ZANCO Journal of Pure and Applied Sciences

TYPE Original article
DOI http://dx.doi.org/10.21271/ZJPAS.37.3.10

OPEN ACCESS

*Corresponding author
Qasim A Marzani
qasim.marzani@su.edu.krd

RECEIVED :27 /11 /2024
ACCEPTED :07/04/ 2025
PUBLISHED :30/ 06/ 2025

KEYWORDS:
Antagonism, Bioagent, Ascochyta rabiei, Biocontrol.

Assessment Of The Anti-Fungal Activity Of *Trichoderma harzianum* Against Seed-Borne Chickpea Ascochyta Blight Under Field Conditions

Qasim A Marzani*, Kamalaldeen M Fatah

Department of Plant Protection, College of Agricultural Engineering Sciences, Salahaddin University-Erbil, Erbil, Kurdistan Region , Iraq.

ABSTRACT

Ascochyta rabiei (Pass.) Labr., the fungal pathogen that causes ascochyta blight, is a serious global danger to chickpea crops, especially in the Mediterranean and other colder, wetter climates. This foliar disease can cause losses of up to 50% and is particularly damaging in humid and rainy environments. Severe outbreaks frequently result in total crop destruction. Chemical control, despite providing quick and efficient intervention, presents challenges such as environmental contamination and the evolution of fungicide resistance due to the heterothallic nature of the fungus. This study aimed to explore the use of antagonistic fungi as a safer alternative for managing Ascochyta blight damage. In a field trial, the commercial product Biocont-T, containing *Trichoderma harzianum*, was applied as a pre-planting treatment and mixed with peat moss at various rates. The experiment followed a randomized complete block design (RCBD) and was replicated three times. Results indicated that the most effective treatment inhibiting the disease (55.55%) involved a peat-based soil inoculation mixture containing 20.8 kg/ha of Biocont-T and 2083 kg/ha of peat moss (T3). This was followed by T1 (20.8 kg/ha of Biocont-T), which inhibited the disease by 52.77%, T2 (41.66 kg/ha of Biocont-T) with a 41.66% inhibition rate, and T6 (1041.66 kg/ha of pre-inoculated peat moss with the bioagent for one week), also with a 41.66% inhibition rate. In conclusion, while using *T. harzianum* as a biocontrol agent did not completely eradicate the disease, it proved an effective method with no adverse environmental effects.

1.Introduction

As a legume crop, chickpea (*Cicer arietinum* L.) is important to agriculture. It is the only cultivated species of the genus *Cicer*, including 43 species. Among these 9 are annual 33 species are perennial. At the same time, one is unclassified, and cultivated chickpea cultivars are broadly grouped into 2 classes: “Desi” grown in the semi-arid tropics, and “Kabuli”, grown in temperate regions (Muehlbauer and Singh, 1987). Its origins can be traced to three closely related wild annual *Cicer* species found in the southeast of modern-day Turkey and neighboring Syria, including portions of northern and western Kurdistan (Van der Maesen, 1987). Chickpeas are an essential pulse crop that is grown all over the world and used for both human and animal nutrition. It is ranked third among food legumes in terms of overall production, and the crop is the second most important legume crop globally, behind only the common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum*) (Diapari *et al.*, 2014, Benzohra *et al.*, 2014). Chickpeas are traditionally cultivated in the spring throughout Iraq, especially in the Kurdistan Region. However, recent research in the region, most notably that funded by Syria's International Center for Agricultural Research in the Dry Areas, or ICARDA, has shown that winter sowing of this crop is feasible (Marzani, 2003).

Chickpea farming is seriously threatened worldwide by Ascochyta blight, a foliar disease of the crop caused by *Ascochyta rabiei*, formerly known as *Didymella rabiei*. This threat is especially great in cool, moist environments like the Mediterranean countries (Stephens *et al.*, 2014, Li *et al.*, 2015a, Sharma and Ghosh, 2016) where sexual reproduction takes place in cool and moist conditions, which are the source of genetic diversity in the pathogen which leads to the emergence of more aggressive races. The two most damaging symptoms are stem breakage and pod infection (Reddy and Singh, 1990). The disease was first recorded in 2003 in Kurdistan's Erbil Province (Marzani, 2003). *Ascochyta rabiei* can infect chickpea plants at different phases of growth in favorable climatic conditions, resulting in significant losses between 40% and 50% (Wise *et al.*, 2011) and in extreme outbreaks, losses can reach 100% (Marzani, 2003).

