J. Agric. Sci. Mansoura Univ., 31 (1): 241 - 247, 2006

SOIL SOLARIZATION AS AN ENVIRONMENTAL FRIEND METHOD FOR CONTROLLING SOIL-BORNE FUNGI INFESTING TOMATO PLANTS.

Zen-El-Dein, Manal M.[1] and Magda F. Abo-Dakika[2]
1- Central Laboratory of Pesticides; Sabahia, Alexandria, A.R.C.
2- Plant Pathology Dept. Faculty of Agriculture, Alexandria Unv., Egypt

ABSTRACT

The effect of soil solarization on the control of soil borne pathogens of tomato plants in the reclaimed sandy regions of Nubaria, El-Beheira Governorate, Egypt was studied. Solar heating gradually reduced the isolated fungi to very low levels, comparable with non-wrapped treatments. Populations of *Aspergillus* spp., *Penicillium* spp., *Fusarium* spp., and *Rhizoctonia solani* were found to be reduced at the end of the solarization treatment (3 months). Tomato plants stand were observed in solarized plots indicating the positive effect of soil heating on reducing numbers of propagules of soil-borne pathogens. Thus, it could be concluded that soil-borne pathogens infest tomato plants can be controlled by planting the crop in solarized fields. These promising results indicate the possibility of using this method to control soil-borne diseases in the reclaimed sandy regions of Nubaria, El-Beheira Governorate, Egypt.

INTRODUCTION

Tomato *(Lycopersicon esculenturn* Mill) is one of the most important Solanaceous economic vegetable crops in Egypt for local consumption and exportation. It is subjected for attacking by numerous diseases wherever the crop is planted. Fungal pathogens are considered as damaging agents causing a considerable reduction of its production. The wilt disease caused by *Fusarium oxysporum* fsp. *lycopersici* (Sace.), and *Rhizoctonia solani* Kuhn have serious effects on tomato plants either in nurseries or in the fields (Besri, 1982).
Soil solarization is the hydrothermal process for disinfestation of soil is widely used nowadays to eliminate soil-borne disease incidence. Soil solarization is non-chemical, but targets mesophylic organisms, which include most plant pathogens and other pests, without destroying the beneficial bacteria and mycorrhizal fungi (Pullman *et al.*, 1981; Stapleton and De Vay, 1984, 1986 and Stapleton, 1991). Promising results for controlling soil-borne pests in regions having high temperature and intense solar radiation could be obtained by applying soil solarization. Egypt possesses factors needed for successful soil solarization, which was introduced as an important technology to minimize the harmful effects of soil-borne diseases in the traditional agriculture in Egypt in 1981, (Satour, 1997). Katan, (1985) and Satour *et al.*, (1991) stated that soil solarization is a very effective treatment against several borne diseases that infect onion, tomato and sorghum, besides, several nematodes and most of the common weed species could also be completely controlled.

Moreover the chemical sterilization of soil affects beneficial and non-beneficial organisms in soil. Ahmed *et al.*, (2002) found that Dazomet, as a pre-planting soil fumigant, had detrimental effects on the different stages of both the Mediterranean fruit fly; *Ceratitis capitata* (Wied.) and the cotton leafworm; *Spodoptera littoralis* (Boisd.) in two different soil types.

So, soil sterilization can be carried out by different methods; physical and chemical techniques. The chemical treatment may be dangerous to environment and soil microbial processes. El-Shahaat *et al.*, (2005) found that Basamid (dazomet)® as soil fumigant had an appreciable decreasing effect on three species of terrestrial snails, pre-pupal stages of both the cotton leafworm and the Mediterreanan fruit fly in a sand loam soil and appeared to decrease the NO_2-N formation when incorporated into soil. Also, this compound highly inhibited dehydrogenase enzyme activity in soil.

The present investigation was carried out to evaluate the importance of using physical soil solarization against soil-borne fungi responsible for damping off diseases of tomato plants in Egypt.

