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A New *Trichoderma Harzianum* Strain for Potato Disease Control: Biocontrol of *Alternaria solani* and Comparative Fungicide Sensitivity

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ABSTRACT

A newly isolated *Trichoderma* strain (TH1D), identified as *Trichoderma harzianum* through ITS sequencing, was evaluated for its biocontrol potential against *Alternaria solani*, the causal agent of potato early blight, under controlled growth chamber conditions. Before evaluating its efficacy on potato plants, the active substances oxathiapiprolin and amisulbrom, formulated in a commercial fungicide, were assessed in vitro against four major potato pathogens (*Alternaria solani, Fusarium solani, Rhizoctonia solani,* and *Sclerotinia minor*). The fungicide was incorporated into potato dextrose agar (PDA) at concentrations of 660, 1320, and 2640 ppm. The TH1D strain was subsequently evaluated in pots experiment comprising five treatments with three replications: untreated control (V1), the chemical fungicide (V2), foliar application of TH1D (V3), combined foliar and root application on an oat-based substrate (V4), and root application on a maize-based substrate (V5). Plants were artificially inoculated with *A. solani* following treatment. Ten days after inoculation with *A. solani*, the lowest disease severity was recorded in the fungicide treated plants and in the treatment receiving root application of TH1D on maize-based substrate. In contrast, foliar application alone and the combined foliar/root treatment resulted in higher disease severity. These results demonstrate that the efficacy of *T. harzianum* TH1D depends strongly on the application method, with root/substrate application providing substantially better disease suppression than foliar treatment under the conditions tested.

Keywords: *Trichoderma harzianum*, *Alternaria solani*, potato, oxathiapiprolin, amisulbrom.

List of Abbreviations: PDA - potato dextrose agar; SDW - sterile distilled water; ITS - internal transcribed spacer; ANOVA - analysis of variance; RH - relative humidity; UV - ultraviolet; ppm - parts per million; CRD - completely randomized design.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important non-cereal food crops worldwide, and its production is frequently constrained by fungal diseases. Among these, early blight, caused by *Alternaria solani* (Ellis & G. Martin) Sorauer, is one of the most widespread and virulent foliar diseases, reducing photosynthetically active leaf area and consequently decreasing tuber yield (Ivanović et al., 2022; Schmey et al., 2024).Conventional disease management relies mainly on synthetic fungicides (Rani et al., 2024); however, increasing concerns regarding the emergence of fungicide-resistant pathogen populations, environmental persistence and food safety have stimulated the search for sustainable biological alternatives (Cojanu et al., 2025).

Fungi of the genus *Trichoderma* are among the most extensively studied biocontrol agents in agriculture, acting through several complementary mechanisms, including mycoparasitism, antibiosis, competition for nutrients and space, and induction of localized and systemic resistance in the host plant (Mukherjee et al., 2022; Dutta et al., 2023; Poveda et al., 2024).

Several strains of *Trichoderma harzianum* have demonstrated antagonistic potential against *Alternaria* spp. in dual-culture assays and other experimental systems. Moreover, field studies have shown that *T. harzianum*, applied as a seed treatment and during vegetation in combination with integrated agroecological practices, can improve crop health and productivity (Petcu et al., 2023). However, relatively few studies have

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evaluated its effectiveness in suppressing early blight under conditions involving whole potato plants, where interactions among the host, pathogen, and biocontrol agent are considerably more complex (Ghazanfar et al., 2019; Metz and Hausladen, 2022).

Alongside biological approaches, chemical fungicides combining active substances with different, complementary modes of action are widely used to delay the development of fungicide resistance and to provide broad-spectrum protection against several economically important potato pathogens, including *Alternaria solani*, *Fusarium solani*, *Rhizoctonia solani* and *Sclerotinia minor*. Root or soil application of oxathiapiprolin-based fungicides, in particular, has been shown to provide prolonged systemic protection against foliar pathogens in several crops, including cucumber, tomato and basil (Cohen and Rubin, 2020).

