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ANTIFUNGAL ACTIVITY OF FOUR *TRICHODERMA* SPECIES AGAINST *PHYTOPHTHORA MEGAKARYA*, THE CAUSAL AGENT OF COCOA POD BROWN ROT IN CÔTE D'IVOIRE

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Aim. In Côte d'Ivoire, cocoa pod brown rot caused by *Phytophthora megakarya* represents a major constraint to sustainable cocoa production due to the severe yield losses it induces. This study aimed to evaluate the antifungal activity of four *Trichoderma species* (*T. harzianum*, *T. asperellum*, *T. virens* and *T. hamatum*) against *P. megakarya* under *in vitro* and *in vivo* conditions using detached cocoa pods. **Methods.** *In vitro* assays were conducted using a dual culture technique on PDA medium to assess the inhibition of mycelial growth of the pathogen. *In vivo* tests consisted of preventive treatments followed by aggressive and non-aggressive inoculations on healthy cocoa pods. **Results.** The *in vitro* results showed a significant inhibition of *P. megakarya* mycelial growth by all *Trichoderma* species, with inhibition rates ranging from 77.27% to 89.27%. *Trichoderma virens* exhibited the highest antagonistic activity. Under *in vivo* conditions, *T. virens* and *T. harzianum* significantly reduced the severity and spread of cocoa pod brown rot, with inhibition rates exceeding 80% depending on the inoculation method. **Conclusions.** The *in vitro* and *in vivo* assays showed that all tested species exert a significant inhibitory effect on the development of the pathogen, although the efficacy varies according to the *Trichoderma* species. Among the evaluated species, *Trichoderma virens* stood out for its strongest ability to inhibit the mycelial growth of *P. megakarya* and for a marked reduction in disease severity on cocoa pods under both aggressive and mild inoculation conditions. These results confirm the strong potential of *Trichoderma species*, particularly *T. virens*, as effective biocontrol agents against *P. megakarya* and support their integration into sustainable management strategies for cocoa pod brown rot, however, further field studies are necessary.

Keywords: biocontrol; cocoa tree; *Phytophthora megakarya*; brown rot; *Trichoderma* spp.

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INTRODUCTION

The Cocoa tree (*Theobroma cacao* L.) is a perennial species native to humid tropical forests and belongs to the family Malvaceae (Jean-Marie et al., 2022). It is primarily cultivated for its beans, which constitute an essential raw material used in the food, cosmetic, pharmaceutical, and confectionery industries (Amari et al., 2025). Globally, cocoa production was approximately 5.87 million tonnes, with a significant share coming from West Africa, particularly Côte d'Ivoire and Ghana (FAOSTAT, 2023).

Despite its socio-economic importance, cocoa production is strongly limited by various biotic and abiotic constraints. Among the biotic constraints, fungal diseases are one of the main factors reducing yields. Black pod disease, caused by species of the genus *Phytophthora*, is one of the most destructive diseases affecting Ivorian cocoa (Coulibaly et al., 2013). The species *Phytophthora palmivora* and *Phytophthora megakarya* are recognized as the main agents responsible for this disease in cocoa-producing areas. *Phytophthora palmivora* has a wide geographic distribution and infects several cocoa organs, while *Phytophthora megakarya* has been more aggressive since its discovery in West Africa. Yield losses associated with these pathogens can reach 20 to 60%, depending on climatic conditions and cultural practices, while also affecting the commercial quality of the beans (Coulibaly et al., 2013).

Control of this disease has become a national priority in Côte d'Ivoire. Management of black pod disease mainly relies on the use of chemical fungicides. However, the intensive and repeated use of these products has negative impacts on the environment and human health and promotes the emergence of resistant pathogen strains (O'Donovan et al., 2020). Given these limitations, the development of alternative control methods, notably biological control using antagonistic fungi, is increasingly recommended (Mpika et al., 2009).

In this context, fungi of the genus *Trichoderma* are widely studied as biological control agents for managing plant pathogenic diseases. In *Trichoderma* species, various mechanisms of action, such as mycoparasitism, competition, antibiosis, and the induction of systemic and local resistances, have been identified for the biocontrol of a broad range of plant pathogens (Sood et al., 2020). These fungi have demonstrated their effectiveness against several cocoa pathogens, including species of the genus *Phytophthora* (Mpika et al., 2009; Amari et al., 2025).