MATERIALS AND METHODS

The experiment was carried out during October-March 2002-2003 and 2003-2004 seasons with tomato seeds of supper strain B in field naturally highly infested with soil-borne pathogens (such as *Fusarium* spp. and *Rhizoctonia solani*). A special tomato nursery was carried out. The experimental field was carried out at the reclaimed sandy loam regions of Nubaria, El-Beheira Governorate, Egypt.

The factorial experiment with complete randomized block design (CRBD) was carried out with 4 replicates for each treatment. The experimental plots were ploughed, leveled and surface irrigated, divided into 4 blocks (divided to plots 3x6 m as replicates) covered on with black or transparent plastic sheets (200µ in thickness) for one, two and three months intervals for soil solarization. Soil temperatures were measured weekly by using a subsoil thermometer.

Soil samples were taken [for count of fungal (cfu)] from the experimental plots of each treatment (at about 15 cm depth around roots of the plants) at the end of each solarization period; 1, 2 and 3 months. Composite samples and three sub-samples from each plot were used for determining the fungal populations according to the method of Grossman (1967). Fungal frequency was recorded in 4 replicate plates after incubation for 7 days at 30°C and the most frequent fungi in the non-covered soil were studied for their tolerance to solarization

The experiment treatments :

1- Untreated roots in untreated (check) plots (traditional method).
2- Roots treated with fungicide Carboxin^{+} 75% in untreated plots.
3- Untreated roots in plots covered with black plastic sheets for 1 month.
4- Untreated roots in plots covered with black plastic sheets for 2 months.
5- Untreated roots in plots covered with black plastic sheets for 3 months.
6- Untreated roots in plots covered with transparent plastic sheets for 1 month.
7- Untreated roots in plots covered with transparent plastic sheets for 2 months.
8- Untreated roots in plots covered with transparent plastic sheets for 3 months.

Tested fungicide :

Fungicides	Formula	Trade name	Rate of application	Method of application	Producer
Carboxin* 75% (Thiram +Carboxin)	W.P.	$Vitavax_{200}$	1.5 gm/ kg seeds	Seed treatment	Uniroyal Chemical Company.

Experimental plots were observed daily after transplanting for slanted and dead plants (by soil borne pathogens only).
Statistical analysis of data collected were carried out according to Cohort, Software, Inc. program (1986).

RESULTS AND DISCUSSION

Soil temperature average, for each month, was calculated and recorded for the covered and non-covered plots at 20 cm depth. The soil temperature was gradually increased during the experimental time with an obvious difference between non-covered and covered soil, Table (1).

Table (1) : The effect of soil solarization on mean of soil temperature at 20cm depth for non-covered and mulched with transparent or black sheets during October-March 2002-2003 and 2003-2004.

Time	Mean temperature (°C)					
	2002/2003			2003/2004		
	Non-covered	Covered (mulched)		Non-covered	Covered (mulched)	
		Black	Transparent		Black	Transparent
October	28.5	32.8	35.4	30.2	34.8	37.5
November	25.2	29.3	29.8	26.0	30.1	30.7
December	19.7	22.2	24.0	21.5	24.2	26.2
January	16.8	19.1	20.6	21.9	25.0	27.0
February	17.6	20.7	22.3	22.3	27.3	29.3
March	19.1	22.6	25.1	23.4	27.9	30.2

Data presented in Table (1) indicated that mulching (soil solarization) generally caused an obvious increase in soil temperature throughout the present investigation. Transparent sheets were more effective than black sheets for soil heating. Many investigators reported the positive effect of soil solarization on increasing soil temperature, (Hillel *et al.*, 1982; Sarhan, 1991 and Satour,1997).

Data presented in Table (2) show the soil borne fungal population density (10^3 cfu/g) at zero time and after one, two and three months of mulching (with transparent and black sheets) or chemical-treated roots ($Vitavax_{200}$) for the four tested fungi during 2002/2003 season. Generally, the data indicated that there were no significant differences between the effect of the mulching period of two and three months but they were significantly differed and positively from one-month mulching period. Also there were no significant differences between the two types of sheets used for mulching treatments but they were differed significantly with the chemical-treated plant roots and the check treatment. The data illustrated that the tested fungi affected by tested treatments in the following order : *Fusarium* spp., *Penicillium* spp., *Rhizoctonia solani* and *Aspergillus* spp. with significant differences among them.

