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Research Article
Trichoderma asperellum Strain T34 Used as Biocontrol Agent Against *Rhizoctonia solani* in Potato Plants

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Abstract

Background and Objective: Potato, (*Solanum tuberosum*), the fourth most important agronomic crop in the world, may be susceptible of diseases caused by *Rhizotocnia solani*. This pathogen causes worldwide serious losses in crops of great economic importance. Many pesticides have been banned globally because of risks to human health and environmental pollution. Integrated pest and disease management is a priority. Biological control and other agronomic practices could replace the use of pesticides in the future. The aim of this study was to evaluate the use of the biological control agent (BCA) *Trichoderma asperellum* strain T34 against phytopathogenic fungus *R. solani* in potato plants, as an alternative to the use of chemical products. **Materials and Methods:** Three methods of application of the biological control agent *T. asperellum* strain T34 were evaluated 1. Prevention in plants, 2. Curative method in plants and 3. Fragments method. Disease incidence (DI%) and disease severity (DS%) were evaluated in plants infected with *R. solani*. **Results:** *Trichoderma asperellum* strain T34 reduced the rates of disease and severity produced by *R. solani* around 60% when added to the substrate and the solution in the curative treatment. The preventive and curative treatments of *T. asperellum* T34 showed satisfactory results. **Conclusion:** The results obtained in this study were mainly attributed to mycoparasitism. *T. asperellum* strain T34 can be a useful biological alternative for the prevention and control of *R. solani* in potato plants.

Key words: Biological control agents, mycoparasitism, *Trichoderma asperellum* strain T34, *Rhizoctonia solani*, *Solanum tuberosum*

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

There is a strong need to control plant diseases to ensure the quality of crops and the abundance of food in the world. Different strategies are used to control and mitigate plant diseases. Crops often depend on the use of chemical fertilizers and pesticides. These products are proven to cause damage to the environment and are harmful to human health with carcinogenic effects in some cases. This problem has prompted the search for new natural alternatives that can eradicate the use of these products while being effective in the treatment of diseases in plants. Within these new strategies, the biological control or biocontrol are common[1-7]. The interest in biological control using microorganisms (fungi and bacteria) against pathogens has increased over the past years[8]. In plant pathology, the term applies to the use of microbial antagonists to suppress diseases and the use of host specific pathogens to control weed populations. In both fields, the organism that suppresses the pest or pathogen is referred to as the biological control agent (BCA). For example, the European Union has proposed the sustainable use of pesticides under the regulation of Directive 2009/128/EC "Aims to achieve a sustainable use of pesticides in the EU by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of integrated pest management and of alternative approaches or techniques, such as non-chemical alternatives to pesticides[9]."

Potato (*Solanum tuberosum*) is a crop that has gained considerable importance in recent decades, based on the total value of production. Potato is native of the mountainous areas of the Andes in South America. It was introduced by the Spaniards in Europe in the 16th century and was distributed throughout the world. Currently, potatoes are grown and eaten in more countries than any other crop. They are the fourth most important crop after three cereals: maize, rice and wheat in the global economy[10,11].

Solanum tuberosum presents several diseases including infections by fungi, bacteria and viruses. Numerous soil fungi are pathogens of economically important horticultural species. Their control with chemicals is very difficult and costly. These organisms have the capacity to remain in the soil using mechanisms of resistance, even under adverse conditions[12]. *Rhizoctonia solani*, a pathogen with a large range of hosts and worldwide distribution, is considered a top fungus and is one of the causes of rotting or damping-off. It kills the seedlings in horticulture. There are numerous biotypes of *R. solani* called anastomosis groups that can bind their hyphae and produce plasmogamy, or cytoplasmic binding. Thus, they may present different symptomatology than the one produced by an individual group and affect a wide range of cultures[13].

Trichoderma spp. is a genus of fungi belonging to the family Hypocreaceae. It can be found worldwide in soil and in different ecosystems. Many studies show that they are opportunistic, a virulent plant symbionts and parasites of pathogenic fungi by their production of antibiotic substances. *Trichoderma* spp. are highly efficient antagonist fungi. They can also compete with other microorganisms. For example, they compete for key exudates from seeds that stimulate the germination of propagules of plant-pathogenic fungi in soil. They compete with soil microorganisms for nutrients and space. Furthermore, they inhibit or degrade pectinases and other enzymes that are essential for plant-pathogenic fungi. *Trichoderma* spp. exerts biocontrol on many species of phytopathogenic fungi like *Sclerotium rolfsi*, *Verticillium dahliae*, *R. solani* among others.

