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Effect of Combination of Solarization and Soil Fumigation on Root-knot Nematodes (*Meloidogyne* spp.) (Nematoda: Meloidogynidae) in Greenhouses

Adem ÖZARSLANDAN[1] Dilek DİNÇER[2] Refik BOZBUĞA[2]
[1]Applied Technology and Management School of Silifke, Mersin University, Mersin, [2]Biological Control Research Institute, 01321, Adana
✉: ozarslandan2001@yahoo.com

ABSTRACT
Root knot nematodes are economically important crop pests that is difficult to control. Soil fumigation and solarization are significant methods to control root knot nematodes. The application of soil fumigation and solarization on nematodes is not fully understood. Therefore, this study was carried out to determine the effect of the combination of the solarization with reduced dose of metam-sodium to control root knot nematodes in pepper. Experiments were conducted in greenhouses in Adanalıoğlu and Kazanlı region of Mersin province in 2014-2015. Following the planting beds were prepared in the experiments, the solarization with reduced metam-sodium fumigant was applied at 750 l/ha. The plots were saturated via drip irrigation, and waited for two days before metam-sodium was applied with 100 ton/ha water. The solarization application in July 2014 combined with reduced metam-sodium treatment were effectively protected pepper against root-knot nematodes until July 2015 where gall formation ranged between 0-1.4. Solarization combination with reduced metam-sodium application resulted with gall formation below 2 while in non-treated parcels were ranged from 6.4 to 7.1. Solarization with reduced metam-sodium application resulted 98,8% to 234,5% yield increase in pepper. Results indicate that combination of solarization with reduced metam-sodium application reduced the root-knot nematodes. It is thought that when the manufacturers apply the solarization with combination of metam-sodium correctly, they will not have nematode problems and the possibility of encountering lower ineffectiveness of the chemicals.

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Seralarda Kök Ur Nematodlarına (Meloidogyne spp.) (Nematoda: Meloidogynidae) Solarizasyon ve Toprak Fümigasyon Kombinasyonunun Etkisi

ÖZET
Kök ur nematodları kontrol edilmesi zor önemli ürün zararlılarındandırlar. Toprak fümigasyon ve solarizasyon kök ur nematodlarını kontrol etmek için önemli birer yöntemlerdir. Nematod kontrolünde toprak fümigasyonunun ve solarizasyonun uygulanması tam olarak anlaşılamamıştır. Bu nedenle, bu çalışma, biberde, düşük dozda metam-sodyum fumigant ile solarizasyon uygulamasının kombinasyonunun kök ur nematodlarına etkisini belirlemek için yapılmıştır. Denemeler 2014-2015 yıllarında Mersin ili Adanalıoğlu ve Kazanlı'da mevcut seralarda yürütülmüştür. Deneme dikim sırtları hazırlanmasından sonra, metam-sodyum fümigantının azaltılmış dozu 750 l / ha'da uygulanmıştır. Parseller damla sulama ile doyurulduktan iki gün sonra metam-sodyum 100 ton/ha su ile verilmiştir. Temmuz 2014'teki solarizasyon ve metam-sodyum kombinasyon uygulamasının Temmuz 2015'e kadar biber köklerinde mevcut ur oranını 0-1.4 arasına düşürdüğü ve bu uygulamanın kök ur nematodlarını azaltmada etkili olduğu saptanmıştır. Azaltılmış metam-sodyum

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uygulamasıyla kombine edilen solarizasyon uygulamalarında gal indeksi 2'nin altında olurken, kontrol parsellerinde 6.4 ile 7.1 arasında bulunmuştur. Azaltılmış metam-sodyum ile solarizasyon uygulamasının % 98,8-234,5 oranında verim artışı sağladığı görülmüştür. Sonuç olarak azaltılmış metam-sodyum uygulaması ile solarizasyon kombinasyonunun kök ur nematodlarına etkili olduğu saptanmıştır. Üreticilerin metamsodium ile solarizasyon uygulamasını doğru uygulama yaptıklarında nematod sorunu yaşamayacakları ve ilaçların etkisizliği ile karşılaşma olasılığının az olabileceği düşünülmektedir.