Table (2) : Comparing the effect of chemical (Carboxin+ 75%) and non-chemical (mulching) treatments on soil borne fungi population density (10^3 cfu/g) during November-February 2002-2003.

Fungi	Time (month)	Fungal frequency				
		Covered			Check	Carboxin+ 75%
		Transparent	Black	Mean		
Aspergillus spp.	0	40.90				
	1	35.88	36.60	36.24	41.76	34.77
	2	33.12	34.86	33.99	34.80	33.12
	3	24.06	29.46	28.26	36.72	30.84
Rhizoctonia solani	0	39.80				
	1	15.36	13.80	14.58	41.92	14.40
	2	8.46	7.26	7.86	46.64	28.36
	3	0.60	3.24	1.92	57.72	37.12
Fusarium spp.	0	17.00				
	1	4.44	5.88	5.16	16.95	5.59
	2	4.86	4.86	4.86	14.40	6.72
	3	4.80	6.12	5.46	21.75	5.81
Penicillium spp.	0	33.70				
	1	11.16	10.56	10.86	30.90	10.80
	2	8.40	6.24	7.32	33.60	18.60
	3	5.52	4.20	4.86	37.65	23.52
$L.S.D_{0.05}$	Time	1.763				
	Treatments	2.036				
	Fungus	2.036				

cfu/g = count of fungal colony forming units per gram of soil weight.

Treatments decreased soil borne fungus (*Aspergillus* spp.) population density from 40.9 to 24.06 under transparent sheet, from 40.9 to 29.46 under black sheet and from 40.9 to 30.84 for chemical-treated roots, where the fungus population decreased naturally from 40.9 to 36.72 x 10^3 cfu/g after three months. *Rhizoctonia solani* population density decreased from 39.8 to 0.6 under transparent sheet, from 39.8 to 3.24 under black sheet and from 39.8 to 37.12 by the chemical treatment, but the untreated treatment showed an increase of *R. solani* population density to 57.72 x 10^3 cfu/g after three months. The tested treatments decreased *Fusarium* spp. population density from 17.0 to 4.8, 6.12 and 5.81 for transparent, black and chemical treatments respectively, but untreated blocks showed significant increase of population density to 21.75 x 10^3 cfu/g after three months. Transparent, black and chemical treatments decreased *Penicillium* spp. population density from 33.7 to 5.52, 4.2 and 23.52 x 10^3 cfu/g respectively, where it increased to 37.65 x 10^3 cfu/g at untreated treatment.

Table (3) : Comparing the effect of chemical (Carboxin+ 75%) and non-chemical (mulching) treatments on soil borne fungi population density (10^3 cfu/g) during October-February 2003-2004.

Fungi	Time (month)	Fungal frequency				
		Covered			Check	Carboxin+ 75%
		Transparent	Black	Mean		
Aspergillus spp.	0	56.2				
	1	43.06	43.92	43.49	50.11	41.72
	2	36.43	38.35	37.39	48.28	36.43
	3	21.65	29.21	25.43	63.05	27.75
Rhizoctonia solani	0	45.1				
	1	19.97	17.94	18.95	48.30	18.72
	2	10.15	8.71	9.43	71.57	22.03
	3	0.57	3.08	1.82	54.83	25.76
Fusarium spp.	0	22.60				
	1	5.33	7.06	6.19	20.31	6.70
	2	6.32	6.32	6.32	18.72	8.74
	3	9.60	12.24	10.92	43.50	11.63
Penicillium spp.	0	37.20				
	1	13.39	12.67	13.03	37.08	12.96
	2	10.08	7.49	8.78	40.32	22.32
	3	6.62	5.04	5.83	45.18	28.22
L.S.D$_{0.05}$	Time	1.278				
	Treatments	1.476				
	Fungus	1.476				

The recorded results of the second season of the experiment showed the same trend of the first season unless the significant differences between the mulching periods; one and two months.

