition of deleterious rhizosphere microorganisms (PRMO) that affect plant metabolism or alter the supply of water, ions or plant growth regulating substances from soil and to investigate the feasibility for application in growth promotion of cucumber seedlings. 120 strains were isolated from soil and identified. Among these 13 strains were selected in laboratory test which has growth promoting effects. Based on these results cucumber seeds were sowed in the substrate of coir dust and then applied with 30 mL solution of culture broth of selected microorganisms respectively. The solution of culture broth diluted with 0.5% using distilled water. Growth characteristics in terms of plant height, hypocotyl length, root length, leaf area and fresh weight of each organs were recorded and analyzed. After 14days the plants treated with beneficial strains showed a significant growth promoting effects. This results suggested that microorganisms selected could be used as a growth promoters in transplant production of cucumber seedlings and commercial production in artificial substrates in glasshouse cropping.

0800-0900

S23-P-62

**GROWTH STIMULATION OF SENESCENT CUCUMBER SEEDLINGS WAS OBTAINED BY THE APPLICATION OF GLUCOSAMINE IN ROOT ZONE**

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Seedlings quality is very important in hydroponically grown cucumber plants for commercial production in greenhouse. To investigate the growth stimulation of senescent cucumber seedlings caused by unfavorable management during raising period. Glucosamine-oligomer (Avg. MW 1,357, degree of deacetylation 92) which is extracted from cuttlefish bone was modified the properties of material. Cucumber seedlings senescent were treated with Glucosamine-oligomer, 0, 15,000 ppm and diluted, 1,500, 150, 15, 7.5 and 3ppm using distilled water and drenched 30ml respectively for 2 days. PBG nutrient solution fed for 14 days. Optimum concentration for growth stimulation of senescent cucumber seedlings was ranged from 2,000\_ to 5,000\_ Glucosamine-oligomer in root zone. Root activity of senescent cucumber seedlings under the normal condition was the largest increases in the diluted solution of 5,000\_, but diluted solution of 2,000\_ showed the inhibition both seedlings growth and root activity. However, worst seedlings which show lowest root activity are favored in 2,000\_ Glucosamine-oligomer treatment in increasing root activity. Consequently, application of Glucosamine-oligomer solution to senescent cucumber seedlings could be stimulated markedly the growth and root activity. These results might be expanded to other senescent seedlings or crops grown in hydroponics.

0800-0900

S23-P-63

**YIELD AND DISEASE CONTROL IN FRESH MARKET TOMATO AS AFFECTED BY PACLOBUTRAZOL AND BIOCONTROL AGENTS**

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Paclobutrazol is used as a commercial plant growth retardant. The few studies conducted on vegetables with paclobutrazol show effects besides height

control. This experiment studies such affects on fresh market tomato while also using the transplant production phase to introduce biocontrol agents with antagonistic properties against *Phytophthora* spp. causing Buckeye Rot in fresh market tomato. We investigated the effects of paclobutrazol with biocontrol agents on transplant quality, yield, and soilborne diseases. In late spring, tomato seed, cv. 'Early Cascade', was soaked in 500 ppm of paclobutrazol and water for 6 h followed by a 16h drying period before planting in plug trays. After 3 weeks in greenhouse, two commercial biocontrol agents MycostopTM a.i. *Bacillus subtilis* GBO3 and CompanionTM a.i. *Streptomyces griseoviridis* K61 (double drench) were applied as a drench and repeated in field at 4 weeks after transplanting. The third treatment, CompanionTM (single drench), was applied in greenhouse at 4 weeks, just before transplanting. Stem diameter and internode length of 4 week old seedlings were measured at transplanting. Reproductive maturity and vegetative habit was recorded at 4 weeks after transplanting followed by disease rating and yield at harvest, 10 weeks after transplanting. It was found that internode length was reduced by 32% and early cluster fruits increased by 68% in the paclobutrazol treated plants. CompanionTM (double drench) reduced disease severity by 35% and 17% compared to chemical control and single drench respectively. A lower disease severity was observed for Buckeye rot whereas 11% higher total disease incidence was observed in plants treated with paclobutrazol. The results obtained from this study indicate that paclobutrazol not only gives a significant reduction in plant height but also gives an earlier reproductive maturity in fresh market tomato. Maximum disease control was obtained with CompanionTM (double drench).