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INTRODUCTION

Root-knot nematodes (*Meloidogyne* spp.) (Nematoda: Meloidogynidae) are known to cause economic losses in a wide range of hosts throughout the world. *Meloidogyne arenaria* (Neal, 1889) Chitwood, *M. incognita* (Kofoid and White, 1919) and *M. javanica* (Treub, 1885) Chitwood are important plant parasite nematodes that lead to damages in vegetables in Turkey (Elekcioğlu and Uygun, 1994; Elekcioğlu et al., 1994; Mennan and Ecevit, 1996; Kaşkavalcı and Öncüer, 1999; Söğüt and Elekcioğlu, 2000; Özarslandan and Elekcioğlu, 2010). It was reported that root-knot nematodes cause significant yield losses in vegetables ranging between 42-54% in tomatoes and 30-60% in eggplants worldwide (Netscher and Sikora, 1990). Annual losses due to nematodes is estimated to be between 12.3% and 20% in several crops and up to 80% in some vegetables (Sasser, 1986; Sasser and Freckman, 1987). It was reported that root nematodes infect more than 5,500 plant species (Trudgill and Blok 2001).

One of the soil disinfection methods is solarization. Initial studies on solarization in agricultural applications were conducted in the mid-1970s on soil-based pathogens in Israel (Katan et al., 1976) Since the MeBr was banned in 2015, solarization is increasingly becoming one of the most important methods that are used to control root pathogens including root-knot nematodes. The effectiveness of solarization depends on the soil type, soil moisture, temperature, daylight and sunlight intensity (Souza, 1994; Coelho et al., 2001). It was reported that the number of plant parasitic nematodes were lowered up to 92-100% at 0-20 cm soil depth via solarization, however the nematode populations could survive in 20 cm depth (Ostrec and Grubisic, 2003). Fumigation is effective against soil nematode populations where solarization is not effective. It was reported that solarization is effective against nematode populations up to 20 cm soil depth, solarization + fumigant application is effective up to 35 cm soil depth, when only solarization is applied, the nematodes can survive under 20 cm soil depth and move upwards over time to reach the depth where they can cause economic damages (McSorley et al., 1999). It was reported that solarization applied field plants grow better compared to those of solarization is not applied (McSorley et al., 1999, Seman-Varner et al., 2008). Using metam-sodium or potassium, which are wide spectrum fumigants in vegetables, exhibit diverse results against root-knot nematodes (Desaeger and Csinos, 2006; Zasada et al., 2010).

It was reported that solarization, alone, is not adequately effective against nematodes and certain soil-borne diseases (Chellemi et al., 1994; Fuentes et al., 1997). Yılmaz et al., (2011) reported in a study that small galls were still observed on cucumber roots after solarization. Therefore, since pepper cultivation lasts about 9-10 months, it is of great importance to include integrated management applications with lower fumigant use in order to increase the effectiveness of solarization against root knot nematodes. In the present study, an integrated management research was conducted with a combination of reduced doses of metam-sodium along with solarization against root-knot nematodes.

MATERIAL and METHOD

Experiments were conducted in grower greenhouses located in Kazanlı and Adanalıoğlu in Mersin province, Turkey, in 2014-2015. Pepper grown in previous year in the same greenhouses was evaluated at the end of the vegetation period. Plant roots were examined, and galled roots were analysed based on the 0-10 root galling index (Barker, 1985). The experiment was set up with the randomized blocks design, where the fumigant was applied to the blocks and each replicate was taken in each block (strip parcel). Experiments were carried out in 2 characters (1 trial dose and 1 non-treated) and 4 replicates of 10 m x 5,5 m = 55 m^2 blocks. An alleyway of 1.5 m was implemented as safety between the blocks and around the experiment area. The application doses were arranged and applied via drip irrigation. Greenhouse experiments were

consisted of solarization and metam-sodium (500 g / lt) combination and control parcels. Greenhouse soil was processed in 0-30 cm depth and purified from plant waste before the applications. The planting beds were prepared, and the drip irrigation pipes were laid out and covered with solarization covers. 1-2 days before spraying, soil was irrigated for 4-6 hours until the wet soil reached between the two dripping pipes. Solarization in the greenhouse was conducted between 21 and 29th of July, 2014. Fumigant application was performed via the drip irrigation system between 2 and 7th of August, 2014. Metam Fluid (500 g/L metam sodium) was provided from Dogal Agricultural Company (Turkey). Liquid metam-sodium (500 g / l) was applied with the drip system after covering the soil with a transparent polyethylene cover. The metam-sodium was administered via approximately 100 ton/ha water. The access to the plots was banned for 6 weeks. The soil types were sandy loam and soil organic matter was between 1 to 3% with a pH of 7.8 to 8.1.