Trichoderma spp. has been used as a biocontrol of *R. solani* the seedling diseases of cotton. Its action is not associated with production of antibiotic or mycoparasitism[14-16]. The action mechanism of *Trichoderma* spp. have been described affecting directly the pathogen by the competition of nutrients, antibiosis, mycoparasitism or indirectly through production of the plant resistance.

Commercial *Trichoderma* spp. is an important agent in the biologic control of fungi species. They have been used in the reduction of *R. solani* diseases in different crops (bean, cotton, tomato, beet, soybean, tobacco, radish and potato) increasing the crop productivity in these cultivars. The use of *Trichoderma* species has not been extensively studied in potato plants[17-24]. Application of *T. brevicompactum* obviously reduced the disease severity of soybean caused by *Phytophthora sojae* in the greenhouse experiment[25]. In the European Union, *Trichoderma* strains are registered as biopesticides for use in agriculture under EU regulation 1107/2009. For example, in the market, *T. asperellum* strain T34 CECT No. 20417 biopesticide under register of patent number US7553657B2 is available for inducing suppression of plant diseases caused by *R. solani* and/or *Fusarium oxysporum* f. sp. *Lycopersici* in tomato plants[26].

The objective of this study was to evaluate the use of the biological control agent (BCA) *T. asperellum* strain T34 against phytopathogenic fungus *R. solani* in potato plants, as an alternative to the use of chemical products.

MATERIALS AND METHODS

Isolation of soil and microorganism (*R. solani*): The present study was carried out between the months of February to November, 2015 in the laboratory of the Department of Plant Physiology. The Faculty of Biology of the University of Barcelona. The first trial soil samples were taken from the experimental fields of the University of Barcelona. Samples were dried and filtered, to remove large aggregates, divided into four glass bottles of 1 L capacity. Samples were moistened and disinfected inserting them in the autoclave for two consecutive days for 1 h. Then, the soil samples were disinfected. Half a potato tubercle was incorporated in each of the cans, divided into pieces of approximately one cm and used as a later nutrient for the pathogen. A new disinfection was carried out in the autoclave for one hour.

Rhizoctonia solani was obtained from the Department of Plant Physiology. The Faculty of Biology of the University of Barcelona. *Rhizoctonia solani* was previously planted with PDA medium. Two plates were used, dividing this material into eight segments and distributed at the rate of four segments for each of the four glass canisters. The entire process was performed in the laminar flow cabinet and with all the aseptic measures required to avoid contamination. Fifteen days later the inoculum proliferated successfully. The bottles were shaken in order to distribute the pathogen over the whole soil sample and waited a couple of days more. The resulting material was dried on the laminar flow cabinet for 48 h, homogenized by passing through a 0.2 cm pore sieve, under sterile conditions and stored in the refrigerator at 4°C. Approximately 500 g of inoculum were obtained.

Design of the assay to establish the inoculum concentration of R. solani: A0 (control), A1 (2.5 g inoculum L^{-1} substrate), A2 (5.0 g inoculum L^{-1} substrate), A3 (10.0 g inoculum) and these three doses were evaluated. Ten plants were used for each dose or treatment assayed and the assays were made for triplicate (n = 30).

Setting up the pathogen inoculation test: From the Kennebec potato tubers, yolks were selected in good condition. Fragments (approximately 4×4 cm) were cut. A mixture of peat, perlite, vermiculite (2:1:1, v:v) was used as substrate, the same one that was inoculated with the different doses previously described, distributing it homogeneously. The fragments were placed in 5 cm of substrate in 2 L pots and completely covered (center of the pot). Then, they were taken to a chamber with controlled conditions (25±2°C, 16 light hours, between 100 and 150 µmoL m^{-2} sec^{-1}) from the Experimental Fields of the University of Barcelona. The first irrigation with approximately 5 mL of nutrient solution (Hoagland) per pot was applied. The same amount was applied daily from the sowing. The plants were extracted after 26 days for observation.

