Symposium 8 (S08): Managing Soil-Borne Pathogens: A Sound Rhizosphere to Improve Productivity in Intensive Horticultural Systems

Monday · August 12

Location: Metro Toronto Convention Centre, Room 206C

1100–1140
S08–O–1
ROLE OF CULTURAL PRACTICES

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Management of soilborne diseases (SBD) should be holistic; it should involve all components of the disease (the pathogen, the host, and the biotic and abiotic environments) and should be implemented before, at and after planting. SBD are especially severe in intensive systems due to frequent cropping. Therefore, sanitation of the inoculum surviving between crops is essential. Cultural practices (CP) should play a role in management of SBD, particularly since the ban methyl bromide use. CP can be used alone or as components of pest management programs. There are three categories of CP for the management of soilborne pathogens: 1) CP for regular purposes which can also be used for disease control, e.g., irrigation. 2) CP which are used solely or mainly for pest control, e.g., sanitation. 3) CP which can be used for both agricultural purposes and pest control, e.g., crop rotation. The following principles should be considered: 1) Any potential control method may be considered, providing that the method is environmentally, technologically and economically feasible. 2) Combining with other chemical or nonchemical methods, while minimizing pesticides, should be the goal. 3) Priority should be given to diseases that are difficult to control, or those which involve problematic pesticides, e.g., methyl bromide. 4) Economic considerations should be adopted. CP include: crop rotation, flooding, soil solarization, adjusting planting date, irrigation, fertilization, composting, sanitation and others. Physical methods, e.g., heating the soil or propagation material and UV irradiation of contaminated water, should also be considered. The emphasis should be placed on practices which can be easily adopted in the crop management of intensive horticultural systems.

1140–1200
S08–O–2
BREEDING ROOTSTOCKS RESISTANT TO BOTH BACTERIAL WILT AND PHYTOPHTHORA ROOT ROT

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Phytophthora root rot caused by *P. capsici* is a very dangerous disease in green pod production of pepper in southern part of Korea. Bacterial wilt caused by *Ralstonia solanacearum* is sporadically causing problem. A breeding program to develop rootstock cultivars resistant to both bacterial wilt and *Phytophthora* blight was commenced in 1997. Crosses were made between *Phytophthora* resistant accessions (SCM334 and AC2258) and bacterial wilt resistant accessions (MC-4 and PBC631). Selection for resistance to both bacterial wilt and *Phytophthora* root rot was practiced to F_2, F_3, and F_4 generations. Every generation, seedlings at age of 1 month after sowing were pulled out and dipped in a bacterial suspension (108 cells/mL) and transplanted to 32-cell trays filled with growing mix. The plants were inoculated with a zoospore suspension (10^4 zoospores/mL) of *P. capsici*. The plants, which were surviving without any symptoms of either disease, were selected and next generation was bred. Highly resistant plants surviving both diseases were recovered every generation and the proportion of the plants showing high resistance to both diseases was increasing with progress of generation. F_5 selections are going to be evaluated for resistance to both diseases and for adaptability to farmers growing field as rootstock. The results will be discussed with growing environmental factors including soil pH, salinity, air and soil temperature.

1200–1220
S08–O–3
INFLUENCE OF SOIL AND PLANTING MATERIAL ON THE DEVELOPMENT OF STRAWBERRY ROOT ROT

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The black root rot disease complex is a common problem in replanted strawberry fields. Ageing rootlets attract saprophytic fungi that may attack even healthy roots. We studied the effect of soil and planting material on the development of strawberry root rot. For the study we chose four old and five young Finnish strawberry fields. As controls we chose two fields with no history of strawberry cultivation. Soil samples were collected from the fields before the establishment of a new strawberry cultivation. Micropropagated strawberry plants, cv. Jonsok, were grown in pots in the soil for two months in a climate chamber. The percentage of blackened roots was used as a measure of the risk of root rot for each established strawberry field. The fungi associated with strawberry root rot were isolated and identified both from the roots and the soil. The degree of rotten roots in the planting material was estimated. Whole plant samples were collected from the fields at the end of the first and second growing season. The percentages of rotten roots and browning in the crown were recorded. Fungi growing in the roots were isolated from all plant samples. The pot plants showed a higher degree of root rot in the soil from old fields than from young fields. The blackening of the root system in the planting material varied from almost zero to over 70%. Mainly *Fusarium* sp. and *Cylindrocarpon* sp. were identified from the damaged roots. However, the incidence of blackened roots in the autumn of the same year did not correlate directly with the health of the planting material or with the number of root lesion nematodes (*Pratylenchus* sp.). One year later the blackening of the roots had increased considerably, especially in the older strawberry fields. The lowest parts of the crowns were also damaged.

1220–1240
S08–O–4
TO BE ANNOUNCED

1340–1440
S08–P–5
CULTURAL MANAGEMENT OF POTATO FOR *VERTICILLIUM* WILT CONTROL, CHANGES IN RHIZOSPHERE, INCREASED POTATO YIELD, AND QUALITY

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Quantitative surveys showed that cultural factors such as the percent of soil organic matter, N, P, and K had a greater impact on *Verticillium* wilt of Russet Burbank potato than soilborne inoculum densities (ID) of *Verticillium dahliae*. Among the cultural factors studied, soil organic matter was the most significant. A 6-year field study involving comparisons between corn and barley green manure (GM) and fallow treatments corroborated these findings. After 2 years of continuous cropping of potato with resulting high soil inoculum densities (ID), there were significant 3-fold differences of soil ID between treatments (84–222 colony forming units/g of soil), GM treatments of either sweet corn or barley for a single year controlled *Verticillium* wilt and restored yields of Russet Burbank to the same yields as existed prior to continuous cropping with potato (47 $t \cdot ha^{-1}$ total yield and 38 $t \cdot ha^{-1}$ U.S. #1 yield). In contrast, when ground was allowed to remain fallow for a year, organic matter was reduced and yields were lower than the GM-treated areas by 21% for total yield and 58% for U.S. #1 yields. Accompanying these cultural management practices were significant changes in soil microflora of the rhizosphere. With increased yields following either a GM of corn or barley for a single year, rhizosphere populations of both *Fusarium solani* and *Ulocladium* were increased by 108% and 45% above the fallow treatment for *F. solani* and *Ulocladium* respectively. Results of this study emphasize that *V. dahliae* may be controlled without a pesticide and without the reduction of soilborne inoculum.

1340–1440

S08–P–6

NITROGEN MANAGEMENT AND CULTIVAR EVALUATION FOR CONTROLLING PETIOLE SPOTTING AND BACTERIAL SOFT ROT OF CHINESE CABBAGE.

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Field studies at the Greenhouse and Processing Crops Research Centre were conducted over 3 years (1999 to 2001) to determine the effects of nitrogen (N) source and rate on petiole spotting (gomasho), bacterial soft rot (*Erwinia carotovora* ssp. *carotovora*) and yield of Chinese cabbage, one of the most extensively grown Asian vegetables in southern Ontario. Using Kasumi as the test cultivar, three N fertilizer sources (ammonium nitrate, urea, and calcium nitrate), were evaluated at 60, 110, 160 and 210 kg N/ha in 1999 and at 100, 200 and 300 kg N/ha in 2000 and 2001 with a zero N rate each year, using a randomized complete block design. Ohken 75, a second test variety, was added as a subplot treatment in 2000. Assessments were made during 1999 and 2000 to determine the effect of storage on the incidence of petiole spotting. Results indicated that both source and rate of N fertilization affected the incidence of petiole spotting and bacterial soft rot, depending on year and cultivar. Kasumi was very susceptible to both petiole spotting and soft rot while Ohken 75 was fairly resistant to the disorders. Petiole spotting severity increased after 4 weeks of storage at 2 °C. In a separate experiment, 15 Nappa-type cultivars arranged in a randomized complete block design were evaluated for petiole spotting, bacterial soft rot, head size and other horticultural characteristics. Cultivars with resistance to the disorders which are also suitable for commercial production in Ontario were identified.

1340–1440

S08–P–7

EFFECT OF FOLIAGE FERTILIZER 1125 ON *RHIZOCTONIA SOLANI* IN CABBAGE

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An experiment was carried out to study the effect of foliage fertilizer 1125 on *Rhizoctonia solani* in cabbage. The result showed that 300x solution of 1125 was more effective than ck in reducing incidence of *Rhizoctonia solani*, in reducing relative electric conductivity and in increasing ratio of root and crown. In increasing activity of peroxidase (POD) and reducing chlorosis of the leaf, much it is more effective than light synthetic fertilizer and ck. But light synthetic fertilizer was much more effective than ck in reducing relative electric conductivity and increasing ratio of root and crown. 1125 and light synthetic fertilizer both can increase the content of chlorophyll. The experiment of inhibition on *Rhizoctonia solani*, which was done indoor, showed that 25¥, 50¥ of 1125 had a little function in restraining the fungi and that 500¥ of light synthetic fertilizer and 200¥, 300¥, 400¥ of 1125 had not any. In all, 1125 is an inorganic growth regulation dose that can remarkably increase plant immunity ability.

