SECOND INTERNATIONAL CONFERENCE ON SOIL SOLARIZATION AND INTEGRATED MANAGEMENT OF SOILBORNE PESTS

Program & Abstracts Book

March 16-21, 1997

ICARDA, Aleppo, Syria

SECOND INTERNATIONAL CONFERENCE ON SOIL SOLARIZATION AND INTEGRATED MANAGEMENT OF SOILBORNE PESTS

Contents

Second International Conference on Soil Solarization and Integrated Management of Soilborne Pests

16-21 March, 1997

Aleppo, Syria

PROGRAM

Sunday, March 16, 1997

09:00-11:00 Registration

11:00-11:30 Opening Ceremony

11:30-12:15 Keynote address

(1) Soil solarization: past, present, and future. ***James E. DeVay (USA). (To be presented on his behalf by James J. Stapleton)***

12:15-13:00 Introductory Presentation

(2) Soil Fumigation: Present and future Constraints. ***Franco Lamberti and J.W. Noling (Italy).***

13:00-14:00 Lunch Break

SESSION ONE: APPLICATIONS OF SOIL SOLARIZATION

Chairman: Mohamed Besri

14:00-14:40 (3) Invited Paper: Pre- and Post-Plant Solarization. ***Waleed Abu-Gharbieh (Jordan).***

14:40-14:55 (4) Evaluation of short periods of treatment by solar chamber for controlling Verticillium wilt of olive. ***Majed Ahmad Al-Ahmad and A. Duksi (Syria).***

14:55-15:10 (5) Assessment of soil solarization efficacy through monitoring of *Verticillium* population in the soil. ***Epaminondas Paplomatas (Greece) and A.J. Termorshuizen (The Netherlands).***

15:10-15:30 (6) Influence of soil moisture content on soil-solarization efficiency. ***Ali Al-Karaghouli and A.W. Al-Kayssi (Iraq).***

15:30-16:00 Coffee Break.

16:00-16:20 **(7)** Comparison of solarization techniques to disinfest soil for containerized nursery production. ***James J. Stapleton, L. Ferguson and M.V. McKenry (USA).***

16:20-16:35 **(8)** A new approach for soil solarization by using parafin-wax emulsion as a mulching material. ***Abdul W. Al-Kayssi and A. Al-Karaghouli (Iraq).***

16:35-16:50 **(9)** Effect of seed-bed solarization on cabbage and lettuce transplants quality. ***Mamdouh M.F. Abdallah, S.A. El-Hadad and M.M. Satour (Egypt).***

16:50-17:15 **(10)** Improvement in plastic technology for greenhouse films. *M. Basile and Franco Lamberti (Italy).*

Monday, March 17, 1997

SESSION TWO: MODE OF ACTION AND LONGEVITY OF SOIL SOLARIZATION

Chairman: Jean Beagle Ristaino

09:00-9:40 **(11)** Invited Paper: Modes of action of solarization and biofumigation. ***James J. Stapleton (USA).***

09:40-10:20 **(12)** Invited Paper: Longevity of solarization and effects of solar heating. ***Eleftherios Tjamos and Polymnia P. Antoniou (Greece).***

10:20-10:35 **(13)** Thermal effects of coextruded black plastic mulches in greenhouse soil solarization. *C. Arcidiacono, **Giovanni Cascone, D. Gutkowski and C.R. Fichera (Italy).***

10:35-10:50 **(14)** Long-term effect of soil solarization on density levels of *Fusarium* spp. in established fruit tree orchards. ***Hifzi A. Abu-Blan, W.I. Abu-Gharbieh, F. Shatat (Jordan).***

10:50-11:15 Coffee Break

SESSION THREE: SOIL SOLARIZATION & CONTROL OF FUNGAL PATHOGENS

Chairman: Waleed Abu-Gharbieh

11:15-11:30 **(15)** Soil Solarization in the control of sclerotial fungi in Pakistan. *S.M.H. Usmani, A.H. Sheikh and Abdul Ghaffar (Pakistan).*

11:30-11:45 **(16)** Effect of soil solarization on root rot of wheat and population of soilborne *Fusarium graminearum* and *Cochliobolus sativus*. ***Mohamed A. El-Meleigi** (Saudi Arabia).*

11:45-12:00 **(17)** Effect of soil solarization and methyl bromide fumigation on Fusarium wilt of muskmelon in the Jordan Valley. ***Zakaria A.M.Musallam and W.I. Abu-Gharbieh (Jordan).***

12:00-12:15 **(18)** Soil Solarization: a management practice for corn stalk rot. ***Yasmin Ahmad, A. Hameed and M. Aslam (Pakistan).***

12:15-12:30 **(19)** Effect of soil solarization on soilborne pathogens in Lebanon. ***Hana Sobh and Y. Abou-Jawdah (Lebanon).***

12:30-12:45 **(20)** Effect of seed-bed solarization on onion smut disease control. ***Medhat Saad Abd El-Megid, A.S. Ibrahim, S.A. Khalid and M.M. Satour (Egypt).***

12:45-14:00 Lunch Break

SESSION FOUR: SOIL SOLARIZATION & CONTROL OF BACTERIAL PATHOGENS
Chairman: Eleftherios Tjamos

14:00-14:20 **(21)** Effect of soil solarization in controlling *Clavibacter michiganensis* subsp. *michiganensis*, the bacterial canker of tomatoes in plastic houses in Greece. ***Polymnia P. Antoniou, E.C. Tjamos and C.G. Panagopoulos (Greece).***

14:20-14:40 **(22)** The effect of soil solarization on bacterial canker of tomato in the Mediterranean region of Turkey. ***Sebiha Tokgönül, Ö. Çinar (Turkey) and K. Rudolph (Germany).***

14:40-15:00 **(23)** The effect of soil solarization on the survival of bacterial speck on the tomato plant debris in soil. ***Yesim Aysan, Ö. Çinar (Turkey) and K. Rudolph (Germany).***

15:00-15:30 Coffee Break

SESSION FIVE: SOIL SOLARIZATION AND WEED CONTROL
Chairman: Clyde L. Elmore

15:30-15:50 **(24)** Soil solarization: an alternative technique for weed management in hot climates. ***Abdur-Rahman Saghir (Lebanon).***

15:50-16:10 **(25)** Effects of soil solarization on weed infestation and on mycorrhiza development. ***Jean-Pierre Caussanel, A. Trouvelot, J. Vivant and S. Gianinazzi (France).***

16:10-16:30 **(26)** Comparative solarization effects on seed germination of *Cuscuta* and *Orobanche* species. ***Barakat E. Abu-Irmaileh and S. Thahabi (Jordan).***

16:30-16:50 **(27)** Effect of soil solarization on *Orobanche* in the central Sudan. ***Nasr Eldin Khairi Abdalla*** *and Z.T. Dabrowski (Sudan).*

16:50-17:10 **(28)** Soil solarization for controlling *Avena sterilis*, *Bromus diandrus* and *Sinapis arvensis* in greenhouse in Greece. *G. Economou, G. Mavrogiannopoulos and* ***Evangelos A. Paspatis*** *(Greece).*

17:10-17:30 **(29)** Soil Solarization for control of dodder and other weeds in Lebanon. ***Mustapha A. Haidar*** *and N. Iskandarani (Lebanon).*

Tuesday March 18, 1997

SESSION SIX: SOIL SOLARIZATION AND CONTROL OF PLANT PARASITIC NEMATODES

Chairman: Franco Lamberti

09:00-09:15 **(30)** Effectiveness of solarization for controlling plant parastic nematodes in plastic houses. ***Fauzi A. Bisheya, W.I. Mansour, A. Abughnia and A. Hagi (Libya).***

09:15-9:30 **(31)** Organic manure has an additive effect to soil solarization for the control of soilborne pests. ***Mehdi Nasr Esfahani,*** *A. Akhiyani and A. Ahmadi (Iran).*

09:30-9:45 **(32)** Effectiveness of soil solarization against *Meloidogyne javanica* and *Heterodera schachtii* in the Jordan valley. ***Haleemah Saeed and W.I. Abu-Gharbieh (Jordan).***

09:45-10:00 **(33)** Potential of soil solarization as a non-chemical approach for managing wheat cyst nematode, *Heterodera avenae* in Gassim region, Central Saudi Arabia. ***Ahmed A. Osman*** *and Medhat M. Belal (Saudi Arabia).*

10:00-10:15 **(34)** Soil solarization to control plant parasitic nematodes. ***Saud Salim Al-Harthy and A. Mani (Sultanate of Oman)***

10:15-10:45 Coffee Break

SESSION SEVEN: SOIL SOLARIZATION AND CROP YIELD

Chairman: Abdur-Rahma Saghir

10:45-11:05 **(35)** Effect of soil solarization and soil fumigation on strawberry yield in southern Italy. *M. Basile,* ***Franco Lamberti*** *and A.C. Basile (Italy).*

11:05-11:20 **(36)** Solarization and Mycorrhizas in the production of ornamental bedding plants. ***Elsa L. Ulla, V.A. Cordaro and M.C. Vidal de Latina (Argentina).***

11:20-11:35 **(37)** Effect of soil on soil-borne diseases control and increasing pepper and cucumber productivity. ***Safwat A. El-Haddad, A.S. Ibrahim and M.M. Satour (Egypt).***

11:35-11:50 **(38)** Effect of soil solarization treatments on weed control and yield of Garlic. ***Ibrahim A. Farag (Egypt).***

SESSION EIGHT: SOIL SOLARIZATION AND INTEGRATED MANAGEMENT OF SOILBORNE PESTS

Chairman: James J. Stapleton

11:50-12:30 **(39)** Invited Paper: Contribution of soil solarization to integrated pest management systems for field production. ***Dan O. Chellemi (USA).***

12:30-13:10 **(40)** Invited Paper: Solarization in integrated management systems for greenhouses. ***Girolamo Cartia (Italy).***

13:10-14:00 Lunch Break

14:00-14:20 **(41)** Experience acquired in southern Italy in controlling soil-borne pathogens by soil solarization and chemicals. ***Girolamo Cartia, N. Greco and P. Di Primo (Italy).***

14:20-14:40 **(42)** Effect of organic amendments, soil solarization, and other interaction on soilborne microorganisms and yield of plastic house cucumber. ***Nazmi K. Abdulhadi, W.I. Abu-Gharbieh and S. Khattari (Jordan).***

14:40-15:00 **(43)** Studies on the effect of soil solarization combined with fumigants and antagonists in greenhouses to control soil borne pathogens in the east Mediterranean region of Turkey. ***Seral Yücel and S. Çali (Turkey).***

15:00-15:20 **(44)** Efficacy of solarization vis-a-vis natural heating of residue amended soils for management of soil-borne pathogens. ***Satish Lodha, S.K. Sharma and R.K. Aggarwall (India).***

15:20-15:45 Coffee Break

SESSION NINE: INTEGRATED MANAGEMENT OF SOILBORNE PESTS
Chairman: Girolamo Cartia

15:45-16:25 **(45)** Invited Paper: Integrated management of soil-borne pests in protected cultivation: Constraints and perspectives. ***Mohamed Besri (Morocco).***

16:25-16:40 **(46)** Effect of garlic extracts and volatiles on *Fusarium oxysporum*. ***Nafisa E. Ahmed and A. Hamid (Sudan).***

16:40-16:55 **(47)** Influence of *Glomus intrardics* on tomato root-knot-wilt disease complex. ***Zuhair A. Stephan, M.S. Hassan, H. Ibrahim, B.G. Antoon and M.Sh. Georgees (Iraq).***

Wednesday, March 19, 1997

09:00-12:00 Visit of field trials at ICARDA and Idlib.

(1) Effect of soil solarization on the control of lentil wilt (ICARDA).
(2) Effect of soil solarization on the control of *Orobanche* (ICARDA).
(3) Effect of soil solarization on the control of Nematodes (ICARDA).
(4) Effect of soil solarization on the control of *Orobanche* (Idleb).

12:00-16:00 Visit of St. Simeon (Lunch boxes will be provided)

Thursday, March 20, 1997

SESSION NINE (CONTINUED): INTEGRATED MANAGEMENT OF SOILBORNE PESTS
Chairman: Eckart Schlosser

09:00-9:15 **(48)** Effect of inoculum source type and cultural practices on the spread of *Phytophthora capsici* in bell pepper. ***Jean Beagle Ristaino, G. Parra and C.L. Campbell (USA).***

09:15-9:30 **(49)** Effect of the water salinity on the development of tomato verticillium wilt. ***Mohamed Besri (Morocco).***

09:30-9:45 **(50)** Towards an integrated disease management of wilt/root rot of chickpea and lentil in WANA. ***Chris Akem, S. Kemal and B. Bayaa (Syria).***

09:45-10:00 **(51)** Integrated control of root-knot nematodes in greenhouse tomato crop. ***Effie Vouyoukalou (GREECE), S. Gowen (United Kingdom) and D. Trudgill (Scotland).***

10:00-10:15 **(52)** Nematode trapping fungi from Sudanese soils. ***El-Nour El-Amin Abdel Rahman (Sudan).***

10:15-10:30 **(53)** Integrated control of root-rot/ wilt diseases in faba bean, lentil and Chickpea. *A. M. Hassanein, G.A. El-Morsy, N.M. Abou-Zeid and Samia A. Mahmoud (Egypt).*

10:30-11:00 Coffee Break

SESSION TEN: PREDICTION MODEL FOR SOIL SOLARIZATION
Chairman: Carl Bell

11:00-11:40 **(54)** Invited Paper: Range of pest controlled by solarization and their heat sensitivity. ***Clyde L. Elmore (USA).***

11:40-12:20 **(55)** Invited Paper: Recent advances in temperature predictive models for soil solarization. ***Jean Beagle Ristaino, K.B. Perry and Y. Wu (USA).***

12:20-12:40 **(56)** A device simulating the thermal regimes of soil solarization in laboratory experiments. *G. Burrafato, G. Cartia and* ***Diego Gutkowski (Italy).***

12:40-13:00 **(57)** Experimental tests on new materials and techniques for soil solarization and mathematical models for the prediction of soil temperature. ***Giacomo Scarascia Mugnozza,*** *G. Russo, G. Vox and F. De Santis (Italy).*

13:00-14:00 Lunch Break

SESSION ELEVEN: ECONOMICS OF SOIL SOLARIZATION
Chairman: Barakat B.E. Abu-Irmaile

14:00-14:40 **(58)** Invited Paper: The Economics of Solarization comapred to Conventional Agricultural production. ***Carl Bell (USA)***

14:40-15:00 **(59)** Impact of the quality of polyethylene on the ecnomics of soil solarization technology. ***Mohamed Y. Sultan (Egypt).***