Contaminated seeds, volunteer chickpea plants, and contaminated stubble are some of the origins of chickpea diseases. The fungus, *A. rabiei*, is one of the seed-transmitted fungal pathogens that play a crucial role in reducing achievable crop yields (Jadon *et al.*, 2020). Thus, the integrated approach should be taken into account for disease control, such as using pathogen-free seeds, proper debris management, crop rotation, and fungicide treatment. It is imperative to plant seeds that are verified or disease-free. On the other hand, cultivating contaminated seeds results in infected seedlings, from which the disease spreads to nearby plants through rain splash (Khaliq *et al.*, 2020).

Numerous management techniques have been employed to control the disease and reduce the losses brought on by this necrotic infection. When the disease was widespread, the most effective and widely utilized approach was the administration of chemicals topically or as a seed treatment (Kahraman and Ozkan, 2016, Benzohra *et al.*, 2020). Fungicides can occasionally be used in conjunction with other techniques to maximize effectiveness and reduce chemical usage (Vandana *et al.*, 2020, Motagi *et al.*, 2020). However, there are risks involved with applying fungicides foliarly, including fungicide resistance (Wise *et al.*, 2009, Bowness *et al.*, 2016, Yin *et al.*, 2023), environmental pollution, and detrimental effects on other species (Gaona *et al.*, 2019, Kozicki and Niesłochowski, 2020), in addition to the need for the necessity for multiple applications, particularly during the wet season (Marzani, 2003). Another determinant of the use of fungicides is the heterothallic nature of the fungus causing ascochyta blight. *Ascochyta rabiei* populations in many parts of the world are at high risk for developing resistance to fungicides (Brent and Holloman, 2007) based on several key indicators such as sexual reproduction of the pathogen (Armstrong *et al.*, 2001), genetic diversity (Chongo *et al.*, 2004), and repeated fungicide application (Chang *et al.*, 2007). Other strategies include shifting the planting date to avoid the disease (Elia and

Marzani, 2005, Mengist *et al.*, 2019), breeding programs to develop resistant cultivars (Kanouni *et al.*, 2011), and biological management with the use of bacteria and fungi that are antagonistic to one another (Rajakumar *et al.*, 2005, Suthar *et al.*, 2017). *Trichoderma harzianum* (Th) is an antagonistic fungus with a potential effect utilized in biological control and combating many plant-pathogenic fungi (Hajieghrari *et al.*, 2008, Kareem and Al-Araji, 2017, Kuzmanovska *et al.*, 2018). The bioagent, *T. harzianum*, is an effective biocontrol agent of several economically important plant pathogenic fungi that can combat fungal plant pathogens in several mechanisms like producing antifungal metabolites, work as a competitor to fungal pathogens for nutrients and space, antibiotic secretion, and also promote plant growth (KüÇük *et al.*, 2007, Horbach *et al.*, 2011, Atanasova *et al.*, 2013, Zeilinger *et al.*, 2016). Additionally*, T. harzianum* was assessed for its ability to inhibit the growth of Ascochyta isolates, with encouraging outcomes (Benzohra *et al.*, 2011). The purpose of this study was to determine how well *T. harzianum*'s commercial product worked against the Ascochyta blight, which starts mainly with infected seeds.

2.Methodology

2.1.Lab experiments

2.1.1.Seed testing

Testing the seeds confirmed that they were infected with the chickpea Ascochyta blight pathogen, *A. rabiei*. To do this, a sample of the seed, containing visible seed infection symptoms, was chosen at random and tested on agar plates. The seeds were surface sterilized by immersing them in a 0.5% sodium hypochlorite (NaoCl) solution for five minutes after being thoroughly cleaned with water. Following three rounds of distilled water rinsing, they were dried on filter paper and plated on potato dextrose agar (PDA) at a rate of five seeds per plate. After two weeks, the Ascochyta-infected seeds were examined under a compound microscope, and the percentage of seed infection was calculated.