0900-0940

S23-0-64

**THEORY AND APPLICATIONS OF RHIZOBACTERIA FOR TRANSPLANT PRODUCTION AND YIELD ENHANCEMENT**Joseph W. Kloepper<sup>1</sup>, M.S. Reddy<sup>1</sup>, Donald S. Kenney<sup>2</sup>, Charles Vavrina<sup>3</sup>, Nancy Kokalis-Burelle<sup>1</sup>, N. Martinez-Ochoa<sup>1</sup>Dept. of Entomology & Plant Pathology, Auburn Univ., AL; <sup>2</sup>Gustafson LLC; <sup>3</sup>Univ. of Florida, USDA/ARS, Ft. Pierce, FL; <sup>4</sup>Univ. of Georgia

Rhizobacteria are root-colonizing bacteria isolated from healthy plant roots. PGPR (plant growth-promoting rhizobacteria) are those rhizobacteria which, upon inoculation onto plants or into soil, benefit the plant. Benefits of PGPR may result in plant growth promotion or biological disease control. Historically, the benefits and mechanisms of PGPR have been investigated by using single strains of PGPR as crop inoculants. Several recent studies have indicated that the combination of two or more strains of PGPR can result in more consistent beneficial effects. Biological disease control by PGPR is reported in many crop and pathogen combinations under experimental conditions. The level of disease control is typically less than that of fungicides or other chemical controls. Current applications of biocontrol with PGPR are aimed at using mixtures of PGPR as components in integrated management systems that include reduced rates of agrochemicals and cultural control practices. A renewed interest in PGPR for practical application in agriculture and horticulture has resulted from the finding that some strains of PGPR can elicit systemic disease protection. This phenomenon is termed "induced systemic resistance" and is similar to systemic acquired resistance, which is elicited by pathogens and some chemical elicitors. According to the theoretical models of systemic resistance developed in laboratory and greenhouse experiments over the past two decades, treatment of plants with appropriate elicitors causes signal transduction in the plant that leads to activation of genes that encode various plant defense compounds. Phenotypically this response is seen by reductions in the severity of diseases following inoculation with a wide range of pathogens, including bacteria, fungi, and viruses. Work at Auburn Univ. with systemic resistance elicited by PGPR has been ongoing since 1989. This work collectively demonstrates that while induced resistance in several crops including vegetables can be achieved by seed or soil treatment of PGPR at the time of planting, the level of disease protection resulting from treatment with PGPR is not great enough to ensure that the crop is protected at an economically significant level. During work aimed at extending use of PGPR and induced resistance to vegetable transplants, we discovered that a combination of two spore-forming PGPR strains and an organic carrier resulted in significant growth promotion of tomato, bell pepper, cucumber, and tobacco. This growth promotion was correlated with induced resistance by the same biological preparation. The preparation has been commercialized by Gustafson, LLC, under the name "BioYield" and will be discussed as a model of how PGPR technologies can be extended

