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Biological control potential of Trichoderma asperelloides LBF 04/04 and Trichoderma koningiopsis LBF 48/11 against potato common scab caused by Streptomyces scabiei

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Short Report

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Abstract

Potato common scab is difficult to manage under field conditions, creating a need for biological options that retain activity beyond in vitro screening. We evaluated two native isolates, *Trichoderma asperelloides* LBF 04/04 and *Trichoderma koningiopsis* LBF 48/11, against phytopathogenic *Streptomyces*using a 12-strain dual-culture screen followed by a greenhouse assay and two field trials with *Streptomyces scabiei*IBSBF 2950 on potato cv. Agata. Tuber fresh weight and number of tubers were also quantified. Both isolates showed antagonistic activity against all tested strains, although LBF 48/11 had the stronger mean *in vitro* score. In the greenhouse, however, LBF 04/04 was more effective, decreasing mean scab-affected tuber surface by 54.6% and lesion-type severity by 30.6% relative to the pathogen control. Field performance was site dependent. LBF 04/04 significantly decreased affected tuber surface by 15.0% at Santo Antônio de Posse, whereas at Mococa the 29.1% lower mean was not statistically significant. Thus, in vitro ranking did not predict in planta performance, and LBF 04/04 emerged as the most consistent candidate for further validation within integrated common-scab management.

Full Text

Potato common scab is a persistent soilborne disease that reduces tuber quality and marketability and remains difficult to manage consistently because disease expression depends on pathogen populations, soil conditions, cultivar susceptibility, and crop management (Corrêa et al. 2015; Braun et al. 2017; Destéfano et al. 2021; Vitor et al. 2023; Destéfano et al. 2026). Biological control is therefore attractive as a component of integrated management, and *Trichoderma*-based treatments have shown activity against common scab either alone or in microbial combinations (Wang et al. 2019; Porto et al. 2022; Haq et al. 2025). Here, two native *Trichoderma* isolates were evaluated sequentially from broad in vitro screening to greenhouse and field assays to determine whether direct antagonism predicted disease suppression in planta and whether treatments affected yield-related variables.

Trichoderma asperelloides LBF 04/04 and *T. koningiopsis* LBF 48/11 were obtained from the Coleção de Fungos Fitopatogênicos do Instituto Biológico - Micoteca "Mário Barreto Figueiredo"; species identities followed the collection records. Fungal isolates were grown on potato dextrose agar at 28°C for three days. The initial screen comprised 12 phytopathogenic *Streptomyces* strains from the Coleção de Culturas de Fitobactérias do Instituto Biológico (IBSBF): *S. scabiei* IBSBF 2049 and IBSBF 2950, *S. brasiliscabiei* IBSBF 2959, *S. caviscabiei* IBSBF 2051, *S. europaeiscabiei* IBSBF 2023, *S. turgidiscabies* IBSBF 2114, *S. reticuliscabiei* IBSBF 2086, and *Streptomyces* spp. IBSBF 3010, 2968, 2949, 2805, and 2394. *Streptomyces* cultures were grown on yeast malt extract agar at 28°C for seven to 14 days.

For each pathogen-antagonist combination, a *Streptomyces* agar disc and a *Trichoderma* mycelial disc were placed on opposite sides of the same Petri dish. Five replicate plates were used per combination and evaluated after seven and 14 days. Antagonism was scored with a seven-class plate-occupation scale ranging from 1, antagonist occupying the entire plate, to 7, pathogen reaching the antagonist inoculation side; lower values indicated stronger antagonistic activity.

For the greenhouse assay, *S. scabiei* IBSBF 2950, a highly aggressive Brazilian potato isolate, was used as the pathogen model. Potato cv. Agata was planted and challenged following the potato-scab inoculation procedure used by Corrêa et al. (2021). Suspensions of LBF 04/04 and LBF 48/11 were applied at 1×10^8 conidia mL^{-1}. A commercial *T. harzianum*-based product, Ecotrich®, applied at 0.25 kg ha^{-1}, was included as a biological comparator. The experiment was completely randomized with seven pots per treatment and one plant per pot. Tubers were harvested after plant senescence, approximately 100–120 days after planting. Mean affected tuber surface was estimated using the diagrammatic classes 0, 0.1, 10, 25, and 50% described by James (1971), and lesion phenotype was scored from 0 to 5, from no lesions to deep lesions, following Wanner (2007). Tuber fresh weight and number of tubers were quantified for each treatment.