The parameters analyzed in the first test are disease incidence (DI) and disease severity (DS). For DI values were 0 = healthy plant, 1 = diseased plant. For DS the values were 0 = healthy plant, 1 = low or mild severity, 2 = average severity, 4 = high severity (dead or rotten plant) (lower than 1, on a scale from 0-4)[27]

The results were expressed as:

$$DI\ (\%) = \frac{C\text{-}vDI}{C} \times 100$$

and:

$$DS\ (\%) = \frac{C\text{-}vDS}{C} \times 100$$

where, vDI is value scale assigned (0 at 1) and C is the control, vDS is value scale assigned (0-4).

Concentration and inoculation of *T. asperellum* strain T34: *Trichoderma asperellum* strain T34 (Biocontrol Technologies, Barcelona-Spain) was used in this study at the final concentration of 10^4 CFU of *T. asperellum* strain T34.

Two additional treatments were performed where *T. asperellum* strain T34 was not inoculated into the substrate, the potato fragments were embedded in a solution with 2.5 g L^{-1} of sterile water. This treatment was made according to the recommendation of the technical department of Biocontrol Technologies, company that provided the product. For example, *S. tuberosum* is 250 g/ 100 L of water for each 1000 kg of potato. Ten plants were used per treatment.

Experimental design of biocontrol assay: Seven treatments were performed with a control, as described in Table 1.

Testing of antagonism and biocontrol: As in the first assay, Kannabec variety potato fragments were used. Buds in good condition without pathogens were present. The fragments of approximately 4×4 cm were cut. A mixture of peat, perlite, vermiculite (2:1:1, v:v) was used as substrate. Two-liter pots

Table 1: Denomination of treatments used in the assays of antagonism effect

Groups	Treatments	Description
Control	A0 = *R. solani*-T34	Without pathogen (*R. solani*), without BCA (*T. asperellum* strain T34)
Prevention in plants	A1 = T34/7+*R. solani*	T34 was inoculated in the substrate for 7 days, *R. solani* was inoculated in the substrate
	A2 = T34/7+*R. solani*/7	T34 was inoculated in the substrate for 7 days before and *R. solani* was inoculated for 7 days in the substrate
Curative in plants	B1 = *R. solani*/7T34	*Rhizoctonia solani* was inoculated in the substrate for 7 days, T34 was inoculated in the substrate
	B2 = *R. solani*/7T34/7	*Rhizoctonia solani* was inoculated in the substrate for 7 days and T34 was inoculated for 7 days in the substrate
Fragments of potato	I1 = T34/7+*R. solani*/7	Fragments were submerged in solution of T34 for 7 days and *R. solani* was added for 7 days in the substrate, fragments were growth for 7 days (total days = 21 days)
	I2 = *R. solani*/7+T34/7	*Rhizoctonia solani* was inoculated in the substrate for 7 days, fragments were submerged in T34 solution and were added for 7 days in the substrate, Then fragments were planted and growth for 7 days (total days = 21 days)

were used to estimate the pre-emergence (damping-off) data, i.e., the disease condition in the early stages of germination. Both *T. asperellum* strain T34 and *R. solani* were inoculated, according to the treatments indicated above (Table 1). The selected dose of *R. solani*, according to the results of the first test was 2.5 g of inoculum L^{-1} of substrate. The test was established in the same chamber and under the same conditions as the first test, where the first irrigation was carried out with 5 mL of nutrient solution (Hoagland) per pot. The same amount was applied daily from the sowing. The plants were extracted for observation after 26 days.

Preventive treatment: To simulate the prevention of the attack of *R. solani*, it first inoculated *T. asperellum* strain T34 into the substrate, allowing it to mature for 7 days for the A1 treatment, likewise for the A2 treatment, only in this case at 7 days we added the inoculum of *R. solani* and left it for 7 more days until the sowing of the potato fragments.

Healing treatment: It quantified the antagonism effect of *T. asperellum* strain T34 on *R. solani* once the disease is already present in the substrate. The pathogen was first inoculated, allowing it to mature for 7 days for treatment B1. Similarly, for treatment B2 and only in this case at 7 days it added the solution of *T. asperellum* strain T34 and it left it for 7 additional days until potato fragments were planted.

Treatment on the potato fragments: To observe differences in methodology of inoculation of BCA, the treatments I1 and I2 were performed. Instead of having the inoculum in the substrate they had it in the potato fragments, the same ones that were embedded as previously explained.

