

**7th International Symposium on Chemical  
and non- Chemical Soil and Substrate  
Disinfestation SD 2009**

**PROGRAM  
AND  
ABSTRACTS**

**Katholieke Universiteit Leuven, Belgium  
Collegium De Valk  
13 – 18 September, 2009**

## WELCOME ADDRESS

It is with great pleasure that we invite all of you to the VII International Symposium on Chemical and non-Chemical Soil and Substrate Disinfestation here in Leuven, Belgium. The first symposium was established in 1973, at the Katholieke Universiteit, Leuven. It was intended to set a forum for open discussions regarding available methods and technologies for managing soilborne pests and diseases. The phase-out of methyl bromide during the last two decades has attracted the industry, the research and the farmers for intensive efforts in order to develop and adopt appropriate and effective technologies. Since the previous symposium in Corfu, 2004 significant advances and developments have led to new strategies and chemicals for effective soil disinfestation. It is obvious that soil disinfestation still plays a major factor, and will maintain a major role in agriculture and horticulture. Hence, the need for improved methods and technologies for soil disinfestation is even more significant. This symposium gives us all an opportunity to look back at the progress we made, and critically assess the needs and bottlenecks for the future. We look forward to inspiring discussions during this symposium. You will make the symposium a success.

Abraham Gamliel – co-convener  
ARO, Volcani Center,  
Bet Dagan, Israel

Jozef Coosemans – co-convener  
Katholieke Universiteit  
K.U. Leuven, Belgium



## ACKNOWLEDGMENTS

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- The Department of Biosystems, Laboratory of Plant Protection, Katholieke Universiteit Leuven, Belgium
- Institute of Agricultural Engineering, Agricultural Research Organization (ARO), Volcani Center, Bet Dagan, Israel
- The Scientia Terrae Research Institute, Sint-Katelijne-Waver, Belgium
- The Hebrew University of Jerusalem, Rehovot, Israel
- The International Society for Horticultural Science (the Commission Plant Protection and the Working Group on Soil-Borne Pathogens, and the Commission Substrates and Soilless Culture) and the BSHS, Benelux Society for Horticultural Science Belgium

All members of the organizing and scientific committee have contributed in a variety of ways to make this symposium possible. We are highly indebted for the thorough and dedicated work. In particular, Mrs. Lut Ooms from the Katholieke Universiteit, Leuven has worked tirelessly over the past few months and her efforts have made the organization of this symposium easier.

Finally, without the generous financial support of the following organizations, this meeting would not have been possible. Their contributions are gratefully acknowledged.



7<sup>th</sup> INTERNATIONAL SYMPOSIUM  
ON CHEMICAL AND NON-CHEMICAL SOIL AND SUBSTRATE  
DISINFESTATION, 13 - 18 SEPTEMBER, 2009

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## SYMPOSIUM PROGRAM

Sunday, 13 September 2009

- 1500-2000 Registration at Collegium De Valk
- 1800-2000 Opening reception at Collegium De Valk, Tiensestraat 41, 3000 Leuven

Monday, 14 September 2009

- 0900-1000 Opening session  
0900-0920 Welcome and introduction - *Prof. Jozef Coosemans (Belgium)*  
Welcome at KULeuven, Faculty of Bioscience Engineering - *Prof. Pol Coppin, Dean of the Faculty (Belgium)*  
Introduction to the scientific program - *Dr. Abraham Gamliel (Israel)*
- 0920 Keynote lecture: Soil and crop health following soil disinfestation - *Jaacov Katan (Israel) and Alfons Vanachter (Belgium)*
- 1000-1200 Special session  
New developments and expectations since the Sixth Symposium - Corfu 2004. Needs, possibilities, legal changes, expectations  
Chairperson: Ian Porter (Australia)
- 1000 Invited lecture:  
Emerging new pests and diseases and new trends in their management - Angelo Garibaldi (Italy)
- 1030 New developments and expectations: Vision from the scientific world - Abraham Gamliel (Israel)
- 1045 New developments and expectations: Vision and expectations from *horticultural and agricultural* sector- Marta Pizano (Colombia)
- 1100-1130 COFFEE BREAK
- 1130 New developments and expectations: Vision from *industry and fumigators* - Husein Ajwa (USA)
- 1145 New developments and expectations: Vision from *decision makers* - Francesca Arena (EC)
- 1200 Discussion
- 1215-1330 Session 1  
MBr Alternatives  
Chairperson : Marta Pizano (Colombia)
- 1215 Progress in the global phase out of methyl bromide and the relative effectiveness of soil disinfestation products to replace fumigation for

- pre-plant soil uses – Ian Porter, M. Pizano, M. Besri, S. Mattner and P. Fraser
- 1230 Is There a Future for 1,3-Dichloropropene and Other Chemical Soil Fumigants in European Agriculture? – Andrew Leader, J. Busacca; J. Dawson; T. Lyall and H. Eelen
- 1245 Adoption of Methyl Bromide Alternatives and a Profile of Turkish Cut flower sector – Suat Yilmaz, M. A. Çelikyurt and B. Sayin
- 1300 Japan's big effort to the phase out of methyl bromide by 2013 – Akio Tateya
- 1330 1430 LUNCH BREAK AND POSTER VIEWING
- 1430-1630 Special Session  
Methyl bromide alternatives : ALTERBROMIDE (EC) project  
Chairperson: Gael du Fretay (France)
- 1430 Invited lecture :  
ALTERBROMIDE, dissemination of sustainable alternatives to Methyl Bromide in soil disinfestation and in post harvest - Gael du Fretay, J. Dasque; J. Auger; J. Coosemans; P. Colla; F. Pauwels and J. Fritsch (France)
- 1500 Current status of chemical and non-chemical soil disinfestations solutions in France – Jerome Fritsch
- 1515 Mechanical or manual applications of soil solarization for the control of soilborne pathogens in plastic house or open field in Greece – Polymnia Antoniou, Sotiris Tjamos and E. C. Tjamos
- 1530 Soil disinfestation treatments with 1.3-dichloropropene and chloropicrin under low temperature conditions for strawberry mother plants – Vicent Cebolla and Serrano Fernando
- 1545 Greenhouse grafting cucumber crop – methyl bromide alternative in Romania – Marian Bogoescu, Madalina Doltu, D. Sora and Niculina Tanasa
- 1600 Soil and substrate microbiologizing: a promising approach for sustainable horticulture – Frans Pauwels
- 1615 Discussions
- 1630-1700 COFFEE BREAK
- 1700-1800 Special Session:  
Methyl bromide alternatives: ALTMET (B) project  
Chairperson: Henri Maraite (Belgium)
- 1700 Efficacy of chemical alternatives for Methyl bromide in lettuce production: field experiment - Ann Ceustermans, E. Van Wambeke and J. Coosemans
- 1715 Combinations of chemical soil fumigants for broad spectrum soil disinfestation- Etienne Van Wambeke, A. Ceustermans ,A. De Landtsheer, K. Gybels and J. Coosemans.
- 1730 Microbial mechanisms involved in the suppression of *Rhizoctonia solani* AG1-1B by lignin incorporation in soil – Sarah Van Beneden, Dries Roobroeck, Soraya C. França, Stefaan De Neve, Pascal Boeckx and Monica Höfte

- 1745 Use of oxamyl in the post methyl bromide era – Johan Desaegeer and J. Wiles
- 1900-2100 Guided city tour and reception at the City Hall
- Tuesday, 15 September 2009
- 0830-1100 Session 2  
Chemical Soil Disinfestation  
Chairperson : Husein Ajwa (USA)
- 0830 Shank application of chloropicrin as an alternative to methyl bromide for peach tree replant – S. Foschi, C. Spotti, A. Minuto, G. Minuto
- 0845 The emulsifiable formulations of Dimethyldisulfide (DMDS) and its mixtures with chloropicrin as alternatives to methyl bromide - Vicent Cebolla, Daniel Llobel, Antonio Oliver, Luís Miguel Valero, Francisco Torró and Andrés Hernández
- 0900 Evaluation of the efficacy of DMDS using drip application for the control of root knot nematodes (*Meloidogyne* spp.) in Turkey – J.J. Heller, E. Korkmaz and P. Charles
- 0915 Multi-tactic Approaches to Manage Soilborne Pathogens of Specialty Crops in North Carolina – Frank Louws, R.M. Welker, J.G. Driver and C.L. Rivard
- 0930 Powdery scab occurrence and control in Israel - Lea Tsrer (Lahkim), O. Erlich, M. Hazanovsky and U. Zig
- 0945 Soil chemical treatments for the control of Fusarium wilt of Carnation in Spain - M. J. Basallote Ureba, M. D. Vela Delgado, F. J. Macías, C. J. López Herrera and J. M. Melero Vara
- 1000 Effectiveness of fumigants alone and in combination with grafting to control Verticillium wilt and root-knot nematode in eggplant and tomato brown rot caused by *Colletotrichum coccodes* – Giovanna Gilardi, M. Baudino, M. L. Gullino and A. Garibaldi
- 1015 Top applications of fungicides for the control of melon sudden wilt caused by *Monosporascus cannonballus* - Shimon Pivonia, A. Maduel, R. Levita and R. Cohen
- 1030 Accelerated degradation of metam-sodium in soil: Isolation and characterization of the involved microorganisms - Shachaf Triky-Dotan, M. Austerweil, B. Steiner, D. Minz, J. Katan and A. Gamliel
- 1045 Discussion
- 1100-1130 COFFEE BREAK
- 1130-1330 Session 3  
Assessment tools for soil infestation and disinfestation  
Chairperson : George Lazarovits (Canada)
- 1130 Invited lecture:  
Assessing the spatial distribution of soil infestation by means of remote sensing and GIS as the “first-aid” for soil disinfestation - Yafit Cohen(Israel)
- 1200 Distribution and control of pod wart disease of peanuts as analyzed using spatial means –Harel Caduri, A. Gamliel and Y. Cohen

- 1215 Unraveling Soil Communities Using the CPN60 Genomic Marker and Pyrosequencing - George Lazarovits, R. Ramarathnam and S.M.Hemmingsen
- 1230 A knowledge based system to Predict Plot infestation with *Verticillium dahliae* and the success of disinfestation in Potato production systems - E. Goldstein, Y. Cohen, A. Hetzroni, L. Tsrur, U. Zig and I. Lensky
- 1245 Methods to monitor MITC for phytotoxicity and in the environment - Etienne Van Wambeke
- 1300 Discussions
- 1330–1430 LUNCH BREAK AND POSTER VIEWING
- 1430-1500 Poster viewing
- 1500-1530 Poster Session discussion  
Chairperson : Alfons Vanachter (Belgium)
- 1530-1630 Session 4  
Integrated Control  
Chairperson: Maria Lodovica Gullino (Italy)
- 1530 Invited lecture:  
Biological control of plant-parasitic nematodes: from fantasy to reality - Yitzhak Spiegel(Israel)
- 1600 Evaluation of some pre-plant soil treatments and chemical disinfectants for control of Fusarium wilt diseases in cut flowers - Timothy O'Neill and K.R. Green
- 1615 TrichoNema: a Trichoderma-based project to develop a commercial biocontrol agent product against phytonematodes - Edna Sharon, M. Mor, M. Bar-Eyal, Y. Oka, S. Van Kerckhove, A. Vanachter, I. Chet and Y. Spiegel
- 1630-1700 COFFEE BREAK
- 1700-1900 Roundtable discussion  
Application of soil disinfestation: bottlenecks, challenges and improvement possibilities:  
Application of fumigants (drip or shank) alone and in combination – Husein Ajwa  
Application of fumigants with other methods (solarization) – Abraham Gamliel  
Application of non-fumigant treatments (soft chemicals) – Steve Fennimore  
Application of soil disinfestation with biocontrol agents – Jozef Coosemans
- 1930-2100 Visit at Inbev Brewery, Leuven : optional

Wednesday, 16 September 2009

Technical Visit to the Vegetable Production in the region of Mechelen and Antwerp

Thursday, 17 September 2009

- 0830-1100 Session 5  
Physical methods of soil disinfestation and solarization  
Chairperson : Eleftherios Tjamos (Greece)
- 0830 Invited lecture:  
Physical methods for soil disinfestation in intensive agriculture: Old methods and new approaches - Willemien Runia and L.P.G. Molendijk (The Netherlands)
- 0900 Combining Effects of Soil Solarization and Grafting on Plant Yield and soilborne pathogens in cucumber – Suat Yilmaz and I. Celik
- 0915 Nitrate leaching after organic amendment under soil solarization in two different soils and its effects on yield and health of escarole and pepper - Vicent Cebolla, Josep Roselló, Carlos Ramos and Fernando Pomares
- 0930 The Effect of Pre-wetting on Thermal Inactivation of Soilborne Pathogens in Connection with Structural Solarization of Greenhouses - E. Shlevin, P. Di-Primo and J. Katan
- 0945 Perspectives of anaerobic soil disinfestation - Willemien Runia, L.P.G. Molendijk and P.O. Bleeker
- 1000-1315 Session 6  
Organic amendments  
Chairperson : José Melero-Vara (Spain)
- 1000 Effect of Biofumigation with Brassica Cover Crops on Weed Populations, Soil microbial Activity, and Fruit Rot in Pickling Cucumber Production - Mathieu Ngouajio and J. W. Counts
- 1015 Green manures and organic amendments to control corky root of tomato - Vincent Michel and L. Lazzeri
- 1030 Effect of Brassica green manure and Brassica pellets in combination with grafting and soil solarization against Verticillium wilt of eggplant and Fusarium wilt of lettuce and basil - Giovanna Gilardi, L. Lazzeri, L. Malaguti, F. Clematis, A. Minuto and M.L.Gullino
- 1045 Use of pelleted Medicago sativa meal for the control of root-knot and cyst nematodes - Trifone D'Addabbo, P. Avato, V. Radicci and A. Tava
- 1100-1130 COFFEE BREAK
- 1130 Kakawate (*Gliricidia sepium*) as a Soil Amendment and Biological Control of Soil-borne Pathogens: The Philippines Experience - Gina Pangga
- 1145 Combined Effects of Bio control Agent and Residues on Root Rot Mortality in Indian Mesquite (*Prosopis cineraria*) – Satish Lodha and L.N. Harsh
- 1200 Additional benefits to the efficacy in containing soilborne pest and pathogens of biofumigant plants and materials – Luca Lazzeri, Onofrio Leoni, Lorena Malaguti and Lorenzo D'Avino
- 1215 Mycofumigation using *Muscodor albus* for control of soilborne plant pathogens - Barry Jacobson, E. Grimme and G. Strobel
- 1230 Induced soil suppressiveness to root diseases by herb amendments and solarization- Eyal Klein, J. Katan and A. Gamliel

- 1245 Plant metabolites derived from Brassica spp. tissues as biofumigant to control soil borne fungi pathogens- Eva Romero Luna, C. Barrau and F. Romero
- 1300 Discussion
- 1315-1430 LUNCH BREAK
- 1430-1630 Session 7 Soilless culture.  
Chairperson : Vicent Cebolla (Spain)
- 1430 Invited lecture :
- 1500 Disease control in soil-less systems - Erik Van Os (The Netherlands)  
Disinfestation of Polystyrene Seedling Trays for Substrate-based Float Systems in Australia - Scott Mattner, D.A. Wite, G.G. Baxter, R.C. Mann, R.J Holmes and I.J. Porter
- 1515 Effect of commercially available composts on plant health - Oliver Gurnett, Maaïke Perneel and Stefaan Vandaele
- 1530 Effect of ozone treatment on suppressivity of composted sewage sludge on *Meloidogyne incognita* - N. Sasanelli, Trifone D'Addabbo, L. Mancini and F. Ciccarese
- 1545 Discussions
- 1600–1630 COFFEE BREAK
- 1630-1800 Closing Session  
- International Society for Horticultural Science – Jo Van Assche (Belgium)  
- Concluding remarks – Monica Höfte (Belgium)  
- General discussion and next meeting – Jaacov Katan (Scientific Committee)

2000 CONFERENCE DINNER at Salons Georges, Leuven

## Posters

### MB alternatives

1. Economic Evaluation of Chemical and Non-Chemical Soil Disinfestation - B. Sayin, M. A. Çelikyurt Suat Yilmaz and İ. Çelik
2. Maintaining Biosecurity and Market Access in the Australian Strawberry Industry Following Methyl Bromide Phase-out – Scott W. Mattner, I.J Porter, R.K. Gounder, R.C. Mann and B. Guijarro
3. Pests and diseases of sweet basil after methyl bromide phase out: the Northern Italian experience - Andrea Minuto, N. Vovlas, A. Troccoli, C. Bruzzone, M. Scortichini and G. Minuto

### Chemical disinfestation

4. Effect of soil fumigants on fungal communities in protected pepper crops in Southeast Spain - Maria Angeles Martínez, M.A. Martínez, M.C. Martínez, J. Torres, C. Ros, M.M. Guerrero and A. Lacasa
5. Efficacy of DMDS as a soil treatment against *Meloidogyne chitwoodii* in the Netherlands - Charles Patrick and Jean Jacques Heller
6. Evaluation of DMDS as Soil Fumigant Application, Distribution and Pest control - A. Gamliel, Miriam Austerweil, Bracha Steiner, Yehudit Riven, Marina Benichis and Sagi Gal
7. Dissipation fumigants in the soil and its impact on the control of nematode and parasitic weeds. R. Allon, Miriam Austerweil, Bracha Steiner, Marina beniches, Miri Grinner, b. Rubin and A. Gamliel

### Integrated control

8. The physiological sudden collapse of grafted melon as a result of a not appropriate growing procedure - A. Minuto, G. Causarano, C. Bruzzone, G. La Lota, S. Longombardo and G. Minuto
9. Evaluation of Steam, Biofumigants, and Fungicides for Strawberry Production in Field Soils - S. Fennimore, J. Weber, J. Samtani, and C. Gilbert
10. A comparison of four pre-plant soil treatments for control of Verticillium wilt in field-grown trees - T.M. O'Neill, T. Locke and C.J. Dyer
11. Chemical and biological alternatives for soil disinfestation in strawberry production - M. Thoelen, F. Meurrens, K. Stevens, J. Kellers, J. Coosemans and S. Clemens
12. Soil-born diseases/pest control research in Lithuania - Sonata Kazlauskaitė, Elena Survilienė, Aurelija Saluchaitė

### Physical methods of soil Disinfestation and solarization

13. Soil Solarization as Alternative to Methyl Bromide for the Control of Protected Vegetable Soil Borne Pathogens in Morocco - Mohamed Besri

### Organic amendments

14. Non-Chemical Options for Managing Soil Borne Plant Pathogens in Indian Arid Zone - Satish Lodha, R.Mawar and V.Singh
15. Effect of biosolarisation using pellets of *Brassica carinata* on soil-borne pathogens in protected pepper crops - M.M. Guerrero, M.A. Martínez, C. Ros, C.M. Lacasa, V. Martínez, A. Lacasa and P. Fernández
16. Efficacy of biosolarisation with sugar beet vinasses for soil disinfestation in pepper greenhouses - C. M. Lacasa, M.M. Guerrero, C. Ros, M.A. Martínez, V. Martínez, A. Lacasa and P. Fernández

17. Integration of Non-chemical Methods of Controlling Fusarium Wilt of Carnation - R. A. Nava-Juárez and J.M. Melero-Vara
18. Application of organic amendments followed by plastic mulching for the control of Phytophthora root rot of pepper in northern Spain - Mireia Núñez-Zofío, C. Garbisu and S. Larregla
19. Effect of meal of *Aster caucasicus* and *A. sedifolius* on the control of root-knot nematodes in glasshouse - Mauro Di Vito, P. Pecchia, F. Catalano, M. Cammareri and C. Conicella
20. Effects of Soil Organic Amendments and Incubation Temperature on the Control of *Fusarium oxysporum f. sp. asparagi* - A. Borrego-Benjumea, J. M. Melero-Vara and M. J. Basallote-Ureba
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26. Tolerance to Allelopathy and Fusarium Disease in Mycorrhizal Asparagus Plants Raised in Decline Soil - Y. Matsubara, T. Okada and A. S. M. Nahiyán

# ABSTRACTS

# PLENARY TALKS

Keynote lecture:

Soil and crop health following soil disinfestation Jaacov Katan (Israel) and Alfons Vanachter (Belgium)

Invited lecture:

Emerging new pests and diseases and new trends in their management - Angelo Garibaldi *and* Maria Lodovica Gullino (Italy)

Invited lecture

## CROP AND SOIL HEALTH FOLLOWING SOIL DISINFESTATION

Jaacov Katan<sup>1</sup> and Alfons Vanachter<sup>2</sup>

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The concept of plant health is far more than the opposite of plant disease, although a freedom from diseases is necessary. A healthy plant has to grow in a "healthy" soil. In such a soil, absence of major (clinical) and minor (subclinical) pathogens and balanced biotic and abiotic environment for plant growth are prerequisites for achieving this goal. A healthy soil means a balanced system as regarding plant growth and agricultural needs for the crop. Additionally, the soil health has to be sustainable, thus the soil has to maintain a certain level of suppressiveness to protect it from pathogen invasions. Soil health should be achieved with minimal disturbance of the environment and depletion of natural resources. Assessment of soil health is done by using a variety of tests: assessment of pathogen populations in soil (using classical, serological and molecular tools e.g. PCR-DGGE), soil analyses (chemical, physical and biological), bioassays with plants and remote sensing techniques.

Decision-making tools can be most helpful. Soil disinfestation (alone or combined with other methods) is a very effective tool for improving soil health in pathogen-infested soils or in soil with sickness (fatigue) or replant problems. Furthermore, soil disinfestation might improve plant health also in noninfested soils, beyond pathogen control. However, soil disinfestations should be part of an holistic approach, in which additional means for improving crop and soil health are needed in order not to depend on a single method. These are: diversification of crops and methods of control, using appropriate composts, organic amendments and biocontrol agents for augmenting soil suppressiveness, breeding for reduced genetic vulnerability, specific pesticides, creation of optimal crop growth conditions and combinations of the above. Economic, social, environmental and legal considerations must also be involved.

Invited lecture

## EMERGING NEW SOILBORNE DISEASES AND NEW TRENDS IN THEIR MANAGEMENT

Angelo Garibaldi and Maria Lodovica Gullino,

AGROINNOVA, University of Torino, Via Leonardo da Vinci, 44, 10095, Grugliasco, Italy (email [angelo.garibaldi@unito.it](mailto:angelo.garibaldi@unito.it))

Horticultural crops are economically important worldwide and share some common features, such as their high value, continuous intensification and innovation in their production systems, presence of a high number of crops and varieties, severe limitations in the use of chemicals,

During the past few years many new diseases caused by soilborne pathogens (such as different *formae speciales* of *Fusarium oxysporum*, *Sclerotinia sclerotiorum*, *Rhizoctonia solani*, *Phytophthora* spp.) have been detected, also as a consequence of the profound changes undergone in the past few years in soil disinfestation. The phytopathological situations of vegetables as well as of ornamental crops will be presented and the evolution of some soilborne diseases as a possible consequence of the current limitations in the use of chemicals, of the globalization of the markets and/or of climate change will be critically discussed. The most recent trends in disease management (use of soilless systems, biological control, biofumigation, soil and substrate solarisation) will be discussed. Moreover, the emerging problems in the management of the new diseases will be presented.

## Special session

# NEW DEVELOPMENTS AND EXPECTATIONS SINCE THE SIXTH SYMPOSIUM - CORFU 2004.

## ORAL

- New developments and expectations: Vision from the scientific world – Abraham Gamliel (Israel)
- New developments and expectations: Vision and expectations from *horticultural and agricultural* sector- M. Pizano, (Colombia) M. Miller and I. Porter
- New developments and expectations: Vision from *industry and fumigators* – Husein Ajwa and Mike Stanghelini (USA)
- New developments and expectations: Vision from decision makers – F. Arena (EU)

Invited lecture

## VISION, DEVELOPMENTS AND EXPECTATIONS IN THE SCIENTIFIC AND RESEARCH IN RELATION TO THE METHYL BROMIDE PHASE-OUT

Abraham Gamliel.

