MEETING

ABSTRACTS OF PRESENTATIONS AT

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Opening Lecture

The Contribution of Epidemiological Research to Plant Disease Management

D. Shtienberg

Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250, Israel [e-mail: danish@netvision.net.il]

Epidemiological research deals with the three components of the disease triangle: the host, the pathogen and the environment. One important goal of epidemiological research is to develop means for rational and cost-effective disease management. In some pathosystems it is possible to identify one (or a few) distinctive factors that govern(s) the occurrence of disease outbreaks. Manipulation of this factor may enable us to prevent the development of an epidemic. However, in most systems the situation is more complicated and many factors, and their interactions, govern the intensity of epidemics. In the 1970s, models based on past (measured) weather and decision rules were used for development of management tools. With the progress in computer science in the 1980s, models that simulated the development of the host and the pathogen were developed. However, simulation models were found inadequate for decision-making. Epidemiological knowledge is currently formulated as relatively simple, hence precise, decision models. These decision models are the frameworks by which epidemiological knowledge is transferred to the decision-maker. Nevertheless, the models would not necessarily be suitable in dissimilar environments. *(L)*

A: PHYSIOLOGY AND RESISTANCE

Endo-1,4-β-Glucanase Activity in Isolates of *Alternaria alternata* in Relation to Their Virulence in Apple Fruit

M. Reuveni,[1] N. Shegalov,[1] D. Shegalov,[1] D. Eshel,[2] Ruth Ben-Arie[3] and D. Prusky[2]

[1]*Golan Research Institute, Qazrin 12900 [e-mail: mreuveni@research.haifa.ac.il];* [2]*Dept. of Postharvest Science, ARO, The Volcani Center, Bet Dagan 50250; and* [3]*Fruit Storage Research Laboratory, Qiryat Shemona 10200, Israel*

The fungus *Alternaria alternata* is one of the principal causal agents of moldy core rot of different strains of 'Delicious' apples. Disease symptoms generally become apparent after cold storage of the fruit, even though the apple core becomes infected in the orchard. Suitable temperature and humidity conditions in the orchard are evidently conducive to inoculation, but the mode and phenology of infection are not yet clearly understood. Artificial inoculation with fungal spores, of fruits at different stages of development, indicated that the initial blossom (10–30%) and full bloom stages were the most susceptible to infection. Of the 150 *A. alternata* isolates collected in three orchards in the Golan Heights and Galilee region, three strains with different levels of virulence were chosen for further study. The degree of virulence was based on the level of disease that developed on postharvest-inoculated fruit. Inoculation of flowers with strains showing low and high virulence resulted in 30%

L = lecture sessions; *P* = poster (market place) sessions.

and 56% disease incidence, respectively, in harvested fruit. In an attempt to clarify the mode of fungal infection of the fruit, the ability of the three strains to produce two hydrolytic enzymes, endo-1,4-β-glucanase (EG) and polygalacturonase (PG), when grown on apple cell walls, was examined. Thus it was found that EG production of the virulent strain was twice and six times higher than that of the strains with intermediate and low levels of virulence, respectively. The level of PG production was 2.3 times higher in the highly virulent than in the least virulent strain. Activity gels following electrophoresis of protein extracts from the three strains indicated quantitative, but no qualitative, differences between the strains. A purified EG preparation caused disease symptom development on sensitive apple fruit skin, similar to symptom development following wound inoculation. Disease development in apple fruit following infection with *A. alternata* may possibly be related to the ability of the fungus to produce EG and PG enzymes in the core and surrounding fruit tissue. *(L)*

Cotton-Associated Vegetative Compatibility Groups of *Verticillium dahliae* in Israel and Their Pathogenicity

Nadia Korolev,[1,*] J. Katan[2] and Talma Katan[1]

[1]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: vpptlg@agri.gov.il]; and* [2]*Dept. of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100, Israel*

A collection of 351 *Verticillium dahliae* isolates from cotton, recovered between 1992 and 2000 at 20 sites in Israel, was tested for vegetative compatibility using nitrate-nonutilizing (*nit*) mutants. Three cotton-associated vegetative compatibility groups (VCGs) were found and identified as VCG1 (34 isolates), VCG2B (218 isolates), and VCG4B (98 isolates). VCG2A was represented by one isolate only, although it was frequently recovered from non-cotton hosts. Three cotton pathotypes were defined among 40 isolates tested, using *G. hirsutum* cv. 'Acala SJ2' as differential. VCG1 isolates induced severe leaf symptoms, stunting and defoliation, and were defined as the previously described cotton-defoliating (D) pathotype; VCG2B isolates also caused severe foliar symptoms, stunting and often death but no-to-partial defoliation, and were defined as cotton-defoliating-like (DL) pathotype; most of the VCG4B isolates induced weak-to-moderate symptoms on cotton and were similar to the previously described cotton-non-defoliating (ND) pathotype. Representatives of each VCG-associated pathotype were tested for their pathogenicity to a range of plant species. The D and DL pathotypes differ in their aggressiveness (D >DL), but the order of hosts (from highly susceptible to resistant) was the same: okra (commercial cultivar), cotton (Acala SJ2), watermelon ('Crimson Sweet'), safflower (PI 251264), sunflower (2053), eggplant ('Black Beauty'), tomato ('Rehovot 13'). The ND pathotype formed another sequence differing from the DL pathotype with respect to cotton tolerance and eggplant susceptibility. Tomato was resistant to all tested cotton isolates and pathotypes. *(P)*

Fusarium verticillioides: The Causal Agent of Corn Blight in Israel?

A. Sharon,[1,*] L. Oren,[1] S. Ezrati[1] and D. Cohen[2]

[1]*Dept. of Plant Sciences, Tel-Aviv University, Tel Aviv 69978 [*e-mail: amirsh@tauex.tau.ac.il]; and* [2]*Northern R&D, Qiryat Shemona 10200, Israel*

Corn rots are the most severe diseases of sweet corn in Israel. The incidence of stalk rot and the associated plant blight has increased in recent years, rendering some areas in northern Israel unsuitable for corn. *Fusarium verticillioides* is known as the causal agent of corn rots, but although previous findings demonstrated that the fungus can be found in the soil, seeds and plants, it is unclear if this pathogen is indeed the primary cause of plant blight. In the current study we characterized the disease using *F. verticillioides*-transgenic strains that express the reporter genes green fluorescent

protein (GFP) and yellow fluorescent protein (YFP). The correlation between symptom appearance and magnitude on the one hand, and inoculum source and quantity on the other hand, was determined in greenhouse and field experiments. The genetic structure and the virulence polymorphism of fungal populations were determined by amplified fragment length polymorphism (AFLP) and by virulence assays. Soil infestation resulted in the appearance of symptoms at the early stages of plant development and the amount of fungus in the soil correlated with the amount in the plants and with symptoms appearance. Seed infection did not cause any visible symptoms on young plants, although the fungus could be isolated from healthy looking seedlings and from mature plants. Work with the transgenic strains revealed that in plants that had developed from infected seeds there was only a trace amount of fungal mycelium, whereas plants grown in infected soil were heavily infected. These and other results indicate that *F. verticillioides* invades the plant soon after seed germination, most likely through the roots. After invasion of the roots, the fungus continues to develop into the upper part of the plants. Heavy soil infection results in heavy infections of the seedlings, which cause delayed development and stunting of the young plants. *(L)*

Induced Resistance to Fusarium Wilt in Melon by *Penicillium janczewskii*

Sarit Ziv and J. Katan

Dept. of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100, Israel [e-mail: zivos@zahav.net.il]

Resistance to plant diseases can be induced by a variety of biotic and abiotic agents. It has been realized in the last decade that this phenomenon (which can be regarded as activation of existing natural defense mechanisms) is involved in many cases of biological control of plant diseases. *Penicillium janczewskii* was isolated from a suppressive soil in Israel. It was found that it induces resistance in melon and cotton against *Rhizoctonia solani*. The objectives of this work were to (i) study the effect of *P. janczewskii* on resistance of melon plants to *Fusarium oxysporum* f.sp. *melonis*, and (ii) investigate the possibility of an effect on the roots *via* foliage treatment, resulting from signal transfer. Treatment of melon with *P. janczewskii* reduced Fusarium wilt incidence, depending on the method of application. The most pronounced disease reduction was achieved by application of *P. janczewskii* in the nursery. Application of *P. janczewskii* to foliage, at certain periods after inoculation, was effective in reducing the disease. Treatment of the above-ground parts of the plant was found to induce changes in the underground parts, apparently due to signal transmission, as verified in various ways: cell-free filtrate of the medium in which *P. janczewskii* grew, induced disease resistance; and foliage treatments induced morphological changes in the roots and changes in the microbial populations and in mineral composition in the roots and the exudates. Induced resistance can be harnessed as an additional acceptable biocontrol method against certain root diseases. *(L)*

Ascochyta Blight Resistance in Chickpea is Controlled by One Major Gene

Judith Lichtenzveig,[1] S. Abbo[1] and D. Shtienberg[2]

[1]*Dept. of Field Crops, Vegetables and Genetics, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100 [e-mail: lyskten@yahoo.es]; and* [2]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250, Israel*

Ascochyta blight, caused by the pathogenic fungus *Dydimella rabiei*, is the most devastating and widespread disease of chickpea in Israel. The fungus attacks all the aerial parts of the plant and a severe ascochyta blight epidemic may result in total loss of the yield. The most effective way to manage the disease is to use resistant cultivars. There are varieties, like the Israeli cv. 'Bulgarit', with a high level of field resistance, and varieties with partial field resistance, such as cv. 'Hadas'.

Controversial conclusions were published concerning the inheritance of chickpea resistance to *D. rabiei*. In our opinion the reason for the controversy is that those studies, without exception, were based on analyses of variances of non-parametric scales. The objective of this project was to study the chickpea resistance to *D. rabiei* while using quantitative tools. In this work, two reciprocal F_3 and F_4 populations were used; the populations originated from a cross between the partially resistant cv. Hadas and the Ethiopian susceptible line ICC5810. The populations and parental lines were tested in the field under either natural infection or artificial infection with local isolates. Disease severity (percent of infected leaf area) was scored for each plant several times during the season and the data were used to calculate the area under the disease progress curve (AUDPC) for each plant. For all the populations, the phenotype distribution was significantly different from a normal distribution. The heritability values were around 0.7 for the F_3 populations and around 0.6 for the F_4 populations. The sibling segregation, for all populations, showed that one major gene and a number of minor genes control the chickpea response to *D. rabiei. (L)*

Evaluation of the Sensitivity of Bitter Almond Rootstocks to *Agrobacterium tumefaciens*

Shulamit Manulis,[1,*] Liora Chalupowicz,[1] Orit Dror,[1] S. Antheman[2] and T. Sigler[2]
[1]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: shulam@netvision.net.il]; and* [2]*Extension Service, Ministry of Agriculture and Rural Development, Bet Dagan 50250, Israel*

Rootstocks of bitter almond are used for growth of several varieties of peaches and plums because of their horticultural traits and resistance to root-knot nematode. However, they are sensitive to *Agrobacterium tumefaciens*, the causal agent of crown gall. Three lines of rootstocks, Alnem-88, Alnem-1 and Lachish, were evaluated for their sensitivity to *A. tumefaciens*. The experiments were conducted on one-year-old trees grown in containers and maintained under an insect-proof net. Inoculations were carried out by dipping wounded roots in bacterial suspension of 10^9 cfu/ml or by inoculating wounds, formed in the crown region of the stem, with 20 μl of bacterial suspension of 10^6-10^8 cfu/ml. A streptomycin-resistant virulent strain of *A. tumefaciens* was used for inoculations. The proportion of trees that developed galls following inoculation of the aboveground crown region of the stem, was 90% in Lachish compared with 57% and 52% in Alnem-88 and Alnem-1, respectively. When inoculation was carried out in the subterranean part of the crown region, the level of developed tumors was 100% in Lachish as compared with 38% and 9.5% in Alnem-88 and Alnem-1, respectively. No galls were detected in any of the rootstocks following inoculation of wounded roots. Exposing the roots of all the trees after 8 months revealed galls in 50% of Lachish, 16% of Alnem-88 and 3% of Alnem-1 trees. None of the bacterial cells isolated from the galls carried streptomycin resistance, indicating that infection occurred at the initial stages of planting. This may indicate that roots of one-year-old trees are not sensitive to infection by *A. tumefaciens*. Results of this study demonstrate that the Lachish rootstock is more sensitive to the pathogen than the two other rootstocks. Furthermore, Alnem-1 is less sensitive than Alnem-88. *(P)*

Identification of Vectors of Phytoplasma Using PCR Analysis of Insect Saliva*

Edna Tanne,[1] D. Clair[2] and E. Boudon-Padieu[2]
[1]*Dept. of Virology, ARO, The Volcani Center, Bet Dagan 50250, Israel; and* [2]*BBCE-IPM Equipe Phytoplasmes, INRA, 21034 Dijon Cedex, France*

Grapevine yellows (GY) is widespread in most viticultural countries, causing damage to various degrees. The disease is associated with phytoplasmas belonging to four different groups, all of them

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generally known to be transmitted by leaf/planthoppers. Controlling the spread of these diseases requires the identification of the vector and the study of its biology. Biological transmission assays are used to demonstrate the inoculativity of an insect. These require controlled growing systems and 3–4 weeks (at least) for symptom appearance. It is further complicated since insect–plant and insect–phytoplasma specificities are known, and these tests may fail due to unsuitable test plants or conditions. We have developed an alternative method to the biological transmission assay that could be used on a large scale to check insects' infectivity: a PCR-based analysis of phytoplasma in the insect's saliva. The validity of the newly developed assay was tested by correlation to actual transmission of a well defined vector–phytoplasma–plant system. *Euscelidus variegatus* is a known vector of flavescence dorée, a phytoplasma disease of grapevine. The biology of the disease and the transmission cycle of this insect have been well defined and recorded. The newly developed PCR method correlated with the transmission cycle of the insect and the saliva test is thus valid to determine the inoculativity of the insect.