Pepper, Safran F1 var. Charleston was planted in the greenhouse 1 and Mert F1 var. Long pepper were planted in greenhouse 2 on October 12, 2014. Maraton F1 var. Charlestonwas planted in Greenhouse 3 on October 10 to 28, 2014. At The galled roots in the experimental fields were analysed at the end of the season, on July 09 to 15, 2015.

Soil samples were taken to determine the number of the second stage juveniles (J2) of pre-application (Pi) and final (Pf) populations at three points in each plot from 0-30 cm soil depth. The nematodes in the soil were analysed with the modified Baermann-funnel method (Hooper, 1986) and nematode J2 densities were determined 50 cm^3 solutions and identified under light microscope. At the end of the growth period, 20 plant roots were removed from each row on July 09 to 15, 2015 and observed based on 0-10 galling index (Barker, 1986). The root with no galling was considered 0 and the root with maximum galling was considered as 10 galling index value.

In the application plots, the Abbott formula was applied to the root-knot nematode juvenile and yield values obtained during the harvest period to determine the percentage effects. Variance analysis was conducted with SPSS 18.0 (SPSS Inc., Chicago, IL, USA) software and the averages were compared with t-test at a significance level of 0.05.

RESULTS and DISCUSSION

Observations indicated that there were no phytotoxic effects on the plants after the fumigation in the experimental field. In the greenhouse, first pepper experiment field, the initial nematode population before the application of solarization + metam-sodium 750 l/ha was 1165 J2 /100g soil, which was down to zero following the application indicating that the application was 100% effective. The initial populations in untreated plot were 985 and 2285 J2 during the harvest. In S + metam-sodium application, the rate of root galling was zero and it was determined that the same figure was 7.10 in the non-treated plot. In the S + metam-sodium application, 148425 kg/ha crop was harvested, while 57675 kg/ha was harvested in the no-application plots and the application was found to increase the yield 157.3%. In the greenhouse second pepper experiment field, it was determined that the initial population of J2's was 750 and no nematode was found in the plots following the application of S + metam-sodium 750 l/ha, which indicates that application was100% effective. The initial nematode population in non-treated soils were 985, 1275, 725 and 2285, 2055, 2560 J2 were identified during the harvest respectively. In the S + metam-sodium application, the rate of galling was zero and was found to be 6.80 in the control. Crop yield for S + metam-sodium treatment was 135875 kg / ha and crop yield for non-treated soil was 40625 kg / ha. It can be concluded that the S + metam-sodium application resulted in a yield increase of 234.5%. The initial second stage juvenile population in the S + metam-sodium application was 750 l/da in the greenhouse of third pepper experiment field and the application was determined to be 100% effective, while 905 J2 were present prior the application. While the initial second stage juvenile population in the non-treated soil was 725, 2560 J2 during the harvest. The rate of galling in S + metam-sodium application was 1.40, while it was 6.40 in the non-treated soil. In S + metam-sodium application, 126925 kg/ha crop was harvested and 63850 kg/ha was harvested in the non-treated soil. It was determined that the metam-sodium application resulted in an increase of 98,8% in crop yield.

Effective protection against root-knot nematodes throughout the entire growth season was achieved with soil disinfection applications in the greenhouses where the experiments were conducted. It has been determined that S + metam-sodium application can be used in pepper cultivation for root nematodes management in experimental fields. Several previous studies reported that solarization as a sole disinfection method for the fields was not sufficient and reduced fumigant dose + solarization was more effective (Chellemi and Olson, 1994; Katan, 1996; Fuentes et al., 1997; Coelho et al., 1999).

Steve (2000) reported some promising results for soil fumigation with 946 l/ha metham-sodium when applied with solarization for 6 weeks. Yücel et al. (2007a) reported that the application of of solarization + 400mg/ha Dazomet was effective against root-knot nematodes in single product pepper and aubergine cultivation..