The transparent sheets decreased the population density of *Aspergillus* spp. (from 56.2 to 21.65), *Rhizoctonia solani* (from 45.1 to 0.57), *Fusarium* spp. (from 22.6 to 9.6) and *Penicillium* spp. (from 37.2 to 6.62 x 10^3 cfu/g). The black sheet decreased the population density of *Aspergillus* spp. (from 56.2 to 29.21), *Rhizoctonia solani* (from 45.1 to 3.08), *Fusarium* spp. (from 22.6 to 12.24) and *Penicillium* spp. (from 37.2 to 5.04 x 10^3 cfu/g). Treating roots with specific fungicide decreased the population density of *Aspergillus* spp. (from 56.2 to 27.75), *Rhizoctonia solani* (from 45.1 to 25.76), *Fusarium* spp. (from 22.6 to 11.63) and *Penicillium* spp. (from 37.2 to 28.22 x 10^3 cfu/g). Untreated blocks indicated that population density of tested fungi increased 12.19% for *Aspergillus* spp., 21.57% for *Rhizoctonia solani*, 92.48% for *Fusarium* spp. and 21.45% for *Penicillium* spp. after three months of the experiment.

These results confirm those obtained by Katan & De Vay (1991) and Pullman and De Vay (1984). They stated that the efficiency of solarization would be improved by increasing the treatment time. Abou-Gharbieh *et al* (1991) and Standifer *et al.,* (1984) also they reported that the effect of transparent sheet on the microorganisms was, generally higher than of the black one.

The observation of field experiment showed that there was no weeds grow in the solarized plots. This result is in agreement with that reported by Dabaj *et al.*, (2005). They showed that soil solarization with plastic sheets was effective against soil inhabiting pests and pathogens, especially root knot nematode; *Meloidogyne* spp. and annual and prennual weeds. Also, Bawazir and Aidaros (2005). Used transparent and black polyethylene sheets mulching for 30 or 60 days in Delta Tuban, Yemen. They found that soil solarization decreased significantly the annual weed population in the field. Mulching with transparent sheets for 30 or 60 days was better than that with black sheets.

The present study indicated the possibility of using mulching method to reduce the population density of soil-borne plant pathogen, in the soil to avoid infection with in such soils in Egypt.

REFERENCES

Abou-Gharbieh, W.I; H. Saleh. And H.A. Abu-Blan. (1991). Use of black plastic for soil solarization and post plant mulching. FAO Plant Production and Protection Paper 109:229-242.

Ahmed, I.A.; M.S. El-Shahaat; M.S. Nassar; K.A. Rahman and H.S. Radwan (2002). Pesticides-soil Relationships. III. Influence of three pesticides on soil stages of some non-target insects. J. Adv. Agric. Res. Vol. 7: 885-93.

Bawazir, A.A. and A.A. Aidaros (2005). Effect of soil solarization on weeds in sesame crop in Delta Tuban, Lahej Governorate, Yemen. Arab. J. Plant Prot. 23:31-36.

Besri, M. (1982). Solar heating (solarization) of tomato supports for control of *Didymella lycopersic* stem canker. (Abstr.). Phytopathology, 72: 939.

Cohort, Software Inc. (1986). Costat Users Manual, version 3.03 Berkelely, California, USA.

Dabaj, K.H., A.A. Kafu; A. Al-Khraz and M.A. Mesbah (2005). Effect of soil solarization on growth and production of cucumber *Cucumis sativas* L. and muskmelon *Cucumis melo* L. under green house conditions. Arab J. Pl. Prot. 23:24-30.

El-Shahaat, M.S.; E.H. Eshra and Y.A. Bakr (2005). Impact of basamide and methomyl bait on non-target pests and some microbiological processes in soil. The 3rd Inter. Conf. of Plant Protection Res. Institute, 26-29 Nov., Published in Egypt. J. Agric. Res. 83: 1007-1016.

Grossman, D.F (1967). Selective isolation of soil microorganisms by means of differential media pp. 19-21. Sourcebook of Laboratory Exercises in Plant Pathology. American Phytopathological Society. San Francisco and London.