Although the efficacy of certain *Trichoderma* strains against *Phytophthora megakarya* has been reported in some regions, notably in Nigeria (Adedeji et al., 2008), agroecological differences, genetic variability of pathogen populations, and varietal and cultural specificities justify the need to evaluate these biological agents under cocoa production conditions in Côte d'Ivoire, the world's leading cocoa producer.

This study aimed to evaluate the *in vitro* and *in vivo* efficacy of *Trichoderma* on detached cocoa pods against *Phytophthora megakarya*, the causative agent of black pod disease, under controlled conditions.

MATERIALS AND METHODS

Fungal material. The pathogenic agent *Phytophthora megakarya* was isolated from cocoa pods showing the typical symptoms of brown rot. Molecular identification of the isolate was performed, and the isolate was designated under the code NAB6_CI_2024. The corresponding sequence was deposited in the GenBank database under accession number PQ157645.1 on August 14, 2024 (N'Guessan et al., 2025a).

Four *Trichoderma* species (*Trichoderma harzianum*, *T. asperellum*, *T. virens*, and *T. hamatum*), isolated from the cocoa tree rhizosphere, were provided by the Plant Health Laboratory of Nangui Abrogoua University. The *Trichoderma* strains were maintained on PDA medium at 24°C and periodically subcultured to preserve their viability. These strains were used for antifungal assays. Molecular identification of these isolates, performed by Yao et al. (2023), yielded the following GenBank accession numbers: OL604510, MT529846, MN102106, and KC403955.

Genomic DNA from the fungal strains was extracted according to the method described by Umesha et al. (2016), based on the CTAB buffer extraction protocol. The polymerase chain reaction (PCR) assay was carried out using ITS rDNA primers. According to Gonzalez-Mendoza et al. (2008), the PCR amplification reaction was performed using the ITS1 F (TCCGTAGGTGAACCTGCGG) and ITS4 R (TCCTCCGCTTATTGATATGC) primer set. Amplification was conducted in 0.2 mL tubes with a reaction mixture containing 2.5 μL of 80–100 ng of genomic DNA, 1 μL of 20 pmol of each primer, and 20 μL of Dream Taq Green PCR Master Mix (containing 0.25 mM of each dNTP, 2 mM $MgCl_2$, and Taq DNA polymerase) purchased from Thermo Scientific, India.

PCR was performed in a master gradient thermal cycler (USA) under the following conditions: initial denaturation at 94°C for 5 min; 30 cycles of 1 min denaturation at 94°C, 1 min annealing at 52°C, 1 min initial extension at 72°C, followed by a final extension of 10 min at 72°C, and cooling at 4°C until the samples were retrieved. The amplified PCR amplicons were confirmed by gel electrophoresis using 1% agarose gel.

The PCR products were sequenced by Macrogen Europe B.V., a laboratory specialized in genomic sequencing and molecular biology services located in the Netherlands. The obtained sequences were then compared with reference sequences available in molecular databases using the BLAST tool, and species identification was confirmed based on a similarity threshold of ≥ 99%.

Preparation of PDA culture medium. The Potato Dextrose Agar (PDA) medium was used for the cultivation of fungal strains following the procedure described by Amadi and Moneke (2012). Three hundred grams of sliced *Solanum tuberosum* tubers (washed but not peeled) were boiled in distilled water for 30 minutes, then filtered and adjusted to a final volume of 1 L. Subsequently, 20 g of dextrose and 20 g of agar were added, and the mixture was sterilized at 121°C for 15 minutes. After cooling to approximately 20°C, 1 g/L of citric acid was added to adjust the pH to 5.5 before dispensing into Petri dishes.

