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Orijinal araştırma (Original article)

Determination of the effect of *Trichoderma* Pers. on root rot caused by *Rhizoctonia solani* Kühn. in pistachios

Bazı *Trichoderma* Pers. türlerinin Antep fıstığında *Rhizoctonia solani* Kühn.'nin neden olduğu kök çürüklüğü hastalığına karşı etkinliğinin belirlenmesi

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ABSTRACT

Due to environmental pollution caused by chemical pesticides used in agriculture, residue problems and the difficulty of chemical control of soil pathogens, alternative methods are being investigated to control some plant diseases. Biological control is a method developed as an alternative to chemical control. *Trichoderma* species are known to be the most widely used antagonists in biological control. This study investigated the effectiveness of some *Trichoderma* species against *Rhizoctonia solani* through volatile metabolites, using a dual culture method and in artificially contaminated potting soil in 2022-2023. The study showed that *Trichoderma* sp. FT1 isolate suppressed the pathogen by volatile metabolites with a rate of 33.88%. In the dual culture method, the *Trichoderma harzianum* TUZ16 isolate demonstrated strong hyperparasitic properties, inhibiting the pathogen by 70.97%. It was determined that the antagonists *T. harzianum* TUZ16, *Trichoderma virens* İB1, *Trichoderma viride* VG18, and *Trichoderma* sp. FT1 suppressed the pathogen in the plant by 66.66%, 60.00%, 56.66%, and 43.33%, respectively in pot study.

INTRODUCTION

There are various biotic and abiotic factors that affect the yield and quality of pistachios. Among these; diseases, pests, fertilization, periodicity, drought, and temperature fluctuations are particularly important. The prevalence of diseases varies by region and climatic conditions. The control of some of these diseases is primarily achieved through the use of chemical pesticides. However, these chemicals have numerous negative effects on both the environment and human health. Additionally, they contribute to environmental pollution, leave residues, and, with continuous use, promote the development of resistant strains of target pathogens (Delen 2020). For these reasons, reducing or, if possible, completely eliminating the use of chemical pesticides in agricultural production has become a key objective. The most effective way to achieve this is through the use of biological control agents, either alone or in combination with other methods to control plant diseases while minimizing the environmental impact of chemical pesticides (Bora and Özaktan 1998).

In recent years, an increase in mortality of pistachio saplings and trees" due to root and root collar damage has been reported in the Southeastern Anatolia Region (Aydın et al. 2023). *Rhizoctonia solani*, *Fusarium solani*, *Fusarium equiseti*, *Fusarium* spp., *Verticillium dahliae*, *Phytophthora palmivora*, *Phytophthora* spp., and *Phoma* spp. have been reported as pathogens responsible for root rot and wilt in pistachio worldwide, including in Turkey (Aydın et al. 2024, Aydın and İnal 2019, Aydın and Ünal 2021, Chen et al. 2013, Chitzanidis 1995, Eskalen et al. 2001, Michailides et al. 1995, Türkölmez et al. 2015). *Rhizoctonia solani* Kühn [Teleomorph: *Thanatephorus cucumeris* (Fr.) Donk], one of these soilborne pathogens is a polyphagous fungus that causes diseases in a wide range of plants and can persist in the soil for extended periods due to the formation of sclerotia (Boosalis and Scharen 1959). *R. solani* typically causes a range of diseases, including root and root collar rot, as well as foliar and stem blights in certain plant species. (Carling et al. 1994, Clarkson and Cook 1983, Mohammadi et al. 2003). In a study conducted in Siirt Province, Southeastern Anatolia, *R. solani* was isolated from diseased pistachio saplings, and its anastomosis group was identified as AG-4 (Aydın and Ünal 2021). In another study conducted in pistachio orchards in this region, *R. solani* was found in large numbers among the fungi isolated from diseased trees, and it was determined to be pathogenic (Aydın et al. 2024).

