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EFFECT OF SOIL SOLARIZATION WITH DOUBLE COVER TO CONTROL THE ROOT-KNOT NEMATODE *Meloidogyne incogaita* IN TOMATO PLANT

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ABSTRACT

The potential of soil solarization with double cover of transparent and black polyethylene sheets at different thickness to control the root-knot nematode *Meloidogyne incogaita* on tomato plants was studied in a field trial during July – August 2006. All soil solarization treatments either transparent polyethylene upper or black sheets upper greatly suppressed the nematode counts in soil reduced numbers of galls, developmental stages, egg masses per root, nematode final population and nematode reproduction as compared with the nonsolarized plot. All solarized treatments significant decreased nematode criteria when compared with the nonsolarized ones. The highest percentage reductions in such nematode criteria were obtained from soil solarized with 300 µm black upper 300 µm clear, 300µm clear upper 300µm black and 200µm black upper 300µm thickness clear sheets, respectively. Whereas, the least reduction was obtained from soil solarized with 120µm black upper 120µm clear, 120µm clear upper 200µm black and 120µm clear/120µm black sheets respectively. Moreover, all solarized treatments improved tomato growth parameters. The highest percentage increase was observed in soil solarized with black sheets 300µm upper 120, 200 and 300µm thickness transparent sheets.

Keywords: Soil solarization, solar heating, polyethylene sheets, *Meloidogyne incognita*, tomato plants, soil cover.

INTRODUCTION

Root-knot nematodes, *Meloidogyne* spp. are more widely distributed throughout the world as a major depressive factor in food production, especially in tropical, subtropical and Mediterranean climates. In Egypt, root-knot nematodes are considered one of the main problems in vegetable crops, especially in tomato production. Chemical control with pesticides have several problems, such as high cost, pollution of environment, toxicity to man and animals as well as disturbance of the natural balance. One of the most effective economic and environmentally safe ways to control plant parasitic nematodes the use of soil solarizrion (Grinstein *et al.*, 1979; Siti *et al.*, 1982; Porter and Merriman, 1983; Raymundo *et al.*, 1986; Heald and Robinson, 1987; Stapleton *et al.*, 1987; Khalaielah-Raida, 1988; Al-Asad and Abu-Gharbieh. 1990; Dhingra and Gaur, 1994; Farahat *et al.*, 1994 and McSorley *et al.*, 1999).

Soil solarization has successfully controlled soil borne fungi (Katan 1980, 1981), plant parasitic nematodes (Stapleton and Heald, 1991) and bacteria (Raio *et al.*, 1997). Eddoudi and Ammati (1995) reported that solarized plots gave 89% reduction of *Meloidogyne* population and no root-rot as compared with non solarized plots. Covering nursery beds with clear film increased soil temperature and greatly decreased (90%) nematode populations and weed infestation (Patel *et al.*, 1995). Black plastic solarization was highly effective in controlling *Meloidogyne* spp. (Moreno *et al.*, 1997). Soil solarization and other methods for controlling root-knot nematodes were reduced nematode population (83%) when compared to the controls (Chakraborti, 1998 and Sotomayor *et al.*, 1999). The efficiency of nematode control in a wet solarization soil was mainly related to reduced soil infestation before planting through stimulation of larval hatching (Horrigue-Raouni and B-chir 1998). Morra *et al.*, (1998) reported that soil solarization reduced *Meloidogyne incognita, Pyrenochaeta lycopersici* and *Fusarium* spp. Vito *et al.*, (1998) suggested that soil solarzation decreased *M. incognita* population and increased lettuce yields comparing to the other control means. In Spain, Blanco-Alonso (1999) concluded that application of soil solarization of one physical practice was insufficient for elimination of *M. incognita* population. McSorley *et al.*, (1999) compared summer solarization, compost, summer cover crops and a resistant cultivar to management *M. incognita* and other plant parasitic nematodes in a double crop system with susceptible vegetable i.e. tomato and pepper as autumn crops and they indicated that population of *M. incognita* reached to minimize levels after summer solarization. Nico *et al.*, (2003) reported that the various periods of solarization was assessed by egg hatch bioassays in sterile water and by infectivity to tomato plants. Solarization reduced egg hatch more than 95% compared with non solarized samples. Soil solarization gives positive results for the control of the root-knot nematode, *M. javanica* on eggplant and increased crop yield in Southern Italy (Candido *et al.*, 2004).