Evaluation of the antifungal activity of four *Trichoderma* species against *P. megakarya*. Mycelial growth of *P. megakarya* and *Trichoderma* species. A mycelial disc of 3 mm in diameter, taken from 7-day-old cultures grown on PDA medium, was placed at the centre of each Petri dish along two perpendicular axes marked on the underside of the plate. For each fungal strain, four replicates were used, giving a total of 16 Petri dishes. The plates were incubated in the dark at 25 ± 1°C for 7 days. Mycelial colony diameters were measured daily until complete colonization of the Petri dishes. The mean daily mycelial growth diameter (D_m) was calculated according to the formulas described by Hendricks et al. (2017) and Dianda et al. (2023):

$$D_m\left(cm/j\right)=\frac{\sum D_j \times n_i}{N}, \quad (1)$$

where:
$$Dj\left(cm/j\right)=\frac{d_1+d_2}{2}; \quad (2);$$

D_m — mean daily diameter of mycelial growth; $\sum D_j$ — sum of the daily diameters of mycelial colonies; n_i — number of days; N — number of replicates; D_j — daily diameter; d_1 — diameter of the fungal colony along axis 1; d_2 — diameter of the fungal colony along axis 2.

The mean mycelial growth rate (V_m) of each fungal strain was calculated using the formula according to Oliveira (1991) and Oliveira et al. (2022):

$$V_m\left(cm/day\right)=\frac{\sum\left(D-D_a\right)}{N}, \quad (3)$$

where: V_m — mycelial growth rate; D — mean daily colony diameter; D_a — mean colony diameter on the previous day; N — number of days after inoculation.

Evaluation of the antagonistic activity of *Trichoderma* species against *P. megakarya*. The antagonistic activity of the four *Trichoderma* species was evaluated using the dual culture assay on PDA medium (Bogumił et al., 2013). A 6-mm-diameter mycelial disc of *Phytophthora megakarya* and a mycelial disc of *Trichoderma*, both obtained from 7-day-old cultures, were placed on the same Petri dish containing PDA medium. The discs were positioned diametrically opposite to each other at a distance of 4.25 cm from the centre of the Petri dish. For each confrontation, three Petri dishes were used, and the experiment was repeated three times. Control plates consisted of *P. megakarya* cultures grown alone on PDA medium. All plates were incubated at 25 ± 1°C, and mycelial growth diameters were measured daily until complete colonization of the control plates. The percentage inhibition of mycelial growth was determined using the formula given by Pakora et al (2018):

$$I\left(\%\right)=\frac{C-C_n}{C}\times 100, \quad (4)$$

where: I (%) — percentage of inhibition of mycelial growth; C — mean diameter of mycelial growth of colonies in control plates; C_n — mean diameter of *P. megakarya* growth in the presence of *Trichoderma*.

EVALUATION OF THE EFFECT OF *TRICHODERMA* SPECIES ON DETACHED COCOA PODS *IN VIVO*

Preparation of cocoa pods.

Twenty (20) mature, unripe and apparently healthy cocoa pods, one day after harvest, were collected from the field. The pods were placed in transparent sterile bags and transported to the laboratory for experimentation. They were surface-sterilized by immersion in a 3% sodium hypochlorite solution for 2 minutes, followed by three successive rinses with tap water. The pods were then placed on sterile filter paper for 5 minutes under a laminar flow hood to remove excess moisture.

Preparation of spore suspensions of *Trichoderma* spp. and *Phytophthora megakarya*.

Aggressive inoculation of cocoa pods. Two superficial wounds of approximately 5 mm in depth, diametrically opposite and spaced 4.5 cm apart, were made on the epicarp of each cocoa pod using a punch according to the method of N'Guessan et al. (2025b). The pods were then separately sprayed with *Trichoderma* spore suspensions at a concentration of 10^6 spores mL^{-1}. Three hours after spraying, a

6-mm-diameter mycelial disc of *P. megakarya*, obtained from a 14-day-old culture grown on PDA medium, was placed into each wound.

Two types of controls were included:

- a positive control consisting of pods inoculated only with *P. megakarya*, without prior treatment with *Trichoderma*;
- a negative control consisting of pods treated only with PDA medium, without inoculation with *P. megakarya* and without prior treatment with *Trichoderma*.
- a negative control consisting of wounded pods treated only with a *Trichoderma* suspension, without pathogen inoculation.

Each treatment was replicated three times.

Non-aggressive Inoculation of cocoa pods. The non-aggressive inoculation was performed following the method of Rubiyo et al. (2008). On the epicarp of each cocoa pod, two circular areas of 8 mm in diameter were delineated at the peduncular and distal ends, and an 8 mm diameter PDA disc containing actively growing *Phytophthora megakarya* mycelium was placed directly on the surface of the fruit.