2.1.2.In vitro evaluation *T. harzianum*

The antagonistic effect of the bioagent, *T. hazianum* was evaluated against *A. rabiei* that was isolated from the infected seeds by dual culture technique using Potato Dextrose Agar (PDA) medium. Young mycelial discs (5 mm diameter) of each *T. harzianum* isolate were cut from the peripheries of expanding colonies grown on PDA for three days of culture with a cork borer and were placed on the edge of each PDA Petri plate. In the same way, the mycelial discs of *A. rabiei* were also placed on those of each PDA Petri plate in the opposite direction. The PDA plates inoculated only with either antagonists or phytopathogen served as controls. The plates were incubated in the laboratory at having ambient temperature. The percentage reduction of the radial growth (PRRG) of *A. rabiei* was calculated after seven days of incubation, following the formula suggested by Sharfuddin *et al.* (2012) as follows:

Percentage reduction in radial growth (PRRG) = (RC – RP)/RC × 100

Where: RC = radial growth of the pathogen in control. RP = radial growth of the pathogen in dual culture experiments with antagonists.

2.2.Field experiment

The field trial was conducted in the College of Agricultural Engineering Sciences, Girdarasha Experimental Research Fields, Salahaddin University-Erbil (about 4 km south of Hawler City) in the Spring of 2018. Flip 6-15, a somewhat sensitive chickpea cultivar, was seeded in a clean field with no previous chickpea debris. The seeds were obtained from a field heavily affected by Ascochyta blight (AB), which has a 54% seed infection rate, the year before. Seeds were tested to confirm infection with *A. rabiei*, the pathogen of chickpea Ascochyta blight. These seeds are employed as a single source to initiate aschochyta blight in chickpea plants. A randomized complete block design (RCBD) used in the field experiment allowed for the drilling of seeds (with a seed infection rate of 54%) in rows that were spaced 25 cm apart, and plant-to-plant intervals (the distance between seeds) of 10 cm. The experiment's net plot size measured 2m (length) × 1.20 m (width), with 5 rows and 20 seeds per row, or 100 seeds per plot. There was a 2 m gap between the replicates (blocks) and treatments (plots) when the treatments were applied in triplicate. As a source of *Trichoderma harzianum*, a commercial product (Biocont-T

from Ain Almasa, Saudi Arabia) was employed as the bioagent. The seeds were treated with the bioagent either pre-coated with the bioagent powder or mixed with peat moss (Solvika Peatmoss, Lithuania). This trial was intended to explore the efficiency of *T. harzianum* against *A. rabiei* when the source of the disease is from seeds. Table 1 displays the treatments that were applied during the experiment:

Table 1: The bioagent treatments used in the field experiment.

Treatment symbol	Application rate (kg/ha) and treatment description
T1	Chickpea seeds pre-coated with the bioagent powder at a rate of 5g/kg seed.
T2	Chickpea seeds pre-coated with the bioagent powder at a rate of 10g/kg seed.
T3	Seeds coated with 5g/kg bioagent, and peat moss at a rate of 2083kg/ha, added as peat-based soil inoculation.
T4	Seeds coated with 10g/kg bioagent and peat moss, at a rate of 2083kg/ha, added as peat-based soil inoculation.
T5	520.83kg/ha of one-week pre-inoculated peat moss with the bioagent.
T6	1041.66kg/ha of one-week pre-inoculated peat moss with the bioagent.
T7	The soil mixed with 520.83kg/ha peat moss only.
T8	The soil mixed with 1041.66kg/ha peat moss only.
T9	The soil mixed with 2083kg/ha peatmoss only.
T0	Untreated control: grown with chickpea seeds only.

Note: For every one-hectare treatment plot, certain quantities of peatmoss (depending on the minimum percentage of organic matter in the soils which is 2-3%) and the commercial product *T. harzianum* (Biocont-T) are allocated.

Seeds covered with the bioagent were cultivated directly in treatments T1 and T2 while the commercial product of *T. harzianum* was combined with peatmoss in specific amounts to reach organic matter in the soils to approximately 2-3%, and the resulting mixture was applied directly to the soil as a peat-based soil inoculant (T3 and T4). After receiving the bioagent and the peatmoss, two treatments (T5 and T6) were given to the soil after a week of incubation. To ascertain and deduct the impact of the peat moss from that of the biotic agent, three more treatments (T7, T8, and T9) were solely administered to peat moss. Regardless of whether the treatments received solitary peat or inoculation with the bioagent, the peat moss was added to the soil, evenly distributed across the soil's surface, and then completely mixed with the rhizosphere layer within each treatment. Chickpea seeds that had not been treated were used to grow as the untreated controls (T0). When it didn't rain, the experimental area was irrigated as needed.