15:00-15:30 Coffee Break

SESSION TWELVE: ROUND TABLE DISCUSSION
Facilitator: James J. Stapleton

15:30-17:00 Conclusions and recommendations

SESSION THIRTEEN: POSTERS ***(Posters will be displayed during the whole period of the conference)***

(P1) Effects of soil plastic coverage on citrus nematode populations, *Tylenchulus semipenetrans* in citrus orchard. ***Ahmed El-Sayed Ismail and H.Z. Aboul-Eid (Egypt).***

(P2) Effect of soil solarization treatments on weed control and yield of faba bean. ***Ibrahim A. Farag (Egypt).***

(P3) Solar chamber as an inclusive method to control *Verticillium* wilt of olive trees. ***Majed Ahmad Al-Ahmad and A. Duksi (Syria).***

(P4) Solarization for controlling soil-borne fungi in plastic houses. ***Salah Al-Chaabi and L. Matrod (Syria).***

(P5) Effect of soil solarization on population densities of some soil microorganisms. ***Salah M. Mahmoud (Egypt).***

(P6) Effects of solarization against strawberry root-rot disease in the East Mediterranean region of Turkey. ***Hülya Pala and A. Çinar (Turkey).***

(P7) Studies on solarization against root-knot nematodes and weeds in vegetable greenhouses in Mediterranean Region of Turkey. ***Ilknur Tekin, Izzet Kadioglu and Ilhan Üremiş (Turkey).***

(P8) Control of *Ditylenchus dipsaci* on onion by soil solarization and fumigant nematicides. ***N. Sasanelli, M. Basile and Franco Lamberti (Italy).***

(P9) Longevity of solarization using black plastic tarping. ***W.I. Abu-Gharbeih and Luma Al Banna (Jordan)***

(P10) Establishment, survival, and growth of apple trees (*Malus domestica* 'Granny Smith') using post-plant solarization in soil infested with *Sclerotium rolfsii*. ***James J. Stapleton (USA).***

(P11) Integrated pest management fresh market tomato (*Lycopersicon esculentum* 'Shady Lady') using combined soil solarization and reflectorized Mulch. ***James J. Stapleton and C.G. Summers (USA).***

(P12) Solarization for Pest Management in Hot Arid Lands. ***Ahmed A. Al Masoum, Ahmed A. Hashim, O. Khalifa and A. Al Asaal (UAE).***

(P13) Fluctuation of population densities of *Fusarium oxysporum* f.sp. *dianthi* after incorporation in natural, solarized and sterilized soil. ***Kalomira Elena, E.C. Tjamos and Z. Tsekoura (Greece).***

(P14) Use of soil solarization for controlling fungal plant pathogens in plastic houses in Libya. ***Fauzi A. Bisheya, A. Abughnia, H. Douzan and M. Gajem (Libya).***

17:00-17:30 Closing

19:00-21:00 Farewell Dinner

Friday, March 21, 1997

Visit to Palmyra and Continue to Damascus

Saturday, March 22, 1997

Departure of Participants.

ORAL PRESENTATIONS

1

SOIL SOLARIZATION: PAST, PRESENT, AND FUTURE. J.E. DeVay. Department of Plant Pathology, University of California, Davis, CA 95616, USA.

Soil solarization, a procedure used primarily for the disinfestation of soil, was described over 20 years ago and quickly became of intense interest because it was nonchemical, environment friendly, and was an effective approach for integrated pest management. The principles of soil solarization and its multiple mechanisms of action for managing plant pathogens have been well defined. However, much remains to be done to define the changes in soil chemistry and biology that induce the increased growth response and crop yields which are associated with its use. Environmental conditions, such as air temperature, day length, and hours of sunlight are limiting in some agricultural regions for effective soil solarization; however, these limitations may be compensated for during solarization in greenhouses. This greenhouse effect can also be accomplished by using double layers of plastic sheets separated by 2 to 3 cm under field conditions. Future advances in soil solarization can be accomplished with improvements in plastic films, the use of double layers of plastic sheets, addition of organic amendments to soil, and the introduction of biocontrol organisms into solarized soil.

2

SOIL FUMIGATION: PRESENT AND FUTURE CONSTRAINTS. F. Lamberti[1] and J.W. Noling[2]. (1) Istituto di Nematologia Agraria, C.N.R., Bari, Italy; (2) University of Florida, IFAS, Citrus Research Center, Lake Alfred, Florida, U.S.A.

Soil fumigation for the control of soil borne plant pathogens and pests has been extensively and profitably used in the last 65 years. Chloropicrin was released in large quantities for soil fumigation on a commercial scale in the early 1930's; in 1941 it was demonstrated that methyl bromide is a broads pectrum biocide; 1,3-dichloropropene, 1,2-dichloropropane mixture (DD) was reported in 1943 as an excellent nematicides; the nematicidal activity of ethylene dibromide (EDB) was discovered in 1944; 1,2-dibromo-3-chloropropane (DBCP), an effective nematicide with a low degree of phytotoxicity, was patented in 1954; sodium methyldithiocarbamate is being used as a nematicide since 1956. Some of these fumigants have now been banned, such as DD, EDB and DBCP or are in the process of being phased out, e.g. methyl bromide. Fumigants are generally very effective biocides or nematicides; however many of them cause major environmental problems and/or may be hazardous to humans and animals. Their costs and technology of applications are also constraints to be considered.

3

PRE- AND POST-PLANT SOIL SOLARIZATION. W.I. Abu-Gharbieh. Department of Plant Protection, Faculty of Agriculture, University of Jordan, Amman, Jordan.

Soil solarization is gradually becoming one of the recognized control strategies of soilborne pathogens, weeds and arthropods. Studies, particularly in hot climate areas, demonstrated effectiveness of this method with many vegetables, field crops, fruit trees, ornamental plants and nursery transplants. Soil solarization causes chemical, physical and biological changes in the soil that improve plant growth and development and often results in substantial yield increases. In some parts of the world, pre-plant solarization is substituting for chemical control or actively integrated in IPM programs in greenhouse and open field production systems. In Jordan, the soils of 350 ha of plastic houses were solarized using transparent PE, and 2000 ha of open field lands were solarized with black plastic tarping, in 1995. More recently, post-plant solarization was employed in established orchards, planted to trees or perennial crops. It proved effective with some crops and under certain conditions, but was less satisfactory, or even inadequate in other instances. More research is required in this area.

4

EVALUATION OF SHORT PERIODS OF TREATMENT BY SOLAR CHAMBER FOR CONTROLLING VERTICILLIUM WILT OF OLIVE. M.A. Al Ahmad and A. Duksi. Plant Protection Division, Directorate of Agricultural Scientific Research, Douma, Syria.

Positive results obtained from solar-chamber to control Verticillium wilt of olive encouraged us to evaluate effectiveness of different periods of exposure and give recommendation for appropriate use of solar-chamber as a tool for controlling such a difficult disease. Many short duration exposures were used in different locations. In Chikh-Alhadeed, exposure periods of 12, 24, 36, 48, 60 hours were used. The percentage of curing was 50, 66, 100, 100 and 100, receptively. In Jendires one exposure period of 24 hours was used and the percentage of curing was 80. In Pesslia, the exposures used were 6, 12 and 24 hours and the percentage of curing were 33, 100 and 66, respectively. in Tapabis the same exposures as in Pesslia were used and the percentage of curing was 50, 100 and 100. The explanation of curing related to elevation of temperature which expose all treated parts to high temperature enough to kill the pathogen. The failure of curing resulted from the fact that the treated trees did not receive enough quantities of temperature to kill the pathogen present inside them, due to low outside temperature and the tightless Chamber. The scorching of new shoots observed in some of the treated trees resulted from exposing trees to high temperatures for a prolonged time. Based on these trials, it was possible to determine a relationship between the outside air temperature and inside chamber temperature and accordingly determine the duration of treatment of diseased trees to achieve recovery as follows:

Air Temperature	Proposed duration of treatment of Solar-Chamber	
30 - 32°C	30	Hours
33 - 34°C	12 - 24	Hours
34 - 35°C	12	Hours
> 36 °C	6	Hours

5

ASSESSMENT OF SOIL SOLARIZATION EFFICACY THROUGH MONITORING OF *VERTICILLIUM DAHLIAE* POPULATION IN THE SOIL.

E.J. Paplomatas[1] and A.J. Termorshuizen[2]. (1) Benaki Phytopathological Institute, 8 S. Delta Str., 145 61 Kifissia, Athens, Greece; (2) Department of Plant Pathology, Wageningen Agricultural University, P.O. Box 8025, 6700 EE Wageningen, The Netherlands.

Quantification of microsclerotia of *Verticillium dahliae* in the soil is one method to assess the efficacy of soil solarization. Monitoring of *V. dahliae* populations employs several methods based on plating of soil dilutions (with or without wet sieving) or dry soil (using the Andersen sampler) on diverse growth media. The objectives of this study was to evaluate detection techniques applied in 12 laboratories worldwide by a group of researchers formed at the Sixth International Verticillium Symposium and coordinated by the second author. Each participant provided an air dried and ground soil sample that was sent to The Netherlands for subsampling and redistribution. Six replicates of each sample were subsequently sent to each participant along with two control soil samples prepared by the coordinator, which contained known densities of 5 and 60 microsclerotia/g soil. In the assessment of the plated agar dishes it appeared that many participants were confusing colonies of *V. dahliae* and *V. tricorpus*. However, this could not explain the very large (up to a factor of 500 times) differences in the number of propagules of *V. dahliae* reported by the participants, since *V. tricorpus* densities were relatively low. Comparison of data for each participant was possible after calibration using the data from the samples with known densities. Recoveries of the control samples ranged between 25-40%. However, it can be concluded that methods which lead to reproducible and not too low recoveries of the known samples could be acceptable as long as they are reproducible for different soil types.

6

INFLUENCE OF SOIL MOISTURE CONTENT ON SOIL SOLARIZATION EFFICIENCY. A. AL-Karaghouli and A.W. Al-Kayssi. Solar Energy Research Center, Jadiriyah, P.O. Box 13026, Baghdad, Iraq.

A field experiment was conducted at Fudhiliyah Agrometeorological Research Station to investigate how soil temperature is influenced by different soil moisture content regimes during soil solarization. Two soils, sandy loam and silty clay loam, were brought to five volumetric moisture regimes (M1-M5). The moistened soils were mulched with a 180 μm transparent polyethylene. Measurements of hourly soil temperatures for the depths 0.00, 0.05, 0.10, and 0.30 m were recorded from the 1st of June to the 30th of September. The results showed that the maximum soil temperatures were decreased with increasing soil moisture content. The relationship between the hourly rise in soil temperature and heat flux were significantly affected by soil moisture content. Moreover soil solarization efficiency was found to decrease with increasing moisture content. Higher temperatures obtained at the moisture content M4 of both soils, resulted in a faster killing of the tested pathogenic fungus, *F. oxysporium* f.sp. *lycopersici*.

7

COMPARISON OF SOLARIZATION TECHNIQUES TO DISINFEST SOIL FOR CONTAINERIZED NURSERY PRODUCTION. J.J. Stapleton, L. Ferguson, and M.V. McKenry. Kearney Agricultural Center, University of California, Parlier, CA 93648, USA.

Solarization was tested during summer 1995 and 1996 for its potential to disinfest nursery soils of certain nematode and fungal pathogens which attack a variety of perennial crops in California's inland valleys. Moist field soils naturally infested with nematode pathogens including the citrus nematode (*Tylenchulus semipenetrans*), lesion nematode (*Pratylenchus vulnus*), or ring nematode (*Criconemella xenoplax*), and with the fungal pathogen *Pythium ultimum*, were placed in black polyethylene (poly) planting sleeves or left in 30 cm high piles and subjected to one of four treatments for a period of one to four weeks: (1) placed on a sheet of black poly in the field and exposed daily to open sun; (2) as #1, but also covered with a single layer of transparent poly film; (3) as #1, but also covered with two layers of transparent poly separated by wire hoops; or (4) not heated. Soil temperatures reached as high as 48, 69, and 72 °C in treatments 1, 2, and 3, respectively. Numbers of each of the test pathogens were reduced by 89-100% by the various solarization techniques. Results of these experiments indicated that solarization may be used commercially in nursery operations in the SJV and other desert areas in California; further tests are underway.

8

A NEW APPROACH FOR SOIL SOLARIZATION BY USING PARAFIN-WAX EMULSION AS A MULCHING MATERIAL. A.W. Al-Kayssi and A. Al-Karaghouli. Solar Energy Research Center, Jadiriyah, P. O. Box 13026, Baghdad, Iraq.

The soil mulching material significantly affects the energy balance and soil thermal regime. In order to study the effect of soil mulching with a parafin-wax emulsion on soil thermal regime, a one-dimentional numerical model was developed, which simulates the microlimate of the mulched soil.The model consists of two layers: soil, and parafine-wax emulsion film. Climatic conditions, soil physical characteristics, and photometric properties of the mulching material are considered. Field measurements verify the model's ability to predict the temperature regime of the mulched soil. Both numerical and field experiments show that mulching the soil with parafin-wax emulsion, rather than transparent polyethylene ones, results in more effective heating of the soil and, therefore, faster killing of soilborne pathogenic fungi. Physically based explanations are given for the measured and computed results.

12

LONGEVITY OF SOLARIZATION AND EFFECTS OF SOLAR HEATING. E.C. Tjamos and P.P. Antoniou. Department of Plant Pathology, Agricultural University of Athens, Votanikos 118 55, Athens, Greece.

Several factors have been implicated in the phenomenon of the long-term effect of soil solarization in controlling certain soil-borne pathogens. The most well studied parameters include: (1) Survival and increase of thermotolerant fungal or bacterial antagonists following application of soil solarization leading to induced fungistasis; (2) Weakening effect imposed by sublethal heating and antagonistic action of prevailing antagonists in biological niches located beyond the region of the direct lethal effect of the method; (3) Induced systemic resistance to disease most possibly triggered by the surviving bacterial microflora. Fungal diseases caused by *Verticillium dahliae* (globe artichokes, tomatoes, and olives) by *Fusarium oxysporum* f.sp. *vasinfectum* (cotton), by *Pyrenochaeta lycopersici* (tomatoes) and recently the bacterial disease known as bacterial cancer of tomatoes caused by *Clavibacter michiganensis* subsp. *michiganensis* are known to be controlled for more than one consecutive cultural periods following a single application of soil solarization. The basic and the current knowledge on the topic will be broadly analysed and discussed.