B: BIOLOGY AND EPIDEMIOLOGY

Mango Malformation Disease – Presence and Identification of *Fusarium subglutinans* in Branches of Mature Trees and Saplings Grafted with Infected Scions, and Importance of Sanitation Treatments in Orchards

C. Lahav,[1,2] A. Sztejnberg,[2] Marcel Maymon,[3] Yulia Denisov[3] and S. Freeman[3]

[1]*Extension Service, Ministry of Agriculture and Rural Development, Bet She'an 10900;* [2]*Dept. of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100; and* [3]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250, Israel [e-mail: freeman@netvision.net.il]*

Mango malformation disease, which is caused by the fungus *Fusarium subglutinans,* was reported in Israel approximately 25 years ago. The disease was initially discovered in India in 1891 and henceforth spread to the major mango growing regions of the world. Recently, the disease has stirred research interest in Israel due to its rapid spread, causing severe economic losses, and lack of efficient means for control and elimination. Currently, the disease is present in 100% of the orchards in the western Negev, Besor and the Sharon coastal plain. Recently (1997), the disease was also identified in the Lake Kinneret (Sea of Galilee) region, in several orchards. In order to test for the presence of the pathogen in infected tree tissues, sections of main branches were sampled from an orchard at Bet Dagan (coastal plain), and mapping the presence of the fungus was undertaken from 15 trees that were heavily infected. Identification was initially carried out after plating disinfected samples on a selective medium for *Fusarium* in petri dishes. Confirmation of identification was done with PCR techniques. *F. subglutinans* was present in all the tree sections throughout the length of the sampled branches. Saplings grafted with infected scion material were tested to determine the direction of growth of the fungal mycelia. Presence and identification were confirmed by plating and PCR. It was found that the main fungal presence was in the grafted scions and new growth, with very few instances of fungal movement below the graft union. At Ginnosar (Lake Kinneret), a 3-year (1998-2001) survey was undertaken in order to observe the effect of sanitation treatments in the infected orchard. The yearly sanitation treatments were found to be effective in markedly reducing the presence, spread and severity of the disease. *(L)*

Utilization of the Weibull Model to Quantify Survival of Soilborne Pathogens under Dynamic Conditions during Structural Solarization

E. Shlevin,[1] S. Saguy,[2] Y. Mahrer[3] and J. Katan[1]

[1]*Dept. of Plant Pathology and Microbiology [e-mail: shlevin@agri.huji.ac.il];* [2]*Inst. of Biochemistry, Food Science and Nutrition; and* [3]*Seagram Center for Soil and Water Sciences, The*

Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100, Israel

Disinfestation of soil or media is an essential procedure in greenhouse management. However, it is difficult to eradicate inocula of plant pathogens adhering to the greenhouse structure, which is a potential source of reinfestation. Sanitation of the greenhouse structure is usually done by applying toxic chemicals such as formaldehyde. Structural (space) solarization is carried out by closing the greenhouse during the hot period between crops. Consequently, air temperatures can reach up to 55–65°C and is accompanied by relative humidity (r.h.) decreases. Although this method utilizes dry heating, typically less effective than wet heating, it can be used as a nonchemical approach for structural sanitation. Most models describing thermal inactivation have considered constant temperature conditions, and fluctuating conditions of temperature and humidity, that could play a significant role, were hardly considered. Our objective was to assess the effectiveness of structural solarization for sanitation and to develop a dynamic model, using dynamic climatic conditions, namely, fluctuating temperatures and r.h., prevailing during the process. Such a model could be utilized for optimization of pathogen inactivation. Inocula of two pathogens were tested: *Sclerotium rolfsii* sclerotia and soil naturally infected with *Fusarium oxysporum* f.sp. *radicis-lycopersici* (*Forl*). Survival curves could not be described by the classic first-order reaction, and were characterized by a dynamic approach using microorganism survival distribution known as the Weibull model. The model is defined by two parameters, *n* and *b*. The relationship found between the model coefficient, *b*, and temperature was exponential and Fermi equation for *Forl* and *S. rolfsii*, respectively. Utilizing the Weibull model for estimation of the survival curves under fluctuating temperatures and constant moisture conditions showed complete inactivation of the two fungi in *ca* 3 days. In practice, this was reached for *Forl* and *S. rolfsii* after 25–30 and 15–20 days, respectively. Including fluctuating greenhouse moisture data of the inocula, showed close agreement between the actual and calculated values, with a high coefficient of determination in nine of 12 experiments. In this work we have proven that even under climatic conditions of a closed greenhouse, which are apparently dry conditions, wetting and drying processes are occurring at a micro level, contributing to enhanced thermal resistance of the inoculum. *(L)*

Effect of Microclimate on *Leveillula taurica* and on Powdery Mildew in Greenhouse-grown Pepper

Y. Mesika,[1,2,3] Y. Elad,[2,*] Y. Nitzani,[2] Dalia Rav David,[2] A. Sztejnberg,[3] M. Brand,[2,3] H. Yekhezkel,[4] D. Shmuel,[4] M. Targerman,[4] Y. Aharon,[4] A. Salpoi,[5] E. Dayan,[5] L. Cordoba[5] and M. Fuchs[5]

[1]*Negev Extension Service, Be'er Sheva 84100;* [2]*Dept. of Plant Pathology and* [5]*Dept. of Environmental Physics, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: elady@netvision.net.il];* [3]*Dept. of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100; and* [4]*R&D South, Besor Station, M.P. Negev 4, 85400, Israel*

Sweet pepper cultivation in heated greenhouses is aimed at the production of quality fruits during winter. The powdery mildew disease (*Leveillula taurica* (Lév.) Arn.) inflicts severe damages to this crop. Fungicide sprays are applied frequently in order to control the disease. In the past we reported that disease severity under conditions of high night temperatures (min. 16°C) and short duration of relative humidity above 80%, was lower than under conditions of lower night temperatures (min. 13°C) and long duration of the high r.h. Experiments were carried out with diseased plants in greenhouses under commercial conditions and with various stages of the pathogen life cycle in the laboratory. Under commercial conditions, 25°C and 18°C respective day and night temperatures, either alone or in combination, resulted in much less disease than at 20°C and 13°C, respectively.

Similar results were obtained in temperature-controlled growth chambers. The effect of temperature on conidial germination, on growth of mycelium in the leaf tissue and on survival of the conidia was tested. Highest germination rate was observed at 20°C, but the viability of conidia exposed to temperatures of 10–40°C was highest at 10–20°C and declined as the temperature increased from 25° to 40°C. Most of the conidia that attempted germination at high temperature had poor viability. Change of r.h. did not have a significant effect on the pepper powdery mildew under controlled conditions. High germination rate was observed under conditions of 50–100% r.h. It is concluded that temperature has a significant effect on pepper powdery mildew and the disease can be suppressed under higher temperatures. *(L)*

Factors Affecting the Production of the Telemorph Stage of *Uncinula necator*, the Causal Agent of Grape Powdery Mildew, in Israel

S. Ovadia,[1,2]* D. Shtienberg,[2] A. Dinoor[1] and A. Sztejnberg[1]

[1]*Dept. of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100 [*e-mail: shmova@zahav.net.il]; and* [2]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250, Israel*

Powdery mildew, caused by the pathogenic fungus *Uncinula necator*, is the most devastating and widespread disease of grapes in Israel and elsewhere. The fungus attacks all the aerial parts of the plant and severe powdery mildew epidemics may result in total loss of the yield. The pathogen may overwinter as dormant hyphae within buds, which initiate in the coming spring as 'flag shoots', or through the telemorph stage by production of clastothecia. The existence of clastothecia on infected grape leaves was reported in Israel *ca* 30 years ago but the prevalence and importance of the telemorph stage are not known. In a comprehensive survey that was conducted in 1997 and 1998, *ca* 400 vineyards were surveyed in all grape production areas of Israel. The severity of powdery mildew, the incidence of leaves containing clastothecia and the quantity of clastothecia on the leaves were recorded. It was found that clastothecia were produced in the autumn and their quantity on the leaves was affected by the severity of powdery mildew infections (which was governed by the genetic resistance of the cultivar to the disease), and varied among regions and between years. The effects of temperature and day length on the production of clastothecia on grape leaves were studied in growth chambers, under controlled environmental conditions. Significantly more clastothecia were produced on leaves of plants that were incubated at day/night temperatures of 25/15°C than on those incubated at 30/20°C. Similarly, significantly more clastothecia were produced (at 25/15°C) under short-day (12 h) than under long-day (14.4 h) conditions. *(L)*

Survival in Soil of Species of *Colletotrichum* Fungi that Cause Anthracnose of Strawberry

Z. Shalev,[1,2] J. Katan[2] and S. Freeman[1,*]

[1]*Dept. of Plant Pathlogy, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: freeman@netvision.net.il]; and* [2]*Dept. of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100, Israel*

A study was conducted of the survival of isolates of the fungus *Colletotrichum*, which cause anthracnose, one of the major diseases in strawberry. In laboratory experiments, we examined the survival of artificially produced conidia of two species of *Colletotrichum*: *C. acutatum* and *C. gloeosporioides*, in untreated, in methyl-bromide-fumigated and in autoclaved field soils. In untreated soil, we also examined survival of naturally produced inoculum of conidia from strawberry fruits. Resistance to heat and the survival of propagules of the two species were also studied.

The survival of natural inoculum (infected crowns) compared with artificially produced inoculum (inoculated mummified fruit) of the species *C. acutatum* was also investigated in untreated and fumigated soils under field conditions. Conidia of the fungus *Colletotrichum* can survive in untreated, methyl-bromide-fumigated and autoclaved field soils for at least 10 months. Population decline of the two species *C. acutatum* and *C. gloeosporioides* in methyl-bromide-fumigated and autoclaved soil was slower than the decline in untreated field soil. *C. acutatum*, the common species in Israel, survived better in mummified fruit (artificially produced) than in crowns (natural inoculum). One isolate of *C. gloeosporioides* has a greater ability to survive and is more resistant to heat, but is not common yet in Israel. Therefore, every effort must be made to prevent its establishment in this country. Heat treatments at 38–44°C that were effective in controlling the pathogen may thus be applied as a preplant treatment of mother plants destined for the nursery. *(L)*

Assessment of Cross-Infection and Survival of *Colletotrichum acutatum* from Strawberry in Host and Non-Host Plants Using GFP Transgenic Isolates

Sigal Horowitz,[1,2] A. Sharon[2] and S. Freeman[1,*]

[1] *Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: freeman@netvision.net.il]; and* [2] *Dept. of Plant Science, Tel-Aviv University, Tel Aviv 69978, Israel*

Colletotrichum acutatum, the causal agent of strawberry anthracnose, is one of the most important fungal pathogens of this crop worldwide. Cross-infection from additional hosts may exist, since many botanical species are hosts to the pathogen and can serve as a source for primary inoculum. Host range, specificity and survival of *C. acutatum* from strawberry were examined with pepper, eggplant, tomato, bean and strawberry. Colonization and survival were confirmed by PCR (polymerase chain reactor)-specific primer amplification for *C. acutatum*. *C. acutatum* transgenic isolates that express the *UidA* (GUS) or *SGFP-TYG* reporter genes were obtained by electroporation of germinating conidia. Elucidation of the mode of infection and colonization of the pathogen in host and non-host tissues was conducted with the GFP (green fluorescent protein)-transgenic isolates. Microscopic observation revealed that the conidia adhere to the cuticle and germinate to produce germ tubes, which in turn differentiate as melanized appressoria on all plant tissues, host and non-host. Major differences between pathogen interaction with the host and non-host were observed 50 h post-inoculation. Highly asymmetric appressoria with lobes and sockets developed on strawberry, compared with symmetric structures without lobes and sockets in non-host tissues. The strategy of invasion in strawberry included a short biotrophic phase in which the hyphae were restricted mainly to the intercellular space between the epidermal cells. Four days after symptom development, a large amount of intercellular and intracellular fluorescence accompanied by hyphal growth was observed with the GFP transformants in strawberry. This marked the necrotrophic phase responsible for anthracnose and blight symptoms. While no visible disease symptoms were observed in the non-host plants, extensive hyphal growth and appressoria were observed on the leaf surfaces but were restricted to the intercellular spaces of the leaf epidermis. It should be considered whether *C. acutatum* from strawberry can adapt as an epiphyte or possesses an asymptomatic endophytic lifestyle in non-host plants. *(L)*

Determination of Vegetative Compatibility Groups in *Colletotrichum coccodes*, the Causal Agent of Black Dot on Potato

N. Nitzan,[1,2] Marina Hazanovsky[2] and Leah Tsror (Lahkim)[2]

[1] *Dept. of Life Sciences, Ben-Gurion University, Be'er Sheva 84105; and* [2] *Dept. of Plant Pathology, ARO, Gilat Experiment Station, M.P. Negev 85280, Israel [e-mail: tsror@bgumail.bgu.ac.il]*

Black dot on potato caused by *Colletotrichum coccodes* is a relatively new disease in Israel and in other potato production areas in the world, causing yield reduction and damage to tuber quality.

The fungus, classified to the subdivision *Deuteromycetes,* is soil-, seed- and airborne. Vegetative compatibility is probably the only means of genetic exchange among isolates of a species lacking a sexual cycle. Vegetative compatibility refers to the ability of individual fungal strains to undergo hyphal anastomosis and form a stable heterokaryon. Strains that are vegetatively compatible tend to be more similar than isolates in different VCGs, forming genetically isolated subpopulations, differing in characteristics such as morphology, physiology and pathogenicity. These subpopulations are referred to as vegetative compatibility groups (VCGs). The objective of the present study was to determine VCGs in *C. coccodes* isolates collected from potato plants and tubers grown in Israel, and to compare them with European isolates originating from imported seed tubers. Vegetative compatibility of 86 isolates (22, 49 and 15 from France, Holland and Israel, respectively) was studied using complementation tests of nitrate non-utilizing (*nit*) mutants. Since this was the first study of VCGs within this species, tester isolates were first chosen for each of the VCGs, based on their ability to anastomose with a large number of isolates. All isolates having both *nit*1 and NitM mutants were self-compatible. Four major VCGs were observed: six isolates were assigned to VCG1 (4 and 2 from France and Holland, respectively); 37 to VCG2 (17, 15 and 5 from Holland, France and Israel, respectively); 16 to VCG3 (11 and 5 from Holland and Israel, respectively); and nine isolates from Holland were assigned to VCG4. In addition, several isolates were not assigned to any of the four major VCGs. *(L)*

Oospore Formation of *Phytophthora infestans* in Potato Tubers

Evgenia Rubin, Aaron Levin, Alexander Baider and Yigal Cohen*
*Faculty of Life Sciences, Bar-Ilan University, Ramat Gan 52900, Israel [*e-mail: coheny@ashur.cc.biu.ac.il]*

Phytophthora infestans, the causal agent of late blight in potato and tomato, is a heterothalic fungus requiring both A1 and A2 mating types for oospore formation. It is suspected that the increased aggressiveness of the pathogen is an outcome of genetic recombinations between the old genotypes and new genotypes which immigrated from Mexico. For this reason we were interested in studying oospore formation in various organs of potato and tomato. Oospores were found to be formed readily on either potato or tomato leaflets floating on water in petri dishes. At 10 days after co-inoculation with A1+A2 sporangia, up to 100 oospores per mm^2 could be observed. In the field, oospores were noted on potato leaves, especially under heavy sprinkler irrigation, but their number was far lower than in the laboratory, *viz.*, up to ~50 per leaflet. Oospore formation in potato tubers in the field as well as the laboratory, was negligible. Oospore counts in tuber tissue increased at time of sprouting. The mechanism controlling oospore formation is not clear. Adding simple sugars, some amino acids, β-sitosterol, gibberellin or ethylene to potato tuber discs enhanced oospore formation slightly. Methyl-jasmonate had no effect. In contrast to potato tubers, tomato fruits supported the formation of abundant oospores upon co-inoculation with A1+A2 sporangia onto the stem-scar of the fruit. Oospores were occasionally seen between the seed hairs but never in the endosperm or the embryo of the seed. It is concluded that potato tubers can not serve as an efficient vehicle for oospore transmission, as opposed to tomato fruits, which can. *(L)*

Infectivity of Oospores of *Phytophthora infestans* to Potato and Tomato

Odelia Pisanti and Yigal Cohen*
*Faculty of Life Sciences, Bar-Ilan University, Ramat Gan 52900, Israel [*e-mail: coheny@ashur.cc.biu.ac.il]*

Phytophthora infestans, the fungal causal agent of late blight in potato and tomato, is heterothalic. It requires both the A1 and A2 mating types to produce oospores. The A2 mating type was first detected in Israel in 1983 and dominated the fungal population until 1995. Oospores of oomycetes

are long-lasting structures that can survive in soil for several years and produce new recombinant genotypes with enhanced aggressiveness. Previous experiments showed that co-inoculation of detached potato or tomato leaves with A1+A2 sporangia resulted in abundant oospores formed in the mesophyll. To test the infectivity of such oospores to their host plants, oospore-containing leaves of potato or tomato were treated in one of the following methods in order to get rid of hyphae and sporangia: *(a)* feeding to water snails; *(b)* homogenizing and incubation in Novozyme; or *(c)* homogenizing and drying the homogenate for 2–3 days. Oospores in such detached leaves were produced by co-inoculation with one metalaxyl-sensitive and one metalaxyl-resistant parent. Offspring of such a cross should be intermediate in their sensitivity to metalaxyl. We found that potato sprouts, or tomato seeds, planted in oospore-containing sterile soil, developed late-blight-infected plants *ca* 40–50 days after sowing. Isolates recovered from such plants were sensitive, intermediate or resistant to metalaxyl, indicating their possible oosporic origin. DNA fingerprinting and isozyme tests are in progress to prove the origin of those infections. *(L)*