The pods were sprayed with *Trichoderma* spore suspensions at a concentration of 10^6 spores mL^{-1}. Three hours after treatment, cotton pads soaked in a *Phytophthora megakarya* spore suspension were placed on the marked areas and secured with adhesive tape.

Three types of controls were included in the experiment:

1. Positive control: pods inoculated only with *P. megakarya*, without prior *Trichoderma* treatment.
2. Negative control 1: pods not inoculated, sprayed only with PDA medium, without *Trichoderma* or pathogen.
3. Negative control 2: pods treated only with the *Trichoderma* suspension, without *P. megakarya* inoculation.

Each treatment, including the controls, was replicated three times. The pods were placed in transparent plastic containers, separated according to the *Trichoderma* species and inoculation type, and incubated in the dark at 25°C for 10–15 days.

After 5 days of incubation, lesion diameters were measured to assess the effect of the treatments on the development of cocoa pod brown rot.

Statistical analysis. All data collected were subjected to statistical analyses using RStudio software (version 4.3.0). Mean values were compared using one-way analysis of variance (one-way ANOVA). When the assumptions of normality were not met, the non-parametric Kruskal–Wallis test was applied. Student's t-test was also used for specific pairwise comparisons. When significant differences were detected at the 5% probability level ($p < 0.05$), Fisher's least significant difference (LSD) test was applied to separate the means and identify the most effective treatments.

RESULTS

1. *In vitro* antifungal activity of *Trichoderma* species against *Phytophthora megakarya.*

Dual culture assays conducted on PDA medium showed that all *Trichoderma* species exhibited faster mycelial growth than *Phytophthora megakarya*. The rapid growth of *Trichoderma* spp. resulted in a significant reduction of *P. megakarya* mycelial development. During the confrontation, the colonies of both organisms continued to grow until contact, forming a distinct interaction zone, demonstrating that the observed effect was due to competition for nutrients and space **(Fig. 1)**. The inhibition rates of *P. megakarya* mycelial growth ranged from 77.27% to 89.27%, depending on the *Trichoderma* species tested **(Fig. 2)**. The highest inhibition rate (89.27%) was observed for *Trichoderma* virens. Statistical analysis revealed a significant difference among the mean inhibition rates induced by the different *Trichoderma* species ($p < 0.05$). T. harzianum, *T. hamatum*, and *T. asperellum* exhibited respective inhibition rates of 77.27%, 78.68%, and 81.96%.

2. *In vivo* effect of *Trichoderma* species against *Phytophthora megakarya* under preventive control on detached cocoa pods.

2.1. *Aggressive inoculation*. After seven days of incubation, all *Trichoderma* species tested (*T. asperellum*, *T. harzianum*, *T. hamatum* and *T. virens*) reduced the mean lesion diameter caused by *P. megakarya* compared with the untreated control. This reduction resulted in limited development of brown rot symptoms on the inoculated cocoa pods. Inhibition rates ranged from 32.07% to 81.17% depending on the *Trichoderma* species used **(Fig. 3)**. *Trichoderma virens* and *T. harzianum* showed the highest inhibition rates, with mean values of 81.17% and 75.06%, respectively. In contrast, *T. asperellum* and *T. hama-*