Various control methods are employed to manage diseases caused by *R. solani*, including chemical, physical, and cultural measures, crop rotation, and resistant varieties (Aydın 2022, Bains et al. 2002, Tsror 2010). Due to the limited effectiveness of these control methods when used alone, alternative approaches have been explored. One of the most significant alternative methods is biological control (Trillas et al. 2006). Today, many biological control agents have been licensed as commercial products and are available for use in agricultural production. Among these, *Trichoderma* species play a significant role. *Trichoderma* is considered important in agricultural production because some of its species exhibit strong antagonistic activity against pathogens such as *Rhizoctonia*, *Fusarium*, *Pythium*, and *Sclerotinia* (Aydın 2015). This antagonistic ability is mediated by various mechanisms of action between *Trichoderma* species and pathogens, including mycoparasitism, the production of antifungal metabolites, and competition for space and nutrients (Aydın 2022, Kredics et al. 2003). *Trichoderma* species have been reported to control *R. solani* while also promoting plant growth and stimulating plant defense responses (Abbas et al. 2017). In one of the most comprehensive studies on *R. solani* antagonists in Türkiye, 14 *Trichoderma* species were isolated. It was reported that 10 of these species were recorded for the first time in Türkiye and significantly suppressed the disease caused by *R. solani* in potatoes (Aydın and Turhan 2009, Aydın et al. 2011).

In this study, the activity of certain *Trichoderma* species against *R. solani* in pistachio was investigated both *in vitro* and *in vivo*. Thus, the effectiveness of biological control, as an alternative method for managing the disease caused by this pathogen in pistachio, was determined for the first time."

MATERIALS AND METHODS

In this study, *Rhizoctonia solani* AG-4, previously isolated from pistachio and identified as pathogenic, was used (Aydın and Ünal 2021). Additionally, *Trichoderma harzianum* TUZ16 and *Trichoderma viride* VG18, obtained from the fungal isolate collection of the Siirt University Faculty of Agriculture Phytopathology Laboratory, were used (Aydın and Turhan 2009). Furthermore, *Trichoderma* sp. FT1 and *Trichoderma* virens IB1, isolated from the roots of pistachio trees and morphologically identified according to the criteria described by Bisset (1991), Samuels (2006), Samuels et al. (1998, 2012), and Cai and Druzhinina (2021), were included as antagonists.

In order to maintain the viability of the antagonist isolates, they were infected into the soil in a climate chamber before the experiments were conducted and re-isolated after one month using the 'Tolclofos Methyl Additive Enhanced PDA Media method' (Aydın and Turhan 2017).

Determination of the antagonistic activity of antagonists

Two methods were used to assess the antagonistic activity of *Trichoderma* species: the determination of activity through volatile metabolites and the dual culture.

To evaluate the effect of volatile metabolites produced by *Trichoderma* species on the inhibition of *R. solani*, 5-mm-diameter agar discs were excised from 5-day-old cultures of both *Trichoderma* and *R. solani* grown on PDA medium and placed separately at the center of two Petri dishes. The dishes were then stacked, with *R. solani* on top and the *Trichoderma* culture on the bottom, and sealed with Parafilm (Mahalakshmi and Raja 2013). The plates were subsequently incubated at 24 °C under a 12-hour dark/12-hour light cycle. In the control plates, PDA medium was used instead of the antagonist. After one week, the radius of the test pathogen was measured in both treatment and control plates, and the inhibition percentage was calculated using the formula described by Dennis and Webster (1971).

$$\text{Inhibition rate (\%)} = 100 \times (A1-A2) / A1 \quad (1)$$

where A1 represents the radial growth of the pathogen in the control, and A2 represents the radial growth of the pathogen in the treatment.

To determine antagonistic activity using the dual culture method, 5-mm-diameter agar discs were excised from 5-day-old PDA cultures of both the antagonists and the test pathogen. The discs were positioned opposite each other at equal distances from the edge of a PDA-coated Petri dish (Stefany et al. 2021). As a control, only the pathogen was placed on one side of the PDA plate and incubated at 24 °C. The experiment was conducted with four replicates. The evaluation was performed after one week using the following formula Vincent 1947:

$$L = (C-T) / C \times 100 \qquad (2)$$

Where, L: Mycelial growth inhibition zone (%), C: Pathogen growth in the control (mm), T: Pathogen growth in the dual culture.

In another evaluation carried out in the dual culture experiment, different criteria were used to assess antibiosis and hyperparasitism. For antibiosis, the time at which the growth of the *R. solani* colony was completely inhibited was recorded. For hyperparasitism, the first antagonist that entirely overgrew the pathogen during the experiment was noted. Antibiotic activity was determined based on the width of the inhibition zone, while hyperparasitic activity was evaluated according to the rate and density of the antagonist's coverage of the *R. solani* colony, using the scale described by Turhan (1990).