The present study had two objectives. First, it evaluated the efficacy of a newly isolated *Trichoderma harzianum* strain (TH1D) applied by different methods - foliar spraying, root application using cereal-based substrates, and combined foliar and root application - in reducing the severity of *Alternaria solani* infection on potato plants grown under controlled environmental conditions, while also assessing its effect on mini-tuber production. Second, the study investigated the **in vitro** inhibitory activity of a commercial fungicide containing oxathiapiprolin and amisulbrom against the mycelial growth of four important potato fungal pathogens.

MATERIAL AND METHODS

Fungal strain isolation and molecular identification

The fungal strain used in this study was isolated from a colony that developed on the surface of a sterile peat-based substrate in pots previously used for raising tomato (*Solanum lycopersicum* L.) seedlings grown in conventional soil-based substrate (Figure 1A). The new colony obtained, designated TH1D, was purified by repeated subculturing on Potato Dextrose Agar (PDA) (Figure 1B) and maintained in Potato Dextrose (PD) liquid medium for genomic DNA extraction.

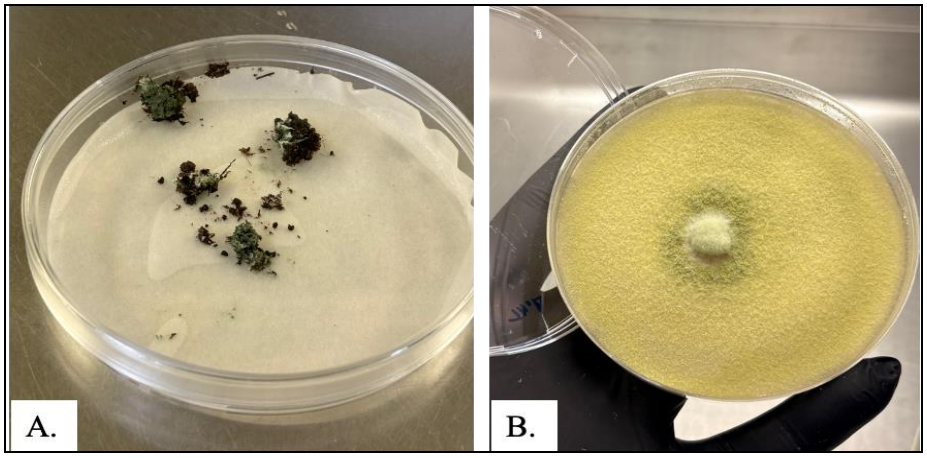

Figure 1. TH1D isolate: (A) fungal colonies observed on the surface of the sterile peat-based substrate, prior to purification; (B) purified culture on PDA medium.

The isolate phenotypic identification was performed with the BIOLOG GEN III Identification System, in addition to molecular identification by ITS sequencing. Molecular identification was performed by amplification and sequencing of the ITS region, using the universal fungal primers ITS1/ITS4 (White et al., 1990). The resulting ITS sequence was compared with reference sequences available in the GenBank database to determine the taxonomic identity of the isolate.

Plant material and tuber preparation

Potato tubers were surface-sterilized by immersion in 70% ethanol for 20 seconds,

followed by 4% sodium hypochlorite for 5 minutes, according to the method described by Chandana et al. (2022). Tubers were subsequently pre-sprouted for two weeks at 15°C until sprouts reached 1-2 cm in length.

Growth substrate preparation

The potting substrate consisted of a peat and compost mixture (0.8 kg peat: 0.35 kg compost). Resulting substrate was sterilized in autoclavable bags at 120°C and 1 bar for 30 minutes, followed by a second sterilization cycle 24 hours later to ensure complete elimination of contaminating microorganisms.

Mass production of the *Trichoderma* TH1D strain

The TH1D strain was propagated on three different organic substrates: oat flakes, wheat grain and maize grain. To each substrate bag (1 kilogram), 350 mL of sterile distilled water (SDW) was added, followed by sterilization at 120°C, 30 min, 1 bar. After cooling, substrates were inoculated with a fungal suspension obtained from fresh TH1D cultures grown on PDA (7 days, 25°C); 10 mL of spore suspension in SDW was distributed over each bag of substrate. Following 30 days of incubation, colonization and spore concentration were assessed for each substrate. A 4 g sample was taken from each colonized substrate and extracted in sterile distilled water (5 mL for maize and wheat; 10 mL for oat, which absorbed proportionally more liquid). The resulting suspensions were homogenized, and conidial concentrations were determined using a hemocytometer.

