

**Alternative strategies to control root-knot nematodes  
(*Meloidogyne* spp.) with different irrigation systems in  
pepper greenhouses**

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**ÖZ**

**Biber seralarında kök-ur nematodlarına karşı farklı sulama sistemleri ile  
alternatif mücadele yöntemlerinin belirlenmesi**

Kök-ur nematodları geniş bir konukçu dizisine sahip olup önemli kültür bitkilerinde ağır verim kayıplarına neden olmaktadır. Türkiye’de nematodlar ile mücadelede nematisit kullanımına önemli kısıtlamalar getirilmekte bunun yanında mücadelede yeni metotlar ortaya konması gerekmektedir. Bu yüzden biber seralarında Kök-ur nematodları ile mücadelede alternatif mücadele programlarının geliştirilmesi büyük önem taşımaktadır. Bu çalışmada toprak solarizasyonu ile birlikte iki farklı kimyasal ve toprak fumigantının iki ve dört hat şeklinde damla sulama sistemi ile kombine edilerek nematodlarla mücadele programlarında kullanılabilirliği araştırılmıştır. Çalışmada solarizasyon + metam sodyum + iprodione uygulaması, dört lateral hatlı damla sulama sisteminde verime ve nematodun kökteki ırlanması üzerine etkili bulunmuştur. Bitki boyu ve nematodun üreme gücüne solarizasyon + iprodione uygulamasının dört lateral hatlı damla sulama sisteminde en yüksek etkiye sahip olduğu saptanmıştır.

**Keywords:** Nematod, Mücadele, Kimyasal, Kök-ur nematodları, Solarizasyon

**ABSTRACT**

Root-knot nematodes possess a wide group of hosts and cause significant yield losses in many economically important plant species. Restrictions on the use of nematicides in Turkey have increased; hence it is needed to discover new control methods for managing Root-knot nematodes. Therefore, establishing alternative control programme to combat

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root-knot nematodes in pepper greenhouse in Turkey remarkably is significant. In this study, soil solarization with two diverse chemicals and soil fumigants combined with two and four drip irrigation pipe in both side of systems for using availability against nematode was investigated. Solarization + metham sodium + iprodione application with four lateral drip irrigation pipes in both side of system were found to be effective on yield and nematode galls on the roots. Solarization + iprodione with four drip irrigation pipe in both sides of systems were found to have the highest impact on plant height and nematode reproduction rate.

**Keywords:** Nematodes, Control, Chemical, Root-knot nematodes, Solarization.

## INTRODUCTION

Root knot nematodes (*Meloidogyne* spp.) are polyphagous pest with the wide range of hosts. They cause economically damage to quality and quantity in the intensive vegetable growing areas in the earth (Netscher and Sikora 1990, Wehner et al. 1991). Root knot nematodes (RKNs) affect plant growth negatively by causing small/big root galls during blocking transmission system of plant nutrients. Thus, RKNs prevent water and nutrient up from the soil and cause a reduction in the plant growth. In addition, they sensitize plants to other fungal and bacterial originated diseases by generating wounds on plant roots and access points (Netscher and Sikora 1990, Söğüt and Elekcioglu 2007). It is stated that depending on the pest population density, RKNs caused crop losses of 29% in tomato, 23% in eggplant, 22% in okra, and 15% in peppers (Sasser 1979). RKNs, represent one of the most important groups of the plant parasitic nematodes, have more than 90 species in the world (Karssen 2002, Karssen and Moens 2006, Palomares Rius et al. 2007). Five different RKN species; *Meloidogyne incognita* (Kofoid and White, 1919) Chitwood, 1949, *M. arenaria* (Neal, 1889) Chitwood, 1949, *M. javanica* (Treub, 1885) Chitwood, *M. hapla* (Chitwood, 1949) and *M. chitwoodi* (Golden, O'Bannon, Santo and Finley); have been reported in Turkey (Elekcioglu et al. 1994, Kaskavalci and Oncuer 1999, Söğüt and Elekcioglu 2000, Devran et al. 2009).