The objective of the present investigation was to assess the effects of double cover soil solarization by using different colour and thickness of plastic sheets for controlling the root-knot nematode *M. incognita* infested tomato plants under field conditions.

MATERIALS AND METHODS

Nineteen field plots (2x2m) with sandy loam soil and naturally infested with the root-knot nematode, *Meloidogyne incognita* were irrigated with water. After 5 days of irrigation, the soil of each field plots was sampled to determine population densities of *M. incognita* per 250g soil. Eighteen field plots were covered with transparent and black polyethylene sheets with thickness (120, 200 and 300µm of both colors). All colour and thickness of polyethylene sheets were used with other colour by three thickness, one time put upper and other time put lower respectively. The polyethylene sheets remained in place for 45 days from 15-July to 30-August 2006. one plot (the nineteenth) was left solarized without plastic cover to serve as check. At the end of solarized period to assay solar heat effect on the nematode population of soil treatment, each plot was planted with tomato seedlings (*Lycopersicon esculentum*) cv. Ace (4 plants/row) and allowed to grow for 55 days at 30±5C°. At the end of the experiment, all plants were harvested and root system of each was carefully removed, gently washed in water and stained in

Lactophenol acid fuchsin Byrd *et al.*, (1983). The number of juvenile per 250g soil for each plots was counted (Goodey 1957). Number of galls, developmental stages and eggmasses per root were also counted. Percentage reductions in such values of nematode parameters due soil treatment were estimated are recorded. Percentage of increase in plant growth parameters of the tested treatments were also estimated and recorded. Data were statistically subjected to analysis of variance (ANOVA) (Gomez and Gomez 1984) flowed by Duncan's multiple-range test to compare means (Duncan, 1955).

RESULTS AND DISCUSSION

Results of the effect of soil solarization on the control of the root-knot nematode, *M. incognita* infecting tomato plants under field conditions, revealed that all solarized treatments either transparent polyethylene upper or black sheets upper greatly suppressed the nematode counts in soil reduced number of galls, developmental stages, egg masses per root, nematode final population and nematode reproduction as compared with those of the non solarized plots (Table 1). Significant differences ($P \leq 0.05$) in such nematode criteria were found between solarized and non solarized plots as a check. Data presented in Table (1) and Fig. (1) show, the highest reduction in number of galls, developmental stages and egg masses per root the were obtained from plots grown in soil solarized with 300 µm black upper 300 µm transparent, 300 µm transparent upper 300µm black, 200 µm black upper 300µm white, 120 µm black upper 300µm clear and 200 µm transparent upper 300µm thickness black with percentage values of 96.5, 96.4 and 92.4%; 94.2, 95.3 and 92.4%; 94.2, 94.3 and 93.1%; 91.2, 93.3 and 91.6% and 89.8, 93.3 and 90.8%, respectively. Significant differences were found between these treatments and other treatments and the control. Whereas, the modest reductions in the nematode criteria were obtained from plants grown in soil solarized with 200µm black upper 200µm transparent, 200µm clear sheets upper 200µm black sheets and 200µm black upper 120µm transparent with values of 90.7, 92.7 and 92.4%; 86.7, 91.2 and 88.5% and 85.8, 89.1 and 91.6%, respectively. On the other hand, the least reductions of such nematode criteria were obtained from plant grown in soil solarized with 120µm black upper 120µm thickness transparent, 120µm transparent upper 200µm thickness black and 120 µm transparent upper 120µm thickness black with values of 81.0, 80.8 and 80.2%; 82.7, 83.4 and 82.4% and 87.8, 80.3 and 80.2%, respectively. Mean while, the lowest values of nematode reproduction were also found in soil solarized with 300µm black upper 120, 200 and 300µm thickness transparent that were amounted to 1.91, 1.90 and 1.89, respectively.