Two independent field trials were conducted with potato cv. Agata and *S. scabiei* IBSBF 2950, one at the BASF Experimental Station in Santo Antônio de Posse and the other at the UPD/IAC experimental area in Mococa, São Paulo State, Brazil. Both trials followed the same plot arrangement: each replicate was a 1.5-m^2 plot containing eight seed tubers, and four plots were used per treatment, totaling 32 plants per treatment. Rows were spaced approximately 70 cm apart and plants 25 cm apart. The pathogen inoculum was distributed in the planting furrow before tuber placement. LBF 04/04 and LBF 48/11 were applied at 1×10^8 conidia mL^{-1}; the Santo Antônio de Posse trial also included Ecotrich® at the manufacturer-recommended rate. Disease, fresh tuber yield, and number of tubers were evaluated at harvest. Each greenhouse and field experiment was analyzed separately, with the pot or field plot as the experimental unit; treatment means were compared within experiments using Tukey's test at $P < 0.05$.

Both native *Trichoderma* isolates antagonized every *Streptomyces* strain included in the *in vitro* screen, with scores ranging from 1.0 to 4.0 (Table 1). *T. koningiopsis* LBF 48/11 showed the stronger overall *in vitro* performance, with a mean score of 1.65, compared with 1.95 for *T. asperelloides* LBF 04/04. Maximum antagonism, score 1.0, was recorded for both isolates against *S. reticuliscabiei* IBSBF 2086 and *S. turgidiscabies* IBSBF 2114. Conversely, *S. scabiei* IBSBF 2950, the isolate subsequently used *in planta*, was the least susceptible target, with mean scores of 4.0 for LBF 04/04 and 3.4 for LBF 48/11. The pathogen selected for greenhouse and field validation therefore represented a comparatively stringent target rather than an isolate selected for high *in vitro* susceptibility.

Table 1
In vitro antagonism of native *Trichoderma* isolates against phytopathogenic *Streptomyces* strains in dual-culture confrontation assays.

***Streptomyces* strain**	**LBF 04/04 score**	**Group**	**LBF 48/11 score**	**Group**
IBSBF 2950	4.0	a	3.4	a
IBSBF 2049	3.4	a	3.2	a
IBSBF 2394	2.2	b	1.6	bc
IBSBF 2051	2.0	bc	1.2	bc
IBSBF 2968	2.0	bc	2.0	b
IBSBF 3010	1.8	bcd	1.6	bc
IBSBF 2959	1.8	bcd	1.2	bc
IBSBF 2805	1.6	bcd	1.2	bc
IBSBF 2949	1.4	bcd	1.0	c
IBSBF 2023	1.2	cd	1.4	bc
IBSBF 2086	1.0	d	1.0	c
IBSBF 2114	1.0	d	1.0	c
Mean score	**1.95**	**-**	**1.65**	**-**

Values are mean scores from five replicate plates evaluated at seven and 14 days. Lower scores indicate stronger antagonism. Means followed by the same letter within each isolate do not differ by Tukey's test at $P < 0.05$. T, type strain.

The ranking changed under greenhouse conditions. The pathogen-inoculated control had 19.94% mean affected tuber surface and a lesion-type severity score of 3.37 (Table 2). *T. asperelloides* LBF 04/04 reduced these values to 9.05% and 2.34, corresponding to decreases of 54.6% and 30.6%, respectively. *T. koningiopsis* LBF 48/11 reduced affected surface to 13.11%, a 34.3% decrease, and lesion-type severity to 2.75, an 18.4% decrease. Ecotrich® produced 12.02% affected surface and a severity score of 2.34, equivalent to decreases of 39.7% and 30.6%. The non-inoculated control remained symptomless, and representative tubers illustrate the reduction in visible scab associated with LBF 04/04 (Fig. 2).