1340–1440

S08–P–8

SOME AGRONOMICAL AND PATHOLOGICAL CRITERIA AFFECTING TOMATO YIELD IN THE BLACK-SEA REGION OF TURKEY

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Tomato is the most intensively growing vegetable variety with the production of 605 578 tons in the Black-sea region of Turkey. Major factors affecting tomato yield in the Black-Sea region are plant density, mulching and late blight disease (*Phytophthora infestans* Mont.de bary) in the region. Some studies were conducted in the region on major factors affecting tomato yield between 1993–2000 years. According to mulching studies the most economical treatment was to plant the tomato on the 15 April together with black polyethylene mulch without setting up low plastic tunnel. It increased total and early yield 1.4 and 22.6 fold more respectively than conventional growing system. As a result of experiments conducted on late blight disease, economical yield losses weren't established during the first and second harvest periods as soon as epidemic outbreak but important yield losses were determined during the following harvests. Thus epidemic occurred at the first week of September didn't cause important yield losses because of the total two final harvest period and it was concluded that it was not necessary to apply chemicals, even if epidemic conditions were favourable, after the third week of August. The equation Y = 7084–5184r for the period in which epidemic outbreak between the last week of August and mid-September and the equation Y = 6947–15046r for the other growing periods were established between apparent infection rate and yield loss. On the other hand regression equations between yield and plant density per decare of tomato cultivars, SC2121 and H2274 were established. As a result of the experiments the relationships between yield and plant density were found as Y = –9E–05x2+1.1747x+4882.8 for tomato cultivar SC2121 and as Y = 0.000x2+1.6202x+4548.7 for tomato cultivar H2274 and Y = –0.0001x2+1.4658x+4632.4 for both cultivar.

1340–1440

S08–P–9

CHEMICAL ALTERNATIVES TO METHYL BROMIDE FUMIGATION IN SEEDBEDS

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For many years methyl bromide fumigation has been the standard treatment for control of nematodes, weeds and soilborne diseases in seedbeds. However, its proposed withdrawal has necessitated the search for alternative chemicals. A number of possible replacements have been tested at Kutsaga Research Station over the past 4 years. A Standard seedbed treatment of 50 g/m^2 of methyl bromide was compared with alternative treatments of 65% 1,3-dichloropropene (1,3-D) plus 35% chloropicrin and combinations of metham-sodium and ethylene dibromide (EDB). 1,3-D and chloropicrin are old chemicals which have been tested and used in Zimbabwe as soil fumigants for many years. However, the mixture of these two chemicals had not been tested for its efficacy in nematode and weed control, and its effect on seed germination and seedling growth. Metham-sodium at 35 mL/m^2 gave adequate weed control and good seed germination and seedling growth. Although nematode pressure was low in the experimental site, metham-sodium applied on its own did not always provide control of root-knot nematodes. When 35 mL/m^2 of metham-sodium was combined with 21 mL/m^2 of EDB, nematode control comparable to that obtained with methyl bromide was achieved. A combination of 1,3-D with 35% chloropicrin applied at the rate of 35 mL/m^2 of the mixture provided good nematode and weed control and improved seed germination and seedling growth.

1440–1500

S08–O–10

UTILIZING PHOSPHOLIPID FATTY ACID ANALYSIS TO DETERMINE THE EFFECT OF COMBINING COMPOSTS WITH METHYL ISOTHIOCYANATE, BRASSICA AMENDMENTS, AND SOLARIZATION TO CONTROL SOUTHERN BLIGHT OF TOMATO

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Signature lipid biomarker analysis is an effective measure of viable biomass and community composition of in situ soil micro biota. Phospholipid fatty acids (PLFAs) are components of intact membranes of viable soil microorganisms. Extraction of PLFAs from soil samples allows for the quantitative evaluation of microbial profiles and permits the evaluation of preplant soil treatments on microbial populations. Since 1999 a research project has been ongoing at the Univ. of Tennessee examining the effectiveness of integrating synthetic soil fumigants with alternate, non-chemical treatments for the prevention of southern blight (*Sclerotium rolfsii*) in plasticulture tomato production. The fumigant methyl isothiocyanate (MITC) is being investigated in conjunction with compost amendments, Brassica biofumigation, and solarization. Data indicates experimental treatments combining composts with other methods of soil disinfestation produced higher yields with lower incidence of disease than the controls. by MITC fumigation at a 50% dosage rate. During the 2001 growing season this treatment produced tomato yields 79% higher than controls. The disease rate for the same treatment was only 5% of that measured in the

controls. Soil PLFA analysis indicates that the mean microbial biomass of the MITC/compost treatment (1.1 ¥ 10^5 pmol/g dry wt) was higher than the controls (77 ¥ 10^5 pmol/g dry wt) and all other treatments except for the compost alone (1.2 ¥ 10^5 pmol/g dry wt). Specific lipid biomarkers were assessed in order to infer microbial community composition. The MITC/compost treatment had the lowest ratio of soil micro-eukaryotes (polyunsaturates) and fungal (18:2w6) biomarkers compared with bacterial biomarkers. From this data a hypothesis could be formed suggesting that a treatment that encourages a high bacteria to fungi ratio in the soil will be effective at disease control.

1500–1520
S08–O–11
MANAGEMENT OF CLUBROOT OF ASIAN BRASSICA CROPS GROWN ON ORGANIC SOILS

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Clubroot of crucifers (*Plasmodiophora brassicae* Woronin) is endemic in most organic soils in Ontario, Canada. Production of cole crops on these soils is limited, but production of Asian *Brassica* crops has increased markedly and clubroot has become an important limiting factor. Applications of lime are recommended for disease management, but results have been variable. Field trials were conducted from 1999 to 2001 evaluate the efficacy calcium cyanamide (Perlka, 50% calcium oxide, 19.8% nitrogen, 1.5% magnesium oxide) for the management of clubroot on muck soil (60% organic matter, pH 6.4). Shanghai pak choy (*Brassica rapa* subsp. *chinensis* var. communius and flowering Chinese cabbage (*B. rapa* subsp. *chinensis* var. *utilis*) were direct seeded in June and August of each year, along with Chinese broccoli (*B. oleracea* var. *alboglabra*) in 1999 and 2000. Perlka at 1000, 500 and 333 (banded) kg/ha, and calcitic lime (4.9 tonnes/ha, 1999 or 8 tonnes/ha, 2000, 2001) were incorporated 14 days before seeding, or in the fall of 2000, prior to seeding in 2001. The untreated check received 200 kg/ha N. In 2000 and 2001, a treatment of 1000 kg/ha Perlka, applied 7 days before seeding, and an additional check with 100 kg/ha N, were included. In the trails seeded in June, all rates of Perlka reduced clubroot incidence (ave. 16%) compared to the untreated check (43%) and lime treatments (33%). Shanghai pak choy had a consistently higher incidence of clubroot than flowering Chinese cabbage (71% vs. 36% in 2001). Clubroot incidence was much lower in the trials seeded in August (maximum 10.9% and 5.8% disease in 1999 and 2000) and no significant differences were detected. Under high disease pressure, clubroot incidence was effectively reduced by Perlka soil amendments. Application of lime was not effective. Crop selection and timing of seeding can also be used to manage clubroot.

1520–1540
S08–O–12
INTERACTION OF PREPLANT TREATMENTS, FERTILIZER APPLICATION TIME AND METHOD, AND CULTIVAR ON PERFORMANCE OF APPLES IN A REPLANT SITE

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After a mature orchard was removed following harvest planting beds of 1.2 m (w) ¥ 122.4 m (l) ¥ 0.20 m (h) were formed and preplant treatments of 1) an untreated check, 2) winter solarization (covered with 1.5 mil black polyethylene) for 6 months, and 3) winter solarization plus soil fumigation with methyl-bromide at 668 kg/ha were applied. Two apple cvs on M.26 (1) Jonee, and 2) Smoothee) were planted at 6 m between trees within rows with guard trees at 3 m spacing, and rows 5 m apart. Six annual fertilzer treatments were applied following planting: 1) no fertilizer, 2) spring top-dress, 3) fall top dress, 4) split spring/fall top-dress, 5) spring fertigation, 6) fall fertigation. Fertilizer application was based upon standard recommendations with equal amounts of N, P, K being applied. The trial was a random complete block, split-split plot design with main plots being cultivar, the split-plot as preplant treatment, and the split-split plot as fertilizer application method with 6 replications of each factorial combination. After 9 seasons and 8 years harvest, the cv Smoothee had greater yields (totally and annually) than Jonee but similar production efficiency. Trees in fumigated plots were somewhat larger than control trees although after 9 seasons there was no difference in tree height. Trees in fumigated plots had greater yields and average fruit size than those from untreated controls. Yields of trees in solarized plots were intermediate to the fumigated and control trees although not statistically different than controls. Fertilized trees had more and larger fruit than unfertilized controls. There was no significant difference between spring and fall fertilizer applications for yield. Tree size and corresponding yield in spring fertigated plots was less than other fertilizer treatments. Spring fertigated trees have very high levels of foliar Mn and showed symptoms of Mn-toxicity induced bark necrosis beginning in the 3rd season