Parameters analyzed in the second test: All treatments (A0, A1, A2, B1, B2, I1, I2) were compared. DI and DS were determined as described above. The populations of *T. asperellum* strain T34 were also recounted by the suspension-dilution method. The samples were incubated in a semi-selective medium[28].

Statistical analysis: Results statistical analysis are expressed as mean±standard deviation (n = 30). To determine if there were significant differences $p<0.05$ it used ANOVA one-way analysis followed by the Tukey Test. The statgraphics statistical tool was used to the analysis.

RESULTS

Test to establish the inoculum concentration of *Rhizoctonia solani*: The biocontrol assays of *T. asperellum* strain T34 against *R. solani* were expressed as a percentage of disease severity (DS %) and the percentage disease incidence (DI %) in potato plants and fragments of potato.

The first step in this study was to establish the inoculum concentration of *R. solani* to be used in potato plans and fragments of potato plants. Figure 1 show the concentration inoculation of *R. solani* assayed. The control group (without inoculum) of potato plants presented a low percentage of DS with a value of 2.5%. Group potato plants infected with the pathogen *R. solani* (2.5, 5.0 and 10 g L^{-1}) showed signs of disease in each of the replicates. The percentage of DS was calculated with the following results: 2.5 g L^{-1} potato plants presented a DS percentage of 35% showing lesions in the plants between mild and moderate. These plants germinated in many cases and could possibly culminate the cycle of culture. At 5.0 g L^{-1}, DS was 90% and at 10 g L^{-1} DS was 92.5%. When groups were compared to the control only 2.5 g L^{-1} presented statistical differences at $p<0.05$. At high level of DS, many plants did not germinate and others failed to emerge. The best concentration of inoculation of *R. solani* was 2.5 g inoculum L^{-1} of substrate.

Evaluation of disease incidence (DI): Figure 2 show DI (%) obtained in curative, preventive and fragments treatments. The group control (A0) presented no signs of disease in potato plants used. All groups of treatments (Preventive = *T. asperellum* strain T34 was inoculated before *R. solani* in the substrate), (Curative = *R. solani* was inoculated before *T. asperellum* strain T34 in the substrate) and (Fragments = *T. asperellum* strain T34 and *R. solani*

were inoculated in solution) presented sign of disease. The group B1(potato plants inoculated with *R. solani* without BCA) presented 100% signs of disease. Preventive treatments A1 and A2 presented DI values of 90 and 80%, respectively. Curative treatments B1 and B2 presented DI values of 100% and 40% respectively. Fragments of potato treatments I1 and I2 presented DI values of 40 and 100%, respectively (Fig. 2). B2 and I1 presented a DI with a value of 40%. Both treatments presented the best DI value. The reduction of DI was of 60% when *T. asperellum* strain T34 was added in the substrate and solution in B2 and I1 respectively. In B2 treatment *T. asperellum* strain T34 was effective when *R. solani* was inoculated 7 days before.

The best treatments for DI were B2 and I1 (Fig. 2), which would ensure better results at the end of the growing cycle. Treatments with BCA *T. asperellum* strain T34 in the substrate are better than applied in the potato fragments. The disease was reduced by 60% comparing the treatment B1 (100% illness) with respect to the treatments B2 and I1 that showed a 40% value.

Evaluation of disease severity (DS): Figure 3 show DS (%) in the treatments used. When performing the general analysis of the second test, treatments with the best response to the severity of the *R. solani* pathogen were A1, B2 and I1 with values of DS (%) of 22.5, 15.0 and 22.6% respectively. Preventive, curative and fragment treatments presented significative reduction of DS (%). B2 curative treatment B2 obtained better results with lower severity of the disease.

***Trichoderma asperellum* strain T34 population count:** Figure 4 show *T. asperellum* strain T34 populations used in the experiments. When counting populations of *T. asperellum* strain T34, estimated in CFU (Colony Forming Units), the highest number of populations was observed in the treatments that have inoculated the pathogen *R. solani* for 7 days in the substrate and *T. asperellum* strain T34 for 7 days (A2, B2, I2).