to use by growers. BioYield is incorporated into the potting mix used to prepare transplants. Treated transplants demonstrate increased shoot and root growth as well as enhanced collar diameter. Upon transplanting to the field, treated seedlings typically show less transplant shock and develop new roots more quickly. Disease protection is sometimes observed; however, the most reproducible effect is growth promotion resulting in yield increases with many tested transplant systems. During the process of conducting demonstration trials with growers in Alabama, the research team at Auburn became interested in beginning the use of systems theory rather than relying solely on the classical reductionist experimental approach. Examples of systems studies include using growers and the transplant industry to provide input into experimental field trials by the university, to conduct demonstration trials, and to advise on needs for sustainable agriculture in general. We are now addressing barriers to wide-spread adoption of sustainable agriculture, including use of PGPR-based technologies, and how adoption impacts rural communities. An emerging area of potential use of PGPR is their application to reduce rates of fertilizers applied to crops while maintaining current yield and quality of the crop. Reduced fertility rates could lower the risk of groundwater contamination with nitrates and surface run-off with phosphates. Nitrate contamination of drinking water is related to human health problems, and phosphate contamination in run-off water is linked to algal blooms. The first PGPR-based products with the claim of allowing reduced fertilizer applications are appearing in the United States, but more research is needed to confirm the potential of PGPR to substitute for standard fertilizers.

**0940-1000**

**S23-0-65**

**USE OF COMMERCIAL SYSTEMIC ACQUIRED RESISTANCE (SAR) INDUCERS; IMPACT ON PLANT GROWTH, DISEASE AND NEMATODA SUPPRESSION IN STAND ESTABLISHMENT**

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The pending loss of methyl bromide for soil fumigation in the United States has prompted research into alternatives, mainly of preexisting commercial products. Preliminary research results from several universities on SAR or induced systemic resistance (ISR) materials has shown some efficacy in the areas of growth enhancement, and disease and insect suppression, hence a plethora of commercial products are presently on the market. A screening program implemented by the Univ. of Florida and USDA to help growers and scientists gain an appreciation of such products has completed its first year of study. Results of this greenhouse and field oriented program generally support findings from controlled environment studies. Data will be presented concerning the impact of 12 materials on tomato growth in greenhouse and field, and disease suppression, and nematode suppression in greenhouse trials. Ramifications of our work on stand establishment will be discussed.

**1000-1020**

**S23-0-66**

**BACTERIAL ENDOPHYTES: THE INFLUENCE OF BIODIVERSITY AND FUNCTIONAL VERSATILITY ON PLANT GROWTH AND DISEASE RESISTANCE IN SUCCESSIVE FIELD GENERATIONS OF POTATOES**

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The frequent recovery of bacteria from within plants indicates the existence of a large and relatively unexplored ecological habitat. The present study provides information on the biodiversity and functional versatility of endophytic bacteria recovered from the tubers of four potato cultivars (Butte, Kennebec, Russet Burbank and Shepody) over four successive field generations. Tubers, produced initially from microplantlets, were colonized by several species of bacteria, of which those from the genera *Pseudomonas*, *Paenibacillus*, and *Bacillus* were the most frequently recovered. Over successive field generations, the population densities of tuber bacterial endophytes did not vary predictably with soil moisture, nor did species-abundance measures of biodiversity. However, the relative ability of endophytic bacteria to promote plant growth (in an

in vitro bioassay) decreased in all cultivars over successive field generations; bacterial strains becoming progressively plant growth inhibitory or plant growth neutral. In contrast, the relative antibiosis ability of endophyte bacteria against the phytopathogen *Phytophthora erythroseptica*, causal agent of the tuber disease pink rot, improved over successive field generations. The role of endophytic bacteria in the growth and development of potato tubers is discussed with a view to creating yield enhancing associations of endophytic communities that promote potato growth and improve disease resistance.