Scytalidium Wilt of 'Star Ruby' Grapefruit

A. Sadowsky,[1,*] D. Gefen,[1] N. Rottman,[1] Y. Oren,[1] Miriam Kimchi[2] and Z. Solel[2]

[1] *Div. of Citriculture, Extension Service, Ministry of Agriculture and Rural Development, Bet Dagan 50250 [*e-mail: avisad@shaham.moag.gov.il]; and* [2] *Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250, Israel*

Since the summer of 1998, sudden wilt of citrus trees has occurred at several locations in the Jordan and Hula valleys in the northeast of Israel. The disease affected 'Star Ruby' grapefruit (*Citrus paradisi* Macf.) only. The collapse developed in two stages. At first, the trees showed characteristics of water stress: yellow foliage with a bronze hue, and the laminae curled and drooped. A few weeks later a sudden collapse of main limbs or of the whole tree became apparent. Gum oozing was common in affected branches. The bark of these branches attained a dark color and the epidermis sloughed off easily, revealing a mass of black powder, resulting from copious sporulation of dark conidia. Both the bark and the xylem were intensively colonized with mycelium. The fungus was identified as *Scytalidium lignicola* Pesante, based on the characteristic mixture of some colorless and dark conidia, produced in branched chains by conversion of the vegetative hyphae. Artificial inoculations induced typical disease symptoms and the fungus was re-isolated, thus confirming Koch's postulates. The disease attacked only 'Star Ruby' trees that were pruned at the end of winter and later suffered from a severe heat stress, a few weeks before their collapse. To control the disease we advise to minimize pruning as far as possible, to apply wound dressings to the cuts, and to avoid water stress during extreme heat spells by ample irrigation. Infected trees might be rescued by pruning the affected branches below the infected xylem. Removing infected tissues will reduce the inoculum potential. *(L)*

C: MOLECULAR STUDIES OF PATHOGENS

Weed Control in Field-Grown Cucurbits Inoculated with an Attenuated ZYMV Virus-Vector Expressing Phosphinothricin Acetyltransferase

Y.M. Shiboleth,[1,*] T. Arazi[1] and A. Gal-On[2]

[1] *ViroGene Ltd., Jerusalem 91460 [*e-mail: zymv@netvision.net.il]; and* [2] *Dept. of Virology, ARO, The Volcani Center, Bet Dagan 50250, Israel*

Weeds reduce crop yield and quality of cucurbit fields by competing for space, light, moisture, nutrients and pollinating insects. Cucurbits are highly sensitive to a wide range of herbicides; thus no selective herbicide for broadleaved weed eradication can be applied. Current weed control measures in cucurbits include preplanting methyl bromide fumigation, plastic mulching, and weeding.

Expression of a phosphinothricin acetyltransferase (PAT) in plant tissues leads to tolerance of these plants to glufosinate–ammonium-based herbicides. We have engineered an attenuated zucchini yellow mosaic virus (ZYMV-AGII) virus-vector to express the PAT gene *bar*, to protect inoculated cucurbits from these herbicides. This vector, AGII-Bar, has been rendered environmentally safe by both symptom attenuation and aphid transmission abolishment. An experiment with potted melons revealed that protection is imparted one week after mechanical inoculation of the plant but not 4 days post-inoculation. Herbicide resistance was maintained over a period of at least 60 days, and at least three passages in potted plants. AGII-Bar also afforded protection from 0.2% glufosinate-ammonium (1% Basta) applied constitutively through the roots of systemically infected squash. To test the applicability of AGII-Bar in a weed-infested field, a controlled experiment including more than 450 plants, inoculated by bombardment with a virus-encoding construct, was performed. A single application of glufosinate-ammonium at doses up to 900 ml/ha (1.5% Basta at 300 *l*/ha) was sprayed on the foliage of two types of melons, two types of watermelons, cucumbers, and squash. AGII-Bar provided protection to all inoculated plants, of all varieties tested, at all dosages, including the highest, which totally eradicated all weeds. Yield of squash and of melons was measured. Weeds inhibited yield drastically in the control. Relief of this inhibition was positively correlated to the glufosinate-ammonium concentration applied. Our results demonstrate the feasibility and efficacy of AGII-Bar to enable weed control in cucurbits. *(L)*

Partial Cloning of Aminotransferases Genes from Downy Mildew-resistant Melon

Dvir Taler, David Kenigsbuch and Yigal Cohen*

*Faculty of Life Sciences, Bar-Ilan University, Ramat Gan 52900, Israel [*e-mail: coheny@ashur.cc.biu.ac.il]*

Cucumis melo PI 124111F (PI) is resistant against downy mildew (*Pseudoperonospora cubensis*). Previous studies showed that P45 – a constitutive, soluble, cytoplasmic, 45 kD protein – co-segregates with resistance of PI to the disease. P45 was purified and partially sequenced. For six peptides (7–26 amino acids each) of P45, degenerated oligonucleotide primers were synthesized and subjected to PCR with cDNA template synthesized from PI. Two DNA products, 500 bp and 1035 bp, were obtained. These DNA products were cloned, sequenced and subjected to RACE reactions. 1422 bp and 1543 bp DNA sequences, designated at-1 and at-2, respectively, were obtained. Comparing the DNA sequences of at-1 and at-2 revealed 80% homology between them. Each gene encodes for a 401 deduced amino acids protein. The two proteins share 93% homology. BLAST analysis revealed over 80% homology of these proteins with serine-glycoxalate aminotransferase (SGT) from *Fritillaria agrestis* and alanine-glyoxalate aminotransferase (AGT) from *Arabidopsis thaliana*. PCR analysis of melon and cucumber lines, resistant and susceptible to downy mildew, showed the occurrence of at-1 and at-2 in all. AGT and SGT were more active in the resistant PI than in the susceptible plants. *(L)*

The Use of Molecular Markers in Breeding for Fusarium Wilt Resistance in Melons

R. Cohen,[1,*] Y. Burger,[1] V. Portnoy,[1] G. Tzuri,[1] U. Saar,[1] S. Shriber,[1] R. Perl-Treves,[2] Y. Brotman[2] and Nurit Katzir[1]

[1] *Dept. of Vegetable Crops, ARO, Newe Ya'ar Research Center, Ramat Yishay 30095 [*e-mail: cron@netvision.net.il]; and* [2] *Faculty of Life Sciences, Bar-Ilan University, Ramat Gan 52900, Israel*

Fusarium wilt of melons, caused by *Fusarium oxysporum* f.sp. *melonis*, is a limiting factor for melon culture worldwide. The most effective means to control this disease is the use of resistant cultivars. The success in breeding for resistance is dependent on the availability and quality of resistance source and on effective methods for inoculating the plants and assessing their response to the disease. The expression of Fusarium wilt following artificial inoculation is dependent on

the virulence of the pathogen, environmental conditions, and the genetic background of the tested genetic material. Thus, unsatisfactory expression of the disease may delay the progress of breeding work and in certain cases may lead to loss of resistance. Molecular markers are therefore capable of facilitating the breeding. In the present study we compared the identification efficacy of melon genotypes response to race 1 of the pathogen by inoculation with the pathogen and with four molecular markers based on RAPD (Random Amplified Polymorphic DNA), SSR (Simple Sequence Repeats) and AFLP (Amplfied Fragment Length Polymorphism). There was high variation in the response of susceptible genotypes to the disease, ranging from 10% to 100% wilting, demonstrating the problematic expression of genetic material to the disease. In certain genotypes the environmental conditions altered disease incidence, whereas other genotypes were indifferent to the surrounding conditions. Variation in the identification ability was found also with the molecular markers. Some markers identified only homozygous resistance, whereas others were capable of identifying heterozygous resistance. Some markers identified a wide range of resistant breeding lines, and others identified breeding lines which originated from a specific geographic region. Therefore, selecting suitable markers for a breeding program requires a preliminary study to evaluate the response of the germplasm used to different markers. *(L)*

Pathogenic Variation Among Sub-populations of *Fusarium oxysporum* f.sp. *radicis-lycopersici*, the Crown and Root Rot Pathogen of Tomato

Gil Arbel,[1] J. Katan,[1] Talma Katan[2] and O. Yarden[1,*]

[1]*Dept. of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot, 76100 [e-mail: yarden@agri.huji.ac.il]; and* [2]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250, Israel*

Fusarium oxysporum f.sp. *radicis-lycopersici* (*Forl*) is the causal agent of Fusarium crown and root rot disease in tomato. Genetically distinct sub-populations have been identified by dividing *Forl* into vegetative compatibility groups (VCGs). According to the results of RFLP analyses, the main VCGs were grouped into two clusters, based on their phylogenetic relationships. Examination of the pathogenicity-related differences between the two clusters has demonstrated that the isolates that belong to cluster I (including VCGs 0090II, 0091I and 0092) were significantly more virulent than those belonging to cluster II (including VCG 0094). The difference in virulence may be caused, in part, by the secretion of toxic secondary metabolites. Spore-free growth medium of cluster I isolates was found to be toxic to tomato seedlings, whereas cluster II medium was less toxic. DNA-based comparison was used in an attempt to examine the evolutionary origin of the two *Forl* clusters. Complete identity of partial (650 bp) sequences of the EF-1α gene of isolates within VCGs suggests a common evolutionary origin. However, 16 positions were found in which single base differences between different VCGs were detected. Furthermore, within each cluster, six of these positions had conserved EF-1α nucleotides. On the basis of these differences, we suggest that a diagnostic procedure can be developed to distinguish between the clusters by using a specific restriction enzyme. Nonetheless, there are positions in the sequence that represent differences that do not correspond to the distribution of isolates into clusters. Therefore, examination of the phylogenetic origin of the isolates on the sole basis of the sequence of this gene, is insufficient to provide a conclusive answer to the evolutionary relationships among the VCGs. *(L)*

Restriction Fragment Length Polymorphism (RFLP) Analysis Reveals that *Fusarium oxysporum* f.sp. *radicis-lycopersici* is Polyphyletic

Sari Kalman,[1] D. Zamir[1,*] and Talma Katan[2]

[1]*Dept. of Field Crops, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100 [*e-mail: zamir@agri.huji.ac.il]; and* [2]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250, Israel*

Tomato can be attacked by two *formae speciales* of *Fusarium oxysporum*: the vascular wilt disease is caused by f.sp. *lycopersici* (*Fol*) and the crown rot disease is caused by f.sp. *radicis-lycopersici* (*Forl*). Unlike *Fol*, physiologic races are not known in *Forl*, but considerable genetic diversity is suggested by the existence of at least nine VCGs, three of which contain at least two subgroups. The genetic relatedness among 32 *Forl* isolates, representing 11 VCGs and subgroups from seven countries, was examined by RFLP analysis using three restriction endonucleases (*Dra*I, *Eco*RI, *Eco*RV) and 14 genomic DNA clones from *Fol* 0-1078. RFLP data were used to generate multilocus haplotypes (MLH) and to calculate similarity coefficients (Ssm). MLH A was assigned to the 18 isolates of VCGs 0090, 0092 and 0096 (Ssm 0.954–1.000). MLH B was assigned to the six VCG 0091 isolates (Ssm 0.996–1.000). The three VCG 0093 isolates were uniform MLH C, the six VCG 0094 isolates were uniform MLH D, and the two VCG 0097 isolates were uniform MLH E. Based on high Ssm values (0.912–0.958) between MLHs A and B, the respective VCGs (0090, 0092, 0096 and 0091) were combined into clonal lineage I. VCGs 0094 and 0097 (Ssm 0.882) were likewise combined into clonal lineage II. Ssm between lineages I and II was 0.806; and it was 0.805 and 0.761, respectively, between them and VCG 0093. Ssm with *Fol* VCGs 0030 and 0031, analyzed in parallel, ranged from 0.637 to 0.805. This analysis indicates that the origin of *Forl* is polyphyletic, with lineages I and II representing two genetically distinct sub-populations of this pathogen. *(L)*

D: VIRUSES

A New Yellowing Disease of Peppers Caused by an Unidentified Luteovirus

Y. Antignus,[1] O. Lachman,[1] Malenia Pearlsman[1] and Orna Ucko[2]

[1]*Dept. of Virology, ARO, The Volcani Center, Bet Dagan 50250 [e-mail: antignus@ias.agri.gov.il]; and* [2]*Extension Service, Be'er Sheva Region, Be'er Sheva 84100, Israel*

During the 1998/1999 growing season a severe yellowing phenomenon was widespread in many bell pepper plots in the Arava Valley, which is located in the extreme southern part of Israel. Leaves of the affected plants were rolled upward into a cup-shaped form and exhibited a severe interveinal bright yellowing. In many cases plants were stunted, with degenerated apical parts, and fruits which were significantly smaller and discolored. The phenomenon was observed in all types of structures: walk-in tunnels, screenhouses and ordinary greenhouses. It was impossible to transmit the disease by mechanical inoculation or by whiteflies. However, successful transmission was obtained by grafting or by aphid transmission. Preliminary transmission experiments with the aphid *Myzus persicae* indicated that the virus/vector relationship is of a semi-persistent or persistent manner. Isometric virus particles similar in morphology to luteoviruses were extracted from infected plants. Purified virus preparations did not react in DAS-ELISA with potato leaf curl virus (PLRV) or beet western yellows virus (BWYV). However, when indirect ELISA was employed instead, a weak positive reaction was obtained with PLRV and cucurbit aphid-borne yellows virus (CABY), indicating a distant serological relationship with this virus. RT-PCR cloning was carried out using the virus RNA as a template. C-DNA clones obtained by this procedure reacted positively with the viral RNA in dot-spot hybridization but failed to react with RNA of unrelated viruses. *(L)*

Control of Cucumber Fruit Mottle Mosaic Virus (CFMMV) on Cucumbers Grown on Artificial Media

Neta Mor,[1] Y. Miron,[2] O. Lachman,[2] Malenia Pearlsman[2] and Y. Antignus[2]

[1]*Ministry of Agriculture and Rural Development, Extension Service, Tel Aviv 61070 [e-mail: netmor@shaham.moag.gov.il]; and* [2]*Dept. of Virology, ARO, The Volcani Center, Bet Dagan 50250, Israel*

CFMMV belongs to a subgroup of the Tobamoviruses and it affects cucurbits. The virus was detected first in Israel in 1992 in Achituv village. Since then it expanded to neighboring villages where successive cropping of cucumbers is an accepted routine, and has inflicted severe losses. In primary laboratory tests methyl bromide and formalin demonstrated a high viricidal effect. However, soil fumigation with these compounds in infested greenhouses was not effective, probably due to their low penetration into the root system area. The present experiment tested the viricidal effect of soil fumigants for the control of CFMMV. The tests were carried out on artificial media such as perlite and scoria (tuff) based on the assumption that the compounds could fumigate the whole volume of the substrates. Under laboratory conditions perlite served as an artificial medium after being artificially inoculated. Right after inoculation, perlite-filled buckets were treated with ForDor 37 (formaldehyde 36%), Edigan (metam-sodium-370 g/*l*), Condor (1,3-dichloropropene 91%), InLine (1,3-dichloropropene 61% + chloropicrin 35%) and chlorine balls, for comparison with untreated control. Cucumber seedlings were transplanted into the buckets and the spread of the viral disease was monitored. ForDor 37 reduced viral infection to 16% *vs* 73% in the control; the other treatments did not provide sufficient disease control. An observation carried out in a previously infected commercial greenhouse comparing the effectiveness of Metamor (metam-sodium 510 g/*l*) and ForDor 37 on viral inoculum incorporated into the scoria substrate and exposed to the greenhouse environment, showed that ForDor 37 at a rate of 5000 *l*/ha reduced considerably the infection levels of cucumber plants. Only 3% of the plants grown after ForDor 37 treatment were infected *vs* 13% of the untreated control plants and 39% following the application of metam-sodium. *(L)*