9

EFFECT OF SEED-BED SOLARIZATION ON CABBAGE AND *LETTUCE TRANSPLANTS QUALITY*. M.M.F. Abdallah[1], S.A. El-Hadad[2] and M.M. Satour[2]. (1) Dept. of Hort. Faculty of Agri., Ain Shams Univ., Cairo, Egypt; (2) Plant Path. Res. Institute, Agric. Res. Center, Giza, Egypt.

A field experiments on Cabbage and lettuce seed-bed solarization were conducted at Ismailia and Kalubia in Egypt, in a field naturally infested with weeds and fungi. The well prepared and pre-irrigated seed-bed plots were covered with 60 μm thick clear polyethylene mulches for the duration of 6 weeks during August and September prior to Cabbage and Lettuce seed-bed planting in October 1994, 1995 and 1996. Seed-bed solarization significantly reduced *Fusarium* spp. and total fungi infestations. Solarization resulted in approximately 100%, 100% and 79% weed reduction in sandy soil at Ismailia and 100%, 94% and 69% reduction in clay soil at Kalubia for annual broad leaved weeds, annual grasses and perennial weed infestation, respectively. Seed-bed solarizarion increased healthy cabbage and lettuce transplants production as compared with the untreated plots. However, the effectiveness of seed-bed solarization on transplants growth of cabbage and lettuce were examined.

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IMPROVEMENT IN PLASTIC TECNOLOGY FOR GREENHOUSE FILMS. M. Basile and F. Lamberti. Istituto di Nematologia Agraria, C.N.R., Bari, Italy.

Some properties of greenhouse films and their behaviour concerning the trasmittance of visible radiations and medium-long infra-red radiations were examined. Different greenhouse films in relation to earliness, quantity and quality of crop production were evaluated to assess their economic importance. Utilization and importance of greenhouse films for covering fruit trees will also be discussed.

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MODES OF ACTION OF SOLARIZATION AND BIOFUMIGATION. J. J. Stapleton. Statewide IPM Project, Kearney Agricultural Center, University of Califoria, Parlier, CA 93648, USA.

Solarization is a passive hydrothermal process of disinfesting soil which utilizes solar radiation trapped under plastic mulch to create a "greenhouse effect", heating soil to temperatures which are deleterious or lethal to a broad spectrum of soilborne pathogens and pests. In addition to heat, other mechanisms of physical, chemical, and biological control have been shown to be involved in the solarization process. Numerous pest organisms have been shown to be susceptible to the effects of solarization, including many fungi, bacteria, nematodes, and weeds. The "heat dosage" of solarization, which is a relationship of soil temperature x time, is affected by numerous factors including diurnal air temperature maxima, minima, and duration, wind speed and duration, soil texture, color, and moisture content, and characteristics of the mulch film. Another critical treatment component is the thermal sensitivity of the target pest(s), which varies widely among species. In many cases, it is not necessary to kill pest organisms - they may be weakened by "sub-lethal" heat to the extent that they are unable to cause damage to plants. Even in the hottest climates, users may wish to combine solarization with more active methods of soilborne pest management. Many types of fertilizers and organic soil amendments can increase the pesticidal effects of solarization when incorporated in soil prior to heating by releasing biotoxic volatile compounds when heated to increase the effect of solarization through a process of "biofumigation", or by stimulating enhanced biological control. Combining solarization with soil pesticides or biological control agents can also improve the treatment effect.

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LONGEVITY OF SOLARIZATION AND EFFECTS OF SOLAR HEATING. E.C. Tjamos and P.P. Antoniou. Department of Plant Pathology, Agricultural University of Athens, Votanikos 118 55, Athens, Greece.

Several factors have been implicated in the phenomenon of the long-term effect of soil solarization in controlling certain soil-borne pathogens. The most well studied parameters include: (1) Survival and increase of thermotolerant fungal or bacterial antagonists following application of soil solarization leading to induced fungistasis; (2) Weakening effect imposed by sublethal heating and antagonistic action of prevailing antagonists in biological niches located beyond the region of the direct lethal effect of the method; (3) Induced systemic resistance to disease most possibly triggered by the surviving bacterial microflora. Fungal diseases caused by *Verticillium dahliae* (globe artichokes, tomatoes, and olives) by *Fusarium oxysporum* f.sp. *vasinfectum* (cotton), by *Pyrenochaeta lycopersici* (tomatoes) and recently the bacterial disease known as bacterial cancer of tomatoes caused by *Clavibacter michiganensis* subsp. *michiganensis* are known to be controlled for more than one consecutive cultural periods following a single application of soil solarization. The basic and the current knowledge on the topic will be broadly analysed and discussed.

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THERMAL EFFECTS OF COEXTRUDED BLACK PLASTIC MULCHES IN GREENHOUSE SOIL SOLARIZATION. C. Arcidiacono[1], G. Cascone[1], D. Gutkowski[2] and C.R. Fichera[3]. (1) Istituto di Costruzioni Rurali, Università di Catania, Catania, Italy; (2) Dipartimento di Fisica, Università di Catania, Catania, Italy; (3) Dipartimento di Scienze e Tecnologie Agroforestali ed Ambientali, Università di Reggio Calabria, Reggio Calabria, Italy.

An experiment of greenhouse soil solarization was performed in summer 1995 including three blocks of four randomized treatments: mulching with ethylvinylacetate (EVA) film, mulching with black polyethylene film, mulching with coextruded EVA-black polyethylene film, bare soil as the check plot. The experiment was carried out inside a plastic greenhouse located in Sicily, Italy. Soil temperatures and moisture contents were measured at four different depths: 1 cm, 5 cm, 15 cm, 30 cm. Soil heat flux was measured at 15 cm depth. The global solar radiation, the air temperature and relative humidity were measured inside and outside the greenhouse during the solarization period. The aim of this study was to test the effectiveness of black polyethylene mulches and coextruded EVA-black polyethylene mulches to increase soil temperature as compared to EVA film during solarization. The experiment showed that the highest soil temperatures were reached under the EVA mulch followed by the coextruded mulch and by the black polyethylene one. The analysis of the thermal regime of the greenhouse soil covered with the coextruded film showed that it could be used for the control of diseases caused by soilborne pathogens. Furthermore, it may be regarded as economically relevant to maintain in place the coextruded film used for the greenhouse soil solarization since black plastic film is generally used to cover the greenhouse soil during the growing season.

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LONG-TERM EFFECT OF SOIL SOLARIZATION ON DENSITY LEVELS OF *FUSARIUM* SPP. IN ESTABLISHED FRUIT TREE ORCHARDS.

H. Abu-Blan, W.I. Abu-Garbieh and F. Shatat. Faculty of Agriculture, University of Jordan, Amman, Jordan.

A field experiment was conducted for three years at the University farm in the Jordan Valley to study the effect of soil solarization on propagules of *Fusarium oxysporum* Schlecht and *Fusarium solani* Maritus in the rhiozisphere of newly established transplants of ten fruit tree crops: apple, banana, grapes, guava, lemon, loquat, mandarin, olives, orange and papaya. Black plastic mulch of 80 μ thickness and 120 cm wide was used in a raw treatment to cover the soil around the seedlings for three and six months periods, non covered treatment was used as control. The experiment was conducted in a randomized block design with three replicates. Each block consisted of 12 trees. Seedlings of each crop were planted in rows of 15 m long, 3 m apart and 1 m between plants. Soil temperature at 10, 20 and 30 cm depths was monitored for the entire period. Results showed that population densities of *Fusarium* spp. were considerably reduced after three or six months of soil tarping. Solarization also improved the growth of transplants. Fungal propagule numbers generally decreased with increased solarization period. Such reduction in CFU of *Fusarium* propagules occurred in all cases of mulched fruit trees compared to the control. At termination, three years after planting, numbers of *Fusarium* propagules increased to their previous levels by recolonization.

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SOIL SOLARIZATION IN THE CONTROL OF SCLEROTIAL FUNGI IN PAKISTAN. S.M.H. Usmani, A.H. Sheikh and A. Ghaffar. Department of Botany, University of Karachi, Karachi, Pakistan.

Mulching of soil with transparent and black polyethylene sheets, during hot summer days of May and June, increased soil temperature at 5 cm depth from 36 to 48°C under wet soil and from 44 to 52°C under dry soil; and at 20 cm depth from 32 to 38°C under wet and from 35 to 39°C under dry conditions for a duration of 1400-1600 h. Complete loss in viability of sclerotia of stem rot of the rice fungus *Sclerotium oryzae* and the charcoal rot fungus *Macrophomina phaseolina* was observed at 5 cm depth after 1 week mulching treatment. At 20 cm depth, *S. oryzae* lost their viability after 8 weeks mulching with 50% loss in viability of sclerotia of *M. phaseolina* in wet soil but were not effective in dry soil. Sclerotia at 15-20 cm depth which retained their viability were eliminated when brought back to surface after ploughing and remulched. Efficacy of mulching treatment was not affected by the color of polyethylene.

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EFFECT OF SOIL SOLARIZATION ON ROOT ROT OF WHEAT AND POPULATION OF SOILBORNE *FUSARIUM GRAMINEARUM* AND *COCHLIOBOLUS SATIVUS*. M.A. El-Meleigi. Plant Protection Department, College of Agriculture and Veterinary Med., King Saud University, Gassim Branch, P. O. Box 1482, Burydah, Saudi Arabia.

The objective of this study was to investigate the effect of solarization on control of the common root rot of wheat (*Triticum aestivum* L.) caused by *Fusarium graminearum* and *Cochliobolus sativus* in central Saudi Arabia. The experiments were conducted during 1995 and 1996 growing seasons in the College of Agriculture Experiment Station. Sandy soil infested with *F. graminearum* and *C. sativus* $\approx 160 \times 10^5$ propagules/m^2 was covered during July and August with white clear 100µm thick polyethylene plastic mulch. A high level of soil moisture was maintained by a dripping irrigation tubes placed under the plastic cover. The population of *F. graminearum* and *C. sativus* was slightly reduced by solarization treatment, and the root rot severity and incidence of diseased plants were significantly decreased. The grain yield of Yecora rojo wheat cultivar was increased up to 10 folds in solarized compared to non solarized treatments. Differences between solarized and non solarized treatments were higher in 1995 than in 1996 growing season.

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EFFECT OF SOLARIZATION AND METHYL BROMIDE FUMIGATION ON FUSARIUM WILT OF MUSKMELON IN THE JORDAN VALLEY. Z.A.M. Musallam, and W.I. Abu-Gharbieh. Department of Plant Protection, Faculty of Agriculture, University of Jordan, Amman, Jordan.

A field experiment was conducted in two sites in the Jordan Valley to evaluate the effectiveness of soil solarization with transparent or black tarping, or methyl-bromide soil fumigation. Also, the relative susceptibility or resistance of three cultivars of muskmelon against the Fusarium wilt caused by *Fusarium oxysporum* f.sp. *melonis*, was studied. Results showed that soil solarization and methyl-bromide fumigation treatments significantly reduced populations of *F. oxysporum* compared with the control at planting date and two months after soil solarization, but no significant differences appeared in subsequent sampling. Soil solarization with transparent or black plastic tarps or methyl-bromide fumigation failed in reducing muskmelon wilt in both experimental sites. However, the amount of marketable yield was significantly increased in the solarized and methyl-bromide fumigated treatments over the control. All three muskmelon cultivars used were susceptible to *F. oxysporum* f.sp *melonis*, but "Rasto" showed relatively delayed wilting than "Galia" and "Caribe" cultivars.

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SOIL SOLARIZATION: A MANAGEMENT PRACTICE FOR CORN STALK ROT. Y. Ahmad[1], A. Hameed[2] and M. Aslam[1]. (1) Crop Diseases Research Institute, National Agricultural Research Centre, Park Road, P.O. NIH, Islamabad, Pakistan; (2) Department of Biological Sciences, Quaid-i-Azam University, Islamabad, Pakistan.

Soil solarization technique was used during summer 1990 to control corn stalk rot at the National Agricultural Research Centre (NARC), Islamabad, Pakistan. Seven weeks solarization of irrigated soil raised its temperature by 11.5 °C over non-solarized soil at 10 cm depth and effectively controlled weeds (98.5%), stalk borer (8.9%) and stalk rot disease (69.1%) in corn. Solarization also reduced symptoms of fungal pathogens., *Fusarium moniliforme* and *Macrophomina phaseolina* significantly by 64.2% and 78.4%, respectively, and completely controlled *M. phaseolina* in corn cultivars, viz. Pool-10, Shaheen and Gauher. Growth of crop planted in solarized plots was better and it yielded almost one to three times more grains in the tested cultivars. Conclusively, the soil solarization had reduced stalk breakage and was found more economical since it provided essential nutrients to the plants in simpler forms and enabled them to withstand the disease without application of any pesticide.

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EFFECT OF SOIL SOLARIZATION ON SOILBORNE PATHOGENS IN LEBANON. H. Sobh and Y. Abou-Jawdah. Crop Production and Protection Department, Faculty of Agricultural and Food Sciences, American University of Beirut, Beirut, Lebanon.

Soil solarization was conducted at two locations on the Lebanese coast using 50 µm polyethylene films. Maximum soil temperatures recorded at 5, 15, and 25 cm depth were 53, 48 and 48°C at Jiyeh and 48, 45, and 43.5°C at Khaldeh, respectively. The mean sustained temperatures in solarized soils were 10 to 15°C higher than those of the nonsolarized soils. At Khaldeh, the soil was artificially infested with three pathogens. Soil solarization resulted in complete destruction of sclerotia of *Sclerotinia* spp. at the three depths studied and in reducing the viability of microsclerotia of *Verticillium* spp. by 99 and 79% and the inoculum of *Fusarium oxysporum* f. sp. *melonis* by 88 and 54% at 5 and 15 cm, respectively. However, reduction at 25 cm was only by 45% and 14%. At Jiyeh, the soil was severely infested with the root-knot nematode *Meloidogyne* spp. A demonstration trial showed that even on a susceptible crop like cucumber the integrated pest management (IPM) approach using soil solarization followed by application of the biological control organisms *Arthrobotrys* spp. and *Dactylella brocophaga* gave a good level of control similar to that of methyl bromide. Neither root-knot indices nor yields were significantly different. Due to the environmental hazards associated with the use of methyl bromide and the expected world wide ban on its use, these preliminary results suggest that soil solarization within an IPM programme can stand as a good alternative control measure.

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EFFECT OF SEED-BED SOLARIZATION ON ONION SMUT DISEASE CONTROL. M.S. Abd El-Megid, A.S. Ibrahim, S.A. Khalid and M.M. Satour. Plant Path. Res. Inst., Agric. Res. Center, Min. of Agric., Giza, Egypt.