Soil solarization, pest, resistant varieties and the chemicals are widely used for controlling the RKNs. However it is strongly recommended to control RKNs by crop rotation (Young 1992, Roberts 1992, Sijmons et al. 1994, Gheysen et al. 1996, Tzortzakakis et al. 1999, Tytgat et al. 2000). Chemical compounds, which are used to control RKNs, have negative effects on the human health and as well on the environmental aspects. Therefore the alternative methods to control the detrimental activity have become very important (Katan 1996, Gilreath et al. 1998, Yucel et al. 2002). Particularly, the using of a single control method against RKNs is not sufficient in covered vegetables grown fields. Because of the nematicides applications has a complex structure containing living and nonliving factors that made the soil to gain resistant against chemical applications over time. It is difficult to control RKNs by conventional methods because of differences in climate,

vegetation and application error. Hence, detailed studies are needed to build up strategies for developing alternative control methods for successful control against RKNs. At this instant, it is important to enlarge alternative programs to control RKNs problem in greenhouse pepper cultivation. For that reason the alternative different chemicals in combination with soil fumigants are necessary to investigate their effectiveness against the pest in the establishing control programs.

The objective of this study was to investigate the effect of one drip lateral and two drip lateral irrigation system with applications using solarization and some nematicides (iprodione and ethoprophos active ingredients) together with soil fumigant (metham sodium) against RKNs in the pepper greenhouse cultivation.

## MATERIALS AND METHODS

### Experimental design

Study was conducted on two different locations in Kazanlı town of Mersin province in pepper greenhouses (greenhouse 1, greenhouse 2).

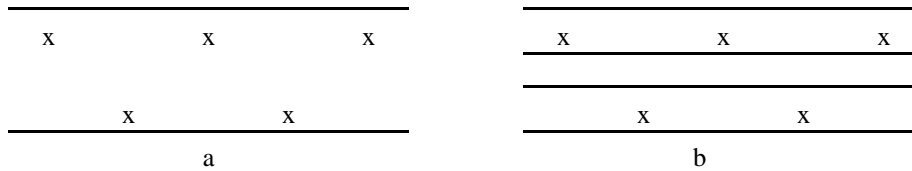


Figure 1. Drip irrigation systems in row (a=two lateral drip irrigation pipes, b= four lateral drip irrigation pipes, x=pepper plants).

First, soil was cultivated 30-40 cm depth and land leveling was completed. Then two different drip irrigation system were established in the greenhouses (Figure 1). In order to increase the sensitivity of thermal conductivity and heat on nematodes in soil solarization, greenhouses were watered about 50-60 cm depth. Soil surface was covered with 70  $\mu\text{m}$  thick transparent polyethylene by hand and the edges were embedded in previously opened furrow (Grinstein and Hetzroni 1989). Polyethylene cover stayed approximately 45 days from 14 July to 30 August 2010. Trials were established by using Erciyes pepper cultivar which are sensitive to RKNs. Trials were planned based on randomized block design with 10 replications and 7 characters. Trial plots consisted of 19.25 m<sup>2</sup> (5.5 m X 3.5 m) and about 80 pepper plants were planted in each trial and 2 security lines were left as empty place between the plots.

Two different drip line irrigation systems (two and four drip lateral line irrigation system) combined with an alternative control programs, solarization + iprodione, solarization + metham sodium + iprodione, solarization + ethoprophos, against

RKNs were assessed. The recommended dose and duration of the chemicals used in the experiments have been illustrated in Figure 2.