Pot experiment set-up and growth conditions

Pots were disinfected with 70% ethanol and exposed to UV radiation for 15 minutes.

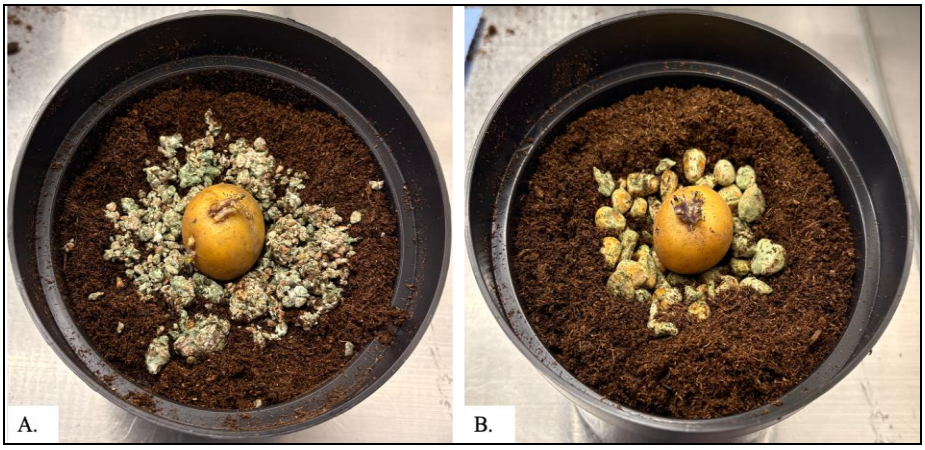

Figure 2. Pot set-up showing the tuber placed on *Trichoderma*-colonized substrate: (A) oat-based substrate; (B) maize-based substrate.

Plants were grown in a controlled environment growth chamber under a 16 h light / 8 h dark photoperiod, with 22°C (day) / 18°C (night) and 60% relative humidity. Each pot was received 100 mL of sterile distilled water every three days. Following artificial inoculation with *Alternaria solani*, the environmental conditionswere adjusted to 25°C and 90% relative humidity to promotedisease development.

Experimental design and treatments

The experiment was arranged in a completely randomized design (CRD) with three replications per treatment, resulting in five treatments (Table 1).

Table 1. Experimental treatments applied in the pot experiment.

Var.	Treatment	Method	Substrate
V1	Untreated control	—	—
V2	Chemical fungicide	Foliar spray	—
V3	*T. harzianum* TH1D	Foliar	—
V4	*T. harzianum* TH1D	Foliar+root	Oat
V5	*T. harzianum* TH1D	Root	Maize

For V3, a *T. harzianum* TH1D conidial suspension (2×10^6 conidia mL^{-1}) was applied to the leaves at a 7-day interval. For V2, the fungicide was applied according to the manufacturer's recommendations, seven days before pathogen inoculation.

Pathogen inoculation

Thirty-five days after planting, plants were artificially inoculated with an *Alternaria solani* spore suspension (1 x 10^6 spores/mL), obtained from cultures grown on Potato Dextrose Agar (PDA) (14 days, 24°C, in the dark) (Figure 3A). The conidial suspension was obtained by collecting surface mycelium, suspending it in sterile distilled water, and filtering through sterile gauze. Inoculation was performed by micro-puncture (4 punctures per leaf, on 3 leaves per plant), followed by application of the spore suspension at the wound sites (Figure 3B).

