Methyl Bromide Alternatives for Controlling Fusarium Wilt and Root Knot Nematodes in Tomatoes in Turkey

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Abstract

Soil disinfestation is a routine application done before plant transplantation in greenhouses. Solarization alone or in combination with low dosage of fumigants has been adopted by a great number of farmers in many Mediterranean countries and has so in Turkey. This study was conducted in tomatoes grown in greenhouse for occurrence of Fusarium wilt (*F. oxysporum* f.sp. *lycopersici*) and root rot nematodes (*Melodiogyne javanica* and *Meloidogyne incognita*). The experiment was conducted in one greenhouse during the summer period in 2006. Solarization in combination with low dosages of Metham Sodium (MS- 2 dosages) and Dazomet (DZ) were tested against soil borne pathogens and nematodes. Effect of different applications on disease incidence, root knot index and the yield was evaluated in 2007. Solarization application alone was not found sufficient with 35% efficiency. When the combination with the low dosages of fumigants was applied, the resulting effect was found successful. In the dosages of Sol.+DZ 400 kg ha^{-1}, Sol.+MS 750 *l* ha^{-1}, Sol. + MS 1000 *l* ha^{-1} the effect was recorded as 54.1%, 51.9% and 83.9% respectively. Tomato yield taken from November to January resulted to be 70 tons ha^{-1} in control plots while it was 110 tons ha^{-1} in combination of solarization with the low dosages of MS and DZ. Density of root knot nematode decreased in all applications of this study.

INTRODUCTION

Tomato, with total production of 9 440 000 t over an area of 255 000 ha, is an important crop in Turkey. The major factors restricting greenhouse tomato production are the soilborne pathogens and nematodes in the eastern Mediterranean region of Turkey. Although methyl bromide (MB) has been used for soil fumigation to control these pests, its usage in Turkey banned in 2007 except for critical uses and quarantine measures. Chemical products belonging to the metham sodium group in liquid formulations and Dazomet in granular formulations are potential substitutes for MB. The toxic molecule of these products is methyl-isothiocyanate, which is formed when the chemicals decompose in the soil (Smelt and Leistra, 1974). These chemicals are known, especially, for their ability to control soilborne fungi and free nematodes (Ben-Yephet and Frank, 1985), but there are no data regarding their toxicity to root knot nematodes. Effect of different applications on disease incidence, root knot index and the yield was evaluated. DZ as an alternative fumigant, and solarization as a non-chemical alternative which is applied particularly in Mediterranean Region, and solarization in combination with low dosages of MS (500 *l* ha^{-1}) for strawberry cultivation in Aegean Region were applied together against soil borne pathogens and/or root knot nematodes. Success of these alternative applications was determined in various rates (Yucel et al., 2007; Benlioglu et al., 2005).

This study aims to evaluate effectiveness of solarization combination with reduced dosage of MS against soil borne pathogens and nematodes in naturally contaminated tomato greenhouses in the Eastern Mediterranean region of Turkey.

MATERIALS AND METHODS

Treatments

The greenhouse was divided into blocks of 50 × 5.5 m, and five treatments (MS 1000 *l* ha^{-1} + solarization, MS 750 *l* ha^{-1} + solarization, dazomet 400 kg ha^{-1}+ solarization, solarization and control) were tested. MS (Sniper Fluid, 500 g a.i./ l^{-1}) and dazomet (Basamid, 98%, granules) were used as soil fumigants, and low dosages of MS were combined with solarization (Table 2). Dazomet was added, and mixed with greenhouse soil irrigated to field capacity. Following soil preparation, a drip irrigation system was installed, and mulching was done with 0.03-mm-thick plastic sheeting. For MS application, pipes were arranged at 30-cm intervals. The required amount of MS was prepared according to the manufacturer's instructions. It was then applied to mulched soil through the drip irrigation system. In order to wash out the remaining MS within the drip irrigation system, a further irrigation was applied. The total amount of water used for application of MS was 10 *l* m^{-2}. Tomato seedlings (F3080) were planted on August 25, 2006.