Yellow Head: A New Virus Disease in Wheat Caused by a Tenuivirus in Gramineae

R. Salomon[1] and Dallas L. Seifers[2]

[1]*Dept. of Virology, ARO, The Volcani Center, Bet Dagan 50250, Israel [e-mail: vprsalom@agri.gov.il]; and* [2]*Kansas State University, Agricultural Research Center, Hays, KS 67601-9228, USA*

Spots of yellow plants in wheat fields were observed in 1997 first in Kansas and in Israel in 1998. The flag leaf was yellow and the ears empty of grains or contained undeveloped valueless grains. This phenomenon repeats itself since then every year. From diseased plants an agent was isolated in Kansas that could be inoculated to sweet corn kernels, cv. 'Spirit', by vascular puncture inoculation. It was otherwise impossible to infect Gramineae plants mechanically. The only plant that was susceptible to mechanical inoculation was *Nicotiana benthamiana.* From symptomatic corn plants a fraction that contains a 28 kD protein was isolated, and specific antibodies against this fraction were prepared. These antibodies reacted with the extracts from infected corn, *N. benthamiana* and symptomatic wheat plants collected from the fields in Kansas during the 2000 season. Sections prepared from symptomatic corn examined in the EM showed clusters of particles only in the phloem cells. For an accurate classification of this virus, the 28 kD protein associated with it was sequenced. Partial information of the sequence shows a very high similarity to the Tenuivirus group; the Tenuiviruses are planthopper-transmitted. The actual vector of this wheat pathogen has not been found yet. We are looking for the intermediary grass hosts in Kansas and Israel, because the appropriate handling of these host and vectors may limit the spread of this virus. *(L)*

Detection of Iris Yellow Spot Virus in Lisianthus

Anat Kritzman, Helena Beckelman, Svetlana Alexandrov, J. Cohen, Miriam Lampel, B. Raccah and A. Gera*

*Dept. of Virology, ARO, The Volcani Center, Bet Dagan 50250, Israel [*e-mail: abedg@netvision.net.il]*

Recently, unusual viral symptoms of systemic necrosis, necrotic spots and rings on lisianthus (*Eustoma russelianum*) leaves, were observed. Preliminary analyses suggested that the disease

was caused by a tospovirus. Crude sap from symptomatic tissue was mechanically transmitted to *Nicotiana benthamiana, Chenopodium quinoa, C. amaranticolor* and *Gomphrena globosa*. On inoculated plants of *N. benthamiana*, chlorotic spots developed on inoculated leaves followed by systemic necrosis, 5 and 10 days postinoculation (DPI), respectively. The virus produced local spots on inoculated plants of *C. quinoa, C. amaranticolor* and *G. globosa*, and necrotic local lesions developed by 4–5 DPI. Leaf samples of lisianthus and *N. benthamiana* were analyzed by transmission electron microscopy (TEM) in leaf dip preparations and thin sections of leaf tissues. Virus particles typical of a tospovirus were observed in samples taken only from symptomatic leaves. Double antibody sandwich enzyme-linked immunosorbent assay tests of leaf sap extracted from naturally infected lisianthus and mechanically inoculated indicator plants, gave a strong positive reaction to iris yellow spot virus (IYSV), demonstrating that this virus was serologically related to IYSV, a tospovirus described in Israel and recently in the Netherlands and Brazil. Polyclonal antibodies prepared against IYSV enable specific detection of the virus in crude sap from infected plants. Western blot analysis showed that IYSV was serologically distinct from tomato spotted wilt virus. Primers specific to the nucleocapsid gene of IYSV were used in a reverse transcription-polymerase chain reaction assay (RT-PCR) to verify the presence of IYSV. RT-PCR gave an expected PCR product of approximately 850 bp. The amplicon was cloned in pGEM-T vector and the recombinant clone was sequenced. The sequence of the cloned nucleocapsid gene confirmed the identity of IYSV, thus verifying IYSV infection of lisianthus. To the best of our knowledge, this is the first report of lisianthus infection by IYSV. *(L)*

Detection of Tobacco Mild Green Mosaic Virus in *Tabernaemontana*

J. Cohen,[1] A. Rosner,[1] Sima Kagan,[2] J. Gotleb,[3] M. Zeidan[4] and A. Gera[1,*]

*[1]Dept. of Virology and [2]Dept. of Ornamental Horticulture, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: abedg@netvision.net.il]; [3]Extension Service, Ministry of Agriculture and Rural Development, Rehovot 76324; and [4]Plant Protection and Inspection Services, Ministry of Agriculture and Rural Development, Bet Dagan 50250, Israel*

Unusual viral symptoms were seen on *Tabernaemontana divaricata*, a member of the family Apocynaceae, grown in a commercial nursery in the Besor area of Israel. The symptoms varied widely and included chlorotic ringspots and banding, oak-leaf patterns and mosaic. At the end of the winter, large yellow spots, which later became necrotic, appeared on fully expanded leaves. The necrotic zones later fell out, leaving 'shot holes'. Preliminary analysis suggested that the disease was associated with a tobamovirus. Rod-shaped particles 300 nm in length, typical of a tobamovirus, were observed by electron microscopy only in samples taken from symptomatic leaves. A partial segment of the 5'-terminus of the viral RNA, which consisted of 533 bp, was cloned and sequenced. Comparison of the predicted amino acid sequence with those of other tobamoviruses revealed 94% identity with tobacco mild green mosaic virus (TMGMV) genome. Primers specific to the coat protein (CP) gene of TMGMV used in a reverse transcription-polymerase chain reaction assay (RT-PCR), gave an expected amplification product of ~455 bp. The amino acid composition of the cloned CP gene shows a complete identity to that of TMGMV, thereby confirming the identity of TMGMV infecting *Tabernaemontana*. Polyclonal antibodies prepared against the virus and used in double antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) enabled specific detection of the virus in crude sap extracted from *T. divaricata* and mechanically inoculated indicator plants. This is the first report of TMGMV infection in *Tabernaemontana* and the first incidence of the virus in Israel. *(L)*

E: CHEMICAL CONTROL OF PLANT DISEASES

Bellkute – A New Fungicide

Y. Benyamini and the Luxembourg Agricultural Team

Luxembourg Industries (Pamol) Ltd., Tel Aviv 61000, Israel [e-mail: yuval@luxembourg.co.il]

Bellkute is a new fungicide, formulated as a wettable powder, containing 40% iminoctadine tris (albesilate), manufactured by Dainippon Ink & Chemicals, Inc., Japan. The product belongs to the chemical group of diguanidines, it has low toxicity (LD_{50} >5000 mg/kg), is selective to bees and was found to be safe in all the chronic studies. Bellkute is effective on a variety of fungi belonging to the *Ascomycetes* and fungi imperfecti groups. It is a contact fungicide and does not move within the plant, it inhibits lipid synthesis and damages the functionality of the cell membranes. Bellkute inhibits spore germination, germ tube elongation, infection hypha formation and appressorium formation. The multi-site mode of action reduces the risk of resistance development in sensitive fungi. Bellkute inhibits lipid synthesis like other triazole products (EBI/DMI), but its active site is different and thus there is no cross-resistance. This was proved by the fact that Bellkute was effective in cucumber against *Sphaerotheca* spp. that were resistant to triadimefon and against *Botrytis* that was resistant to iprodione. Bellkute is registered worldwide for use in orchards, vegetables and field crops for the control of powdery mildew, *Botrytis*, scab, *Alternaria*, anthracnose, *Stemphylium*, etc. In Israel, Bellkute is registered at 0.05% for the control of powdery mildew in cucumber, vineyards and apple. It was also found to be effective in controlling powdery mildew in mango, nectarine, melon, watermelon, etc. Following are some representative results from field trials in Israel that were carried out in the last 3 years: Powdery mildew in cucumber, 1997: Bellkute 0.05%, 98% control *vs.* Standard EBI, 34% control. Cucumber, 1998: Bellkute - 100% control, higher efficacy than three other strobilorinone products tested. In five trials in vineyards, Bellkute gave an average control of 93% and the standard EBI gave 98% control. In five trials in apple: Bellkute 0.05% and 0.1%, compared with Standard EBI, resulted in an average control of 82%, 91% and 94%, respectively. In mango, nectarine, watermelon and melon, the average control was >90%. From these results it is clear that Bellkute is an effective fungicide for powdery mildew control under Israeli conditions. Since it belongs to a chemical group that is not used in Israel, it is an excellent tool for IPM programs. *(L)*

Rugby – A Product for the Control of Nematodes in Deciduous and Citrus Orchards, Vineyards and Nurseries

Luxembourg Agricultural Team,[1] Y. Oka,[2] Y. Kozodoy,[3] J. Gotlib,[4] E. Harkavi,[4] D. Balchinski,[4] A. Avtavi[4] and T. Sigler[4]

[1]*Luxembourg Industries (Pamol) Ltd., Tel Aviv 61000 [e-mail: yuval@luxembourg.co.il];* [2]*Dept. of Nematology, ARO, Gilat-Besor, M.P. Negev 85280;* [3]*Plant Protection and Inspection Services, and* [4]*Extension Service, Ministry of Agriculture and Rural Development, Bet Dagan 50250, Israel*

Rugby is a nematicide from the organophosphorus group, acting as a contact poison on a wide variety of nematodes and soil pests. The product is formulated as a microemulsion, containing 100 g cadusafos per liter and is manufactured by FMC, USA, and distributed in Israel by Luxembourg Industries (Pamol) Ltd. Rugby has a low degradation rate and low soil mobility that ensure its long-lasting effect. Its mobility in the plant is limited; thus it can also be applied during the growing season. From accumulated experience in nematode trials in orchards, we know that the use of nematicides is more effective when they are applied in nurseries, or in young plantations. Many factors cause an increase in nematode infestation in orchards; among the most important are: using infested seedlings, planting in infested soil, using sensitive rootstocks and using a drip irrigation system (this causes permanent humidity in the rootlet area and thus an increase in the number of rootlets – ideal conditions for nematode development). In trials that were carried out in deciduous and citrous orchards, vineyards and nurseries, Rugby at 30 *l*/ha proved very efficacious in controlling nematodes. In peaches and nectarines Rugby controlled more than 90% of nematodes *Meloidogyne* spp. in comparison with the standard product that gave no more than 50% control. In vineyards

Rugby controlled 98% of nematodes *Meloidogyne* spp. in comparison with 73% control by the standard product, and gave 99% control of *Heliocotylenchus* spp. (average of four field trials). In trials in apple nurseries Rugby, at a rate of 5 ml per seedling, controlled 100% of the nematode *Pratylenchus vulnus* and in young apple orchards it controlled 97% of the nematodes in comparison with 47% control by the standard product. In citrus nurseries Rugby (as other organophosphorus products) controlled 100% of the nematode *Tylenchulus semipenetrans* for a period of one year from application. In young citrus orchards Rugby, after one application, resulted in 89% control, in comparison with 55% control by the standard product; after two applications Rugby's efficacy increased to 99%. Today, Rugby is the only nematicide in Israel which was found to be effective and that is registered for use in nurseries and orchards. *(P)*

Control of *Alternaria* spp. by Bravo, Using Various Application Methods in Potatoes and Carrots

H. Kaplan and E. Yogev

Luxembourg Industries (Pamol) Ltd., Tel Aviv 61000, Israel [e-mail: lola_k@netvision.net.il]

Bravo is a flowable fungicide containing 500 g chlorothalonil per liter. The product is manufactured by Zeneca Agrochemicals, England, and is distributed in Israel by Luxembourg Industries (Pamol) Ltd. Chlorothalonil binds to S-H groups on amino acid molecules and causes the inhibition of many important metabolic processes, mostly of enzymes in the Krebs cycle. The multi-site mode of action significantly decreases the risk of resistance development in the fungi. Bravo prevents disease development in many crops and is especially effective as a protectant prior to fungal establishment, by inhibition of spore germination. The active ingredient sticks to the leaf surface and is not washed away by irrigation or rain. Bravo's formulation is unique because of its high rain-fastness and thus has a longer residual activity than other products containing the same active ingredient. Bravo was tested in potatoes in early blight (*Alternaria solani)* trials in recent years. Ground application of Bravo at biweekly intervals or injected weekly through the irrigation system was compared with standard weekly aerial application. Bravo provided very good efficacy in preventing early blight in potatoes, reduced the level of infestation and increased potato yield. Economic calculation showed that ground application of Bravo at longer intervals or injection through the irrigation system improves crop profits by saving the aerial application cost and improving yields. The efficacy of Bravo, among other products, in controlling *Alternaria dauci* in carrots, was examined by Shtienberg *et al.* in 1998, and by Ben Noon *et al.* in 1997. Bravo was even more effective in preventing *A. dauci* in carrot – than the systemic products that were examined. It increased carrot yield by up to 73%, in comparison with the untreated control. The results presented prove that Bravo is an excellent product for the control of *Alternaria* spp. in potatoes and carrots and that ground application of Bravo at longer intervals or through the irrigation system is very efficient and cost-effective. *(P)*

Preharvest Control of Postharvest Bunch Decay of Table Grapes in Israel

A. Lichter,[1,*] Y. Zutkhi,[1,*] Z. Shacham,[1] T. Kapulonov,[1] O. Dvir,[1] Ruth Ben-Arie,[1,**] D. Rav David,[2] Y. Elad[2] and Y. Hameiri[3]

[1]*Dept. of Postharvest Science of Fresh Produce, and* [2]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: ntlicht@netvision.net.il];* [3]*Extension Service, Ministry of Agriculture and Rural Development, Bet HaShita, 18910; **Current address: Fruit Storage Research Laboratory, Qiryat Shemona 10200, Israel*

Infection of grape berries with fungal spores in the vineyard does not always lead to disease symptoms at harvest. However, during prolonged cold storage, the fungal spores (primarily those of *Botrytis cinerea*) may germinate and lead to severe bunch decay. A 4-year field trial was conducted

as part of the effort to expand the means to control postharvest bunch decay in Israel. In the first year, eight different fungicides were applied at different combinations after flowering and during fruit maturation. The fruits were stored for 4 weeks at 0°C and bunch decay was scored after 3 days at 20°C. Three commercial formulations, namely, Switch (cyprodinil and fludioxonil), Mitos (pyrimethanil) and Frowncide (fluazinan), were relatively effective in controlling bunch decay, but only when applied late in the season. In the second year, three formulations (Switch, Mitos and Teldor [fenhexamid]) were tested in three vineyards. One application, 11 days before harvest, was less effective than two or three applications in the course of the month before harvest. The level of chemical residues of the most effective formulation, Switch, was higher than permitted. In the third season, a single application of this formulation, 3 weeks before harvest, was effective both in controlling bunch decay and in maintaining the residue level below 1 ppm. A combination of the preharvest treatment in the vineyard, and a postharvest treatment, resulted in complete eradication of bunch decay. Thus, it is suggested that timely application of fungicidal treatments can minimize health risks and costs, without compromising fruit quality.