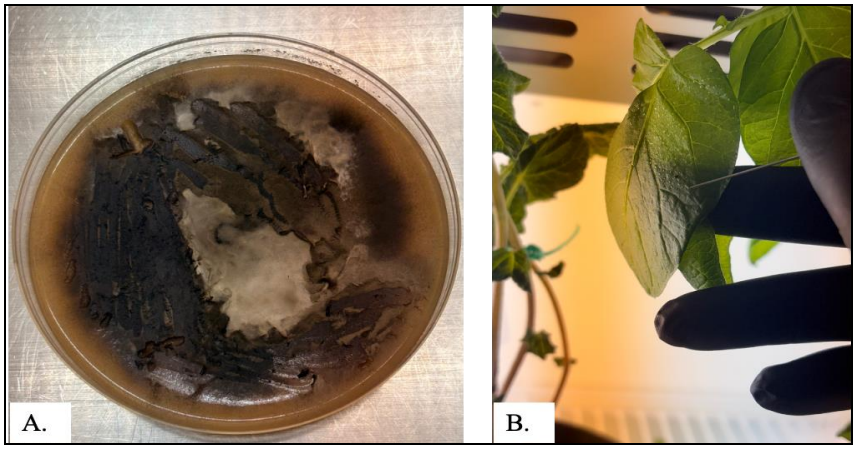

Figure 3. Alternaria solani inoculation procedure: (A) 14-day-old culture on PDA used for conidial suspension preparation; (B) micro-puncture inoculation of potato leaves.

Disease severity assessment

Ten days after inoculation, disease severity was scored using an ordinal scale from 1 to 5, based on symptom intensity (chlorosis, necrosis, lesion extension) adapted from Alfiky et al. (2024). For each replicate, the number of inffected leaves, estimated percentage of diseased leaf area, and number of lesions per leaf were also recorded.

At the end of the experiment (10 days after *Alternaria solani* inoculation), the plants were removed from the pots and mini-tubers were collected, counted, and measured by recording two perpendicular diameters for each tuber).

***In vitro* antifungal bioassay against four potato pathogens**

The commercial fungicide (oxathiapiprolin and amisulbrom) was tested *in vitro* against four fungal pathogens: *Alternaria solani* (isolated from potato leaves), *Fusarium solani* (isolated from eggplant), *Rhizoctonia solani* (isolated from potato) and *Sclerotinia minor* (isolated from potato). Fungal isolates were purified and maintained on PDA. Before the experiment, each isolate

wassubcultured and incubated at 24°C in darkness for seven days to obtain actively growing, homogeneous cultures.

The fungicide was incorporated into PDA medium (45 mL/Petri dish plates) to obtain final concentrations of 660 ppm, 1320 ppm and 2640 ppm. After the medium had solidified, a 6 mm mycelial discs cut from the actively growing colonies were placed centrally, mycelium-side down, on PDA plates (9 cm diameter), after which plates were incubated at 24°C in the dark. Three replicates were used per treatment. Mycelial growth was measured at 3, 5, 7 and 10 days after inoculation, as the mean of two perpendicular colony diameters. Percentage inhibition of mycelial growth was calculated as:

$$\% \text{ inhibition} = (C - T) / C \times 100$$

where C is the mean colony diameter of the untreated control, and T is the mean colony diameter of the treated variant.

Statistical analysis

For the *in vitro* fungicide bioassay, colony diamete was recorded individually for each of the three replicate plates per pathogen, concentration and observation day. These raw replicate values (not means) were analyzed by one-way ANOVA (concentration as factor) separately for each pathogen and observation day, followed by Tukey's HSD test ($p < 0.05$) for pairwise comparisons among concentrations, using Python (SciPy). Percentage inhibition of mycelial growth was calculated from the treatment and control means, as described above.

Disease severity data from the pot experiment (V1-V5) are presented as means ± standard deviation of three replicates per treatment. Given the limited replication (n = 3) and the multiple interacting factors inherent to the whole-plant system (application method, substrate type and timing of pathogen challenge), the data are presented and interpreted descriptively rather than subjected to formal inferential statistical testing. Accordingly, the emphasis is placed on identifying overarching trends and biologically meaningful patterns across treatments.

RESULTS AND DISCUSSION

Isolate identification

Phenotypic identification of the TH1D isolate using the BIOLOG GEN III Microbial Identification System did not allow reliable species identification, showing low-confidence similarity (SIM 0.003-0.005) to several *Trichoderma* species, including *Trichoderma viride* and *Trichoderma harzianum*. Molecular identification based on ITS sequencing subsequently confirmed the isolate as *Trichoderma harzianum*, showing 100% nucleotide identity and 92% query coverage (E-value = 0.0) to multiple GenBank *Trichoderma harzianum* accessions (top match: isolate G92, accession MW812030.1).