Table (1): Effect of soil solarization with double cover of polyethylene sheets in controlling the root-knot nematode, *Meloidogyne incognita* on tomato plants.

Treatments and thickness	No. of juvenile/ 250g soil			No. of galls/ root	No. of developmental stages/root	No. of egg masses/ root	No. of eggs/ egg mass	Nematode final population (Pf)	Nematode reproduction (Pf/Pi)
	Before application	After application	% reduction						
Transparent/black									
120µm/120µm	1134	278	82.2	48 b	38 b	26 b	282 a	7370	6.49
120µm/200µm	1186	274	83.0	39 d	32 c	23 c	278 a	6426	5.42
120µm/300µm	1196	264	84.0	25 f	16 f	17 d	279 a	4759	3.97
200µm/120µm	1073	251	83.0	36 d	26 d	15 de	277 a	4181	3.89
200µm/200µm	1223	275	84.0	30 e	17 f	15 de	276 a	4157	3.39
200µm/300µm	1118	224	86.0	23 fg	13ghi	12 fg	274 a	3301	2.95
300µm/120µm	1180	254	85.0	24 fg	14fgh	17 d	275 a	4689	3.97
300µm/200µm	1185	255	85.0	21 g	10 kl	13 ef	278 a	3624	3.05
300µm/300µm	1213	235	86.0	13 h	9kl	10 gh	270 a	2709	2.23
Black/transparent									
120µm/120µm	1232	236	86.0	43 c	37 b	26 b	275 a	7187	5.83
120µm/200µm	1276	242	87.0	36 d	31 c	21 c	274 a	5785	4.53
120µm/300µm	1287	244	87.0	20 g	13 hij	11fgh	265 a	2928	2.28
200µm/120µm	1274	224	88.0	32 e	21 e	11fgh	284 a	2925	2.29
200µm/200µm	1333	234	88.0	21 f	14 fgh	10gh	287 a	2684	2.01
200µm/300µm	1335	224	89.0	13 h	11 ijk	9 h	283 a	2378	1.78
300µm/120µm	1370	222	89.0	20 g	15 fg	10 gh	280 a	2615	1.91
300µm/200µm	1372	217	89.0	16 h	10 ik	10 gh	280 a	2610	1.90
300µm/300µm	1388	216	89.0	8 i	7 i	10 gh	283 a	2637	1.89
check	1338	1789	0.0	226 a	193 a	131 a	281 a	35694	26.68

- **means followed by the same letters within a column are not significantly different ($P<0.05$) according to Duncan's multiple range test. Reducation in j_2 in soil according to Handerson and Tilton (1955).**

%reduction in j_2 in soil=(1- [

$$\frac{j_2 \text{ in soil of treated plots after application}}{j_2 \text{ in soil of treated plots before application}} \times \frac{J_2 \text{ in soil of check plots before application}}{J_2 \text{ in soil of check plots after application}}] \times 100)$$

Data on plant growth presented in Fig. (2) proved that all treatments of solarized soil with black sheets upper or transparent upper of all thickness improved the plant growth than that of the non solarized soil. The increment of lengths and fresh weights of both shoots and roots of tomato plant varied greatly according to the type of tested solarized. The highest percentage of increase in such plant parameters was obtained in plant grown in solarized soil with black sheets with 300µm thickness upper 120,200 and 300µm thickness transparent.