VSH, VSA (Very Strong Hyperparasitism or Antibiosis): Inhibition zone wider than 10 mm, or the antagonist has completely overgrown the pathogen colony.

SH, SA (Strong Hyperparasitism or Antibiosis): Inhibition zone between 7–10 mm, or the antagonist has shown strong growth over the pathogen colony.

H, A (Moderate Hyperparasitism or Antibiosis): Inhibition zone between 3–6 mm, or the antagonist has displayed noticeable spread over the pathogen colony.

WH, WA (Weak Hyperparasitism or Antibiosis): Inhibition zone narrower than 3 mm, or the antagonist has shown very weak growth over the pathogen colony.

L (Lytic Effect): The antagonist has caused lysis of the pathogen.

O (No Effect): No visible effect was observed.

Pot studies to evaluate the effectiveness of Trichoderma species against Rhizoctonia solani

The potting soil was prepared by mixing equal parts (1/3 each) of garden soil, sand, and peat. The soil mixture was sterilized in an autoclavable bag at 121 °C for 15 minutes using an autoclave.

The modified wheat bran culture method was employed to prepare the pathogen inoculum (Turhan 1992). For this purpose, 100 g of wheat bran, 40 g of wheat grain, and 10 g of maize flour were mixed, moistened with 15 ml of water, and transferred into suitable glass containers. The mixture was subsequently sterilized in an autoclave at 121 °C for 30 minutes and then allowed to cool.

At the same time, four mycelial plugs were excised from actively growing colonies of the fungal pathogen on PDA medium using a sterile inoculation needle and transferred into the bran medium in each flask. The flasks were then incubated in the dark at 24 °C for 15 days. Following incubation, the stock inoculum was mixed with potting soil at a ratio of 1:75.

Trichoderma isolates were cultured on PDA medium for one week to prepare antagonist suspensions. Sterile water was then added, and the fungal growth was scraped with a spatula and filtered through cheesecloth. The spore concentration was adjusted to 1×10^6 spores/ml using a haemocytometer. Subsequently, 0.05% carboxymethyl cellulose (CMC) and three drops of Tween 20 per liter were added. Finally, the suspensions were placed on a shaker for 30 minutes to obtain a homogeneous suspension.

Fruits of the Siirt variety, cultivated in the Siirt region, were used in the study following germination by the folding method (Abu-Qaoud 2005, Ak et al. 1995). For surface disinfection, the fruits were soaked in 2% NaOCl for 5 minutes and then rinsed twice with sterile water.

The disinfected seeds were immersed in spore suspensions of Trichoderma species for 60 minutes prior to sowing. Subsequently, they were planted in 5-liter pots containing either sterile soil or pathogen contaminated soil prepared one day earlier, with three seeds per pot.

The experiment was designed according to a randomized plot experimental design under room conditions (25–30 °C) and was initiated on April 14, 2023. The experimental setup included the following groups:

- Positive control: Contaminated soil + untreated clean seed
- Negative control: Clean soil + clean seed
- Treatment groups: Four antagonists + contaminated soil

Each group consisted of six characters and four replications. Regular irrigation and maintenance were carried out throughout the trials.

Evaluation of pot studies

Plant emergence was monitored regularly throughout the experiment, and wilted plants were recorded. On July 25, 2023, all plants were uprooted and evaluated for disease severity using the following 0–5 scale:

(0) No lesions; plants healthy, (1) Damage to ≤ 20% of the roots or slight wilting of the upper part of the plant, (2) Damage to 21–40% of the roots, loss of some lateral roots, or wilting of one-third of the upper parts, (3) Damage to 41–60% of the roots, (4) Damage to 61–80% of the roots, loss of most lateral roots, or wilting of half of the upper parts, (5) Damage to 81–100% of the roots, loss of all lateral roots, or complete wilting of the upper parts.