Substrate colonization

The three organic substrates differed in their capacity to support conidial production by *Trichoderma harzianum* TH1D after 30 days of incubation (Table 2). On a substrate-weight basis, the oat substrate produced the highest conidial concentration (9.25×10^7 conidia g^{-1}), followed by maize (5.90×10^7 conidia g^{-1}) and wheat (2.86×10^7 conidia g^{-1}).

Based on these results, the oat substrate, which yielded the highest conidial concentration, was selected for the combined foliar and root application treatment (V4). The maize substrate, which ranked second in conidial production, was included as an additional root application treatment (V5) to evaluate whether substrate type influenced the efficacy of *T. harzianum* under greenhouse conditions.

Table 2. Conidal production of *Trichoderma harzianum* TH1D on three organic substrates after 30 days of inoculation

Substrate	Conidia (mL^{-1})	Conidia (g^{-1} substrate)
Oat	3.7×10^7	9.25×10^7
Maize	4.7×10^7	5.90×10^7
Wheat	2.28×10^7	2.86×10^7

***In vitro* efficacy of oxathiapiprolin + amisulbrom against four potato pathogens**

Prior to its application as the positive chemical control in the pot trial, the commercial fungicide (oxathiapiprolin + amisulbrom) was evaluated in vitro against four potato pathogens to verify its efficacy under controlled conditions. One-way ANOVA confirmed a highly significant effect of fungicide concentration on mycelial growth for all four pathogens at day 10: *A. solani*: $F = 402.7$; *F. solani*: $F = 814.4$; *S. minor*: $F = 506.4$; all $p < 0.0001$) (Table 3).

Table 3. Mycelial growth (cm) of four potato pathogens and calculated inhibition (%) relative to the untreated control at different fungicide concentration and incubation time

Pathogen	Day	Control (cm)	660 ppm (cm / % inhib.)	1320 ppm (cm / % inhib.)	2640 ppm (cm / % inhib.)
A. solani	3	1.72	0.80 / 53.5%	0.75 / 56.4%	0.43 / 75.0%
A. solani	5	3.32	1.95 / 41.3%	1.73 / 47.9%	1.35 / 59.3%
A. solani	7	4.68	2.82 / 39.7%	2.50 / 46.6%	2.03 / 56.6%
A. solani	10	6.27 a	3.52 b / 43.9%	3.27 bc / 47.8%	2.78 d / 55.7%
F. solani	3	1.78	1.13 / 36.5%	0.85 / 52.2%	0.83 / 53.4%
F. solani	5	3.68	2.63 / 28.5%	2.02 / 45.1%	1.65 / 55.2%
F. solani	7	5.72	4.13 / 27.8%	3.28 / 42.7%	2.57 / 55.1%
F. solani	10	8.40 a	5.93 b / 29.4%	4.82 c / 42.6%	3.85 d / 54.2%
R. solani	3	8.40	5.77 / 31.3%	3.12 / 62.9%	2.63 / 68.7%
R. solani	5	8.40	8.40 / 0.0%	6.45 / 23.2%	4.52 / 46.2%
R. solani	7	8.40 a	8.40 a / 0.0%	8.40 a / 0.0%	5.62 b / 33.1%
R. solani	10	8.40	8.40 / 0.0%	8.40 / 0.0%	8.40 / 0.0%
S. minor	3	2.17	1.27 / 41.5%	0.73 / 66.4%	0.48 / 77.9%
S. minor	5	4.43	2.37 / 46.5%	1.53 / 65.5%	1.23 / 72.2%
S. minor	7	6.65	2.72 / 59.1%	2.22 / 66.6%	1.97 / 70.4%
S. minor	10	8.40 a	3.65 b / 56.5%	2.92 c / 65.2%	2.87 c / 65.8%