2.3.Measured parameters

Plants were observed for the onset of the disease, and the following table (Table 2) lists the parameters that were considered when recording data:

Table (2): Measured parameters in the field experiment.

Parameter	Details (time and measurement)
Disease incidence (DI) and Disease severity (DS)	Average of 10 plants per treatment replication at flowering and pod formation
Germination rate (GR)	After 1 month of growing
Plant height (PH)	At the end of the season and before harvest (average of 10 plants/treatment replication)
Plant dry weight (PDW)	At the end of the season and before harvest (average of 10 plants/treatment replication)
Grain yield (GY)	An average yield of 10 plants per treatment replication
Biological yield (BY)	Average of 10 plants per treatment replication
Percentage of disease inhibition (PDI)	After counting disease severity

2.4. Disease assessment, calculations, and data analysis

The disease, as the blight symptoms of the aboveground parts, represented by disease incidence and disease severity, was assessed at flowering and pod formation at a rate of 10 plants per treatment. Disease incidence (DI) was measured by the following formula:

DI = I * 100/T

Where: I: number of infected plants, T: total number of samples.

The disease severity was assessed using a 0 - 5 evaluation scale (Porta-Puglia *et al.*, 1996) which is adapted from a 0 - 4 evaluation scale provided by Vir and Grewal (Vir and Grewal, 1974) as follows:

0 = no evident lesions.
1 = a few little lesions on the stem and/or leaf, up to 5 mm in size.
2 = lack of stem girdling and superficial stem lesions larger than 5 mm^2.
3 = severe and deep stem lesions, stem girdling capable of breaking a single branch only.
4 = deep and widespread girdling stem lesions that result in several branch breaks and widespread withering.
5= death of the plant.

Based on the reaction patterns of the host plant, the following categories are applied to the averages of individual records:

0-2.5 resistant; >2.5=susceptible

The Disease severity index (DSI) was computed using data on the severity of the condition (MicKiney, 1923):

$DSI = \Sigma (A \times B) \times 100 / \Sigma B \times 5$

where: A: disease class (0, 1, 2, 3, 4, or 5), B: the number of plants exhibiting that disease class for each treatment.

To compute the percentage of disease inhibition (PDI), this formula was used:

PDI = (DIUC – DIIT) * 100 / DIUC

Where:

PDI = percentage of disease inhibition
DIUC = disease incidence in untreated control
DIIT = disease incidence in the interesting treatment

The germination rate (GR) was calculated as follows:

GR (%) = G*100/T

Where: G is the number of germinated chickpea seeds, and T is the total number of grown seeds.

Plant height (PH) was measured using a standard ruler at the end of the season and before harvest. The mean of plant height was measured in centimeters from the ground level to the tip of the plants in each replicate. Plant dry weight (PDW) was measured by drying 10 plants in each treatment in an oven at 40 °C for one week and then weighing them with a digital balance. Grain yield (GY) was calculated by

taking the average yield of 10 plants per treatment in grams and then expressed in kilograms in hectare, and finally, biological yield (BY) was calculated by using the following formula:

Biological Yield (BY) = the total weight (grain + straw) of an average of 10 plants per treatment replication.

Fischer's least significant difference (LSD) test at $P = 0.05$ was used to compare the means of the data after it was analysed using StatGraphics Centurion program.

3.Results and Discussion

3.1.Seed testing and isolating of the pathogen

The pathogen of the chickpea seeds showing dark brown symptoms was isolated, and its characteristics were investigated both on culture media and microscopically. The results indicated that the features of the pathogen were identical to *A. raiei,* depending on the previous work achieved by Marzani (2003). Where black to dark brown spots are usually observed on the seed coats. The color of the colony of the isolated fungus was white in the beginning, then shortly turned dark because of the formation of pycnidia. The fungus has a dark, septate, and branched mycelium. The pycnidia were circular or ovular in shape, yellow to brown, and had an average diameter of 152.43 x 181.84µm. The pycnidiospores (conidia), which were bright and hyaline and usually non-septate, have an average width and length of 4.37 and 9.19µm, respectively.

