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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

The efficacy of two different formulations and concentrations of Abamectin on the Root-knot nematode in tomato and cucumber

Domates ve hıyarda Kök-ur nematoduna karşı iki farklı Abamectin formülasyonu ve konsantrasyonunun etkinliği

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ABSTRACT

The aim of the study was to investigate the effects of different Abamectin formulations and concentrations (Abamectin 18 g L^{-1} EW, Abamectin 20 g L^{-1} SC and Abamectin 50 g L^{-1} SC) licensed in Türkiye on the suppression of *Meloidogyne incognita* infection on tomato and cucumber under climate chamber conditions. Tomato and cucumber seedlings were transplanted after soil application of 0.1 mL, 0.2 mL and 0.08 mL/30 mL concentrations of Abamectin 18 EW, Abamectin 20 SC and Abamectin 50 SC, respectively and inoculated. Sixty days later, the study was evaluated. The nematicidal activity of Abamectin varied depending on the formulation and concentration. Abamectin 50 SC, Abamectin 18 EW and Abamectin 20 SC applications suppressed gall formation by 100%, 78% and 16% in tomato and 100%, 75% and 19% in cucumber, respectively. EW formulation showed lower suppressive effect than SC formulation but higher suppressive effect than 20 SC formulation. Although both were SC formulations, significant differences were found in their nematicidal effects ($p \leq 0.05$). The highest suppressive effect in tomato and cucumber was observed in Abamectin 50 g L^{-1} SC application and it was determined that it had a positive effect on plant and root wet weight in tomato. It is important to conduct more detailed studies on formulation types and concentrations for Abamectin, an active ingredient used as an alternative against root-knot nematodes.

ÖZET

Çalışmanın amacı, Türkiye'de ruhsatlı farklı Abamectin formülasyonlarının ve konsantrasyonlarının (Abamectin 18 g L^{-1} EW, Abamectin 20 g L^{-1} SC and Abamectin 50 g L^{-1} SC) iklim odası koşullarında domates ve hıyarda *Meloidogyne incognita* enfeksiyonunun baskılanması üzerine etkilerini araştırmaktır. Abamectin 18 EW, Abamectin 20 SC ve Abamectin 50 SC'nin sırasıyla 0.1 mL, 0.2 mL ve 0.08 mL/30 mL konsantrasyonları toprağa uygulandıktan sonra domates ve hıyar fideleri şaşırtılmıştır ve nematod inokulasyonu yapılmıştır. Abamectin'in nematisidal etkinliği, formülasyona ve konsantrasyona bağlı olarak değişmiştir. Abamectin 50 SC, Abamectin 18 EW ve Abamectin 20 SC uygulamaları domateste sırasıyla %100, %78 ve %16, hıyarda ise sırasıyla %100, %78 ve %19 oranlarında gallenmeyi baskılamıştır. EW formülasyonu, 50 SC formülasyonundan daha düşük ancak 20 SC formülasyonundan daha yüksek baskılayıcı etki göstermiştir. Her ikisi de SC formülasyonları olmasına rağmen nematisidal etkilerinde önemli farklılıklar bulunmuştur ($p \leq 0,05$). Domates ve hıyarda en yüksek baskılayıcı etki Abamectin 50 g L^{-1} SC uygulamasında olmuş ve domateste bitki ve kök yaş ağırlığında olumlu etki yarattığı belirlenmiştir. Kök ur nematodlarına alternatif olarak kullanılan etkin madde Abamectin için formülasyon tipleri ve konsantrasyonları hakkında daha detaylı çalışmaların yapılması önem taşımaktadır.

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INTRODUCTION

Tomato is the most produced vegetable in Türkiye and ranks 3rd (13.1 million tons) after China and India. Tomato production is carried out both in the open field and greenhouse in Türkiye. The amount of tomato production in greenhouses constitutes 31.8% (4.1 million tons) of the total tomato production (Anonymous, 2023). Cucumber production is quite common in Türkiye and, was approximately 1 871 712 tons in 2022. Tomato and cucumber, which are important vegetable products exported by Türkiye, can be exposed to different diseases and pests during cultivation. Plant parasitic nematodes are one of these pests and especially root-knot nematodes (*Meloidogyne* spp.) cause significant yield losses in vegetables (Moens & Perry, 2009). The most visible indicator of *Meloidogyne* infection is the formation of galling of roots that affect water and nutrient uptake (Baale et al., 2021). In addition, root-knot nematodes provide a favorable niche for the infection of secondary root pathogens and increase yield losses (Kumar, 2024). Cucurbitaceae family plants are highly susceptible to nematodes that can cause losses of up to 10-25% in these plants (Khan et al., 2023). In tomato production, root-knot nematodes have been reported to cause a 26.5-73.3% decline in tomato production and cause an annual loss of approximately 125 billion dollars worldwide (Gowda et al., 2018).