1540–1600
S08–O–13
LIMING AND CALCIUM CYANAMIDE FOR CLUBROOT CONTROL IN CAULIFLOWER

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Clubroot of crucifers is a major problem in worldwide. Liming has been used as a control measure since the early 19th century. Liming must be done so as to raise soil pH to a suitable level as quickly as possible. For this purpose, relatively massive applications may be used sometimes with faster acting lime types than agricultural lime. However, the single use of lime often falls short of a satisfactory control on the disease. This study compared the effects of six control strategies involving calcium cyanamide, a nitrogen fertilizer known as having disease control properties, together with lime treatments in a randomized latin square design for a cauliflower crop. Application of calcitic lime [$CaCO_3$] was made in fall, just after ploughing. Two rates were applied (5 t/ha and 25 t/ha). In spring, calcium cyanamide (500 kg CyCa/ha preplant or post-planting) and hydrated lime [CaOH] (1,5 t/ha banded at planting) treatments were applied on top of the different calcitic lime treatments. Soil pH was monitored throughout the growing season. Even if the control plot received 5 t/ha of calcitic lime, the yield losses caused by clubroot was important with a marketable yield of only 1,2 t/ha. The best control strategy was calcium cyanamide applied in preplant on top of 25 t/ha of calcitic lime, with a marketable yield of 18,8 t/ha. Hydrated lime banded at planting in combination with 5 t/ha of calcitic lime also showed good results, with a marketable yield of 13,1 t/ha. Our results indicate a synergetic effect among treatments. Calcitic lime application alone, even at 25 t/ha, did not provide satisfactory control. Considering that warm temperature with drought affected cauliflowers yields during the 2001 season, the results obtained are particularly promising.

1600–1620
S08–O–13–A
TO BE ANNOUNCED

1620–1640
S08–O–13–B
TO BE ANNOUNCED

1640–1700
S08–O–13–C
TO BE ANNOUNCED

Tuesday · August 13

1100–1140
S08–O–14
MICROBIAL OPTIMISATION IN SOILLESS CULTIVATION: A REPLACEMENT FOR METHYL BROMIDE

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In Europe the soil fumigant methyl bromide is still in use to control soilborne diseases in greenhouses and field-grown vegetables. Methyl bromide is extremely

toxic and harmful to the environment. New European regulations require a reduction of methyl bromide use to 50% of the 1991 level by the end of 2005 for all sectors. Replacement of soil-grown crops by closed soilless growing systems has significant advantages: conservation of scarce water resources, no leaching of nutrients and pesticides and improved crop quality. A disadvantage of closed systems is the potentially rapid dispersal of soilborne pathogens by the recirculating nutrient solution. Disinfection of the nutrient solution either by active (sterilisation) or passive (part of the resident microflora survives the treatment) methods may eliminate harmful pathogens, but it has been suggested that with passive methods a suppressive microflora can be built up, preventing (severe) outbreaks of certain pathogens. A 4-year EU-funded project aimed to characterise the (suppressive) microflora in the nutrient solutions and assess temporal changes in these microbial populations during the cultivation of three crops (tomato, cucumber, gerbera). Part of each crop was inoculated with *Pythium aphanidermatum* or *Phytophthora cryptogea*, whilst the recirculating nutrient solution was disinfected either with Ultra Violet radiation (active method) or slow sand filtration (passive method). Results indicate that disinfection of the nutrient solution is needed to achieve economic yields. It was not proven that a more suppressive microflora could be built up by a passive disinfection method than with active disinfection. However, a shift in the composition of the microflora could be detected, depending on the disinfection method. Application of certain antagonists also shifted the composition of the total microflora during cropping, but did not increase the suppression of either of the target pathogens. A review of results will be presented.

1140–1200
S08–O–15
EVALUATION OF *PAENIBACILLUS POLYMYXA* PKB1 FOR BIOCONTROL OF *PYTHIUM* DISEASE OF CUCUMBER IN HYDROPONIC SYSTEMS

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Seedling blight and root rot caused by *Pythium* spp. is an important disease in greenhouse cucumber plants. Growers suffer considerable economic losses due to the disease every year. Effectiveness of the bacterium *Paenibacillus polymyxa* PKB1 was evaluated for its ability to protect cucumber plants against *Pythium* spp. in vitro and in hydroponic systems in a greenhouse. In the in vitro test, *P. polymyxa* PKB1 showed inhibitory effect against nine *Pythium* strains isolated from cucumber roots, on potato dextrose agar and nutrient agar plates. *Paenibacillus polymyxa* PKB1-coated cucumber seeds had significantly higher germination and survival rates than uncoated seeds when tested against *Pythium* spp. on water agar plates. In the greenhouse test, the bacterium was added at the rate of 1 ¥ 10^6 spores/mL to circulated and non-circulated nutrient solution in hydroponic systems. The bacterium survived in the nutrient solution and significantly reduced the disease severity of cucumber plants in both the systems. The yield of bacterium-treated cucumber plants was significantly higher than those of *Pythium*-treated or untreated control plants. In the treatment containing *P. polymyxa* PKB1 without *Pythium*-inoculant, the bacterium protected the plants from opportunistic fungal infections, resulting in significantly higher plant root dry weight and cucumber yield. The results of the present study demonstrate that *P. polymyxa* PKB1 has good potential as a protective biocontrol agent in greenhouse cucumber industry.

1200–1220
S08–O–16
PHYSIOLOGICAL CHANGES ASSOCIATED WITH *PYTHIUM* ROOT ROT IN HYDROPONIC LETTUCE AND CHRYSANTHEMUM

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Whole plant and leaf level alterations accompanying *Pythium* infection in two vegetative greenhouse crops, lettuce and chrysanthemum, were examined. Hydroponic lettuce (*Lactuca sativa* L.) inoculated with *Pythium dissocotum* displayed cultivar-specific reductions in primary productivity associated with disease progression. Bella Green, a susceptible cultivar, showed inhibited whole plant photosynthesis (measured as NCER, net carbon exchange rate) and C accumulation, resulting in 35%–40% growth reductions (leaf area, shoot dry weight). Source leaf gas exchange and export of ^{14}C were reduced as early as 7 days after inoculation (DAI). In contrast, the more resistant cultivar, Buttercrunch, showed signs of rapid recovery following inoculation, with plentiful root regrowth, minimal alterations in whole plant NCER and C gain, and no evidence of growth inhibition at final harvest. Buttercrunch displayed no differences in leaf gas exchange or export of fixed ^{14}C associated with *Pythium* infection; however, the allocation pattern was markedly different between 14 and 21 DAI, indicating that roots were a more dominant sink early in the infection process until resistance was established. Hydroponic chrysanthemum (*Chrysanthemum morifolium* L. cv Fina) inoculated with *Pythium aphanidermatum* showed whole plant photosynthetic responses similar to the susceptible lettuce cultivar under low light conditions. Transpiration was also less inhibited in infected chrysanthemum plants, consistent with the expected vascular and/or cortical blockage associated with *Pythium* root rots. In summary, C metabolism and water relations were significantly affected by *Pythium* infection in both lettuce and chrysanthemum, indicating that physiological parameters may be useful in early diagnosis of root disease and more accurate than visual parameters such as root browning.

1220–1240
S08–O–17
TO BE ANNOUNCED

1340–1440
S08–P–18
ROOT-KNOT NEMATODE CONTROL WITH CHEMIGATION THROUGH DRIP IRRIGATION ON CUCUMBERS

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Root-knot nematode, *Meloidogyne hapla*, is a problem on late season cucurbits in southern New Jersey. Soil temperatures rise through the season along with nematode populations and control is necessary before planting cucurbits on sandy loam soils. This study compared the use of a soil fumigant, metam-sodium, to a nematicide, oxamyl, on cucumbers. The metam-sodium was injected through 3 drip lines 19 days before seeding at a rate of 50 gal/acre. The oxamyl was applied through the drip irrigation at 1 qt/acre, 2 qt/acre, 1 gal/acre, and at 2 qt/acre plus 50 gal metam-sodium. The oxamyl treatments were applied over the growing season at different intervals so that the total amount delivered before harvest was 5 qt/acre, 2 gal/acre, 3 gal/acre, and 1 gal/acre plus the 50 gal metam-sodium rate. The cucumbers were harvested six times and evaluated for early yield, total yield, vigor, and root galling percentages in a galling index system (GIS). Root-knot nematode levels were high in this study and the metam-sodium treatments showed significantly greater early and total yield compared to the untreated check. The oxamyl treatment at the high rate (3 gal/acre) reduced the root galling equal to the metam-sodium treatment, but was not as effective on cucumber yield or vigor.