3.2.In vitro evaluation *T. harzianum*

The efficacy of the bioagent *T. harzianum* was assessed, and the findings demonstrated that the antagonistic fungus prevented the growth of the pathogen *A. rabiei*, exhibiting over 80% of the fungal pathogen's radial growth. Based on this outcome, the field trial was carried out to evaluate the bioagent's effectiveness in the field. *Ascochyta rabiei* is one of the fungal plant infections against which the antagonistic efficacy has been assessed, and the bioagent's inhibitory effectiveness has been verified (Subash *et al.*, 2013, Yassin *et al.*, 2021, Morcuende *et al.*, 2024).

3.3.Field experiment

Chickpea Ascochyta Blight was observed in all treatments up until the crop's flowering and pod-formation stages, at which point the disease was assessed. The findings showed that T3 (44.44%) had the lowest incidence, followed by T1 (47.22%), T2 (58.33%), and T6 (58.33%). Figure 1a shows that there were no significant differences between any of these treatments, but the differences were significant between the remaining treatments and the untreated control. The disease severity percentage results (Figure 1b) indicated that T2 (22.22%) had the lowest disease severity, followed by T3 (25%) and T6 (42.77%), with no discernible differences between them. Comparing T3 and T6 to T1, there was no apparent difference. The highest disease severity, which did not differ significantly from the untreated control, was exhibited by treatments T4, T5, T7, T8, and T9, which demonstrated the least efficacy (Figure 1b). According to the disease inhibition percentage results (Figure 2), T3 (55.55%) was the most successful treatment, followed by T1 (52.77%), T2 (41.66%), and T6 (41.66%).

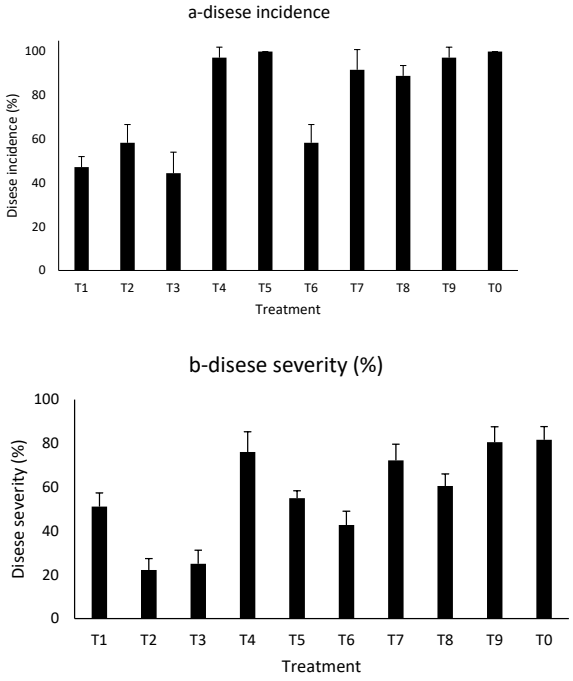

Figure 1: The impact of treatments based on *Trichoderma* on the incidence and severity of chickpea blight (a, b). Table (1) lists all the treatment details (T1 through T0) in full. Fischer's least significant difference (LSD) test at $P = 0.05$

is 12.17 for disease incidence and 26.86 for disease severity.

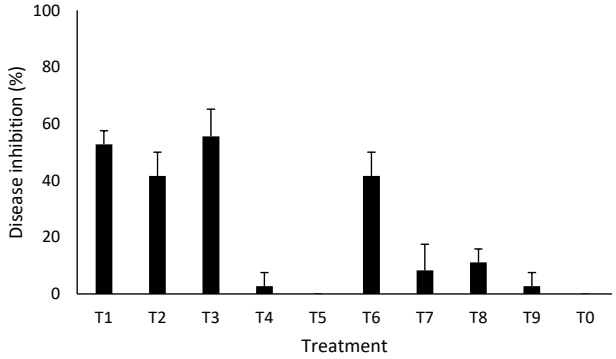

Figure 2: The inhibition efficacy of Trichoderma-based treatments on chickpea blight. The full details of all treatments (T1 – T0) are found in Table (1). Fischer's least significant difference (LSD) test at *P* = 0.05 is 12.17

The agronomic traits of the crop were significantly impacted by the field application of Trichoderma-based treatments. The plant height, biological yield, grain yield, dry weight, and growth pace were all substantially impacted by all treatments. (Table 3). The highest plant height was obtained for T8, T4, T3, and T5, which were significantly different from the rest of the treatments. T3, T1, T8, T9, and T2 performed the best in terms of biological yield. There were no discernible differences in the seed yield of T2, T4, T9, T5, T3, T8, and T1, with T2 exhibiting the highest seed yield (3444.44 kg/ha). However, the treatments had no discernible impact on the crop's germination rate and dry weight.