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Chemical fumigants provided great advantage to agricultural production for many years. The phaseout of methyl bromide which initiated in 1992 until 2005 has driven intensive research programs for effective soil disinfestation strategies. During the last years the research is focused in the following directions:

During the last 15 years, the quest for new fumigants was intensive. The performance and behavior of these fumigants were studied, in order to develop and adapt the optimal application technology. To date only two new fumigants have been developed as commercial products. Under such situation, research efforts are focused to maximize the performance of the available fumigants. these efforts include understanding the rate of dissipation of the fumigants in different soil in order to adjust the rate and timing for effective disinfestation results. The use of impermeable films is extended to all fumigants resulting in improved pest control with reduced rates. The research is also directed to improved distribution and application in order to capture the fumigants in soil and transfer them to the desired soil layer, in order to achieve effective pest control at all depths. Sequential application of fumigants is implemented to extend the spectrum of controlled pests and overcome application limitations.

None of the available methods used to control soilborne diseases is effective against all pathogens or can be used in all instances. Combining fumigants can improve pathogen control, thereby, enabling reduced dosage and emission of each fumigant, and minimizing other negative environmental attributes. Combined fumigants can result in an additive effect, when each method is directed to control a specific pathogen. Combined treatment can also result in a synergistic effect, when one control agent increases the vulnerability of the pathogen to the other.

Combining fumigant at reduced dosage with solarization is an approach which expands during the last years: capturing the fumigant under the plastic tarp; increased toxic activity of the fumigants under in the heated soil and increased susceptibility of propagules. Combination of solarization with fumigants at very low dosage gave effective control of soilborne pathogens in greenhouse and in the open field. Combining solarization with a fumigant can improve pest control and extend its use against wider spectrum of pests. Trapping fumigants under the plastic film may also enable dosage reduction.

Crop specific strategies are also intensively studied. This approach includes various steps of pest control beginning in soil disinfestation, followed by treatments during crop growth and sanitation at the end of the crop.

Invited lecture

## VISION, DEVELOPMENTS AND EXPECTATIONS IN THE HORTICULTURAL SECTOR IN RELATION TO THE METHYL BROMIDE PHASE-OUT

M. Pizano<sup>1</sup>, M. Miller<sup>2</sup> and I. Porter<sup>3</sup>,.

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The phase-out of methyl bromide (MB), as required by the Montreal Protocol and by pesticide regulations in some countries, has led to substantial changes in production practices in the horticultural sectors that relied on this fumigant in the past, both in industrialised and developing countries. The major sectors that have used MB for soil fumigation (pre-plant) in the past are cucurbits, tomatoes, strawberry fruit, cut flowers, peppers and eggplant, orchard replant, potatoes, tobacco seedbeds and other propagative materials. The remaining consumption of MB in 2007 (excluding quarantine uses) was 5,958 tonnes in industrialised countries (about 11% of the 1991 baseline) and 6,235 tonnes in developing countries (39% of the baseline).

Adoption of alternatives has happened at varying rates in different countries and productive sectors, but on average, a period of 3 to 4 years has been necessary to achieve their implementation. Replacement of MB has been achieved with chemical fumigants where registered (1,3-dichloropropene, chloropicrin, metham sodium, dazomet and more recently methyl iodide) and with non-chemical options (soil-less substrates, grafting, resistant varieties, biological controls, solarization, biofumigation). Very often, the best results have been found when combining and integrating alternatives; this has usually required growers to change production approaches significantly, undertake additional investments, adapt technologies to specific circumstances and acquire relevant training. However, these changes are generally offset by good yields and quality. At this stage, and although some hurdles remain, alternatives that are equally effective to MB have been found for virtually all previous soils uses of MB.

This presentation discusses adoption and outcomes of alternatives that are now widely adopted such as grafting in the vegetable sectors; substrate production in floriculture, vegetables and strawberries; solarization plus alternative fumigants; and addition of composts and organic amendments to increase organic matter content in soils. It further focuses on how these practices are better geared towards sustainable production and protection of the ozone layer whilst still achieving profitable production levels.

Invited lecture

## DEVELOPMENT OF ALTERNATIVE FUMIGANTS: RESEARCH AND INDUSTRIAL VIEWPOINTS

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The repeated use of limited land to grow specific crops can result in the severe build-up of pest populations, which impact crop yield. Soil fumigation is a critical agricultural practice that assures better crop yields and provides greater benefits to growers. The traditional soil fumigant, Methyl bromide (MeBr), has been used for decades to control a wide array of soil-borne pests including nematodes, fungal pathogens, and weeds. There are no known cases of pesticide resistance to methyl bromide, due to its mode of action. The phase-out of MeBr, as an ozone depletor has resulted in increased use of alternative fumigants and other pesticides. Available soil fumigants include the following five active ingredients: 1,3-dichloropropene (1,3-D); methyl isothiocyanate (MITC, a primary breakdown product of metam-sodium/potassium or dazomet); chloropicrin (trichloronitromethane); carbon disulfide (CS<sub>2</sub>, a primary breakdown product of sodium tetrathiocarbonate); and iodomethane (methyl iodide). Other chemicals, such as dimethyl disulfide, sodium azide, furfural, 2-bromo ethanol, and acrolein are being evaluated as alternatives to MeBr soil fumigation. However, stringent environmental regulations targeting emission control largely affect the use of all fumigants. Every fumigant has its own particular set of concerns: efficacy under diverse field conditions, toxicity and air-borne exposure, soil mobility and offsite movement, or simple economic constraints. Regulatory restrictions underline the need for careful fumigant application methods and consideration of a combination of fumigants to achieve efficacy without negative impact on the environment. Although numerous approaches are currently being investigated and implemented in many countries, several strategies are the most promising for minimizing fumigant emissions. These strategies require using retentive films, water treatment, chemical seal, and organic amendment. Fumigant registrants, applicators, and growers are committed to finding practical solutions that simultaneously achieve efficacy to control soil pests and to comply with stringent regulations. This paper will present research on new methods and technological developments that reduce fumigant emissions and will address the utility of these strategies from the industrial perspective.

Invited lecture

## NEW DEVELOPMENTS AND EXPECTATIONS: VISION FROM DECISION MAKERS

Francesca Arena

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The current year marked two important achievements in the EU regulatory history of plant protection products.

First, in January 2009, the European Parliament adopted in second reading a new Regulation on the placing on the market of plant protection products that will replace Directive 91/414/EEC. This Regulation contains measures for shorter and clearer approval criteria, streamlined procedures, provisions for the substitution of active substances with safer alternatives and improved mutual recognition rules among the Member States.

Secondly, in March 2009, the Commission finalized the review program, of existing pesticides under Directive 91/414/EEC. Of some 1000 active substances on the market in at least one Member State before 1993, 26 % have passed the harmonised EU safety assessment. The majority of substances (67%) have been eliminated because dossiers were either not submitted, incomplete or withdrawn by industry. About 7% of substances failed the review and have been removed from the market, because the evaluation carried out did not show acceptable uses with respect to human health and the environment. The programme started slowly, but the work accelerated as of 2005. In short, 75% of the decisions were taken in the last four years, including those on methyl bromide, 1,3-dichloropropene, chloropicrin, metam and dazomet. Currently, none of these substances is included in the positive list of Directive 91/414/EEC, but industry resubmitted new dossiers for some of them, according to the accelerated procedure laid down in Regulation (EC) No 33/2008. Those three substances are currently under evaluation and decision making is expected to be finalised soon.

The experience gained with the application of Directive 91/414/EEC allows us to draw some conclusions: 1) with the completion of the review programme, it has become clear that soil fumigants have a very high risk profile; 2) given the high application rates, one of the critical issues that has been identified so far in the evaluation process concerns the presence of impurities; 3) so far, no dossier for newly developed active substance in this area has been submitted at EU level. Will safer and newer chemical alternatives be developed and supported in Europe?

# SESSION 1

## MBR ALTERNATIVES

### ORAL

- Progress in the global phase out of methyl bromide and the relative effectiveness of soil disinfestation products to replace fumigation for pre-plant soil uses – Ian Porter, M. Pizano, M. Besri, S. Mattner, and P. Fraser
- Is There a Future for 1,3-Dichloropropene and Other Chemical Soil Fumigants in European Agriculture? – Andrew Leader; Busacca, J; Dawson, J; Lyall, T and Eelen, H.
- Adoption of Methyl Bromide Alternatives and a Profile of Turkish Cut flower sector – Suat Yilmaz, M. A. Çelikyurt and B. Sayın
- Japan big effort to phase out of methyl bromide by 2013 – Akio Tateya

# PROGRESS IN THE GLOBAL PHASE OUT OF METHYL BROMIDE AND THE RELATIVE EFFECTIVENESS OF SOIL DISINFESTATION PRODUCTS TO REPLACE FUMIGATION FOR PRE-PLANT SOIL USES

I.Porter<sup>1</sup>, M. Pizano<sup>2</sup>, M. Besri<sup>3</sup>, S. Mattner<sup>1</sup>, and P. Fraser<sup>4</sup>.

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Global methyl bromide (MB) consumption for pre-plant soil disinfestation has been reduced from 65,000 tonne (t) in 2005 to approximately 12,000 t in 2009 under the Montreal Protocol. Pre-2005 stocks and quarantine/preshipment use for several industries mean a further 4,000-5,000 t of MB are used for preplant soil use each year. Only five of the fifteen developed countries that have applied for 'Critical Use' exemptions under the Montreal Protocol since 2005, re-applied in 2009. Alternatives being adopted to replace MB are chemical (a range of alternative fumigants and barrier films) or non-chemical methods (grafted plants or other resistant plants, substrates, or solarisation combined with other methods). All developed (non A5) countries and most developing (A5) countries have dramatically reduced consumption in all sectors. The key sectors still using MB are cucurbits and melons, cut flowers, peppers and eggplants, orchard replant, strawberry fruit and a range of nursery industries (strawberry, forests, ornamentals, turf).

Adoption of alternatives has led to a 50% fall in bromine from MB in the lower atmosphere and this is having a significant effect on stratospheric ozone layer recovery. Internationally, pressure is mounting to restrict the use of all fumigants under tightening regulations (EC Reg 2037/US Cluster Analysis) and new volatile organic compound regulations in the US, and this is changing approaches for soil disinfestation of soil-borne pathogens and weeds. The pressure on fumigant use is stimulating development of a greater knowledge on mechanisms for control of soil-borne pathogens, more sustainable crop protection, biosecurity and integrated pest management (IPM) strategies which have great benefits worldwide.

This presentation will also discuss the relative effectiveness of alternatives (chemical and non-chemical) to MB for soil disinfestation in a meta-analysis of 168 international studies on strawberry and tomato crops, and some of the consequences of future fumigant regulations and soil health changes on management of soil-borne pathogens.

## IS THERE A FUTURE FOR 1,3-DICHLOROPROPENE AND OTHER CHEMICAL SOIL FUMIGANTS IN EUROPEAN AGRICULTURE?

Leader, A, J<sup>1</sup>; Busacca, J <sup>2</sup>; Dawson, J<sup>3</sup>; Lyall, T<sup>4</sup>; Eelen, H<sup>5</sup>.

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1,3-Dichloropropene (1,3-D) and other soil fumigants play an essential role in the cost-effective production of high quality, fresh fruits and vegetables. Following the phase-out of methyl bromide, European agriculture utilised a combination of cultural and chemical pest control methods, including alternative soil fumigants. 1,3-D is appreciated as the most biologically effective nematocide and has played a critical role so European growers can maintain a significant position in the international market. There is unprecedented demand for soil fumigants from these growers. This was recognised by the European commission and Member States (MS) at the time of the non inclusion of 1,3-D on Annex I to Directive 91/414/EC in September 2007 by extending approval for use until 20<sup>th</sup> March 2009. Since that date emergency authorisations have been granted by individual MS to meet agronomic demand. Annex I re-registration for 1,3-D is being aggressively pursued via the submission of a robust technical dossier, including new studies to address original concerns and a regulatory decision is expected by early 2010.

Regulatory and political pressures in Europe are threatening the continued availability of all soil fumigants and to date none are included on Annex I. During their regulatory review, a number of concerns, common to all fumigants, relating to the toxicity and high use rates of these products, have arisen. Dow AgroSciences recognises the need for stewardship programmes for soil fumigants and has invested substantially to increase safe usage of 1,3-D to protect farmers, consumers and the environment. When used selectively with comprehensive stewardship, fumigants, such as 1,3-D, currently represent the only viable option until the next generation pest control methods are available as viable alternatives for use in intensive cropping systems. The key role that chemical soil fumigation plays to support economically-viable and sustainable agriculture in Europe continuously needs to be emphasized to regulatory authorities or agriculture risks losing these essential products for ever.

# ADOPTION OF METHYL BROMIDE ALTERNATIVES AND A PROFILE OF TURKISH CUT FLOWER SECTOR

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Surveys were carried out in 2003 and 2007 to determine the adoption levels of Methyl Bromide (MB) alternatives in cut flower sector under "Turkish Methyl Bromide Phase out Project". In this study, a profile of cut flower sector was also analyzed. Samples of 124 growers in 2003 and 430 growers in 2007 were selected from Antalya, Isparta and İzmir provinces where almost all of the protected cut flowers are grown in Turkey. A simple random sampling method was used to determine sample sizes and growers were interviewed by face to face meetings.

Results indicated that 82.3% of the cut flower growers questioned was using MB to disinfect soil in 2003; however, this number was sharply reduced to 0.4% in 2007. Use of MB was replaced by solarization with alternative chemicals (89.3%) such as; metham sodium, dazomed and 1,3-dichloropropene. Grower awareness on MB alternatives and deleterious effects of MB on environment and human healthy was significantly increased during project implementation. Among the soil borne problems in protected areas, soilborne diseases was the most prevalent. This was followed by nematodes, weeds and other problems. Acceptance of MB alternatives by growers was very satisfactory with a 79% of support at end of the project.

Size of protected-houses for cut flower production was very small, 82% of which was less than half hectare in 2007. Most of these houses were plastic (95.8%) and contained only side ventilation. Carnation was a predominant crop with a 63.6% of production area. Crop profile was mainly affected by crop prices and market demands. Education level of growers was about 7.3 years and 76.5% of growers were in between 31 and 50 years old. In this sector, 90.5% of growers had more than 5 years experience. In conclusion; MB use was phased out at the end of 2007 and alternatives were successfully adopted in cut flower sector in Turkey.

## JAPAN BIG EFFORT TO PHASE-OUT OF METHYL BROMIDE BY 2013

Akio Tateya

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Japan had released complete phase out of methyl bromide for critical use for the control of soil transmitted virus of cucumber, melon, pepper and watermelon and Pythium of ginger by 2013 in revised National Management Strategy being made public in April 2008.

The use and development of alternative technologies have been vigorously pushed forward in a campaign by the leadership of government adopting environment preservation agriculture. Growers have been quite encouraged to use alternatives by the helpful advices from agriculture technology experts.

Soil treatments are generally carried out by the growers themselves in Japan, not by pest control operators in business which is quite different from overseas countries. They are strongly requested to observe application instructions stated in the pesticide container label to avoid poisoning. No serious accident has been reported so far.

As the existing alternatives, chloropicrin liquid, its capsule and tape, 1,3-dichloropropene, dazomet, metham sodium, fosthiazate, cadusafos, oxyamil, pyraclofos, cyazofamid, propamocarb and metalaxyl are available to the majority of crops. Increase use of chloropicrin has fortunately attended improvement of dose application machinery. Pesticides under development are of mixture of metalaxyl M and azoxystrobin, methyl iodide, phosphorous acid sodium and amisulbrom.

As non chemical alternatives, solarization, soil reduction redox potential, humus acceleration from plant debris as sanitation in terms of IPM, hot water treatment, vapor heat treatment, grafting with disease resistant stock including grafting robot, disease resistant variety are available to growers.

For the complete replacement of methyl bromide for critical use nomination, Japan has undertaken the nation-wide trials for the development of the alternatives applicable in the respective production regions of the critical use nomination. Development of attenuated virus to hold wild virus infection and bio decomposing pot for avoiding contamination with infected soil are included. This project is now zealously undertaken from 2008 to 2012 as a transition means. These approaches are recognized as clear cut evidence how positively Japan tackles for the complete phase out of methyl bromide by 2013.

# MB ALTERNATIVES

## POSTERS

- Economic Evaluation of Chemical and Non-Chemical Soil Disinfestation - B. Sayin<sup>1</sup>, M. A. Çelikyurt Suat Yilmaz and İ. Çelik
- Maintaining Biosecurity and Market Access in the Australian Strawberry Industry Following Methyl Bromide Phase-out – Scott W. Mattner, I.J Porter, R.K. Gounder, R.C. Mann, B. Guijarro
- Pests and diseases of sweet basil after methyl bromide phase out: the Northern Italian experience - Anedrea Minuto, N. Vovlas, A. Troccoli, C. Bruzzone, M. Scortichini, G. Minuto

# ECONOMIC EVALUATION OF CHEMICAL AND NON-CHEMICAL SOIL DISINFESTATION APPLICATIONS FOR TOMATO PRODUCTION IN TURKEY

B. Sayin<sup>1</sup>, M. A. Çelikyurt<sup>1</sup> S. Yilmaz<sup>1</sup> and İ. Çelik<sup>1</sup>

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Methyl bromide (MB) had been used for soil disinfestations more 20 years in protected production areas, in Turkey. The peak consumption reached 1319 tons in 1998. In the framework of Montreal Protocol, Turkey gradually reduced MB use for soil disinfestations starting from 2003 and completely terminated at the end of 2007; even though, Turkey was to phased out MB by 2015. MB alternatives such as solarization, grafting, soilless culture, chemicals and their combinations were introduced and successfully adopted in protected production.

This study was carried out in 2006-2007 production season in Antalya Province. Solarization, grafting with different rootstocks, chemicals (metham sodium, dazomet and 1,3-dichloropropene) and their combinations were economically compared. In this study, cost and benefit analysis of different alternatives based on experimental data were evaluated by using partial budgeting method.

Climatical conditions of Mediterranean and Aegean costs in Turkey were very suitable for solarization in summer seasons especially for protected production. Our results indicated that solarization alone or combination with chemicals between June and September months for 60 days provided very satisfactory outcomes. Effects of 1,3-D, metham sodium and dozamet on plant yields statistically were in same group; however, easy of use of the metham sodium and 1,3-D by drip irrigation promotes their usage by growers. Grafting can be also considered a good alternative to MB, because this technology can provide good quality, high yields and resistance to soilborne pathogens.

# MAINTAINING BIOSECURITY AND MARKET ACCESS IN THE AUSTRALIAN STRAWBERRY INDUSTRY FOLLOWING METHYL BROMIDE PHASE-OUT

S.W. Mattner<sup>1</sup>, I.J Porter<sup>1</sup>, R.K. Gounder<sup>1</sup>, R.C. Mann<sup>1</sup>, B. Guijarro<sup>1,2</sup>

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The biosecurity and market access of the Australian strawberry industry is presently under threat from current and possible future withdrawals of soil fumigants. Currently, regulatory authorities in some states only grant certification or accept entry of strawberry transplants if they are produced in soils treated with methyl bromide (MB). A key issue is that thresholds that meet certification for soil-borne diseases in transplants are not clearly defined in Australia or worldwide. Therefore there is no benchmark to compare the health status of transplants produced under alternative systems with those produced in MB-treated soils. Our research has commenced developing and applying molecular and traditional tools to better define soil-borne disease thresholds that meet certification standards. Preliminary data suggests that the incidence of crown rot caused by *Phytophthora cactorum* in transplants grown in MB-treated soil may be in the range of 0.01 - 1.0 %, but the development of molecular-based screening and appropriate sampling strategies is important to better define certification standards for this pathogen.

The strawberry nursery industry in Australia has trialled alternatives to MB since 1995. Generally, alternative fumigants currently registered in Australia (metam sodium; dazomet; chloropicrin and 1,3 dichloropropene) have controlled soil-borne pathogens and weeds to similar levels as MB (e.g. 1,3-D / Pic reduced *Rhizoctonia solani* AG2.1 from 65 pg DNA / g soil to undetectable levels). However, due to their low volatility, the registered alternative fumigants have sometimes caused phytotoxicity in strawberry transplant crops (up to 40 % yield loss). This is exacerbated under the cold conditions (< 5°C soil temperature) and heavy soils present in the nursery industry. Volatile alternative fumigants, such as methyl iodide and ethanedinitrile, have given more consistent yield responses in trials and are currently undergoing registration in Australia. As long-term solutions, trials are investigating soil-less systems (e.g. hydroponics and soil-less substrates) and non-pesticide methods (e.g. biofumigation and mycofumigation) as alternatives to MB and other soil fumigants for strawberry transplant production.

Pests and diseases of sweet basil after methyl bromide phase out: the Northern Italian experience

## PESTS AND DISEASES OF SWEET BASIL AFTER METHYL BROMIDE PHASE OUT: THE NORTHERN ITALIAN EXPERIENCE

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Sweet basil (*Ocimum basilicum* L.) is an economically important herb crop in several countries including Italy. Several soilborne diseases may affect this soil grown crop including vascular wilts and basal and root rots. In addition, soilborne root knot nematodes (*Meloidogyne* sp.) may often cause severe yield losses while the foliar nematode (*Aphelenchoides ritzemabosi*) is less frequently detected. In the past, the control of soilborne pest and disease complex was easily obtained by the use of methyl bromide or steam due to the wide spectrum of activity against pests, disease and weeds of both methods. As consequence of the phase of methyl bromide under open field conditions soil disinfection is generally carried out with MITC generators or throughout the soil injection of chloropicrin and 1,3 dichloropropene mixtures. Nevertheless, since open field crops are directly sowed at the beginning of May in soil fumigated at least 21 days earlier, cold soil temperature often strongly limits the soil treatment. Under protected crop, several basil growers shifted from soil to soilless crop in order to skip the risk of economical disruption, particularly after MB phase out. Open soilless system is the most common growing method and plastic trays filled with potting mix substrate, are the most common substrate containers.

After MB phase out some pests and diseases increased in protected and open air basil fields. In open field crops the presence of *Meloidogyne arenaria* race 2 was detected, particularly in fields where the fumigation was only occasionally carried out. Moreover due to the shift from soil to soilless growing methods a leaf bacterial disease (*Pseudomonas viridiflava*) and the leaf nematode (*A. ritzemabosi*) caused severe damages. The present contribution illustrates the pests and the diseases recently found on basil crops and the relationship of the shift from traditional to new growing systems due to MB phase out.