Root-knot nematodes are difficult to control due to their high reproduction rate and short generation time (Trudqill & Blok, 2001). Chemical pesticides are generally used in the control of root-knot nematodes. Although chemical nematicides provide effective control, some of them have been banned or restricted due to its negative effects on human health and the environment (Dianli et al., 2019). This has forced chemists to search for new molecules to find new nematicides or to test already registered substances such as fungicides, insecticides and acaricides against plant parasitic nematodes (Faghihi et al., 2007; Becker & Ploeg, 2012). Abamectin is one of these available options and studies have shown that it has nematicidal as well as acaricidal and insecticidal effects (Chukwudebe et al., 1996; El-Marzoky et al., 2022). Abamectin is part of the avermectin group of lactone macrocyclic metabolites produced during the natural fermentation process of *Streptomyces avermitilis* bacteria, which is known to contain approximately 80% avermectin B1a and 20% avermectin B1b (Khalil, 2013). Avermectins inhibit the transmission of electrical activity in nerves and muscle cells by stimulating the release and binding of gamma-amino butyric acid (GABA) at nerve endings. This causes chloride ions to enter the cells, leading to hyper polarization and subsequent paralysis of neuromuscular systems and subsequent death (Cully et al., 1994; Burkhart, 2000; Khalil, 2013). Soil application of Abamectin (Vertemic 1.8% EC) in different vegetable crops has been reported to suppress root-knot nematodes (Hamida et al., 2006; Saad et al., 2012). The half-life of Abamectin in soil has been reported between 1.1- 46.5 days (Dionisio & Rath, 2016). Although abamectin is not hydrolytic at pH 4-7, it was reported by EFSA (European Food Safety Authority) in 2020 that it is easily photolyzed under natural light (Jıang et al., 2024). The most common application method of abamectin for root-knot nematode control in tomato and cucumber is soil drenching or seed coating (Qiao et al., 2012; Cheng et al., 2015). Massoud et al. (2023) reported that the effect of Abamectin formulations (EC, EW, ME, SC) on growth parameters and macroelement (N, P and K) content of cucumber plants in the presence of root-knot nematodes showed different levels of response.

In present study, the effects of different abamectin formulations licensed in the Turkish market (Abamectin 18 g L^{-1} EW, Abamectin 20 g L^{-1} SC ve Abamectin 50 g L^{-1} SC) on the suppression of *M. incognita* infection in tomato and cucumber and on plant growth parameters were investigated.

MATERIALS and METHODS

Material

This study was carried out in the Nematology Laboratory and climate chamber (24±1 °C, 60%±5% humidity) of the Department of Plant Protection, Faculty of Agriculture, Isparta University of Applied Sciences (ISUBU). Abamectin formulations used in the study were obtained commercially (Table 1). The study was conducted with Özkan F1 tomato cultivar and Ayda F1 cucumber cultivar, which are susceptible to root knot nematode and obtained from Olympos Seedling (Kumluca/Antalya, Türkiye). The ISP isolate, which was pure cultured and morphologically identified in previous studies (Göze Özdemir et al., 2022), was used as the root knot nematode population.

Table 1. Commercial nematicides with Abamectin active ingredient
Çizelge 1. Abamectin etken maddeli ticari nematisitler

Formulations	License	Company®	Amount of active substance	Recommended dose	Active ingredient g ha^{-1}
Abamectin® 18 EW	Acaricide, Nematicide	FMC	18 g L^{-1}	200 mL da^{-1} (4 applicatons between 10-14 days intervally)	144 g
Abamectin® 20 SC	Nematicide	Syngenta	20 g L^{-1}	400 mL da^{-1} (2 application between 10-14 days)	160 g
Abamectin®50 SC	Nematicide	Rotam	50 g L^{-1}	160 mL da^{-1} (2 application between 10-14 days)	160 g

Mass production of root-knot nematode

Mass production was carried out with 15 Tueza F1 tomatoes under climate chamber conditions. The second juvenile larvae (J2) were obtained from the pure cultivated galling tomato root by removing the egg masses under a stereo binocular microscope using the petri method. Plastic pots with a volume of 250 mL and sterile soil mixture containing 68% sand, 21% silt and 11% clay were used. Then, small holes were made in the soil near the root collar of each tomato seedling and 1000 J2 larvae were inoculated in 1000 microliters of water. Mass production was terminated 8 weeks after inoculation.