At this concentration range, *A. solani* showed no significant difference between 660 and 1320 ppm (Tukey HSD, $p = 0.19$), while all other pairwise comparisons were significant ($p < 0.05$). *F. solani*, by contrast, showed a fully dose-dependent response, with all three concentrations differing significantly from each other and from the control ($p < 0.0001$ for all comparisons) throughout the incubation period. *S. minor*, inhibition leveled off from 1320 ppm upward, as 1320 and 2640 ppm did not differ significantly from each other ($p = 0.99$). *R. solani* followed a markedly different pattern: colonies in the control, 660 ppm and 1320 ppm treatments had already reached the edge of the plate by day 7, leaving no residual variance among these groups by day 10, so ANOVA could not be performed at that time point. At day 7 ($F = 2145.3$, $p < 0.0001$), only 2640 ppm differed significantly from the other three treatments ($p < 0.0001$), confirming that the inhibitory effect on this pathogen was strong but only transient. Overall, *Alternaria solani* and *Fusarium solani* showed a clear, sustained dose-response relationship maintained through day 10; *Rhizoctonia solani* showed a strong inhibitory effect during the early stages of incubation; and *Sclerotinia minor* was the most consistently and strongly inhibited species, with inhibition remaining between 56-66% (Figure 4).

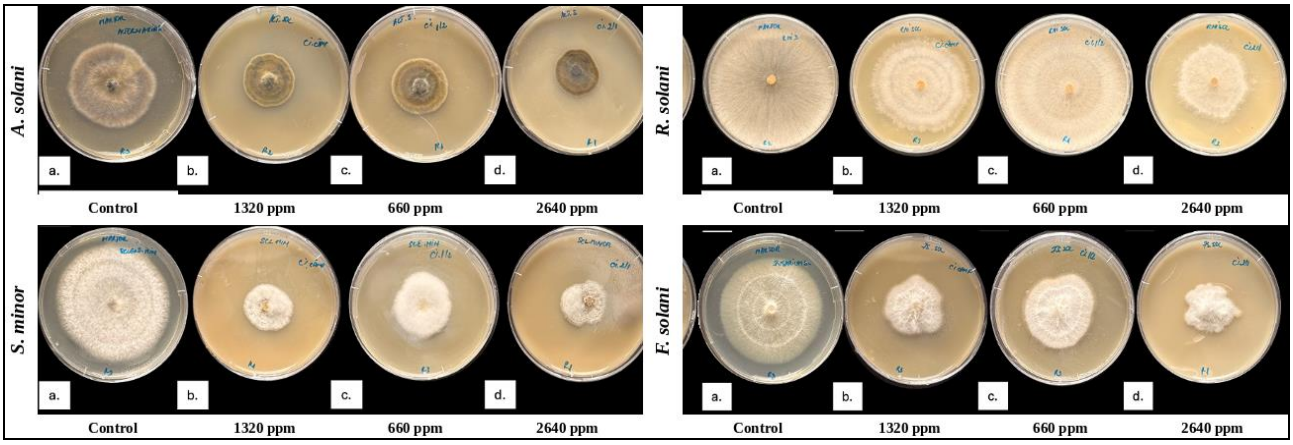

Figure 4. Colony growth of the four tested pathogens on PDA at the final observation time (day 10 for *Alternaria solani*, *Fusarium solani* and *Sclerotinia minor*; day 7 for *Rhizoctonia solani*).

Taken together, these results confirmed the fungicide as an effective, reproducible reference standard against *A. solani* in particular, supporting its selection as the chemical control treatment (V2) in the pot trial.

Effect of *Trichoderma* application method on *Alternaria solani* disease severity

Disease severity was assessed 10 days after *Alternaria solani* inoculation, based on the percentage of leaf area affected, the number of lesions per leaf, and an overall severity score (1-5 scale) (Table 4).

The untreated control (V1) showed a moderately high severity (mean score 2.67 ± 1.15), with 25-50% of leaf area affected and 2-7 lesions per leaf, reflecting the natural progression of infection in the absence of treatment. On the other hand, the chemical fungicide (V2) resulted in the lowest severity among all treatments (mean score 1.33 ± 0.58), with only 1-10% of leaf area affected and 1-3 lesions per leaf, consistent with its confirmed *in vitro* efficacy against *A. solani* (see above). Foliar application of TH1D (V3) did not reduce disease severity relative to the control (mean score 3.33 ± 0.58), with 25-75% of leaf area affected and numerous, often confluent lesions. The combined foliar and root treatment (V4) showed severity similar to V3 (mean score 3.33 ± 0.58), with 15-60% of leaf area affected; partial regeneration of apical tissue was observed in this variant, suggesting a limited effect of the root-applied component.