Each plot measured approximately 60 m2 (12 m × 5 m), and consisted of five rows, each of which had 25 plants. The distance between rows and between plants was 90 cm and 40 cm, respectively. Thirty plants for each plot were evaluated, and two border rows were not considered in the calculations. The experimental design consisted of four replications of each of the five treatments. Treatments continued for 5 weeks, from July 1 to August 15.

Soil Temperatures

These were recorded by data loggers (Onset Computer Corporation, Bourne, MA, USA) placed at depths of 10 and 20 cm in solarized and non-solarized soil.

Effects of Treatment on Soilborne Pathogens and Nematodes

The plants were periodically examined during the vegetation period for soilborne diseases. Thirty plants from each plot were uprooted approximately 5 months (on February 1) after transplanting and were examined for diseases. Records were kept of plants exhibiting discoloration in xylem and phloem tissues, and the plants were taken to the laboratory for pathogen isolation studies. Disease incidence was calculated according to the formula: MG1%= [(DC-DT)/DC].100, where MG1% = the percent effect, DC = number of diseased plants in control, and DT = number of diseased plants in treatments.

The population density changes of *M. incognita* second stage juveniles (J2) from soil were recorded for each replicate before treatment applications and at the end of the growing season in order to determine both initial population (IP) density and final population (FP) density. Soil samples were taken from replicated plots (60 m^2 each) by removing three cores from the 0–30-cm soil layer. Soil nematodes were extracted using a modified Baermann funnel method (Hooper, 1986). J2 root-knot nematodes were collected from 50ml of soil and counted under a light microscope.

The root galling index was determined on ten plant root systems per plot using a galling index scale of 0 to 10 (Barker,1985), where 0 = roots with no galls and 10 = roots with maximal degree of galling at the end of the growing season.

Statistical Analysis

The data were statistically analyzed according to Student's t-test, Randall analyses were performed by least significant difference (LSD) at the P=0.05 confidence level.

RESULTS

F. oxysporum f.sp. *lycopersici (Fol*) was isolated from the plants exhibiting wilting, and the gallforming nematodes were identified as *M. incognita*.

Soil Temperatures

Maximum soil temperature (47.5°C) was recorded at the 10-cm soil depth, and was 7.5°C higher than that of non-solarized control plots. The maximum soil temperature in solarized plots at the 20-cm soil depth was 43.0°C. In non-solarized plots, the corresponding soil temperature was 37.1°C (Table 1).

Effects of Treatments on Soilborne Pathogens and Nematodes

Disease incidence (*Fol*) in non-solarized control plots in greenhouse was 62.5%. Solarization alone reduced the disease incidence to 39.2% in greenhouse. The effectiveness of reduced doses of MS (750, 1000 l ha^{-1}) in combination with solarization in controlling pathogens was 51.9% and 83.9%, respectively, in greenhouse. However, dazomet combined with solarization reduced the disease incidence to 28.3 (Table 2). The effect of this treatment on disease incidence was similar to that of MS (750 *l* ha^{-1}) combined with solarization in greenhouse.

Galling index and number of J2 larvae within the plant roots in treated plots were very low. Galling indexes of untreated control plots were 6.4 and all the treatments tested controlled root-knot nematodes until the end of the vegetation period (Table 3).

DISCUSSION

Maximum soil temperature differences between solarized and nonsolarized soils detected from experimental greenhouse was found to be 7.5 and 5.9°C at 10 and 15 cm soil depth respectively. Chellemi and Olson (1994) reported an average of 8°C temperature difference between solarized and control plots at 15 cm soil depth in Florida. In the east Mediterranean region of Turkey, 7°C and 6°C temperature difference were reported at 10 cm soil depth in 1990 and 1991 respectively (Yücel, 1995).