1340–1440
S08–P–19
EFFECTS OF *MELODOGYNE INCOGNITA* AND *FUSARIUM SOLANI* ON THE GROWTH AND YIELD OF TOMATO CULTIVARS

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The objective of the study was to investigate the combined effect of *Fusarium solani* and *Meloidogyne incognita* on the growth and yield of three tomato cultivars, Fadebegye (regarded locally as highly resistant) Awisa 2E (tolerant) and NR 44 Local (susceptible). The trial was carried out at the Experimental Farm of the Univ. of Cape Coast Ghana, during the 1997 farming season in pots. Reduction in plant height, biomass, root length, root weight, number of flower per plant and mean fruit weight were significant between the control and the concomitant treatments in all the cultivars. Also yield reduction was significant when seedlings were inoculated with nematodes 2 weeks prior to the fungus. There was significant increase in root-knot severity in treatments inoculated

concomitantly with fungi and nematodes compared with treatments where seedlings were inoculated with nematode alone. Although concomitant inoculation of fungus and nematode did not affect wilt severity, it resulted in significant yield reduction of NR 44 Local and Awisa 2E. Wilt severity and yield of Fadebegye on the other hand was not significantly affected by the combined infection of the fungus and the root-knot nematode. It was concluded that the combine inoculations of the *M. incognita* and the *F. solani* significantly reduce yield of both Awisa 2E and NR44 Local and that measures to prevent the spread of both pathogens in the field and nursery would be beneficial.

1440–1500

S08–O–20

BIOLOGICAL CONTROL OF *FUSARIUM* AND *PYTHIUM* ROOT ROTS ON GREENHOUSE CUCUMBERS GROWN IN ROCKWOOL

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The two most important root rot pathogens on greenhouse cucumbers in British Columbia are *Fusarium oxysporum* f.sp. *radicis-cucumerinum* and *Pythium aphanidermatum*, for which there are no chemical pesticides registered for disease control. Biological control agents (BCA) may therefore provide a potential means of disease control if efficacy data were available to support their use. Several commercially available BCA were evaluated for their ability to reduce disease due to these two pathogens. Mycostop (*Streptomyces griseoviridis* strain K61), Plantshield (*Trichoderma harzianum* strain T-22), Soilgard (*Gliocladium virens* strain GL-21), and Prestop and Primastop (*Gliocladium catenulatum* strain J1446) were each evaluated for their potential to reduce root and stem rot (RSR) due to *Fusarium* and root rot and damping-off (DO) due to *P. aphanidermatum* on cucumbers grown in rockwool. Each BCA was applied to the germination plug of rockwool blocks as a drench, or was incorporated into vermiculite and then added to the plug, at seeding time. For RSR, the pathogen was applied 24 hours after seeding as a drench and disease development was evaluated after 35 days. For DO, the BCA was applied at seeding and again 11 days after seeding, followed by the pathogen 24 hours later. Disease development was evaluated after 19 days. The most effective BCA in reducing mortality (by up to 65%) due to RSR and DO were Prestop and Primastop, while Mycostop also reduced both diseases, but to a lesser extent. Ambient humidity appeared to affect the efficacy of these BCA against DO, with Mycostop requiring high humidity (>90%) and Primastop performing well at low relative humidity (<70%). Plantshield and Soilgard did not reduce RSR or DO significantly. The application of commercially available BCA at seeding time has the potential to reduce the severity of *Fusarium* and *Pythium* root rots on cucumbers grown under greenhouse conditions.

1500–1520

S08–O–21

CHLORINE DISINFECTION OF RECYCLING EFFLUENTS OF ROSE CROPS CONSEQUENCES ON THE RHIZOSPHERE BACTERIAL COMMUNITIES

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In soilless cultures, the process of recycling drainage water is a good way to implement the laws with respect to water-saving and limiting polluting effluents. Nevertheless, it is possible that this process could favour the dissemination of pathogens. To avoid potential risks for plant health, the disinfection of irrigation water is an alternative. Several techniques of disinfection were estimated and the chlorination, usually used for the treatment of drinking water, presented the best efficiency-cost ratio. This method was applied to soilless cultures of tomato, gerbera and rose. The reliable and successful results stemming from these experiments allowed an application of the technique in commercial greenhouses. However, key questions remained unresolved :–What are the agronomic consequences of a long-term treatment ? What is chlorine action on the rhizosphere bacterial communities? The first step to answer to these questions was to conceive a trial allowing a maximal control of the plant environment. A partial management of the greenhouse climate as well as the use of the NFT (Nutrient Film Technique) allowed to reach this objective. The pH was regulated at 6 on chlorinated and on non-chlorinated cultures. The rate of chlorine applied was maintained at 0,15 ppm. On the agronomic side, yields, kinetics of growth, photosynthetic activity and quality post-harvest were compared between the non-chlorinated and the chlorinated cultures. On the microbiological side, the application of the technique PCR-SSCP (Single Strand Conformation Polymorphism) allowed to develop an interesting approach to follow-up the rhizosphere bacterial communities. Chlorine had a significative action on bacterial diversity.

1520–1540

S08–O–22

SLOW SAND FILTRATION AS METHOD TO REDUCE INCIDENCE OF *PHYTOPHTHORA CRYPTOGEA* ON *GERBERA* IN SOILLESS SYSTEM IN ITALY

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The results obtained in different experimental trials carried out under greenhouse conditions in Liguria (Northern Italy) by comparing different nutrient solution disinfestation systems to reduce the spread of *Phytophthora cryptogea* on gerbera are reported. Slow sand filtration and UV radiation were compared in a closed artificially inoculated soilless system in order to evaluate its interest for Italian growers. Disease spread (percent of diseased plants), quality and quantity of production (n flower/plant, n flower/m^2, stem length), nutrient solution conditions (pH, electric conductivity, oxygen saturation) were evaluated. The data collected underline the good efficacy of slow sand filtration and UV radiation. Slow sand filter adoption seems to be suitable with less maintenance costs. The monitored nutrient solution parameters appeared to be affected by the disinfestation system, with limited effect on flower production.

1540–1600

S08–O–23

EVALUATION OF *TRICHODERMA HARZIANUM* STRAINS TO CONTROL CROWN AND ROOT ROT OF GREENHOUSE FRESH-MARKET TOMATOES

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Greenhouse tomato growers in the United States have few products available for chemical control of plant pathogens. Biological control of soilborne plant pathogens by antagonistic microorganisms is a potential alternative to the use of chemical pesticides during greenhouse production. Biological control experiments were conducted to test the effects of commercial and noncommercial strains of *Trichoderma harzianum* against *Fusarium oxysporum* f. sp. *radicis-lycopersici* on tomato plants grown in two different hydroponic media, coir and rockwool. *Trichoderma harzianum* is fungi that attack a range of economically important phytopathogenic fungi. Tomato (*Lycopersicon esculentum* Mill., cultivar Caruso) plants were inoculated with *T. harzianum* strains (PlantShield, T22 and T95) prior to challenge with the pathogen. They were applied into growing media prior to sowing and to roots at transplanting at two inocula densities, 10^6 or 10^7 conidia/mL. The results of this study demonstrated that *T. harzianum* strains, especially applied at transplanting, decreased disease incidence 79% for coir and 73% for rockwool, decreased disease severity 45% for coir and 48% for rockwool, and increased fruit yield 37% for coir and 21% for rockwool on tomato for *Fusarium* control.

1600–1620

S08–O–24

AUTOMATED DETECTION OF PLANT PATHOGENS IN RECIRCULATING HYDROPONIC SYSTEM—HOW AND WHEN?

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The medical and biosecurity research fields are creating novel diagnostic technologies with unprecedented capabilities for multiplexing, high throughput and portability, which will provide new opportunities for plant pathology

and pathogen detection. Because of the important investments per cultivated unit area, managers of intensive horticultural systems are likely to be the first users of these novel technologies once adapted for agriculture. Implementation of automated microbial detection systems will be more amenable to greenhouses with recirculating systems because sampling and DNA extraction issues will be more readily solved than in other cropping systems. DNA arrays are at the core of many of the existing or under development medical diagnostic devices for multiplex testing. The first DNA array for plant pathology was designed for *Pythium* and *Phytophthora* species. The latest microarray version covers all species of *Pythium* and *Phytophthora* which can be detected in a single assay. It is also possible to detect simultaneously bacterial pathogens and fungal pathogens. A software was designed to identify species specific oligonucleotides from large databases. Once a sequence database of all important pathogenic and beneficial microorganisms in hydroponic systems becomes available, it will be possible to design a DNA microarray capable of providing a profile of the species present at a given sampling time. By producing such microarray inside one of the devices recently developed for medical diagnostics, routine profiling of the microbial community in hydroponic systems should become possible.