Table 4. Alternaria solani disease severity indicators recorded 10 days after inoculation, by treatment (n = 3 replicates per treatment)

Variant	Treatment	Leaf area affected (%)	Lesions/leaf	Severity score (mean ± SD)
V1	Untreated control	25-50%	2-7	2.67±1.15
V2	Chem. fungicide	1-10%	1-3	1.33±0.58
V3	Trich., foliar	25-75%	>5	3.33±0.58
V4	Trich., fol.+root (oat)	15-60%	3-5	3.33±0.58
V5	Trich., root (maize)	0-10%	0-2	1.17±0.29

The lowest severity among the biological treatments - comparable to the chemical fungicide - was recorded in V5 (TH1D applied at the root on a maize-based substrate; mean score 1.17 ± 0.29), with 0-10% of leaf area affected and 0-2 lesions per leaf (Figure 5).

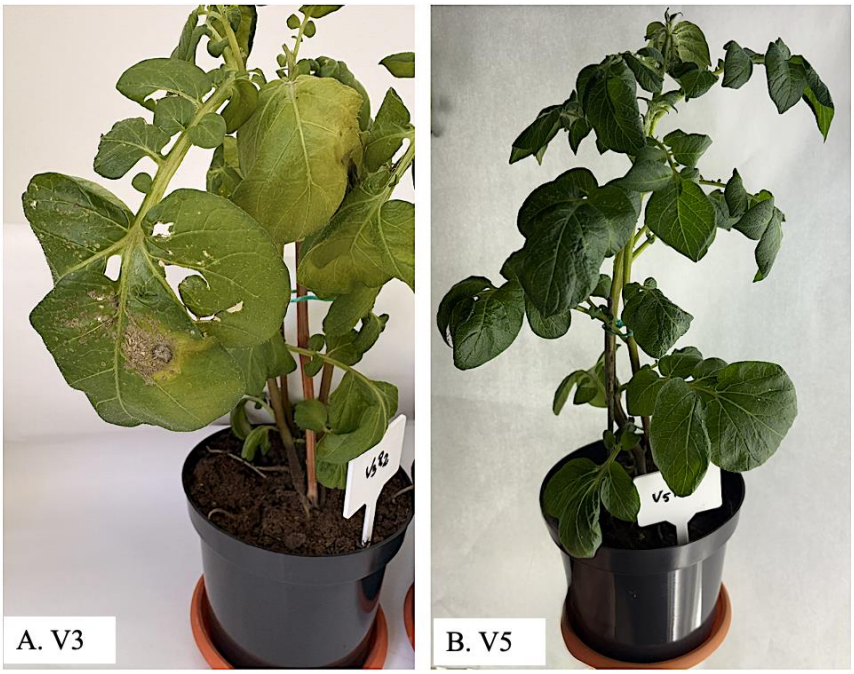

Figure 5. Alternaria solani symptom severity on potato plants 10 days after inoculation: (A) V3 (foliar TH1D application); (B) V5 (TH1D applied at the root, maize-based substrate).

Mini-tuber production

Mini-tubers were harvested at the end of the experiment, immediately after the evaluation of *Alternaria solani* symptoms on potato plants. The number and size of mini-tubers produced per plant differed among treatments (Table 5).

Table 5. Number and diameter of mini-tubers formed per plant, by treatment (n = 3 replicates per treatment)

Variant	Treatment	Mean tubers/plant ± SD	Mean diameter (mm) ± SD
V1	Untreated control	0.67±1.15	10.54±5.58
V2	Chem. fungicide	4.33±1.15	15.07±6.41
V3	*Trichoderma* foliar application	4.67±1.15	18.57±6.18
V4	*Trichoderma*foliar+root application (oat substrate)	1.33±1.53	9.54±1.75
V5	*Trichoderma* root application (maize substrate)	4.67±1.15	16.07±3.34