## SPECIAL SESSION

# METHYL BROMIDE ALTERNATIVES : ALTERBROMIDE (EC) PROJECT

### ORAL

- Invited lecture
- ALTERBROMIDE, dissemination of sustainable alternatives to Methyl Bromide in soil disinfestation and in post harvest - Gael du Fretay, J Dasque J Auger; J Coosemans; P Colla; F Pauwels; and J Fritsch.
- Current status of chemical and non-chemical soil disinfestations solutions in France – Jerome Fritsch
- Mechanical or manual applications of soil solarization for the control of soilborne pathogens in plastic house or open field in Greece – Polymnia Antoniou, Sotiris Tjamos and E. C. Tjamos
- Soil disinfestation treatments with 1.3-dichloropropene and chloropicrin under low temperature conditions for strawberry mother plants – Vicent Cebolla, and Serrano. Fernando
- Greenhouse grafting cucumber crop – methyl bromide alternative in Romania – Marian Bogoescu, Madalina Doltu, D.Sora, and Niculina Tanasa
- Soil and substrate microbiologizing: a promising approach for sustainable horticulture' – Frans Pauwels

Invited lecture

ALTERBROMIDE, DISSEMINATION OF SUSTAINABLE  
ALTERNATIVES TO METHYL BROMIDE IN SOIL DISINFESTATION  
AND IN POST HARVEST

Gael du Fretay<sup>1</sup>, J Dasque<sup>1</sup> J Auger<sup>2</sup> J Coosemans<sup>3</sup> P Colla<sup>4</sup> F Pauwels<sup>5</sup> and J Fritsch<sup>6</sup>

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Objective of this project was to set up and implement a coordination framework improving the delivery of sustainable alternatives in the countries where Methyl Bromide is essential and more especially where the critical uses requested by member states are the higher. This European project (Framework Programme Priority 8.1 Policy-oriented research Thematic Priority: agriculture and forestry management contract n°022660) was coordinated by AREFLH (Assemblée des Régions Européennes Fruitières Légumières et Horticoles) from September 2006 to October 2008. The partnership was composed of partners from seven countries, Belgium (KULEUVEN Katholieke Universiteit Leuven, SAFE European fumigator association), France (BGSO-HORTIS Comité Economique du Bassin du Grand Sud Ouest, CRITT Innophyt, LNDS Laboratoire National Denrées Stockées), Greece (AUA Agricultural University of Athens, ED European Dynamics), Italy (AGROINNOVA Centro di Competenza per l'Innovazione in Campo Agro- ambientale), Spain (IFAPA Instituto Andaluz de Investigacion y Formacion Agraria, IMIDA Instituto Murciano de Investigacion y Formacion Agraria, IVIA Instituto Valenciano de Investigacion y Formacion Agraria), Netherlands (WU Wageningen University) and Romania (HORTING Research and Development Institute for Horticulture). The members involved with AlterBromide represents & works closely with different types of organisations: technical transfer organisations in direct contact with growers, research organisations & experimentation in direct contact with scientists, national agencies in direct contact with decision makers, union representing in direct contact with fumigators. Alterbromide produced the following actions: review reports of MB alternatives in Europe, good fumigation practice guides and technical leaflets, training courses, local open days, national conferences, papers, participation at international conferences, web site dissemination [www.alterbromide.org](http://www.alterbromide.org). This project contributed to the replacement of Methyl bromide by existing alternatives like grafting and combination of 1.3D with chloropicrin and contributed to the development of new suitable alternatives like solarization, biofumigation, integrated pest management solutions including methods of diagnosis, Dimethyl disulfide and other means.

## CURRENT STATUS ON CHEMICAL AND NON CHEMICAL SOIL DISINFESTATIONS SOLUTIONS IN FRANCE.

### J. FRITSCH

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Because of present and future European and national regulations on pesticides, french growers are using less and less chemical soil fumigants. They started between 1998 and 2007 with a linear decrease on Methyl Bromide (Mebr) consumption combined with standardized Virtually Impermeable films NF T 54 195.

Cases studies of European Alterbromide Project on main crops and countries concluded that 70% around of total vegetable surfaces are disinfested with chemical fumigants mainly mixture of 1.3 dichloropropene and chloropicrine, metam sodium and at least dazomet i.e. major european and french vegetable and ornamental crops are depending of fumigants.

A new quarantine pest (*Meloidogyne chitwoodi*) was recently detected in North of France on potatoes and soil disinfestations will be imperative in this case.

Moreover, several successful research focus on lower rates of active ingredients per hectare with methyl isothiocyanate generators i.e metham sodium and dazomet. Theses new ways are now adopted by french farmers : dazomet at 500 Kg or 250 kg and VIFs, metham sodium and rototiller plus packing soil at only 600 liters/ha with an homogenous repartition over the soil layer at the time of application.

Metham sodium through drip irrigation system on strawberry in the Perigor area (South West of France) is the only available alternative to the ban of Mebr.

Soil solarization alone or combined with low rates of chemicals (8% of total vegetables crops in Europe following Alterbromide conclusions ) is a very promising tool to reduce soil fumigants consumption keeping biological specially on big vein on lettuces in South West of france. (2008). Around 250 hectares are solarized in South East and West of France.

New soil fumigants such as dimethyl disulfide or iodomethane with promising results are not yet registered.

A wide choice of physical methods can be largely used by growers themselves : steam or hot air with new technologies.

## MECHANICAL OR MANUAL APPLICATIONS OF SOIL SOLARIZATION FOR THE CONTROL OF SOILBORNE PATHOGENS IN PLASTIC HOUSE OR IN FIELD CROPS IN GREECE

Polymnia Antoniou, Sotiris Tjamos and E. C. Tjamos

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Watermelon plants grafted on rootstocks resistant to *Fusarium oxysporum* f.sp. *niveum* could avoid Fusarium wilt. However, this protection is not extended to *Verticillium dahliae* infections. Indeed watermelon cultivations established in fields previously cultivated to potato or cotton (Both susceptible to *Verticillium* wilt) cause widespread infections of watermelons regardless of the use of *Fusarium* resistant rootstocks. In July 2007 strip soil solarization was applied in 10 hectares sandy loam field previously cultivated to potatoes. A strip of 2 m wide was covered mechanically by impermeable transparent plastic films (actual width 2.80 m ) while a between corridor 1.50 m wide was left uncovered. Machine application was carried out by a specifically regulated tractor in dry soil while irrigation tubes one m apart were also inserted during covering to be used to extensively water the soil. Two months after the application of soil solarization the plastic film was teared in the middle to allow rain water to water the field during winder. In February 2008 the soil was cultivated with a ripper without soil mixing while the plantation was established in March 2008 and transparent plastic tunnels covered the plants. Enumeration of *Fusarium oxysporum* propagules in solarized or unsolarized control strips revealed that two months soil solarization almost destroy all *Fusarium oxysporum* propagules. Regarding symptom development in unsolarized strips up to 50-60 % of the plants developed brown vascular discoloration indicating a vascular wilt diseases. laboratory examinations and pathogen isolation revealed that almost 80% of symptomatic plants were infected by *Verticillium dahliae*. On the contrary no vascular wilt symptoms nor *Verticillium dahliae* was isolated from watermelon plants grown in solarized strips proving the effectiveness of the root stocks against Fusarium wilt. Preliminary calculations of the effect of solarization on the number of produced watermelon fruits per plant with commercial value showed that the difference between treated and untreated plots was not significant (the corresponding figures were 2.5 to 3.2 ). However the mean weight of watermelon fruits from the untreated was per 8-10 Kg compared to 14-16 Kg from the solarized plots. This significant difference in th total production and the size of fruits justified the low cost extensive machine application of soil solarization in the Amaliada region of Helia county in Peloponnesus Greece (Cost of application 750 Euro per ha). Various examples of succesful soil solarization application refer to globe artichoke, lettuce, tomato and cucumber against several soilborne pathogens. In Iria region against *Verticillium dahliae* and *Sclerotinia minor* for the last 25 years. Mechanical application in region o Lechaina Helia and Lapa Achaia for the control of *Sclerotinia minor* and other soilborne pathogens of lettuce. Soil solarization is also applied in Preveza county for the last 30 years now for the control *Pyrenochaeta lycopersici* *F. oxysporum* f.sp. *cucumerinum* και *Clavibacter michiganensis* subsp. *Michiganensis*. Solarization is a useful alternative of methyl bromide for the control of soilborne pathogens in Greece.

## SOIL DISINFESTATION TREATMENTS WITH 1,3-DICHLOROPROPENE AND CHLOROPICRIN UNDER LOW TEMPERATURE CONDITIONS FOR STRAWBERRY MOTHER PLANTS

Cebolla Vicent, Serrano. Fernando

Dep Prot Veg y Biotech. IVIA. Montcada Valencia (Spain)

Some crops do not adapt to winter disinfestation because low temperatures reduce the evaporation capacity of fumigants and its spatial distribution can't be done with the desired uniformity, on the other hand remaining fitotoxic residues need more time to be eliminated.

The most problematic case in Spanish farming is on strawberry mother plants crop in highland nurseries, where disinfestation before plantation is done with soil temperatures about 10°C during application.

Main problems are soil fungi and the presence of weeds in springtime and summer with the mother plants still developing.

In a first season three adjuvants were studied for new formulations of 1,3-dichloropropene 55.2% + chloropicrin 30.3 % at 50 gm<sup>2</sup> furnished by Agroquímicos de Levante SA., (Agrocelhone NE); methyl bromide 50%.+ chloropicrin 50% at 40 g/m<sup>2</sup> and a non disinfested check. The experiment was conducted at Chañe (Segovia, Spain)

Application has been done by shank injection, as is usually done, on mid March and crop started beginning of May.

On a second season, at the same site, the best adjuvant was compared added or not to a set of standard mixtures of 1,3-D 36.7% and Chloropicrin 52.8%; 1,3-D 55.2% and Chloropicrin 30.3% formulated for shank injection and with emulgents and compared to methyl bromide

On a third season, 100 plants per plot, produced in our second season mother plant experiment, were transplanted in a commercial field at Lucena (Huelva, Spain) in order to monitor the yield, vigour and healthy state along a standard crop.

The first season results showed that there are no significant differences with respect to weed control among treatments except for the check. In check treatment weeds seize the whole plot and finally plants together with weeds were eliminated. Runner production was improved by the new formulation up to the level of methyl bromide. The new formulation showed a better control of weeds than the standard mixture.

On the second season, emulsifiable formulation and special formulations gave better control of weeds,

On the third season no differences among treatments were found on yield and healthiness even in the check treatment, but diameter of rhizomes on MB and especial formulations with adjuvant were significantly higher than standard formulations.

## GREENHOUSE GRAFTING CUCUMBER CROP – METHYL BROMIDE ALTERNATIVE IN ROMANIA

M. Bogoescu, Madalina Doltu, D. Sora, Niculina Tanasa

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In Romania, the cucumbers represents one of the most important crops in greenhouse, generally adopting a continuous monoculture. Since crop rotation is rarely adopted, the reduction of yield, both in quantity and quality, progressively affects the crops, thus making necessary the adoption of soil disinfestations practices or, other methods.

Investigations at Horting Institute showed that after 4 years of continuous cucumber monoculture a yield reduction up to 38% occurred. Methyl bromide is, probably, the only fumigant that is effective against nematodes, weeds, pathogens, insects, and rodents. The treatment of soil with methyl bromide was used only by large commercial farmers (107.72 methyl bromide tons in 2003). Since the adhesion to the Montreal Protocol, Romania government decided to phase out methyl bromide use starting 2005. The efficacy of the chemical fumigants metham sodium (100ml/m<sup>2</sup>), 1,3 D + chloropicrin (45g/m<sup>2</sup>) and a non-chemical method (grafting cucumbers) were tested and compared to that of methyl bromide(75g/m<sup>2</sup>) (standard control).

Results of the demonstrative plots (MAKIS-project) from 2007/2008 showed that, under Romanian soil and environmental conditions, the following methyl bromide chemicals alternatives were suitable for soil disinfection: metham sodium, 1.3 dichloropropen + chloropicrin (chemicals methods) and grafting cucumbers (non-chemical method). Due to EU environmental policy on the medium or long term, the 1.3 dichloropropen + chloropicrin utilization in European Member States is uncertain.

## SOIL & SUBSTRATE MICROBIOLOGIZING®: A PROMISING APPROACH FOR SUSTAINABLE HORTICULTURE

Frans Pauwels

De Ceuster – Division Plant Health & Soil Fertility, Belgium

Intensive horticulture is characterized by sky-high yields and thoroughgoing specialization, but sometimes also by very vicious problems, like soil exhaustion, especially after several years of monoculture at high plant densities. Market gardeners often produce their own soil exhaustion problems for lack of crop rotation. Can't we learn a thing or two from the positive and practical experience of extensive cropping systems, where such soil sickness problems do not occur at all? Maybe we should translate and integrate certain of these positive ingredients into our current highly intensive, but monocultural economic production systems ?

Sure enough, with more insight into the microbiological reality of the rhizosphere, crystallized into a novel and good horticultural practice !

Soil inoculation in itself, in short "Soil Occupizing®", but also combined in an integrated soil disinfestation process, can contribute substantially to a more sustainable cultivation technique for soils, both in glasshouses and in the open air, but also for growing media !

SPECIAL SESSION:  
METHYL BROMIDE ALTERNATIVES:  
ALTMET (B) PROJECT

ORAL

- Efficacy of chemical alternatives for Methyl bromide in lettuce production: field experiment - A. Ceustermans, E. Van Wambeke and J. Coosemans
- Combinations of chemical soil fumigants for broad spectrum soil disinfestation- E. Van Wambeke, A. Ceustermans A. De Landtsheer, K. Gybels and J. Coosemans
- Microbial mechanisms involved in the suppression of *Rhizoctonia solani* AG1-1B by lignin incorporation in soil - Sarah Van Beneden, Dries Roobroeck, Soraya C. França, Stefaan De Neve, Pascal Boeckx and Monica Höfte
- Use of oxamyl in the post methyl bromide era - J. Desaeger and J. Wiles

## EFFICACY OF CHEMICAL ALTERNATIVES FOR METHYL BROMIDE IN LETTUCE PRODUCTION: FIELD EXPERIMENT.

A. Ceustermans<sup>1</sup>, E. Van Wambeke<sup>2</sup> and J. Coosemans<sup>1</sup>

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In Belgium the production of lettuce is economically very important. The major problems in lettuce production are the plant pathogen fungi *Sclerotinia sclerotiorum* (causing lettuce drop) and *Rhizoctonia solani* (causing bottom rot). These fungi can survive for different years in the soil as sclerotia and can cause serious crop losses. Until January 2006, Methyl bromide played a key role in the production of lettuce. However, Methyl bromide is phased out as it is an ozone-depleting chemical and alternatives are needed. The chemical alternative should be effective against fungi, weeds and nematodes. Therefore, the efficacy of different fumigants and combinations was tested in a field experiment against fungi, nematodes and weeds. The tested fumigants were Methyl bromide (MeBr), Methyl iodide (MI), MI with Chloropicrine (CP), Metam sodium, Metam potassium, Dichloropropene (DD), Dimethyldisulfide (DMDS), Dazomet, DD with Dazomet, DMDS with Dazomet, CP and CP with DD. Lettuce was planted 4 weeks (during autumn) and 27 weeks (during spring) after disinfestations. In both cultures lettuce weighted more than the control for each treatment, however less significant differences were found during the second one. Almost no significant differences were observed regarding infestation degree of *Sclerotinia* and *Rhizoctonia* (only tested in the second culture). This resulted in no significant differences in lettuce drop caused by *Sclerotinia*. Concerning the efficacy of the different fumigants against fungi in general, only in the first culture significant differences were found, indicating that the efficacy of the fumigants is reduced after 27 weeks. This could also be observed for the efficacy of the fumigants against weeds, where the efficacy of the fumigants was significantly higher during the first cultivation. During the second one less significant difference were found.

## COMBINATIONS OF CHEMICAL SOIL FUMIGANTS FOR BROAD SPECTRUM SOIL DISINFESTATION

E. Van Wambeke<sup>1</sup>, A. Ceustermans<sup>2</sup>, A. De Landtsheer<sup>2</sup>, K. Gybels<sup>2</sup> & J. Coosemans<sup>2</sup>

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Many years already before methyl bromide started phasing out, a tremendous number of studies was dedicated to possible alternatives. Among the available chemical compounds only one candidate, i.e. methyl iodide (iodomethane), could match with the broad spectrum performance of methyl bromide.

Other, more widely registered soil fumigants, such as 1,3-dichloropropene (1,3-D, DD or Telone), metam-sodium and metam-potassium, and dazomet (Basamid) show more specific activities, i.e. nematicidal or weaker broad spectrum including fungicidal and herbicidal. In the meantime, new interesting development offers chances for e.g. dimethyl disulfide (DMDS) with principally nematicidal activity at reasonable dose rates.

Although the idea of applying two fumigants with different action spectrum simultaneously is not new, a choice was made for DD + Basamid and DMDS + Basamid.

Basic research with these combinations for their fungicidal, nematicidal and herbicidal value at full as well as at half dose rate of each component revealed synergistic activity in many cases reaching methyl bromide performance level.

The experimental setup consisted of modular soil columns with packed biological test materials at different depths. Classic among the phytopathogenic fungi: *Rhizoctonia solani*, *Sclerotinia minor* and *S. sclerotiorum* sclerotes. *Meloidogyne incognita* infested soil was used for nematicidal activity check, and cress and tomato seeds for herbicidal activity and phytotoxicity check. The choice for mainly studying these target organisms is their fit in the theme of the ALTMET project on research for methyl bromide alternatives in the control of butterhead lettuce pests and diseases.

Combined application of fumigants at reduced dose rates was proven to perform well under practical conditions in greenhouse and outdoor crops which is reported in a separate lecture of this symposium.

# MICROBIAL MECHANISMS INVOLVED IN THE SUPPRESSION OF *RHIZOCTONIA SOLANI* AG1-1B BY LIGNIN INCORPORATION IN SOIL

Sarah Van Beneden<sup>1</sup>, Dries Roobroeck<sup>2</sup>, Soraya C. França<sup>1</sup>, Stefaan De Neve<sup>3</sup>, Pascal Boeckx<sup>2</sup>, Monica Höfte<sup>1</sup>

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*Rhizoctonia solani* is an important soilborne pathogen. In Belgian lettuce greenhouses it is considered as the predominant causal agent of basal rot, i.e. rotting and wilting of the lower leaves. Sclerotia of *R. solani* remain viable for several years and are an important source of primary infection. The only effective way to control this soilborne pathogen is by killing its survival structures in soil, as achieved with fumigations. Last decades sustainable control measures have gained interest. In this study the efficacy of lignin was assessed in two different soil types collected from commercial fields in Belgium, labelled Oppuurs soil and Leest soil. Evaluating sclerotial viability after 4 weeks incubation in the two soils amended with 1% (w/w) Kraft pine lignin demonstrated a soil dependent effect. In Leest soil the addition of lignin resulted in a significantly reduced sclerotial viability, together with an increased mycoparasitism by *Trichoderma* spp.; in Oppuurs soil, on the other hand, only a slight and insignificant reduction in sclerotial viability was observed. Based on phospholipid fatty acid analysis, different changes in microbial community structure upon lignin amendment were detected in the two soils. Both soils showed a significant increase in gram negative bacteria. In Leest soil this increase was accompanied with a significantly higher increase in fungi and actinomycetes compared with Oppuurs soil. In addition, Kraft pine lignin resulted in both soils in a small but significant increase in manganese peroxidase activity and this increase tended to be higher in Leest soil. Manganese peroxidase produced by lignin degrading basidiomycetes has previously been shown to degrade melanin, which protects the sclerotia against biotic and abiotic stress. We hypothesize that lignin degrading fungi are involved in making the sclerotia more susceptible to sclerotial antagonists like *Trichoderma*, gram negative bacteria and actinomycetes. Clearly, the effect observed here does not rely on the stimulation of one microbial group, but is the result of an interaction of different groups.

## USE OF OXAMYL NEMATOCIDE IN THE POST METHYL BROMIDE ERA

J. Desaeger and J. Wiles

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For decades methyl bromide (MBr) was the standard for nematode control in high-value vegetable and fruit crops. With the imminent phase-out of MBr, there is an urgent need for alternative nematode control products. In EU the best alternative fumigant for nematode control, 1,3-dichloropropene (1,3-D) has come under regulatory pressure and in the US 1,3-D supplies have been limited due to the crisis in the automobile industry. In addition, many of the non-fumigant nematicides (organophosphates and carbamates) are facing similar regulatory pressure. For growers all around the world, it is becoming increasingly harder to effectively control nematode pests.

Oxamyl (Vydate®) is a systemic oxime carbamate used to control nematodes and insects and one of the few remaining products that can be applied after planting. When nematode pressure is high, pre-plant fumigation with MBr alternatives such as 1,3-D, chloropicrin and/or metam sodium often does not provide acceptable nematode control and additional post-plant applications of oxamyl have shown to significantly improve nematode control and increase crop yields. Although oxamyl applications without pre-plant fumigant will provide better yields than no treatment at all, they are only recommended when nematode pressure is low to moderate. Even in cases where no nematodes are present, carbamates, such as oxamyl, often have a general positive impact on yield.

## SESSION 2

# CHEMICAL SOIL DISINFESTATION

### ORAL

- Shank application of chloropicrin as an alternative to methyl bromide for peach tree replant – S. Foschi, C. Spotti, A. Minuto, G. Minuto
- The emulsifiable formulations of Dimethyldisulfide (DMDS) and its mixtures with chloropicrin as alternatives to methyl bromide - Vicent Cebolla, Daniel Llobel, Antonio Oliver, Luís Miguel Valero, Francisco Torró, Andrés Hernández
- Evaluation of the efficacy of DMDS using drip application for the control of root knot nematodes (*Meloidogyne spp.*) in Turkey – JJ. Heller, E. Korkmaz, P. Charles.
- Multi-tactic Approaches to Manage Soilborne Pathogens of Specialty Crops in North Carolina – F.J. Louws, R.M. Welker, J.G. Driver and C.L. Rivard.
- Powdery scab occurrence and control in Israel - L. Tsrer (Lahkim) O. Erlich, M. Hazanovsky and U. Zig
- Soil chemical treatments for the control of Fusarium wilt of Carnation in Spain - M. J. Basallote Ureba, M. D. Vela Delgado, F. J. Macías, C. J. López Herrera, and J. M. Melero Vara
- Effectiveness of fumigants alone and in combination with grafting to control Verticillium wilt and root-knot nematode in eggplant and tomato brown rot caused by *Colletotrichum coccodes* - Gilardi G., Baudino M., Gullino M. L. and Garibaldi A
- Top applications of fungicides for the control of melon sudden wilt caused by *Monosporascus cannonballus* - Shimon Pivonia, Amikam Maduel, Rahel Levita, and Ron Cohen
- Accelerated degradation of metam-sodium in soil: Isolation and characterization of the involved microorganism - S. Triky-Dotan, M. Austerweil, B. Steiner, D. Minz, J. Katan and A. Gamliel

## SHANK APPLICATION OF CHLOROPICRIN AS AN ALTERNATIVE TO METHYL BROMIDE FOR PEACH TREE REPLANT

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The poor growth of fruit trees that occurs after replanting on a site that previously supported the same or closely related species has been termed “replant disease” or “replant disorder.” Peach replant disorder occurs when a new orchard is planted in soil that has recently been in peach production. Trees in a replant disorder site have reduced growth and produce leaves that are light green to yellow-green rather than dark green. Fruit production is delayed and yields are reduced. Numerous soilborne organisms have been implicated as potential causal agents of apple replant disease. *Armillaria mellea* has been associated with the occurrence of peach replant disease. Armillaria root disease is an important disease of fruit, nut, and vine crops. Reports of increased incidence of Armillaria root disease in peach have also recently come from Emilia Romagna in northern Italy. Nevertheless other microorganisms and abiotic factors including low or high soil pH, phytotoxins, unbalanced soil nutrition, heavy metal contamination, poor soil structure and drainage, and cold or drought stress have been considered affecting factors. Peach replant disease has primarily been dependent upon the use of biologically broad spectrum soil fumigant such as methyl bromide or chloropicrin alone or combined with 1,3 dichloropropene. Since 2004 three field trials were organized in Emilia Romagna (Northern Italy) and aimed at evaluating the efficacy of treatments with chloropicrin (200 – 400 – 800 kg/ha) combined with 240 kg/ha of 1,3 dichloropropene applied throughout shank injection against *A. mellea* and compared with non treated plots. Trials were carried out in naturally and heavily infested fields. Fumigations were done in October 2004 and 2008. The assessments were focused at evaluating the plant development after transplanting, the incidence of the soilborne disease and the yield. Moreover collapsed plants were collected and brought to the laboratory to confirm the presence of *Armillaria mellea*. The data confirmed the positive effect of the soil fumigation on the plant development and on the yield. Moreover a significant reduction of plant collapses due by *A. mellea* infection was consistently recorded. No differences in term of efficacy were observed between 400 and 800 kg/ha, while 400 kg/ha performed better than 200 kg/ha in term of disease control, yield and plant development.