Control of Black and Silver Scurf on Potato Seed Tubers

Leah Tsror (Lahkim),[1] Orly Erlich,[1] M. Aharon,[1] M. Lavy[2] and I. Peretz-Alon[2]
[1]*Dept. of Plant Pathology, ARO, Gilat Experiment Station, M.P. Negev 85280 [e-mail: tsror@bgumail.bgu.ac.il]; and* [2]*Ma'on Enterprises, M.P. Negev 85465, Israel*

Black and silver scurf on potatoes caused by *Rhizoctonia solani* and *Helminthosporium solani*, respectively, are considered as blemish diseases that became serious during the past few years due to increased awareness and lowered defect tolerances of washed pre-packed potatoes. They reduce tuber quality of all market classes of potatoes, and usually do not cause yield losses at harvest, but silver scurf does cause weight loss of stored potatoes due to increased water loss. Field experiments were conducted in the northern Negev to determine the efficiency of fungicides in controlling black and silver scurf. Monceren (pencycuron) and Monti (pencycuron + TMTD), Rizolex (tolclofos-methyl + TMTD), Telem (flutolanil) and Celest (fludioxonil) sprayed either in furrow at planting, or on seed tubers (at low volume), significantly reduced black scurf incidence on daughter tubers. Dusting seed tubers with Mancidan (mancozeb) and Antracol (propineb), or low-volume spraying with Rovral (iprodione) and Vitavax (carboxin + TMTD), or furrow treatments, reduced disease incidence, but to a lesser extent. A correlation between levels of infection on seed tubers and disease level on daughter tubers was observed. In field experiments where control of silver scurf was evaluated, all tested fungicides applied as seed tuber treatments were significantly better than spraying in furrow. Low-volume seed spraying with Celest, Octav (prochloraz) and Amistar (azoxystobin), or dusting with Mancidan and Antracol, significantly reduced silver scurf incidence on daughter tubers. Combined treatments of low-volume sprayed agents applied with Mancidan dusting in reduced dosage were also effective. Magnate (imazalil) and Sunzil (imazalil) were moderately effective. Ohio (fluazinam) had not reduced disease incidence. In a separate experiment where different timing of imazalil application to seed tubers (by low-volume spray) was studied, application both pre- and post-storage, or only post-storage, significantly reduced disease incidence. In previous experiments pre-storage treatments were more effective than in the present work. *(P)*

Effect of Hydrogen Peroxide Plus (HPP) on Silver Scurf Disease in Stored Potatoes

U. Afek, Janeta Orenstein and E. Nuriel
Dept. of Postharvest Science of Fresh Produce, ARO, Gilat Experiment Station, M.P. Negev 85280, Israel [e-mail: afekuzi@netvision.net.il]

One of the major reasons for loss of potatoes in storage is decay caused by various pathogens; among them is the fungus *Helminthosporium solani*, which causes silver scurf. This important

disease spreads during storage with no known solution for controlling it. The potato damage is expressed in two ways: (i) decreased quality of the tubers, and (ii) increased weight loss and shrinkage of the potatoes following evaporation of water through the damaged skin. HPP (hydrogen peroxide plus) stabilized with a mixture of substances is an environmentally friendly disinfectant, and was successful in controlling this pathogen during storage. After 5 months of storage, the properties of infected tubers in vars. 'Desirée' and 'Mondial' following five treatments with 10% HPP by fogging the storage rooms *via* the Tabor Atomizing System, was 0% compared with 33% and 35% in the non-treated control of the two varieties, respectively. Five months postharvest, the level of decay after a single treatment with 10% HPP was 15% and 17%, respectively. Furthermore, treatments with HPP controlled the progress of the fungus on the skin of infected harvested tubers. *(L)*

Characterization and Control of Root Diseases on Anigozanthus

Tslila Ben-David,[1] Irit Dori,[2] E. Matan,[2] Marina Hazanovsky,[3] Sara Mordechai-Leviush[3] and Leah Tsror (Lahkim)[3,*]

[1]*Extension Service, Ministry of Agriculture and Rural Development, Tel Aviv 61070;* [2]*R&D, Besor Experiment Station, M.P. Negev 85400; and* [3]*Dept. of Plant Pathology, ARO, Gilat Experiment Station, M.P. Negev 85280, Israel [*e-mail: tsror@bgumail.bgu.ac.il]*

The exotic flowers of Kangaroo Paw (especially the 'mini' varieties) grown in Israel in greenhouses and exported to Europe, are susceptible to soilborne diseases under conditions of high temperature and humidity. The most prevalent pathogen involved in plant mortality is *Pythium myriotylum*; however, in symptomatic plants also *Rhizoctonia solani, Fusarium oxysporum, Fusarium* spp. and *Myrothecium* were observed. In pathogenicity tests conducted in a greenhouse at the Besor Experiment Station, 22.5% of the plants inoculated with *P. myriotylum* had collapsed 18 days after inoculation; 24 days later 78% had collapsed, whereas only 5% of the plants inoculated with *R. solani* had collapsed; 88% of the plants inoculated simultaneously with both pathogens had collapsed. Disease incidence 60 days after inoculation was between 90% and 100% in plots inoculated with *P. myriotylum* either alone or in combination with *R. solani*. These results demonstrate clearly that *P. myriotylum* is the dominant pathogen. In order to determine the possible potential sources of contamination with *P. myriotylum*, samples from plants in tissue cultures (Australian origin), in different stages at the nursery, and in growth mixture medium were examined for the presence of the pathogen; it was not detected in any of these sources. *F. oxysporum* and *Fusarium* spp. were detected in several plants in tissue culture and in the nursery, but they were found to be non-pathogenic in pathogenicity tests. Control of the disease was tested in laboratory and greenhouse experiments. *In vitro* tests indicated that Terraclor Super X (etridiazole+PCNB), fenamidon, Ridomil Gold (mefenoxam), Sandocur (oxadixyl+cymoxanil) and Dynone (prothiocarb) inhibited the fungal colony growth in 40–80% of the cases at 1–2 ppm. Efficiency of the fungicides was evaluated in the greenhouse: in 1999, Terraclor Super X and fenamidon significantly reduced the incidence of diseased plants, 41 days after inoculation; in 2000, Fenamidon, Ridomil Gold, Dynone and Terraclor Super X combined with *Trichoderma harzianum* in plantlets reduced disease incidence by 24%, whereas yields were improved by Terraclor Super X, *T. harzianum* and Ridomil Gold. Biological treatments were tested in a pot experiment: *T. harzianum* in the plants' roots, mycorrhizae applied into the potting mixture, combined treatment of *T. harzianum* and mycorrhizae, and supplement of grape marc compost (10%). Every one of the treatments reduced disease incidence, but compost supplement increased the number of flowers and their quality. *(L)*

F: ALTERNATIVES TO METHYL BROMIDE

ForDor 101, An Economical Substitute for Methyl Bromide in Agriculture

Y.A. Perez[1] and G. Kritzman[2]

[1]*R&D, Yaham Ma'on District Settlements, Negev 85465; and* [2]*Inst. of Plant Protection, ARO, The Volcani Center, Bet Dagan 50250, Israel [e-mail: kritzgio@netvision.net.il]*

Methyl bromide will be in use until the year 2005. It is a broad-spectrum pesticide used in the control of pest insects, nematodes, weeds and plant-pathogenic fungi. Alternatives to methyl bromide as a soil treatment are those treatments that cover some parts of the spectrum of activity of methyl bromide. The formulations of ForDor 101 (marketed by Smadar Ltd., Ashqelon, Israel) have proven effective against a wide range of plant pathogens: bacteria, fungi and nematodes. ForDor 101 covers a wide area of the spectrum of methyl bromide activity; it is therefore a real alternative to methyl bromide. Some facts about this formulation: *(a)* friendly to the environment and is converted rapidly to CO_2 and H_2O without leaving residues; *(b)* simple application to the desired soil depth or medium; *(c)* controls a wide spectrum of pests (bacteria, fungi and nematodes); *(d)* economical substitute for methyl bromide; and *(e)* recommended for pathogen-free quality seed production. Examples of the uses of ForDor 101 formulation to control successfully a wide spectrum of pests are as follows: Peanuts – pod wart disease (*Streptomyces* spp.), *Pseudomonas* spp., *Pythium* spp. and free nematodes. Carrot - *Pythium* spp., scab (*Streptomyces* spp.) and free nematodes. Tomatoes - *Clavibacter, Xanthomonas* spp., *Pseudomonas* spp., *Erwinia* spp., *Verticillium, Fusarium, Pythium*, corky roots, and free nematodes. Potatoes - *Streptomyces* spp. (potato scab), *Pseudomonas* spp., *Erwinia* spp., *Pythium, Verticillium, Fusarium, Rhizoctonia solani, Colletotrichum* spp. and nematodes. Lettuce – significant reduction in crop losses due to a complex of pathogens (bacteria and fungi). ForDor 101 is new and better for controlling soilborne pathogens – efficiently and economically, and is friendly to the environment. *(P)*

Soil Fumigation with Telopic (C-35) to Control Verticillium Wilt

Leah Tsror (Lahkim)[1], Orly Erlich[1], M. Aharon[1], Y. Cahlon[2], A. Hadar[2], Y. Cohen[3], M. Shmueli[3], E. Shlevin[4], E. Ben-Nun[4], B. Meler[5], Z. Bigel[5] and I. Peretz-Alon[6]

[1]*Dept. of Plant Pathology, ARO, Gilat Experiment Station, M.P. Negev 85280 [e-mail: tsror@bgumail.bgu.ac.il];* [2]*Agrichem Ltd., Petah Tiqwa 49002;* [3]*Dead Sea Bromine Ltd., Be'er Sheva 84101;* [4]*Kibbutz Sa'ad, M.P. Negev 85140;* [5]*Kibbutz Alumim, M.P. Negev 85138; and* [6]*Ma'on Enterprises, M.P. Negev 85465, Israel*

Potato early dying caused primarily by *Verticillium dahliae* may cause 50% yield loss in susceptible cultivars. The pathogen produces microsclerotia that infect the soil for more than 15 years. The objective of the present study was to evaluate the effectiveness of the soil fumigant Telopic [C-35 (61% 1,3-dichloropropene and 35% chloropicrin)] in controlling *V. dahliae* in potato, and in other subsequent susceptible crops. In field experiments at Gilat (1998/99), incidence of infected plants and colonization levels of the fungus were significantly reduced by C-35 and methyl bromide (MBr) applied with plastic covering, compared with C-35 without plastic and with the control. Yields obtained in the controls were 20% lower than in the other treatments. At Besor (1998), disease incidence was reduced to 0, 0, 86% and 41% by MBr, C-35, Bromopic (BrP, 70% methylbromide + 30% chloropicrin) and ForDor (37% formaldehyde), respectively. Yields obtained from BrP-, C-35- and MBr-fumigated plots were significantly higher than those from plots treated with ForDor or the control. At Alumim (2000), yields were significantly increased by C-35, MBr and BrP treatments. However, C-35 without plastic was similar to the non-treated control. Incidence of infected plants and daughter tubers was lower in C-35, MBr and BrP plots than in control and C-35 without plastic. To study the long-term effect of C-35 fumigation on subsequent susceptible crops, eggplant and watermelon seedlings were planted immediately after the potato harvest at Gilat. Eggplant yields obtained in the control and C-35 without plastic were lower than in C-35- and MBr-fumigated plots. Disease incidence in the control and C-35 without plastic was higher in eggplant and watermelon.

In summary, Telopic effectively reduced *V. dahliae* in the soil and thus can be used as a soil

fumigant prior to potato. Moreover, a long-term effect of the treatment was observed also in other susceptible crops. *(P)*

Application of Dazomet (Basamid) for Soil Disinfestation

Yael Cornfeld,[1] A. Gamliel,[1,*] A. Grinstein[1] *[deceased]*, Miriam Austerweil,[1] Bracha Steiner,[1] L. Klein[2] and J. Katan[3]

[1]*Lab. for Pest Management Research, Inst. of Agricultural Engineering, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: agamliel@agri.huji.ac.il]; [2]Dead Sea Bromine Group, Be'er Sheva 84101; and [3]Dept. of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Sciences, Rehovot 76100, Israel*

The application of Basamid as a potential soil fumigant was tested in the laboratory, small-field plots and commercial application. Basamid granular is a micro-granular formulation of the active ingredient dazomet. The breakdown of dazomet is rapid in moist aerobic soils, resulting in methylisothiocyanate (MITC) as the major breakdown product (98%) and other products (CS_2, HCHO, H_2S and NH_3) in very low amounts. MITC generation and dissipation were studied over a spectrum of soil temperatures and water contents. The generation of the active ingredient was enhanced at high soil temperature; at lower temperatures MITC generation was slower. The dissipation of MITC was faster at high temperatures and slower at low temperatures. Efficacy of control of pathogens was reduced when they were exposed to Basamid products in soil at temperatures below 20°C. Positive correlation was obtained between MITC generation and control of sclerotia of *Verticillium dahliae* and chlamydospores of *Fusarium oxysporum* f.sp. *radicis lycopersici*. At soil temperature of 35°C, complete control of the propagules was obtained at a rate of 30 ppm Basamid, whereas <50% control was achieved at the same rate at 18°C. Disinfestation activity of Basamid was tested in different seasons and at different soil temperatures in small field plots. It was reduced significantly when soil temperature decreased in winter. When maximal soil temperature was below 20°C, only partial control was achieved even at a depth of 30 cm. The efficacy of Basamid in controlling pathogens is reduced at deep soil layers, due to its inefficient incorporation and to poor downward mobility of the breakdown products. This results in partial control of fungal propagules at a depth of 50 cm. All experiments were done using plastic tarp with low-density polyethylene films. Combination of Basamid with solarization further enhances rapid generation of MITC. The peak of MITC under solarization is higher and attained faster, and its dissipation is also shorter. Thus, a combination of Basamid and solarization can enable effective control of pathogens at reduced dosage. The combination of solarization and Basamid at a reduced rate was tested on commercial farms and found to be very effective in controlling crown rot of tomatoes, and sudden wilt of melons. Fumigation with Basamid alone or combined with solarization usually resulted in increased yield quantity and quality, thus confirming the effectiveness of this fumigant for soilborne pest control. *(L)*

Methyl Bromide Substitutes on Cucumbers and Their Long-term Effect

H. Yunis,[1,*] N. Omri,[1] Y. Cahlon,[2] M. Shmueli[3] and D. Barel[3]

[1]*Extension Service, Ministry of Agriculture and Rural Development, Tel Aviv 61070 [*e-mail: yhisham@shaham.moag.gov.il]; [2]Agrichem Ltd., Petah Tiqwa 10156; and [3]Bromine Compounds Ltd., Be'er Sheva 84101, Israel*

Annual methyl bromide applications for the control of *Pythium* spp., root-knot nematodes and weeds are the accepted soil fumigation routine for greenhouse-grown cucumbers. Screening tests for methyl bromide substitutes have been carried out at several locations in Israel over the last 3 years. Of the several promising results, the following substitutes have been tested: dazomet at two

rates in combination with 1,3-dichloropropene, a Telone and chloropicrin mixture, and fenamiphos compared with the methyl bromide standard. Dazomet at rates of 250 and 450 kg/ha in combination with Telone 150 *l*/ha, the Telone/chloropicrin mixture at 400 *l*/ha and Telone at 150 *l*/ha provided effective control of root-knot nematodes for a period of 64 days. Eighty-five days after transplanting, the infestation rate in these treatments reached 5%. Fenamiphos at 20 *l*/ha did not provide effective control, the infestation rates reaching 65% after 64 days and 100% after 85 days. Methyl bromide provided complete control, the infestation rate being nil. Dazomet with Telone at both dosages, the Telone/chloropicrin mixture and methyl bromide prevented build-up of *Pythium* infestation. Telone and fenamiphos did not prevent *Pythium* and a drench application had to be applied to replanted seedlings. The highest and statistically significant yield was attained in the methyl bromide plots. Yields attained in the dazomet, Telone/cholropicrin mixture and Telone plots were significantly higher than those attained in untreated control plots. Yields in the fenamiphos plots were on par with the untreated control. In a second cycle of transplanting, 210 days after soil fumigation, vegetative growth was normal. Final observations on root-knot nematode infestation rate and yield will be made 280 days after soil fumigation. *(L)*