Four field experiments on onion seed-bed solarization were conducted at Nekla, Giza Governorate, in fields naturally infested with *Urocystis cepulae*, the causal pathogen of onion smut. The well prepared and pre-irrigated seed-bed plots were covered with 100 µm thick clear UVA polyethylene sheets for 6 weeks, during July and August, prior to seeding in October 1995/1996 and 1996/1997. Seed-bed solarization significantly reduced smut pathogen and improved seedling stand and characters. Smut disease was completly controlled by soil solarization in both seasons. In the nontreated plots disease infection ranged from 31-47%, and 11-33% in both seasons, respectively. Seed germination was improved in the solarized plots, being 515 and 628 seedlings /m^2 compared with 264 and 456 seedlings/m^2 in the untreated plots, respectively. Other transplants chracters were improved including root and shoot lengths, number of leaves, fresh and dry weight. Thus, soil solarization was very effective in improving onion transplants with respect to disease control, plant stand and growth of transplants.

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EFFECT OF SOIL SOLARIZATION IN CONTROLLING *CLAVIBACTER MICHIGANENSIS* SUBSP. *MICHIGANENSIS*, THE BACTERIAL CANKER OF TOMATOES IN PLASTIC HOUSES IN GREECE.

P.P. Antoniou, E.C.Tjamos and C.G. Panagopoulos. Agricultural University of Athens, Department of Plant Pathology, Votanikos 118 55, Athens, Greece.

A three-year evaluation of soil solarization in controlling *Clavibacter michiganensis* subsp. *michiganensis* with parallel investigation of the sensitivity of the inocula of the pathogen to the application of soil solarization and methyl bromide fumigation was studied. Evidence was provided suggesting that a serious bacterial disease, like bacterial canker of tomato, could be successfully controlled by the application of soil solarization. The steady effectiveness of the method upon three continuous applications (three different cropping seasons) and in many experimental plots demonstrated that the temperatures developed during soil tarping are sufficient to reduce significantly or eliminate bacterial inocula. This have been proved directly for inocula which have been grown into glass vials or infiltrated into tomato stem segments and incorporated into the soil during various treatments.Furthermore, a significant reduction in disease incidence and an increase in yield were demonstrated. On the contrary, methyl bromide soil fumigation at the recommended rates of 70 g/m^2 did not control the disease and various combinations of methyl bromide doses and plastic sheets did not affect the populations of the pathogen in soil. Further more, annually repeated application of soil solarization affected positively the survival and the increase of tomato rhizosphere bacterial population belonging to the genera *Bacillus*, fluorescent *Pseudomonads* and *Streptomyces* group in contrast to the variable and frequently negative influence of methyl bromide application.

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THE EFFECT OF SOIL SOLARIZATION ON BACTERIAL CANKER OF TOMATO IN THE MEDITERRANEAN REGION OF TURKEY. S. Tokgönül[1], Ö. Çinar[2] and K. Rudolph[3]. (1) Plant Protection Research Institute, Adana, Turkey; (2) Department of Plant Protection, Faculty of Agriculture, University of Çukurova, Adana, Turkey; (3) Institute für Pflanzenpathologie und Pflanzenschultz der Universitat, Grisebachstr. 6, 37077 Göttingen, Germany.

The effect of soil solarization in the development of bacterial canker on tomatoes were examined in a commercial plastic house in the crop season 1995-96 in Içel province, Turkey. The soil was plowed, rotavated and irrigated to approximately field capacity and covered with transparent polyethylene sheets (0.03 mm thick) for 8 weeks. In these experiments soil solarization did not reduce canker development, because disease incidences were about 12 and 33% in non-solarized and solarized soil, respectively. The maximum soil temperatures at depths of 5, 10, 15, and 30 cm were 52, 46, 43 and 39 °C in solarized soil and 40, 36, 32 and 31°C in non-solarized soil. Refampicin resistant strains of *Clavibacter michiganensis michiganensis* (Rif Cmm) were used to investigate the effect of soil solarization on survival of the pathogen on infested tomato plant debris and soil in the greenhouse and a plastic tunnel in Adana. Survival of Rif Cmm associated with infested tomato plant debris was greater for debris on the soil surface than for debris that was buried in the soil. The population of Rif Cmm associated with infested soil and plant debris was not significantly effected by solarization. Experiments in a plastic tunnel showed that solarization effected the population of Rif Cmm in infested plant debris very slightly at a depth of 5 cm but not in the other samples.

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THE EFFECT OF SOIL SOLARIZATION ON THE SURVIVAL OF BACTERIAL SPECK ON THE TOMATO PLANT DEBRIS IN SOIL.

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A preliminary field study on soil solarization was conducted in Adana against bacterial speck. Prior to soil solarization, soil was infested by incorporating plants infected with bacterial speck. Moistened soil was covered with polyethylene film with a tickness of 30 µm from 15 July until 30 August, 1994. Soil temperatures recorded in solarized and non-solarized soil with soil thermometers. In February 1995, tomato seeds were sown in solarized and non solarized soil. After one month, infected transplants and lesions on cotyledonous leaves were counted, before the lesions confluenced. In non solarized soil, the average number of lesions per plant were 1.05, in contrast to only 0.24 in solarized soil. Also, there were 104 infected transplants in non solarized soil, whereas solarized soils harbored only 39 infected transplants. These results suggested a reduction in disease incidence of 63% by soil solarization.

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SOIL SOLARIZATION: AN ALTERNATIVE TECHNIQUE FOR WEED MANAGEMENT IN HOT CLIMATES. A.R. Saghir. P. O. Box 11-8281, Beirut, Lebanon.

Solar energy is very abundant in developing countries of the Middle East. Conventional methods for weed control are becoming costly or impractical. The use of effective herbicides require adequate knowledge on proper application techniques and full understanding of herbicide interaction with the crops, weeds and the ecosystem. Hence alternative ecofriendly methods of weed management become essential. Soil solarization has been introduced in the region to control soil-borne organisms including weeds. This technique is simple, cost-effective and does not cause any pollution to the environment. This is done by wetting the soil during the hot season, then covering it with thin transparent polyethylene sheets for several weeks, followed by planting with vegetable crops with minimum soil disturbance. Field experiments were conducted in naturally weed infested plots of cabbage and cauliflower in the United Arab Emirates. Handweeded, unweeded and non-covered plots were included as controls. The results showed that soil solarization for three months gave 94% weed control, with a 37% increase in weight per cabbage head as compared to the unweeded control. In the case of cauliflower, solarized plots for three and four months resulted in substantial increases in the yield and size of cauliflower heads, which were not significantly different from the handweeded control. It may be concluded that soil solarization during the hot summer months is an effective, safe and economical weed management practice in the Middle East.

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EFFECTS OF SOIL SOLARIZATION ON WEED INFESTATION AND ON MYCORRHIZA DEVELOPMENT. J-P Caussanel[1], A. Trouvelot[2], J. Vivant[3] and S. Gianinazzi[2]. (1) Laboratoire de Malherbologie; (2) Laboratoire de Phytoparasitologie INRA/CNRS; (3) Unité Expérimentale Serres et Cultures Jardinées, Institut National de la Recherche Agronomique, B.V. 1540, 21034 Dijon, France.

A field experiment on soil solarization was conducted at Dijon, France, in a field naturally containing mycorrhizal fungi and weeds. The well prepared and moistened plots were (i) covered with clear plastic (polyethylene) mulches for the duration of three hot summer months (June, July, August) or (ii) disinfected with steam. Half of the plots were inoculated with a *Glomus mosseae*/ *Glomus intraradices* mixture (50/50). On half of the plots mycorrhiza-susceptible plant (*Valerianella locusta* (L.) Laterrade) were sown in September 1996. Soil solarization significantly increased soil temperature and significantly reduced weed infestation compared to the untreated plots. Effects on weeds and on arbuscular mycorrhizas will be discussed in relation to soil treatment.

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COMPARATIVE SOLARIZATION EFFECTS ON SEED GERMINATION OF *CUSCUTA* AND *OROBANCHE* SPECIES. B.E. Abu-Irmaileh[1] and S. Thahabi[2]. (1) Dept. of Agricultural Resources and Environment, Fac. of Agric., University of Jordan, Amman, Jordan; (2) National Center of Agricultural Research and Technology Transfer, Ministry of Agric., Amman, Jordan.

Seeds of two *Cuscuta* spp., *C. campestris* Yuncker and *C. monogyna* vahl. and three *Orobanche* spp., *O. cernua* Loefl., *O. crenata* forssk. and *O. ramosa* L. were placed at either 0, 10, 20, 30, 40, or 50 cm depth in three plots per treatment. Solarization treatments were done for either one month or two months using either black or clear polyethylene (PE) sheets and compared with non-solarized treatment as a check. *Orobanche* seed germination was sensitive to solarization. Germination of *O. cernua* was most affected. The effect deminished with depth. Solarization with clear PE and for two months was more effective than solarization with black PE and for one month. *Cuscuta* seed germination was not significantly affected by solarization and *Cuscuta* seedlings were able to attach to the host.

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EFFECT OF SOIL SOLARIZATION ON *OROBANCHE* IN THE CENTRAL SUDAN. N.E.K. Abdalla and Z.T. Dabrowski, The FAO/ARC IPM Project GCP/SUS/025/NET, P.O. Box 126, Wad Medani, Sudan.

In the 1994/95 winter season, a number of fields with winter tomato crop have shown a heavy infestation by *Orobanche* and 40-80% yield reduction. The participatory interactions with vegetable farmers through the IPM Farmer Field Schools (FFS) indicated that the farmers affected were not aware of *Orobanche* biology, mode of its spread and preventive control methods. Realizing the increasing threat of the *Orobanche* to vegetable production by small scale farmers, the FAO/ARC IPM Project has initiated participatory research with farmers of the Farmer Field School located in the Fadasi village (Gezira State) to validate some selected control methods recommended for the region. The field of high and uniform *Orobanche* infestation of up to 50 mature branches per 1 m long row in the previous growing season was selected for experimentation. The control methods have included the following activities: (a) effectiveness and economic evaluation of regular hand-pulling of *Orobanche* plants; (b) soil solarization by covering of the top of well irrigated soil by transparent polyethylene sheet for 6-7 weeks; (c) effect of various levels of N and P on *Orobanche* and tomato crops; and (d) application of herbicide chlorsulfuron. Only soil solarization has eliminated *Orobanche* and majority of weeds from the treated plots. The yield has increased from 7.8 t/ha on untreated control plots to 21.08 t/ha on plots treated with solarization in the 1995/96 growing season. the experiment is repeated in two locations during the present 1996/97 winter season.

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SOIL SOLARIZATION FOR CONTROLLING *AVENA STERILIS, BROMUS DIANDRUS* AND *SINAPIS ARVENSIS* IN GREENHOUSE IN GREECE. G. Economou[1], G. Mavrogiannopoulos[2] and E.A. Paspatis[1]. (1) Department of Weeds, Benaki Phytopathological Institute, Kiphissia, Greece; (2) Agricultural University of Athens, Athens, Greece.

Weed control by solarization was approached considering that heat has a destructive action on weed seeds when applied above a certain temperature and over a period of time. The results from experiments to investigate seed death of three weed species (*Avena sterilis, Bromus diandrus* and *Sinapis arvensis*) buried in the soil at two depths, 5 and 10 cm, using soil solarization, are presented. After two weeks solarization, the effect of solar heating was evident on three weed species, buried at the depth of 5 cm. Seeds of the same weeds buried at the depth of 10 cm exhibited low germinability for the same period but solarization for a period of one month, killed completely the weed seeds in the two depths of burial. Laboratory experiments showed that the effect of temperature (35, 40 and 45°C) on seed germinability was related to time of exposure by using the thermal time concept. Estimation of the weed destruction in relation to temperature and time are based on the degree-hours (D.H.) procedures was carried out. Seeds exposed to temperatures of 40 and 45°C showed the same trend of reduced germinability at the same D.H. amount. In all cases, germination was drastically reduced at 400 D.H. Modelling solar heating effect on three weeds, based on the results of the experiments conducted in this study, will be discussed.

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SOIL SOLARIZATION FOR CONTROL OF DODDER AND OTHER WEEDS IN LEBANON. M.A. Haidar and N. Iskandarani. Department of Crop Production and Protection, Faculty of Agricultural and Food Sciences, American University of Beirut, Lebanon.

The effect of different durations of solarization on germination of scarified and nonscarified dodder seeds present in bags at different depths, and on controlling other weeds in cabbage was investigated. Clear polyethylene (0.3 mm thick) sheets were applied to the soil for 0, 10, 20 and 40 days between July and August of 1995. Peak soil temperatures reached 63, 58, 50, 44 and 40°C at depth of 0, 5, 10, 15 and 20 cm, respectively. All tested solarization treatments significantly reduced weed number and dry weight in cabbage during the following season. Solarization for 10, 20, 30 or 40 days significantly increased fresh and dry weight of cabbage as compared to control. Results on germination and viability of dodder seeds will be discussed.

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EFFECTIVENESS OF SOLARIZATION FOR CONTROLLING PLANT PARASITIC NEMATODES IN PLASTIC HOUSES. F.A. Bisheya[1], W.I. Mansour[1], A. Abughnia[2] and A. Hagi[1]. (1) Department of Plant Protection Agr. Research Center; (2) Department of Botany, Faculty of Science, Al-Fatch University, Tripoli, Libya.

The efficacy of soil solarization is based on the sensitivity of nematodes to relatively high temperature. Two years of soil solarization experiments were carried out in two geographically different sites to investigate the efficacy of solarization on the control of plant parasitic nematodes and yield of vegetable crops. Three plastic houses were mulched with transparent polyethylene film for six weeks during summer of 1991-1992 in each site. The remaining uncovered plastic house served as the control. Soil samples were collected before and after solarization. Nine genera of plant parasitic nematodes have been isolated. Results obtained showed a decrease in nematode population in both sites during 1992 when compared with nematode population during 1991. The yield of cucumber grown in solarized plastic house was increased.

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ORGANIC MANURE HAS AN ADDITIVE EFFECT TO SOIL SOLARIZATION FOR THE CONTROL OF SOILBORNE PESTS.