After calculating the disease severity of each replicate as a percentage using the Townsend & Heuberger method (1943), the mean values were determined and compared with the positive control values. The percentage effect of the treatments was then evaluated using the Abbott method (1925) according to the following formulas:

$$\text{Disease Severity (\%):} \quad \frac{\sum(n \times V) \times 100}{Z \text{x} N} \tag{3}$$

n: Number of plants in different damage groups

V: Degrees of damage assigned to each group

N: Total number of plants in the experiment

Z: Highest scale value

$$\text{Percentage Effect (\%):} \quad \frac{(X - Y) \text{ x } 100}{X} \tag{4}$$

X: Mean disease severity (%) in positive control plots

Y: Mean disease severity (%) in treated plots

The data obtained were analyzed using ANOVA (Analysis of Variance), and differences between the means were compared using the Significant Difference (SD) test. All statistical analyses were conducted using JMP Version 13 statistical software.

RESULTS

Determination of the antagonistic activity of antagonists

Three evaluations were performed to determine the antagonistic activity of the antagonists under in vitro conditions.

The results of the initial in vitro evaluation of antagonistic activity via volatile metabolites are presented in Table 1.

Table 1. Antagonistic activity of *Trichoderma* isolates through volatile metabolites

Treatment	Average of Repetitions (mm)	% Effect According to Abbott
Trichoderma virens İB1	68.25 ^{a*}	9.42
Trichoderma sp. FT1	49.82 ^{b}	33.88
Trichoderma viride VG18	68.92 ^{a}	8.53
T. harzianum TUZ16	71.12 ^{a}	5.61
Rhizoctonia solani AG-4	75.35 ^{a}	-
Standard error of the mean	5.73	-
P-value	<.0.05	-

*Differences between the means shown with the same letters in the same column are not statistically significant at p<0.05 level

Analysis of Table 1 showed that *Trichoderma* sp. FT1 (group b) exhibited the strongest inhibition, achieving a 33.88% suppression rate through metabolites produced by the antagonist and pathogen without direct contact. This was followed by *T. virens* IB1, *T. viride* VG18, and *T. harzianum* TUZ16, which were grouped under category a.

The results of the second evaluation, conducted to assess the interaction between *R. solani* and *Trichoderma* species using the dual culture method *in vitro*, are presented in Table 2.

Table 2. Determination of the antagonistic activity of *Trichoderma* species against the pathogen by dual culture method

Treatment	Average of Repetitions (mm)	% Effect According to Abbott
Trichoderma virens İB1	26.17 ^{c*}	53.45
Trichoderma sp. FT1	34.07 ^{b}	39.39
Trichoderma viride VG18	20.72 ^{d}	63.14
T. harzianum TUZ16	16.32 ^{e}	70.97
Rhizoctonia solani AG-4	56.22 ^{a}	-
Standard error of the mean	0.86	-
P-value	<.0001	-

*Differences between means followed by the same letter in the same column are not statistically significant at the p < 0.01 level

Analysis of Table 2 revealed that *T. harzianum* TUZ16 and *T. viride* VG18 were the most inhibitory antagonists against the pathogen, followed by *T. virens* IB1 and *Trichoderma* sp. FT1. During the experiment, *T. viride* VG18 formed an inhibition zone against the pathogen on the medium and continued to overgrow it over time. *T. harzianum* TUZ16 exhibited rapid growth and effectively suppressed the pathogen. Similarly, *Trichoderma* sp. FT1 created an inhibition zone and inhibited the growth of the pathogen.

The results of the third evaluation of the experiment, assessing the antagonistic activity against the pathogen using the dual culture method, are presented in Table 3.

Table 3. Effects of antagonists against *Rhizoctonia solani* under *in vitro* conditions

Antagonists	1.Repeat	2.Repeat	3.Repeat	4.Repeat
Trichoderma virens İB1	A	A	A	A
Trichoderma harzianum TUZ16	VSH	VSH	VSH	VSH
Trichoderma viride VG18	SA	SA	SA	SA
Trichoderma sp.FT1	SA+H	SA+H	SA+H	SA+H

A: moderate antibiosis, SA: Strong antibiosis, H: moderate hyperparasitism, VSH: Very strong hyperparasitism

Table 3 shows that *Trichoderma harzianum* TUZ16 exhibited very strong hyperparasitism (VSH), *T. viride* VG18 displayed strong antibiotic activity (SA), and *T. virens* IB1 showed moderate antibiotic activity (A). *Trichoderma* sp. FT1 demonstrated both strong antibiotic (SA) and moderate hyperparasitic (H) activity, as illustrated in Figure 1.