Table 3: Impact of treatments based on *Trichoderma* on chickpea plant agronomic parameters.

Treatment	Plant height (cm)	Biological yield (kg/ha)	Grain yield (kg/ha)	Dry weight (kg/ha)	Germination rate (%)
T1	28.72	5266.67	2526.67	457.78	94.58
T2	29.85	4688.89	3444.44	407.56	94.17
T3	30.90	5311.11	2606.67	533.11	87.08
T4	30.98	4666.67	2733.33	343.11	94.58
T5	30.82	4288.89	2622.22	447.56	90.83
T6	25.32	4244.44	2400.00	434.44	93.33
T7	15.07	3866.67	2244.44	129.89	90.00
T8	31.18	4822.22	2533.33	258.33	90.00
T9	14.12	4688.89	2693.33	169.33	90.42
T0	14.92	4600	2155.56	225.00	87.08
Standard Error	0.695	227.17	120.6	20.52	
LSD (0.05)	2.052	694.39	954.37	60.54	7.52

Note: The full details of all treatments (T1 – T0) are mentioned in Table (1).

In the present study, in-field suppression of chickpea blight caused by seed-borne fungal pathogen, *Asscochyta rabiei*, was evaluated by using Biocont-T. The commercial product, which contained *T. harzianum*, the active bioagent, was applied to the soil either pre-inoculated or alone or combined with peat moss. The findings demonstrated that a few of the treatments (Figure 1) significantly reduced the incidence and severity of the disease. When employed as biocontrol agents against various plant infections, microorganisms that can thrive in the rhizosphere of plants demonstrated the most potential; this agent is present in the first line of defense for the root against the pathogens (Alabouvette *et al.*, 1993, El-Saadony *et al.*, 2022). Because *Trichoderma harzianum* can directly function as a mycoparasite on other fungi, it is a vigorous colonizer of soil (Pani *et al.*, 2021). The fungus, *T. harzianum* is described as the most important species of *Trichoderma* in biological control, as it has several genes that play a role in destroying the cell wall of pathogens, such as Gene Tri5, which is responsible for producing Trichothecene, which inhibits the production of DNA and protein in pathogen cells and thus inhibits their growth, and also the gene responsible for stopping the production of the enzyme Cellulase and Xylanase in the cell wall of