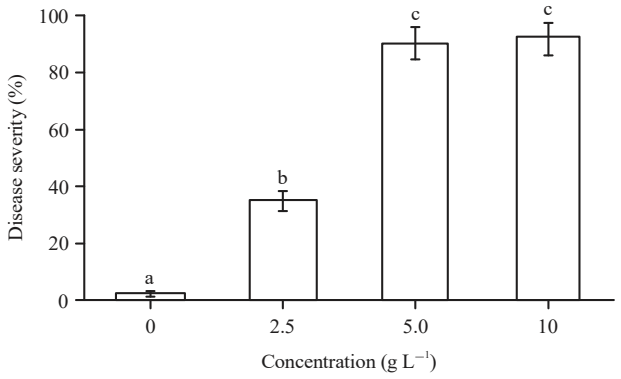

Fig. 1: Disease severity (%) in potato plants (*Solanum tuberosum*) infected with *Rhizoctonia solani* at a concentration of 5×10^5 CFU

0 g: Control no infected plant, 2.5 g: Inoculum L^{-1} substrate, 5 g: Inoculum L^{-1} substrate, 10 g: Inoculum L^{-1} substrate, data are expressed as the mean±standard deviation (n = 30), different letters differ significantly (p<0.05) using ANOVA one way followed of Tukey's test

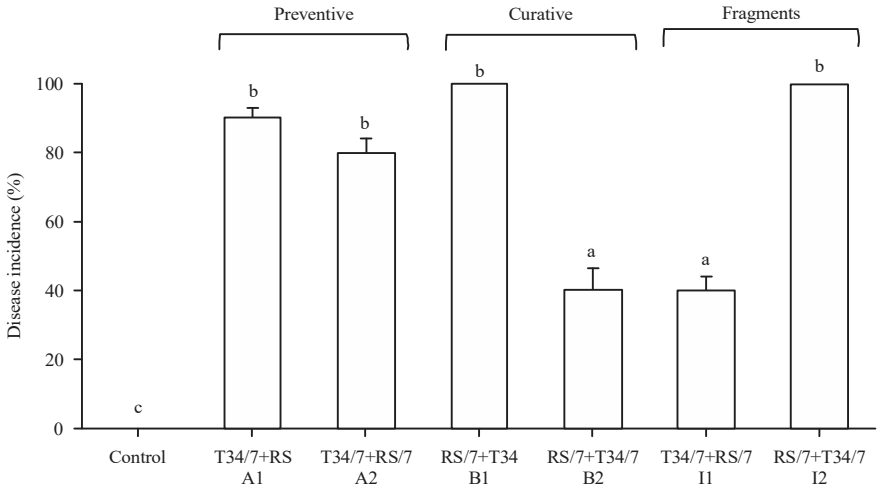

Fig. 2: Disease incidence (%) in potato plants, plants infected with *R. solani* at a concentration of 10^5 CFU mL^{-1} of substrate

Control: *Rhizoctonia solani* T34, A1: T34/7 days in the substrate + *R. solani*, A2: T34/7 days in the substrate+*R. solani*/7, B1: *Rhizoctonia solani*/7 days in the substrate+T34 substrate, B2: *Rhizoctonia solani*/7 days in the substrate+T34/7 days in the substrate, I1: T34/7 days in solution+*R. solani*/7 days in the substrate, I2: *Rhizoctonia solani*/7 days in the substrate+T34/7 days in solution, *T. asperellum* strain T34 was inoculated at a concentration of 10^4 CFU mL^{-1} of substrate in plants, data are expressed as the mean±standard deviation (n = 30), different letters differ significantly (p<0.05), ANOVA and Tukey test