Hill, D.E.; L. Hankin and G.R. Stephen. (1982). Mulches and their effect on fruit set, timing and yield of vegetables. The Connecticut Agric. Exp. Stat., 805.15 pp.

Katan, J. (1985) Solar Disinfestations of soils, Proc. Fourth Inter. Congress of Plant Pathol. P.274. Parker, C.A., A.D. Rovera, K.J. Moore, and P.T.W. Wong, Eds. The Amer Phytopathol. Soc., St., Paul.

Katan, J. and J.E De Vay. (1991). Soil Solarization : Historical perspectives principals and uses. Pages 13 – 38 in J. Katan and J.E. De Vay, Eds. Soil Solarization, CRC Press, Boca Raton.

Pullman, G.S. and J.E. De Vay. (1984). Soil solarization : A non-chemical method for controlling disease and pests. Cooperative Extension Davis, University of Calltornia Division of Agriculture and Natural Resources, Leaflet 21377.

Pullman, G.S.; J.E De Vay; R.H. Garber and A.R. Weinhold. (1981). Soil solarizatlon : effects on Verticilil wilt of cotton and soil-borne populations of *Verticillium dahhae, Phythium* spp, *Rhizoctonia solani* and *Thielaviopsis basicala.* Phytopathology, 71: 954-959.

Sarhan, A.R.T. (1991). Control of *Fusarium solani* in broad by solar heating of the soil heating in North Iraq.; FAO plant Production and protection paper, 109:108-117.

Satour, M.M. (1997). Prospects of implementation of soil solarization In Egypt. 14th Int. Congr. For Plastic in Agric. Tel-Aviv, Israel. March 9-14, 1997.

Satour, M.M.; E. Sam; M. El-Sherif; L. El-Ghareeb; S.A. El-Haddad and H.R. El-Wakil. (1991). Achievement of soil solarization in Egypt. FAO plant Production and protection Paper, 109: 200-211.

Standifer, L.C.; P.'V. Wilson and R. Proche-Sorbet. (1984). Effects of solarization on soil weed populations. Weed Sci., 32: 569-573.

Stapleton, J.J. (1991). Soil solarization in tropical agriculture for pre-and post-plant applications. FAO plant production and protection paper, 109:220-224.

Stapleton, J.J. and J.E. De vay. (1984). Thermal components of soil solarization as related to changes in soil coot microflora and increased plant growth response. Phytopathology, 7: 255-259.

Stapleton. J.J. and J.E. De vay. (1986). Soil solarization: A non chemical approach for management of plant pathogens' and pests. Crop Protection, 5:190-199.

طريقة صديقة للبيئة لمكافحة فطريات التربة التى تصيب محصول الطماطم

منال محمد زين الدين[1] – ماجدة فهمى ابو دقيقة[2]
١ – المعمل المركزى للمبيدات–الصبحية – الاسكندرية
٢ – قسم امراض النبات – كلية الزراعة – جامعة الاسكندرية – مصر

تم دراسة تاثير عملية تشميس التربة فى مكافحة الممرضات النباتية فى التربة التى تصيب الطماطم فى الأراضى المستصلحة بمنطقة النوبارية بمحافظة البحيرة بمصر.
أظهرت النتائج فى الأراضى المستصلحة الرملية بمنطقة النوبارية بمحافظة البحيرة أن عملية تسخين (تشميس) التربة بإستخدام البولى إثيلين (٢٠٠ ميكرون) الأسود والشفاف قد أدى إلى خفض شديد فى تعداد الفطريات الممرضة (*Aspergillus* spp., *Penicillium* spp., *Fusariurn* spp., and *Rhizoctonia solani*) بالمقارنة بالتربة الغير مشمسة بعد ثلاث شهور من التغطية. كما لوحظ أن عملية التشميس أدت إلى زيادة نسبة النباتات القائمة فى الحقل مما يوضح إنخفاض نسبة الإصابة بأعفان الساق وأن الممرضات الفطرية بالتربة والتى تصيب نباتات الطماطم يمكن مكافحتها بنجاح بتغطية التربة حول نباتات الطماطم فى الحقل.