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Several reports indicated that soil-solarization either does not or at least partially control root-knot nematodes (*Meloidogyne* spp.) in the soil. For this purpose, experiments were conducted in the fields, with the objective to enhance the effect of tarping with polyethylene sheets by the addition of farm yard manure (cow dung) as an organic substance. Studies on the effect of soil-solarization, farm yard manure (40 ton/ha) and the integration of both on incidence of root-knot nematodes *(M. javanica* as a dominant species with about 70%) on cucumber roots and on the total parasitic and free-living nematodes in the field were conducted. Treatments were applied during the hotest period in the months of July-August for about five weeks in two successive years (1992 and 1993) in Esfahan. Results indicated that the temperature under the polyethylene mulch were increased by 10°C at 5 cm soil depth with 80% of the moisture preserved. Infection with root-knot nematodes was reduced by 50, 57 and 83 percent in the respective treatments, and the total population of the parasitic nematodes *Aphelenchoids* and *Helicotylechus* were reduced by 72, 75 and 86 percent, respectively, as compared with the check. The total free-living nematodes (*Aphelenchus*, *Cephaloubus* and *Rabdisis*) were increased only in the farm yard manure and the integrated treatment by 30 and 53 percent, respectively. In addition to, the control of root-knot nematodes, soil-solarization alone or in integration with farm yard manure, effectively controlled the soil-borne fungal diseases and the weeds present in the fields. It was also observed that there was a highly significant increase in plant growth.

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EFFECTIVENESS OF SOIL SOLARIZATION AGAINST *MELOIDOGYNE JAVANICA AND HETERODERA SCHACHTII* IN THE JORDAN VALLEY. H. Saeed, and W.I. Abu-Gharbieh. Department of Plant Protection, Faculty of Agriculture, University of Jordan, Amman, Jordan.

A field experiment comprised of the following six treatments was conducted in the Jordan Valley: solarization using transparent or black traping, each for one or two months (starting Jul. 10), in addition to inoculated-nontarped and noninoculated-nontarped treatments. Moslin bags of one liter capacity and 10 cm height were filled with soil inoculated with either 50 eggmasses of *M. javanica* or about 100 cysts of *H. schatii*. Each five bags of the same treatment were arranged vertically in a wire-quaze basket cylinder (representing 5 depths of 10 cm each). Baskets were installed in trenches and completely covered with methyl-bromide fumigated soil. Bags from all treatments were recovered two months after initiation. Soil samples of *M. javanica* treatments were planted to tomato, while those of *H. schactii* were planted to sugarbeet. Results indicated that transparent tarping provided effective control of *M. javanica* to 40 cm soil depth, but was more pronounced in the two months duration; while black plastic tarping was effective to 30 cm depth. On the other hand, transparent and black plastic tarping provided control of *H. schactii* to only 30 and 20 cm depths, respectively.

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POTENTIAL OF SOIL SOLARIZATION AS NON-CHEMICAL APPROACH FOR MANAGING WHEAT CYST NEMATODE, *HETERODERA AVENAE* IN GASSIM REGION, CENTRAL SAUDI ARABIA.

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Two field experiments were set up in two successive years (94-95) to evaluate the potentiality of soil solarization for controlling wheat cyst nematode, *H. avenae* in Gassim fields. Soil solarization was performed over a 60 days period prior to cultivation (July-August). Moisture was maintained under polyethylene sheets (10μm thick) by a dripping irrigation system. Each trial was in a complete randomized design replicated four times. Soil solarization greatly affected both nematode population and plant growth. Significant reduction in the density of *H. avenae* following soil solarization occurred in the upper 15 cm of soil. Plant growth and grain yield components were highly improved and increased 10 times compared to check. Nematode population density was remarkably decreased compared to check (67.75%). Soil solarization could be implemented in IPM programs to attain high degree of nematode suppression and improve plant growth.

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SOIL SOLARIZATION TO CONTROL PLANT PARASITIC NEMATODES. S.S. Al-Harthy and A. Mani. Agricultural Research Centre, Rumais, Ministry of Agriculture and Fisheries, P.O. Box 50, SEEB, PC 121, Sultanate of Oman.

A field experiment to evaluate the effect of soil solarization using plastic mulches revealed that clear plastic mulch was more effective than black plastic mulch in raising the soil temperature and reducing the nematode populations. Solarization with clear plastic mulch for a period of 1-3 months between June and August greatly reduced the nematode populations by 76.3-97.3 per cent as against 62.2-87.3 per cent with black plastic mulch. A significant negative correlation was recorded between monthly mean maximum temperature, maximum temperature recorded during the months and soil temperature recorded at 5, 10 and 20 cm depths and the nematode populations in solarized plots.

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EFFECT OF SOIL SOLARIZATION AND SOIL FUMIGATION ON STRAWBERRY YIELD IN SOUTHERN ITALY. M. Basile, F.Lamberti and A.C. Basile. Istituto di Nematologia Agraria, C.N.R., Bari, Italy.

Two experiments, one in 1994-1995 outdoor and the other in 1995-1996 in a plastic house, were carried out in a sandy-silty soil infested by *Rhizoctonia fragariae, Cylindrocarpon descructous* and *Fusarium solani* to evaluate the effect of soil solarization and two fumigants on yields of strawberry in southern Italy. In both trials all treatments increased significantly marketable yields compared to the control. However, concentrations of total bromides were increased in strawberries produced in plots treated with 50 g/s m of methyl bromide.

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SOLARIZATION AND MYCORRHIZAS IN THE PRODUCTION OF ORNAMENTAL BEDDING PLANTS. E.L. Ulla[1], V.A. Coradaro[1] and M.C. Vidal de Latina[2]. (1) Cátedra Microbiologia Agricola; (2) Cátedra Plants Ornamentales y Floricultura, Facultad de Agronomia y Zootecnia. U.N.T., Avda. Roca 1900-4000, San Miguel de Ticuman. Republica Argentina.

With the objective of evaluating the action of solarization on native mycorrhization in ornamental bedding plants, a bioassay was carried out in the experimental field of the Faculty. Seeds of *Calendula officinalis* were sown in non treated soil (T_0), soil treated with sodium methyl dithiocarbamate (T_1) and solarized soil for 60 days (T_2). Results were evaluated through measurements of dry weight (dw) of plants flowering and the percentage of infection with Vesicular-Arbuscular mycorrhizas in lamine. An increase in dw was observed in T_2 as compared to T_1 and T_0. The percentage of infection in T_0 was about 20% while in T_1 and T_2 there was no mycorrhizal colonization. Although results represent first experience in this area, they have shown that with solarization plants with good morphophisiological quality can be obtained. However, in contrast to what has been observed by other authors, solarization affected native mycorrhization. It is suggested to continue such studies under different conditions.

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EFFECT SOIL SOLARIZATION ON SOIL-BORNE DISEASES CONTROL AND INCREASING PEPPER AND CUCUMBER PRODUCTIVITY. S.A. EL-Haddad, A.S. Ibrahim and M. M. Satour. Plant Path. Res. Inst., Agric. Res. Center, Min. of Agric. Giza, Cairo, Egypt.

Soil solarization trials to control soil-borne diseases on cucumber and pepper plants were carried out at three localities in Ismailia Governorate, Fayed, Sarabyoum and Ismailia, during summer 1994/1995 in plastic houses and 70 cm. high low tunnels. Soils were mulched, before planting, for 30 days in plastic houses and 45 days in areas with low tunnels. UVA polyethylene sheets, 100 μm thick, were used. After treatment, the greenhouses were transplanted with seedlings of the pepper cv. Godion. On the other hand, low tunnels were seeded with cucumber seeds cv. Beta Alfa. Agronomic and phytopathological parameters were recorded. The results indicated that there was a good control of all soil-borne pathogens especially *Pythium aphanidermatum*, and disease incidence was decreased from 60.47% to 2.77% in the nontreated and solarized greenhouses, respectively, in Ismailia. In addition, the yield of pepper in Ismailia was increased from 3.97 to 5.35 kg/m^2 (134.76%). In Fayed experiment the increase was from 3.82 to 6.59 kg/m^2 (172.51%). Moreover, cucumber yield was also increased from 37.5 to 86.5 ton/ha. (230.66%) at Sarabyoum under low tunnels experiment.

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EFFECT OF SOIL SOLARIZATION TREATMENT ON WEED CONTROL AND YIELD OF GARLIC. I.A. Farag. Horticulture Dept., Fac. of Agriculture, Assiut University, Assiut, Egypt.

The effect of 5 and 10 weeks of soil solarization with single or double layers polyethylene and with or without addition of organic manure on weed control and yield of El-baladi garlic was studied in 1990/1991 and 1991/1992 seasons at the experimental farm, Faculty of Agriculture, Assiut. Soil solarization for 10 weeks gave the lowest total number and weight of weeds/m^2, although cyperes were not affected. However solarization gave the highest total bulb yield, average bulb weight and diameter. Double layers of polyethylene sheet gave the lowest total number and fresh weight of weed/m^2, followed by single layer although cyperes were not affected. Also double layers gave the highest total bulb yield, average bulb weight and diameter compared to the non solarized treatment. Addition of organic manure increased total fresh weight of weeds, total bulb yield, average bulb weight and diameter. However total number of weeds was not affected. Soil solarization for 10 weeks by using double layers of plastic sheets gave the lowest total number and fresh weight of weeds. Also yield of garlic bulb, average bulb weight and diameter was increased. Solarization with double layers of plastic sheets and addition of organic manure gave the lowest total number and fresh weight of weeds/m^2. Also total bulb yield, average bulb weight and diameter were increased.

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CONTRIBUTION OF SOIL SOLARIZATION TO INTEGRATED PEST MANAGEMENT SYSTEMS FOR FIELD PRODUCTION.

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Current and future contributions of soil solarization to integrated pest management systems (IPM) for field production of agricultural crops is discussed. Factors which limit the utilization of soil solarization in IPM systems include its compatibility with standard production practices and other pest management tactics, its efficacy against selected pests and its cost effectiveness. In certain instances, performance has been enhanced and application costs reduced when soil solarization was integrated into existing crop production systems. Synergistic interactions have been observed between soil solarization and other pest management tactics including biological control, organic amendments and chemical fumigants. Acceptance of soil solarization as an individual pest management tactic with site and pest specific activity, rather than a broad spectrum soil disinfestation procedure, will facilitate its integration into IPM systems. With the impending loss of methyl bromide as a prepalnt fumigant, increasing emphasis will be placed on IPM systems, which in turn will foster additional opportunities to utilize soil solarization.

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SOLARIZATION IN INTEGRATED MANAGEMENT SYSTEMS FOR GREENHOUSES. G. Cartia. Dipartimento di Agrochimica e Agrobiologia, Sez. Difesa delle piante., University of Reggio Calabria, 89061-Gallina, Italy.

This study reviews the historical and current knowledge on soil solarization in Italy referring to the detailed experiences carried out in Sicily and reports on the application and development of the method to control the most diffused soil borne agents, in commercial protected cultivations and in the laboratory. In addition, it reports and discusses the results of research on soil solarization in the past decades conducted in naturally infested soil both in plastichouse and glasshouse against pathogenic fungi such as *Verticillium dahliae, Phoma lycopersici, Pyrenochaeta lycopersici, Phytophthora capsici, Sclerotinia* spp., *Fusarium oxysporum* f.sp. *radicis-lycopersici* and nematodes such as *Meloidogyne incognita* and *M. javanica,* on various crops (tomato, pepper, eggplant). This method was also tested in an integrated management system to assess the effectiveness of a short period of solarization in combination with low dosages of pesticides. At present, soil solarization is applied in about 6-7% of Sicilian plastichhouses, during the hot season. Recently, soil disinfestation by solarization in the years achieved the goals (namely, reduction of the use of pesticides) of the National Phytopathological Integrated Management Project formulated by the Italian Ministery of Agriculture and Forestry ten years ago (1987). In 1990, the Sicilian Government approved a law that subsidizes growers (80% of the costs) applying soil solarization. In conclusion, this tecnique could reduce the use of fumigants, or even avoid their application in organic farming systems in Sicily.

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EXPERIENCE ACQUIRED IN SOUTHERN ITALY IN CONTROLLING SOILBORNE PATHOGENS BY SOIL SOLARIZATION AND CHEMICALS. G. Cartia[1], N. Greco[2] and P. Di Primo[1]. (1) Dipartimento di Agrochimica e Agrobiologia University of Reggio Calabria, 89061-Gallina, Italy; (2) Istituto di Nematologia Agraria del CNR, 70126 Bari, Italy.

Results obtained with soil solarization, chemicals and their combinations in controlling soilborne pathogens of vegetable crops in plastichouse and open field, in southern Italy, are briefly reviewed. Soil solarization alone is, in many cases, as satisfactory as chemical disinfestation. However, its combination with reduced rates of a chemical generally results in increased effectiveness against pathogenic fungi, nematodes, and weeds in the soil profile explored by plant roots. This approach is an important integrated control strategy for vegetable crops which migth allow reduction in the amount of chemicals used in agriculture and of the length of the soil solarization period. The use of biodegradable films for soil solarization would limit the negative impact on the environment of the mulching materials. Soil fumigation with 20 g of methyl bromide/m^2 is as effective as the use of standard rates against nematodes, irrespective of the mulching material type. With this rate, to obtain the same level of effectiveness against fungal diseases a virtual impermeable plastic film is necessary. This would reduce the amount of methyl bromide required for soil disinfestation and its emission in the atmosphere. To avoid environmental pollution problems due to soil disinfestation it is necessary to develop appropriate agronomic practices easy to integrate with chemical and physical methods.

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EFFECT OF ORGANIC AMENDMENTS, SOIL SOLARIZATION, AND THEIR INTERACTION ON SOILBORNE MICROORGANISMS AND YIELD OF PLASTIC HOUSE CUCUMBER. N.K. Abdulhadi, W.I. Abu-Gharbieh and S. Khattari. Department of Plant Protection, Faculty of Agriculture, University of Jordan, Amman, Jordan.

This experiment was conducted in a plastic house in the Jordan Valley. It comprised solarized and nonsolarized treatments, with or without soil amendments using: poultry manure, alfalfa, cauliflower, tomato, and olive-cake residues, in addition to a nonsolarized-nonamended soil treatment. The results indicated that solarization alone or soil amendment alone treatments significantly reduced densities of second stage juveniles of *Meloidogyne javanica*, reduced root galling and increased yield of cucumber. Organic amendments reduced densities of *Fusarium* spp., generally increased *Aspergillus* spp., while *Trichoderma* spp. were not affected. However, soil solarization did not affect the densities of these fungi compared to the nonsolarized. Combinations of solarization and addition of amendments substantially augmented each other, particularly with poultry manure, alfalfa hay, and to a lesser extent with cauliflower and tomato residues.

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STUDIES ON THE EFFECT OF SOIL SOLARIZATION COMBINED WITH FUMIGANT AND ANTAGONISTS IN GREENHOUSES TO CONTROL SOIL BORNE PATHOGENS IN THE EAST MEDITERRANEAN REGION OF TURKEY. S. Yücel and S. Çali. Plant Protection Research Institute, POB 21, Adana, Turkey.