Growth-related measurements showed that the biological treatments also affected plant performance (Table 2). In the absence of the pathogen, LBF 04/04 produced the highest fresh tuber weight, 358.5 g pot^{-1}, followed by LBF 48/11, 316.2 g pot^{-1}. Under pathogen challenge, LBF 48/11 produced the highest number of tubers, 57, compared with 39 tubers in the pathogen-inoculated control. These data indicate that responses to the native isolates were not limited to symptom suppression, although growth and yield responses depended on the isolate and on pathogen presence.

Table 2
Greenhouse suppression of potato common scab and growth-related responses in potato cv. Agata challenged with *Streptomyces scabiei* IBSBF 2950.

Treatment	Mean affected tuber surface (%)	Lesion-type severity score (0–5)	Fresh tuber weight (g pot^{-1})	Nº. of tubers
S. scabiei IBSBF 2950	19.94 a	3.37 a	188.1 d	39 c
S. scabiei IBSBF 2950 + LBF 04/04	9.05 c	2.34 c	262.8 c	40 c
S. scabiei IBSBF 2950 + LBF 48/11	13.11 b	2.75 b	293.71 bc	57 a
S. scabiei IBSBF 2950 + Ecotrich®	12.02 b	2.34 c	246.8 c	39 c
Non-inoculated control	0 d	0 d	275.4 c	46 b
LBF 04/04	-	-	358.5 a	46 b
LBF 48/11	-	-	316.2 b	47 b
Ecotrich®	-	-	285.84 bc	37 c

Values are treatment means from seven pots. Means followed by the same letter within a column do not differ by Tukey's test at $P < 0.05$. Dashes indicate variables not assessed for treatments without pathogen inoculation.

Field responses were more modest and depended on site (Fig. 3; Table 3). At Santo Antônio de Posse, LBF 04/04 reduced mean affected tuber surface from 4.13% in the pathogen control to 3.51%, a 15.0% decrease that was significant at $P < 0.05$. LBF 48/11 and Ecotrich® produced lower numerical means, 3.83 and 3.79%, respectively, but neither differed significantly from the pathogen control. Lesion-type severity remained essentially unchanged among pathogen-inoculated treatments, ranging from 1.89 to 1.92. Fresh yield increased from 25.8 t ha^{-1} in the pathogen control to 28.5, 29.2, and 29.2 t ha^{-1} for LBF 04/04, LBF 48/11, and Ecotrich®, respectively, but remained below the non-inoculated control.

At Mococa, mean affected tuber surface was 29.1% lower with LBF 04/04, 4.62 versus 6.52%, and 17.9% lower with LBF 48/11, 5.35 versus 6.52%, but both treatments shared statistical groups with the pathogen control. Lesion-type severity was not reduced at this site and was numerically higher in both *Trichoderma* treatments. Yield differences were less pronounced than at Santo Antônio de Posse, but pathogen-challenged plots treated with LBF 04/04 or LBF 48/11 had slightly higher fresh yield than the pathogen control. The number of tubers increased from 244 in the pathogen control to 328 with LBF 04/04 and 296 with LBF 48/11. The field data therefore support partial, environment-dependent suppression mainly expressed as reduced affected tuber surface rather than uniform reduction of lesion severity.

Table 3
Field performance of native *Trichoderma* isolates against potato common scab and yield-related responses at two locations in São Paulo State, Brazil.