## THE EMULSIFIABLE FORMULATIONS OF DIMETHYLDISULFIDE (DMDS) AND ITS MIXTURES WITH CHLOROPICRIN AS ALTERNATIVES TO METHYL BROMIDE.

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Dimethyl disulfide (DMDS) is an important compound of *Allium* sp, specially of garlic. Although its fumigant effects are recently discovered, DMDS has been used by petrochemical industry and even as aroma agent because of its strong smell to garlic.

DMDS is a wide spectrum fumigant with nematocidal, fungicidal, insecticidal and herbicidal effects.

Since the year 2003 to 2008 we have studied its effects as an alternative to Methyl bromide for the pepper crops on two locations, of Valencian country (Spain), one in the inland (Canal de Navarrés) and the other in the south (Pilar de la Horadada), by using emulsified formulations applied by the drip irrigation system, stand alone or mixed with chloropicrin at 50% or 25 %.and also was compared to the mixtures of 1,3-dicholopropene and chloropicrin.

DMDS stand alone, at high rates (105 g/m<sup>2</sup>), have a remarkable herbicidal capacity; at lesser dosage, its mixtures with chloropicrin own an excellent fumigant effect that is improved when applied under VIF sheet. The fungicidal effect is also improved by the mixture.

Once the application technique was debugged The fruit quality as well as the yield is alike to those obtained with the classical methyl bromide soil disinfestation technique and the mixtures of 1,3-dicholopropene and chloropicrin.

# EVALUATION OF THE EFFICACY OF DMDS USING DRIP APPLICATION FOR THE CONTROL OF ROOT KNOT NEMATODES (*MELOIDOGYNE SPP.*) IN TURKEY

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Fumigants are mostly used in vegetables grown under protected conditions in south and south-west part of Turkey. Tomatoes account for more than 50% of the vegetable production followed by cucumber, pepper & eggplant. Fumigants are used to control nematodes, in particular root knot nematodes (*Meloidogyne spp.*) and also soil borne diseases. Fumigation is standard practice and methyl bromide application was commonly adopted for soil disinfection in Turkey. Dimethyl disulfide (DMDS) is currently under development as an alternative to methyl bromide and existing fumigants. Ten experimental trials were carried out in 2007- 2008 with this new product in naturally infested soil in Anatolya and Mugla areas on tomatoes, eggplants, peppers and cucumbers. All trials were carried out under greenhouse on sandy loamy and clayey loamy soils following a randomized complete block design with three or four replicates under compliance with Good Experimental Practices in collaboration with TARSAV Akdeniz Cad. 1347 Sok. N°: 8/507 Izmir Turkey (A. Kapkin, Y Arinç). DMDS EC formulation application rates were 100 l/ha, 200 l/ha and 300 l/ha under virtually impermeable film (VIF), 150 l/ha, 300 l/ha, 450 l/ha under low density polyethylene film (LDPE), application was by drip fumigation. DMDS was compared with drip application of 1,3-Dichloropropene and with combination of solarization with nematicides. Nematode severity was evaluated according to the Gall Scale Index (0-10), average weight of marketable fruits per plant, plot, m<sup>2</sup> were gathered from each plot at each harvest. DMDS provided good nematode (*Meloidogyne spp.*) control, based on root gall ratings. In addition, this product significantly increased marketable yields of tomato, eggplant, pepper and cucumber. As a result of the conclusions of the studies DMDS at 300 l/ha under VIF or at 450 l/ha under LDPE using drip irrigation system can be recommended against root-knot nematodes (*Meloidogyne spp.*) on vegetables under greenhouse in Turkey.

## MULTITACTIC APPROACHES TO MANAGE SOILBORNE PATHOGENS OF SPECIALTY CROPS IN NORTH CAROLINA.

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Methyl bromide (MeBr) combined with chloropicrin has been the primary product to manage soilborne pathogens in strawberry and vegetable plasticulture production systems in NC. A multi-year and interdisciplinary program was implemented to develop, evaluate and extend viable alternatives to MeBr. This report highlights soilborne disease outcomes.

The program was executed in 3 phases: Phase I projects evaluated new products, methods of application or farming systems research on research stations; Phase II included on-farm-research experiments typically using relatively small replicated plots; Phase III included large scale on-farm projects that focused on viable chemical alternatives and in many cases were replicated studies.

The program conducted discovery research to determine the primary pathogens in each system (mainly strawberries and tomatoes). Biology-based knowledge informed tactic development and extension of alternatives. Standard alternative fumigants such as 1-3-dichloropropene, chloropicrin, metam sodium and various combinations suppressed plant pathogens similar to MeBr:Pic combinations and in some cases were documented as more economically viable. Grafting was explored as a tool to manage southern bacterial wilt, fusarium wilt, root knot nematodes and to some extent verticillium wilt (race 2). Finally, advances in soil microbial ecology were pursued to complement chemical-based tactics. Multiple regional extension agent and grower training programs were conducted to translate information gained to field implementation.

## POWDERY SCAB OCCURRENCE AND CONTROL IN ISRAEL

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Powdery scab in Israel occurs mainly in the spring season, but outbreaks of the disease were observed also in the fall season. Although some factors -- such as lack of waterlogged soils and relatively high soil temperature during the spring season -- are unfavourable for *Spongospora subterranean* subsp. *subterranean* infection, the disease became prevalent during recent years in Israel. Amongst the two major potato production areas in Israel, the disease is more prevalent in the coastal area (Sharon) than in the southern area (Negev), due to different growth conditions such as soil type, pH, crop sequences, etc. In the past, soil fumigation with methyl bromide (MB) was efficiently applied for controlling the soilborne inoculum, however as it is no longer permitted to use MB, other soil fumigants are being tested. Contaminated seed tubers which are the primary inoculum source, arrive through certified seed lots imported from Northern-Europe (mainly from Scotland). Therefore, the need for efficient seed tuber treatment in order to prevent the spread and establishment of the disease under local growth conditions is also of high priority.

The main objectives of the present study were to evaluate the efficacy of soil fumigation and seed treatments in controlling the disease. Soil fumigation treatments including Telopic (a mixture of 61% 1,3-dichloropropene and 35% chloropicrin) and matam sodium were evaluated in field experiments. In a field trial conducted in 2005, disease incidence on daughter tubers was reduced by 86% and 98% by Telopic (at 400 kg/ha) and MB (at 500 kg/ha), respectively. In a field trial conducted in 2007, disease incidence on daughter tubers was reduced by 71% and 94% by metam sodium (at 800 L/ha) and Telopic (at 500 kg/ha), respectively. Among different seed tuber treatments tested in field trials, only fluazinam (500ml/ton) and fludioxonil (200 ml/t) reduced the disease incidence on daughter tubers but to a limited extent.

## SOIL CHEMICAL TREATMENTS FOR THE CONTROL OF FUSARIUM WILT OF CARNATION IN SPAIN

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Intensively managed carnation systems in southwest Spain, one of the important production areas in Europe, are severely affected by Fusarium wilt (FW) caused by *F. oxysporum* f. sp. *dianthi* (Fod). To study the effectiveness of soil chemical disinfestation treatments in its control, two experiments were carried out during 2006-08 and 2008-09 in a naturally infested greenhouse planted with the susceptible carnation cv. Master. Na azide (65 ml.m<sup>-2</sup>), 1,3 dichloropropene (1,3-D)+chloropicrine (CP) (40+10 ml.m<sup>-2</sup>), and dimethyl disulphide DMDS+CP (30+10 ml.m<sup>-2</sup>) were applied in early August 2006 (Experiment 1). In early July 2008 (Experiment 2) the two former treatments and DMDS applied, combined or not with soil solarisation (SS), respectively at the rates of 53 and 80 ml.m<sup>-2</sup> were tested. An untreated control was included in both experiments.

In 2006, viability of Fod was nil at 30 cm depth in plots treated with DMDS+CP and low residual viability was observed at 15 cm depth, while it was much reduced with 1,3-D+CP at both depths. In 2008, both fumigants eradicated Fod at 15 cm depth, except DMDS applied without SS. In experiment 1, FW incidence reached 100% in the control plots 13 mo after planting whereas in the other treatments were under 20%. At the end of this experiment, 7 mo later, FW incidence ranged 14-44% for 1,3-D+CP and Na azide, respectively. Ten mo. were required in experiment 2 to reach 82% FW incidence in the control plots, whereas FW incidence was 58% in Na azide-treated plots and the rest of treatments were under 9%. This suggests a consistency in the efficacy of 1,3-D+CP and DMDS, but Na azide had a low efficacy. Total yields (number of stems.m<sup>-2</sup>) in experiment 1 were increased to 412% that of the control in 1,3-D+CP-treated plots, 248% for Na azide and 371% in the case of DMDS+CP treatment; yields in experiment 2 were 292% and 236% for the first two, and 283% for DMDS (53 ml.m<sup>-2</sup>) whereas, in DMDS (80 ml.m<sup>-2</sup>), it reached 333% that of the control. DMDS and 1,3-D+CP treated plots showed a significantly lower percentage of the lower commercial quality stems than the control, thus improving qualitative yield.

# EFFECTIVENESS OF FUMIGANTS ALONE AND IN COMBINATION WITH GRAFTING TO CONTROL VERTICILLIUM WILT AND ROOT-KNOT NEMATODES IN EGGPLANT AND TOMATO BROWN ROOT ROT CAUSED BY *COLLETOTRICHUM COCCODES*

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The use of chemical compounds and especially fumigants is still a safe eradicator method to control high infestation levels of soilborne pathogens, nematodes and weeds. The first set of trials have been carried in 2005-2006 out considering the problems related to reduced resistance of grafted eggplants against *Verticillium dahliae* and the partial results of available fumigants against *Verticillium dahliae* and *Meloidogyne incognita*. Dimethyl disulfide (DMDS) alone (30, 40, 60, 80 g a.i. m<sup>-2</sup>) and DMDS at 35, 30 and 20 g a.i. m<sup>-2</sup> in mixture respectively with chloropicrin at 5, 10 and 20 g a.i./m<sup>2</sup> were evaluated in comparison with chloropicrin alone at 20 g a.i. m<sup>-2</sup> and with the mixture of 1,3 D at 20 g a.i. m<sup>-2</sup> + chloropicrin (20 g a.i. m<sup>-2</sup>). The fumigants were applied under VIF film by drip irrigation (20 mm of water). One month after the treatments, eggplants (cv Prospera) were transplanted into the fumigated beds. The effectiveness of different treatments on the percentage of dead plants as a consequence of combined attacks of *Verticillium dahliae* and root-knot nematode was evaluated during the cropping season. In the presence of a very high infestation of soil by both parasites, the best results were provided by the mixture DMDS + chloropicrin respectively at 20+20 g a.i. m<sup>-2</sup> and 30 +10 g a.i. m<sup>-2</sup> also in terms of marketable eggplant fruit weight. The DMDS + chloropicrin mixture performed better than 1,3-D+CP probably for a lower activity of CP against *V. dahliae* when used at 20 g a.i. m<sup>-2</sup>. DMDS used alone showed a good activity only at high doses (80 g m<sup>-2</sup>). In the second set of trials, in an attempt to find effective control measures against *Colletotrichum coccodes*, an emerging pathogen causing root rot on tomato in northern Italy, four experimental trials were carried out during the years 2005 and 2006 in order to evaluate the effectiveness of the combination of different rootstocks ("Beaufort F1", "He Man F1", "Maxifort") with metham sodium, chloropicrin alone and combined with DMDS (20 + 20 g a.i. m<sup>-2</sup>) and DMDS at 20, 40 and 80 g a.i. m<sup>-2</sup>. In the presence of medium to high disease incidence, the best results were obtained by combining the use of a resistant tomato rootstock with soil fumigation with DMDS at 40 or 80 g a.i. m<sup>-2</sup> or metham sodium at 192 g a.i.m<sup>-2</sup>. Chloropicrin, applied at 20 g a.i.m<sup>-2</sup>, and the tested rootstocks alone, did not allow effective control of the pathogen.

## TOP APPLICATIONS OF FUNGICIDES FOR THE CONTROL OF MELON SUDDEN WILT CAUSED BY *MONOSPORASCUS CANNONBALLUS*.

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Sudden wilt (vine decline) of melon, caused by *Monosporascus cannonballus* is a world-wide problem in arid and semi-arid regions. Pre-planting soil disinfestations with methyl bromide was a common treatment for disease management, however, since this treatment is no longer allowed, alternative measures for disease control are needed. Fungicide application to the soil during the growing season is one such possible treatment. Of 13 fungicides evaluated *in vitro* for *M. cannonballus* suppression, seven were evaluated under field conditions. The fungicides azoxistrobin, prochloraz and pyraclostrobin+boscalid exhibited high and similar efficacy in controlling sudden wilt disease under field conditions. Fludioxonil applied at high rates was also effective but was phytotoxic. Fluaziman, the first fungicide found capable of suppressing sudden wilt and that has been used in Israel since the year 2000, was less effective. The results indicate that two applications of a fungicide throughout the short fall season should be sufficient for effective control of the disease. In the long spring season there is a need for at least three applications for protecting the melon crop throughout the growing season.

# ACCELERATED DEGRADATION OF METAM-SODIUM IN SOIL: ISOLATION AND CHARACTERIZATION OF THE INVOLVED MICROORGANISMS

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Accelerated degradation (AD) of methyl-isothiocyanate (MITC), the active ingredient of metam-sodium (MS), develops in soils following repeated application of MS. The present study was carried out under controlled environment conditions and in agricultural field. AD of MITC can also be induced in soils by incorporating non-history soil (non-degrading soil) with MS history soil (degrading soil). The objectives of the present study were to isolate and to characterize the soil microorganisms which are involved in AD of MITC. We developed a method to "extract" and concentrate the degrading organisms from the history soil. The liquid soil extraction contained microorganisms which can rapidly degrade MITC. Addition of formalin (1000 ppm) to the soil extract from history soil did not reduce AD of MITC. Two bacteria which rapidly degrade MITC were isolated from Rehovot history soil and were identified by DNA sequence and fatty acid profile analysis. Both isolates belong to the Oxalobacteraceae family and were identified as *Naxibacter* sp. Mixing bacteria culture with nonhistory soil resulted in AD in this soil. We also found rapid degradation of MITC in En Tamar soil (non-degrading soil) after its inoculation with one of the bacteria. By using molecular analysis, we found that the Oxalobacteraceae population was dominant in Rehovot soil, after the first application of MS. These results indicate that the signal for MITC degrading is induced in soil already after one application. However, the bacterial populations were not dominant, indicating that other populations may be also involved in degradation of MITC.

# CHEMICAL SOIL DISINFESTATION

## POSTERS

- Effect of soil fumigants on fungal communities in protected pepper crops in Southeast Spain - Maria Angeles Martínez M.A. Martínez, M.C.Martínez, J. Torres, C. Ros, M.M. Guerrero, A. Lacasa
- Efficacy of DMDS as a soil treatment against *Meloidogyne chitwoodii* in the Netherlands - Charles Patrick and Jan Jacque Heller
- Evaluation of DMDS as Soil Fumigant Application, Distribution and Pest control - A. Gamliel, Miriam Austerweil, Bracha Steiner, Yehodit Riven, Marina Benichis, Sagi Gal)
- Dissipation of fumigants in soils and its impact on the control of parasitic nematodes and weeds. R. allon, Miriam Austerweil, Bracha Steiner, Marina Beniches, Miri Grinner, B. Rubin and A. Gamliel

## EFFECT OF SOIL FUMIGANTS ON FUNGAL COMMUNITIES IN PROTECTED PEPPER CROPS IN SOUTHEAST SPAIN

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In Southeast Spain are located about 2,000 ha of pepper crops grown as a monoculture under greenhouse conditions. Soils have been usually disinfected with methyl bromide (MB) for over twenty five years until its banning in 2005. The reasons that have been justified the use of MB in this area were two overall: the reduction of the incidence of soil-borne pathogens (*Phytophthora capsici* and *Meloidogyne incognita*) and the effect of "soil fatigue". There are signs of a strong microbiological compound in the soil fatigue effect.

Assays were performed at one greenhouse where different alternatives to MB were studied: the combination of 1.3-dichloropropene+chloropicrin and Propylene Oxide. Both fumigants were compared with MB. Disinfestation effects were measured through the soil fungi density isolated before and after fumigation with two types of analyses to know the total fungal density and the fusaric one. In addition, soil samplings were made during the growing season in two greenhouses to complete the knowledge about fumigant effects.

Results showed that 1.3-Dic+Pic at 50g/m<sup>2</sup> was the only fumigant able to reduce significantly the total fungal density (from 8,470 UFC/g dry soil before soil fumigation to 2,500 UFC/g dry soil after soil fumigation) while both MB (from 9,000 UFC/g to 12,730 UFC/g) and Propylene Oxide at 600 l/ha (from 13,700 UFC/g to 14,770 UFC/g) were not able to do. In relation to the total fusaric density, MB did not reduce it either (from 394.30 UFC/g to 318.63 UFC/g) although 1.3-Dic+Pic (from 111.69 UFC/g to 1.80 UFC/g) and Propylene Oxide (from 983.61 UFC/g to 16.21 UFC/g) did it.

## EFFICACY OF DMDS AS A SOIL TREATMENT AGAINST *MELOIDOGYNE CHITWOODII* IN THE NETHERLANDS

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The root-knot nematode *Meloidogyne chitwoodi* is a quarantine nematode in the Netherlands which threatens seed potato production. At the moment on *M. chitwoodi* infested fields, seed potatoes cannot be grown because transportation of infested potatoes is strictly prohibited. Soil disinfection nowadays is restricted to the application of metam sodium once in five years. Other methods for soil disinfection are economically not feasible. Since 2001 a new product for soil disinfection was developed on the basis of dimethyl disulfide (DMDS). DMDS is a substance naturally present in some plants especially in *Alliums*. Preliminary results are encouraging from the point of efficacy against root-knot nematodes, root-lesion nematodes and cyst nematodes. In this situation DMDS could be an alternative to other soil disinfection methods for *Meloidogyne chitwoodi* control. The efficacy of the fumigant DMDS as a soil treatment against root-knot nematode *Meloidogyne chitwoodi* was tested in 2 field trials with potatoes in 2007 and 2008 with the collaboration of Wageningen University PPO-AGV P.O.Box 430, 8200 AK Lelystad The Netherlands (W. Runia & L. Molendjik). DMDS application rates were 200 l/ha, 200 l/ha under virtually impermeable film (VIF), 400 l/ha 600 l/ha, 800 l/ha and 1000 l/ha. Metam sodium (510 g active ingredient g/l) application rate was 300 l/ha. Application of both fumigants was by standard rotary spading injection. Soil samples for analysis on nematodes were collected in each plot on three dates, before application, three weeks after fumigation and at the end of the growing season, directly after potato harvest. To establish the quality of the potato tubers, out of each plot, tubers were selected randomly and assessed for the tuber symptom index. After DMDS applications with dosages of 600 l/ha or more potato quality was nearly perfect with an index next to zero. Fumigation of soil with DMDS against the root-knot nematode *Meloidogyne chitwoodi* resulted in a higher potato yield, a better potato quality and low nematodes counts after growing potato.

## EVALUATION OF DMDS AS SOIL FUMIGANT: APPLICATION, DISTRIBUTION AND CONTROL OF SOILBORNE PESTS

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DMDS has been developed and evaluated in France, Italy, Spain and USA as a viable alternative to methyl bromide for control of soilborne fungi and nematode species. The objectives of this study were to study the behavior of DMDS in the soils of Israel, explore the technology for its application, in order to develop an effective use of this fumigant for the agricultural industry in Israel. DMDS which is applied under plastic tarp in the field, dissipated from the soil after a period of 4-7 days depending on the applied rate. DMDS is highly toxic to *Meloidogyne javanica*. In contrast, the toxicity of DMDS to soil fungi varied among certain pathogens. *Fusarium* species appear to be the most sensitive among the tested fungi, *Macrophomina phaseolina* was highly tolerant to DMDS. When applied through the drip irrigation system, DMDS moves mainly along the water front. The lateral movement of DMDS, however, is limited resulting in decreased concentration away from the drip pipe. Thus, effective and uniform distribution of DMDS requires a spacing of 40 cm between the drip pipes. Similar results were obtained by injecting the fumigant to a depth of 20 cm using hand injectors.

DMDS permeates rapidly through a common LDPE film. In contrast, application of DMDS under impermeable film resulted in higher amounts of the fumigant in the soil, more uniform distribution in the soil profile, and extended retention period. Combination of solarization with DMDS yielded effective control of pathogenic fungi and nematodes at all tested soil depths. Such combination enabled reducing the rate of DMDS and shortening the solarization period (two weeks), with the same level of pest control.

## Dissipation of fumigants in soils and its impact on the control of parasitic nematodes and weeds

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The efficacy of fumigants in different soils is affected by dissipation rate and by the physical and chemical properties of the fumigant. Fumigant toxicity is a function of its concentration (C) and exposure time (T). The objectives of this study were to evaluate the dissipation rate of the fumigant 1,3-Dichloropropene (1,3-D) in different soils and to evaluate the relationship to the dissipation rate of Methyl isothiocyanate (MITC) and its impact on the control of root knot nematode, *Meloidogyne javanica*, and the parasitic weed, *Orobanche aegyptiaca*.

In a controlled system, 1,3-D undergoes degradation in the soil after 5-21 days. The dissipation curves of 1,3-D varied among agricultural soils following 1,3-D application, as determined by Solid Phase Microextraction in conjunction with gas chromatography. Viability of root knot nematode and germination of seeds of *Orobanche* were reduced by 90% and 60% in all soils, respectively, following application of 1,3-D. MITC dissipates after a shorter period (2-15 days). The toxicity of MITC towards the test organisms varied between the different soils. We did not find any relationship between the CxT products of 1,3-Dichloropropene (1,3-D) and of Methyl Isothiocyanate (MITC) following application of 1,3-D and metham sodium, respectively, in the tested soils.

Repeated application of 1,3-D in soils from 'Rehovot' and 'Beeri' resulted in shorter dissipation time; However there was no adverse effect on the loss in the control efficacy on *M. javanica*. In 'Beeri' and 'Saad' soils with two pretreatments of 1,3-D the control of *O. aegyptiaca* was reduced by 7% and 5%, respectively, following application of 1,3-D (not significantly different,  $P \leq 0.05$ ). Further studies are needed to explore the behavior of 1,3-D following repeated application.

## SESSION 3

# ASSESSMENT TOOLS FOR SOIL INFESTATION AND DISINFESTATION

## ORAL

- Assessing the spatial distribution of soil infestation by means of remote sensing and GIS as the "first-aid" for soil disinfestation - *Yafit Cohen (Israel)*
- Distribution and control of pod wart disease of peanuts as analyzed using spatial means – Caduri Harel, A. Gamliel, Y. Cohen
- Unraveling Soil Communities Using the CPN60 Genomic Marker and Pyrosequencing - G. Lazarovits, R. Ramarathnam, and S.M.Hemmingsen
- A knowledge based system to Predict Plot infestation with *Verticillium dahliae* in potato crop - Goldstein E. Cohen Y, Hetzroni A., Tsrur, L., Zig U., Lensky, I.
- Methods to monitor MITC for phytotoxicity and in the environment - Etienne Van Wambeke

Invited lecture

## ASSESSING THE SPATIAL DISTRIBUTION OF SOIL INFESTATION BY MEANS OF REMOTE SENSING AS THE "FIRST-AID" FOR SOIL DISINFESTATION

Yafit Cohen

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Remote and proximal sensing enables the acquisition of measurements of an object without physical contact between the measuring device and the object. Specific properties of soil and vegetation healthy or infected influence the radiation features and amount reflected and/or emitted from them. Application of this technology to soil infestation research is of great interest. Various state-of-the-art tools of remote and proximal sensing in different parts of the electromagnetic spectrum (Visible, near, mid, and thermal infra-red) will be presented and their possibilities in mapping soil and plants infected by soil-borne diseases. Studying the potential of proximal sensing tools in detecting soil-borne diseases will enable the routine of intensive sampling of soil and plants to map the spatial distribution of a disease. Integration of spatial distribution with disease development models will support site-specific soil-disinfestation to optimize its application in space. It can be also used to effectively select homogenous experimental sites for research. Various thermal sensing tools including ADF (auto-direction finder) small-robots mounted with thermal camera and GPS can be used for screening only healthy seedlings before their distribution for planting. Last but not least, there are few satellites which provide soil temperature and moisture in relatively high spatial and temporal resolution. These spatio-temporal data can be integrated in soil-borne disease development models for mapping areas under risk and better decision making.