Two lateral drip irrigation system				Four lateral drip irrigation system			
I	II	III	IV	V	VI	VII	VIII
Solarization + iprodione	Solarization + metham sodium+ iprodione	Solarization + ethoprophos	Untreated Control	Solarization + iprodione	Solarization + metham sodium+ iprodione	Solarization + ethoprophos	Untreated Control

Figure 2. Trial carried out with the aim of developing an alternative to the control program against to Root-knot nematodes plan in the pepper greenhouse

### Root-knot nematodes assessment

#### Second stage juvenile population and reproduction rate

To observe nematode reproduction rate ( $R_o$ ), second stage larvae population ( $P_f$ ) on each experiment and the initial population ( $P_i$ ) were used. For this purpose, at the beginning and the end of the trial, 8 different soil samples were collected with the help of the probe at 0-30 cm depth from each plots. Second stage larvae were extracted from soil by using Baermann-funnel method (Hooper 1986) and counted under the light microscope.

#### Roots gall rate

The galls caused by Root-knot nematodes on plant roots were determined by using 0-10 gall index scale (Zeck 1971). Plant roots were removed from soil and washed tab-water, and then they were evaluated by examining the 10 plant root system.

#### Yield evaluation

Yield was harvested ten times during the growing season in the both greenhouses. The yield of each plot was recorded at the end of the harvest on the basis of applications. Then total yield (kg/ha) was determined.

#### Plant height

Twenty randomly selected plants were used to verification data on plant height using tape measure after one month of the application and effectiveness of applications on pepper vegetative development was evaluated.

One way analysis of variance was conducted to evaluate the yield and plant height. Duncan multiple range test was used for comparison statistical differences between the means using the 0.05 significance level. SPSS ver.16.0 (SPSS Inc., Chicago, Il., USA) computer software package was used for statistical analysis.

## RESULTS

### Second stage larvae population and reproduction rate

In this study, initial and final root-knot nematode population were evaluated each greenhouses (Figure 3).

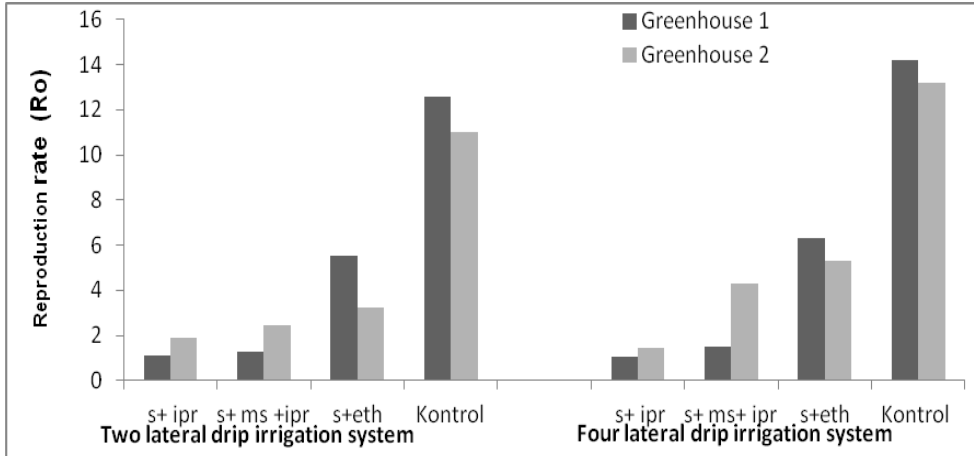


Figure 3. The reproduction rate of *Meloidogyne* spp. in two different irrigation system with chemicals (s= solarization, ms: metham sodium, ipr: iprodione, eth: ethoprophos).

The maximum effect of the reproductive rate of the root knot nematodes in both drip irrigation system was determined on solarization + iprodione treatments. Then solarization + metham sodium + iprodione treatment was followed. The lowest impact of the treatment on nematode reproduction was found on solarization + ethoprophos treatments in both drip irrigation systems. The four lateral drip line irrigation systems were more effective than the two lateral drip line irrigation systems, to reduce nematode reproduction potential in both experiments.

### Root gall rate

The effect of the root-knot nematodes on root galling were evaluated in the greenhouse 1 and 2 (Table 1). The maximum effect on the root galling was found in four lateral drip line irrigation system, solarization + metham sodium + iprodione applications and solarization + iprodione application followed by two drip irrigation system. The least effect was found on two lateral drip line irrigation system with the treatment of solarization + metham sodium + iprodione. The least

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effect was found in four lateral drip line irrigation system combined with solarization + ethoprophos.