Site	Treatment	Mean affected tuber surface (%)	Lesion-type severity score (0–5)	Fresh tuber yield (t ha^{-1})	N°. of tubers
Santo Antônio de Posse	*S. scabiei* IBSBF 2950	4.13 a	1.89 a	25.8 c	235 b
	S. scabiei IBSBF 2950 + LBF 04/04	3.51 b	1.92 a	28.5 b	264 b
	S. scabiei IBSBF 2950 + LBF 48/11	3.83 ab	1.92 a	29.2 b	264 b
	S. scabiei IBSBF 2950 + Ecotrich®	3.79 ab	1.89 a	29.2 b	306 a
	Non-inoculated control	0 c	0 b	33.4 a	325 a
Mococa	*S. scabiei* IBSBF 2950	6.52 ab	1.70 ab	12.1 ab	244 d
	S. scabiei IBSBF 2950 + LBF 04/04	4.62 abc	2.26 a	12.60 ab	328 abc
	S. scabiei IBSBF 2950 + LBF 48/11	5.35 abc	2.40 a	12.94 ab	296 abcd
	Non-inoculated control	0 d	0 d	13.43 ab	292 abcd

Each treatment comprised four 1.5-m^2 field plots with eight seed tubers per plot. Means followed by the same letter within a column and site do not differ by Tukey's test at $P < 0.05$. Ecotrich® was included only at Santo Antônio de Posse. For Mococa, letters are retained from the original full analysis.

The most informative feature of this study is the reversal between the in vitro and *in planta* rankings. LBF 48/11 had the strongest average direct antagonism in dual culture, whereas LBF 04/04 consistently provided the larger disease reduction in the greenhouse and the clearest field response. Direct confrontation assays capture competition under a simplified nutrient-rich environment but do not measure establishment in soil, persistence near developing tubers, interaction with the potato host, or activity under local physicochemical conditions. These processes are known to contribute to the biological performance of *Trichoderma* spp. (Harman et al. 2004; Shoresh et al. 2010; Hermosa et al. 2012), but they were not directly measured here and should not be inferred as confirmed mechanisms.

The growth- and yield-related results add a second layer to the interpretation. In the greenhouse, LBF 04/04 increased tuber fresh weight when applied without the pathogen, whereas LBF 48/11 increased tuber number under pathogen pressure. In the field, biological treatments generally improved fresh yield

relative to the pathogen control at Santo Antônio de Posse and produced small numerical increases at Mococa. These responses are consistent with previous reports that *Trichoderma*-containing microbial treatments can suppress potato common scab and, in some systems, improve crop performance (Wang et al. 2019; Porto et al. 2022; Haq et al. 2025). However, the variable field response, especially for lesion-type severity, indicates that these isolates should be considered as complementary tools rather than stand-alone control measures.

Overall, *T. asperelloides* LBF 04/04 was the most consistent candidate across experimental scales. Its strong greenhouse effect, significant reduction at one field site, numerical reduction at the second site, and associated yield-related responses justify further evaluation of formulation, application timing, soil persistence, and performance across additional cultivars and production environments as part of integrated common-scab management.

Declarations

Conflict of interests:

The authors declare no conflict of interest.

Ethics approval:

Not applicable.

Funding:

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Author contributions:

LV and SALD conceived the study and interpreted the results. AAT, LV, MFT, ETL, MPA conducted the experiments and compiled the data. RH contributed to fungal isolate identification and revised the manuscript. LV drafted the manuscript. MFT, MPA and SALD revised the manuscript. All authors read and approved the final manuscript.

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Data availability:

The data generated and analyzed during this study are available from the corresponding author on reasonable request.