The untreated control (V1) produced the lowest number of mini-tuber (0.67 ± 1.15 tubers/plant), with only one of three replicates producing mini-tubers. The combined foliar and root treatment (V4) also showed low production (1.33 ± 1.53 tubers/plant). The chemical fungicide (V2), the foliar (V3) and root-applied (V5) *Trichoderma* treatments resulted in comparable, higher and more consistent numbers of mini-tubers per plant (4.33-4.67 tubers/plant, SD 1.15 in all three), with V3 showing the largest mean tuber diameter (18.57 ± 6.18 mm), followed by V5 (16.07 ± 3.34 mm). The results demonstrate that the efficacy of *Trichoderma harzianum* TH1D against *Alternaria solani* in potato is strongly dependent on the method and site of application, rather than being an application-independent property of the strain. Foliar application (V3) failed to reduce disease severity relative to the untreated control, most likely due to limited colonization of the leaf surface and insufficient direct interaction with the pathogen at the infection site. In contrast, root/substrate application (V5) resulted in the lowest disease severity among all treatments, comparable to the chemical

fungicide, suggesting that rhizosphere-mediated interactions - whether through induced systemic resistance, competition, or both - are more effective in this pathosystem than direct foliar antagonism. This is consistent with previous reports indicating that *Trichoderma*-mediated protection against *Alternaria* pathogens is more readily achieved through root or substrate-based delivery than through direct foliar application (Metz and Hausladen, 2022).

The combined treatment (V4) showed only a modest improvement over foliar application alone. Although both variants involved root application, V4 utilized an oat-based substrate, whereas V5 relied on a maize-based matrix. This points to a broader pattern observed throughout the study: the carrier material used for *Trichoderma* multiplication appears to influence not only disease suppression, but also mini-tuber production. Although the oat-based substrate yielded the highest spore concentration during the multiplication phase, it was the maize-based substrate that produced the strongest disease-suppressive effect in plants (V5), while the oat-based treatment (V4) performed poorly both in disease control and in mini-tuber number, remaining close to the untreated control on both counts. This double underperformance of the oat-based substrate - despite its superior spore yield *in vitro* - indicates that spore concentration at the multiplication stage is not predictive of in vivo biocontrol or growth-promoting performance, and suggests that the carrier itself (through differences in nutrient availability, water retention, or physical structure) may actively interfere with effective root colonization or rhizosphere activity of the fungus once introduced into the potting substrate.

The results obtained with the chemical fungicide further emphasize the importance of pathogen-specific sensitivity in integrated disease management strategies. While Sclerotinia minor and Alternaria solani showed strong and persistent sensitivity to oxathiapiprolin + amisulbrom under **in vitro** conditions, Rhizoctonia solani exhibited only temporary growth suppression, with colonies recovering by the end of the incubation period. These differences indicate that fungicide performance may vary considerably among pathogens and support the integration of chemical and biological approaches for broader and more sustainable disease management.

CONCLUSIONS

A new *Trichoderma* strain (TH1D) was isolated and identified as *Trichoderma harzianum* by ITS sequencing (100% nucleotide identity to reference GenBank sequences). *In vitro*, the tested fungicide (oxathiapiprolin + amisulbrom) showed concentration-dependent inhibition of all four pathogens, though efficacy was pathogen-dependent — strong against *Sclerotinia minor* and *Alternaria solani*, moderate against *Fusarium solani*, and only brief against *Rhizoctonia solani*.

Application method strongly determined TH1D's efficacy against *Alternaria solani* in potato: root application on a maize-based substrate (V5) gave the lowest disease severity, comparable to the fungicide, while foliar application did not protect the plants. This pattern extended to mini-tuber production, where V5 matched the best-performing treatments with the least variability, whereas the oat-based combined treatment (V4) underperformed on both measures - despite oat yielding the highest spore concentration during multiplication, showing that spore concentration alone does not predict in vivo performance.

These results demonstrate that the root application of *Trichoderma harzianum* TH1D on a maize-based substrate holds significant promise as a core biological component within an Integrated Pest Management (IPM) framework against potato early blight. Being an indigenous strain isolated in Romania, TH1D represents a promising candidate for development into a commercial bioproduct due to its presumed adaptation to local ecosystems. By incorporating a bio-based strategy, growers can potentially reduce

reliance on conventional synthetic treatments. Furthermore, combining this targeted biological intervention with specific fungicide applications - systematically guided by pathogen sensitivity profiles - proves to be a robust, dual-action approach. This not only enhances disease control efficacy but also mitigates the risk of pathogens developing resistance to chemical active ingredients.

ACKNOWLEDGEMENTS

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