## DISTRIBUTION AND CONTROL OF POD WART DISEASE OF PEANUTS AS ANALYZED USING SPATIAL MEANS

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Peanut pod wart which is caused by *Streptomyces scabies* reduces the quality of exported in-shell peanuts controlling the pathogen is done by preplant chemigation with formalin using the commercial irrigation systems (moving lines, sprinklers). In recent years there are evidence of increased incidence of pod wart in fumigated fields. The objectives of the current study was to examine possible the factors which affect the efficacy of pod wart control by fumigation with formalin. The main hypothesis was that separate analysis of each of the possible factors is not practical. Therefore, we chose to use the concept of "data mining" with the aid of a Geographical information system (GIS). With this approach we identified the possible factories which were to be analyzed in large field observation including Soil type, inoculum severity, fumigant application methods. During 2007-2004 forty commercial peanut fields representing the variables factors of agricultural practices and fumigation procedures were sampled. Sampling locations in each plot were incorporated into field's maps using GIS. In each field a non fumigated plot was left as a control to represents the potential of disease onset. Difference in pod wart incidence and severity was obtained among geographical regions and soil type. Sandy soils tends to have greater disease compared with clay soils. The major factor which dominated fumigation efficiency was the Irrigation system used for the chemigation. Moving irrigation lines were the most effective method compared with sprinklers which were inferior. Rototilling prior to formalin application further improved the fumigation effect. From these findings a model was developed to analyze the affect of each variable on the success of soil fumigation. The model is based on four components: disease severity at control, Application method, soil type, and soil preparation. The Model was validated in most fields. Data mining and GIS system can be useful tool disease distribution and factors for success or failure of soil treatments.

## UNRAVELING SOIL COMMUNITIES USING THE *CPN60* GENOMIC MARKER AND PYROSEQUENCING

G. Lazarovits<sup>1</sup>, R. Ramarathnam<sup>1</sup>, and S.M.Hemmingsen<sup>2</sup>

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Soil fumigation, a successful technology for managing populations of deleterious microorganisms, is known to also destroy beneficial microbial communities that can enhance plant growth and reduce disease incidence even when pathogens are present. As the use of fumigants continues to be curtailed due to negative human and environmental impacts, we need to develop a greater understanding of beneficial microbial communities and how agricultural practices affect their composition. The highly complex nature of the microbial communities in the rhizosphere has been a major limitation in trying to differentiate ecosystems where plant growth is enhanced versus one where the microbial community limits plant productivity. Attempts to describe microbial communities by either traditional microbiological or molecular methods have been limited in both scale and precision. The availability of genomic technologies offers an unprecedented opportunity to conduct more comprehensive characterizations of such communities. Hill et al. 2002, (Appl. Envir. Microbiol. 68:3055) described a novel technique for molecular diagnostics of complex microbial ecosystems using a method based on the chaperonin-60 sequence, in combination with high-throughput sequencing. The original process involved creating libraries of *cpn60* amplicons generated by PCR of DNA extracts and high throughput sequencing. About 1000-3000 cloned *cpn60* sequences could be analyzed. With pyrosequencing sequences from 20,000-50,000 PCR amplicons were obtained and no cloning was required. The taxonomic origins derived from the sequences ranged from unable to assign an identity, to placement at the genus level, and for some up to 100% DNA sequence identity with a species. However, the reference database at the moment is fairly small at about 7000 bacteria. Results will be presented from tests of this technology using DNA extracts of soil attached to potato roots, and roots washed free of soil. The data indicate that pyrosequencing will become a powerful tool for generating microbial fingerprints for the rhizosphere.

## A KNOWLEDGE-BASED SYSTEM TO PREDICT PLOT INFESTATION WITH *VERTICILLIUM DAHLIAE* IN POTATO

Goldstein E.<sup>1,2</sup>, Cohen Y.<sup>1</sup>, Hetzroni A.<sup>1</sup>, Tsrur, L.<sup>3</sup>, Zig U.<sup>4</sup>, Lensky, I.<sup>2</sup>

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Intensive production of field crops in the south-west part of Israel implements a meticulous crop rotation scheme to minimize the damage from polyphagous soil-borne pathogens. Plot allocation and scheduling requires the consideration of various factors such as infestation and susceptibility to soil-borne pathogens, soil characteristics, and many other parameters. The objective of this study was to develop a knowledge-based system (KBS) to predict plot infestation with *Verticillium dahliae* in potato. A comprehensive historical database was characterized and constructed. Biotic and abiotic factors affecting the manifestation of *V. dahliae* were selected by a panel of three researchers and a potato grower. These factors were weighed and ranked using multi-criteria pairwise comparison. The ranking were combined using geometric-mean to a new ranking matrix which was found to be acceptable. The combined result was then used for the multi-criteria mechanism of the KBS. The multi-criteria mechanism implemented a weighted linear combination. A disease development model of *V. dahliae* in potato cultivars of differing susceptibility was proposed by one of the experts and was used to calibrate the KBS. The model was based on a hypothetical situation of growing potatoes consecutively on a disease free plot. Twenty-two plot records collected between 1998 and 2007 from an agricultural area in the south-west part of Israel and 23 records from studies conducted in Israel and in Idaho, USA were used for initial validation of the KBS. The KBS obtained more than 90% prediction accuracy with 0.91 Kappa coefficient and spearman correlation coefficient of 0.71. Based on the developed KBS a decision-support system (DSS) was then developed for crop allocation by ranking fields according to the predicted infection with *V. dahliae*.

# METHODS TO MONITOR MITC FOR PHYTOTOXICITY AND IN THE ENVIRONMENT

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Soil fumigation with the methyl isothiocyanate (MITC) generators metam-sodium, metam-potassium and dazomet gives rise to residual gasses that need to be checked prior to sowing or planting. Different factors determine the residual amount: dose rate, soil type, organic matter content, soil humidity, soil temperature, soil porosity and tarping.

Under practical conditions this safety check is made after soil tarp removal or, if not covered by plastic film, prior to soil aeration e.g. by rotovation. Forced aeration is often standard practice and will speed up the removal of potential phytotoxic gasses. MITC monitoring will help to decide on the necessity of forced aeration or even repetition of it.

Classic test for phytotoxic risk evaluation only is the cress seed germination test. Alternative seeds, such as lettuce, are also in use. This is the slowest method, needing at least 2 days.

Another possibility of monitoring is the use of specific gas detection tubes giving sensitive response within 3 minutes and especially of interest in the fumigated environment, e.g. operator and bystander exposure or risk for neighbouring residents. A hand held pump is needed and the tubes are consumables.

A specific measuring principle is by quartz micro balance (QMB). This is also known as the 'electronic nose' and was beyond other applications also developed for MITC. The instrument can become operated in the field with a car power adaptor. The whole procedure takes 45 minutes.

Photo ionization detection is possible with hand held instruments. It is not very specific but among MITC and other volatile and active degradation compounds majority of the instrument response is for MITC with a 10.6 eV lamp. It is also very useful for environmental monitoring. Measuring and response time is a few seconds.

Other possibilities need to become explored or are under consideration, e.g. infrared analyzer allowing specific detection.

## SESSION 4

# INTEGRATED CONTROL

## ORAL

- invited lecture: Biological control of plant-parasitic nematodes: from fantasy to reality - *Yitzhak Spiegel (Israel)*
- Evaluation of some pre-plant soil treatments and chemical disinfectants for control of Fusarium wilt diseases in cut flowers - T.M. O'Neill and K.R. Green
- TrichoNema: a *Trichoderma*-based project to develop a commercial biocontrol agent product against phytonematodes - E. Sharon, M. Mor, M. Bar-Eyal, Y. Oka, S. Van Kerckhove, A. Vanachter, I. Chet and Y. Spiegel

Invited lecture

## BIOLOGICAL CONTROL OF PLANT-PARASITIC NEMATODES: FROM FANTASY TO REALITY

Y. Spiegel

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The research and development in biological control has been faced a new era, probably as an outcome of several progressions : 1. The inconsistent results, especially under field conditions, led to the acquaintance that an intensive understanding of the interaction mechanism(s) between the parasite and the microorganism, and even the more complicated multitrophic interactions between plant, parasite and the microorganism , will result in an improvement of the biocontrol agent and perhaps will help with a better understanding of the interaction mechanism(s) between microorganisms, in general. 2. The new tools equipped by the researchers in the research Institutes. 3. The acquaintance to environmental issues that brought research groups from other disciplines to deal with the topic in 'ecological' perspectives. 4. The constrains forced upon the industry following the restrictions in the registration process of biological control agents. Examples of the understanding of biocontrol mode-of-action using morphological, biochemical, molecular, genomic and metabolomic tools, will be presented.

# EVALUATION OF SOME PRE-PLANT SOIL TREATMENTS AND CHEMICAL DISINFECTANTS FOR CONTROL OF FUSARIUM WILT DISEASES IN PROTECTED CUT FLOWERS

T.M. O'Neill and K.R. Green

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In the UK fusarium wilt diseases have recently caused significant losses in cut flower crops of stock (*Matthiola incana*) and lisianthus (*Eustoma grandiflorum*) grown intensively in the soil in greenhouses. A series of experiments was done to evaluate some pre-plant treatments for disinfecting soil and some chemicals for disinfecting surfaces against *F. oxysporum*.

The effect of pre-plant soil treatments on survival of *F. oxysporum* was investigated on commercial nurseries in Eastern England. Nylon bags containing naturally infected stem and root pieces of stock or lisianthus, mixed with moist sand, were buried at various depths in the soil. After treatment, plant tissues were recovered, surface sterilised and plated onto agar to determine viability of the fungus. Significant reductions in the incidence of tissue pieces with viable *Fusarium* sp. were achieved by sheet-steaming (soil above 80°C for 10 h), a steam plough (soil above 80°C for 1 h), chloropicrin (K&S Chlorofume at 20 mL/m<sup>2</sup>), dazomet (Basamid at 76 g/m<sup>2</sup>), formaldehyde (Formalin at 0.5 L/m<sup>2</sup>) and metam-sodium (Discovery 510 at 90 mL/m<sup>2</sup>); calcium cyanamide (Perika Microgran at 100 g/m<sup>2</sup>) was ineffective. None of the treatments was fully effective under the conditions of these tests. Negative pressure steaming was more efficient than conventional sheet steaming in raising soil temperature.

Six disinfectant products all prevented growth of *F. oxysporum* when used at their recommended rate for as little as 5 minutes to treat a spore suspension in water. Only two products reduced growth of *F. oxysporum* when used to treat mycelium of the fungus grown in filter paper discs.

Effective management of fusarium wilt diseases of cut flowers grown in greenhouses is unlikely to be achieved by soil and substrate disinfection alone; the use of high health planting material (seed and plug plants), good nursery hygiene, manipulation of crop culture and fungicide treatments should all be considered within an integrated management strategy.

## TRICHONEMA: A *TRICHODERMA*-BASED PROJECT TO DEVELOP A COMMERCIAL BIO-AGENT PRODUCT AGAINST PHYTO-NEMATODES

E. Sharon<sup>1</sup>, M. Mor<sup>1</sup>, M. Bar-Eyal<sup>1</sup>, Y. Oka<sup>2</sup>, S. Van Kerckhove<sup>3</sup>, A. Vanachter<sup>3</sup>, I. Chet<sup>4</sup> and Y. Spiegel<sup>1</sup>

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In the frame of the TrichoNema (EU, Marie Curie) project, several *Trichoderma* species and isolates have been tested against plant-parasitic nematodes. The main targets are the root-knot nematodes *Meloidogyne incognita* and *M. javanica*, which are polyphagous sedentary-endoparasitic species, damaging worldwide. Biocontrol pot experiments are conducted mainly with *T. hamatum*-382 and a *T. asperellum* isolate, in nematode-inoculated sandy soil and potting-mixes, with vegetable and ornamental hosts, respectively. This report will focused on ornamental plants. Following screening of several hosts for their nematode sensitivity and growth enhancement by the fungi, *Begonia* and *Impatiens* have been chosen as the main model ornamental hosts. *Trichoderma* peat-wheat bran (fresh or dry) preparations were applied into the potting-mixes pre-planting, with or without pre-colonization of seedlings with the fungi. *Trichoderma* treatments reduced root galling and nematode reproduction, and plants growth was improved; treatments of seedlings usually enhanced the biocontrol activity. The *Trichoderma* preparations were applied also to soils naturally-infested with other polypagous plant-parasitic nematodes: *Pratylenchus penetrans* (migratory endo-parasite), *Rotylenchus robustus* (ecto-parasite) and *Paratylenchus projectus* (ecto-parasite), planted with lettuce. *Trichoderma* treatments reduced the populations of the parasitic nematodes in soils from the pot experiments. Both *Trichoderma* species showed the ability to control several plant-parasitic nematodes. Fungal formulations are further tested with various application approaches, in order to define the most efficient methods for implementation of the biocontrol agents. Modes of action of these species are studied, aiming to improve their activity against plant-parasitic nematodes.

# integrated control

## POSTERS

- The physiological sudden collapse of grafted melon as a result of a not appropriate growing procedure - A. Minuto, G. Causarano, C. Bruzzone, G. La Lota, S. Longombardo, G. Minuto,
- Evaluation of Steam, Biofumigants, and Fungicides for Strawberry Production in Field Soils - S. Fennimore, J. Weber, J. Samtani, and C. Gilbert
- A comparison of four pre-plant soil treatments for control of Verticillium wilt in field-grown trees - T.M. O'Neill, T. Locke and C.J. Dyer
- Chemical and biological alternatives for soil disinfestation in strawberry production - M. Thoelen, F. Meurrens, K. Stevens, J. Kellers, J. Coosemans and S. Clemens
- Soil-born diseases/pest control research in Lithuania - Sonata Kazlauskaitė, Elena Survilienė, Aurelija Saluchaitė

## THE PHYSIOLOGICAL SUDDEN COLLAPSE OF GRAFTED MELON AS A RESULT OF A NOT APPROPRIATE GROWING PROCEDURE

A. Minuto<sup>1</sup>, G. Causarano<sup>2</sup>, C. Bruzzone<sup>1</sup>, G. La Lota<sup>2</sup>, S. Longombardo<sup>2</sup>, G. Minuto<sup>1</sup>,

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Melon (*Cucumis melo*) production is a significant component of the vegetable industry in Italy. Methyl bromide has been the widest used pre-plant soil fumigant for controlling soilborne diseases of crops such melons. Grafting melons onto vigorous, disease-resistant rootstocks is an alternative to soil fumigation providing resistance/tolerance against soilborne diseases and tolerance to heat/cold/saline stress. In Italy melons are usually grafted onto *Cucurbita* spp. (Shintosa, RS841, ...) as well as *Cucumis melo* (Dinero, ...) rootstocks depending from the season, the growing area and the disease pressure. Earliest melon production (late March – beginning April) are obtained in Sicily (Southeast coast). Since 2006 sudden and heavy melon collapses were observed, particularly in Agrigento costal area. Several samples were yearly brought to the laboratory in order to identify possible biotic causal agents. Strains of *Fusarium* sp., *Rhizoctonia* sp., and *Pythium* sp. were repeatedly isolated but none of them was able to reproduce the symptoms observed in the field. At the beginning of 2008 a field survey was organized and aimed at clarifying the common growing procedure adopted in the area where the collapses were more severe. Thus the same year three experimental tests were organized in order to clarify the relationships between the growing procedure commonly adopted and the melon collapses. Data did not showed any correlation between the grafting procedures and the collapse incidence, while consistent correlation were observed both between the scion/rootstock combination, the use of exogenous auxins and the collapse incidence. "Fiola" grafted onto "Shintosa" was the most sensitive scion/rootstock combination and the collapse was particularly severe when the use of the mixture of naphthaleneacetic acid (NAA), 2-naphthyloxy-acetic acid (BNOA) and 2-(1-naphtyl) acetamide (NAD) was applied both by foliar spray and drip irrigation, particularly under hot climate conditions. The data are in accordance with other studies carried out in Israel and this paper describes the growing procedures able to enhance the collapse of grafted melons under commercial field conditions.

## EVALUATION OF STEAM, BIOFUMIGANTS, AND FUNGICIDES FOR STRAWBERRY PRODUCTION IN FIELD SOILS

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In the USA, and California specifically, fumigant regulations are the main force in preventing the complete transition from methyl bromide (MB) to alternative fumigants rather than technical limitations of the alternative fumigants themselves. Alternative fumigants such as 1,3-dichloropropene (1,3-D) and chloropicrin are being used on about half of the California strawberry hectareage. However, annual 1,3-D use limits of 40.9 t per 93.2 km<sup>2</sup> prevent a more complete replacement of MB with 1,3-D plus chloropicrin. To avoid regulatory constraints and public resistance to all fumigant use, we have concluded that production systems must be developed that do not use fumigants. Therefore, we have undertaken research to identify effective treatments to produce California strawberry that do not use fumigants. Trials were conducted during 2007 and 2008 to evaluate several heat (steam), fungicide and biofumigant treatments for control of soil pests and strawberry fruit yield compared to methyl bromide plus chloropicrin (MBPic). Field studies were conducted near Salinas and Watsonville, California, USA. The treatments included: steam, mefenoxam + fludioxanil 3 times per season at 560 + 560 g ha<sup>-1</sup>, furfural at 672 kg ha<sup>-1</sup>, mustard seed meal at 2240 kg ha<sup>-1</sup>, and MBPic 392 kg ha<sup>-1</sup>. Weed densities and fruit yields were monitored throughout the season. Treatments which controlled weeds were steam, and MBPic. Furfural effectively controlled weeds at Salinas, but not at Watsonville. The reason for this furfural inconsistency is unknown. Treatments with strawberry fruit yields similar to MBPic were steam, mustard seed meal and furfural. With the exception of steam, we conclude that treatments such as mustard seed meal or furfural will require use in combination with an herbicide such as oxyfluorfen to control both soilborne diseases and weeds.

# A COMPARISON OF FOUR PRE-PLANT SOIL TREATMENTS FOR CONTROL OF VERTICILLIUM WILT IN FIELD-GROWN TREES

T.M. O'Neill, T. Locke and C.J. Dyer

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Verticillium wilt is a serious disease of several high-value ornamental tree species grown as field crops. The causal fungus *Verticillium dahliae* is widespread in UK soils. Until 2006, land was generally treated with methyl bromide before planting species susceptible to verticillium wilt in order to reduce risk of the disease. A field experiment was done to determine effectiveness of four potential alternative pre-plant soil treatments for control of verticillium wilt in *Acer platanoides* and *Tilia cordata*.

The experiment was established in 2005 on land naturally infested with *V. dahliae* at a mean level of 15 cfu/g, as determined by a soil-plating test. Pre-plant soil treatments were: 1. Untreated fallow; 2. Sudan grass grown on site and incorporated as a green manure; 3. Biological Soil Disinfestation (BSD) using Italian rye-grass; 4. Chlorofume (chloropicrin) injected to 35 cm depth; 5. Basamid (dazomet) incorporated to 20 cm depth applied simultaneously with Sistan 51 (metam sodium) injected at 25-35 cm depth. In spring 2006, the land was planted with two verticillium susceptible species, *A. platanoides* 'Emerald Queen' and *T. cordata* 'Greenspire'.

Basamid/Sistan 51, Chlorofume and BSD significantly reduced levels of *V. dahliae* in the soil to <1, 3 and 10 cfu/g respectively; sudan grass was ineffective. Bark cracking in *Acer* first occurred in 2007, the second growing season after planting. This symptom of verticillium wilt was significantly reduced by Chlorofume (8%) and Basamid/Sistan (6%) soil treatments compared with the untreated control (22%). No definitive symptoms of verticillium wilt occurred in *Tilia* at this time.

In autumn 2007, one-third of the trees were cut down and the stem bases tested for *V. dahliae* by isolation onto agar. The fungus was recovered from 35% of *Acer* and 18% *Tilia* trees on untreated land. The incidence of infection in *Acer* was significantly reduced by Chlorofume (16%) and Basamid/Sistan (17%); the incidence of infection in *Tilia* was reduced by the two chemical treatments (nil infection) and BSD (9%). Levels of infection in *Tilia* were greater in 2008 than in 2007, with some diseased trees in all treatments. The incidence of tree infection is discussed in relation to the level of soil infestation with *V. dahliae* at planting.

## CHEMICAL AND BIOLOGICAL ALTERNATIVES FOR SOIL DISINFESTATION IN STRAWBERRY PRODUCTION

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Chemical soil disinfestation in strawberry production is a common method that is used successfully to control harmful nematodes and soil-borne fungi. For some of the chemicals used, there is no long-term prospective and their use will probably be forbidden in the future. Applied research in chemical alternatives for these compounds tries to meet both the economical and the social-ecological impact of this strawberry cropping measure. A biological approach of soil disinfestation could be a suitable alternative or replenishment of chemical methods. Biofumigation is based on the biocide effect of compounds that are set free during the degradation of species such as the *Brassicaceae* family, when they are incorporated as amendments to the soil. Besides the suppression of various soil-borne diseases, biofumigation will also improve soil structure and soil microbial activity.

Different chemical soil disinfestation methods s.a. 1,3-dichlorepropene, metam sodium, chloropicrin and sulphur- or iodine-containing compounds were compared with some biological alternatives. Biofumigation was carried out with leaves and/or roots of broccoli (*Brassica oleracea*) and cauliflower (*Brassica oleracea*). Also a commercially available concentrated mustard extract was tested.

The results showed a higher production level after chemical soil disinfection in comparison to biological alternatives. The highest production level was obtained with the combination of two chemical products (metam sodium and the sulphur component; chloropicrin and 1,3-dichlorepropene). Chemical disinfection showed also better results against *Verticillium* wilt (caused by *Verticillium sp.*). On the other hand, biofumigation showed less infection of *Phytophthora cactorum*. Harmful nematodes (e.g. *Pratylenchus penetrans*) were only successfully suppressed with a 1,3-dichlorepropene treatment.

Although, not yet as effective as chemical soil disinfection, biological alternatives may have a promising future on strawberry fields.

## SOIL-BORN DISEASES/PEST CONTROL RESEARCH IN LITHUANIA

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Different problems in integrated pest management including soil-born diseases are investigated at several institutions in the Republic of Lithuania. With reference to scientific publications regarding to soil-born diseases the most important or prevalent pathogens in Lithuanian soils recognized fungi belonging to genera *Alternaria*, *Aspergillus*, *Cladosporium*, *Fusarium*, *Mucor*, *Penicillium*, *Pythium*, *Rhizoctonia*, *Verticillium*. Sugar-beet cyst nematode *Heterodera schachtii* was the most common among plant parasitic nematodes.

Various pest management strategies against soil-born diseases were investigated. Assay of resistance/susceptibility to the pathogens of different cultivars of plants takes an important part. Several studies on chemical and non-chemical treatment of substrates, seeds were carried out as well. Most of publications present results of research on chemical plant protection products efficiency. Conditions for biological control are limited in Lithuanian Agriculture. Nevertheless, some research is pursued especially concerning greenhouse plants pest management.

The main objective of this study is to review the most important soil-born pathogens their incidence and current pest management measures in the country.