Telone EC as a Possible Alternative to Methyl Bromide

L. Klein,[1] M. Shmueli,[1] A. Hadar,[2] Y. Cahlon,[2] Y. Cohen[1] and T. Sultan[2]

[1]*Dead Sea Bromine Ltd., Be'er Sheva 84101 [e-mail: assarafm@dsbg.com]; and* [2]*Agrichem Ltd., Petah Tiqwa 49002, Israel*

As a direct consequence of the methyl bromide (MBr) phaseout, there is an urgent need to develop chemical and non-chemical alternatives to this soil sterilant. Telone (1,3-dichloropropene) is a common soil fumigant, developed by Dow AgroSciences, which is an effective and inexpensive nematicide. The emulsifiable concentrate (EC) formulation, Telec, has been developed to facilitate its application *via* the irrigation system, as well as to expand its usage to greenhouses, where Telone application is complicated. We investigated the possibilities to combine Telec with other pesticides or with soil solarization, for the control of root-knot nematodes. The efficacy of Telec (195 kg/ha) in the control of *Meloidogyne* sp. in cucumber plants in greenhouses, was studied in plots heavily infested due to continuous cropping of cucumber plants. Among the parameters checked were visualization of plant roots and evaluation of disease severity on a scale of 0 (healthy) to 10 (the most severe symptoms), plant height, and yield weight. Results were compared to MBr treatment using a half dosage (250 kg/ha) with virtually impermeable film (VIF) and to non-treated control. Roots of plants grown in non-treated control plots showed the most severe symptoms, as compared with only marginal symptoms in plants grown in Telec- and MBr-treated plots. Plants in plots treated with Telec or MBr were 30% taller than those in non-treated plots. The highest yield (161 t/ha) was achieved using Telec, followed by 140 and 80 t/ha in MBr- and non-treated plots, respectively. Similar results were obtained when Telec was used as a preplant treatment for pepper and tomato crops. When combined with dazomet or metam-sodium, Telec increased plant growth, which resulted in increased yield. Our findings lead to the conclusion that Telec, or Telec combined with soil solarization, can be used as an efficient replacement for MBr to control root-knot nematodes in vegetables in greenhouses. *(P)*

Methyl Bromide Substitutes for the Control of Root-knot Nematodes on Greenhouse Cucumbers and Peppers

Neta Mor,[1,*] S. David,[1] N. Ganaim,[1] H. Yunis,[1] Y. Sachs,[1] Y. Posalsky,[1] Y. Cahlon,[2] T. Sultan,[2] M. Shmueli,[3] D. Barel,[3] Y. Cohen,[3] L. Klein,[3] Y. Aizenberg,[4] E. Urieli,[4] M. Lang,[5] Y. Benyamini,[5] M. Keren Zur[6] and A. Grimberg[6]

[1]*Extension Service, Ministry of Agriculture and Rural Development, Tel Aviv 61070 [*e-mail: netmor@shaham.moag.gov.il]; [2]Tarsis-Agrichem Ltd., Petah Tiqwa 10156; [3]Bromine Compounds*

Ltd., Be'er Sheva 84101; [4]Agan Ltd., Ashdod 77102; [5]Luxemburg Chemicals and Agriculture, Tel Aviv 61000; and [6]Minrav Ltd., The Biological Division, Jerusalem 91291, Israel

Three field trials were carried out during the 1999 and 2000 seasons for the control of root-knot nematodes on cucumber and pepper under greenhouse conditions, and on pepper under plastic tunnels, respectively, with methyl bromide substitutes. The trials were conducted in light, loamy and heavy soils all heavily infested with root-knot nematodes. Nematicides were added to treatments with fungicidal effect such as metam-sodium and/or solar sterilization in order to produce substitutes that emulate methyl bromide's range. Single treatments of methyl bromide, Condor (1,3-dichloropropene 91%), and control were compared with mixed treatments of Basamid (dazomet 98%) or Edigan (metam-sodium 370 g/*l*), with Condor, Rugby (cadusafos 200 g/*l* CS) or Bionem (*Bacillus firmus*), respectively, on cucumbers. All treatments were effective in controlling nematodes. They were significantly superior to the untreated control and were on a par with the standard methyl bromide application. The parameters checked were: gall index, growth index and yield. In addition to the compounds tested in the previous trial, the field trial on pepper involved soil sterilization with and without metam-sodium application in addition to the nematicide (Bionem or Condor) or InLine (1,3-dichloropropene 61%+ chloropicrin 35%) alone. All treatments controlled root-knot nematodes effectively. They performed better than the untreated control showing effectiveness similar to the methyl bromide standard with regard to growth rate and yield. With the exception of soil sterilization-*cum*-Bionem, all treatments reduced root-knot nematode infestation on the root system throughout the cropping season. Soil sterilization-*cum*-Bionem was less effective with respect to the gall index but performed better than the untreated control. No benefit was reaped from combining metam-sodium or soil sterilization with a nematicide such as Condor. The compounds did not pose any problems of phytotoxicity. *(L)*

Novel Application of Vydate L to Control the Root-Knot Nematode in Vegetables

N. Mogilner,[1] M. Zidan,[1] Z. Shechener,[1] A. Bahat,[1] J. Barkay[1] and D. Orion[2]
[1]*Milchan Bros., Ramat Gan 52117 [e-mail: agro@milchanbros.co.il]; and* [2]*Dept. of Nematology, ARO, The Volcani Center, Bet Dagan 50250, Israel*

Vydate L (240 g/*l* oxamyl), a carbamate pesticide produced by DuPont Inc., USA, is registered in Israel for the control of leafminers and sucking insects in vegetables by foliar spray application. It is also used as a nematicide in many countries to control plant parasitic nematodes in various crops. Vydate L is a systemic pesticide translocated in the plant both acropetally (in the xylem system) and basipetally (in the phloem). The chemical is hydrolyzed in the soil, its moderate half-life is very much influenced by water soil pH. The hydrolytic degradation is faster in alkaline than in acidic soil pH. In a series of field experiments carried out in Israel during the last 2 years, Vydate L was found to be an efficient chemical to control or delay the development of the root-knot nematode *(Meloidogyne javanica)* in tomatoes and cucumbers. Its application resulted in lower galling indices, better growth and higher yields compared with untreated controls. Best results were obtained when Vydate L was applied with a spot gun applicator, as a soil split drench treatment. Vydate L was applied on the day of planting and in further sequential applications of 0.6 or 1.2 kg a.i./ha at 1- or 2- week intervals, respectively, for 6 to 8 weeks after planting with a total amount of 3.6 to 4.8 kg a.i./ha. The Vydate L solution was acidified by means of phosphoric acid or the surfactant BB5 to reach pH 6. The split application was meant to maintain the presence of oxamyl in the soil for a prolonged period, aiming to control the hatching juveniles. Vydate L was also tested in the same manner as a complementary treatment after Edigan (metam-sodium) or Rugby (cadusafos) which were applied as a preplant treatment. Vydate L could be applied through the drip irrigation system when separate from the drinking system. Unlike other nematicides, Vydate L is very safe and can be applied right from the day of transplanting. No oxamyl residues above the tolerance limit (2 ppm) were detected

in tomatoes and cucumbers harvested 3 days and more after Vydate L application. During the 2 years of the experiments no damage in the treated plants was observed. In the light of the ban on methyl bromide, the necessity to find adequate substitutes is becoming urgent; Vydate L could serve as a unique complementary, efficient and convenient means to control nematodes and insects in various crops. *(P)*

Control of *Fusarium* and of Root-knot Nematodes in Carnations Using Steam or Chemicals

Michal Reuven,[1] M. Mor,[2] Y. Szmulewich,[1], Ina Kolesnik,[1] A. Gamliel,[3,*] Y. Mor[4] and Y. Ben-Yephet[1]

[1]*Dept. of Plant Pathology,* [2]*Dept. of Nematology, and* [3]*Inst. of Agricultural Engineering, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: agamliel@agri.huji.ac.il]; and* [4]*Extension Service, Ministry of Agriculture and Rural Development, Bet Dagan 50250, Israel*

The most destructive soilborne pathogens of carnation (*Dianthus caryophyllus* L.) are *Fusarium oxysporum* f.sp. *dianthi* and root-knot nematodes, *Meloidogyne javanica*. A comparison between methyl bromide and soil steaming, Edigan (metam-sodium) or Basamid (dazomet) in controlling the two pathogens, was carried out in a naturally infested field. The field was divided into ten blocks of which five were fumigated with the liquid nematicide Telone (1,3-dichloropropene, 25 ml/m^2. Then, each of the ten blocks was treated with the five following treatments: control – irrigation with water, Edigan – 180 ml/m^2, Basamid – 60 g/m^2, soil steaming for 4–5 h using a negative pressure method, and methyl bromide – 70 g/m^2. Efficiency of the Fusarium control was determined by counting *F.o. dianthi* propagules in soil collected from three depth layers of each replicate: 0–20, 20–40 and 40–60 cm. The *M. javanica* population was qualitatively estimated on tomato roots planted in soil collected from the 0–20 cm layer. Three carnation varieties: 'Hermon' – highly susceptible, 'Lior' – susceptible, and 'Galit' – moderately resistant to *F.o. dianthi*, were planted at the end of June. Disease incidence of the two diseases was estimated at 14-day intervals from 90 to 180 days after planting. Propagule counts of *F.o. dianthi* with Edigan, steam or methyl bromide were below detection level in the three soil layers tested. Basamid was less effective as compared with the other treatments. Telone reduced gall incidence on tomato roots to below the detection level and *F.o. dianthi* counts by 20%. In control plots not treated with Telone, disease incidence caused by *F.o. dianthi* reached the maximal level faster and growth inhibition caused by *M. javanica* was greater as compared with control plots treated with Telone. Disease incidence by the two pathogens in methyl bromide plots with or without Telone was similar and very low. Steam or Edigan treatments were similar to methyl bromide in reducing disease incidence caused by *F.o. dianthi* but had only a partial effect on disease caused by nematodes. Addition of Telone fumigation improved nematode control in both treatments. Basamid was less efficient than Edigan in reducing disease incidence caused by *F.o. dianthi* or nematodes. Disease incidence caused by *F.o. dianthi* was the highest in var. 'Hermon' and the lowest in 'Galit'. In conclusion, steam or Edigan treatments with the addition of Telone reduce damage to carnations caused by *F.o. dianthi* and *M. javanica. (L)*

Floriculture in the Post Methyl Bromide Era – Model Farms

M. Gokkes,[1,*]A. Gamliel,[2] Tslila Ben-David,[3] Neta Mor,[3] Tamar Lahav,[3] M. Levi,[3] E. Siti[4] and Yael Skutelski[4]

[1,3,4]*Extension Service, Ministry of Agriculture and Rural Development:* [1]*Bet Dagan 50250,* [3]*Central District, Ra'ananna 43000, and* [4]*Negev District, Be'er Sheva 84203; and* [2]*Inst. of Agricultural Engineering, ARO, The Volcani Center, Bet Dagan 50250, Israel [*e-mail: mghokas@shaham.moag.gov.il]*

During 1999 methyl bromide alternatives for soil disinfestation in floriculture were tested on model farms on a semi-commercial scale. The methods tested were different chemical compounds,

such as metam-sodium, dichloropropene, dazomet, and nonchemical methods, such as solarization and soil desiccation. Integrated methods were tested as well. All alternative treatments were tested in gerbera, lilies, ornithogalum var. 'Dubium', aconitum and lisianthus, compared with methyl bromide and an untreated control. During the first year no differences were detected between the treatments in gerbera, lily, ornithogalum and aconitum for all parameters tested (disease distribution, yield and quality). In lisianthus the yield and flower length were higher where methyl bromide fumigation was applied. In most instances the untreated controls were more infested with weeds. It may be assumed that most likely no disease appeared in the untreated plots due to the long-lasting effect of multi-annual treatment with methyl bromide and the fact that it takes more than one season to obtain re-infestation with soil pathogens. This season we are testing again the same treatments at exactly the same locations, in gerbera, lily and ornithogalum. So far the untreated plot in gerbera became infested with root-knot nematodes. In lisianthus a certain advantage could be observed for the fumigated plots, compared with the untreated one. Methyl bromide was inferior to metam-sodium with dichloropropene. In solidago (tested in one year only), a severe infestation with the free nematode *Longidorus* sp. was identified and the plant's development was greatly depressed. Reasonable alternatives for methyl bromide fumigation exist for flower crops susceptible to fungal soil pathogens, combined or not with root-knot nematodes. The alternatives are metam-sodium compounds with or without dichloropropene or cadusafos. Additional solarization may reduce the necessary rates of the above mentioned materials. *(L)*

G: BIOLOGICAL AND AGROTECHNICAL CONTROL

Organic Amendments Combined with Soil Solarization as a Non-Chemical Approach to Soilborne Pest Management

A. Gamliel,[1,*] Miriam Austerweil,[1] G. Kritzman,[2] I. Peretz-Alon[3] and O. Heiman[4]

[1] *Lab. for Pest Management Research, Inst. of Agricultural Engineering [*e-mail: agamliel@agri.huji.ac.il], and* [2] *Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250;* [3] *Hevel Ma'on, M.P. Negev 85465; and* [4] *Dor Chemicals Ltd., Haifa 26110, Israel*

Combining organic amendments with soil solarization is a non-chemical approach to improve the control of soilborne pests. Heating of soils covered with plastic film and amended with appropriate organic material, actuates chain reaction of chemical and microbial degradation leading to the generation of toxic compounds in the vapor and liquid soil phase. Generation of toxic compounds increases with temperature. These toxic compounds accumulate under the plastic mulch, and enhance toxic activity against the soil flora and fauna, especially soilborne plant pathogens. The plastic mulch traps the volatile compounds and creates an atmosphere in soil, which enhances the degradation of the organic matter. The toxicity of the generated volatile compounds is expected to be higher under the high soil temperature prevailing during solarization. At the end of the process, the soil contains less pathogens, and a different microflora, which may suppress new establishment of pathogens in this soil. Significant qualitative and quantitative differences in volatile compounds from heated and non-heated soil amended with plant residues (crucifers, and aromatic herb plants) or high nitrogen organic material (poultry manure, soymeal) were evident in both controlled-environment studies and field experiments. Microbial activity in heated or solarized soil amended with plant residues increased after the first 2 weeks of incubation, or solarization as compared to non-amended soil. Apparently, microbial activity is involved in pathogen control during solarization of amended soil. Solarization of organic amended soil as a control method was tested under small-plot field conditions. Combining soil solarization with soymeal effectively controlled Verticillium wilt, *Rhizoctonia* and scab of potatoes, and peanut pod wart of peanuts. These treatments were also effective in controlling cyst nematodes in second and third sorghum and wheat crops without any additional treatment before the second crop. Effective control of peanut pod diseases was evident in a fourth crop after the disinfestation treatments. The effect of solarization of organic amended soil as a control method was

tested also under large-scale field conditions. Combining soil solarization with soymeal followed by a short wheat crop as green manure effectively controlled Verticillium wilt, *Rhizoctonia* and scab of potatoes, and peanut pod wart of peanuts. This validates the efficacy of organic amendments combined with solarization as a tool to control soilborne plant pathogens. *(L)*

Biological Control of Black Scurf on Potato under Organic Management

Leah Tsror (Lahkim),[1] B. Sneh,[2] O. Kleifeld,[3] M. Zinger[4] and Ayala Raviv[4]