References

1. Braun, S., Gevens, A., Charkowski, A., Allen, C., & Jansky, S. (2017). Potato common scab: a review of the causal pathogens, management practices, varietal resistance screening methods, and host resistance. *American Journal Of Potato Research*, *94*, 283–296. https://doi.org/10.1007/s12230-017-9575-3
2. Corrêa, D. B. A., Salomão, D., Rodrigues-Neto, J., Harakava, R., & Destéfano, S. A. L. (2015). Application of PCR-RFLP technique to species identification and phylogenetic analysis of *Streptomyces* associated with potato scab in Brazil based on partial *atpD* gene sequences. *European Journal Of Plant Pathology*, *142*, 1–12. https://doi.org/10.1007/s10658-014-0584-5
3. Corrêa, D. B. A., do Amaral, D. T., da Silva, M. J., & Destéfano, S. A. L. (2021). *Streptomyces brasiliscabiei* sp. nov., a new pathogenic species associated with potato common scab in Brazil. *Antonie van Leeuwenhoek*, *114*, 913–931. https://doi.org/10.1007/s10482-021-01566-y
4. Destéfano, S. A. L., Vitor, L., Corrêa, D. B. A., Tomaseto, A. A., & Monteiro, R. P. S. (2021). *Streptomyces* spp. associadas à sarna da batata. *Revisão Anual de Patologia de Plantas*, *27*, 91–117. https://doi.org/10.31976/0104-038321v270005
5. Destéfano, S. A. L., Vitor, L., Amaral, D. T., Ferreira-Tonin, M., Chuahy, D. S., & Corrêa, D. B. A. (2026). Occurrence and distribution of Streptomyces species causing potato scab in Brazil – characterization of two new species Streptomyces pococaldensis sp. nov. and Streptomyces shimoyamaii sp. nov. *Trop Plant Pathol*, *51*, 76. https://doi.org/10.1007/s40858-026-00857-x
6. Haq, I. U., Munir, M., Qadir, S., Ahmad, M., Ikram, A., Asif, M., Mukhtar, Z., Mubeen, F., Akhtar, M., & Qureshi, I. A. (2025). Suppression of common scab disease in potato via application of antagonistic *Trichoderma harzianum* and *Bacillus subtilis*. *Journal Of Plant Diseases And Protection*, *132*, 126. https://doi.org/10.1007/s41348-025-01123-z
7. Harman, G. E., Howell, C. R., Viterbo, A., Chet, I., & Lorito, M. (2004). *Trichoderma* species - opportunistic, avirulent plant symbionts. *Nature Reviews Microbiology*, *2*, 43–56. https://doi.org/10.1038/nrmicro797
8. Hermosa, R., Viterbo, A., Chet, I., & Monte, E. (2012). Plant-beneficial effects of *Trichoderma* and of its genes. *Microbiology*, *158*, 17–25. https://doi.org/10.1099/mic.0.052274-0

9. James, W. C. (1971). An illustrated series of assessment keys for plant diseases, their preparation and usage. *Can Plant Dis Surv*, *51*, 39–65.
10. Porto, J. S., Rebouças, T. N. H., José, A. R. S., José, A. R. S., Destéfano, S. A. L., & Vargas, A. A. L. (2022). Antagonist species to *Streptomyces* sp. that causes common potato scab. *Braz Arch Biol Technol*, *65*, e22210059. https://doi.org/10.1590/1678-4324-2022210059
11. Shoresh, M., Harman, G. E., & Mastouri, F. (2010). Induced systemic resistance and plant responses to fungal biocontrol agents. *Annual Review Of Phytopathology*, *48*, 21–43. https://doi.org/10.1146/annurev-phyto-073009-114450
12. Vitor, L., Amaral, D. T., Corrêa, D. B. A., Ferreira-Tonin, M., Lucon, E. T., Appy, M. P., Tomaseto, A. A., & Destéfano, S. A. L. (2023). *Streptomyces hilarionis* sp. nov. and *Streptomyces hayashii* sp. nov., two novel species associated with potato common scab in Brazil. *Int J Syst Evol Microbiol*, *73*, 005916. https://doi.org/10.1099/ijsem.0.005916
13. Wang, Z., Li, Y., Zhuang, L., Yu, Y., Liu, J., Zhang, L., Gao, Z., Wu, Y., Gao, W., Ding, G. C., & Wang, Q. (2019). A rhizosphere-derived consortium of *Bacillus subtilis* and *Trichoderma harzianum* suppresses common scab of potato and increases yield. *Comput Struct Biotechnol J*, *17*, 645–653. https://doi.org/10.1016/j.csbj.2019.05.003
14. Wanner, L. A. (2007). A new strain of *Streptomyces* causing common scab in potato. *Plant Disease*, *91*, 352–359. https://doi.org/10.1094/PDIS-91-4-0352