The effect of the treatments of soil solarization alone and in combination with half dose of methyl bromide (MB) (40 g/m^2) to control phytophthora crown blight (*phytophthora capsici* Leonian) on peppers, and the mixture of *Trichoderma harzianum* + bran + sawdust (150 g/m^2) to control Fusarium wilt (*Fusarium oxysporum* f.sp. *lycopersici*) on tomatoes were investigated. Solarization was achieved by covering all plots with polyethylene sheet, 0.03 mm thick for 8 weeks. Soil temperature reached 47°C and 35°C at 5 cm and 30 cm soil depth, respectively, pepper trials grown in plastic houses which were taken away during summer. Soil temperature was 52.3°C and 37.1°C at 5 cm and 30 cm soil depth, respectively, in the tomato trials in the glasshouse. The average incidence diseased plants in solarized plus a half dose of MB, the recommended dose of MB, solarized and untreated plots in 1991 and 1992 were 17.6 and 13.3%; 20.8 and 16.8%; 24.1 and 19.7%; and 42.9%, respectively. All treatments significantly reduced disease incidence. In tomato trials, one week before planting, *T. harzianum* + bran + sawdust (150 g/m^2) was applied into the MB (85 g/m^2) treated, solarized and untreated plots, and the disease incidence was 40.7%; 66.4% and 69.5%, respectively. Solarization was not found effective to control Fusarium wilt of tomato but treatment with the antagonist increased the yield.

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EFFICACY OF SOLARIZATION VIS-A-VIS NATURAL HEATING OF RESIDUE AMENDED SOIL FOR MANAGEMENT OF SOIL-BORNE PATHOGENS. S. Lodha, S.K. Sharma and R.K. Aggarwal. Plant Pathology Laboratory, Central Arid Zone Research Institute, Jodhpur-342003, India.

Under dry and warm growing conditions of India arid region *Macrophomina phaseolina* (Tassi) Goid. causes seedling blight, charcoal rot and root rot of several economically important crops. During summer months, temperature of bare soil in hot arid region often reach lethal ranges (50-60°C) but were found ineffective for reducing the viability of sclerotia of *M. phaseolina* because soil remains dry. Soil moisture greatly affected the sensitivity of sclerotia to heat treatment. Thus, by one summer irrigation a reduction of 25-42% in the population of *M. phaseolina* was achieved. Solarization further augmented this reduction in the top soil layer but a sizable proportion of propagules survived in lower soil depth. To improve pathogen control, experiments were conducted to evaluate efficacy of cruciferous residues combined with summer irrigation (natural heating) and/or solarization on the population of *M. phaseolina* at 0-30 cm soil depth. In our studies, soil temperatures under natural heating or elevation due to solarization were higher than those observed in other parts of the world with similar climatic conditions. Combining soil solarization with cruciferous amendments almost completely eliminated viable propagules of *M. phaseolina* up to 30 cm soil depth. These amendments also augmented the efficiency of natural heating by reducing propagules of *M. phaseolina* by 74-96% at this depth. Efficiency of this method was further improved by applying irrigation only after weakening of propagules by natural heating of the dry soil. This finding has a potential value and important implications for irrigated pockets of hot arid zone of India as well as for many countries with similar climate. The present paper highlights our research findings on beneficial effects of soil solarization and natural heating for the management of soil-borne pests.

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INTEGRATED MANAGEMENT OF SOIL-BORNE PESTS IN PROTECTED CULTIVATION: CONSTRAINTS AND PERSPECTIVES. M. Besri. Institut Agronomique et Véterinaire Hassan II, Rabat, Morocco.

The intensification of protected cultivation has created new optimal conditions for the development of many pests and particularly soil borne-pests. The problems were relatively simple in the early years, but they increased in importance as intensive cultivation continued. Methyl Bromide (MB) is widely used in North Africa and in the Middle East to control soilborne pests. MB was listed in 1993 by the parties of the Montreal Protocol as an ozone-depleting compound. Alternatives to MB for the control of soil borne pests are presented and discussed. All these alternatives are complementary and should be used together in an Integrated Pest Management (IPM) Program. This program should integrate all the sustainable alternatives in a compatible way to maintain the soil pests populations at levels below the economic injury level.

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EFFECT OF GARLIC EXTRACTS AND VOLATILES ON *FUSARIUM OXYSPORUM* F.SP. *VASINFECTUM*. N.E. Ahmed[1] and A. Hamid[2]. (1) Plant Pathology Unit, Agricultural Research Corporation, Medani, Sudan; (2) Medical Laboratory, Gezira University, Medani, Sudan.

Crude aqueous extracts of garlic cloves and their volatiles at concentrations of 250 and 500 mg ml^{-1} inhibited mycelial extension of *Fusarium oxysporum* f.sp. *vasinfectum*. The microconidia formation was inhibited by 50, 250 and 500 mg ml^{-1} while macroconidia was inhibited by the highest concentration. The inhibitory effects were reversible except when the spores were exposed to the extracts and volatiles containing the highest concentration of garlic.

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INFLUENCE OF *GLOMUS INTRARDICS* ON TOMATO ROOT-KNOT-WILT DISEASE COMPLEX. Z.A. Stephan[1], M.S. Hassan[2], H. Ibrahim[3], B.G. Antoon[1] and M.Sh. Georgees[1]. (1) Plant Protection, Res. Center, Abu-Ghraib; (2) Plant Protection Dept., Agric. College, Abu-Ghraib; (3) Soil Res. Center, Abu-Ghraib, Baghdad, Iraq.

Mycorrhizal fungus *Glomus intrardics* changes the predisposition of tomato plants to infection by root-knot nematode *Meloidogyne javanica* and the fungus *Fusarium solani* toward more resistance under greenhouse conditions. Disease and Root-Gall Index, simultaneous, 2, 4 and 6 weeks after inoculation was significantly adversely affected by the presence of *G. intrardics*. The mycorrhizal fungus infection significantly (P=0.05) increased tomato plant growth compared to non-mycorrhizal plants. *M. javanica* alone or in combination with *F. solani* significantly suppressed growth below that of mycorrhizal plants.

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EFFECT OF INOCULUM SOURCE TYPE AND CULTURAL PRACTICES ON THE SPREAD OF *PHYTOPHTHORA CAPSICI* IN BELL PEPPER. J. B. Ristaino, G. Parra, and C. L. Campbell. Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695.

The pepper-*Phytophthora capsici* pathosystem is more complex than other Phytophthora pathosystems in that virtually every part of the plant can be infected and the pathogen can spread by several distinct mechanisms including: (I) movement from root to root down rows either by (a) root growth to inoculum, (b) inoculum movement to roots, or (c) root-to-root contact; (II) inoculum spread in surface water; (III) splash dispersal from soil to leaves, stems, or fruit; and IV) aerial dispersal from sporulating lesions on leaves, stems or fruit. *P. capsici* was dispersed primarily by movement from root to root down rows and by surface water in grower fields. Spatial and temporal components of epidemic development in artificially infested plots were affected dramatically by modifications of pathogen dispersal mechanisms. Disease incidence was 72% and spread within and across rows occurred when all dispersal mechanisms were operative in infested plots with bare soil. However, when soil, splash, and surface water dispersal were suppressed by planting pepper into stubble from a winter wheat cover crop, disease incidence was only 2.5%, little spread occurred within rows and no across-row spread occurred. Dispersal of inoculum in surface water from a sporulating fruit placed on plastic mulched beds resulted in 42% disease and within- and across-row spread occurred. Ridomil in the drip system did not suppress within-row spread of surface inoculum in water but did limit across-row spread and disease incidence was 11.5%. We are now asking the questions: (1) What are the characteristics of the dispersal gradient of introduced inoculum of *P. capsici* in soil and what are the effects of inoculum source type (sporangia versus oospores) and cultural practices (bare soil, rye-vetch, or black plastic) on spatial and temporal components of epidemic development on roots and aboveground portions of plants?; (2) Can a specific PCR technique be developed to monitor spread of the pathogen in fields? We have identified operative mechanisms of dispersal in fields and are now developing management strategies that are more sustainable for this Phytophthora disease than traditional strategies.

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EFFECT OF THE WATER SALINITY ON THE DEVELOPMENT OF TOMATO VERTICILLIUM WILT. M. Besri. Institut Agronomique et Véterinaire Hassan II, Rabat, Morocco.

Verticillium wilt (*Verticillium dahliae*) is a serious problem particularly on tomato grown under plastic tunnels. The salinity of the soil and of the irrigation water has a great effect both on the pathogen virulence and on the plant susceptibility. When the medium salinity increases,the pathogen mycelial growth, the number of the fungus conidia and microsclerotia increase. Tomato seedlings irrigated with saline water are more susceptible to the pathogen than the tomato seedlings irrigated with non saline water. The race 1 tomato resistant hybrids are not infected by this race and did not show any symptom when the plants were grown in non saline soil and irrigated with non saline water. However, when salt is added to the substrate, and to the irrigation water, the race 1 resistant tomato cultivars became susceptible to this race.

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TOWARDS AN INTEGRATED DISEASE MANAGEMENT OF WILT/ROOT ROT OF CHICKPEA AND LENTIL IN WANA: THE RATIONALE. C. Akem[1], S. Kemal[1] and B. Bayaa[2]. (1) Germplasm Program, ICARDA, P.O.Box 5466, Aleppo, Syria; (2) Faculty of Agriculture, Aleppo University, Aleppo, Syria.

Wilt/root rots of chickpea and lentil are major diseases in WANA countries. They are mainly caused by *Fusarium oxysporum* f.sp. *ciceris* and f.sp. *lentis*, *F. solani*, *Rhizoctonia solani*, *R. bataticola* and *Sclerotium rolfsii*. They cause damage of varying levels at different growth stages of the crops and directly or indirectly affect yields. Many single control methods have been tried to reduce damages caused by these diseases, but none of them has provided adequate protection to the host plants. Emphasis has been given to the development of resistant cultivars but the main focus has been on the Fusarium wilts because they dominate the wilt/root rot complex. The presence of the root rot pathogens in the field makes wilt-resistant cultivars less durable. The existence of races in *F oxysporum* f.sp. *ciceris* and the possibility of variability in *F. oxysporum* f.sp. *lentis* populations, call for continued monitoring and multilocational testings of all breeding lines. To minimize frequent shifts in resistance in the absence of multiple resistance to wilt/root rots, there is a need to adopt an integrated disease management strategy. However, efforts to develop host resistance and other control components will continue to be evaluated in the IDM approach.

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INTERGATED CONTROL OF ROOT-KNOT NEMATODES IN GREENHOUSE TOMATO CROP. E. Vouyoukalou[1], S. Gowen[2] and D. Trudgill[3]. (1) N.Ag.Re.F. Institute of Subtropical Plants and Olive tree, 73100 Chania, Greece; (2) Department of Agriculture, The University of Reading, Earley Gate, P.O. Box 236, Reading, RG6 2AT Berks, U.K.; (3) S.C.R.I., Invergowrie, Dundee DD2 5DA, Scotland.

Root-knot nematodes are important pests of tomato in Crete and agrochemicals are widely used for their control. As an alternative method to reduce the number of nematodes in a greenhouse crop, four rotations were applied in a *Meloidogyne incognita / javanica* naturally infested soil in which the bacterial parasite of root - knot nematodes *Pasteuria penetrans* was incorporated as dry root powder at plant sites. After three cropping cycles with tomato (*Lycopersicon esculentum*) alternating with beans, resistant beans (*Phaseolus*) and pepper (*Capsicum*) the numbers of nematodes in the soil were highly reduced. The highest population reduction occured when pepper was the intermediate crop. There was an increase of the *Meloidogyne* J_2' s infested with spores of *P. penetrans*. The production of bacterial spores in tomato roots was, also, increased in all treatments, but was lower in pepper.

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NEMATODE TRAPPING FUNGI FROM SOME SUDANESE SOILS.

E.E. Abdel Rahman. Dept. of Crop Protection, Faculty of Agricultural, Sciences, University of Gezira, Sudan.

Soil samples were collected from some areas on the bank of Blue Nile around Wad Medani town, Sudan. The sites chosen were croped to vegetables, like tomatoes, eggplant and legumes commonly infected with nematodes. The sites were mostly moist and rich in organic matter. Soil samples were collected in polyethylene bags or at times immediately inoculated on agar plates in the center of a Petri dish containing 30 ml of corn meal agar. Plates were incubated at room temperature and examined periodically for dead nematodes associated with fungi. The most common nematode trapping fungi that appeared on Petri plates were: *Arthrobotrys* spp. *Dactylaria* spp. and *Monacrosporium* spp.; some endozoic fungi were also isolated like *Verticillium* spp. and *Harposrium anguillulae.*

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INTEGRATED CONTROL OF ROOT-ROT/WILT DISEASES IN FABA BEAN, LENTIL AND CHICKPEA. A.M. Hassanein[1].; G.A. El-Morsy[1], N.M. Abou-Zeid[1] and S.A. Mahmoud[2]. (1) Food Legume Dis. Dept., PPRI., ARC; (2) Food Legume Crops Dept., FCRI, ARC, Giza, Cairo, Egypt.

An experiment for controlling root-rot/wilt diseases in faba bean, lentil and chickpea was conducted at Giza Res. Station. Two cultivars from each crop, two fungicides and two fungal pathogens were used to study the interaction between all of them. Results showed that, the interaction between fungicides, fungi, and cultivars were significant in faba bean and lentil crops, but not significant in the chickpea crop. Results also indicated that fungicides were effective in controlling these diseases in the three crops especially at the seedling stage. Effect of cutivars on the incidence of the diseases varied among the crops.

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RANGE OF PESTS CONTROLLED BY SOLARIZATION AND THEIR HEAT SENSITIVITY. C.L. Elmore, Weed Scientist, Weed Science Program University of California, Davis, California, USA.

Soil solarization controls a broad spectrum of soil pests. Organisms have a thermal tolerance range after which they can be killed or injured severely and become susceptible to other biotic and abiotic factors. Organisms that are active during moderate temperatures (15 to 35°C) such as winter annual weeds all seem to be sensitive to the change of temperatures of solarization. Organisms active during high temperatures are more tolerant to solarization. Characteristics such as hard seed (*Melilotus* sp.), mobility (nematodes) and exceptionally deep perennial structures such as rhizomes and tubers also reduce the level of residual effectiveness of soil solarization. Some organisms have a high tolerance to heat such as certain members of the genera *Macrophominia*, *Fusarium* and *Pythium* and the soil-borne bacterium *Pseudomonas solanacearum*. A time and temperature relationship will be discussed for several organisms.

