Case Studies and Implications of Chemical and Non-Chemical Soil Disinfection Methods in Turkey

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Abstract

This study was conducted in tomato crops grown greenhouses with a history of Fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*) root rot (*Rhizoctonia solani*) and root knot nematodes (*Meloidogyne incognita*). The experiments were conducted in 2 greenhouses during the summer season of 2011 in Mersin province of the eastern Mediterranean region of Turkey. Solarization in combination with reduced dosages of metam potassium (MP) (600, 800 L/ha) were tested against soil borne pathogens and nematodes. The effect of different applications on disease incidence and galling index were determined in 2012.

Disease incidence reduction values were 50.80-54.60 and 74.98-76.50% in solarization alone and MP applied greenhouses, respectively. The effect on disease incidence increased to 77.72-91.15% when solarization and MP (600-1000 L/ha) were combined. Gall formation caused by root-knot nematodes in solarization and MP (1000 L/ha) alone, MP+solarization (600 L/ha) were 2.5-2.2, 0.3-0.4, 0.3-0.4, respectively. Solarization in combination with reduced dosages of MP controlled root-knot nematodes until the end of the vegetation period.

INTRODUCTION

In Turkey, greenhouse vegetable production is being conducted on 61,000 ha with 5,8 million tons of production (TUIK, 2012). Mediterranean and Aegean regions cover 93% of the cultivated area under protection in Turkey. Soilborne diseases and nematodes cause considerable plant loss and yield reduction in greenhouses (Can et al., 2004; Altınok, 2005; Yücel et al., 2012). *Meloidogyne incognita*, *M. javanica* and *M. arenaria* are the most common and economically important root-knot nematodes in vegetable growing areas in Turkey (Elekcioğlu and Uygun, 1994; Kaşkavalcı and Öncüer, 1999; Söğüt and Elekcioğlu, 2000; Özarslandan and Elekcioğlu, 2010). Kaşkavalcı and Öncüer (1999) reported that yield losses caused by root-knot nematodes in the processing tomato growing areas in Aydın province (western Anatolia) were approximately 80.1%, depending on nematode density.

Application of soil disinfestation methods before transplanting for controlling soil borne pathogens and nematodes are routine practices in greenhouse grown crop plants. Solarization becomes to be a widespread application in Turkey after restraining of methyl bromide (MB) except for quarantine usage in 2008. However, in greenhouse conditions where disease and nematode density is high from previous season, solarization is combined with reduced dosage of a fumigant to decrease disease incidence. Soil fumigating formulations like dazomet and metam sodium (MS) are reported to have considerable effect on controlling soil borne pathogens and nematodes when combined with solarization at reduced dosages (Minuto et al., 2000; Yücel et al., 2007a). In addition, metam potassium (MP) is decomposed like that of MS to methyl-isothiocyanate (MITC). Thus, the ultimate purpose of this study was to evaluate effectiveness of solarization combination with reduced dosage of MP against soil borne pathogens and nematodes in naturally contaminated tomato greenhouses in the eastern Mediterranean region of Turkey.

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MATERIALS AND METHODS

Fumigant Applications

The experiments were conducted in 2 different greenhouses located in the Mersin province of the eastern Mediterranean region of Turkey. The greenhouses had a history of Fusarium wilt (*F. oxysporum* f. sp. *lycopersici*), root rot (*Rhizoctonia solani*) and root knot nematode (*M. incognita*). The soil structure of the greenhouses was sandy clay loam. The greenhouses were divided into blocks of 40×5.5 m, and 7 treatments (Solarization, MP1000, MS1000, MP600+solarization, MP800+solarization, MP1000+solarization, control) were tested. MS (Sniper Fluid, 500 g/L a.i.) and MP (Tamifume, 690 g/L a.i.) were used as soil fumigants, and low dosages of MP were combined with solarization. Each plot was about 55 m^2 (10×5.5 m), and contained 5 rows each of which had 110 plants. The experimental design was arranged in a way which allowed the four replications of seven treatments. The applications continued for 7 weeks which took from July 11 to August 28. Only the MS and MP1000 L/ha applications were continued for 3 weeks before transplanting. The soil surface was covered for a week following fumigant application and tomato seedlings (‘Melis F_1’, agtohum) were planted on October 1, 2011.

Soil temperatures were recorded by Onset Computer Corporation data loggers placed at 10 and 20 cm soil depth in solarized and non-solarized soil (Table 1).

Determination of the Treatment Effects on Soil Borne Pathogens and Nematodes

The plants were periodically examined during the vegetation period for soil-borne diseases and nematodes. Thirty plants from each parcel were uprooted after about 6 months (on March 27) following transplanting and they were examined for disease symptoms and nematodes. Plants exhibiting discoloration at root part, xylem and phloem tissues were recorded, and were taken to the laboratory for pathogen isolation studies.

Disease incidence (%) in each application was calculated using the formula; number of diseased plants/number of total plants in parcel×100. Effect (%) of application was calculated using the formula; $MG_I\%=[(D_C-D_T)/D_C]\times100$, where $MG_I\%$ = the percent effect, D_C = disease incidence (%) in control, D_T = disease incidence (%) in treatments.