These results are in agreement with those Walker (1962) who reported that 48C° for a time period longer than 6 min. was shown to be the thermal death threshold of eggs and egg mass of *Meloidogyne* spp. Moreover, Katan *et al.,* (1976), Katan (1981) and Gokte and Mathur (1995) stated that soil solarization with transparent plastic cover to capture solar energy during hot months leads to heat soil temperatures lethal to plant pathogen.

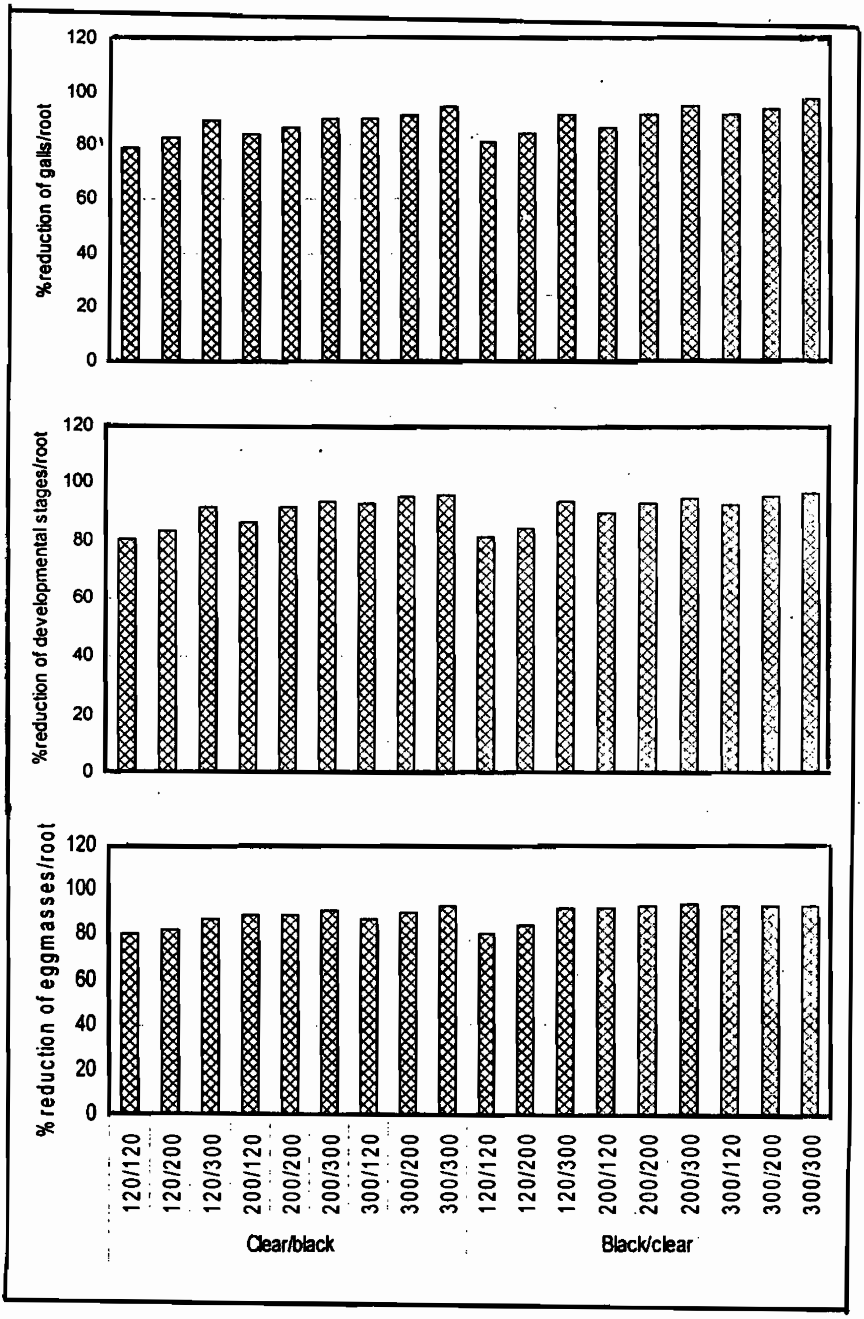

Fig.(1):Effect of siol double covered with black and clear polyethylene sheets at different thickness on percentage reduction of galls, developmental stages and egg masses per root of *Meloidogyne incognita* on tomato plants.