Table 1. Effects of solarization + metam-sodium reduced-dose on pepper cultivation and soil disinfection applications on root-knot nematodes

Applications	Greenhouse 1					Effect %
	Pi	Pf	Effect %	Galling index	Yield rate	
S+Metam-sodium 750 L/ha	1165±146	0,0±0,0	100	0,0±0,0	148425±2062	157,3
Non-treated	985±118	2285±499		7,10±0,27	57675±2041	
	Greenhouse 2					
S+Metamsodium 75 L/ha	750±97	0,0±0,0	100	0,0±0,0	135875±2472	234,5
Non-treated	1275±343	2055±253		6,80±0,29	40625±1583	
	Greenhouse 3					
S+Metam-sodium 75 L/ha	905±245	0,0±0,0	100	1,40±0,22	126925±1679	98,8
Non-treated	725±188	2560±312		6,40±0,33	63850±2282	

*Pi: İnitial population **Pf: Final population

Yücel et al. (2007b) reported that the application of S + metam-sodium (500,750,1000 l/ha), and S + dazomet (400 kg/ha) in tomato cultivation was effective on root-knot nematodes compared to the control and S + metamodium1000 L/ha application (Yücel et al., 2014) Söğüt and Elekcioğlu (2007) found that the combination of solarization with dazomet (400 kg/ha) was effective on pepper (Yücel et al., 2009). Toktay et al. (2015) reported that the combination of solarization with metam sodium or dazometone was more effective when compared to the application of solarization + metham sodium + iprodione and solarization + iprodione against root nematodes. The nematode control was successfully achieved in metam sodium application for water high affinity of metham sodium (Noling and Becker, 1994; McGovern et al., 1998; Desaeger et al., 2017). The results of the above-mentioned studies were consistent with the previous studies. It has been reported that only solarization is effective for only 4-5 months against root-knot nematodes and galling usually appears at the end of this period (Katan, 1987, Ioannou, 2001, Yilmaz et al., 2011). The producers plant pepper seedlings when the air begins to cool down during the month of November and when nematode activity is reduced. In pepper greenhouses without proper applications, nematode damage is observed in April and adequate control cannot be obtained and adequate crop yield cannot be harvested despite the costs incurred to the damaged plants during this period. Therefore, solarization and reduced fumigant application should be conducted during the summer when there are no plants.

In the study, yellowish leaves, small fruits and non-marketable fruit formation were determined in the control plants. Observable losses in yield were determined in control plots. When applied to a flat field, solarization application is effective up to a soil depth of 20 cm. When fumigant is applied during the preparation of the planting bed in the greenhouse, the effects on the sides and top of the bed are better. In areas where reduced dose fumigation is applied with solarization, it was observed that plants developed better (Figure 1).

When pepper is planted in September, pepper plants were small in the control plots and yield losses were observed. When the late planting was conducted in mid-November, the plants in the control parcels were grown well, but the leaves were yellowish in April and May due to lack of nutrients.

Figure 1. Application of solarization (left), low-dose fumigant with solarization (left) and development status of plants in control (non-solarised soil) (right).

Figure 2. Low-dose fumigant with solarization and control parcels(left). and development status of plants in control (non-solarised soil) (right).

As nematode activity was decreasing since November, plants grew, and in April, the leaves became yellow similar to nutritional deficiency due to the loss induced by nematodes. Since the nematode deteriorates root systems due to disruptions in water and nutrient intake, plant leaves become yellowish causing reduction in fruit production. Fruits in certain greenhouses were insufficient for the market (Figure 2). Desaeger et al. (2017) indicated that high seedling mortality was observed in non-treated beds during the first month after transplantation and half of the seedlings died in non-treated plots. In summer, during fumigant applications were conducted with solarization, no nematode-induced problems until July of the following year. The greenhouses, where adequate applications were conducted with solarization, were productive in mid-July and early-August. However in May, the plants had to be demolished due to nematode damage in the greenhouses, where good practices were not conducted. Solarization with reduced dose fumigants was found to be effective against nematodes up to a depth of about 35 cm, sustaining the plant for a long period of time and keeping the lowest galling. However, after solarization, the population of nematodes, which can survive below 20 cm soil depth, move towards the upper layers. Therefore, nematode damage is observed in April due to higher soil temperatures. At that time, controlling nematode population is not possible and economic production cannot be achieved. If the soil is impermeable or treated after the application of solarization in the fields, it should be processed in more than 10-15 cm in depth. Failure of the reduced dose fumigant application in combination with solarization is due to inadequate application practices. In the present study, it was determined that reduced dose metam-sodium fumigant application can be used against root nematodes via the application of pre-planting solarization in pepper cultivation. Fumigant application with summer solarization increased the yield between 98,8 and 234,5 % times since the root-knot nematode is a major yield-limiting factor. It was determined that the yield losses were due to application errors instead of inadequacy of the chemicals. The productivity increased across the applications in different greenhouses. The Mersin Chamber of Commerce reported that 150 million TL annual loss was prevented thanks to the present project in Mersin province (Anonymous, 2016). Fumigant applications should be accompanied with solarization in the period when producers finish the harvest in summer. Seedling deaths are observed when there is no control against root-knot nematodes in summer. In summer months, solarization should be applied in combination with low-dose fumigants when plants are uprooted.