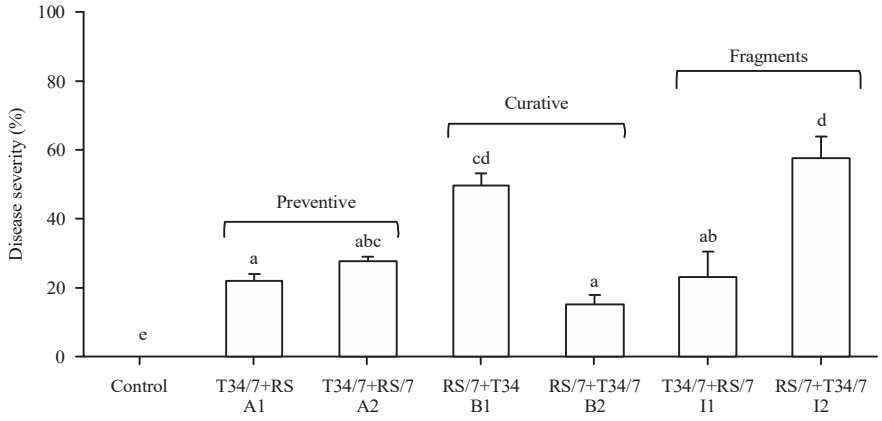

Fig. 3: Disease severity (%) in potato plants, plants were infected with *R. solani* at a concentration of 10^5 CFU mL^{-1} of substrate
Control: *Rhizoctonia solani*, T34, A1: T34/7 days in the substrate+*R. solani*, A2: T34/7 days in the substrate+*R. solani*/7, B1: *Rhizoctonia solani*/7 days in the substrate+T34 substrate, B2: *Rhizoctonia solani*/7 days in the substrate+ T34/7 days in the substrate, I1: T34/7 days in solution+*R. solani*/7 days in the substrate, I2: *Rhizoctonia solani*/7 days in the substrate+T34/7 days in solution, *T. asperellum* strain T34 was inoculated at a concentration of 10^4 CFU mL^{-1} of substrate in plants, data are expressed as the mean±standard deviation (n = 30), different letters differ significantly ($p<0.05$), ANOVA and Tukey test

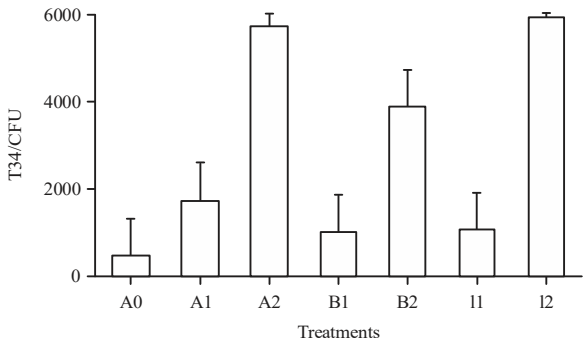

Fig. 4: Graph of results of population counts performed in the different treatments, expressed in CFU, by the suspension-dilution method, in a concentration of 10^{-3}
A0: *Rhizoctonia solani*, T34, A1: *Rhizoctonia solani*+T34 substrate, A2: *Rhizoctonia solani*+T34 substrate, B1: *Rhizoctonia solani*-T34 substrate, B2: *Rhizoctonia solani*+T34 substrate, I1: *Rhizoctonia solani*+T34 fragments), I2: *Rhizoctonia solani*+T34 fragments

DISCUSSION

Trichoderma asperellum strain T34 commercial reduced the percentages of DI and DS produced by *R. solani* in *S. tuberosum* with ranges around of 40-60%, respectively, when was added the substrate and the solution in the curative treatment. The preventive and curative treatments of *T. asperellum* T34 showed high of reduction of DI (%) with values of 90 and 100%, respectively. Global losses caused by crop diseases have been estimated to range from 9-14.2% of the potential yield. About 14.1% of produce may be lost due to crop diseases for approximately $220 billion per year. Developing countries have more economic losses compared to developed countries[29].

Rhizoctonia solani is a parasitic non-specialized fungus that forms sclerotia that survive for a long time in the absence of hosts, or through thick-walled hyphae either in the soil or on plant residues. These sclerotia remain attached to the tubers that are then propagated. Approximately 80% of the commercial seed is contaminated[14].

Rhizoctonia solani is also a pathogen of worldwide distribution present in almost all horticultural crops that develop in or on the soil. It is considered that there is no effective chemical fungicide against this disease[29]. Hence, the interest in alternative methods that can reduce the disease and are also respectful of the environment and health. *Rhizoctonia solani*, is a soil-borne fungal plant pathogen which can cause serious losses in potato production worldwide. Symptoms of infection include lesions on below-ground shoots, stems and stolons, resulting in variations in numbers and size of tubers and in some instances tuber malformations. Lesions can infect and destroy emerging shoots ('nipping'), delaying crop emergence. The fungus also forms sclerotia ('black scurf') on the surface of tubers which are important inoculum sources and can remain active in the soil for several years[30,31]. In the present study, *T. asperellum* strain T34 was able to reduce 60% of disease in potato produced for *R. solani.* Our results are in accordance with the report of the use of *Trichoderma* strains as biocontrol agent against *R. solani*. These results are in line with other authors.