[1]*Dept. of Plant Pathology, ARO, Gilat Experiment Station, M.P. Negev 85280 [e-mail: tsror@bgumail.bgu.ac.il];* [2]*Dept. of Plant Sciences and Inst. for Nature Conservation Research, Tel-Aviv University, Ramat Aviv 69978;* [3]*Mycontrol Ltd., Allon haGalil 17920; and* [4]*Efal-Agri Ltd., Netanya 42293, Israel*

Field experiments were conducted at the Gilat Experiment Station, to determine whether *Trichoderma harzianum*, nonpathogenic *Rhizoctonia* (np-R), and cattle manure compost amendment, could reduce black scurf incidence in organically grown potatoes. In the first experiment, in-furrow application of *T. harzianum* (50 g/m) significantly reduced black scurf incidence in daughter tubers. In the second experiment, application of half that dose (25 g/m) reduced disease incidence to a lesser extent. Incorporation of *T. harzianum* in soil had a relatively small effect. Application of two isolates of nonpathogenic-binucleate *Rhizoctonia* (RS 521 and RU 56-8 - AG-P) significantly reduced the incidence of infected tubers in both experiments. Cattle manure compost amendment (CMC-H) also reduced the incidence of infected tubers. In these experiments the yields were not affected by any of the treatments. However, in a third field experiment (Kibbutz Sufa, 1999), the total yield and the relative proportion of large-sized tubers were increased by application of *T. harzianum* to the soil (15 g/m) at the point where the seed tuber had been planted. This study demonstrated for the first time the efficiency of *T. harzianum* and np-R in reducing the incidence of black scurf in daughter tubers, using naturally infected soil and contaminated seed tubers. In addition, application of a suppressive cattle manure compost in-furrow (CMC-H) was also effective in controlling the disease. *(P)*

Organic Fertilizers of Microbial Origin Enhance Growth and Reduce Infection by *Fusarium moniliforme* of Sweet Corn

Junping Gao,[1,2] Bat Chen Ben-Daniel[3] and Yigal Cohen[1,*]

[1]*Faculty of Life Sciences, Bar-Ilan University, Ramat Gan 52900, Israel [*e-mail: coheny@ashur.biumail.biu.ac.il];* [2]*On sabbatical from the Dept. of Ornamental Horticulture, China Agricultural University, Beijing 100094, China; and* [3]*Argogene Ltd., Sharsheret 21, Negev 85252, Israel*

Two field experiments were conducted to evaluate the effects of organic fertilizers of microbial origin on growth and yield of sweet corn and on the development of *Fusarium moniliforme* in corn plants and in the soil. In the first experiment the soil was amended with four products (dry mycelium, Biosol, Agrobiosol, and Bactosol) in various doses and *F. moniliforme* was applied before sowing. In the second experiment only one product (dry mycelium) was added to the soil, no artificial infestation took place; half of the plots were solarized before sowing, with air-tight plastic covers in place for 35 days after organic amendment. The results showed that organic amendments enhanced growth and yield of corn in a significant manner, similar to, or better than, a mineral fertilizer. They enhanced the saprophytic fungal population in the soil and reduced soil colonization with the pathogen. Plants growing in amended soils exhibited reduced incidence of stalk and kernel infection with *F. moniliforme*. The combination of organic amendment and solarization resulted in higher yields than organic amendment alone, but disease control was not enhanced. *(P)*

Reduction of Fusarium Wilt of Carnations and *Fusarium* Counts in Field Soil Treated with a Combination of NH_3 and Limed Sludge (N-Viro Soil)

A. Gips,[1] P. Fine,[2,*] Rivka Rosenberg,[2] V. Solopanov[2], Michal Reuven[3], Y. Shemulevitz[3], Ina Kolesnic,[3] Leah Tsror (Lahkim)[3] and Y. Ben-Yephet[3]

[1]*Extension Service, Ministry of Agriculture and Rural Development, Ra'ananna 43208;* [2]*Inst. of Soil, Water and Environmental Sciences and* [3]*Inst. of Plant Protection, ARO, The Volcani Center, Bet Dagan 50250, Israel [*e-mail: finep@netvision.net.il]*

N-Viro soil (NVS) is the mixture product of de-watered biosolids and CaO (as cement kiln dust, CKD). This high-pH product (>12) is pathogen-free, yet it continues to stabilize and produce ammonium in amended soils. At adequate soil solution pH, all soil NH_4 resides in the gaseous form. NH_3 is known to be an effective disinfectant. Results from 2 years of field and laboratory experiments showed clearly that application of NVS+NH_4 to neutral or calcareous soils can reduce counts of *Fusarium oxysporum* f.sp. *dianthi (F.o. dianthi)*, *Verticillium dahliae, Rhizoctonia solani, Sclerotinia sclerotiorum* and *Streptomyces* spp. and other fungi below detection limits. We tested the efficacy of NVS+NH_4 in reducing *F.o. dianthi* and Fusarium wilt in carnations, in field mini-plots (1 m^2 each) on a light-textured soil that was heavily infected by *F.o. dianthi*. The soil was amended with NH_4 (as $(NH_4)_2SO_4$) and/or NVS. If added, NVS was given at a ratio of 75 Mg/ha (on a dry weight basis). All amendments were manually incorporated in the 0–20 cm soil layer. Six treatments were tested: (i) no addition, (ii) NVS only, (iii) biosolids at 14.3 Mg/ha (equal to the amount contained in the NVS), and treatments (iv), (v) and (vi): NVS plus the following respective amounts of NH_4-N: 156, 312.5 and 625 kg/ha (62.5, 125 and 250 mg/kg). Soil was sampled before incorporation, 5 days after, and several times during the growing season (July–December 2000). Soil samples were analyzed for chemical parameters and for *F.o. dianthi* count. Each of the 32 carnation plants in every replicate (altogether 1536 plants) was inspected for wilt symptoms at 2-week intervals from day 90 to harvest (180 days after planting). At harvest, the 20 plants on the plot margins were sampled separately from the inner circle 12 plants. The canopies were weighed and stems were inspected for Fusarium-related browning of the xylem (= 'diseased plant'). Generally, there was good agreement between the estimates of disease from canopy symptoms and from the browning of the xylem. All NVS treatments reduced *F.o. dianthi* counts in the soil. Maximum reduction was achieved in combination with 250 mg NH_4-N/kg, where counts decreased to zero 5 days after application and were ~12% of the original count 160 days later. Biosolids alone did not have such an effect. At harvest, the number and weight of diseased plants in the inner circle, as percentages of overall number and weight, were 89, 76, 63, 51, 47 and 44%, and 90, 76, 61, 54, 44 and 40% for treatments i, ii, iii, iv, v and vi, respectively. *(L)*

Reduction of *Verticillium dahliae* and *Rhizoctonia solani* in Potato by the Combined Application of NH_4 and Limed Sludge (N-Viro Soil, NVS)

A. Gips,[1] P. Fine,[2,*] V. Solopanov,[2] R. Rosenberg,[2] T. Markowitz,[2] Y. Ben-Yephet[3] and Leah Tsror (Lahkim)[4]

[1]*Extension Service, Ministry of Agriculture and Rural Development, Ra'ananna 43208;* [2]*Inst.of Soil, Water and Environmental Sciences and* [3]*Inst. of Plant Protection, ARO, The Volcani Center, Bet Dagan 50250; and* [4]*Dept. of Plant Pathology, ARO, Gilat Experiment Station, M.P. Negev 85250, Israel [*e-mail: finep@netvision.net.il]*

The efficacy of NVS+NH_4, incorporated into the soil, in controlling *Verticillium dahliae* and *Rhizoctonia solani* in potato, was tested in a field experiment conducted on a loamy loessial soil, heavily infected with these pathogens. Treatments included: (i) NH_4-N (250 mg N/kg soil – the same rate was applied also in the following treatments), (ii) NH_4 + the biosolid component of the NVS (14.3 Mg/ha), (iii) NH_4 + 75 Mg NVS/ha, (iv) NH_4 + 150 Mg NVS/ha, (v) double the NH_4 (1250 kg N/ha) + 75 Mg NVS/ha. Amendments were plowed into the 0–0.2 m layer. Treatments were in six replicates of 60 m^2 each. All plots were covered with polyethylene for 3 weeks after plowing.

NVS raised the pH of a 1:5 soil:water extract above 10.5. However, while the pH decreased below 9 after 20 days, the EC was still $\geq$ 4 dS/m at planting. This probably caused the observed initial delay in emergence and growth, which was eventually relieved in all treatments except for no. iv. Incidence of *V. dahliae*-infected plants was substantially reduced from 52–68% in the controls (treatments i and ii) to 20–27% in NVS treatments. Similarly, colonization levels of *V. dahliae* were significantly reduced from 223 and 380 cfu/g in the controls to 4–20 cfu/g in the NVS-NH_4 treatments. *R. solani* incidence on daughter tubers also decreased from 11% and 21% in the controls to a range of 2.3–6.9% in the various NVS+NH_4 treatments. The suppression most likely resulted from NH_3 toxicity to the soilborne pathogens, boosted up at the high pH of the soil solution. Hence, NVS+NH_4 applied prior to potato growth can reduce diseases caused by major soilborne pathogens, in addition to its value as a fertilizer substitute. The agro-technique still needs adjustment, mainly to reduce overloading and salination of the soil. *(P)*

Reduction of Melon Sudden Wilt Incidence by Manipulating the Irrigation Regime

S. Pivonia,[1] R. Cohen,[2,*] S. Cohen,[1] J. Kigel,[3] Rachel Levita[1] and J. Katan[4]

[1]*Arava R&D, Sapir 86825;* [2]*Dept. of Vegetable Crops, ARO, Newe Ya'ar Research Center, Ramat Yishay 30095 [*e-mail: cron@netvision.net.il];* [3]*Dept. of Agricultural Botany and* [4]*Dept. of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100, Israel*

The effect of irrigation regimes on disease expression in melon plants infected by *Monosporascus cannonballus* was studied during two summer growing seasons in the Arava Valley of southern Israel. In both experiments, reduced irrigation treatments, postponed the onset of plant collapse, reduced the rate of disease progress and lowered disease incidence. Postponement of disease progress in infested fields by lowering irrigation frequency and quantity allowed crop harvest before plant collapse, but reduced yield compared with that harvested in disease-free plots with similar irrigation regimes. The yield harvested from melon grown under reduced irrigation in the infected plots was improved due to lowering of the disease incidence, but fruit quantity and quality were relatively low due to water shortage. The delay in plant collapse under the reduced irrigation treatments was associated with development of a deeper root system. Roots of the daily-irrigated plants reached a depth of 25 cm and the main root system was concentrated in the upper 15-cm soil layer. In the reduced irrigation treatment roots penetrated to a depth of 40 cm and were uniformly distributed throughout the soil profile. It is suggested that the change in root growth pattern improved plant ability to overcome the increasing water demand of the maturing diseased plant. *(P)*

Bio-Filters for the Control of Plant Pathogens in Recycling Irrigation Water Systems

Iris Dornai,[1] Y. Hadar,[2] Y. Dishon,[3] D. Silverman,[4] B. Kirshner,[1] Miriam Kimchi,[1] Valeria Pekarsky,[1] J. Postma,[5] E.A. van Os[6] and G. Kritzman[1,*]

[1]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250, Israel [*e-mail: kritzgio@netvision.net.il];* [2]*The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100, Israel;* [3]*Greenhouse Education Center, Kibbutz En Gedi, 86980, Israel;* [4]*Extension Service, Ministry of Agriculture and Rural Development, Bet Dagan 50250, Israel;* [5]*Plant Research International, Wageningen, the Netherlands; and* [6]*Inst. of Agriculture and Environmental Engineering, Wageningen, the Netherlands*

In recent years growers have been changing from soil-grown to soilless methods of cultivation. The irrigation methods have also changed and increasing numbers of farmers are collecting the drainage water for recycling into the irrigation systems. To overcome the problems of the presence and distribution of plant pathogens in the irrigation water, different methods for treating the water are used. The objective of this work was to develop a system for the prevention of root diseases

in closed soilless growth systems by optimizing microbial suppression in the root environment. In a greenhouse of the Education Center in Kibbutz En Gedi, eight different systems for treating the irrigation water with different growth media were compared. In four of the systems a bio-filter (slow sand filtration) was used with three different media: volcanic ash, volcanic ash + compost, and rock-wool. The other bio-filters were: volcanic ash and sand with aeration. In addition, a UV system and untreated control were compared. The test plant was cherry tomato, sensitive to bacterial and fungal diseases; 100 seedlings were included in every system tested. The recirculating irrigation water was inoculated with the fungus *Fusarium oxysporum radicis-lycopersici* and with the bacterium *Pseudomonas corrugate.* During the tomato growth period, samples were collected from the water and plant tissues for estimation of the pathogen populations. All of the bio-filters were found to be effective in reducing the *Fusarium* population. Slow sand filtration without aeration was better than the other systems in eliminating *P. corrugate* in the tested systems and not significantly different from the UV system. It was thus demonstrated that it is possible to reduce the levels of the tested pathogen and to eliminate disease by treating the irrigation water with UV or with a bio-filter. *(P)*

'Deformation Disease' in *Gypsophila paniculata* Mother Plants and Effect of Nutrition on the Disease

Y. Ben-Yephet,[1,*] Michal Reuven,[1] Aida Zviebil,[1] Y. Szmulewich,[1] Irit Lavkovits,[2] T. Markovits,[2] Shoshana Soriano,[2] Y. Mor[3] and B. Bar-Yosef[2]

*Depts. of [1] Plant Pathology and of [2] Soil Chemistry and Plant Nutrition, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: yephet@netvision.net.il]; and [3] Extension Service, Ministry of Agriculture and Rural Development, Bet Dagan 50250, Israel*

An unknown disease in *Gypsophila paniculata* L. (Baby's Breath) mother plants was described; it causes severe deformations of the emerged cuttings, which consequently reduces the yield of cuttings by up to 50%. We suggest the name 'deformation disease' for this affliction. Involvement of viruses, viroids, phytoplasmas or mites, as well as nutrition deficiencies as causal agents of the disease in mother plants, were ruled out. Deformation disease was induced by placing roots from diseased mother plants underneath planted cuttings. Inoculation test results and, in particular, indirect results from substrate disinfection with fungicides or bactericides, strongly suggest involvement of both fungi and bacteria in inducing the disease. In another set of experiments we studied the effects of the fertilizer NPK 20:20:20 plus microelements, or its components (N,P,K or microelements), on the incidence of deformation disease in mother plants. Four levels of a compound fertilizer were tested: 0, 900, 1800 and 3600 mg/*l* water applied weekly to each 10-*l* container packed with a naturally infected tuff (crushed volcanic stones) substrate. Disease incidence was highest (~100%) in mother plants receiving no fertilizer and lowest (0–10%) in those receiving the highest fertilizer concentration. When P, K or microelements mixture was the sole variable, increasing the concentration had no significant effect on the level of incidence. However, elevating nitrogen (50% urea-N, 50% NH_4NO_3-N) significantly reduced disease incidence, similarly to the response observed in the fertilizer. When elevating concentrations of different forms of nitrogen (urea, NO_3^-, NH_4NO_3 or NH_4^+), all reduced disease incidence similarly, although NH_4 was the most efficient. The pH value of the leached irrigation water was negatively correlated with nitrogen concentration. In conclusion, increasing the level of N in the fertilizer reduces deformation disease in gypsophila mother plants. Whether this effect was due to elevated N concentration in the plant or to modified rhizosphere pH – which has an indirect effect on rhizospheric microflora – is yet to be evaluated. *(L)*

Combining Biocontrol Agents to Improve Efficacy and to Reduce the Variability of Biological Control

Ruth Guetsky,[1,2] Y. Elad,[2] D. Shtienberg[2] and A. Dinoor[1]