the pathogen, and also the gene responsible for producing the enzyme Serine Protease, which is one of the most important factors for the success of *T. harzianum* fungus in biological control (Sharma *et al.*, 2011). This mycoparasitic activity is linked to the synthesis of several substances with antibiotic properties, such as cell wall-degrading enzymes, gliotoxins, viridin, and trichodermin (Tyśkiewicz *et al.*, 2022). In addition, ethyl acetate, one of the physiologically active heat-stable metabolites that makes it one of the effective possible biocontrol agents (Mohiddin *et al.*, 2021). A few of the treatments, T2 (10 g Biocont-T/ kg chickpea seed), T1 (5g Biocont-T/kg chickpea seed), T3 (5 g Biocont-T/kg chickpea seed and 2083kg/ha peat moss), and T6 (520.83kg/ha of one-week pre-inoculated peat moss with the bioagent), considerably decreased the percentage of disease severity and incidence. According to several studies, (Sharma *et al.*, 2023, Izurdiaga *et al.*, 2023), *Trichoderma* produces chitinase and β-1-3 glucanase, which are important enzymes in the lysis of the polysaccharides in the fungal cell wall of phytopathogenic fungal cells during Trichoderma's antagonistic action. *Trichoderma* spp. fungal cell wall-degrading enzymes are hence particularly significant in plant defense mechanisms. All treatments, however, had no discernible impact on the treated plants' growth rate % when compared to the untreated control. Nevertheless, the treatments T3, T2, T1, and T8 significantly increased the dry weight, seed yield, and biological yield (soil mixed with 1041.66kg/ha peat moss only) and T9 (soil mixed with 2083kg/ha peat moss only). The observation that certain *Trichoderma* species release growth factors that accelerate seed growth contributes credence to these findings (Dos Santos *et al.*, 2020, Kthiri *et al.*, 2020). In the present work, except for T7 (15.07cm) and T9 (14.12cm), all treatments significantly increased plant height (25.3167cm- 31.1833cm), compared to untreated control (14.9167cm). These results concur with the findings of (Marzani *et al.*, 2017), who attested to the fact that root colonization by *Trichoderma* strains often improves the growth of chickpea plants' roots and shoots and raises biomass and yield through improved root development. The introduction of *Trichoderma* positively correlated with the abundance of soil microbes, which is positively correlated with the level of available nutrients in the soil because the biological activities of *Trichoderma* in the rhizosphere can mediate the solubility, and hence the availability, of metal ions at root surface (Cai *et al.*, 2015). *Trichoderma* may stimulate plant growth firstly through the production of hormone-like substances which promote root system development and plant growth. Then, plants with superior growth prompt an increase in microbial population and activity through the release of higher amounts of root exudates, which in turn makes more nutrients available. Then this process continues cyclically during the whole growth period of the plants (Li *et al.*, 2015b). The results of this investigation are corroborated by multiple research that indicates a decrease in the frequency and intensity of diseases results in increased crop yields in soil and seeds treated with *Trichoderma* (Marzani *et al.*, 2017, Mishra *et al.*, 2020, Ahmad *et al.*, 2021). Among the three levels of commercial peat mosses (2083, 1041.66, and 520.83kg/ha treatment) used alone and amended jointly with *T. harzianum*, the results showed that using 2083kg/ha peat moss mixed with 20.8 kg/ha of *T. harzianum* as soil inoculation gives the best results regarding all studied parameters. Previous research demonstrating the reduction of plant diseases when compost was employed supports these conclusions. According to Woo *et al.* (2014) treatments containing *Trichoderma* are effective plant growth boosters and stimulants that ward off fungal infections. *Trichoderma harzianum* acts as a promoter of plant resistance, a growth enhancer, a bio-fertilizer, and a bio-pesticide. It shows significant potential against pathogens, greatly boosts photosynthesis, enhances plant growth, and improves nutrient use efficiency, leading to impressive crop yields (Asad, 2022). Furthermore, the efficacy of *Trichoderma* species may refer to the fact that they can readily establish themselves in various rhizosphere soils and can persist for several months. Their effectiveness as antagonists is evident from their high colonization rates and dominance over competing microorganisms,

making them strong local bio-control agents. *Trichoderma* thrives in the rhizosphere, supported by interactions with diverse soil microbes and root exudates. These fungi enhance plant defense through the production of microbe-associated molecular patterns (MAMPs) like xylanases and peptaibols, and employ various antagonistic mechanisms such as antibiosis, parasitism, enhanced host-plant resistance, and competition (Adnan *et al.*, 2019). For the antagonistic rhizosphere microorganisms, such as *Trichoderma* spp., natural resistance, peat moss, and organic matter in general are thought to be the primary substrate, providing sustenance to the crops. As a result, nutrition will increase production and yield. (Hoitink and Boehm, 1999, Pascual *et al.*, 2018, Carlile *et al.*, 2019).

4.Conclusions

A pre-planting treatment with the commercial product Biocont-T, which contains *T. harzianum*, successfully stopped the disease's progression. Even if total eradication is not possible, the bioagent *T. harzianum* provides a workable substitute for managing the disease without negatively impacting the ecology. Chickpea growers can be advised to use biocontrol agents for treating their seeds before sowing in the field. Such an approach will reduce disease incidence and increase yield. For confirmation, this study needs to be repeated in different agroclimatic zones of the Kurdistan region using different selected chickpea varieties, using cheap agricultural waste with the bio-agent, and testing the compatibility of the bioagent with different carrier materials.

Author contributions

The first author proposed and designed the experiment. The second author implemented the lab experiment. Both implemented the field trial, wrote and analysed data.

5.Conflicts of Interest

The authors of this research do not have any conflicts of interest.

6.Funding

Funding is not applicable for this research.

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