The population density changes of *M. incognita* juveniles (J2) from soil were determined for each replicate before treatment applications and at the end of the growing season to determine initial population density (Pi) and final population density (Pf) (Hooper, 1986). The root gall index was determined by examining of 20 plant’s root system per plot using a gall index scale of 0 to 10 (Barker, 1985). The effect of each application on tomato yield was assessed by investigating fruits taken from 25 m^2 of each application consisting of 4 replicates.

The data were statistically evaluated according to Student’s test, and analyses were performed by Duncan’s multiple comparison tests at 0.05 confidence level.

RESULTS AND DISCUSSION

Disease incidences of Fusarium wilt and root rot in non-solarized control plots in greenhouses 1 and 2 were 24.17 and 28.33%, respectively (Table 2). Solarization alone reduced the disease incidence to 10.83 and 12.50% in greenhouses 1 and 2, respectively.

Effect of MP (600, 800, 1000 L/ha) combined with solarization on reduction of disease incidence was 77.72, 87.26 and 90.83% in greenhouse 1, respectively. In greenhouse 2, the values were 82.40, 88.82, and 91.15% for MP dosages of 600, 800, 1000 L/ha, respectively (Table 2). In the case of MP and MS fumigants alone at 1000 L/ha applications, the effect was low, however, it increased when solarization was combined with 600-1000 L/ha dosages of the fumigants. Eshel et al. (2000) reported increased control of soil borne diseases in tomato in Israel when short period of solarization is combined with reduced dosages of MS. Similarly Yucel et al. (2007b) used MS/dazomet combination with solarization against Fusarium crown and root rot (*F. oxysporum* f. sp. *radicis-lycopersici*) and root knot nematodes (*M. javanica* and *M. incognita*) in tomato and reported increased effect on disease control. In addition to these results, Gamliel et al. (2009) found delay in Fusarium crown and root rot disease emergence in solarization applied tomato grown greenhouses in Israel. Nonetheless, the same researchers also reported that when dazomet was used alone or in combination with solarization, the disease incidence was considerably reduced and the yield increased.

Galling index and number of J2 larvae within the plant roots in treated plots were very low. Galling indexes of untreated control plots were 6.6 to 6.1, and number of J2 larvae of untreated control plots were 2075, 1165 in two greenhouses, respectively. The galling indices in solarization alone, MS (1000 L/ha), MP+solarization (600 L/ha) treatments were 2.5, 0.4, 0.4, respectively. All the treatments tested in this study controlled root-knot nematodes until the end of the vegetation period and that no statistical difference was observed among treatments (Table 3). Similarly, Bogoescu et al. (2010) reported soil borne disease and nematode control effect of MS at 100 ml/m^2 dosage in cucumber.

The soil temperatures in solarized plots at 10 and 20 cm soil depth were 46.6 and 42.2°C, respectively. In non-solarized plots, soil temperatures, however, were 36.4 and 34.9°C, at 10 and 20 cm depths, respectively, and that 10.2-7.3°C difference was recorded (Table 1).

The yield parameters in tomato are given in Figure 1. According to these results, the highest increase in yield (60%) relative to control plots was obtained in MP+solarization application that reached to 6.4 kg/m^2 (Fig. 1).

CONCLUSIONS

Tomato takes first place in protected vegetable production in Turkey with a yield of 3 million tons (TUIK, 2012). The principal factor restricting production is yield loss caused by soil borne pathogens and nematodes. The soil has become infested through continuous cultivation of certain crop plants and chemical control measures applied following seedling plantation to soil have not been effective and economical. For these reasons solarization is combined with licensed fumigants such as metam sodium, metam potassium, dazomet, etc. before transplanting in greenhouses. However, there are restricted number of fumigants available and some of them are not preferred by the farmers since their application is difficult and the cost is high. Among these fumigants, it is known that application of dazomet is relatively difficult and methyl iodide has high cost and may have phytotoxic effect when applied improperly. Dimethyl disulfide is registered only for nematodes in Turkey. Farmers prefer to use metam sodium at 600-1000 L/ha concentration since it could be applied easily through drip irrigation and its cost is relatively low when compared to other soil fumigants. It was reported that metam sodium is widely used in Israel at 300-1000 L/ha dosages before transplanting (Ben-Yephet et al., 1983). However, Di Primo et al. (2003) reported increased dispersion rate of methyl-isothiocyanate (MITC) in continuous metam sodium or dazomet applied soils which in turn results in decrease in pathogen control.

The results of this study revealed that *F. oxysporum*, *R. solani* and root knot nematodes in the greenhouse grown tomatoes could be effectively controlled by solarization combined with reduced dosage of metam potassium (600, 800 L/ha). Further research will also be conducted on plastic types and short term (2-3 weeks) application of solarization combined with fumigant applications, where time is restricted.

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Tables

Table 1. Maximum soil temperatures (°C) in solarized and non-solarized plots during the application period in 2011*.