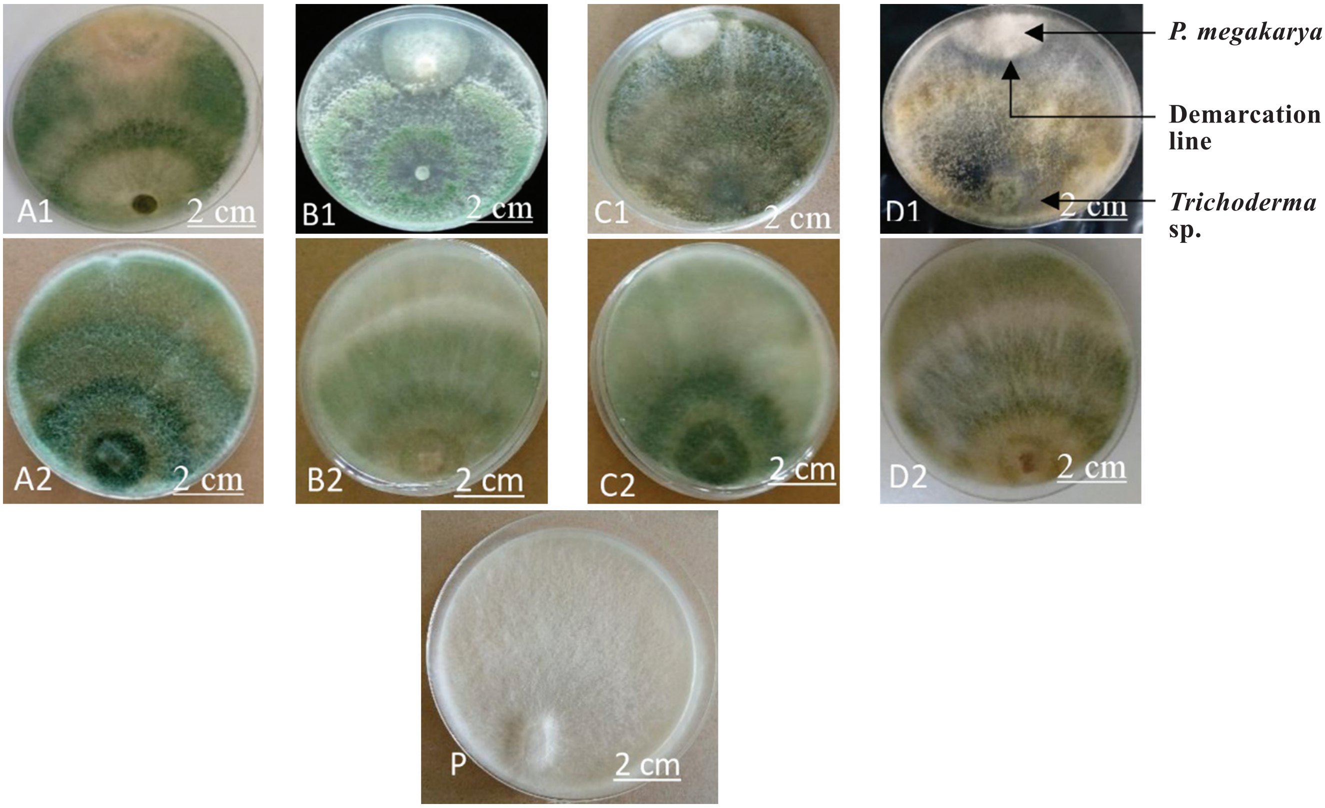

Fig. 1. Mycelial colony morphology of *Trichoderma* spp. and *Phytophthora megakarya* after 7 days of dual culture on PDA medium: A1 — *Trichoderma virens*; A2 — *Trichoderma virens* control; B1 — *Trichoderma harzianum*; B2 — *Trichoderma harzianum* control; C1 — *Trichoderma hamatum*; C2 — *Trichoderma hamatum* control; D1 — *Trichoderma asperellum*; D2 — *Trichoderma asperellum* control; P — *Phytophthora megakarya* grown on PDA medium

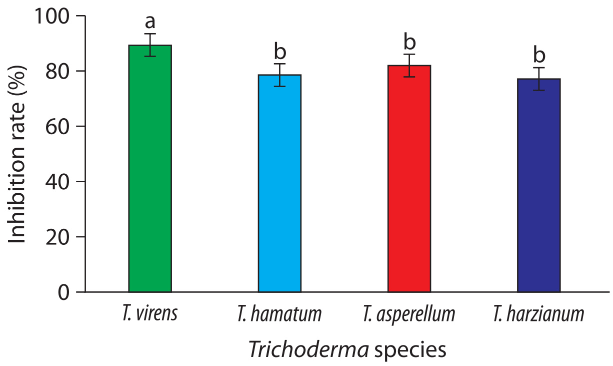

Fig. 2. Inhibitory effect on the mycelial growth of *Phytophthora megakarya* by *Trichoderma* species after 7 days of dual culture.