Table 1. The effect of treatments carried out in order to establish the control programs against to the root-knot nematodes in the pepper greenhouses (Zeck Scale 0-10).

Drip irrigation systems	Applications	Greenhouse 1	Greenhouse 2
Two lateral pipe drip irrigation system	solarization+ iprodione	0,3939 ab*	0,65 b
	solarization + metham sodium+ Iprodione	1,2727 bc	0,26 a
	solarization +ethoprophos	1,0303 bc	1.80 c
	control	4,1624 d	3,54 d
Four lateral pipe drip irrigation system	solarization + iprodione	0,5455 ab	0,25a
	solarization + metham sodium+ Iprodione	0,0000 a	0.20a
	solarization+ethoprophos	1,4242 c	0,77 b
	Control	3,3939 d	2,24 d

\* Similar letters in the same column are not different each other according to P<0.05 Duncan or Tukey.

### Plant height

The results of experiment applications to study plant lengths were given in Figure 4.

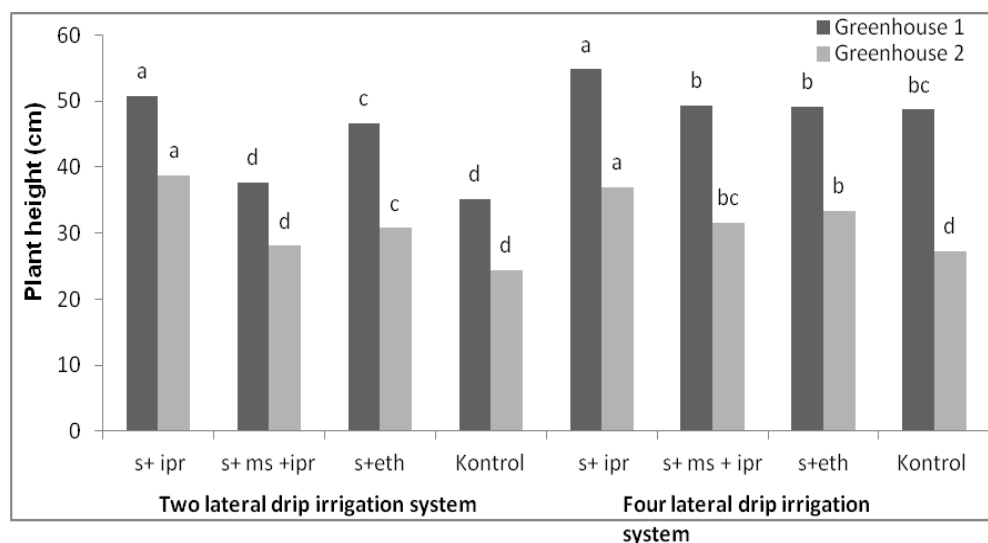


Figure 4. The effect of treatments on the plant heights (s: solarization, ms: metham sodium, ipr: iprodione, eth: ethoprophos).

The highest effect on plant height was determined in four drip lateral irrigation system with solarization + iprodione treatments and the least effect was found in two drip lateral irrigation system with solarization + metham sodium + iprodione applications in greenhouse 2.

### Yield evaluation

Pepper yield evaluation of the study for controlling root knot nematodes in two different drip irrigation systems and combination effects of soil fumigants and nematicides (Figure 5).