## SESSION 5

# PHYSICAL METHODS OF SOIL DISINFESTATION AND SOLARIZATION

## ORAL

Invited lecture: Physical methods for soil disinfestation in intensive agriculture:  
Old methods and new approaches - W.T. Runia, L.P.G. Molendijk

Combining Effects of Soil Solarization and Grafting on Plant Yield and soilborne  
pathogens in cucumber - S. Yilmaz and İ. Çelik

Nitrate leaching after organic amendment under soil solarization in two different  
soils and its effects on yield and health of escarole and pepper - Vicent Cebolla,  
Josep Roselló, Carlos Ramos, Fernando Pomares

The Effect of Pre-wetting on Thermal Inactivation of Soilborne Pathogens in  
Connection with Structural Solarization of Greenhouses - E. Shlevin<sup>1</sup>, P. Di-  
Primo<sup>2</sup>, and J. Katan<sup>3</sup>

Perspectives of anaerobic soil disinfestation - J. Lamers, W.T. Runia, L.P. G.  
Molendijk, P. O. Bleeker

Invited lecture

## PHYSICAL METHODS FOR SOIL DISINFESTATION IN INTENSIVE AGRICULTURE: OLD METHODS AND NEW APPROACHES

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Physical soil disinfestation is worldwide mainly applied in protected cropping systems or in small-scale intensive field crops. Continuous cropping of monocultures or different host plants for the same pest or pathogen often leads to heavily infested soils which forces growers to disinfest the soil thoroughly.

The oldest method is steam sterilization which is applied for more than a century. Sheet steaming is most common; steam is applied under a sheet and left to penetrate the soil. Another more active method is negative pressure steaming with perforated tubes buried in the soil which suck air out of the soil and thus drawing steam downwards.

In the nineteen seventies hot water treatment of soils was developed in Japan. Hot water is applied to the soil surface to raise soil temperatures to lethal levels. In flat fields a dragging system with hot water sprayer is used and in more hilly fields heat resistant tubes distribute hot water.

Since the nineteen eighties inundation became a new method in the Netherlands and is applied in bulb cultures. This so-called flooding of soils is based on anaerobic soil conditions in which qualitative and quantitative microbial changes take place.

A new approach in soil disinfestation in the current century is hot air treatment which is developed in Israel. The method is based on blowing extremely hot air into soil particles which are thrown above soil surface into a heat chamber by a rotary spading device.

New developments in the Netherlands are radiation of soil with radio waves or micro waves. Radiation of soil has been studied for decades. The mechanism is that the heat produced by radiation is lethal to pathogens and pests.

Anaerobic soil disinfestation (ASD) with incorporation of fresh organic matter in soil is a method developed in the Netherlands. A new and promising Dutch development in ASD is the application of defined vegetable rest products. The mechanism of ASD will be studied in the next years by Wageningen University & Research by measuring oxygen and other gases, fatty acids and microbial shifts in relation to efficacy.

Advantages and disadvantages of all methods will be presented in this contribution.

## COMBINING EFFECTS OF SOIL SOLARIZATION AND GRAFTING ON PLANT YIELD AND SOIL-BORNE PATHOGENS IN CUCUMBER

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A trial was conducted in a greenhouse of Bati Akdeniz Agricultural Research Institute located in Antalya in 2008 fall season as term production. Combining effects of soil solarization and grafting on soil-borne pathogens, plant height and yield in cucumber were compared. The experiment was set in split plot design containing; 1 month summer solarization, 2 months summer solarization, 4 months whole season solarization, 5 months whole season solarization and non-solarized control plots on which grafted Maximus F1+ Bergama F1 and non-grafted Bergama F1 were grown.

Almost all of plants grown in non-solarized plots were infected with root-knot nematodes with severe root damages; however, only a few plants were affected by this nematode in 4 and 5 months solarized plots with very slight root galls. No resistance to root-knot nematodes was observed in both grafted and non-grafted plants. More than half of the plants grown on non-solarized control plots were infected with *Fusarium oxysporum* f. sp. *cucumerinum* with relatively slight disease symptoms. Higher plant growth and yields were observed on the plants grown on whole season solarized plots than the plants grown on non-solarized control plots. Grafted plants had relatively more plant heights and yields than non-grafted plants. Higher soil temperature during growing season might be effective to have more plant heights and yields in whole season solarized plots. In conclusion; whole season solarization provided very satisfactory results compared to non-solarized control.

## NITRATE LEACHING AFTER ORGANIC AMENDMENT UNDER SOIL SOLARIZATION IN TWO DIFFERENT SOILS AND ITS EFFECTS ON YIELD AND HEALTH OF ESCAROLE AND PEPPER.

Vicent Cebolla, Josep Roselló, Carlos Ramos, Fernando Pomares

IVIA. Valencia. Spain

The use of high dosages of manure before solarization is an increasingly accepted practice by Spanish pepper and vegetable growers. Nevertheless the EU directive 91/676/CEE establishes a limit of 170 kg N/ha of nitrogen content for every organic amendment, according to the analytical data, to avoid nitrate leaching. This directive does not distinguish among different kind of soils, nor climates.

In order to study the possible increase in nitrate leaching due to solarization combined with manure, we have performed an experiment since 2003 to 2008 (still in progress) under a greenhouse with loamy-clay soil and a tunnel with loamy sand soil at the IVIA Experimental Station of Carcaixent (Valencia, Spain). Annually, the amounts equivalent to 0, 170 and 340 kg N/ha of manure was incorporated before solarization since 1st August to mid September.

The statistical design was done with three replicates randomly distributed in blocs.

Soil temperatures were monitored during solarization at 10 and 20 cm depth. Fungicidal effect was determined by biological probes containing infested roots at 10, 20 and 30 cm depth. On 1<sup>st</sup> October was planted an escarole crop, until end December or beginning of January, followed by a pepper crop up to mid July.

As the nitrate content in irrigation water was high (about 200 ppm) and soil was reach on P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O no mineral fertilizers were added at all along this period. In order to reduce the nitrates in irrigation water, when available, the crop was irrigated with rain water.

*Sclerotinia sclerotiorum* was isolated every year from escaroles and *Meloidogyne incognita* from pepper after three repeated crops.

In loamy sand soil the best healthy escaroles were frequently got on the treatment with 340 kg/ha of N.

Generally there are not yield differences on pepper yield except on the 2008 when pepper plats suffered an attack by *Meloidogyne incognita* with a significant reduction of yield in check plots in loamy sand soil. Treatment check, without manure, did not control *Meloidogyne* on pepper crop in loamy sand soil, while higher rates of manure reduced gall number in roots.

There was not a clear difference in NO<sub>3</sub>-N content in soil (0-60 cm) throughout the experiment between treatments. However, soil nitrate levels in the loamy sand soil were much lower than in the loamy clay soil.

No cumulative effects of treatments on soil nitrate levels in the 0-60 cm layer were apparent after 5 years, with a total N application of 340 kg/ha/year in the highest N rate treatment. Irrigation water added to the soil about 280 kg/N/ha/year.

## THE EFFECT OF PRE-WETTING ON THERMAL INACTIVATION OF SOILBORNE PATHOGENS IN CONNECTION WITH STRUCTURAL SOLARIZATION OF GREENHOUSES

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Structural solarization of the greenhouse, which is a complementary disinfestation approach for sanitation of the greenhouse structure, involves dry heating to 60°C and higher at a consequent low relative humidity (ca. 15%). Dry heating is less effective than wet heating in thermal inactivation of organisms. Attempts to increase inoculum moisture during the hot hours of the day resulted in less effective pathogen control by structural solarization, due to inoculum cooling. This result led us to investigate the process of pre-wetting of inoculum prior to heating process, in order to study its effect on thermal inactivation of soilborne pathogens. Two types of propagules were tested: 1) sclerotia of *Sclerotium rolfsii* and macroconidia of *Fusarium oxysporum* f.spp. *radicis-lycopersici*, *lycopersici* and *basilici*. The above represents multicellular propagules. 2) chlamydospores of *F. oxysporum* f.sp. *radicis-lycopersici* and *F. oxysporum* f.sp. *melonis* representing unicellular propagules. The inocula were exposed to various durations of pre-wetting and matric potentials of wetted soil. We found that pre-wetting treatments reduced significantly the heat sensitivity of the multicellular propagules and the converse (increased heat sensitivity) was observed in the unicellular ones. Treating sclerotia of *S. rolfsii* with cycloheximide, which suppresses protein biosynthesis, increased significantly heat sensitivity. This indicates the possible involvement of metabolic process during exposure of *S. rolfsii* sclerotia to pre-wetting. Scanning electron microscope (SEM) observations revealed cracks in the rind of heated *S. rolfsii* sclerotia, whereas untreated sclerotia appeared smooth and with fewer cracks. Pre-wetting treatments reduced significantly the number of cracks on heated sclerotia. It has been shown that cracked sclerotia are more easily invaded by soil organisms. Heated macroconidia of *F. oxysporum* f.sp. *basilici* showed distortion, while pre-wetted ones had no damage. Thus, revealing the effects of various moisture regimes on pathogen control, can provide tools for improving structural solarization.

## PERSPECTIVES OF ANAEROBIC SOIL DISINFESTATION

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Biological soil disinfestation is an environmentally friendly method to disinfest the soil. From now on we refer to it as anaerobic soil disinfestation (ASD). With ASD a green manure crop (40 tonnes per ha) is homogeneously incorporated into the topsoil. Then the field is lightly compacted and irrigated. Subsequently the field is mechanically covered with air tight plastic film (VIF) to restrict oxygen supply to the topsoil. The soil is left covered for 6 weeks in the summer. In this period anaerobic conditions develop rapidly and a redox potential of - 200 mV is established in which toxic fermentation products are formed. These conditions are responsible for elimination of fungal and bacterial pathogens as well as parasitic nematodes, insects and weeds. With ASD a high level of inactivation is achieved and moreover soil resistance against diseases remains intact. For this reason soilborne pathogens do not recolonize rapidly. In the Netherlands since 2004 anaerobic soil disinfestation (ASD) was applied on approximately 70 ha mainly for asparagus and strawberry runners production. When the asparagus crop was replanted ASD proved to be profitable for many years by control of *Fusarium oxysporum*. Although highly effective against soilborne pathogens and pests ASD is not applied widely in the Netherlands due to the high costs of about € 4000 per ha. Apart from the costs this technique needs special attention to overcome problems with the thin VIF and gluing of the plastic. Moreover the mechanism behind ASD is not well defined which makes it difficult to explain any disappointing efficacy. A new and promising development in ASD is the application of defined, standardized vegetable products on a basis of mixtures of carbon hydrates and proteins. The mechanism of ASD will be studied in the next few years with some of these products by measuring gases and fatty acids. Chemical soil disinfestation with fumigants is restricted more and more and a non-chemical approach of soil disinfestation like ASD is urgently needed.

# PHYSICAL METHODS OF SOIL DISINFESTATION AND SOLARIZATION

## POSTERS

- Soil Solarization as Alternative to Methyl Bromide for the Control of Protected Vegetable Soil Borne Pathogens in Morocco - Mohamed Besri

# SOIL SOLARIZATION AS ALTERNATIVE TO METHYL BROMIDE FOR THE CONTROL OF PROTECTED VEGETABLE SOIL BORNE PATHOGENS IN MOROCCO

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The attitude that Methyl Bromide is the universal panacea to control soil-borne pathogens, nematodes, bacteria and weeds is still prevailing among many protected vegetables growers producing mainly for export. The soil disinfestation cost with Methyl Bromide is very low and represents only 2.03 % of the total tomato cost production. The low part of the fumigant in the total investment and also its high efficacy to control soil borne pathogens explain why it is very popular and is widely used in vegetables covered cultivation. In addition, preplant application of the fumigant permits the soil to be replanted within a short waiting period, vegetable growers having only one to two months to prepare the next crop. Only the plant rows are fumigated. Tarps are then used as mulch for the plant and are removed only at the end of the season.

Because of the European increasing demand for non chemical treated products and the awareness of the vegetables growers on the risk of Methyl Bromide for the ozone layer, the use of Methyl Bromide is decreasing. It has been completely phased out from tomato production but is still used on many other vegetables crops such as cucurbits, beans, eggplant and peppers. Various non chemical and chemical alternatives are adopted. In the Moroccan conditions, solarisation alone or combined with some chemicals has proved to control most of the vegetables soil borne pathogens, except some weeds and nematodes. In the plastic house conditions, certain weeds e.g. *Digitaria debilis*, *Eleusine indica*, *Hordeum sp.*, *Setaria verticillata*, *Cyperus sp.*, *Heliotropium europaeum*, *Chenopodium album*, *Convolvulus arvensis*, *Portulaca olearacea* develop in the mulched plots. Some of these weeds are attacked by root-knot nematodes (*Meloidogyne* spp.). Consequently, the weeds could multiply the nematode populations in the soil even in the absence of vegetable. Therefore, it is recommended to combine solarisation with other alternatives such as herbicides and nematicides.

In some Moroccan regions, all the vegetables grown under green-house conditions are attacked and severely damaged by the broomrape *Orobanche ramosa*. Methyl bromide is widely used in Morocco and in many other countries to control this holoparasite. The other control methods e.g. resistant varieties, plant grafting, crop rotation did not control this pathogen. Solarisation has proved to control the broomrape under plastic tunnels conditions. On Melon for example, three months after planting, 100 % of the plants in the non solarized plots were attacked by the broomrape and only 7 % in the solarized ones. The number of broomrape inflorescences is 12 times higher in the non solarized plots than in the solarized ones. Soil solarization increases also significantly the Melon yield. Most of the melon plants in the non solarized plots died 4 weeks before the plants grown in the solarized plots.

# SESSION 6

## ORGANIC AMENDMENTS

### ORAL

Effect of Biofumigation with *Brassica* Cover Crops on Weed Populations, Soil microbial Activity, and Fruit Rot in Pickling Cucumber Production - Mathieu. Ngouajio and J. W. Counts

Green manures and organic amendments to control corky root of tomato - V. Michel and L. Lazzeri

Effect of *Brassica* green manure and *Brassica* pellets in combination with grafting and soil solarization against *Verticillium* wilt of eggplant and *Fusarium* wilt of lettuce and basil - A. Garibaldi, G. Gilardi, L. Lazzeri, L. Malaguti, F. Clematis, A. Minuto and M.L.Gullino

Use of pelleted medicago sativa meal for the control of root-knot and cyst nematodes - T. D'Addabbo, P. Avato, V. Radicci and A. Tava

Kakawate (*Gliricidia sepium*) as a Soil Amendment and Biological Control of Soil-borne Pathogens: The Philippines Experience Gina Pangga

Combined Effects of Bio control Agent and Residues on Root Rot Mortality in Indian Mesquite (*Prosopis cineraria*) - Satish Lodha and L.N. Harsh

Additional benefits to the efficacy in containing soilborne pest and pathogens of biofumigant plant and materials - Luca Lazzeri, Onofrio Leoni, , Lorena Malaguti, Lorenzo D'Avino

Mycofumigation using *Muscodor albus* for control of soilborne plant pathogens - B. Jacobsen, Grimme E. and Strobel, G

Induced soil suppressiveness to root diseases by herb amendments and solarization E. Klein, J. Katan, and A. Gamliel

Plant metabolites derived from *brassica* spp. Tissues as biofumigant to control soil borne fungi pathogens- E. Romero, C. Barrau and F. Romero

# EFFECT OF BIOFUMIGATION WITH BRASSICA COVER CROPS ON WEED POPULATIONS, SOIL MICROBIAL ACTIVITY, AND FRUIT ROT IN PICKLING CUCUMBER PRODUCTION

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Use of brassica cover crops for biofumigation has increased tremendously over the last decade. This is mainly due to the ability of brassica species to produce glucosinolates, which upon degradation release toxic volatile compounds like isothiocyanates. Despite the growing interest in brassica cover crops, few studies have tested their impacts on soil microorganisms, especially in sites infested with soilborne diseases.

Studies were conducted in 2007 and 2008 to test the effects of brassica biofumigants and Metam sodium (MS) on weed populations, soil microbial activity, and fruit rot in cucumber production. A commercial vegetable field with a uniform infestation of *Phytophthora capsici* was used. Treatments included oilseed radish (*Raphanus sativus* L.), Oriental mustard (*Brassica Juncea* L. Czerniak), brown mustard (*Brassica Juncea* L. Czerniak), cereal rye (*Secale cereale*) used as negative control, and MS used as positive control. A randomized complete block design with four replications was used.

In each year, the cover crops were sown the last week of April and were allowed to grow until the third week of June when they were chopped with a flail mower and incorporated by disking. MS was applied at 1,000 L/ha through two drip tapes the first week of July. The seedbed was allowed to set for a minimum of 14 days before sowing 'Journey' pickling cucumbers. Insects, weeds, foliar diseases, and nutrients were managed according to local recommendations for commercial cucumber production. Evaluations consisted of weed control and soil microbial activity (microbial biomass and community structure) assessments, and cucumber fruit rot at harvest and during storage.

Brassica cover crops provided some degree of weed suppression; however, the level of weed control was low compared to MS. No significant fruit rot was observed at harvest. However, a significant amount of fruit was lost due to rot after harvest. The highest percentage of fruit rot occurred after five days of storage, with values ranging from 13 to 20%. Regardless of the treatment, the percentage of fruit rot peaked three days after harvest. Diagnostic evaluation showed that *Pythium spp.* were responsible for most of the fruit rot recorded. As expected MS fumigation resulted in low soil microbial biomass. Soil microbial biomass in the brown mustard treatment was also reduced and was equivalent to values observed with MS. All brassica cover crops reduced the number of functional groups of microorganisms in the soil compared to the control (rye cover crop) and MS. This was observed for overall microbial activity, microbial richness, and microbial diversity. The ability of the brassica cover crops to selectively affect certain groups of soil microorganisms has been the major reason for their use as biofumigants for disease management in cropping systems. Our results also show that despite its effect at reducing total soil microbial populations, MS had limited effect on soil microbial community structure.

## GREEN MANURES AND ORGANIC AMENDMENTS TO CONTROL CORKY ROOT OF TOMATO

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Corky root of tomato, caused by *Pyrenochaeta lycopersici*, is a major soil-borne disease in greenhouse tomato production of Switzerland. Alternatives to methyl bromide, which is prohibited in Switzerland already for nearly 20 years, are steam-sterilisation of soil, grafting on resistant rootstocks, and soil-less production systems. These methods are efficient but have also their inconvenients (high energy input, partial loss of resistance, high investment costs) and search for other methods to control corky root and other soil-borne diseases are needed.

The use of green manures, especially with biocidal mustard plants (biofumigation), a product based on defatted mustard seed meal (biofumigation pellets), and a chitin-containing organic fertiliser was tested to control corky root in pot and greenhouse trials. The use of resistant rootstocks was another factor included in these studies.

Incorporating green manures one week before planting a susceptible tomato cultivar were the most efficient treatments in the pot trial. Biocidal mustard plants incorporation achieved the same results as steam sterilising the soil. Non-biocidal plants such as canola had a slightly lower efficiency. Both organic amendments tested were less efficient than the green manures but better than the control treatment.

In the green house trial, soil was amended with the chitin-containing fertiliser for three years. Grafted and non-grafted susceptible tomatoes were planted and the impact on yield and root health was assessed. Grafting on resistant rootstocks gave a significant higher yield in two of three years. Root health of the resistant rootstocks was significantly better in all three years compared to the non-grafted tomato roots. In contrast, the organic soil amendment did not improve the plant yield and the root health.

## EFFECT OF BRASSICA GREEN MANURE AND BRASSICA PELLETS IN COMBINATION WITH GRAFTING AND SOIL SOLARIZATION AGAINST VERTICILLUM WILT OF EGGPLANT AND FUSARIUM WILT OF LETTUCE AND BASIL

A. Garibaldi<sup>1</sup>, G. Gilardi<sup>1</sup>, L. Lazzeri<sup>2</sup>, L. Malaguti<sup>2</sup>, F. Clematis<sup>1</sup>, A. Minuto<sup>1</sup> and M.L.Gullino<sup>1</sup>

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The biocidal activity of Brassica green manure is due to presence of the glucosinolatemyrosinase system in the plant and to its capacity after incorporation to release in soil a number of biologically active compounds, including isothiocyanates, nitriles, epithionitriles and thiocyanates. In recent years, several tests have shown a potentially wide biocidal effect against soilborne pests and diseases such as nematodes wireworms and fungi. In this presentation it will be reported a first set of trials carried out in Liguria (northern Italy), to test the efficacy of a biofumigant green manure of Brassica juncea ISCI20 (Cerealtoscana-Italy ) sown (10-14 kg ha<sup>-1</sup>) in November 2003, 2004 and 2005. The same experimental design were adopted during the three years in a naturally infested soil with *Verticillium dahliae*. In May 2004, 2005 and 2006 *B. juncea* at flowering time was chopped and tilled into the soil. Some plots were then mulched with a clear plastic film. After 25- 30 days of mulching, mulched plots were uncovered and grafted eggplants (cv Prosperosa) were transplanted at 2 plants/m<sup>2</sup>. Severe infections of *V. dahliae* were recorded in control plots (63-56- 85% infected plants during the three years), and in plots without plastic mulch (66-65-55% infected plants). Soil mulching alone and biofumigation alone provided only partial results. In contrast, treated and mulched plots showed a significant reduction of disease incidence (52-49-12% infected plants), particularly in 2005 and 2006. The combination of biofumigation and grafting on resistant rootstocks provided the best results (more than 75% disease reduction).

A second set of trials were carried out during the years 2005 and 2006 in microplots in order to evaluate the effectiveness of soil application of biofumigant pellets based on a patented formulation of Brassica carinata defatted seed meals, combined or not with a simulation of soil solarization (carried out by heating the soil at 45 ± 2° C for 7, 14, 21 days) against Fusarium wilt of lettuce and of basil. Biofumigant pellets alone, applied at 2 or 4 g/l of soil, partially reduced disease incidence. Simulated solarization carried out for 3 weeks confirmed a very good efficacy. The combination of dried Brassica pellets and 1- 2 weeks of solarization provided very good results against both *Fusarium oxysporum* f. sp. *lactucae* and *Fusarium oxysporum* f. sp. *basilici*. Some side effects, such a slight phytotoxicity of dried pellets, need further studies.

## USE OF PELLETTED *MEDICAGO SATIVA* MEAL FOR THE CONTROL OF ROOT-KNOT AND CYST NEMATODES

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Soil amendments with green or dry biomass of many plant species were already known to be suppressive on phytoparasitic nematodes. Plant materials from *Medicago* species were recently demonstrated to be nematotoxic either on root-knot and cyst nematodes in potting mixes, mainly due to the content of saponins and other biocidal compounds.

The nematicidal potential of soil amendments with a pelleted dry *M. sativa* meal was evaluated on the root-knot nematode *Meloidogyne incognita* on tomato and the cyst nematode *Heterodera carotae* on carrot in two field experiments in Southern Italy. In both experiments application of 20 and 40 T ha<sup>-1</sup> pelleted *M. sativa* meal (0.8% dw saponins) was compared with 30 l ha<sup>-1</sup> of a quillay commercial formulation and 30 l ha<sup>-1</sup> of a phenamiphos liquid formulation; nontreated plots were used as a control.

Both amendment rates strongly suppressed soil population density of *M. incognita* and gall formation on tomato roots compared to the nontreated soil, though nematode infestation was significantly lower at the highest pellet dosage. Moreover, plots amended with both rates of *M. sativa* meal resulted in a tomato yield significantly higher than control and soil treated with fenamiphos or quillay formulation. In the experiment on *H. carotae*, both rates of *M. sativa* pellet suppressed soil nematode population at the same level of phenamiphos and remarkably increased tap root yield compared to nontreated control.

Content of bioactive saponins of *M. sativa* meal seems to be only partially responsible of the nematode suppression, probably resulting from the action of different mechanisms.

Soil amendments with pelleted formulation of meals from *Medicago* species seem to be a valuable option for an environmentally safe control of phytonematodes, also due to their technical feasibility and economic convenience as well as to their the collateral positive effects on soil fertility.