1620–1640
S08–O–24–A
TO BE ANNOUNCED

1640–1700
S08–O–24–B
TO BE ANNOUNCED

Thursday · August 15

1100–1140
S08–O–25
PRODUCTION AND UTILIZATION GUIDELINES FOR DISEASE SUPPRESSIVE COMPOSTS

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Composts can provide natural biological control of diseases of roots as well as the foliage of plants. Many factors must be controlled, however, to obtain positive effects consistently. The raw materials from which composts are prepared, the process used to make the compost, the stability or maturity of the compost, microorganisms which colonize the compost after peak heating, and finally, chemical and physical properties of the compost product all affect efficacy in biological control. Loading rates of composts used in the field due to fertility effects of the product have a direct effect on some diseases. Timing of applications relative to cropping cycles also has an effect. Utilization in container media requires even more specific considerations. It is not surprising, therefore, that composts have provided very desirable but also frustratingly negative effects. Quality control in compost production is key to consistent success. For control of diseases caused by pathogens which produce sclerotia, specific biocontrol agents must be inoculated into the compost after peak heating. Specific inoculants also must be introduced to induce systemic resistance in plants. A brief overview of each controllable factor will be presented.

1140–1200
S08–O–26
FURTHER EVALUATION OF THE ALLELOPATHIC POTENTIAL OF FINE LEAF FESCUE CULTIVARS

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One of the main turfgrass species currently used in the Northeast U.S. for turf and lawns, fine and tall fescues (*Festuca rubra* L. and *Festuca arundinacea* Schreb.) have long been reported to possess strong allelopathic properties, which are genotype-dependant. Based on the evaluation of the 78 fine leaf fescue cultivars established for the National Turfgrass Evaluation Program (NTEP), we observed a consistent difference in weed suppressive ability among the cultivars over two growing seasons, with several exhibiting strong weed suppression in the field. Using agar and sand media, laboratory evaluation of the allelopathic potential of eight suppressive fine leaf fescue cultivars was performed using seedling bioassays with selected weed species. Weed suppression was shown to be cultivar-dependant with four cultivars exhibiting strong allelopathic potential. The living root systems of all eight cultivars of fine fescue studied exuded growth inhibitors into the rhizosphere of developing weed seedlings, resulting in significant growth reductions and chlorosis. Light microscopy of the living root system revealed that two week old fine leaf fescue seedlings exuded tiny droplets of yellow-brown substance. For chemical and physiological studies, this root exudate was collected using a modified capillary mat system, which resulted in the production of large quantities of healthy root tissue and root exudate. Using microscopic evaluation, the root exudate production appears to be localized in actively dividing root tissue. Presently, we are elucidating the chemical structures and the mode of action of the bioactive substances contained in fine leaf fescue root exudates. We are also evaluating a diverse collection of fescue germplasm to select for enhanced weed suppressivity, using both traditional and molecular approaches, and we hope to produce a turfgrass requiring significantly reduced herbicide application for use in home, public, or commercial settings.

1200–1220
S08–O–27
SNAP BEAN COMMON ROOT ROT SUPPRESSION AND SOIL PROPERTIES IN AN AMENDED SAND

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The objective of this study was to determine the relationships between soil properties and suppressiveness to common root rot of snap bean (causal agent *Aphanomyces euteiches*) in an amended sandy field soil decomposing over time. Soils were sampled from a field trial conducted on a Plainfield sandy loam in Hancock, WI. Field trial treatment soils were amended each year from 1998 to 2001 with two rates of raw paper mill sludge (PS; applied at 22 and 33 dry Mg/ha) and composted paper mill sludge (PSC; 38 and 76 dry Mg/ha). A fertilized unamended treatment was used as a control. Treatment soils were sampled in April 2001 (1 year after amendment and before annual reamendment) and September 2001 (5 months after reamendment). Treatment soils were incubated at room temperature and assayed for suppressiveness and soil properties monthly. Soils were assayed for root rot suppressiveness with a greenhouse snap bean root rot bioassay. Four seeds of snap bean "91G" were sown in treatment soils placed in cone tubes. Root rot was rated after one month as: 0 = healthy; 1 = slightly discolored roots, hypocotyl firm; 2 = moderately discolored roots, hypocotyl collapses under pressure; 3 = darkly discolored roots, hypocotyl collapses easily under pressure; 4 = dead or dying plant. Soils were assayed for beta-glucosidase, aryl sulfatase, and fluorescein diacetate activities; microbial biomass carbon (by chloroform fumigation); and water stable aggregation. Preliminary data indicate that common root rot of snap bean was suppressed by both PS and PSC, and that high rates were more suppressive than low rates. Root rot severity was negatively related to beta-glucosidase and aryl sulfatase activities. More complete data on the relationships between soil properties and root rot suppression as treatment soils decomposed over time will be presented.

1220–1240
S08–O–28
POTATO GENOTYPES, A TOOL FOR MANAGING SOILBORNE PATHOGENS—A SUMMARY

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Verticillium resistant potato clones [A68113-4(-4) and A66107-51(-51)] suppressed increases of inoculum densities (ID) of *Verticillium dahliae* in soil and *Verticillium* wilt of potato >50% when susceptible varieties were grown in the same locations following resistant clones (–4 and –51). Suppression occurred even though *V. dahliae* ID was sufficiently high for maximum disease development (>80 g cfu/g of soil). Significant increases of suppressive factors occurred with the growing of the resistant –51 clone. The cropping of –51 was accompanied by significant increases of bacterial antagonists in both the rhizosphere and

on roots along with increases of populations of nitrogen-fixing bacteria (*Azotobacter* and *Azomonas*) in both the soil and rhizoplane. In addition to increases of beneficial bacteria, the growing of resistant clones (–4 and –51) resulted in 8–50 fold increases of a fungal biocontrol agent, *Verticillium tricorpus*, compared to the susceptible Russet Burbank. These studies demonstrate the effects of potato genotypes on both soil ecology and *Verticillium* wilt control. In addition to effects on bacterial and fungal populations, the Butte potato also suppressed root lesion nematode populations in a manner that was similar to either of two nematocides (isophenphos and aldicarb) at recommended rates, and showed biocontrol against both *Pratylenchus neglectus* and *P. penetrans*. These results are based on over 15 years of research at the Univ. of Idaho Research Center, Aberdeen.

1340–1440

S08–P–29

MICROBIOLOGICAL EVALUATION OF VARIOUS RHIZOSPHERE SOILS OF OLD ORCHARDS

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Soil samples of 32 years old orchards of mango (*Mangifera indica*), grapes (*Vitis vinifera*), guava (*Psidium guajava*), citrus (*Citrus paradisi* Macf) and jujube (*Ziziphus mauritiana*) were collected near the secondary, tertiary and feeder roots to evaluate the different rhizosphere soils in respect to the population of various microorganisms. Results revealed that among the various rhizosphere soils, maximum microbial population was recorded in the soil of old jujube orchard whereas it was least in the soils of mango orchards. Jujube orchard soils contained maximum bacterial population with *Bacillus* as the predominant genera.

1340–1440

S08–P–30

HOST RANGE, PROTEIN PATTERN AND BIOCHEMICAL CHARACTERISTICS OF THE STRAINS OF *XANTHOMONAS AXONOPODIS* PV. *CITRI* AND *XANTHOMONAS AXONOPODIS* PV.? FROM IRAN

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Citrus bacterial canker disease for more than a decade is prevalent on *Citrus aurantifolia* and *C. limettioides* and causes economic crop losses in Iran. Phenotypic features, protein pattern and host range of the isolated strains of the causal bacterium were determined. Results showed two distinct groups of the strains based on their host range pattern. First group were pathogenic on *C. aurantifolia*, *C. limettioides*, *C. limon*, *C. jambhiri*, *C. aurantium*, *C. sinensis*, *C.grandis, C. paradisi*, *Poncirus trifoliata*, *P. trifoliata* x *C. paradisi*, *C. medica*, *C. reticulata* and *C. sinensis* x *P. trifoliata* similar to *X. a. pv. citri*. Strains of the second group were pathogenic on *C. aurantifolia*, *C. limettioides*, *C. limon*, *C. jambhiri*, *C. aurantium* and *P. trifoliata* x *C. paradisi* and they were unique based on this approach. Protein electrophoretic pattern analysis by Gel Compar software and determination of phenotypic features by BIOLOG system could not differentiated strains from two pathogenicity groups. Studied strains formed different clusters not matched with host range pattern by both methods.