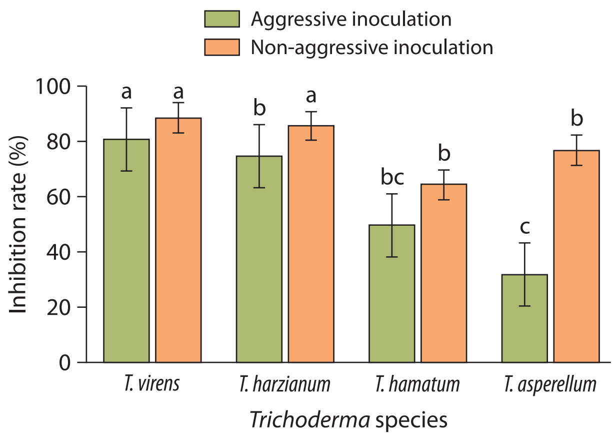

Fig. 3. Inhibitory effect on the mycelial growth of *Phytophthora megakarya* by *Trichoderma* species after aggressive and non-aggressive inoculation on detached cocoa pods. Bars sharing the same letter are not significantly different at the 5% significance level ($p < 0.05$)

tum exhibited lower inhibition rates of 32.07% and 49.95%, respectively. Statistical analysis revealed a significant difference among treatments ($p = 0.001$).

2.2. *Non-aggressive inoculation.* Under non-aggressive inoculation conditions, *Trichoderma* species also reduced lesion development caused by *P. megakarya* after ten days of incubation compared with the control. The observed inhibition rates ranged from 60.07% to 88.95% depending on the species tested (Fig. 3). *Trichoderma asperellum*, *T. harzianum* and *T. virens* showed high inhibition rates, with mean values of 79.08%, 86.10% and 87.45%, respectively. In contrast, *T. hamatum* recorded the lowest inhibition rate (66.61%). Statistical analyses indicated a significant difference among treatments.

DISCUSSION

The antagonistic activities of *Trichoderma* species against *Phytophthora megakarya* were evaluated *in vitro* through the analysis of the observed competitive mycelial growth with direct confrontation. The results revealed a significant reduction in the colony diameter of *P. megakarya* in the presence of all *Trichoderma* isolates, reflecting their competitive potential. This competitive activity could be attributed to the ability of *Trichoderma* species to 1) faster growth rate; 2) synthesis of a wide range of secondary metabolites with antifungal activity, including antibiotics and other bioactive compounds toxic to phytopathogenic agents. These compounds are believed to disrupt the physiological and structural mechanisms of the pathogen, thereby inhibiting its growth and development. According to Tchameni et al. (2017), these mechanisms are often associated with strong competition for nutrients and space, leading to enhanced suppression of phytopathogenic fungal growth. The results of the present study are consistent with the observations of Saddek et al. (2020), who reported significant inhibition of Fusarium spp. mycelial growth by *Trichoderma* in dual culture assays.

Among the species tested, *Trichoderma virens* exhibited superior efficacy under both *in vitro* and *in vivo* conditions. This performance may be related to the synergistic action of multiple mechanisms, particularly mycoparasitism, characterized by the coiling of *Trichoderma hyphae* around those of the pathogen, followed by penetration of the cell wall through hydrolytic enzymes such as chitinases and glucanases (Mukherjee et al., 2022; Kumari et al., 2025). In addition, *T. virens* is known to produce various antifungal secondary metabolites and to exhibit strong competitive ability for nutrients and space, resulting in direct or indirect toxic effects on pathogenic fungi. These results are in line with the findings of Adedeji et al. (2008) and Amari et al. (2025), who highlighted the strong biocontrol potential of a number of undetermined *Trichoderma* spp. against *P. megakarya*. The strong inhibitory capacity of *Trichoderma* species against *Phytophthora* spp., combined with the significant reduction of disease symptoms observed on cocoa pods, underscores their relevance as potential effective biocontrol agents for cocoa pod brown rot. Moreover, our results also match those reported by Youassi et al. (2024), who demonstrated the effectiveness of *Trichoderma* extracts in reducing the progression of cocoa pod brown rot while promoting the activation of host plant defense mechanisms.

Chóez-Guaranda et al. (2023) demonstrated variable antifungal activity of *Trichoderma* extracts against different cocoa pathogens, confirming the influence of both species and formulation on biocontrol efficacy.