Preparation of nematode inoculum

After washing the roots of Tueza F1 tomato cultivar in tap water, egg masses were taken from the roots under stereo microscope and incubated in a petri dish in water at 25±2ºC for three days. After three days, J2s emerging from the eggs were counted under a light microscope and placed in 1 ml tubes after adjusting the number to be used in the experiments (Göze Özdemir, 2022).

Experimental design

Abamectin formulations given in Table 1 and concentrations adjusted from the field recommended dose were used in the study. The experiment for tomato and cucumber was conducted separately under climate chamber conditions. Only nematode inoculated plants (NC+) and untreated plants (NC-) were used as a controls. The study was established in plastic pots with a volume of 250 mL with 6 replications for each treatment in a randomized plots experimental design. Each pot was filled with 300 g of sterile soil mixture (68% sand, 21% silt and 11% clay).

Abamectin 18 g L^{-1} EW, Abamectin 20 g L^{-1} SC ve Abamectin 50 g L^{-1} SC were applied to the soil at the 0.1 mL/30 mL, 0.2 mL/30 mL and 0.08 mL/30 mL concentrations, respectively and the seedlings were transplanted. Each replicate was planted with 1 tomato or 1 cucumber seedling according to the experiment. Nematode inoculation was performed 3 days after transplanting. Nematode inoculation was performed with 1 mL of water and 1500 *M. incognita* J2 in holes drilled near the root collar of tomato or cucumber (Massoud et al., 2023).

The experiment was terminated 60 days after inoculation. Afterwards, the lenght and wet weight of the plants were taken and the roots were removed from the soil and the roots were cleaned from the soil. The roots were washed with clean water and the lenght and wet weight of the roots were taken and classified using a scale of 0-10 (Bridge & Page, 1980) on the basis of gall and egg mass. The differential scale based on the level of infection by root-knot nematode is depicted in Table 2. J2s were obtained from 100 g of soil from each pot using the improved Baerman funnel method and counted under a light microscope to calculate the density (Barker, 1985).

All data obtained as a result of the study were subjected to statistical analysis using SPSS 20 software package. Analysis of variance (ANOVA) was used to test the differences between the means of the data obtained. Means were compared by Tukey HSD test at P≤ 0.05.

Table 2. Root gall index (Bridge & Page, 1980) caused by *Meloidogyne* spp.

Çizelge 2. Meloidogyne spp.'nin neden olduğu kök gal indeksi (Bridge & Page, 1980)

Gall index	Symptom
0	Healthy plant root system without knot formation
1	Very few small knots, difficult to find and can only be detected on close inspection
2	Small knots only, but clearly visible, main roots clean
3	Some larger knots visible, main roots free
4	Larger knots predominate but main roots free
5	50 % of roots are infested. Knotting on parts of main roots, reduced root system
6	More knotting on main roots
7	Majority of main roots knotted
8	All main roots knotted. Few clean roots visible
9	All roots severely knotted and plant usually dying
10	All roots severely knotted. No root system. Plant usually dead

RESULTS

In tomato, the mean lenght of the nematode inoculated plants (NC+) was 20.0±1.1 cm, while the mean lenght of the control plants (NC-) was 36.0±0.6 cm. The mean lenght of the plants treated with Abamectin 50 SC was higher than the plants treated with Abamectin 20 SC and Abamectin 18 EW. The difference between the lenght averages of plants treated with Abamectin 20 SC and Abamectin 18 EW was not statistically significant (p≤0.05). The mean plant wet weight was 7.4±0.4 g in NC- treatment. In the plants treated with Abamectin 50 SC, the mean plant wet weight was the highest with 10.0±0.3 g. The highest root height mean was found in NC- and Abamectin 50 SC treatments and they were in the same statistical group (p≤0.05). The average root wet weight was similar in NC- (8.5±0.3 g) and Abamectin 50 SC (8.9±0.5 g) treatments. The mean root wet weight of the plants treated with Abamectin 20 SC and Abamectin 18 EW was found to be statistically insignificant (p≤0.05). However, the mean root wet weight of the plants treated with Abamectin 50 SC was higher than those of the other formulations and the difference between them was found to be significant (p≤0.05). This may be due to other ingredients in the formulation. However, the company did not specify the other ingredients in the label information. Compared to NC+ treatment, Abamectin 50 SC, Abamectin 20 SC and Abamectin 18 EW treatments had higher root wet weight averages (Table 3).