1340–1440

S08–P–31

INFLUENCE OF FUSANTS OF *PSEUDOMONAS PUTIDA* AND *AZOTOBACTER VINELANDII* ON THE GROWTH AND YIELD OF TOMATO

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To improve the yield of crops in an environmentally desirable way, a single strain of bacteria created by protoplast fusion of two or more bacteria could be used as biofertilizer. The fused bacteria typically display the desirable properties of the individual strains. In this context, the paper examined the growth promoting performance of *Azotobacter vinelandii* (N fixer) and *Pseudomonas putida* (phosphate solubilizer) on tomato (*Lycopersicon esculentum*) var. Pathar Kutchi. Through in vitro and in vivo experiments, it was established that the newly generated strain by protoplast fusion of the two bacteria had the property of both nitrogen fixation and phosphate solubilization. The different bacterial cultures—individual, mixed (1:1) as well as fused—were applied on tomato in three different ways, viz., i) seed treatment by impregnation method (SEED), ii) soil treatment—where inoculum was applied 1 day before seeding (SOIL1), and iii) soil treatment—where inoculum was applied 5 days before seeding (SOIL2). The impact on several growth parameters such as plant height, plant dry biomass, number of flowers per plant, number of fruits per plant etc. were studied. It was found that for most of the growth parameters, the growth of treated plants for both the mixture and the fused bacterial culture—irrespective of application treatment—led to higher yield in tomato compared to the control and the individual bacterial treatments (in case of SOIL2 plant height and fruit numbers were respectively, control-29.6 cm, 0; *P. putida*-36 cm, 1; *A.vinelandii*-45.3 cm, 2; mixed-53.1 cm, 3; fused-55 cm, 3) establishing that bacteria obtained by protoplast fusion can significantly increase the yield of tomato.

1440–1500

S08–O–32

SUPPRESSING SOILBORNE PATHOGENS THROUGH BIOSTIMULATION

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Integrated Crop Management (ICM) aims to encourage the activities of benign soil microbes which are antagonistic to soilborne pathogens. Biostimulants have the potential to become important components in ICM strategies. Biostimulants are natural or synthetic products of either mineral or organic composition that by their mode of action positively contribute to crop nutrition and the development of healthy plants. Research has investigated biostimulants containing active ingredients such as amino acids, quaternary ammonium compounds (betaines), carbohydrates (laminarin), fatty acids (triacontanol), vitamins (folic acid) and growth regulators (indoles, gibberellins, cytokinins). Soils and substrates treated with biostimulants show substantially increased microbial activity. This has been quantified through enhanced production of extra cellular enzymes, increased ATP and ergosterol concentrations and numbers of fluorescent *Pseudomonas* spp. The infection court must contain biostimulants in advance of the onset of pathogen invasion. Hosts treated with biostimulants show increases in several components such as leaf area, chlorophyll content, stomatal numbers, root length and volume, root and aerial fresh and dry weight and seed size and number. The effects of biostimulants resemble aspects of natural soil suppressiveness. Possibly they also stimulate forms of acquired host resistance. These attributes will be discussed.

1500–1520

S08–O–33

INFLUENCE OF ARBUSCULAR MYCORRHIZAL FUNGI AND *MELOEDOGYNE INCOGNITA* ON ENZYME ACTIVITY IN GRAPE ROOTS

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The potential role of mycorrhizal fungi as biocontrol agents for nematode has received considerable attention, but little was known about the mechanisms of the nematode control in mycorrhizal root. Grape cultivars 'Kyoho' and 'Shuangyou' were inoculated with arbuscular mycorrhizal (AM) fungus, *Glomus versiforme* Berch and root-knot nematode (*Meloidogyne incognita*). The mycorrhizal colonization, root-knot nematode penetration, dynamic changes in activities of peroxidase (POD), phenylalinine ammonia-lyase (PAL), ß-1 3-glucanase and chitinase in grape roots were analyzed at intervals. Results showed that root colonization by *G. versiforme* was not affected by the presence of pathogen root-knot nematode, but penetration rate of root-knot nematode was consistently lower in the grape roots pre-inoculated with *G. versiforme* in comparison to that in non-mycorrhizal grape roots inoculated with root-knot nematode. Activities of the four enzymes in grape roots colonized by *G. versiforme* were higher than that in control roots, and they were also higher in roots pre-inoculated with the fungus and post-inoculated with *M. incognita* than that in non-mycorrhizal roots inoculated with M. incognita. Furthermore, the peaks of enzyme activities in grape roots pre-inoculated with the fungus and post-inoculated with *M. incognita* appeared earlier than that in non-mycorrhizal roots inoculated with *M. incognita*, in addition,

the time when the peaks occurred was just when the AM fungi colonization increased and root-knot nematode penetration decreased fast in the mycorrhizal grape roots inoculated with *M. incognita*. It was suggested that AM fungi could activate firstly the defense mechanism of grape, and then predispose the grape roots react quickly to *M. incognita* infection.

1520–1540
S08–O–34
GENE ISOLATION FOR GENETICALLY ENGINEERING BIOHERBICIDE PRODUCTION INTO CROPS

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Weed control is very important to crops. Allelopathy offers potential for biorational weed control through the production and release of allelochemics, chemicals not toxic to the originating plant but toxic to other vegetation. Sorghum (*Sorghum bicolor* L. Moench) roots exude a potent bioherbicide–sorgoleone (2-hydroxy-5-methoxy-3-[(8'Z, 11'Z)- 8', 11', 14'-pentadecatriene]-p-benzoquinone). It is produced in living root hairs and is phytotoxic to broadleaf and grass weeds at concentrations as low as 10 μM. Our laboratory has attempted to isolate the gene(s) responsible for sorgoleone production in sorghum root hairs in order to gain a better understanding of the regulation of production of root exudates, and possibly to genetically engineer allelochemical production into other agronomic crops. We have isolated a candidate gene from sorghum cv. SX-17 roots. This gene, named SOR9, was shown to express exclusively in hair-plus sorghum roots. Previous work in our laboratory, by M. Czarnota, revealed that johnsongrass roots produced ≈10 times more sorgoleone than sorghum cv. SX-17 roots, and ≈20 times as much sorgoleone as shattercane roots. The expression level of SOR9, as measured by quantitative PCR analysis, was much higher in johnsongrass roots than in sorghum or shattercane roots. Sequence analysis of SOR9 has confirmed that this gene is a novel desaturase, which might be involved in the formation of unique specific double bond within the long hydrocarbon tail of sorgoleone. SOR9 could not be detected in wheat 2552 (Pioneer), corn 37M81 (Pioneer), sweet corn 725 (Thompson & Morgan) and rice cv. Cocodrie and cv. Cypress (RiceTec) using PCR analysis of genomic DNA.

1540–1600
S08–O–35
***PASTEURIA PENETRANS* AND ITS POTENTIAL FOR THE CONTROL OF NEMATODES IN GHANA**

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Shade house studies were undertaken at KNUST., Kumasi, Ghana, to assess the potential of two isolates of *Pasteuria penetrans* from Malawi and Trinidad singly and in a mixture for the control of a mixed population of root-knot nematodes, *Meloidogyne* species. A local cultivar of tomato used as a test crop was inoculated (at transplanting) with second stage Meloidogyne larvae pre incubated with the bacteria. The experimental design was a Completely Randomised Block Design (CRBD) with three treatments and a control and replicated five times. All the treatments incorporating *P. penetrans* whether singly or in a mixture suppressed root gall formation by up to 60%. The treatments also reduced the final numbers of larvae of root-knot nematodes by up to 75%. Fresh shoot and root weight increases for the single bacteria treatments were not significant when compared with the weights of the control, that is, the nematode alone treatments. The treatments with the mixture of the two isolates of *P. penetrans* however, gave significant increases in fresh shoot and root weights. It was also observed that all the three treatments resulted in significant increases (P = 0.01) in plant heights when compared with the nematode alone treatment. In all the observations the mixture of the two isolates of the bacteria performed better than the single isolates. It is now established that *P. penetrans* can suppress root-knot nematodes on tomatoes in Ghana resulting in better plant growth. Further research is needed for search for local isolates of the bacteria for the management of plant nematode pests in Ghana.