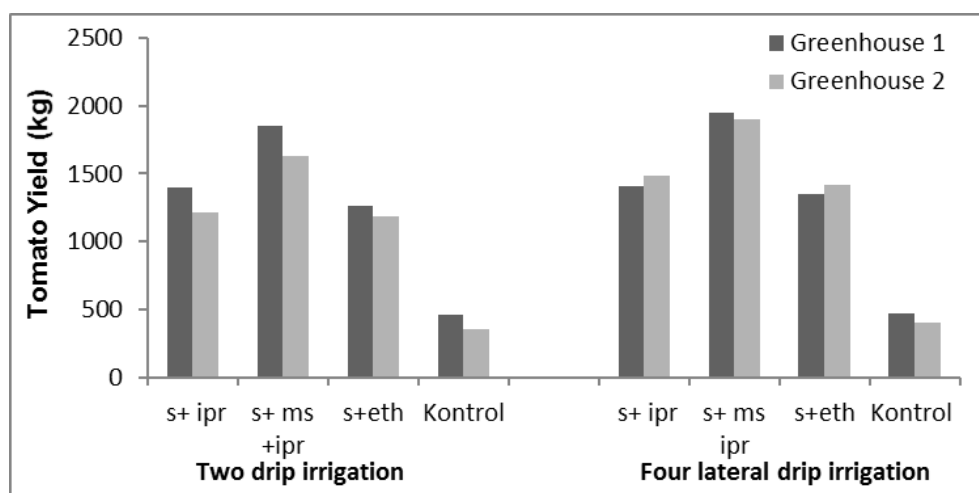


Figure 5. The effect of treatments on pepper yields against to Root-knot nematodes in greenhouse (s: solarization, ms: metham sodium, ipr: ipridione, eth: ethopropos).

The highest significance in pepper yield was observed on four drip lateral line irrigation system with solarization + metham sodium + iprodione treatment and the lowest pepper yield was recorded in both drip irrigation system with solarization + ethoprophos plots. Solarization + metham sodium + iprodione treatments had the highest yield with 1946,6 kg yields/da. Whereas the least yield determined as 1264,8 kg/da in two lateral drip irrigation system with solarization + ethoprophos treatments. Yield differences between the two applications were 682 kg/da (Figure 5).

## DISCUSSION

In spite of chemical control, biological control, rotation and resistant cultivars have been offered for controlling the root knot nematodes; (Gheysen et al. 1996, Sijmons et al. 1994). Chemical substances and fumigant applications have commonly practiced in Turkey. Multi-purpose fumigant pesticides (Methyl Bromide) and nematicides had been used to control root knot nematodes and soil

borne fungal and bacterial diseases until the 2000s (Yücel et al. 2007). However, these chemical compounds were phased out because of hazards to human health and environmental harms. As a result demanding studies have been initiated in the world and in Turkey to find out the alternative methods to control nematodes and soil borne diseases and some nematicides due to the prohibition of Methyl bromide (Katan 1996, Gilreath et al. 1998, Yucel et al. 2002). Pests and soil borne diseases are major constraints for growing products in greenhouse in Turkey. For this reason to the establishment of effective control programs in vegetable growing areas is crucially important. Before planting and during the growing season, there is a need to transfer alternative chemicals and without residue applications in the drip irrigation system. In this context, alternative control methods for the introduction of new techniques and the application of chemical compounds and practitioners in both the public and private sector demonstration activities has been initiated in Turkey since 2000 (Yucel et al. 2002, Yucel et al. 2007). But the studies on the determining the effect of combined chemical and soils fumigants applications is not desired level.

In order to reach the successful results, both solarization and nematicides applications should be used altogether. The most suitable period of nematode infection is nursery period. For this reason, nematodes should have been suppressed by using nematicides before this term. Further used practices at soil temperatures have risen. Some subtracts which stimulate the roots growth should have been used after applying nematicides if high temperatures continue in the soil before starting the winter. In case of increasing production period, additional nematicides applications are needed by making nematodes analysis in the soil. Because nematodes activation starts as temperatures increased in April and May.

In this study, the using of integrated soil solarization and chemical compounds, the soil fumigant as the main method was determined as effective way to control the root knot nematodes. In this aspect, four drip lateral pipe irrigation system with solarization + metham sodium + iprodione and solarization + iprodione applications can be suggested as an alternative control programs against to root knot nematodes.

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