## KAKAWATE (*GLIRICIDIA SEPIUM*) AS A SOIL AMENDMENT AND BIOLOGICAL CONTROL OF SOIL-BORNE PATHOGENS: THE PHILIPPINES EXPERIENCE

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There has been increasing concern worldwide on the adverse effects of intensive farming activities on the environment, quality and safety of food. The change from high-input and chemically-intensive agriculture to a more sustainable form of agriculture is not only desirable, but also significantly needed. In the Philippines it is not easy to find economically viable and efficient alternatives to the use of chemicals against soil-borne pathogens. As the compatibility at farm level must be maintained by all means, the economic considerations will play a major role in introducing alternatives.

A documentation study was conducted on different plant materials utilized as alternatives of chemical fertilizers and pesticides in selected areas in southern Luzon, Philippines. In all farms visited, results showed that ingenious, successful farmers utilized kakawate (*gliricidia sepium*) on their rice farming. These farmers make use of the kakawate leaves in various ways: incorporated into the soil during land preparation, spread over as mulch and applied as spray on standing crops. The latter was a concoction of fermented leaves (popularly known for local farmers as "kakawate plus") sprayed on the rice crop at maximum tillering to reproductive stages. This multi-purpose tree is popularly known to many farmers because of its high mineral composition that provides nutrients to crops, and chemical compounds that help control the insects and decrease population of soil-borne pathogens.

The efficiency of kakawate documented from farmers' experiences is supported by the results of a long-term field experiment conducted on a low-fertility clayey soil (*Aquandic epiaqualf*) at International Rice Research Institute-U.P. Los Baños experiment station. After 6 rice croppings kakawate significantly improved the soil properties providing healthy plants comparable to those plants with chemical fertilizers, and supporting the activities of beneficial soil organisms. General findings indicative of kakawate's pesticidal activity is the capability to boost the resistance of the rice crop to root infection, insect and disease infestation. The effectiveness of kakawate as nutrient source and bio-control of soil-borne pathogens can be an option for the future, as it guarantees yields, reduces costs, environmentally friendly and contributes to the sustainability of agriculture.

## COMBINED EFFECTS OF BIO CONTROL AGENT AND RESIDUES ON ROOT ROT MORTALITY IN INDIAN MESQUITE (*PROSOPIS CINERARIA*)

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Indian mesquite [*Prosopis cineraria* (L.) Druce] locally known as *khejri* is the most important tree species and forms the integral part of agro-forestry systems of Indian arid region. Farmers are maintaining 30-60 trees in a hectare because annual crops in association with this tree perform better than those grown with other tree species. It is considered as lifeline of desert dwellers due to its multiple uses as an alternative source of livelihood particularly during the periods of drought. In recent years, large scale mortality in this tree has been witnessed in many pockets of the region. On detailed investigations, an insect- disease association was found to be the major cause pre mature drying. Attack of *Acanthophorus serraticomis* insect predispose tree to infection by a root invading pathogen *Ganoderma lucidum* (Leyes) Karst. In the present study, an effort was made to evolve a practical management strategy against *Ganoderma* root rot, which can be easily implemented by resource deficient farmers of the region. Effectiveness of bio control agents viz., *Trichoderma harzianum* and *Aspergillus versicolor* and residues of mustard, radish, cauliflower, onion and weeds (*Aerva persica* and *Verbisina enceloides*) was tested on *Ganoderma* colonized bits in the soil. Maximum reduction in viable colonized bits was recorded in onion followed by cauliflower residue amended soil. Interestingly, both the residues encouraged multiplication of one native strain of *Aspergillus terreus* in soil, which rapidly colonized bits by eradicating *Ganoderma*. Dual culture tests also confirmed antagonism of *A. terreus* against *Ganoderma*. In field demonstrations also, significant improvement in the condition of *A. terreus* and onion residues amended *P.cineraria* trees was recorded. *A. terreus* is a heat tolerant strain, which can withstand high soil temperatures (50-55<sup>0</sup>C) prevalent during summer months in the region. Residues of onion and cauliflower have a proven ability to control many soil borne plant pathogens. Our findings demonstrate potentials of utilizing these residues in combination with native biocontrol agents for managing *Ganoderma* induced root rot mortality in important tree species of Indian arid region.

## ADDITIONAL BENEFITS TO THE EFFICACY IN CONTAINING SOILBORNE PEST AND PATHOGENS OF BIOFUMIGANT PLANT AND MATERIALS

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Biofumigation by Brassicaceous plant materials is a non chemical alternative for soil disinfestation studied from more than ten years and now applied even at a commercial level in several countries in both organic and conventional farming systems. The incorporation of selected Brassica plants and products containing the Glucosinolate-Myrosinase sistem, in addition to the significant organic matter effect, determines a control of some soil borne pathogens and pest as fungi (*Phytophthora*, *Rhizoctonia*), nematodes (*Meloidogyne incognita*, *Heterodera schachtii*) and wireworms as showed in ten years of scientific and applicative experiences.

The aim of this presentation is to report and discuss the additional benefits to the biofumigant effect derived from the incorporation of biofumigant materials as a partial or total alternative to the conventional chemical treatments. So, firstly it will be reported the chemical characterization of Biofumigant plants (*Brassica juncea* and *Eruca sativa*) and materials (a formulation in pellets based on defatted Brassica carinata seed meals) described for their content of macro (Nitrogen, Phosphorous and Potassium) and minor (Calcium, Iron, Magnesium, Manganese, Copper, Sulphur and other) components determined by the conventional analytical methods. The results will be discussed from an energetic and environmental point of view, considering the positive charge on CO<sub>2</sub> equivalents balance derived from the incorporation of significant organic matter amounts.

Starting from these evaluations, it will be even presented an environmental balance (expressed again as CO<sub>2</sub> equivalents) to evaluate the different emission of greenhouses gases (input- output rate) derived after the application of a biofumigant approach in comparison to a conventional chemical one. As a case study, it will be presented and discussed the environmental balance of a thirteen-year experience of a biofumigant green manure (*Brassica juncea*) application in potato rotation in Moses Lake area (WA, USA) evaluated following the procedures inserted in the European Directive FER 28/09 for the sustainability evaluation. The results show how the complete replacing of chemical fumigant treatment (based on Metham Sodiium) conventionally applied in potato rotation and the organic matter incorporation by biofumigant green manure made possible to save more than 5 ton of CO<sub>2</sub>eq for hectare.

## MYCOFUMIGATION USING MUSCODOR ALBUS FOR CONTROL OF SOILBORNE PALN PATHOGENS.

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*Muscodor albus*, isolate 620 (MA) is an entophytic fungus isolated from *Cinnamomum zeylanicum* that produces volatile organic compounds (VOC's) that inhibit or kill a wide range of microorganisms including bacteria, fungi, and nematodes. Use of these fungal produced VOC's for microorganism control is termed mycofumigation. *In vivo* and *in vitro* research has shown partial or complete control of the following pathogens: *Rhizoctonia solani*, *Verticillium dahliae*, *Aphanomyces cochlioides*, *Colletotrichum coccodes*, several *Pythium* sp., several *Phytophthora*, *Helminthosporium solani*, *Botrytis cinerea*, several *Aspergillus* sp., Several *Penicillium* sp., several *Fusarium* sp., *Streptomyces scabies*, *Erwinia carotovora*, Several *Meloidogyne* sp., *Pratylenchus penetrans* and *Paratrichodorus allius*. The fungus M. albus has been licensed to AgraQuest (Davis, CA) for commercial development and its use has full registration by the US EPA for suse in soil and other post harvest applications.

Mycofumigation using MA is a new concept of soil fumigation with broad application potential, and it is critical to understand the effects of the mycofumigant fungi and their VOC on both plant pathogenic and beneficial organisms. MA is not phytotoxic to tested representative from the plant families *Rosaceae*, *Asteraceae*, *Graminae*, *Cruciferae*, *Cucurbitaceae*, *Leguminaceae*, *Chenopodiaceae*, and *Solanaceae* and no evidence of plant tissue colonization has been noted. Consequently, mycofumigation is not expected to control weeds. Incorporating MA into soil had no negative effect on *Trichoderma* sp. and the arbuscular mycorrhizal (AM) *Glumus intraradices* and AM colonization of onion roots was increased in MA treatments. *In vitro* experiments showed that the ectomycorrhizal fungi, *Laacria* sp., *Rhizopogon salebrosus*, *Suillus brevipes* and *Suillus* sp. were inhibited in the presence of MS VOC's but were able to grow when removed from MA VOC's. *Hebeloma laterinum* was killed by MA.

In field research using MA colonized barley applied in furrow ant 15-448 kg/ha resulted in control of scab, *Rhizoctonia* canker, *Verticillium* wilt and black dot root rot of potato. Colony forming units of *V. dahliae* and *C. coccodes* were reduced by 48-100% in tree different soil types at up to 9 cm from MA infested barley. No proliferation of MA was detected in sterile soil by either PCR or dilution plates.

# INDUCED SOIL SUPPRESSIVENESS TO ROOT DISEASES BY HERB AMENDMENTS AND SOLARIZATION

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Incorporation of herb residues into soil, combined with soil solarization can be effective in controlling soilborne plant pathogens. Moreover, in many cases a phenomenon of soil suppressiveness against reestablishment of pathogen also develops. The objective of this study was to document induced soil suppressiveness under controlled conditions and to validate it under commercial field conditions. The suppressiveness assays included amendment of Rehovot soil with herb residues (1% w/w) and incubation for four weeks, solarized or not, under field conditions. Soil suppressiveness was tested by inoculation of the treated soil, or cucumber transplants with eggs of *Meloidogyne javanica* or macro-conidia of *Fusarium oxysporum* f. sp. *radicis-cucumerinum* (FORC), respectively. The most potent herb residues to induce soil suppressiveness and reduce disease severity were *Diplotaxis tenuifolia* (wild rocket), *Artemisia dracunculus* L. (tarragon), and *Salvia officinalis* L. (sage). Disease incidence - galling index in tomato and basil plants, or wilting cucumber seedlings, in soil which was previously amended by these herbs, was reduced by 50% and 60%, respectively, compared with nonamended soil. Soil suppressiveness to FORC following the incorporation of herb residues was evident in three different soils, "Ein-Tamar", "Beit-Dagan", and Rehovot, which differ in their physical and chemical properties. Suppressiveness was evident even after three repeated inoculation and planting cycles of cucumber seedlings without additional soil treatments. Field experiment, in soil infested with *Meloidogyne javanica*, was carried out with tomato crop. The plots were amended with *Diplotaxis tenuifolia* (wild rocket) which was grown in the plots previously for 6 months, and moderate solarization was applied, to achieve only a partial control of the pathogens in the soil. Indeed, nematode viability in the tomato greenhouse was not affected by any of the treatments. However, disease index of nematodes on tomato roots (cv. 870) was reduced by 40% (severe galling index) by amending wild rocket or soil solarization, compared with the control. The yield of tomato fruits did not differ among the treatments. The role of soil microorganisms in induced soil suppressiveness is currently studied.

# PLANT METABOLITES DERIVED FROM *BRASSICA* SPP. TISSUES AS BIOFUMIGANT TO CONTROL SOIL BORNE FUNGI PATHOGENS

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Biofumigation (B) is nonchemical alternative method for soil borne pathogens control. B control is based on the action of volatile compounds derived of secondary metabolites present in *Brassicaceae* plants, essentially isothiocyanates (ITCs) produced by the hydrolysis of glucosinolates (GLs).

In this work, different species of *Brassica* (*B. juncea*, *B. carinata*, *B. nigra* and *B. napus*) were used as biofumigants because of their different concentrations and types of ITCs emission during their decomposition that are different in their toxicity against pathogenic fungi *Phytophthora cactorum* and *Verticillium dahliae*.

*In vitro* the most effective species and stages of *Brassica* spp. to control *P. cactorum* and *V. dahliae* were selected by means of the evaluation of the pathogens growth exposed to different concentrations of the macerated *Brassica* spp. fresh tissues in the different stages of plant development (vegetative, flowering and maturing). Qualitative and quantitative determination of the GLs content in the *Brassica* species was determinate by HPLC-UV analysis, according to the ISO 9167-1 method.

The results showed the existence of variability in the suppressive effect *in vitro* of *P. cactorum* and *V. dahliae* depending on *Brassica* spp. The growth of isolates studied was significantly suppressed when exposed to the different species of *Brassica*. *B. juncea* and *B. nigra* were the species with major suppressive effect. It was associated with the variation in individual GLs profile of the plant. The highest suppression of soil borne fungi was related to the stages flowering and maturing where were found the highest values of GL sinigrin (2-propenyl-GL). Corroborating the role of sinigrin in the response of *P. cactorum* and *V. dahliae* against *Brassica* spp. in different stages of the plant life cycle.

# ORGANIC AMENDMENTS

## POSTERS

- Non-Chemical Options for Managing Soil Borne Plant Pathogens in Indian Arid Zone - Satish Lodha, R.Mawar and V.Singh
- Effect of biosolarisation using pellets of *Brassica carinata* on soil-borne pathogens in protected pepper crops - M.M. Guerrero, M.A. Martínez, C. Ros, C.M. Lacasa, V. Martínez, A. Lacasa, P. Fernández
- Efficacy of biosolarisation with sugar beet vinasses for soil disinfestation in pepper greenhouses - C. M. Lacasa, M.M. Guerrero, C. Ros, M.A. Martínez, V. Martínez, A. Lacasa, P. Fernández
- Integration of Non-chemical Methods of Controlling Fusarium Wilt of Carnation - R. A. Nava-Juárez and J.M. Melero-Vara
- Application of organic amendments followed by plastic mulching for the control of *Phytophthora* root rot of pepper in northern Spain - Mireia. Núñez-Zofío, C. Garbisu and S. Larregla)
- Effect of meal of *Aster caucasicus* and *A. sedifolius* on the control of root-knot nematodes in glasshouse - *Mauro Di Vito* M. Di Vito, P. Pecchia, F. Catalano, M. Cammareri, C. Conicella
- Effects of Soil Organic Amendments and Incubation Temperature on the Control of *Fusarium oxysporum* f. sp. *Asparagi* - A. Borrego-Benjumea, J. M. Melero-Vara and M. J. Basallote-Ureba
- Effects of Several Soil Amendments on Allelopathy and Tolerance to Violet Root Rot in Mycorrhizal Asparagus Plants. A. S. M. Nahiyan, Y. Yagi, T. Okada and Y. Matsubara

## NON-CHEMICAL OPTIONS FOR MANAGING SOIL BORNE PLANT PATHOGENS IN INDIAN ARID ZONE

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In Indian arid region, soil borne plant pathogens like *Macrophomina phaseolina*, *Ganoderma lucidum* and species of *Fusarium* causes root rot and wilts in many economically valuable crops and trees. Concerned with the conservation of fast deteriorating environment, efforts were made to develop eco- friendly management options suited to rainfed and irrigated agriculture in order to avoid dependence on expensive and hazardous chemical means of control. In rainfed agriculture, amendment of soil with composts prepared from residues of *Prosopis juliflora*, *Calotropis pocera*, *Acacia nilotica*, *Azardirachta indica* and on farm weeds was found effective in increasing microbial population and activity in soil and in reducing incidence of *M.phaseolina* induced charcoal rot on legumes. In field experiments, least plant mortality due to charcoal rot on guar ( *Cyamopsis tetragonoloba* ( L.) Taub.) was recorded in weed and *P.juliflora* (5.5- 6.7 %) compost amended plots compared to 16.6 % in non amended control. Beneficial effects of composts were also discernible in yield promotion by 39.9% in *P.juliflora* compost amended plots. In irrigated agriculture, soil solarization elevated the soil temperature by 2.5 – 13.1<sup>0</sup>C compared to non solarized plots, resulting in 70.4- 100% and 69.3 – 94.7% reduction in viable propagules of *Macrophomina* and *Fusarium oxysporum* f. sp. *cumini*, respectively. This reduction was reflected in reduced incidence of root rot and wilt on guar and cumin (*Cuminum cyminum* L.) crops, respectively. As an alternative to soil solarization, *Brassica* amendments combined with one summer irrigation was also found effective in reducing population of these soil borne plant pathogens. One additional benefit accrued was in the form of enhanced population and activity of native bio control agents like *Bacillus firmus* and *Aspergillus versicolor* against *Macrophomina* and *Fusarium*. Technological interventions of these strategies singly or in integrated manner at farmers' field for management of these diseases have produced encouraging results.

## EFFECT OF BIOSOLARISATION USING PELLETS OF *BRASSICA CARINATA* ON SOIL-BORNE PATHOGENS IN PROTECTED PEPPER CROPS

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*Phytophthora* spp. and *Meloidogyne incognita* are the main soil-borne pathogens of greenhouse pepper crops in Southeast Spain. Between 1985 and 2005, soils were disinfected every year with methyl bromide (MB). Nowadays, among the different alternatives to MB, biosolarisation with fresh sheep manure is applied at 450 ha, using 1.3-dichloropropene+chloropicrin in the rest of surface (1,500 ha). Disinfectant efficacy of biosolarisation with *Brassica carinata* pellets at doses from 100 to 300 g/m<sup>2</sup> alone or mixed with fresh sheep manure at different dates of application has been evaluated at experimental and commercial greenhouses. When biosolarisation was carried out in August, the survival of *P. capsici* oospores was as low as MB and the incidence of *Meloidogyne* was similar to MB (Nodulation Index (NI= 0.0; percentage of infested plants IP=0%). Results showed that efficacy was better when pellets were mixed with fresh sheep manure (NI=0.5; IP=13.3%) although the incidence using pellets alone (NI=2.3; IP=46.7%) was inferior to fresh sheep manure alone (NI=4.1; IP=86.7%) that improved the control (NI=5.6; IP=100.0%).

When biosolarisation was initiated in October, disinfectant efficacy decreases, since the incidence of *Meloidogyne* and the survival of *P. capsici* inoculum increases using either pellet alone or mixed with manure.

## EFFICACY OF BIOSOLARISATION WITH SUGAR BEET VINASSES FOR SOIL DISINFESTATION IN PEPPER GREENHOUSES

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In Region of Murcia (Southeast Spain), sweet pepper is a monoculture in 2,000 ha of greenhouses for over twenty five years. *Phytophthora* spp. and *Meloidogyne incognita* are the main soilborne pathogens. Methyl bromide (MB) has been used as a common soil disinfectant during twenty years until its banning in 2005. MB has been replaced by 1.3 dichloropropene+chloropicrin in a great part of the surface and by biosolarisation (450 ha) using sheep manure as amendment.

Sugar beet vinasse is a by-product proceeding from the industrial extraction of sugar at low cost with a high value as a fertilizer.

Disinfectant efficacy of biosolarisation with sugar beet vinasse at doses from 0.75 to 1.5 l/m<sup>2</sup> alone or mixed with sheep manure at different rates, has been evaluated at several experimental greenhouses. When solarisation was initiated in August, the survival of *P. capsici* oospores was very low and similar to MB; *M. incognita* control was better when sugar beet vinasse was mixed with the fresh sheep manure (Nodulation Index (NI)= 0.7; percentage of infested plants IP=20%) in relation to the fresh sheep manure alone (NI=1.5; IP=40%), with no difference in relation to vinasse alone (NI=1.2; IP=35%) and improving the effect of MB (NI=2.8; IP=48%) or the control (NI=5.6; IP=86.7%).

Pepper yield at biosolarisation treatments (from 12.3 to 13.1 kg/m<sup>2</sup>) was similar than MB (13.1 kg/m<sup>2</sup>). Results showed that when biosolarisation treatments are carried out in September or October, disinfectant efficacy decreases, since the incidence of *Phytophthora* and *Meloidogyne* increases using either sugar beet vinasses alone or mixed with fresh sheep amendment.

# INTEGRATION OF NON-CHEMICAL METHODS OF CONTROLLING FUSARIUM WILT OF CARNATION

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The effect of three organic amendments (fresh poultry manure, PM, grape marc compost, GM, and composted olive residue, OR) applied to soil mixture artificially infested with each of three *Fusarium oxysporum* f.sp. *dianthi* (*Fod*) isolates, i.e. A1 (race 1), and A2 and A3, (race 2) on the control of Fusarium wilt on two susceptible cultivars of carnation: Medea for replicated experiments I and II (conducted in greenhouse) and Activa for experiments III and IV conducted in growth chambers. Infestation was achieved by growing the fungal isolates on sterile sand:silt mixture incubated for 30 days at 25°C in the dark, and then mixed with soil mixture at the rate of 3 Kg / 47 dm<sup>3</sup>. The infested soils were placed in 50-litres containers watered to field capacity and then tarped or not with PE films and incubated in a closed greenhouse for 4 wk. Afterwards they were aerated for 10 days before their distribution into 1.5-litre pots, and subsequently planted to carnation cv. Medea (5 replicates, 1 plant/pot each) which were incubated in greenhouse from September 2008 to May 2009. Furthermore, cv. Activa was planted in pots (with similar design and replications) that were incubated since early December, in two growth chambers at 24-27°C, with a 12-h photoperiod. Sequential evaluations of foliar symptoms severity until early May 2009 allowed the calculation of integrated areas under the curve of severity (AUCS).

The similar trends of results in experiments I and II allowed to pool them and conclude that GM and PM significantly reduced AUCS due to the three *Fod* isolates in PE-tarped treatments as compared to the control without amendment, whereas OR amendment reached maximum disease control only with isolate A3, while AUCS for isolates A1 and A2 increased when GM or PM were added to the soil mixture, thus suggesting an increase of inoculum potential. There were significant differences between experiments III and IV, the symptoms being more severe in the latter, perhaps due to differences in light intensity in both growth chambers. Nevertheless, when the amendments were PM or GM and were PE-tarped, significant reductions of AUCS were found in plants grown in soil infested with isolate A1 whereas isolates of race 2 kept similar values to those of the controls. In contrast, AUCS for isolates A1 and A2 were significantly increased for the soil amendment with OR. When the treated soils were not PE-tarped increased AUCS was found for all the *Fod* isolates except for A3 that showed a reduced AUCS when infested soil was amended with PM.

## APPLICATION OF ORGANIC AMENDMENTS FOLLOWED BY PLASTIC MULCHING FOR THE CONTROL OF *PHYTOPHTHORA* ROOT ROT OF PEPPER IN NORTHERN SPAIN

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The application of organic amendments followed by soil plastic mulching is considered an environmentally-friendly approach for the control of soilborne plant pathogens. Our objective was to evaluate the effectiveness of this technique in the Basque Country, northern Spain, an area characterized by humid temperate climate, and during a period of the year compatible with protected pepper culture in which climatic conditions have a low soil heating effect. A greenhouse experiment was carried out to compare the effects of plastic mulching, alone and in combination with three different organic amendments, on *Phytophthora* root rot of pepper caused by *Phytophthora capsici*. Organic soil amendments, *i.e.* a mixture of fresh sheep manure and chicken litter (2.33:1, dw:dw), a semicomposted mixture of horse and chicken manure (1:1, fw:fw) and *Brassica carinata* commercial pellets, were incorporated into artificially infested soil and covered with plastic film during 40 days. After this time, pepper plants (*Capsicum annuum*, cv. "Derio") were planted and inoculum survival evaluated. During crop development, disease incidence was periodically controlled as well as plant production and vigour (plant height). Although temperature in plastic mulched soil at 15 cm depth was not high enough for thermal inactivation of the buried inoculum (832 h at 12.5-25°C, 134 h at 25-30°C and 10 h at 30-32.5°C), the incorporation of fresh sheep manure mixed with chicken litter managed to significantly reduced *P. capsici* inoculum in soil. However, final disease incidence was significantly reduced by 80-90% with both animal amendments, possibly through increasing soil suppressiveness. Manure application increased plant growth and resulted in more productive plants, compared to untreated controls. Our results suggest that some organic amendments followed by plastic mulching may reduce the incidence of *Phytophthora* root rot in the Basque Country. More research is needed to investigate the impact of this technique on soil functioning.