[1]*Dept. of Plant Pathology and Microbiology, The Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, Rehovot 76100 [e-mail: guetski@agri.huji.ac.il]; and* [2]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250, Israel*

Adoption of biological control as a routine practice in commercial production is often hindered due to the variability and inconsistency of the disease suppression. Moreover, sometimes the biocontrol agents fail to reduce disease adequately. One of the main reasons for this phenomenon is the fact that the biocontrol agents, which are living organisms, are affected by the biotic and abiotic factors, as do the pathogens. One possibility to cope with the problem of variability and inconsistency in biocontrol is to combine two or more biocontrol agents, differing in their ecological requirements. Two biocontrol agents, a yeast (Y2) and a bacterium (B16), were tested separately and together for suppression of *Botrytis cinerea* on strawberry leaves. Applied separately, the biocontrol agents significantly inhibited spore germination, lesion formation and lesion development at most temperatures, relative humidities and spray-timing combinations. However, under certain combinations, control efficacy was not adequate. Control efficacy achieved by the biocontrol agents applied separately ranged between 38% and 98% (mean 74%). The coefficient of variation ranged from 9.7% to 75%. The mixture of B16 and Y2 suppressed *B. cinerea* effectively (80–99.8% control) under all conditions and the coefficients of variation were as low as 0.4–9%. Thus, application of both biocontrol agents not only resulted in better suppression of *B. cinerea*, but also reduced the variability of disease control. Therefore, the application of more than one biocontrol agent is suggested to be a reliable means of reducing the variability and increasing the reliability of biological control. *(L)*

Nematicidal Activity of Essential Oil Components Against the Root-knot Nematode *Meloidogyne javanica*

Y. Oka

Dept. of Nematology, ARO, Gilat Experiment Station, M.P. Negev 85280, Israel [e-mail: okayuji@netvision.net.il]

Nematicidal activity of essential oil components: *trans*-anethole, anis alcohol, *p*-anisaldehyde, benzaldehyde, 4-methoxyphenol, *trans*-cinnamaldehyde, (*R*)-(+)-pulegone, 2-furaldehyde, and of a non-essential oil component – anisole, was tested against the root-knot nematode *Meloidogyne javanica* in solutions; in 200-ml and 3-*l* pots; and in microplots. Among the anisole derivatives, *p*-anisaldehyde showed the highest nematicidal activity in solutions and in soil. However, *trans*-cinnamaldehyde, 2-furaldehyde and benzaldehyde showed higher nematicidal activity than *p*-anisaldehyde in the 3-*l* pot experiment. EC_{50} values of *trans*-cinnamaldehyde for juvenile immobilization and hatching inhibition *in vitro* were as low as 15 and 11.3 $\mu l/l$, respectively. In the 3-*l* pot experiment, *trans*-cinnamaldehyde, 2-furaldehyde, benzaldehyde and carvacrol at a concentration of 100 mg/kg greatly reduced the root galling of tomato roots caused by the nematodes, whereas *trans*-anethole was ineffective. In a microplot experiment, soil treatment with *trans*-cinnamaldehyde (50 ml/m^2) reduced the galling index and increased the shoot weight of tomato plants. Although further experiments, such as development of formulations and application methods, are needed, some essential oil components, especially aldehydes, can be developed into low-toxicity nematicides. *(L)*

Phytopathogenic Fungi of the Parasitic Plant Egyptian Broomrape (*Orobanche aegyptiaca*)

E. Dor, D. Plakhine and J. Hershenhorn

Dept. of Weed Research, ARO, Newe Ya'ar Research Center, Ramat Yishay 30095, Israel [e-mail: evengeniad@netvision.net.il]

The genus *Orobanche* (broomrape) consists of chlorophyll-lacking parasitic plants that attack the roots of dicotyledonous hosts. The small seeds produced by the parasite are spread by water, wind, animals and agricultural machinery. In response to root exudates, *Orobanche* seeds germinate and produce radicles that elongate and, upon contact with the root, penetrate and establish connection with the phloem and xylem of the host root system. At the end of its life cycle the parasite produces inflorescences that emerge above the soil surface and bear hundreds of thousands of seeds. Broomrapes cause severe quality and yield reduction in tomato (*Lycopersicon esculentum*), potato (*Solanum tuberosum*), eggplant (*Solanum melongena*), pepper (*Capsicum annuum)* and more than 30 other food and ornamental crops in the Middle East. Broomrapes are extremely difficult to control because of their close anatomical–physiological association with the host. Diseased Egyptian broomrape (*Orobanche aegyptiaca)* inflorescences were collected from a heavily broomrape-infested tomato field. Microorganisms isolated from the diseased inflorescences were tested for their ability to cause symptoms in a polyethylene bag system. The fungi *Alternaria alternata, Macrophomina phaseolina, Rhizoctonia solani, Fusarium solani* and the bacterium *Bacillus* spp. caused severe disease symptoms on the parasite, although these microorganisms are not known as pathogens of Egyptian broomrape. Inoculation with *F. solani* and *M. phaseolina* caused 70% mortality in all developmental stages of the parasite. At the end of the experiment 0.5 inflorescence was counted per bag as compared with 6.5 inflorescences for the control bags. *A. alternata* and the bacterium caused 50% parasite mortality. Both pathogens caused severe damage to young parasite stages and minor damage to inflorescences. Inoculation with *R. solani* caused 60% mortality of 'tubercle' and 'spider' stages of growth of the parasite without any visible damage to inflorescences. Total mortality of the parasite at the end of the experiment was 29%. The nature of the symptoms and the relative susceptibility of the various developmental stages of the parasite are currently being investigated in pots under greenhouse conditions. *(L)*

H: CONTROL STRATEGIES FOR FIREBLIGHT

Prevalence and Intensity of Fire Blight of Pears in Israel: Results of a Survey Conducted in 1996–2000

D. Oppenheim,[1,*] D. Shtienberg,[2] M. Peres,[3] Z. Herzog,[1] Miriam Zilberstaine[1] and G. Kritzman[2]

[1]*Extension Service, Ministry of Agriculture and Rural Development, Bet Dagan 50250 [*e-mail: dovop@shaham.moag.gov.il]; [2]Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250; and [3]Agriculture Corp., Galil Eliyyon 90000, Israel*

The pear production area in Israel is 1500 ha, most of which (*ca* 1200 ha) is located in the northern part of the country. Fire blight (caused by the bacterium *Erwinia amylovora)* was first observed in Israel in that region, in 1985, and the disease has prevailed there ever since. In a comprehensive survey conducted in 1996–2000, data were collected and observations were made yearly in one-third to one-half of the pear production area in Israel. The purpose of the survey was to document the prevalence and intensity of fire blight in commercial orchards and to use the data to evaluate the efficacy of management measures employed for its suppression. Region-wise, a severe fire blight epidemic developed in 1996 and 2000, moderate epidemics developed in 1998 and 1999, and a mild epidemic developed in 1997. The intensity of fire blight in the preceding season in a specific orchard was more influential on current season severity in a season with a mild epidemic than in a season with a moderate epidemic. Analysis of disease onset records and weather data revealed that a few (1–3) infection episodes occurred in individual orchards each year. The efficacy of bactericide sprays applied during bloom was not related to the number of sprays applied but to the timing of spraying. Adequate control was achieved in orchard plots sprayed soon before or after the occurrence of infection episodes. The proportion of orchards where sprays were not timed properly was 41% in 1998, 32% in 1999 and 35% in 2000. The proportion of orchards where sprays were

applied on time and in which the disease was suppressed adequately was 11% in 1998, 34% in 1999 and 72% in 2000. *(L)*

Population of *Erwinia amylovora* in Pear Blossoms

G. Kritzman,[1,*] H. Shwartz,[1] A. Levin,[2] Z. Herzog,[3] Miriam Zilberstaine,[3] D. Oppenheim,[3] Anat Yogev,[3] Miriam Kimchi,[1] B. Kirshner,[1] Iris Dornai,[1] Valeria Pakersky,[1] S. Zarka[4] and D. Shtienberg[1]

[1]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: kritzgio@netvision.net.il]; [2]Kibbutz Revivim, 85515; [3]Extension Service, Ministry of Agriculture and Rural Development, Bet Dagan 50250; and [4]Tapazol Ltd., Rishon LeZiyyon 75100, Israel*

The life cycle of *Erwinia amylovora,* the causal agent of fire blight in pears, is complicated and consists of several stages. The pathogen overwinters in cankers located in the wooden parts of the trees. In the spring, the cankers become active, the bacteria multiply and produce droplets of ooze on the surface of the bark. These are called 'holdover cankers'. Pollinating insects, including honeybees, are attracted to the ooze and may transfer the bacteria to the site of infection, the blossoms. When weather conditions are supportive, the bacteria multiply in and infect the blossoms, resulting in the common fire blight symptom. Effective fire blight suppression relies on decreasing the amount of initial inoculum produced on holdover cankers and application of bactericides to the blossoms, which protects them from infection. The timing of spraying is critical for adequate disease suppression and several models have been developed for timing of sprays. However, most models deal exclusively with weather data, under the assumption that the bacteria exist, at least in some of the blossoms. This assumption was not tested because the process of isolation and identification of the bacteria lasts at least 3–4 days – too long for decision-making. In the present study we dealt with both decreasing the amount of initial inoculum produced on holdover cankers and development of a method for rapidly determining if blossoms are infected by *E. amylovora.* A diagnostic, selective medium was developed by which it is possible to identify the presence of *E. amylovora* bacteria. Blossoms sampled from the orchard are touched gently onto the agar medium (ten blossoms per plate) and placed at room temperature; 26–30 h later, *E. amylovora* colonies have typical red color, which is distinctively different from the shape and color of other bacteria (including *E. herbicola).* In order to decrease the amount of initial inoculum produced on holdover cankers, the trees were sprayed before bloom with the bactericide Bacteriol (TH_4). By using the selective medium, it was found that the incidence of blossoms (at the early stages of flowering) that were infected by *E. amylovora* was significantly lower in trees treated with Bacteriol as compared with untreated control trees. *(L)*

Factors Affecting the Progression of *Erwinia amylovora* in Pear Branches

D. Shtienberg,[1,*] Miriam Zilberstaine,[2] Z. Herzog,[2] D. Oppenheim,[2] S. Levi,[3] H. Shwartz[1] and G. Kritzman[1]

[1]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: danish@netvision.net.il]; [2]Extension Service, Ministry of Agriculture and Rural Development, Bet Dagan 50250; and [3]Granot Regional Research, Hadera 38364, Israel*

The most destructive symptom of fire blight (caused by *Erwinia amylovora*) is the progression of the bacteria from infected blossom-clusters to the branches of the trees. The disease progresses from branch to branch, inducing wilting and death; when it reaches the trunk, the entire plant may die. Observations made in pear orchards where blossom-clusters were naturally infected by *E. amylovora*, revealed that the rate of disease progression within the woody parts varies from tree to tree. Whereas in some trees the rate of disease progression reached 1–2 cm/day, in other trees the disease did not progress at all and the symptoms remained restricted to blossom-clusters. In the latter

case the damage induced by the disease was limited. In a series of experiments and observations conducted in pear orchards, factors affecting the rate of disease progression within the woody parts of the plants were studied. One-year-old branches were artificially inoculated in spring (April) or autumn (October), and the rate of disease progression on the branches was recorded over time. The main results of the experiments are as follows. (i) The disease progresses much more rapidly on herbaceous than on woody branches. (ii) In the spring, the rate of disease progression in branches of trees with many sprouts is faster than in trees with few sprouts; in autumn the situation is the opposite. (iii) Progression of infections originating in the spring stops in June–July, but infections originating in autumn progress until the next spring. (iv) Pruning of infected branches may result, in some cases, in rapid progression of the disease on the branches and in much more severe damage to the trees than in non-pruned trees. *(L)*

Use of Warning Systems for Timing Sprays Against Fire Blight in Pears in Israel

H. Shwartz,[1] D. Shtienberg,[1,*] D. Oppenheim,[2] Miriam Zilberstaine,[2] Z. Herzog,[2] M. Peres[3] and G. Kritzman[1]

[1]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250 [*e-mail: danish@netvision.net.il];* [2]*Extension Service, Ministry of Agriculture and Rural Development, Bet Dagan 50250; and* [3]*Agriculture Corp., Galil Eliyyon, Israel*

Fire blight, caused by the bacterium *Erwinia amylovora,* is the most destructive pathogen of pears and other pome fruit-trees worldwide. Bactericides are applied during bloom to protect the blossoms from infection and proper timing of spraying is the key for success. Several warning systems were developed for timing sprays in different places of the world, *viz.*, 'Maryblight' (developed in Maryland, USA); 'Cougarblight 98C' (developed in Washington State, USA); 'BIS95' (developed in England); and the 'Fire Blight Control Advisory' system, FBCA (developed in Israel). All systems were tested and found accurate in the locations of origin. The accuracy of the systems was tested using data recorded in a comprehensive survey conducted during 1996–2000, in one-third to one-half of the pear production areas in Israel. The tests included 193 cases in total, recorded in ten different sub-regions in northern Israel. A success was defined whenever the systems predicted the precise occurrence of an infection event. The local system, FBCA, predicated the occurrence of infections successfully in the 4 years of the study (99–100% success). However, there was a large variation in the success of the foreign systems. The average success rate of Maryblight was 34% (ranging from 0 to 100%), that of Cougarblight 98C was 34% (ranging from 15% to 56%), and that of BIS95 was 29% (ranging from 0 to 85%). Analysis of the false predictions of the foreign systems revealed that they failed since the thresholds of temperature and wetness (and their interactions) are apparently not suited to the Israeli conditions. On the other hand, the systems occasionally predicted infections that did not actually occur. The FBCA system was tested in eight orchard experiments and in all cases provided adequate recommendations for fire blight suppression, with 1.6–2.6 fewer sprays than in the 5-day schedule treatment. *(L)*

Pruning Infected Tissues as a Tool to Cope with Fire Blight in Pears

Miriam Zilberstaine,[1,*] D. Shtienberg,[2] Z. Herzog,[1] S. Levi,[3] H. Shwartz,[2] D. Oppenheim[1] and G. Kritzman[2]

[1]*Extension Service, Ministry of Agriculture and Rural Development, Bet Dagan 50250 [*e-mail: mirzil@netvision.net.il];* [2]*Dept. of Plant Pathology, ARO, The Volcani Center, Bet Dagan 50250; and* [3]*Agricultural Research, Central Region, Hadera 38364, Israel*

Fire blight, caused by the bacterium *Erwinia amylovora*, is a devastating disease of pomaceous fruit trees. The bacteria penetrate the plant through the flowers and wounds. The disease then progresses within the tree tissues, causing wilting and death of branches; if it reaches the truck,

the entire tree may die. Pruning and removal of infected tissues is one of the means to cope with the disease and growers are advised to cut infected tissues *ca* 30 cm below the site of the symptoms. The only factor taken into account in this recommendation to prune is the pathogen. The effects of various factors related to the host on the success of pruning were tested in a series of experiments conducted in pear orchards naturally infected by fire blight. The factors were the: (i) place of pruning (removing only the infected tissues or 30 cm below the point of visual symptoms); (ii) growth habit of the tree (few, moderate number or many new branches); (iii) time of infection (spring or autumn); and (iv) phenological stage of the trees at the time of pruning (blooming, fruit set, etc.). It was found that the success of the pruning procedures is governed, to a large extent, by the physiology and phenology of the tree. Moreover, in some cases it is preferable not to prune at all (because the bacteria remain restricted to the blossom clusters) than to prune (because the cutting induced rapid progression of the bacteria within the branches). Based on the results, the recommendations to growers were modified and now host factors, as well as the pathogen, are considered. *(L)*