In tomato, the mean of gall index in NC+ treatment was 6.6±0.4 galls/plant, while no galls and egg masses were found in the roots of Abamectin 50 SC treated plants. The mean gall index of the roots of the plants treated with Abamectin 20 SC was 5.6±0.3 galls/plant and was in the same statistical group with NC+ ($p \leq 0.05$). Compared to NC+ treatment, Abamectin 50 SC, and Abamectin 18 EW treatments significantly suppressed galling in roots except Abamectin 20 SC ($p \leq 0.05$). The highest soil J2 density was found in the NC+ treatment (4336.6±279.5 individuals), while the J2 density in the plant soil treated with 2658.3±289.3 individuals in Abamectin 20 SC treatment and the difference between them was statistically significant ($p \leq 0.05$). No J2 was found in the soil of Abamectin 50 SC treated plants and the difference with the other treatments was significant ($p \leq 0.05$) (Table 3).

Table 3. Efficacy Effect of soil applications of Abamectin formulations on plant growth and infection of *Meloidogyne incognita* in tomato

Çizelge 3. Abamectin formülasyonlarının toprak uygulamalarının domates bitkisinde Meloidogyne incognita enfeksiyonu ve bitki büyümesi üzerine etkisi

Treatments	**Mean±Standard Error**					
	Plant Lenght (cm)	Plant Wet Weigth (g)	Root Lenght (cm)	Root Wet Weight (g)	Gall Index (0-10)	J2 density in soil (individuals/100 g soil)
Abamectin 50 SC	30.7±2.3 *b	10.0±0.3 a	27.0±0.9 a	8.9±0.5 a	0.0±0.0 c	0.0±0.0 d
Abamectin 20 SC	24.6±0.6 cd	5.3±0.4 bc	16.9±0.8 bc	6.4±0.7 bc	5.6±0.3 a	2658.3±289.3 b
Abamectin 18 EW	25.4±1.5 bc	6.5±0.9 bc	19.8±1.7 bc	6.6±0.4 bc	1.5±0.2 b	278.3±130.4 c
NC-	36.0±0.6 a	7.4±0.4 b	26.4±1.2 a	8.5±0.3 ab	0.0±0.0 c	0.0±0.0 d
NC+	20.0±1.1 d	4.1±0.3 c	12.7±1.4 c	5.1±0.3 c	6.6±0.3 a	4336.6±279.5 a

* Different letters in the same column indicate significant differences at $p \leq 0.05$. NC-: Only nematode, NC+: Only sterile water

In cucumber, the mean plant lenght in NC- treatment was the highest with 25.7±1.0 cm, while the second was taken by the plants treated with Abamectin 50 SC with a mean of 17.4±1.0 cm. The mean height of the plants treated with Abamectin 20 SC and Abamectin 18 EW were similar and the difference between them was not statistically significant ($p \leq 0.05$). The lowest mean plant wet weight was found in NC- (4.2±0.2 g) and Abamectin 20 SC (5.8±0.3 g) treatments and there was no statistically significant difference between them ($p \leq 0.05$). The plant wet weight averages of Abamectin 50 SC and Abamectin18 EW treatments were similar and they were in the same statistical group with NC- ($p \leq 0.05$). The highest root lenght mean was found in Abamectin 50 SC, Abamectin 18 EW and NC- treatments and they were in the same statistical group ($p \leq 0.05$). The mean root lenght of the plants treated with Abamectin 20 SC lower than Abamectin 50 SC and Abamectin 18 EW treatments. The average root wet weight was highest in NC- (11.5±1.4 g) treatment and the lowest in NC+ (4.2±0.4 g) and Abamectin 18 EW (4.1) treatments in experiment. The average root wet weight of the plants treated with Abamectin 18 EW (9.4±0.8 g) was higher than Abamectin 50 SC (7.6±0.6 g). Compared to NC+ treatment, the average root wet weight of the plants treated with Abamectin 18 EW and Abamectin 50 SC was higher except Abamectin 20 SC (Table 4).