**1020-1040**

**S23-0-66-A**

**TO BE ANNOUNCED**

**1400-1420**

**S23-0-67**

**TO BE ANNOUNCED**

**1420-1440**

**S23-0-68**

**BIOTIZATION AND BIOFUNCTIONAL COMPOSTS FOR BIOTIC AND ABIOTIC STRESS TOLERANCE IN TRANSPLANTS**

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Microplants can be of poor physiological quality which results in establishment failure, slow growth post vitrum and high susceptibility to damping-off pathogens. They may also be rejuvenated which also may make them more vulnerable to pathogen attack. Unlike seedlings which are non-aseptic, they have no established microflora to biologically buffer them against damping-off pathogens at weaning. Finally, they may show adverse effects to chemicals developed to protect seedlings and other vegetative propagules against pathogens. A number of microbial inoculants based on biocontrol bacteria and mycorrhizal fungi have been developed for application to seedlings and other vegetative propagules. These inoculants used singly and in combination, have been developed both to protect the young propagules against biotic and abiotic stresses and also for protection of the crop. An alternative biological control strategy to microbial inoculation, or biotization, is biological amendment of the plant growth substrate to develop a pathogen antagonistic microflora, for example, by amendment of peat substrates with chitin-containing shellfish waste to promote the activity of lytic-enzyme producing microorganisms. More recently, environmentally friendly elicitor fungicides have been developed for crop protection. These act by eliciting host resistance pathways e.g. by induction of pathogenesis-related proteins. Here, results will be presented for the evaluation of the above biological control methods primarily for the protection of microplants but also for other vegetative propagules and the crops derived from these transplants. Factors that will be considered will be selection of inoculants for specific genotypes and the plant genotype-pathogen isolate-growth substrate interaction. Predictive parameters for the effects of inoculants on plant growth and crop yield will be discussed. Finally, strategies for holistic biocontrol based on combinations of the above biocontrol methods will be reported.

**1440-1500**

**S23-0-69**

**ENDOPHYTE ENHANCEMENT OF TRANSPLANT STRESS RESISTANCE IN POTATO AND VEGETABLES**

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Using an in vitro dual culture system of potato and a plant growth promoting rhizobacterium (PGPR), *Pseudomonas* sp. strain PsJN, we were able to enhance vigor and disease resistance of the transplanted microplants. The bacterium promoted root development, lignin accumulation in stems, increased titer of chlorogenic acid in stems and leaves and improved stomata functioning. Tests with tomato seedlings, conducted in vitro and in vivo, have demonstrated that the establishment of a minimal endophytic population threshold is required to induce such responses. Various inoculum delivery methods were



tested with both clonally propagated potatoes and vegetable seeds/seedlings. In potato, under in vitro tuberization conditions, the bacterium can translocate from plantlets to microtubers. Moreover, greenhouse minitubers produced from non-inoculated plantlets could be effectively bacterized by soaking in the bacterial suspension. In sweet pepper and tomato, seedling bacterization, after root injury, was more effective than the inoculation of seeds. In all tested crops, the degree of the response varied between cultivars. GFP (green fluorescent protein) marked strains are currently being used to follow the inoculum passage and the bacterium survival in and ex planta.

**1500–1520**

**S23–0–70**

**CHANGES IN PLANT GROWTH AND DEVELOPMENT BY RHIZOSPHERE BACTERIA THAT MODIFY PLANT ETHYLENE LEVELS**

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Rhizosphere bacteria can promote plant growth by variety of mechanisms, including nitrogen fixation, phosphate solubilization, sequestering iron, synthesizing auxin and cytokinin, and lowering plant ethylene levels. Various rhizo-

sphere bacteria use different combinations of these mechanisms at different times during the life cycle of the plant. Bacteria that can lower plant ethylene levels do so by means of the activity of the cytoplasmically localized bacterial enzyme ACC deaminase, which cleaves ACC, the immediate precursor of ethylene in plants, to form alpha-ketobutyrate and ammonia. Decreasing plant ethylene levels with ACC deaminase-containing bacteria yields plants with longer roots and significantly decreased damage to plants from environmental stresses, including flooding, heavy metals, and phytopathogens. The use of ACC deaminase-containing bacteria has the potential to become an important component of horticultural practice.

**1520–1540**

**S23–0–71**

**TO BE ANNOUNCED**

**1540–1600**

**S23–0–72**

**TO BE ANNOUNCED**