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REFERENCES

Anonymous 2015. http://www.turktob.org.tr /tr/mersinde-biber-uretimini-artiran-solarizasyon-ve-ilac-projesi/19331, http://www.mtso.org.tr/tr /haberler/biberde-kalintiyla-mucadelede-gunes-etkisini-gosteriyor

Barker KR, Townshend JL, Bird GW, Thomason IJ, Dickson DW 1986. Determining nematode population responses to control agents. In: Hickey KD editor. Methods for Evaluating Pesticides for control of Plant Pathogens, 1st Ed, St. Paul, MN, USA: APS Press, pp 283-296.

Chellemi DO, Olson SM 1994. Effect of Soil Solarization and Fumigation on Survival of Soilborne Pathogens of Tomato in Northern Florida. Plant Disease, 78 (2): 1167-1172.

Coelho L, Chellemi DO, Mitchell DJ 1999. Efficacy of solarization and cabbage amendment for the control of Phytophthora spp. in North Florida. Plant Dis. 83: 293-299.

Desaeger J, Csinos A 2006. Root-knot nematode management in double crop plasticulture vegetables. Journal of Nematology 38:59–67.

Desaeger J, Dickson DW, Locascıo SJ 2017. Methyl Bromide Alternatives for Control of Root-knot Nematode (Meloidogyne spp.) in Tomato Production in Florida. Journal of Nematology 49(2):140–149.

Elekcioğlu İH, Uygun N 1994. Occurrence and distribution of plant parasitic nematodes in cash crop in Eastern Mediterranean region of Türkiye. In: Proceedings of 9th Congress of the Mediterranean Phytopathological Union, KuşÇadası-Aydın-Türkiye, pp. 409-410.

Elekcioğlu İH, Ohnesorge B, Lung G, Uygun N 1994. Plant parasitic nematodes in the Mediterranean region of Turkey. Nematologia Mediterranea, 22: 59-63.

Fuentes P, Aballay E, Montealegro JR 1997. Soil solarization and fumigation for the control of nematodes in a monocultivated soil with tomatoes . Lima Peru, Association Latinoamerica de Fitopatologia (AFL) . Fitopatologia (Abst. 32).

Hooper DJ 1986. "Handling, Fixing, Staining and Mounting Nematodes. In: J.F., Southey (ed.). Laboratory Methods for Work With Plant on Soil Nematodes, 59- 80." Her Majesty's Stationery Office, London, 59-80.

Ioannou N 2001. Integrating soil solarization with grafting on resistant rootstocks for management of soil-borne pathogens of eggplant. J. Hort. Sci. and Bio. 4: 396-401.

Kaşkavalcı G, Öncüer C 1999. Investigations on distribution and economic importance of Meloidogyne Goeldi, 1887 (Tylenchida: Meloidogynidae) species found in the major areas of hot climate vegetables in Aydın province. Turkish Journal of Entomology, 23 (2): 149-160.

Katan J, Greenberger A, Alon H, Grinstein A 1976. Solar Heating by Polyetilene Mulching for the Control of Diseases Caused by Soil- Borne Pathogens. Phytopathology, 66: 683-688.

Katan J, Grinstein A, Greenberger A, Yarden O, Devay JE 1987. First decade 1976-1986 of soil solarization solar heating-A chronological bibliography. Phytoparasitica, 15: 229-255.

Katan J 1996. Principles and practice of managing soilborne plant pathogens. In: Soil Solarization. (Ed.: R. Hall). APS Press, pp.

Netscher C, Sikora RA 1990. Nematode Parasites on Vegetables. In: Plant Parasitic Nematodes in Suptropical and Tropical Agriculture. (Eds.: M. Luc, R. A. Sikora and J. Bridge). CAB International, 231-283 pp.

McGovern RJ, Vavrina CS, Noling J, Datnoff LA, Yonce HD 1998. Evaluation of application methods of metham sodium for management of fusarium crown and root rot in tomato in southwest Florida. Plant Disease 82:919–923.