In cucumber, the average gall index in NC+ treatment was 7.1±0.3 galls/plant, while no gall and egg masses were found in the roots of Abamectin 50 SC treated plants. The mean gall index in the roots of plants treated with Abamectin 20 SC was 5.8±0.3 galls/plant, which was significantly higher than that of Abamectin 18 EW treatment ($p \leq 0.05$). Compared to NC+ treatment, soil applications of Abamectin formulations significantly suppressed galling in roots ($p \leq 0.05$). After NC+ treatment, the highest gall index average and J2 density in soil were determined in

Abamectin 20 SC treatment. No J2 was found in the soil of Abamectin 50 SC treated plants and the difference with the other treatments was significant (p≤0.05) (Table 4).

Table 4. Effect of soil applications of Abamectin formulations on plant growth and infection of *Meloidogyne incognita* in cucumber

Çizelge 4. Abamectin formülasyonlarının toprak uygulamalarının hıyarda Meloidogyne incognita enfeksiyonu ve bitki büyümesi üzerine etkisi

Application	Average±Standard Error					
	Plant Lenght (cm)	**Plant Wet Weight (g)**	**Root Lenght (cm)**	**Root Wet Weight (g)**	**Gall Index (0-10)**	**J2 density in soil (individuals/100 g soil)**
Abamectin 50 SC	17.4±1.0 b *	8.0±0.3 a	20.7±1.3 a	7.6±0.6 bc	0.0±0.0 d	0.0±0.0 d
Abamectin 20 SC	16.2±0.6 bc	5.8±0.3 ab	19.4±1.2 ab	4.1±0.4 c	5.8±0.3 b	4250.0±278.7 b
Abamectin 18 EW	15.1±1.0 bc	7.8±0.7 a	21.3±1.8 a	9.4±0.8 ab	1.6±0.2 c	545.0±61.1 c
NC-	25.7±1.0 a	7.7±0.5 a	24.4±1.4 a	11.5±1.4 a	0.0±0.0 d	0.0±0.0 d
NC+	12.6±0.7 c	4.2±0.4 b	14.3±1.6 b	4.2±0.2 c	7.1±0.3 a	6135.0±413.0 a

* Different letters in the same column indicate significant differences at p ≤0.05. NC-: Only nematode, NC+: Only sterile water

In the study, differences were determined in the suppressive effect of Abamectin formulations on tomato and cucumber root-knot nematode infection. Abamectin 50 SC, Abamectin 18 EW and Abamectin 20 SC treatments suppressed galling in tomato by 100%, 78% and 16%, respectively, while in cucumber by 100%, 75% and 19%, respectively. The suppression on J2 density in soil was 100%, 94%, and 39% in tomato and 100%, 92% and 31% in cucumber, respectively. In both crops, the highest nematicidal effect was determined in Abamectin 50 SC treatment. Although Abamectin 50 SC and Abamectin 20 SC were of the same formulation, their nematicidal effects were significantly different.

DISCUSSIONS

Despite the variations, all tested formulations had a lethal effect on J2 density in soil and suppressive effect on galls in both tomato and cucumber compared to the only nematode control under controlled conditions. These findings are in agreement with what have been previously reported in many studies against the plant-parasitic nematodes. Sasanelli et al. (2021) reported that avermectin had nematicidal properties against *M. incognita*, *Pratylenchus penetrans*, *Rotylenchulus reniformis*, *Globodera pallida*, *Heterodera schachtii*, *H. avenae,* and *H. carotae*. Its mode of action could be summarized as blocking γ-aminobutyric acid by stimulating chloride channels, leading to the opening of chloride channels, resulting in nematode paralysis. Abamectin seed treatment was also found to be effective in suppressing root-knot nematode (Abawi et al., 2003; Becker et al., 2003; Cabrera et al., 2009). Root-knot nematodes were controlled by general soil tillage with granular or liquid formulations of abamectin (Sasser et al., 1982; Jansson & Rabatin, 1998). Abamectin soil application has the potential to be used as an effective alternative to fumigants for nematode control in tomato production in Shandong Province (Qiao et al., 2012).

The formulation of the commercial product may be influenced by the inclusion of the active ingredient, solvents, surfactants, other ingredients and adjuvants (Wang & Liu, 2007). However, a significant proportion of other/inert ingredients in formulations may interact and alter the toxicity of the active ingredient(s) (Beggel et al., 2010).