1600–1620
S08–O–36
IMPACT OF RAW AND COMPOSTED DAIRY MANURE AMENDMENTS ON CORN AND BEAN ROOT ROTS IN A VEGETABLE ROTATION

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The objective of this work was to determine the effect of raw and composted dairy manure amendments on a sweet corn root rot complex (putative causal agents, *Phoma* and *Pythium* spp.) and snap bean root rot (causal agents *Fusarium solani* f. sp. *phaseoli*, *Rhizoctonia solani*, and *Pythium* spp.) in a western Oregon processed vegetable rotation. A field trial was established on a continuously cropped vegetable field in April 2001. Treatments included two rates of fresh (MS) and composted (MSC) dairy manure separated solids amended at low (L) and high (H) rates (MSC, 28.0/56.3 dry Mg·ha^{-1} ; MS, 16.8/33.6 dry Mg·ha^{-1}) and an unamended control. Treatments were applied in May and plots were planted to sweet corn 'Golden Jubilee' in June. In situ sweet corn and snap bean root rot bioassays were planted in June and evaluated 5 weeks later. Greenhouse bean and corn root rot bioassays were conducted in cone tubes during the same period. Yield and quality of the field grown sweet corn was assessed. There were no treatment effects on sweet corn or snap bean root rot severity in in situ root rot bioassays. In greenhouse bioassays, all amended treatments significantly reduced the severity of bean root rot relative to the control. Corn root rot incidence in greenhouse bioassays was significantly lower than the control in MSC H, MSC L, and MS H. Fluorescein diacetate activity was significantly higher in MSC H and MS H than in all other treatments. Sweet corn yields were significantly higher in the unamended and MSC H treatments. More complete data on the relationships between soil properties (total organic matter, protected and unprotected light fraction, microbial activity, bulk density, and macro- and micronutrients) and root rot incidence will be presented.

1620–1640
S08–O–36–A
TO BE ANNOUNCED

1640–1700
S08–O–36–B
TO BE ANNOUNCED

Friday · August 16

0800–0900
S08–P–37
BIOLOGICAL CONTROL OF ROOT-KNOT NEMATODE (*MELOIDOGYNE* SP.) ON TISSUE CULTURE BANANA (DWARF CAVENDISH CV BASARAI)

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Biocontrol powder phule *Thricoderma* has been successfully used on a number of horticultural crops. The present investigation was carried out to explore the nematicidal properties of phule *Thricoderma* against the root-knot nematode (*Meloidogyne* sp.) infesting the tissue culture banana (Dwarf Cavendish cv Basarai). In vitro tests showed that the various concentrations of phule *Thricoderma* prevented nematode egg hatch and resulted in 100% mortality of nematode juveniles. Tissue culture banana plantlets were also dipped into various concentrations of phule *Thricoderma* before planting out into plastic bags. And each plantlet was inoculated with 250 nematode juveniles and after 10 days, the roots were stained with cotton blue lactophenol and nematodes counted under a dissecting microscope. The results indicated that the higher the concentration of phule *Thricoderma* in banana plantlets, the lower the ability of the nematode to penetrate the roots. Furthermore, the nematode juveniles that entered into the treated roots were found dead; and this could have resulted from the toxic metabolites produced from phule *Thricoderma*. Also, root zone treatment of plants treated with phule *Thricoderma* prevented the development of gaint cells and roots Knots

in treated plants while the development of glant cells and root-knots were observed in untreated plants exposed to nematode infestation.

0800–0900

S08–P–38

ESTIMATION OF SOME BIOLOGICAL METHODS OF PINK ROOT ROT CONTROL ON LEEK

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Pink root rot infestation caused by *Pyrenochaeta terrestris* has been observed on onion and leek mostly in south region of Poland. In countries with hot climate where pink root rot is often observed in onion production popular controlling method of this disease is solarisation of the soil for 6–9 weeks or its fumigation. The field experiment was initiated in order to examine various methods of biological controlling of pink root rot on leek grown in naturally infested soil. There were tested 1% and 2% extracts of fresh garlic used in different ways: dipping of seedlings root in water solution before planting with or without supplementary saturation of plants in the field with the same solution, and the only saturation of plants in the field once or twice, after 2–3 and 5–6 weeks from planting date. In another treatments isolates of *Trichoderma viride* tolerant to iprodione were used for inoculation of peat substrate before leek seed sowing. Some transplant roots were treated by water suspension of this antagonist fungus as well as with supplementary saturation of plants in field with 2% solution of Rovral. In chemically controlled treatments 0,1% Topsin 70WP and 2% Rrovral FLO 255 SC were used for dipping of transplants roots. Results of three years study proved suitability of biological methods in controlling pink root rot in leek production. The most simple and effective disease control was provided by dipping of leek transplant root in 2% extract of fresh garlic solution, but also the other methods of using this extract like using 0,1% Topsin application were also efficient and gave similar effect. Garlic extract as well as *Trichoderma viride* inhibited growth of mycelium in leek roots slightly less than chemical control with Rovral and Topsin.

0800–0900

S08–P–39

EFFECTS OF ARBUSLAR MYCORRHIZAL FUNGI INOCULATION ON THE GROWTH/YIELD AND FRUIT QUALITY OF STRAWBERRY IN REPLANTED SOIL

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The effect of arbuslar mycorrhizal fungi on potted strawberry was studied by inoculating three species of. *Glomus mosseae*, *Glomus intraradices* and *Glomus versiforme* under greenhouse conditions. The mycorrhizal infection rates were different among different fungi species of inoculation. Same fungi species the infection rate were also different from inoculation of one growth stage to another. Under both sterilized and unsterilized soil, the plant growth, average fruit weight, number of fruit per plant and each plant fruit yield were increased significantly by mycorrhizal inoculation. The average plant yield was increased by 27.6%–39.5%. The blooming date was 4–12 days earlier while the mature date was 4 to 6 days earlier compare inoculated plant to non-inoculated. The contents of vitamin C and sugar in strawberry fruit were increased while the content of titratable acid decreased by mycorrhizal inoculation.

0800–0900

S08–P–40

INFLUENCE OF VESICULAR ARBUSCULAR MYCORRHIZA ON THE GROWTH AND YIELD COMPONENTS OF PICKLING CUCUMBERS

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VAM (vesicular arbuscular mycorrhiza) fungi are ubiquitous symbiont of many plant species, including most horticultural crops. Advantages of their application in vegetable crops production are specially expressed in vegetables grown from transplants. Besides being grown by direct sowing of seeds, pickling cucumbers are increasingly grown from transplants, because this enables an easier choice of the optimal planting time aimed at avoiding downy mildew infection. Since good effects of VA mycorrhiza have been proven, it might be expected that early inoculation of cucumber transplants with the endomycorrhizal fungus *Glomus etunicatum* could lead to larger and better developed transplants. Next hypothesis is that cultivars Levina and Furax grown in this way may achieve higher yields and have a better resistance to diseases. On the basis of the results obtained, the authors have concluded that a significant increase in the weight of transplants was achieved in both cultivars inoculated with the VA mycorrhizal fungus *Glomus etunicatum*. A significant increase in the weight of marketable fruits of inoculated plants, in comparison with the check, was achieved only in cultivar Furax.

0800–0900

S08–P–41

TREHALOSE ACCUMULATION IN CARROT PLANTS THROUGH ARBUSCULAR MYCORRHIZAL FUNGUS SYMBIOSIS

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Influence of arbuscular mycorrhizal (AM) fungus symbiosis on composition and content of free sugar in carrot (*Daucus carota* L., cv. Koyo no.2) was investigated. Infection level of AM fungi, *Glomus fasciculatum* (GF) and *Gigaspora margarita* (GM), and plant growth promotion with the increase in dry weight of shoots and roots through symbiosis differed with the fungal species. No difference appeared in water content of both shoots and roots among the treatments. Six or ten weeks after inoculation, exceeding noninoculated plants, almost of the AM plants gave greater values of phosphorus content in shoots and roots. As for HPLC analysis of free sugar (sucrose, glucose, fructose, trehalose) 6 weeks after inoculation, total free sugar content increased in shoots and tap roots of AM plants compared with non-AM ones, irrespective of the fungal species. In this case, free sugars, which caused the increase in total free sugar content, differed among the parts of the plants and fungal species. In non-AM plants, no detection of trehalose occurred, however, trehalose was detected in tap roots with no infection and branched roots with infection in GF and GM plants. Ten weeks after inoculation, total free sugar content gave greater values in both shoots and tap roots of AM plants than in non-AM ones; no difference appeared in branched roots. Trehalose detection occurred in shoots, tap and branched roots of GF plants, while in shoots and tap roots of GM ones. These findings indicate that AM fungus symbiosis affects free sugar content and induces trehalose accumulation in carrot plants.

0900–0940

S08–O–42

NO ABSTRACT PROVIDED

0940–1000

S08–O–43

THE EFFECT OF *TRICHODERMA HARZIANUM* STRAINS ON THE GROWTH OF TOMATO SEEDLINGS

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An experiment was performed with commercial and noncommercial *Trichoderma harzianum* strains to test whether they have any effect on the growth of tomato seedlings. The tomato (*Lycopersicon esculentum* Mill. cv Caruso) seedlings were grown in a greenhouse and watered daily by hand. The 2-week-old seedlings were transplanted into plastic pots filled with potting mix previously inoculated with *Trichoderma harzianum* strains Plantshield, T22, and T95 (10^7 conidia plus mycelial fragments/mL). Randomized complete block design was used and treatments were replicated three times. At 6 weeks, the seedlings were sampled for growth comparisons on seedling emergence, number of true leaves, fresh and dry weights of roots and shoots, stem caliper, shoot height, and root length. The data were subjected to ANOVA and the means tested by LSD. The results demonstrated that *Trichoderma harzianum* strains, except for PlantShield, improved tomato seedling growth. There were differences between the untreated control and the treatments for all of the growth parameters at 4 weeks after inoculation with the exception of seedling emergence, root fresh and dry weight.