Figures

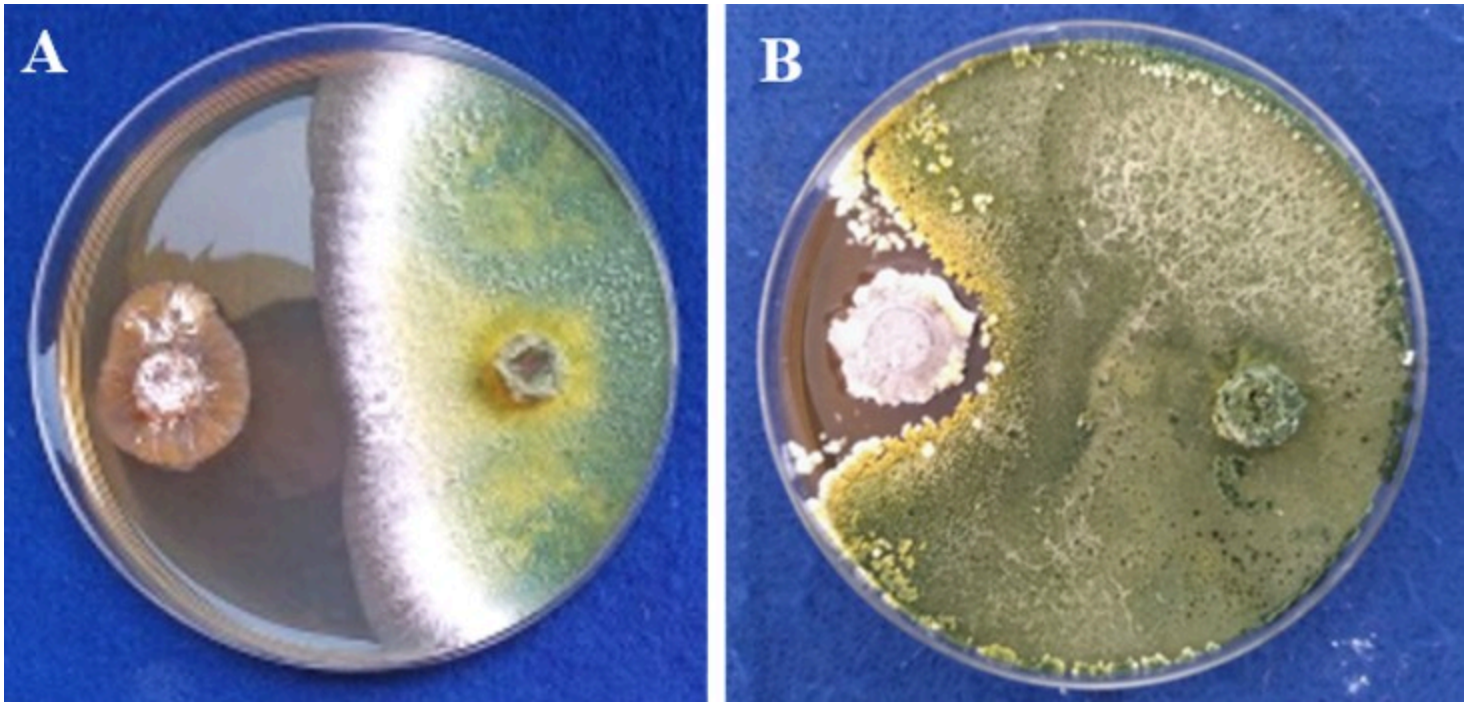

Figure 1

Dual-culture confrontation assay. **A.** *Streptomyces europaeiscabiei* IBSBF 2023 confronted with *Trichoderma koningiopsis* LBF 48/11 after seven days of incubation; **B.** same interaction after 14 days.



Figure 2

Representative potato cv. Agata tubers from the greenhouse assay after challenge with *Streptomyces scabiei* IBSBF 2950. **A.** pathogen-inoculated control; **B.** IBSBF 2950 + *Trichoderma asperelloides* LBF 04/04.