Solarization period	Depth (cm)	Solarized soil temperature (°C)	Non-solarized soil temperature (°C)
8/7/2011-31/8/2011	10	46.6	36.4
	20	42.2	34.9

* Temperatures were recorded hourly by a data logger.

Table 2. Average disease incidence values and effect of applications (in %) in greenhouses 1 and 2.

Treatments	Disease incidence (%) (Greenhouse 1)	Effect (%)	Disease incidence (%) (Greenhouse 2)	Effect (%)
Solarization	10.83 b	50.80 c*	12.50 b	54.60c
MP **1000	5.83 bc	74.98 b	6.67 cd	76.50 ab
MS 1000	5.83 bc	73.55 b	7.50 bc	73.27 b
MP 600+S	5.00 bc	77.72 ab	5.00 cd	82.40 ab
MP 800+S	2.50 cd	87.26 ab	3.33 de	88.82 a
MP1000+S	1.67 d	90.83 a	2.50 e	91.15 a
Control	24.17 a		28.33 a	

* Letters next to numbers indicate different groups determined by Duncan's multiple comparison tests (p<0.05).
** MP=metam potassium, MS=metam sodium, S=solarization.

Table 3. Effect of soil treatments on *Meloiogyne* spp. in tomato during 2011-2012 growing season.

Treatments	Greenhouse 1			Greenhouse 2		
	Initial pop.Pi* larva/ 100 g soil	Final pop.Pf* larva/ 100 g soil	Gal index**	Initial pop.Pi larva/ 100 g soil	Final pop.Pf larva/ 100 g soil	Gal index
S***	975	40	2.5 b	700	80	2.2 b
MP 1000	460	0	0.6 a	815	0	0.6 a
MS 1000	620	0	0.3 a	875	0	0.4 a
MP 600+S	695	0	0.3 a	965	0	0.4 a
MP 800+S	770	0	0.4 a	590	0	0.3 a
MP1000+S	915	0	0.2 a	675	0	0.4 a
Control	680	2075	6.6 c	525	1165	6.1 c

* Pi: Initial population of J2. Pf: Final population of J2.
** According to the 0-10 galling index scale (Barker, 1985). The lower capitals next to numbers indicate different groups determined by Duncan's multiple comparison tests (p<0.05).
*** MP=metam potassium, MS=metam sodium, S=solarization.

Figures

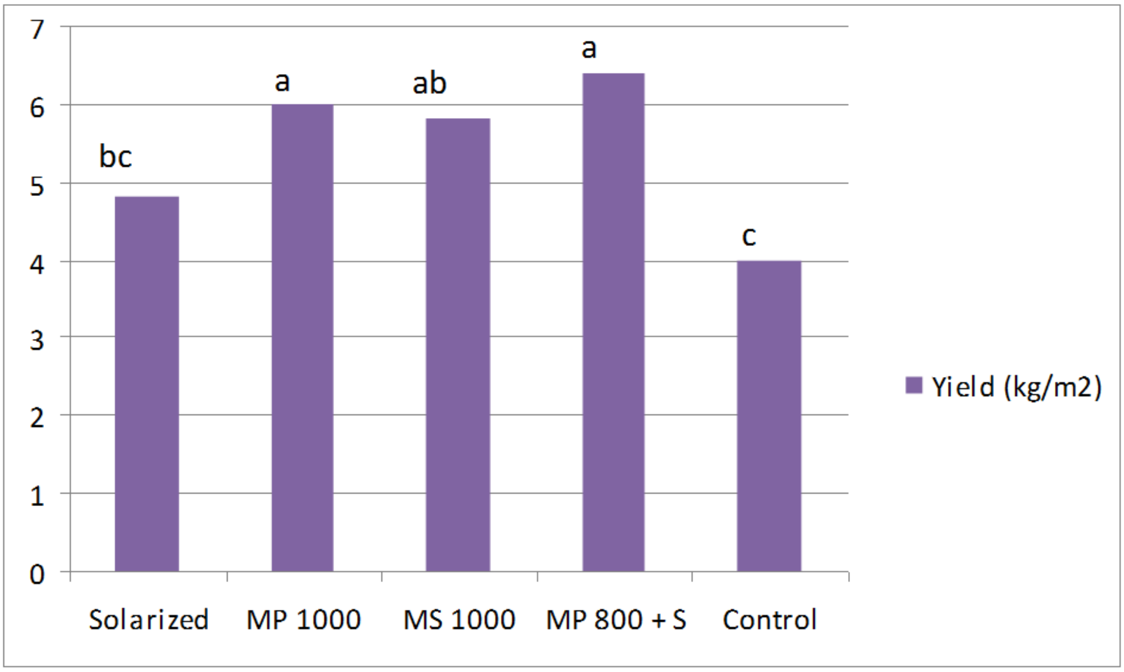

Fig. 1. Effect of different applications on yield in tomato. Different letters on bars indicate significant difference (*P*=0.05). *MP=metam potassium, MS=metam sodium, S=solarization.