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RECENT ADVANCES IN TEMPERATURE PREDICTIVE MODELS FOR SOIL SOLARIZATION. J. B. Ristaino[1], K. B. Perry[2] and Y.Wu[3]. (1) Department of Plant Pathology; (2) Department of Horticultural Sciences; (3) Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC 27695.

We have conducted experiments on the integrated control of *Sclerotium rolfsii* on bell pepper and tomato using soil solarization and biocontrol in North Carolina since 1989. During these experiments we measured soil temperatures extensively in raised and flat bed production systems that were fallow or planted with crops. Soil solarization effectively reduced the incidence of southern blight caused by *S. rolfsii* in coastal plain areas of North Carolina on a sandy loam soil in repeated studies. We (Wu et al., 1996, Agric. For. Meteor. 81:299-323) recently developed a physically based model which uses easily accessible meteorological data to predict soil temperatures of both bare and mulched soils from meteorological data. This model could be used to estimate soil temperatures under mulched soil so that regional predictions could be made on areas where solarization might be applied. Several other soil temperature models have been developed including the models of Mahrer, Mahrer and Katan, Cenis, and Sui et al. The benefits and limitations of these models will be discussed. The required dynamic inputs for the Wu et al model are hourly measurements of global radiation, air temperature, dewpoint, wind speed and rainfall. The model was validated with field data from measurements made in 1990 in Clinton, NC. The model worked well on clear and rainy days in most instances. The percentages of absolute differences less than 2 degrees between hourly estimated and measured soil temperatures at 10, 20, and 30 cm were 89, 95, and 95 for mulched soil and 94, 98, and 100 for bare soil, respectively. Correlations between estimated and measured soil temperatures yielded R square values between 0.82 and 0.93. The model was more sensitive to parameters such as soil bulk density, quartz fraction, and mulch transmissivity to solar radiation than surface roughness, soil clay fraction and mulch transmissivity to long wave radiation. The use of the Wu et al model could lessen the necessity to conduct wide scale experimental solarization studies under different climatic conditions and in the long term could enhance the adoption of solarization worldwide.

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A DEVICE SIMULATING THE THERMAL REGIMES OF SOIL SOLARIZATION IN LABORATORY EXPERIMENTS. G. Burrafato[1], G. Cartia[2] and D. Gutkowski[1]. (1) *Dipartimento di Fisica*, Universitá di. Catania, Italia; (2) Dipartimento di Agrochimica ed Agrobiologia, Universita di Reggio Calabria, Italia.

In natural conditions, soil solarization experiments can be performed only in summer . This fact puts severe constraints in planning the time table of a soil solarization research design. Furthermore some basic phenomena involved in soil solarization can be better studied and understood if the random perturbation to the main regular conditions are made negligeable. The above consideration motivate the opportunity of implementing soil physical regimes which simulate typical soil solarization ones but are under control and can be reproduced whenever desired. In order to meet such a request a device simulating the thermal regimes of soil solarization in laboratory experiments was realized. It essentially consists of a cubic box whose exterior edge is 76 cm. The box walls are thermally insulated. At the top there is a grating of 11x11=121 squares formed by a set of pipes which constitute a circuit in which a liquid can flow, passing through a thermostate. At the bottom a liquid passes through a thermocryostate in a similar circuit. A constant temperature can be chosen for the thermocryostate in a wide range. For each circuit an electrovalve rules the liquid flow. The system is equipped with a computer and a software which allows to establish at $n \leq 999$ arbitrarily chosen instants $t_1, t_2, \ldots, t_n$ an arbitrarily chosen value of the temperature of the liquid in the grid. The temperature chosen at a time t such that $t_k < t < t_{k+1}$ is calculated by linear interpolation. The measured temperature of the liquid in the grid is compared with the chosen one at chosen time intervals, and the electrovalve ruled accordingly. The box is filled with soil, the soil is then wetted and the box is covered with a plastic film. Soil temperatures are measured and recorded at ten depths ranging from 6 cm to 60 cm at chosen time intervals. Results concerning soil thermal regimes will be presented.

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EXPERIMENTAL TESTS ON NEW MATERIALS AND TECHNIQUES FOR SOIL SOLARIZATION AND MATHEMATICAL MODELS FOR THE PREDICTION OF SOIL TEMPERATURE. G.S. Mugnozza, G. Russo, G. Vox and F. De Santis. Istituto di Costruzioni Rurali, University of Bari, Italy.

In order to test innovative environmental sustainable materials and higher energy efficiency techniques for soil solarization, field experiments were carried out during July and August 1993 using photobiodegradable plastic film (12 μm thick) for mulching both in single and double layer with enclosed air. After 30 days from the beginning of the trial, the film began to degrade and to break, and completely deteriorated after two months. Field temperatures were measured at different depths (10, 20, 30 and 50 cm) in the mulched soil and mathematical models for the prediction of soil temperatures under the two different solarization techniques were developed. The results obtained by means of simulation were compared with the measured data. The standard errors of estimate, calculated between experimental and predicted data for the depths from 10 to 50 cm, were in the range of 0.93-1.43°C and 0.87-1.99°C for the single and double layer solarized soil, respectively. The efficacy of the double layer solarization technique produced an increase of soil temperature of 10-15% with respect to the single mulching system and a higher mortality rate of soilborne pathogens. Indeed the mortality rate of sclerotia, buried in the soil at 10, 20, 30 and 50 cm depth before the solarization, was 0-46% for the single layer and 100% for the double layer solarized soil at different depths. Finally the reduction in weed natural infestation, at the soil depths between 0 and 40 cm, was 15 - 58% for the single layer and 21-55% for the double layer.

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THE ECONOMICS OF SOIL SOLARIZATION COMPARED TO CONVENTIONAL AGRICULTURAL PRODUCTION. C.E. Bell. University of California Cooperative Extension, Holtville, CA USA

Soil solarization has been repeatedly shown to be an effective way to manage soilborne pests. Under most conditions, solarization will also improve crop yield compared to conventional practices. Adoption of solarization as part of routine farming practice has, however, been slow worldwide. Reasons that solarization is still an ucommon practice after 20 years of research and development would include the availability of familiar and trustworthy alternatives, the lack of concerted educational effort on the value of solarization, and the lack of reliable comparative data on the economic value of solarization relative to conventional practices. The agricultural areas of southern California and Arizona in the USA are ideal locations to utilize soil solarization. Thousands of hectares of high value vegetables are sown in the fall after a summer fallow for a winter harvest. Combined soilborne pest control costs (e.g. for weeds, soil fungi, and nematodes) are only slightly less than the cost of solarization. An analysis of five of these crops (broccoli, cabbage, carrot, crisphead lettuce, and onions) indicated that the yield increase required by solarization to compensate for increased costs are small, from 1 to 5%, when all other costs and crop market values are held the same. Yet, at present, the only adoption of solarization has been for about 600 hectares of organically grown carrots. The most important factor influencing the use of soil solarization for organic crop production is the high cost of hand labor for weeding. Solarization also is used to improve soil fertility and tilth by enhancing the decomposition of organic matter before planting. This use of solarization has demonstrated that growers can substitute solarization for conventional soilborne pest control practices without extensive disruption of other crop production practices.

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IMPACT OF THE QUALITY OF POLYETHYLENE ON THE ECONOMICS OF SOIL SOLARIZATION TECHNOLOGY. M.Y. Sultan. Agric. Economics Resh Institute, ARC, Ministry of Agriculture, Cairo, Egypt.

The land area for agriculture is severely limited, increased output is traditionally obtained via declining increments of output per unit of input as input intensity increases. the result is rising costs, which must be offset by rising prices if incentives are to prevail. it is apparent that cumulatively increasing relative food prices are not socially acceptable. Thus it is essential that the incentive to produce more in face of constantly rising costs be met by technological change rather than by price increases. Continuous, comulative technological change is the proven effect of institutionalized agricultural research system. However, the search for new, effective, safe, simple and economic methods for the control of pests is needed and is a continuous task. Therefore this paper evaluates the impact of the quality of polyethylene on the economics of soil solarization technology that has been conducted at an experimental site in Giza Research Station. The crop rotation employed in this study is broad beans-soybean-broad bean for the agricultural seasons 1988/89 and 1989/90. The analysis evaluates total income, variable cost, benefit/cost ratio and Marginal Rate of Return (MRR) for solarized plots (using local and imported polyethylene) as compared to the control plot. The results showed that the long-term effect of that technology for the low kind of polyethylene in this experiment is economically feasible for the second approache presented in this paper. Statistical analysis of the differences between solarized (local and imported polyethylene) and untreated plot in terms of gross return has proved to be significant, but insignificant for the cost of inputs, variable costs and income above variable costs. Also, the results revealed that the imported polyethylene is more profitable than the local one, as long as the MRR is higher for the imported than the local polyethylene.

POSTERS

P1

EFFECTS OF SOIL PLASTIC COVERAGE ON CITRUS NEMATODE POPULATIONS, *TYLENCHULUS SEMIPENETRANS* IN CITRUS ORCHARD. A.E. Ismail and H.Z. Aboul-Eid. Nematology Laboratory, Plant Pathology Department, National Research Center, Dokki, Cairo, Egypt.

A field experiment on using black or white plastic covers (80 µm or 160 µm) was conducted at Ismailia governorate, Egypt in a citrus orchard (Navel orange) naturally infested with fungi and the slow decline nematode *Tylenchulus semipenetrans*. The well prepared and moistened plots were covered with black or white plastic mulches with different rates of covering during 1995 season. Soil solarization, either with black or white plastic covering substantially increased soil temperature, significantly (P=0.01 and 0.05) reduced fungi and nematode infestations in both soil and root and hence increased navel orange yield compared with the uncovered plots. However, clear plastic 75% covering (160 µm thick) gave the best results in reducing nematode population (85%) after six months of covering; use of 160 µm thick black plastic at 75% covering attained the highest reduction (90%) after seven months covering and using 80 µm thick black plastic at 75% covering was more effective in reducing nematode population after eight months of covering (89% reduction) compared with the untreated plots.

P2

EFFECT OF SOIL SOLARIZATION TREATMENTS ON WEEDS CONTROL AND YIELD OF *FABA BEAN*.

I. A. Farag. Horticulture Dept., Faculty of Agriculture, Assiut Univ., Assiut, Egypt.

Two experiments were conducted in 1990/1991 and 1991/1992 seasons to study the effect of length of soil solarization (5 or 10 weeks starting from June 22), using a single or double layers of polyethylene sheets (50 μm), and the addition of manure on weed control, including broomrape, on yield of faba bean. Results revealed that soil solarization for 10 weeks gave the highest reduction in total fresh weight of weeds and number of broomrape plants per m^2, but Cyperus was not affected. This treatment also gave the highest total yield compared to 5 weeks soil solarization. Double layers of polyethylene sheets gave the lowest total number and weight of weeds and prevented broomrape plants from appearing on the soil surface, though, Cyperus was not affected. Also total seed yield of faba bean increased compared to single layer of polyethylene sheet. Addition of organic manure reduced total number of weeds/m^2 and number of broomarpe plants, though total fresh weight of weeds was increased. However, total seed yield of faba bean was not increased. The combination between 10 weeks of soil solarization and double layers of plastic sheet gave the lowest number and fresh weight of weeds and prevented broomrape plants to appear on the soil surface and increased total seed yield. The combination of organic manure and double layers of plastic sheet gave the lowest total number of weeds and prevented broomrape plants from appearing on soil surface. Soil solarization for 10 weeks and covered with double layers of plastic sheet and addition of organic manure gave the lowest total number and total fresh weight of weeds/m^2 and prevented broomrape from appearing on the soil surface. Also total seed yield of faba bean was increased.

P3

SOLAR CHAMBER AS AN INCLUSIVE METHOD TO CONTROL VERTICILLIUM WILT OF OLIVE TREES. M.A. Al Ahmad and A. Duksi. Plant Protection Division, Directorate of Agricultural Scientific Research, Douma, Syria.

Solar-Chamber as a technique for controlling Verticillium wilt of olive trees was innitiated in 1990 and since that time the trials were continued and the technique was improved. Control of Verticillium wilt is not an easy task because the pathogen exist in the root, trunk and branches of infected trees, in addition to surrounding soil. Therefore the target of Solar-Chamber was to control the pathogen in all of these sites. To achieve this, four indlependent trials were conducted by exposing the diseased trees to (a) Solar-Chamber for 10, 15 and 20 days, (b) 5, 10, 15 and 20 days, (c) 2, 4, 5, 10, 15 and 20 days and (d) 1, 2 and 3 days. Results obtained showed that Solar-Chamber was a very effective technique for controlling Verticillium wilt of olive. Results of the first trial indicated that re-isolation of the pathogen from treated trees after one year of application was not possible. Second trial gave better result than the first and treated trees were also pathogen-free after one year of application. Inspite of reducing the exposure time in the third and forth trials, the same result was obtained. The recovery of treated trees was attributed to elevation of the temperature inside the Solar-Chamber, which subsequently increased the acquired temperature by the trunk and branches of treated trees to a level lethal to the fungus. Some burning symptoms of new branches was observed but without adverse effect on their growth and yield.

P4

SOLARIZATION FOR CONTROLLING SOILBORNE FUNGI IN PLASTIC HOUSES

S. Al-Chaabi[1], L. Matrod[1] and J. Faddoul[2]. (1) Directorate of Agr. Sci. Research, Plant Protection Division, Douma, P.O. Box 113, Damascus, Syria; (2) Faculty of Agriculture, Damascus University, Damascus, Syria.

Root rot is one of the serious tomato diseases in plastic houses culture in Syria. Soil solarizarion, using transparent polyethylene (PE) mulches, was applied during July and August (1994-1996) in Tartous province for controlling soilborne pathogenic fungi. Results obtained so far indicated that native fungal populations in covered moist soil supplied with or without sulfur at two depth levels of 5-10 cm and 15-20 cm, were significantly reduced in comparison with the uncovered treatment. The sterilization efficacy (SE) at the two depths were 84.8-99.2% and 61.4-82.7%, respectively. Solar heating inhibited the growth of *Pythium* spp and *Phytophthora* spp, and reduced the number of propagules by 80.4-100% at 5-10 cm depth and 66.5-100% at 15-20 cm depth. Meanwhile, SE for Fusarium were 66.5-100% at 5-10 cm soil depth and 43-77.6% at 15-20 cm depth. SE for fungal populations fluctuated between 30.0 and 77.8% at 25-30 cm soil depth. In this case, the number of *Pythium* and *Phytophthora* propagules were reduced by 41.5-100%, and for Fusarium by 26.7-76.6%. Satisfactory control was obtained against soilborne fungi by using dazomet 50g a.i/m^2 in addition to covering with transparent PE film for 10 days. Efficacy of such treatment was 95.0-97.1% at 5-10 cm soil depth and 79.5-93% at 15-20 cm or at 25-30 cm soil depths. *Pythium*, *Phytophthora* and *Fusarium* were efficiently (88.5-100%) controlled at 5-20 cm soil depth.