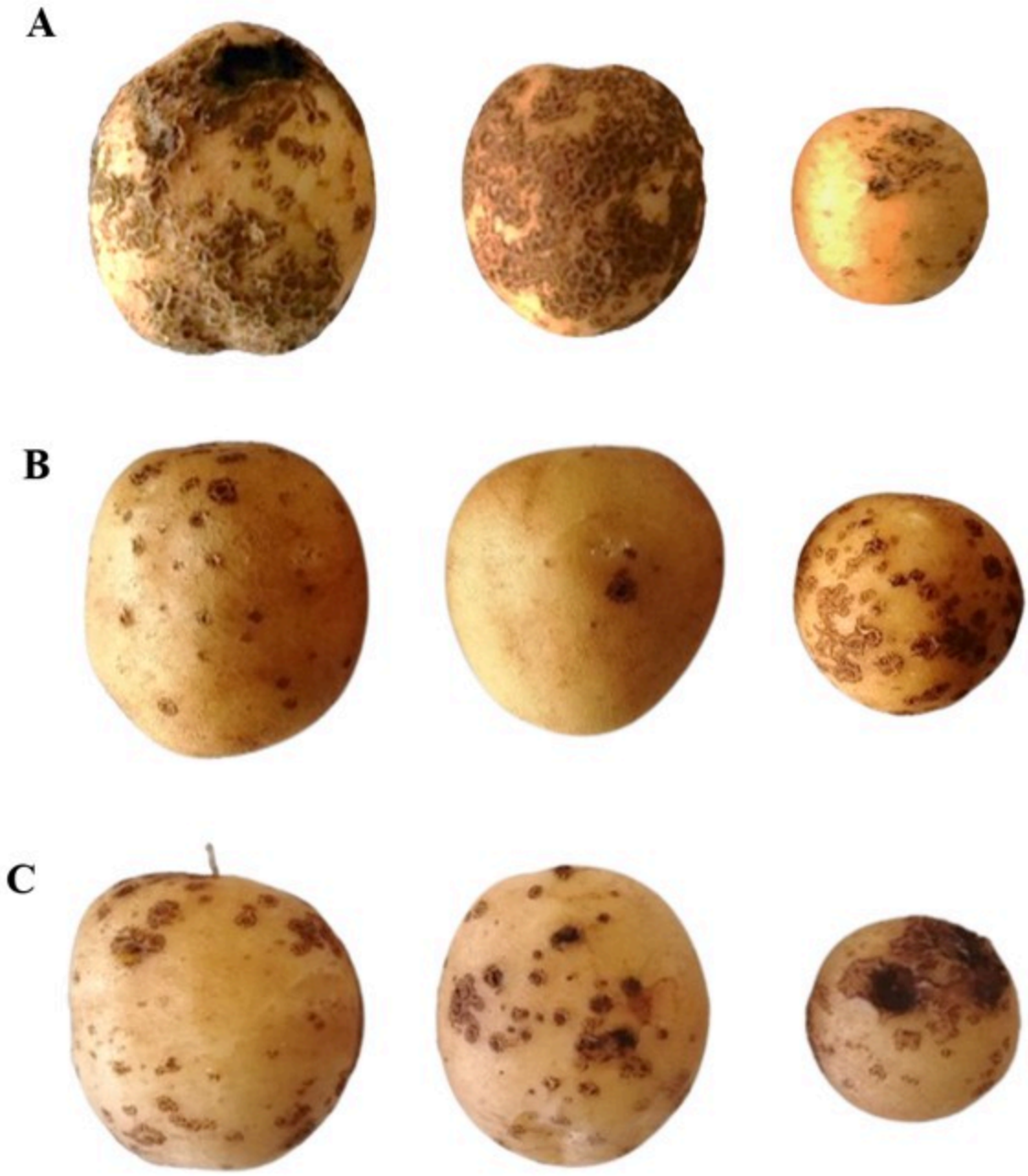

Figure 3

Representative potato cv. Agata tubers from the Santo Antônio de Posse field trial after inoculation with *Streptomyces scabiei* IBSBF 2950. **A.** pathogen-inoculated control; **B.** IBSBF 2950 + *Trichoderma asperelloides* LBF 04/04; **C.** IBSBF 2950 + *Trichoderma koningiopsis* LBF 48/11.