Solarization combined with the low dosages of MS (750, 1000 *l* ha^{-1}) reduced disease incidence of *Fol* to a level similar to that of solarization in combination with dazomet that is widely applied by the farmers. Disease incidence of control plots were found as 62.5% , while this rate were recorded as 28.3% in DZ 400 kg ha^{-1} and 29.9% and 11.6% in MS applied plots in doses of 750 and 1000/ ha^{-1}, respectively. The soil of greenhouse which has a high disease infestation were lowered around 40% only by means of solarization. Further incidence was lowered by the applications of combined fumigations. A related study (Frank et al., 1986) comparing the effects of MS at 900 *l* ha^{-1}, solarization and the two treatments combined, revealed that yields of peanut pods without necrotic spots increased by 114%, 440% and 893%, respectively. The study reported that pre-wetting the soil with MS instead of water when preparing the soil for solarization may be useful in controlling additional soilborne disease agents. Similar results were reported by Tjosvold in floriculture and nurseries and MS (935 *l* ha^{-1}) combined with solarization for 6 weeks was considered to be a good alternative to MB(Tjosvold, 2000).

In this study; all applications of solarization alone, Solarization + DZ 400 kg ha^{-1}, solarization + MS 750/ ha^{-1}, solarization + MS 1000/ ha^{-1} were also found successful in controlling root-knot nematodes. Galling indexes in all plots with applications were found as 0%, while this rate was found as 6.4% in control plot. Effectiveness of solarization, DZ 400 kg ha^{-1}, low dosages of MS (S+ MS500, S+ MS750, S+ MS1000 ve MS1250 *l* ha^{-1}) in combination with solarization were evaluated in two different greenhouses where tomatoes are produced. All applications were recorded as successful against root-knot nematodes and lowered galling indexes (0-0.4) while galling indexes were recorded as 5.7-6.6 in unapplied plots (Yucel et al.,2007). Previous tests conducted in the same region by our group in greenhouses where cucumber, pepper, eggplant and strawberry were grown resulted in effective control of root-knot nematodes by solarization alone or in combination with a low dose of dazomet (Yucel et al., 2002). Studies have revealed that MS, chloropicrin, 1,3-dichloropropene, 1,3-dichloropropene + 17% chloropicrin, and 1,3-dichloropropene + 35% chloropicrin as alternatives to MeBr are effective in tobacco, tomato and pepper pest and disease control (Csinos et al., 2000). The fumigants were used alone or in combination for 2 years in three different areas for weed, insect and nematode control, and MS application was found to be the most effective.

The results of the present study suggest that all the treatments tested in greenhouses with Fusarium wilt and root-knot nematodes could be adopted in the eastern Mediterranean region of Turkey. The farmers prefer solarization in combination with low doses of soil fumigants in monoculture greenhouses having high disease incidence. This necessitates more research on the effect of solarization combined with reduced doses of soil fumigants.

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Tables

Table 1. Maximum soil temperatures (◦C) in solarized and non-solarized plots during the application period, July 1–Aug. 15, 2006 (temperatures were recorded hourly with a data logger).

Depth (cm)	Solarized soil	Non-solarized soil
10	47.5	40.0
20	43.0	37.1

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

Treatments	Disease Incidence*	Effect %
Solarization	39.2 c	35.0 c
MS 750 + Solarization	29.9 b	51.9 b
MS 1000 + Solarization	11.6 a	83.9 a
Dazomet + Solarization	28.3 b	54.1 b
Control	62.5 d	
LSD %5	6.9	8.9

*In each column means followed by different letters are statistically different (one way ANOVA at $p \leq 0.05$)

Table 3. Effect of different treatments on *Meloidogyne* spp. in tomato greenhouses during the 2006–2007 growing season.

Treatments	Initial pop. larva/100g soil(Pi)	Final pop. larva/100g soil(Pf).	Gal index
Solarization	850	0a	0a
MS 750 + Solarization	880	0a	0a
MS 1000 + Solarization	775	0a	0a
Dazomet + Solarization	680	0a	0a
Control	630	1630b	6.4b