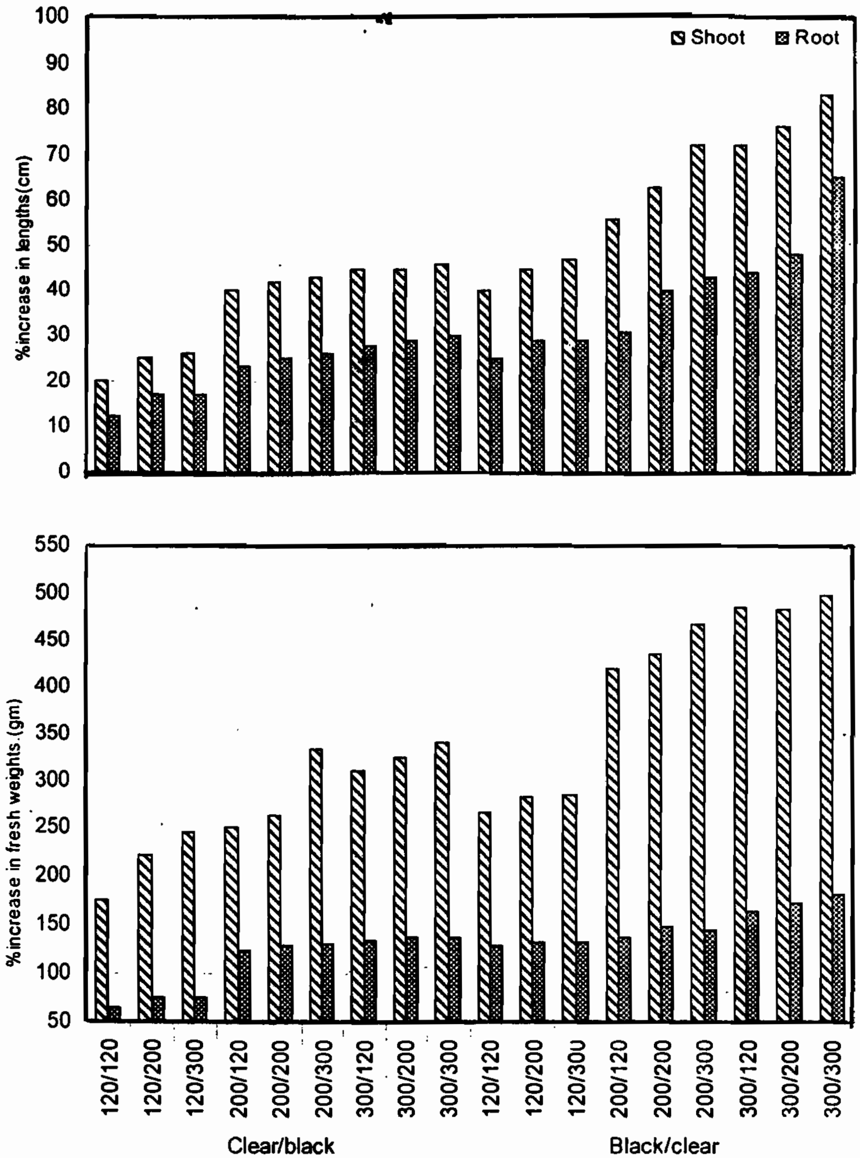

Fig.(2):The influence of soil double covered with black and clear polyethylene sheets at different thickness on the percentage increase of lengths and fresh weights of both shoots and roots of tomato plants infected with *Meloidogyne incognita.*