## EFFECT OF MEAL OF *ASTER CAUCASICUS* AND *A. SEDIFOLIUS* ON THE CONTROL OF ROOT-KNOT NEMATODES IN GLASSHOUSE

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Root-knot nematodes (*Meloidogyne* spp.) are a severe economic constraint of vegetable and industrial crops also in the Mediterranean region. Fumigant and non fumigant nematicides can satisfactorily control these nematodes but the use of most of them is not permitted on these crops because of environmental concerns. To find alternatives to nematicides, investigations are being conducted to evaluate the nematocidal efficacy of natural compounds of plant origin. Therefore, the nematocidal activity of triterpene saponins, a particular class of secondary metabolites, was assessed as they are known to possess notable and wide biological activities against insects, fungi, nematodes and weeds as well as a remarkable structural variety. An extremely rich chemical diversity characterizes *Aster* species and several triterpene saponins were isolated from plants in this genus. Three of these compounds, named astersedifolioside A-C, were isolated from aerial plant parts and roots of *Aster sedifolius*, while none was found in *A. caucasicus*.

Therefore, the efficacy of meal of leaves and roots of *A. caucasicus* or *A. sedifolius* was assessed at the rates of 0.5 and 1 g per pot containing 100 cm<sup>3</sup> sterilized sandy soil inoculated with 10,000 eggs of *M. incognita* race 1 and transplanted with a 20-days-old tomato cv. Rutgers seedlings in a glasshouse at 25 ± 2°C. Also, the effect of 1.19, 2.38 and 4.75 mg of saponins of *A. sedifolius* /100 cm<sup>3</sup> soil on the control of *M. incognita* was evaluated in glasshouse as described before. Finally, the mortality of *M. incognita* as affected 12.5, 25, 50, 100, 200 or 400 µg of saponins of *A. sedifolius*/ml distilled water, in 1 ml Eppendorf vials, containing 1000 second stage juveniles of the nematode was evaluated after incubation for 1, 6, 12, 24 or 48 hours in a growth chamber at 20 ± 1 °C.

Meals of leaves and roots of *A. caucasicus* and *A. sedifolius* did not affect the growth of tomatoes nor the root gall index by *M. incognita*, while the reproduction of the nematode was greatly and significantly affected as it was reduced of about 97% with 0.5 and 1 g of meal of leaves and roots of *A. sedifolius* compared with untreated tomato plants (16,681 eggs/root). With *A. caucasicus*, a reduction of 82.3 and 92.7% of the nematode eggs per tomato root was recorded with 0.5 and 1 g of meal of leaves of, respectively, but no effect occurred with meal of roots. When the soil was treated with 1.19, 2.38 or 4.75 mg of purified saponins from *A. sedifolius* the reproduction of the nematode was not affected. The mortality of second stage juveniles of *M. incognita* was not affected by any of the concentrations of saponins of *A. sedifolius* at the exposure times tested.

The fact that leaf and root meals of *A. sedifolius* are effective against the nematode while its saponins does not conflict with a the mechanism of action of *A. sedifolius* saponins. However, the possibility that compounds other than saponins are also involved in the control of the nematodes by leaf and root meals cannot be excluded.

# EFFECTS OF SOIL ORGANIC AMENDMENTS AND INCUBATION TEMPERATURE ON THE CONTROL OF *FUSARIUM OXYSPORUM* F. SP. *ASPARAGI*

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*Fusarium oxysporum* f.sp. *asparagi* (*Foa*) is one of the most important pathogens causing crown and root rot of asparagus, a disease inflicting serious losses worldwide. Soil mixture (sand:silt, 2:1, v) was artificially infested with *Foa* and thereafter amended with either poultry manure (PM), the pellet of this amendment (PA), or composted olive residues (OR) at 1 and 2% concentrations each. Thoroughly homogenised soil was used to fill 50-ml tubes which were incubated at 30 and 35°C in the dark for different periods (15, 30 and 45 d), with 3 replications for every combination of treatments. Serial dilution plating of the soil aliquots on a selective agar medium was performed at the initiation of the experiment and after the different incubation periods; the variations of inoculum viability in the different combinations of treatments were assessed by counting of *Fusarium* colonies after 7-d. After incubation, the remaining soil in the tubes was individually added to growth substrate aliquots (300 ml) filling containers in which seedlings of the susceptible asparagus cv. Grande were planted. To determine the efficacy of the different soil treatments on the disease, a greenhouse experiment was conducted to evaluate symptoms development and final weights of the plants after 3 mo incubation.

*Foa* viability was reduced in >90% in PA-amended (1-2%, w) and PM-amended (2%, w) soils incubated at 30°C for 45 d; similar results were obtained when soils amended with PM, PA or OR, or non-amended, were incubated at 35°C for >30 d. Root severity (% affected tissues) was reduced to 55 and 31%, as compared to their control plants, respectively growing on the PM- and PA-treated pots which were incubated at 30°C for 45 d. PA-treated (2%, w) *Foa*-infested soil incubated at 30°C for 30 or 45 d determined a 325% increase of fresh plant weight, whereas increases of 58 and 32% were observed in plants growing in un-infested PM and OR-amended soils that were incubated for 15 d at 35°C. In general, 45-d incubation reduced inoculum viability and root severity and improved fresh plant weight, but these effects were stronger at 35°C than at 30°C.

# EFFECTS OF SEVERAL SOIL AMENDMENTS ON ALLELOPATHY AND TOLERANCE TO VIOLET ROOT ROT IN MYCORRHIZAL ASPARAGUS PLANTS

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Asparagus decline is a very severe problem in the asparagus producing region in the world. Nowadays, this problem decrease of farmer's motivation, which has been a serious problem in abroad and Japan. Asparagus decline is caused by the contribution of abiotic factors (allelopathy etc.) and biotic factors (*Fusarium* species, *Helicobasidium mompa* etc.). Violet root rot caused by *Helicobasidium mompa*, which attacks underground organs of a very wide range of plants from trees to grasses, is a serious disease in asparagus cultivation in Japan followed *Fusarium* species. However, no effective control has been found for this disease. In this study, the effect of growth pre-inoculating asparagus seedlings with arbuscular mycorrhizal fungi (AMF) on their tolerance to violet root rot and the effect of adding different soil amendments to the decline field soil on AMF infection and to tolerance allelopathy were investigated.

In disease tolerance experiment, asparagus (*Asparagus officinalis* L., cv. Mary Washington 500W and Welcome) plants inoculated with *Glomus intraradices* in autoclaved bed soil. Asparagus seedlings were inoculated with *H. mompa* (MAFF305915) 12 weeks after AMF inoculation by using apple twigs. After AMF inoculation, incidence of disease was investigated. Symptom of violet root rot appeared in all the treatments 12 weeks after *H. mompa* inoculation, and the disease incidence and severity were less in AMF inoculated plants than AMF noninoculated plants. In soil amendments experiment, asparagus (cv. Welcome) seedlings were raised in activated charcoal (50 times dilution, 5 ml per plant) and coffee residue (10%, v/v) added decline field soil contained allelochemicals determined by bioassay, and inoculated by *Glomus intraradices* and *Gigaspora margarita*. Twelve week after AMF inoculation, it was observed that for the growth improvement of the asparagus addition of coffee residue together with Gi was comparatively effective than activated charcoal with Gi. Plant growth promotion via symbiosis and allelopathy tolerance was appeared in micorrhizal asparagus plants.

These results reveal that tolerance to violet root rot was increased by AMF colonization and the addition of coffee residue to bed soil is effective for increasing the tolerance to allelopathy effect on micorrhizal asparagus plants.

# SESSION 7

## SOILLESS CULTURE.

### ORAL

- Invited lecture: Disease control in soil-less systems - Erik Van Os
- Disinfestation of Polystyrene Seedling Trays for Substrate-based Float Systems in Australia - D.A. Wite, S.W. Mattner, G.G. Baxter, R.C. Mann, R.J Holmes, and I.J. Porter,
- Effect of commercially available composts on plant health – Oliver Grunert, Maaïke Perneel, and Stefaan Vandaele\*
- Effect of ozone treatment on suppressivity of composted sewage sludge on *Meloidogyne incognita* - N. Sasanelli, T. D'Addabbo, L. Mancini and F. Ciccacese

Invited lecture

## DISEASE CONTROL IN SOILLESS SYSTEMS

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Irrigation water is often a source for the dispersal of soil-borne diseases all over the nursery. A systematic approach to water treatment can minimize the spread. Treatment may be executed at the moment the irrigation water enters the nursery, but it should certainly be treated if water is reused. Reuse of supply water is useful for a number of reasons. First there are savings of costs for the grower on water and fertilizers. Secondly a more stable environment of beneficial micro-organisms may develop around the roots, which may form a barrier against pathogens. Third, fewer fertilizers and remnants of crop protection products are leached to the environment resulting in a better ecological condition of ground- and surface water as prescribed by the EU Water Frame Work Directive.

A number of water treatment methods can be used to eliminate pathogens out of the water. Heat treatment, UV-C radiation, slow sand filtration are a few to be mentioned here. These and others will be discussed technically and phytopathologically.

Additional other control aspects will be discussed which may lead to a more efficient use of water, fertilizers and crop protection products.

## DISINFESTATION OF POLYSTYRENE SEEDLING TRAYS FOR SUBSTRATE-BASED FLOAT SYSTEMS IN AUSTRALIA

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Internationally, a move by the tobacco and some vegetable industries to substrate-based float systems has dramatically reduced their use of methyl bromide (MB) for soil disinfestation. The float system utilises expanded polystyrene trays, filled with soil-less substrate, seeded with tobacco or vegetables, and floated on a common pool of water (containing fertilisers) within polyhouses. By 2004, almost 100% of Australian tobacco growers had adopted the float system for transplant production. Growers re-use their trays as many times as possible to minimise cost and waste disposal issues. As trays age and deteriorate, their potential to harbour propagules of key pathogens (e.g. *Rhizoctonia*, *Fusarium* spp.) increases. Furthermore, the micro-environment of the float system (i.e. high plant densities and humidity, plant roots in a common pool of water, etc) favours the development of some diseases, particularly those caused by pathogens with motile spores (e.g. *Pythium* spp.). Prior to phase out, Australian growers fumigated their used trays with MB to minimise the risk of disease occurring in the float system.

Our research investigated four approaches to provide growers with alternatives to MB for tray disinfestation: (a) improved hygiene practices, (b) heat disinfestation, (c) biocidal dips, and (d) alternative fumigants. Results showed there was a strong association between improved hygiene practices by growers (particularly tray handling and storage,  $p = 0.01$ ) and reduced fungal populations on their used trays. Heat disinfestation with aerated steam (1 hr, maximum temperature 80°C) or solarisation (6 wks, maximum temperature 75°C) provided practical and consistent alternatives to MB, reducing fungal populations on trays to undetectable levels and the viability of artificial inoculum of *R. solani* and other pathogens embedded in trays to nil. Although biocides (e.g. NaOCl) and fumigants (e.g. methyl iodide) also reduced pathogen populations on trays, they sometimes caused phytotoxicity in transplants. For example, residues of methyl iodide were detected in trays for 7 days following their removal from fumigation chambers.

Overall, our research showed that improved hygiene practices and tray disinfestation with steam or solarisation provided viable alternatives to MB for minimising the risk of used trays carrying pathogens into the float system.

## EFFECT OF COMMERCIALY AVAILABLE COMPOSTS ON PLANT HEALTH

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Due to increased public concern and strict legislation, plant growers are forced to search for alternatives to chemical fungicides. Biocontrol agents have proven their efficacy *in vitro* and *in vivo*, however the implementation of these agents has not yet been fully adopted. Very often biocontrol agents are too expensive for plant growers or do not survive when mixed with potting soil, since they are not indigenous to potting soil. In addition the efficacy of biocontrol agents depends on many environmental factors which are difficult to control.

Potting soil producers may be able to introduce biocontrol agents for plant growers in the potting soil, on condition that they create a good environment for the biocontrol agents. Many studies demonstrated that compost contains many beneficial micro-organisms which can suppress plant diseases. In this study we examined the effect of different commercially available composts on plant health. Composts were produced from different raw materials which are abundantly available in Belgium. One compost was enriched with *Trichoderma* strains. In this study we compared the effect of sterilized and non sterilized compost at plant level. A large scale plant experiment was conducted in collaboration with plant growers. The results of these experiments will be presented.

## EFFECT OF OZONE TREATMENT ON SUPPRESSIVITY OF COMPOSTED SEWAGE SLUDGE ON *MELOIDOGYNE INCOGNITA*

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Soil amendments from composted sewage sludge is reported to be potentially suppressive to soil phytoparasitic nematodes. A preliminary treatment of compost with gaseous or liquid ozone can reduce heavy metals and suppress biological contaminants contained in raw sewage sludge, but effects on nematode suppressivity of compost amendments are not known.

An experiment on tomato in potting mixes infested by the root-knot nematode *Meloidogyne incognita* was carried out to verify the effect of gaseous ozone treatment on the nematicidal properties of a sewage sludge compost (70% urban green residues and 30% municipal sewage sludge). Composted sewage sludge was treated for 3, 6 and 9 hours with gaseous ozone and then added at 10, 20, 40 and 80 g kg<sup>-1</sup> soil rated to a soil infested by *M. incognita*. Five 1.5 l tomato planted pot replicates were provided for each ozonation time x compost rate combination, whereas controls were represented by infested and nontreated or phenamiphos-treated and untreated and noninfested soil. No ozone treatment affected the nematicidal effect of the compost, as *M. incognita* population from ozonated compost treatment were not statistically different from the nonozonated compost, as well no significant effect was observed on tomato plant growth. All the rates of the sewage sludge compost significantly reduced nematode population density, either in soil and on tomato roots, compared to the no composted soil, whereas only the two highest compost rates significantly reduced formation of galls on tomato roots. Moreover, all the compost amendment resulted also in a significant increase of tomato plant growth.

Gaseous ozone treatments consistently affected the content of soluble heavy metals of the compost, as Mn and Cu concentration was reduced by six and four times, respectively, after a 3 hour ozone treatment, whereas Ni and Fe were reduced by 55 and 60%, respectively, after a 9 hour ozonation.

# SOILLESS CULTURE.

## POSTERS

Effects of Zeolite-Peat Mixtures on Yield and Some Quality Parameters of - S. Kazaz<sup>1</sup>  
and S. Yilmaz<sup>2</sup>

# EFFECTS OF ZEOLITE-PEAT MIXTURES ON YIELD AND SOME QUALITY PARAMETERS OF CARNATION GROWN IN SOILLESS CULTURE

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Soil-borne pathogens have become more and more problematic due to continuous production of carnation in recent years in Isparta Province of Turkey. Methyl bromide (MB) was the most effective soil fumigant to control soil-borne diseases, pests and weeds. However, the use of MB had been phased out at the end of 2007 in Turkey. Other methods such as steam, solarization and some chemicals currently used to control these problems are hazardous, ineffective and costly. Therefore, soilless culture may be an effective tool to control soil-borne pathogen in Turkey.

Initial investment cost of soilless culture is also expensive; however, locally available substrates may reduce production cost in the long term. Substrates (zeolite and peat) used in this study are locally and large quantitatively available in Turkey. Effects of zeolite and peat mixtures on carnation yields and some quality parameters were investigated in this study. An open soilless culture system was used to grow carnations under plastic-houses. Two standard carnation varieties (Silkroad and Falcon) grown on two different sizes of zeolite and peat mixtures (particle sizes: 0-0.5 mm and 0.8-2.8 mm) at ratios of 1z:1p, 2z:1p and 3z:1p, v/v were produced.

Results of this study indicated that effects of growing media and varieties on yields and quality parameters were statistically significant. The highest yields for per plant in both varieties (Falcon; 4.87 stems, Silkroad; 4.68 stems) were obtained from 0-0.5 mm sizes of zeolite+peat mixture at the ratio of 3z:1p, v/v. The lowest yield was in 0-0.5 mm sizes of zeolite medium for both varieties. In conclusion; mixtures of zeolite and peat can be successfully used to grow carnations. However, 0-0.5 mm size of zeolite alone may not be suggested for carnation production in Isparta Province.

# biological control

## POSTERS

- Biocontrol of Eggplant Bacterial Wilt with Combination of Avirulent Bacteriocin Producing Strain of *Ralstonia solanacearum* and Rhizosphere Bacteria - Triwidodo Arwiyanto<sup>1</sup> and Suhartiningsih Dwi Nurcahyanti<sup>2</sup>
- Determination of Deoxynivalenol in corn crop at Ardabil province in Iran and related Fusarium species in 2007-2008 - Z.Aliakbari<sup>1</sup>, H. Aminian<sup>1</sup>, M. Mirabolfathi<sup>2</sup> and R. Karami-Osboo<sup>2</sup>
- Evaluation of Trichoderma Isolates for Biological Control of Crown and Root rot in wheat (*Bipolaris spicifera*(Bain.)Subram) - H. R. Etebarian and M. Mohammadifar
- Tolerance to Allelopathy and Fusarium Disease in Mycorrhizal Asparagus Plants Raised in Decline Soil - Y. Matsubara, T. Okada and A. S. M. Nahiyani

## BIOCONTROL OF EGGPLANT BACTERIAL WILT WITH COMBINATION OF AVIRULENT BACTERIOCIDIN PRODUCING STRAIN OF *RALSTONIA SOLANACEARUM* AND RHIZOSPHERE BACTERIA

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Bacterial wilt of eggplant (*Ralstonia solanacearum*) is difficult to control by any available means. Biological control based on antagonism was conducted by protecting root system with antagonistic bacteria. A fluorescent pseudomonad (*Pseudomonas putida*, Pf-20 strain) isolated from the rhizosphere of *Mimosa invisa* proved could suppress *R. solanacearum in vitro*, reduced disease intensity in the greenhouse and field experiments. However, the degree of protection is low. The use of more than one species of microorganisms to control plant pathogen likely enhance the protection level.

An avirulent-bacteriocin producing strain of *R. solanacearum* (Rs-127) was chosen as a companion of Pf-20 to control eggplant bacterial wilt. Rs127 could inhibited the growth of other *R. solanacearum* isolate with the inhibition zone of 12,63 mm in average and as much as 86% of other isolate were inhibited. Rs-127 did not inhibit the growth of Pf-20 in YPGA and CPG medium. However, Pf-20 inhibited the growth of Rs-127 in King's B medium but not in YPGA and CPG medium. The greenhouse test showed that dipping eggplant root system in bacterial suspension of Rs 127 and Pf 20, both singly and in combination was able to suppressed the disease and lengthen the incubation period. The treatment also increased the fresh weight and dry weight of shoot and root.

# DETERMINATION OF DEOXYNI VALENOL IN CORN CROP AT ARDABIL PROVINCE IN IRAN AND REALATED FUSARIM SPECIES IN 2007-2008

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Corn ear rot disease can reduce yield and quality of corn. Some of the *Fusarium* species that infect corn ears may produce mycotoxins such as trichothecenes, that are harmful, and can be fatal. Deoxynivalenol contamination of forty maize samples of Ardabil province (Moghan) were collected at harvest time were estimated. All of the kernels of each sample were grounded with Romer II mill. 200ml distilled water was added to 25g of each grounded samples and shook in 150rpm for 30min. Extracted Deoxynivalenol was filtrated by Whatman filter paper NO 1. 1.4 ml of filtrated solution was cleaned up through (R-biopharm) immunoaffinity columns. deoxynivalenol was measured using HPLC at 222 nm, the mobile phase was Acetonitrile: Methanol: Water (8: 8: 84v/v). Standard curve was drown in range of 12.5-2000ng/gr (R2=0/9995). Validation of the method was determined using 500 and 1000 ng/g spike samples, the recovery of the method for 500 and 1000 ng/g spike samples were 101/9%, 96% respectively. 55% samples are contaminate to DON. The range of contamination was 35.4- 542.55 ng/g. The mean of contamination was 165.7 ng/g that was less than maximum rate limit of deoxynivalenol which was recommended in the world (1ppm). In mycological studies all of the 40 kernel samples cultured on Nash-synder and Czapek media to isolate *Fusarium* species. For identification of *Fusarium* species PDA,CLA and SNA media and Leslie species description were used. Based on morphological and some of the phvsiological characteristics *F.verticioillides*(36%) ,*F.proliferatum*(21%) ,*F.noniliforme*(15%), *F.nygamaie* (10%) and *F.oxysporum* (18%) were collected. To identify the toxicogenic character of each species, rice matrix were contaminated artificially with representatives of each species and deoxynevalenol of each inoculated media estimated using IAC+ HPLC metho. In finally, *F.proliferatum* was toxicogenic within isolates

## EVALUATION OF *TRICHODERMA* ISOLATES FOR BIOLOGICAL CONTROL OF CROWN AND ROOT ROT IN WHEAT (*BIPOLARIS SPICIFERA* (BAINER) SUBRAM)

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*Trchoderma harzianum*M, *T.harzianum* T39, *T.viride*(MO) and *T.virens* DAR74290 were used as potential biological agents for control of wheat crown and root rot caused by *Bipolaris spicifera*. Dual culture and volatile test were used for antifungal activity of Trichoderma isolates. Percentage of growth inhibition of *Bipolaris spicifera* by *T.harzianum* M, *T.harzianum* T39, *T.viride* and *T.virens* DAR 74290 were 53.39, 37.37, 33.11 and 40.4 in dual culture and 71.5 , 52, 66.5 and 5.64 in volatile test respectively. Results of glasshouse experiments indicated that *T.viride* (MO) was the most effective. All isolates reduced disease incidence and disease severity in micro plot test. There were no significant differences between benomyl and Trichoderma treatments. The effect of benomyl and Trichoderma isolates was similar on reducing disease of crown and root rot of wheat.

# TOLERANCE TO ALLELOPATHY AND FUSARIUM DISEASE IN MYCORRHIZAL ASPARAGUS PLANTS RAISED IN DECLINE SOIL

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In asparagus producing regions, early decline or replant problem frequently occur in the fields. These phenomena are known as asparagus decline. Asparagus decline is supposed to be caused by the contribution of both abiotic (allelopathy etc.) and biotic (disease) factors. Previously, we clarified *Fusarium oxysporum* f. sp. *asparagi* (Foa) and *Fusarium proliferatum* (Fp) were most important biotic factors in Japan by PCR-SSCP method. In this study, the efficacy of growth control with arbuscular mycorrhizal fungi (AMF) on allelopathy and diseases were investigated.

Asparagus (*Asparagus officinalis* L. cv, Welcome) plants inoculated with 4 AMF species were raised in decline field soil, contained allelochemicals determined by bioassay, and in commercial substrate. Ten weeks after AMF inoculation, conidial suspensions ( $10^6$  cfu/ml) of Foa (MAFF305556) and Fp (SUF1207) were inoculated to mycorrhizal plants, and Hoagland solution was fertilized every 2 weeks and raised in greenhouse. After AMF inoculation, plant growth, incidence of diseases and contents of antioxidative substances (polyphenol and ascorbic acid) were investigated. Ten weeks after AMF inoculation, dry weight of shoots and roots increased in AMF plants of both the decline soil and substrate, regardless of the species. Thus, plant growth promotion via symbiosis and allelopathy tolerance appeared in mycorrhizal asparagus plants. On the other hand, contents of polyphenol and ascorbic acid showed higher values in most of the AMF plants than in non-AMF ones; the effect depends on plant portions. As for disease tolerance, incidence and severity of both Foa and Fp were lower in AMF plants than in non-AMF ones, though the effect differed according to AMF species with *Glomus intraradices* and *Gigaspora margarita* being most effective.

From these findings, it is suggested that plant growth promotion through AMF is effective for inducing tolerance to allelopathy and diseases in asparagus plants. This proposal seeks to develop a sustainable practice to manage the disease and improve plant health, thus contributing to an improvement in asparagus decline.