There are studies that suggest that diluents can significantly alter the performance of the active ingredient, potentially rendering the final product more toxic or less effective than the underlying active ingredients in the formulation (Mesnage et al., 2013; Mesnage & Antoniou, 2018). In the study, the nematicidal effect of the EW formulation was significantly higher compared to the nematode inoculated control. The nematicidal effect of EW formulation treatments on tomato and cucumber was lower than that of Abamectin 50 SC, but higher than that of Abamectin 20 SC. D'Errico et al. (2017) reported that in tomato infected with *M. incognita*, the SC formulation of abamectin reduced the soil population in the range of 23.40-43.29%, while the EW formulation recorded a reduction in the range of 25.67-34.37% and no phytotoxicity was detected for both formulations. In our study, phytotoxicity was not detected in tomato and cucumber plants, and it was determined that Abamectin 50 SC application had a positive effect on plant and root wet weight in tomato. The variations between abamectin formulations on plant and root height and weight may depend on the local effect of abamectin in the rhizosphere and the degradation of the nematicide by the time (El-Markozy et al., 2022). In studies conducted with abamectin, no studies were found to have a negative effect on plant development (Qiao et al., 2012; Khalil & Abd El-Naby, 2018; Khalil et al., 2022; El-Markozy et al., 2022). In addition, Abamectin SC formulation was found to be effective on root-knot nematode (Radwan et al., 2019; El-Marzoky et al., 2022; Khalil et al., 2022). The use of formulations as water-based suspension concentrate (SC) provides environmental, economic and social advantages for applicators and the environment, such as safety, ease of use, relatively low cost, high concentration of insoluble active ingredients and the ability to add water-soluble adjuvants for enhanced biological activity (Hazra et al., 2017). Massoud et al. (2023) compared four abamectin formulations (DIVA (1.8% EW), RIOMECTIN (5% ME), AGRIMEC GOLD (8.4% SC) and ZORO (3.6% EC)) with two reference nematicides CROP NEMA (5% CS) and Abamectin (2% SC) in cucumber. Galling was significantly suppressed by 75.23%, 59.44%, 56.90%, 56.90%, 56.72%, 37.75% and 23.05% in SC (8.4%), CS, SC (2%), ME, EC and EW formulations, respectively. Compared with EC, SC, ME and NC, abamectin MC had the lowest toxicity toward *M. incognita* J2 owing to the size effect and release behaviour (Fu et al., 2019). Lee et al. (2023), evaluated twenty-one formulations of abamectin by comparing their sublethal toxicities and reproduction inhibition potentials against *Bursaphelenchus xylophilus*, a well-known devastating pathogen of pine tree stands. Paralysis generally occurred at an application dose of 0.06 µg ml^{-1} or higher, and formulations with high sublethal toxicity demonstrated that, despite variations, the doses tested caused significant levels of paralysis. Ismail et al. (2004) discussed that the water-based insecticide formulations (EWs) offer many advantages to the end-users/operators over the solvent-based insecticide formulations (EC). Cost of production for EW-insecticides formulation can be less expensive compared to the EC insecticides formulation because they replace about 70 to 80% of the oil (solvent) with water. Solvents and surfactants derived from palm based materials have better environmentally friendly characteristics than the petroleum based surfactants and mineral oils. While the chemical industry posits that some formulations do not imply significant variations between them, there is a lot of confidential information that is not known to the end user, which prevents easily discriminating when variations are expected or when not. For the same reason, and because the effectiveness or protection periods may be severely affected by variations between formulations, further comparative inquiries are required to discriminate between product profiles for pest control (Buzzetti, 2017).

As a result, it was revealed that the active ingredient Abamectin showed a significant efficacy in the control of the root-knot nematode and this efficacy varied depending on the formulation and the amount of active ingredient. In the SC formulation, the higher the amount of active ingredient, the higher the nematicidal effect. The EW formulation showed lower nematicidal effect than the 50 SC formulation but higher than the 20 SC formulation. In tomato and cucumber plants treated with Abamectin 50 SC, no gall and egg masses were found in the roots, indicating that it had the highest effect on the root knot nematode. The study needs to be supported by field results. More detailed research on abamectin formulations and concentrations is also needed.

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STATEMENT OF CONFLICT OF INTEREST
The authors of the articles declare that they have no conflict of interest.

AUTHOR'S CONTRIBUTIONS
The authors declare that they have contributed equally to the article.

STATEMENT OF ETHICS CONSENT
Since this article does not contain any studies with human or animal subjects, ethical approval is not required.

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