Soil solarization is an effective control mean against pathogen which gave soil-borne maximum temperature varying between 45-53°C and 38-45°C at depths of 10-20 cm, respectively. Giblin and Verkade (1988) suggested that exposure to a constant temperature above 46°C for 4 hours should be above minimum lethal temperature exposure necessary for soil disinfestations of many phytoparasitic nematodes. Al-Asa'd and Abu-Gharbieh (1990) also suggested that plant growth responses and yields of tomato as well as eggplant were significantly less in the non covered control than in solarized soil or in methyl bromide fumiganted. Solarization of piled soil at a maximum depth of 40cm provided bigger than 95% control of *M. incognita* eggs and egg masses in soil after 10 days treatment, which should satisfy the standard required for the adequate control of *M. incognita*, (Whitehead 1998). Furthermore, the thermal threshold for inactivating free eggs and egg smasses of *M. incognita* reached by solarization may also control other plant parasitic mematodes (Nico *et al.*, 2003).

Generally, solarized soil with polyethylene sheets in hot months decreased such tested nematode parameters and improved plant growth of tomato.

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تأثير التعقيم الشمسي للتربة بالتغطية المزدوجة لمكافحة نيماتودا تعقد الجذور ميلودوجينا إنكوجنيتا على نباتات الطماطم

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تمت دراسة استخدام التعقيم الشمسى للتربة باستخدام التغطية المزدوجة لتفعيل الطاقة الشمسية خلال أشهر الصيف الحارة لرفع درجة حرارة التربة إلى مستويات قاتلة للمسببات المرضية مثل نيماتودا تعقد الجذور (ميلودوجينا إنكوجنيتا) على الطماطم (صنف Ace) وذلك باستخدام الأغطية البلاستيكية مختلفة الألوان والسمك و تم استخدام البلاستيك الأسود والشفاف بدرجات سمك 120، 200 ، 300 ميكرون – حيث تم استخدام كل سمك من البلاستيك الأسود مع كل سمك من البلاستيك الشفاف مره أعلى ومره أخرى أسفل وذلك في حقل ملوث طبيعياً بهذه الآفة ومنزرع الطماطم الصيفي خلال شهري يوليو واغسطس عام 2006م.

ولقد أوضحت النتائج أن كل المعاملات سواء كان البلاستيك الأسود أعلى أو الشفاف قد أدت إلى حدوث نقص معنوي في أعداد الأطوار اليرقيه لنيماتودا تعقد الجذور بالتربة وكذلك عدد العقد النيماتودية والأطوار المختلفة بالجذور وكتل البيض على جذور نباتات الطماطم التي زرعت في التربة المعاملة بالتعقيم الشمسي عند مقارنتها بالتربة غير المعاملة (الكنترول). ولقد كان أعلى معدل للنقص في عدد العقد النيماتودية والأطوار المختلفة بالجذور وكتل البيض على جذور نباتات الطماطم في التربة المغطاة بالمعاملات التالية: 300 ميكرون أسود /300 ميكرون شفاف ، 300 ميكرون شفاف /300 ميكرون أسود و 200 ميكرون أسود و300 ميكرون شفاف – بينما كان أقل معدل في التربة المعاملة بكل من 120 ميكرون أسود /120 ميكرون شفاف، 120 ميكرون شفاف /200 ميكرون أسود و 120 ميكرون أبيض /120 ميكرون أسود على التوالي.

كما أوضحت النتائج أن كل معاملات التعقيم الشمسى للتربة قد أدت إلى تحسن واضح مميز في نمو نباتات الطماطم عند مقارنتها بمثيلاتها التي زرعت في تربة غير معاملة بالتعقيم الشمسى حيث كانت افضل المعاملات هي استخدام 300 ميكرون اسود اعلي وبسمك 120 , 200 و300 ميكرون شفاف في تحسين نمو مقاييس النباتات وكذلك خفض قيم لمقاييس النيماتودا المختبرة.