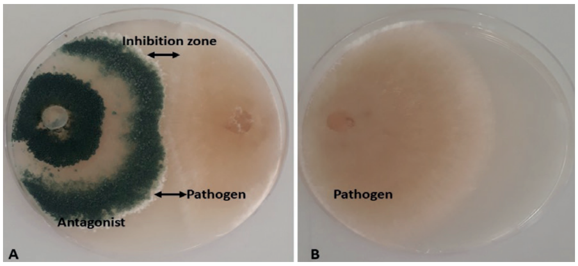

Figure 1. Interaction between *Trichoderma* sp. FT1 and the pathogen (A) and the pathogen in the control treatment (B)

Finally, the antagonist and the pathogen were inoculated in dual cultures on 1/10-strength PDA medium and examined both macroscopically and microscopically. On PDA medium, hyperparasitism was defined as the antagonist continuing to overgrow the pathogen and, under the microscope, enveloping and penetrating the hyphae of *R. solani*. Figure 2 illustrates the interaction between the antagonists and the pathogen under the microscope.

Pot studies to evaluate the effectiveness of Trichoderma species against Rhizoctonia solani

In the pot study evaluating the effectiveness of antagonists against *R. solani*, plant emergence was monitored throughout the experiment, and wilted plants were recorded according to the severity scale. The average disease severity of the replicates and treatment groups, as well as the effectiveness of the treatments applied to *Trichoderma*-treated pistachio seeds in artificially infested soil, are presented in Table 4.

According to Table 4, the antagonists formed four distinct groups and exhibited varying levels of disease suppression.

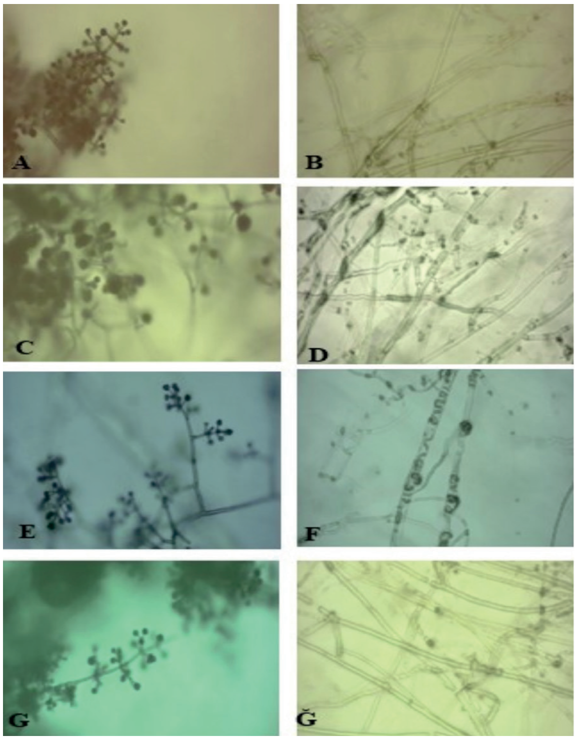

Figure 2. Light microscope images of Trichoderma isolates and their interactions with the pathogen: *Trichoderma* sp. FT1 (A) and pathogen hyphae envelopment (B), *Trichoderma virens* IB1 (C) and pathogen hyphae envelopment (D), *Trichoderma harzianum* TUZ16 (E) and pathogen hyphae envelopment (F), *Trichoderma viride* VG18 (G) and pathogen hyphae envelopment (H)

The most effective antagonist was *T. harzianum* TUZ16, which achieved a 66.66% disease reduction, followed by *T. virens* IB1, *T. viride* VG18, and *Trichoderma* sp. FT1. The

Table 4. Mean disease severity of replicates, groups and effectiveness of treatments in trials established in artificially infected soil

Treatment	Mean Disease severity of replications (%)	% Effect According to Abbott
Trichoderma virens İB1	30.00 ^{bc}	60.00
Trichoderma sp. FT1	42.50 ^{b}	43.33
Trichoderma viride VG18	32.50 ^{bc}	56.66
Trichoderma harzianum TUZ16	25.00 ^{c}	66.66
Rhizoctonia solani AG-4	75,00 ^{a}	-
Standard error of the mean	4.37	-
P-value	<0.001	-

*Differences between the averages shown with the same letters in the same column are not statistically significant at p<0.01 level

effect of antagonist applications on pathogen suppression is illustrated in Figure 3.