McSorley R, Ozores-Hampton M, Stansly PA, Conner JM 1999. Nematode management, soil fertility, and yield in organic. vegetable production. Nematropica 29:205-213.

Mennan S, Ecevit O 2001. Race determination on some populations of Meloidogyne incognita (Kofoid and White, 1919) (Nemata: Heteroderidae) obtained from Bafra and Carşamba Plains. Turkish Journal of Entomology, 25 (1): 33-39.

Noling JW, Becker JO 1994. The challenge of research and extension to define and implement alternatives to methyl bromide. Supplement to the Journal of Nematology 26:573–586.

Özarslandan A, Elekçioğlu İH 2010. Identification of the Root-knot nematode species (Meloidogyne spp.) (Nemata: Meloidogynidae) collected from different parts of Turkey by molecular and morphological methods. Turkish Journal of Entomology, 34 (3): 323-335.

Ostrec L. Grubisic D 2003. Effects of soil solarization on nematodes in Croatia. J. Pestic. Sci. 76:139-144.

Sasser JN, 1986. Economic importance of *Meloidogyne* in tropical countries In: Lamberti, F. and Taylor, C.E. (Eds) Root-knot nematodes (*Meloidogyne* species) systematics, biology and control. London, Newyork Academic Press, pp. 256-268.

Sasser JN, Freckman DW 1987. A world perspective on nematology: the role of the Society. In: Veech, J.A. and Dickson, D.W. (Eds) Vistas on Nematology. Society of Nematology, Hyattsville, Maryland, pp. 7-14.

Seman-Varner R, McSorley R, Gallaher RN 2008. Soil nutrient and plant responses to solarization in an agroecosystem utilizing an organic nutrient source. Renewable Agric. Food Syst. 23:149-154.

Söğüt MA, Elekçioğlu İH 2000. Determination of Meloidogyne Goeldi, 1892 (Nemata: Heteroderidae)

species races found in vegetable growing areas of the Mediterranean region of Turkey. Turkish Journal of Entomology, 24: 33-40.

Sögüt MA, Elekcioglu IH 2007. Methyl Bromide alternatives for controlling *Meloidogyne incognita* in pepper cultivars in the Eastern Mediterranean region of Turkey. *Turkish Journal of Agriculture and Forestry* 31(1):31-40.

Souza NL 1994. Solarizacao do solo. Summa Phytopathologica 20:3-15.

Steve T 2000. Univ. of California Cooperative Extension CORF News- 4 (4) : 6.

Toktay H, İmren M, Bozbuga R 2015. Alternative strategies to control root-knot nematodes (Meloidogyne spp.) with different irrigation systems in pepper greenhouses. Bitki Koruma Bülteni, 55(3): 215-224 ıssn 0406-3597

Trudgill DL, Blok VC 2001. Apomictic polyphagous root knot nematodes: exceptionally successful and damaging biotrophic root pathogens. Annual Review of Phytopathology 39:53-77.

Yılmaz S, Çelik I, Zengin S 2011. Combining effects of soil solarization and grafting on plant yield and soil-borne pathogens in cucumber. International Journal of Plant Production 5(1):1735-8043

Yucel S, Elekcioglu IH, Can C, Sögüt MA, Ozarslandan A 2007a. Alternative Treatments to Methyl Bromide in the Eastern Mediterranean Region of Turkey. Turkish Journal of Agriculture and Forestry, 31(1): 47-53.

Yücel S, Özarslandan A, Çolak A, Ay T, Can C 2007b. Effect of Solarization and Fumigant Applications on Soilborne Pathogens and Root-knot Nematodes in Greenhouse-Grown Tomato in Turkey. Phytoparasitica 35(5): 450-456.

Yucel S, Ozarslandan A, Colak A, Ay T 2009. Methyl bromide alternatives for controlling Fusarium wilt and root knot nematodes in tomatoes in Turkey. Acta Hortic. 808:381-385.

Yücel S, Özarslandan A, Can C, Gunactı H 2014. Case Studies and Implications of Chemical and Non-chemical Soil Disinfection Methods in Turkey. Proc.VIIIth on Chemical and Non-Chemical Soil and Substrate Disinfestation. Acta Hort.1044:295-300.

Zasada IA, Halbrendt, JM, Kokalis-Burelle N, LaMondia J, McKenry MV, Noling JW 2010. Managing nematodes without methyl bromide. Annual Review of Phytopathology 48:311–328.