P5

EFFECT OF SOIL SOLARIZATION ON POPULATION DENSITIES OF SOME SOIL MICROORGANISMS. S.M. Mahmoud. Soil and Water Dept., College of Agri., Assiut University, Egypt.

This study was carried out at the Agricultural Experimental Farm, Assiut University, in 1991 and 1992 summer seasons. The objective of this work was to investigate the effect of soil solarization, as well as application of chicken manure on the population densities of some soil microorganisms. Data showed that mulching of soil with single and double layers of polyethylene sheets for 10 weeks resulted in increasing soil temperature at 10 and 20 cm depths, compared to the unmulched soil. Results also indicated that soil solarization for 5 and 10 weeks in 1991 season caused clear reductions in the population density of *R. leguminosarum* biovar viceae. Nodulation of faba bean plants was greatly affected by mulching the soil surface with the transparent polyethylene sheets. Similarly, total numbers of bacteria, actinomycetes and fungi were decreased in solarized soil, in both seasons. The decreases in counts of *R. leguminosarum*, total bacteria, actinomycetes and fungi were greater in soil mulched with a double layer of the polyethylene sheets for 10 weeks than those in soil solarized with a single layer for 5 weeks. The application of chicken manure reduced the severe effect of soil solarization on the counts of those microorganisms in soil.

P6

EFFECTS OF SOLARIZATION AGAINST STRAWBERRY ROOT-ROT DISEASE IN THE EAST MEDITERRANEAN REGION OF TURKEY

H. Pala[1] and A Çinar[2]. (1) Plant Protection Research Institute, Adana, Turkey; (2) Subtropical Fruits Research and Experimental Center, University of Çukorova, Adana, Turkey.

The aim of this study was to investigate the effect of soil solarization on strawberry root-rot (*Rhizoctonia solani* Kuhn.) which causes about 30% plant death every year in Eastern Mediterranean Region. Soil solarization was done by covering irrigated soil with transparent 0.03 mm thick polyethylene sheets for 8 weeks during July-August. The max temperature was recorded both in covered and uncovered plots. Thermal death points of *R.solani* was found to be one hour at 52°C and 14 hours at 40°C. The elimination rates of the pathogen were 100.0, 92.50, 81.25 and 76.17% at 10, 20, 30, and 40 cm soil depths, respectively. In non-solarized plots, the rates were 100.0, 77.7, 62.5 and 50.0% at the same soil depths. Artificial inoculation also showed that pathogen growth was stopped at 10 and 20 cm depths, but developed at 30 and 40 cm. Pathogen population was monitored 1, 2, and 4 weeks after solarization. The effect of solarization was evaluated on the basis of reducing plant mortality. Solarization signigicantly reduced disease incidence.

P7

STUDIES ON SOLARIZATION AGAINST ROOT-KNOT NEMATODES AND WEEDS IN VEGETABLE GREENHOUSES IN MEDITERRANEAN REGION OF TURKEY. I. Tekin[1], I. Kadioglu[2] and I. Üremiş[1]. (1) Plant Protection Research Institute Adana, Turkey; (2) Dept. of Plant Protection, Agriculture Fac., GOP University, Tokat, Turkey.

Studies were conducted on control possibilities of Root-kont nematodes (*Meloidogyne* spp.) and weeds in different vegetable greenhouses in 1993-1995. Treatments evaluated were solarization, solarization+1/2 dosage of methyl-bromide and full dosage of methyl-bromide. The effectiveness result of solarization against root-knot nematodes were 86.60, 13.68 and 42.24%; in solarization+1/2 dosage of methyl-bromide were 88.90, 96.90, 79.57% and full dosage of methyl bromide were 94.10, 99.57 and 100.00 in the three years, respectively. The solarization was found effective on *Capsella bursa-pastoria, Orobanche, Scandix pecten-veneris, Stellaris media, Urtica urens.* Solarization+1/2 dosage of methyl bromide were found effective on *Amaranthus* spp., *Anagallis, C. bursa-pastoris, Cyperus rotundus, Mercurialis annua, Orobanch* spp., *S. pecten-veneris, S. media, U. urens.* The use of full dosage of methyl-bromide was found effective on *Amaranthus* spp., *A. arvensis, C. bursa-pastoria, C. rotundus, M. annua, Orobanch* spp., *S. pecten-veneris, S. media, Veronica hederifolia, Vicia* spp., *U. urens.* In the second and third year, yield increases in solarization plot were 12.44 and 12.15%, in solarization +1/2 dosage of methyl-bromide were 10.23 and 14.56%, and in full dosage of methyl-bromide were 17.00 and 10.58%. In conclusion, solarization application was not sufficient for controlling the root-knot nematodes (*Meloidogyne* spp.) but it was effective for weeds control. The solarization+1/2 dosage of methyl-bromide application could be accpted as an alternative control method because of its reliable effect on nematodes and some weeds. In addition, its application is easy and it has positive effects on soil texture and plant growth and controls other soil pathogens, weeds and other nematodes.

P8

CONTROL OF *DITYLENCHUS DIPSACI* ON ONION BY SOIL SOLARIZATION AND FUMIGANT NEMATICIDES. N. Sasanelli, M. Basile and F. Lamberti. Istituto di Nematologia Agraria, C.N.R., Bari, Italy.

The effect of soil solarization on the control of *Ditylenchus dipsaci* on onion was compared to that of dazomet (400 Kg/ha), 1,3 D (100 or 200 l/ha) and methamsodium (800 Kg/ha) in a field trial carried out in 1994-1995 in southern Italy. Soil solarization, 1,3 D at 100 l/ha and methamsodium were the only treatments which increased statistically the marketable yield of onions compared to the control. Treatments had no effect on the nematode final soil populations, but application of dazomet, 1,3 D at 200 l/ha or methamsodium reduced significantly population densities of *D. dipsaci* in bulb tissues.

P9

LONGEVITY OF SOLARIZATION USING BLACK PLASTIC TARPING: W.I Abou-Gharbeih and L. Al Banna. Department of Plant Protection, Faculty of Agriculture, University of Jordan, Amman, Jordan.

The long-term effect of soil solarization on the root-knot nematode *Meloidogyne javanica* Chitwood was investigated. The experiment was conducted in the Jordan Valley under plastic house conditions and planted to either cucumber or tomato for three consecutive growing seasons (1989-1992). Soil solarization was performed using black plastic tarp (60 μm) for 12 weeks (July-October). Six treatments, each comprising different combination of solarized or nonsolarized sequence, were included in this study. Root galling, number of second stage juveniles (J2s) of *M. javanica* as well as the total yield of cucumber and tomato for each treatment were determined. Results showed that the number of J2s and root galling at the end of the experiment were significantly lower in solarized plots for two or three continuous growing seasons than the other treatments. These results indicated that effectiveness of a single solarization treatment for one season was not extended to the next, but solarization for two consecutive seasons was effectively extended to the third season. Total yield of cucumber was the highest when the soil was solarized for three continuous growing seasons. However, there were no significant differences in tomato yield among the different other treatments. This might be due to the moderate level of soil infestation by the nematode and to the high level of tolerance of the tomato plants against root-knot nematodes.

P10

ESTABLISHMENT, SURVIVAL, AND GROWTH OF APPLE TREES (*MALUS DOMESTICA* 'GRANNY SMITH') USING POST-PLANT SOLARIZATION IN SOIL INFESTED WITH *SCLEROTIUM ROLFSII*. J.J. Stapleton. Kearney Agricultural Center, Univ. of California, Parlier, CA 93648, USA.

An eight-year field experiment was initiated in 1988 to study the effect of various post-plant solarization treatments for control of southern blight (*Sclerotium rolfsii*) in replanted apple trees (*Malus domestica* 'Granny Smith' on 'Malling 111' rootstock) in the San Joaquin Valley. Transparent or black plastic mulches were placed around replanted trees for 11-20 weeks in summer 1988. Soil temperatures reached 46, 39, and 34°C at 23 cm depth under transparent, black, and nonmulched treatments, respectively. No damage to trees from treatments was visible. Two years after treatment, survival of replanted trees was 38, 86, 86, and 75% after no treatment, or solarization with black film, transparent film (11 weeks), or transparent film (20 weeks), respectively. No significant differences in tree growth among treatments (as measured by tree girth) were found from 1988-96.

P11

INTEGRATED PEST MANAGEMENT IN FRESH MARKET TOMATO (*LYCOPERSICON ESCULENTUM* 'SHADY LADY') USING COMBINED SOIL SOLARIZATION AND REFLECTORIZED MULCH. J.J. Stapleton and C.G. Summers. Kearney Agric. Center, Univ. of California, Parlier, CA 93648, USA.

Vegetable crops in the San Joaquin Valley of California are attacked by flying insects, insect-vectored virus diseases, and soilborne pests. Solarization is useful as a soil disinfestant, while reflectorized mulches can reduce damage due to insects and the viruses they vector. A field experiment was conducted during summer 1996 to test effects of solarization, reflectorized mulch, and various combinations of the two strategies on yield of fresh-market tomato. The greatest yield was obtained from plots treated with solarization with transparent plastic which was then sprayed with silver paint to repel insects and left in place as a mulch. Next best was a similar treatment using commercially formulated silver mulch for both solarization and plant mulch. These two treatments produced mature green or ripe tomato yields 2.8-fold and 1.9-fold greater, respectively, than the nontreated control plots.

P12

SOLARIZATION FOR PEST MANAGEMENT IN HOT ARID LANDS. A.A. Al Masoum[1], A.A. Hashim[1], O. Khalifa[2] and A. Al Asaal[2]. (1) Dept. of Plant Production, Faculty of Agricultural Sciences, UAE University, Al Ain, UAE; (2) Dept. of Agriculture and Animal Production, Al Ain, UAE.

Increasing concern for the environment in the U.A.E. has stimulated the research for environmentally sound pest control including weed management under farm conditions. Hence, the effectiveness of soil solarization for weed management in a naturally infested plot of tomato at Al-Ain was evaluated using transparent and black mulches during July, August and September of 1993. After land preparation, the moist soil was covered with either transparent or black mulches, or left uncovered throughout the season. The soil temperature was measured at 5, 10 and 20 cm depths. Both transparent or black mulches significantly increased the soil temperature which resulted in proper control of the soil-borne fungi, nematodes and weeds. Solarization by both transparent or black mulches caused an increase in soil temperature which resulted in a significant reduction in weed infestation and increase in tomato yield. Transparent mulching tended to be more efficient as the soil temperature at 5 cm depth was increased by 37.5% and the weed infestation was reduced by up to 99% and the tomato yield was increased by 314% when compared with non mulched plots. Based on these encouraging preliminary results, it is recommended that solarization for pest management in hot arid lands is an environmentally sound, profitable and easy agricultural practice which should be implemented in the U.A.E.

P13

FLUCTUATION OF POPULATION DENSITIES OF *FUSARIUM OXYSPORUM* F. SP. *DIANTHI* AFTER INCORPORATION IN NATURAL, SOLARIZED AND STERILIZED SOIL. K. Elena[1], E.C. Tjamos[2] and Z. Tsekoura[1]. (1) Benaki Phytopathological Institute, 8 S.Delta str., 145 61 Kifissia, Athens, Greece; (2) Agricultural University of Athens, 118 55 Votanicos, Athens, Greece.

Soil solarization has been shown to be effective for controlling *Fusarium* wilt of carnation in fields and greenhouses in Greece. To study the survival of *Fusarium oxysporum* f.sp. *dianthi* (F.o.d.) population when introduced to the soil, three different soils, collected from the same greenhouse, natural, solarized and sterilized (in the laboratory), were used. Inocula ($7x10^4$ conidia/g soil) of one chlorate resistant strain and its parent F.o.d. isolate were incorporated into these soils in the laboratory. In natural soil the population had a rapid decline from the 2nd day after inoculation and the 32nd day $0.9x10^4$ for the wild and $1.3x10^4$ cfu/g soil for the mutant strain were counted. In solarized soil also on the second day a rapid decline of the introduced inoculum started and at the 32nd day the cfu/g of soil were similar to those in natural soil $1.5x10^4$ for the wild and $0.4x10^4$ cfu/g soil for the mutant strain, since in sterilized soil the population had a rapid increase 100% by the 32nd day, $7.5x10^5$ for the wild and $7.6x10^5$ cfu/g soil for the mutant strain were counted. The fluctuation of the population between the two strains did not differ significantly in the three soils, but the fluctuation of the two strains were significantly different in sterilized than in the natural and solarized soil. As indicated, the solarized soil similar to the natural one, suppresses the F.o.d. inoculum introduced into it.

P14

***USE OF SOIL SOILARIZATIOFOR CONTROLLING* FUNGAL PLANT PATHOGENS IN PLASTIC HOUSES IN LIBYA.** F.A. Bisheya[1], A. Abughnia[2], H. Douzan[3] and M. Gajem[1]. (1) Department of Plant Protection, Agr. Research Center; (2) Department of Botany, Faculty of Science, Al-Fateh University; (3) Dept. of Plant Protection, Faculty of Agriculture, Tripoli, Libya.

Two years of soil solarization experiments of plastic houses were conducted in two different sites to evaluate the effectiveness of solarization against soil borne phytopathogenic fungi during 1991-1993 for 45 days. The first experiment was carried out in the coastal sandy soil at Tajoura and the second on clay soil at Al-Azizia. Both sites were naturally infested with different genera of phytopathogenic fungi with soil inoculum density averaging 2400, 2860, 900, 1820 propagules per gram of soil for *Fusarium oxysporum*, *F. moniliforme*, *Helminthosporium* sp. and *Alternaria alternata*, respectively at Al-azizia, while 4000, 5000, 5000, 3000, 500, 1000 propagules per gram of soil or *F. oxysporum*, *F. moniliforme*, *F. Solani*, *Helminthosporium* sp., *A. alternata*, *Pythium*, and *Rhizoctonia* sp., respectively at Tajoura. Non pathogenic species of fungi also have been isolated. Solarization raised soil temperature (at 15-20 cm depth) up to 46.8°C at Al-Azizia and 43.0°C at Tajoura during the second week of August. Results obtained indicated a decrease of fungal population after 45 days of solarization in both sites. Variations in isolated fungal species and their population existed. Solarization was effective against different specie of *Fusarium*, *Phytophthera* and *Pythium*, the causal agents of damping off disease on vegetable crops grown in plastic houses.

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