1000–1020
S08–O–44
INCREASED SEVERITY OF PEA ROOT ROT CAUSED BY THE SYNERGISTIC INTERACTION OF *APHANOMYCES EUTEICHES* WITH NON-PATHOGENIC *FUSARIUM SOLANI*

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Using pea as a bait host, isolates of *Aphanomyces euteiches*, an important root-rotting pathogen of peas, are routinely recovered from infested soils in Wisconsin. When plating pea tissues infected with *A. euteiches* onto cornmeal agar, isolates of *Fusarium solani* are often recovered as well. This observation led to the establishment of a series of experiments designed to study the effect of single or co-inoculation of *A. euteiches* and/or *F. solani* on disease expression in pea seedlings. Inoculation of pea seedlings with A. euteiches produced typical root rot symptoms, whereas the isolate of *F. solani* selected for study was non-pathogenic to pea. However, co-inoculation of peas with *A. euteiches* and non-pathogenic *F. solani* resulted in significantly ($P = 0.05$) greater disease severity than inoculation with *A. euteiches* alone. Both microorganisms could be reisolated, singly or in combination, from pea seedlings following individual or dual inoculation, respectively. The synergism documented in this study indicates that the interactions of pathogens with nonpathogens colonizing host tissues can have an impact on disease severity. This is one explanation for the reduced performance of disease-resistant plant cultivars which can occur following their introduction to different agroecosystems, each with its own unique associated microbial communities.

1020–1040
S08–O–44–A
TO BE ANNOUNCED

1400–1420
S08–O–45
ANTAGONISTIC EFFECTS OF *TRICHODERMA HARZIANUM* ON *PHYTOPHTHORA DRECHSLERI*, THE CAUSAL AGENT OF CUCUMBER DAMPING–OFF

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Soilborne plant pathogens cause important damages to plant health. One of the most important disease of cucumber is phytophora damping–off caused by *Phytophthora drechsleri* Tucker. Traditionally, the disease has been controlled by fungicides whose ecological damage and pathogen resistance resulting from the use of chemical compounds have prompted research into biological control as an alternative approach. Biocontrol of plant pathogen fungi was carried out by using the antagonistic microorganisms, which among these, *Trichoderma* species are the antagonists of a number of soilborne plant pathogens. Experiments were carried out with one isolate of *Trichoderma harzianum* in comparison with some fungicides: metalaxyl, mancozeb and metalaxyl–mancozeb. This isolate was used to investigate its biocontrol trait in vitro and its ability to suppress the cucumber damping-off in vivo. The antagonistic mechanisms occurred through hyphal contact, coiling vacuolation and lysis. Volatile metabolites of *T. harzianum* caused 86/6% inhibition of fungal growth. The results of antagonist ability to suppress cucumber damping off in vivo indicated that the isolate of *T. harzianum* was effective against *P. drechsleri* in soil microcosms. The cucumber plants were protected 45% with *T. harzianum* isolate. metalaxyl–mancozeb provided about 60% control. The *T. harzianum* isolate increased plant wet weight in comparison with control treatment.

1420–1440
S08–O–46
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.

1440–1500
S08–O–47
ISOLATION OF MICROORGANISMS THE FROM RHIZOSPHERE OF GERBERA GROWN SOILLESS AS POTENTIAL SOURCE OF ANTAGONISTS TO *PHYTOPHTHORA CRYPTOGEA*: PRELIMINARY RESULTS IN ITALY

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The control of *Phytophthora* root rot caused by *Phytophthora cryptogea* on gerbera can be achieved adopting the soilless cultivation system. The necessity to reduce its environmental impact, due to the fertiliser release, stimulate the use of recirculating nutrient solution in a closed system: this can induce an increase of problems due to spread in water of zoospores of *P. cryptogea*. To evaluate the possibility to isolate, select and utilize natural microorganisms as biocontrol agents against *P. cryptogea*, two experimental trials were carried out in greenhouse condition in Liguria (Northern Italy). The data obtained indicate the potential availability of microorganisms able to suppress the root rot and/or to improve the growth and productivity of the crop. The use of microorganisms, evaluated in an open inoculated system, can be considered promising. More problematic, but interesting, seems its usage in a closed system, alone or integrated with a passive nutrient solution disinfestation techniques.

1500–1520
S08–O–48
INTEGRATION OF CHEMICALS AND BIOCONTROL AGENTS IN THE MANAGEMENT OF WHITE ROOT ROT OF APPLE

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White root rot (*Dematophora necatrix*) is a pernicious soilborne disease of apple in India. The disease is highly destructive in nurseries as well as grown up orchards and becomes epidemic during rainy season when the soil moisture and temperature are favourable. Presently the disease is being managed by drenching chemicals deep in the soil, which is not only cumbersome and expensive but also disturbs the soil ecology. Therefore, a study was conducted with the objective to determine the compatibility of biocontrol agent with commercially effective chemicals. The carbendazim fungicide (Bavistin) and biocontrol agents such as *Trichoderma viride*, *T. harzianum*, *Gliocladium virens* and *Enterobacter aerogenes* which were found effective under in vitro and pot trials during the previous studies were further evaluated in different combinations. Bavistin was applied as aqueous suspension at 250 mL/pot (30 cm diameter) at three concentrations viz. 0.025%, 0.05%, 0.1% separately, 48 hour

before application of antagonists, simultaneous and post inoculation stages of the pathogen application. Out of the various chemicals tested under in vitro conditions against antagonists, Bavistin was inhibitory to all the fungal antagonists whereas, mancozeb and phorate were least inhibitory at 200 ppm. However, *E. aerogenes* was insensitive to all these chemicals. The pot evaluation of Bavistin in combination with different antagonists revealed that application of *E. aerogenes* + Bavistin (0.1% or 0.5%) showed more than 92% disease control when applied at preinoculation stage to pathogen. In simultaneous inoculation, 0.1% Bavistin in combination completely prevented the appearance of the disease, however, 0.05% combination with *E. aerogenes*, *T. viride* and *G. virens* gave 90.35%, 86.91%, and 80.96% disease control, respectively. The post-inoculation application of these were less effective. These treatments also delayed the appearance of the disease and increased the weight of the roots as compared to control.

1520–1540
S08–O–49

CONTROL OF *FUSARIUM OXYSPORUM* SCHL. F. SP. *LYCOPERSICI* (SACC.) SNYDER AND HANSEN IN GREENHOUSE TOMATO BY THE USE OF SOIL SOLARIZATION IN COMBINATION WITH CHITIN AND SULPHUR WITH *THIOBACILLUS* SPP.

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Fusarium oxysporum f. sp. *lycopersici* (Fol) responsible for the adrofousariosis of tomato causes serious damages in greenhouse cultivations This trial examined the possibility of controlling Fol through the application of soil solarization in combination with the addition of chitin and sulphur containing several species of the genus *Thobacillus* spp. The experiments lasted two consecutive cultivation periods in unheated plastic greenhouses with tomato Early pack No 7 cultivar. Soil solarization was performed for 3 weeks using transparent polyethylene film of 50 μm thickness for the soil coverage. Chitin and sulphur with *Thiobacillus* were used at the doses of 150 and 100 g/m^2 of the commercial products Antinem and Acidem AVC 50 respectively. In the experimental units where soil solarization in combination with Antinem and Acidem AVC 50 were applied, the percentage of the infected plants was reduced at 1,99 (first period) to 2,02% (second period) while the percentage for the control reached 63,11%–56,18% respectively. Proportional results were observed regarding the criteria of production per plant and number of plants presented apoplexy symptoms. Indeed, in the experimental units where soil solarization in combination with Antinem and Acidem AVC 50 were used, the production per plant ranged from 7,830 to 7,610 kg while plants with apoplexy symptoms were not observed. In the control, these criteria were 3,300-3,530 kg/plant and 18–13,5 dead plants respectively. Results obtained from the treatments where soil was solarized with the simultaneous addition of one of the two commercial products showed potential for practical application. In the conditions of the experiment, it seems that soil solarization in combination with chitin and sulphur with *Thiobacillus* could substitute methyl bromide for the control of adrofousariosis on greenhouse tomato even if soil coverage last only for 3 weeks.

1540–1600
S08–O–50

TO BE ANNOUNCED