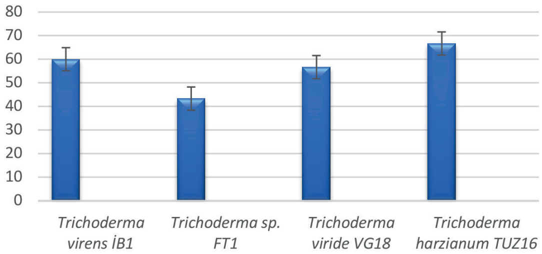

Figure 3. Effect of antagonist applications on disease prevention (%)

Figure 3 illustrates that the most effective isolate was *T. harzianum* TUZ16, followed by *T. virens* IB1, *T. viride* VG18, and *Trichoderma* sp. FT1, respectively. The morphological effects of the antagonists in the experiment, compared with the controls, are shown in Figures 4 and 5.

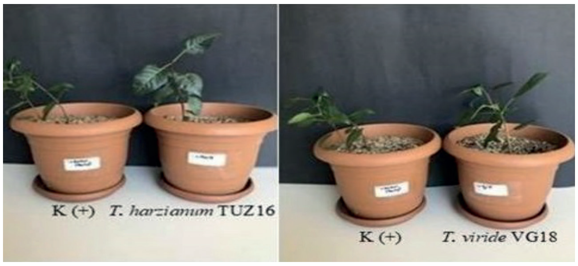

Figure 4. *Trichoderma harzianum* TUZ16 treated plant and positive control (left), *Trichoderma viride* VG18 treated plant and positive control (right)

According to the images in Figures 3 and 4, the root and height development of the antagonist-treated plants was better than that of the untreated plants.

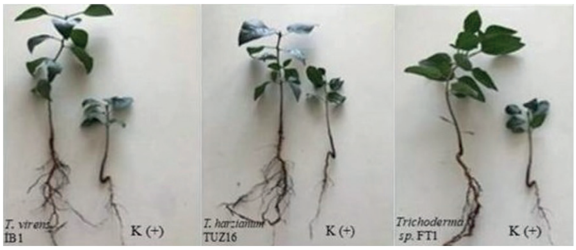

Figure 5. Comparison of plants treated with *Trichoderma virens* IB1 (left), *Trichoderma harzianum* TUZ16 (middle), and *Trichoderma* sp. FT1 (right) alongside their respective positive controls

DISCUSSION

In recent years, pistachio production areas in the Southeastern Anatolia Region have been steadily expanding. However, diseases caused by soil-borne pathogens have been reported in these areas, leading to tree decline and drying (Aydın et al. 2023). One of the most significant soil-borne pathogens is *R. solani*, which causes root rot. A study conducted in the Southeastern Anatolia Region reported that *R. solani* is a major pathogen affecting pistachio, leading to seedling decline and drying (Aydın and Ünal 2021). Another study emphasized that this pathogen is often prioritized in biological control research due to its broad host range and its ability to produce numerous sclerotia in the soil (Ganeshamoorthi and Dubey 2015). Moreover, *R. solani* is among the most extensively studied soil pathogens, and many antagonistic organisms have been identified against it (Aydın 2015, 2022).

In this study, the efficacy of four antagonistic isolates—*Trichoderma harzianum* TUZ16, *T. virens* IB1, *T. viride* VG18, and *Trichoderma* sp. FT1 was evaluated against R. solani in pistachio. The results showed that Trichoderma sp. FT1 was the most effective antagonist, exhibiting a

33.88% inhibition rate in the volatile metabolite assay. This suggests that the isolate suppresses the pathogen through the production of volatile compounds, possibly including antibiotic substances. Furthermore, the results of the dual culture assay (Table 3) support this finding, indicating that *Trichoderma* sp. FT1 possesses antibiotic (A) properties. Various studies have reported that one of the mechanisms of action of *Trichoderma* species is antibiosis (Aydın 2015, Baker and Cook 1974, Bell et al. 1982, Dennis and Webster 1971).