For example, Hicks *et al.*[32] reported in their study suppression of *R. solani* in potato with use of six *Trichoderma* strain (*T. virens* LU549, *T. atroviride* LU144 and *T. barbatum* LU1482, *T. harzianum* LU1491, *T. barbatum* LU1489 and *Trichoderma* sp. 792 LU1483) with reductions of 41-46% of disease stolons depending on the *Trichoderma* strains used. In this study, it reports for the first time, activity of inhibition of *R. solani* in potato plants by *T. asperellum* strain T34. Al-Askar *et al.*[33] reported *T. harzianum* WKY5 was used as control biological agent against *R. solani* managing to reduce the disease in potato plants

Cotxarrera *et al.*[25], reported *T. asperellum* isolate of compost vegetable able to reduce diseases caused by *F. oxysporum* f. sp. *lycopersici* in tomato plants. Bidellaoui *et al.*[34] reported the effect of *T. asperellum* strain T34 against *F. oxysporum* f. sp. *lycopersici* in tomato plants with a reduction of DI (%) of 54%. *Trichoderma asperellum* strain T34 increase the height of the plants and allowed the assimilation of certain metals and considerable increase of chlorophyll. Commercial strains of *Trichoderma* spp. are registered and used in agriculture as biopesticides under EU Regulation 1107/2009.

Trichoderma asperellum strain T34 has been registered as biopesticide by the U.S. Environmental Protection Agency with the code EPA 87301-R (*T. asperellum* strain T34 Biocontrol)[35-39]. *Trichoderma asperellum* strain T34 as a biocontrol BCA method for *R. solani* in potato plants is nonexistent in Ecuador. The use of this type of biocontrol would benefit the Ecuador potato industry and may have wider applications in potato production.

In this study, when strain T34 was inoculated into the substrate prior to the pathogen (A2) the preventive effect of BCA was clear. The different species of *Trichoderma* spp exert biocontrol in an indirect way either by competition of nutrients or space, antibiosis, modifying environmental conditions or by the production of substances that promote plant growth and directly by mycoparasitism[40]. The use of biological control agents to prevent or control diseases in cultivated plants is a sustainable alternative that has shown effectiveness in many cases[41].

The best results were obtained by simulating a curative action (B2). These results are attributed to the mycoparasitism exerted by *T. asperellum* strain T34 when encountering *R. solani*. Direct attack from one fungus to another is a very complex process involving sequential events, including recognition, attack and subsequent penetration, followed by death to the host. *Trichoderma* spp. can exert direct control by mycoparasitism, detecting other fungi and growing on it[42].

The process of mycoparasitism exerted by *Trichoderma* spp. occurs in several successive stages. It begins with the chemotrophic growth of *Trichoderma* spp. towards the host, stimulated by molecules coming from the host, of an unknown nature. The only ones that have been detected so far are amino acids and sugars. The induction is not expected to be host-specific[43-45].

The antagonistic effect of *T. asperellum* strain T34 on *R. solani* of the second trial has been demonstrated. All treatments in which it inoculated the BCA managed to suppress the disease. Previous studies tested with *T. asperellum* strain T34 associated with some types of compost already showed positive results of *R. solani* on cucumber seedlings[26].

When counting populations of *T. asperellum* strain T34, it observed that the treatments with the highest presence of BCA are precisely those in which the pathogen is inoculated. One of the biocontrol mechanisms is competition. A good antagonist can overcome the fungistatic effect resulting from the presence of different metabolites produced by other species, including plants. The antagonist survives under adverse or competitive conditions[37]. Starvation is the most common cause of death for microorganisms, competition for limiting nutrients results in a biological control of phytopathogenic fungi, antagonists and mycoparasites[30].

CONCLUSION

Trichoderma asperellum strain T34 has an antagonism effect against *R. solani* in potato plants. The treatment that simulates the preventive and curative action presented positive results. The curative treatment was the best treatment tested in this study. Commercial *T. asperellum* strain T34 can be used as biocontrol in potato crops and can increase crop quality and productivity. This strain can be commercialized in development countries such as Ecuador as a good tool to prevent the use of agrochemical in potato cultivars.

SIGNIFICANCE STATEMENT

The present study evaluated for the first time the use of commercial strain BCA named *Trichoderma asperellum* strain T34 in the reduction of disease produced for *Rhizoctonia solani* using potato plants and fragment of potato plants in conditions controlled of laboratory.

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