The antagonistic activity of *Trichoderma* isolates was evaluated using the dual culture method, and *T. harzianum* TUZ16 was identified as the most effective isolate, exhibiting a 70.97% inhibition rate in the second evaluation. In the third evaluation, a very strong hyperparasitic (VSH) interaction was consistently observed across all replicates. Hyperparasitism, also referred to as mycoparasitism, is regarded as one of the most critical mechanisms through which *Trichoderma* suppresses plant pathogens.

In the pot experiment, *Trichoderma harzianum* TUZ16 was identified as the most effective antagonist against the pathogen, exhibiting an inhibition rate of 66.66%. This *Trichoderma* species is among the most extensively studied for the control of diverse plant pathogens and is commonly bioformulated for use in commercial production processes (Aydın 2015). In a study conducted between 1983 and 1985 in the Çukurova region, it was reported that covering the soil with polyethylene for 4–8 weeks reduced the impact of *Rhizoctonia solani*, and that the subsequent application of *T. harzianum* further decreased disease severity (Biçici and Erkılıç 1986).

In addition to the use of antagonists against *Rhizoctonia solani* and other soil-borne pathogens, various complementary practices can enhance disease control and improve the efficacy of antagonistic organisms. For this purpose, antagonistic species are often combined with chemical fungicides and cultural control methods to reduce soil-borne disease severity. These combined strategies are referred to as integrated disease management, in which different control methods are applied in a complementary manner to achieve improved outcomes. Research has shown that fungicidal products derived from *Trichoderma* species are increasingly used in agriculture and are now widely available as commercial formulations, particularly in Europe (Whipps and Davies 2000).

This study was conducted at the Phytopathology Research Facilities of Siirt University, Faculty of Agriculture, between 2022 and 2023, focusing on the activity of various *Trichoderma* species against the pathogen *Rhizoctonia solani*. The study aimed to assess the potential of using *Trichoderma* antagonists for biological control in pistachio saplings. To the best of our knowledge, this is the first study of its kind on pistachio conducted under Türkiye conditions. Based on the data and observations from this study, the following conclusions were drawn: In agricultural production, the use of biological control—particularly Trichoderma species—is recommended as an alternative to chemical control for managing diseases caused by various pathogens. Furthermore, it is advisable to implement these practices under horticultural conditions, with particular emphasis on pistachio nurseries.

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ÖZET

Tarımsal üretimde kullanılan birçok kimyasal ilacın yol açtığı çevresel kirlilik, kalıntı sorunu ve toprak patojenleriyle mücadelenin zor olması nedeniyle, bitki hastalıklarıyla mücadelede alternatif yöntemler araştırılmaktadır. Biyolojik mücadele bu alternatif yöntemlerin en önemlilerinden biridir. *Trichoderma* Pers. türleri biyolojik mücadelede en fazla kullanılan antagonistlerdir. Bu çalışmada, bazı *Trichoderma* türlerinin *Rhizoctonia solani* Kühn.'e karşı uçucu metabolitler yoluyla, ikili kültür yöntemiyle ve yapay bulaştırılmış saksı toprağında etkinlikleri araştırılmıştır. Çalışma sonucunda uçucu metabolitler yoluyla *Trichoderma* sp. FT1 izolatının %33.88 oranıyla patojeni en fazla engelleyen izolat olduğu belirlenmiştir. İkili kültür yöntemiyle yapılan çalışmada ise *Trichoderma harzianum* TUZ16 izolatının patojeni %70.97 oranında engelleyerek güçlü hiperparazit özelliği gösterdiği tespit edilmiştir. Uygulama yapılmış Antep fıstığı tohumlarıyla kurulan saksı denemesinde *Trichoderma harzianum* TUZ16, *Trichoderma virens* İB1, *Trichoderma viride* VG18 ve *Trichoderma* sp. FT1 antagonistlerinin sırasıyla, %66.66, %60.00, %56.66 ve %43.33 oranında patojeni baskıladığı belirlenmiştir.

Anahtar kelimeler: Antep fıstığı, biyolojik mücadele, *Rhizoctonia solani*, *Trichoderma* sp.

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