In vivo results further indicated that preventive treatments based on *Trichoderma* species were particularly effective in reducing the severity of cocoa pod brown rot. This enhanced efficacy may be attributed not only to direct competitive mechanisms observed *in-vitro*, but also to antagonism *in vivo* and the induction of systemic resistance in the host plant (Yao et al., 2023). Similar reductions in mycelial growth and tissue susceptibility of *P. palmivora* after treatment with *Trichoderma* isolates were reported by Yao et al. (2023), who conducted *in vitro* and *in vivo* confrontation assays between *P. palmivora* and three *Trichoderma* isolates. According to Yao et al. (2023), the *Trichoderma* species exhibited significant antagonistic activity against *P. palmivora*, with inhibition rates ranging from 65% to 87.5% on detached pods and from 75% to 88.7% on culture medium. According to Amari et al. (2025), applications of these spore- and extract-based biofungicides significantly reduced the development of cocoa pod brown rot, with average reduction rates of 68.68% for the spore-based treatment and 38.81% for the extract-based treatment, compared to the untreated control under field conditions. Under laboratory conditions, cocoa pods treated with *Trichoderma* spp. spores after inoculation with *Phytophthora palmivora* showed no symptoms of black pod rot. According to Sriwati et al. (2019), the superior *in vivo* performance of *T. virens* reduced both the infection rate and disease intensity on the treated cocoa pods by 40,61 and 38,02%. Overall, the use of *Trichoderma*-based formulations fits well within a sustainable agriculture framework, as it contributes to reducing reliance on chemical fungicides, which pose increasing risks to the environment, human health and promote the emergence of resistant pathogen populations (Harman et al., 2021). However, despite the promising results obtained in this study, further investigations under field conditions are required to assess strain persistence, interactions with soil microbiota and the influence of environmental factors on biocontrol efficacy.

CONCLUSION

The present study evaluated the antifungal activity of four *Trichoderma* species (*T. harzianum*, *T. asperellum*, *T. virens* and *T. hamatum*) against *Phytophthora megakarya*, the causal agent of cocoa pod brown rot. Both *in vitro* and *in vivo* assays demonstrated that all tested *Trichoderma* species exerted inhibitory effects (77.27% to 89.27%) on pathogen development, although their efficacy varied among species.

Among the evaluated species, *Trichoderma virens* showed the highest capacity to inhibit the mycelial growth of *P. megakarya* and reduced (85,06%) disease severity on cocoa pods under both aggressive and non-aggressive inoculation conditions. *Trichoderma harzianum* also exhibited promising performance, confirming its potential as a biological control agent. These findings highlight the possible relevance of *Trichoderma* species as effective and sustainable biocontrol agents against cocoa pod brown rot. Their use could contribute to reducing dependence on synthetic fungicides and promoting environmentally friendly cocoa production in Côte d'Ivoire. Nevertheless, additional field trials are necessary to validate the large-scale effectiveness of these strains and to assess their stability and persistence within cocoa agroecosystems.

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Conflict of interests. The authors declare the absence of any conflicts of interests.

Adherence to ethical principles. This article does not contain results of any studies, involving humans and animals, conducted by any of the authors.

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АНТИФУНГАЛЬНА АКТИВНІСТЬ ЧОТИРЬОХ ВИДІВ ГРИБІВ *TRICHODERMA* ПРОТИ *PHYTOPHTHORA MEGAKARYA* — ЗБУДНИКА БУРОЇ ГНИЛІ ПЛОДІВ КАКАО В КОТ-Д'ІВУАРІ

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Мета. У Кот-д'Івуарі бура гниль плодів какао, спричинена грибами *Phytophthora megakarya*, є серйозною перешкодою для сталого виробництва какао через значні втрати врожаю, які вона викликає. Метою цього дослідження було оцінити протигрибкову активність чотирьох видів грибів *Trichoderma* (*T. harzianum*, *T. asperellum*, *T. virens* та *T. hamatum*) проти *P. megakarya* в умовах *in vitro* та *in vivo* з використанням відокремлених плодів какао. **Методи.** Дослідження *in vitro* проводили з використанням техніки подвійної культури на середовищі PDA для оцінки інгібування росту міцелію збудника. Дослідження *in vivo* передбачали профілактичну обробку, після якої проводили агресивні та неагресивні інокуляції на здорові плоди какао. **Результати.** Результати *in vitro* показали значне інгібування росту міцелію *P. megakarya* всіма видами грибів *Trichoderma*, причому показники інгібування коливалися від 77,27% до 89,27%. Найвищу антагоністичну активність проявив *Trichoderma virens*. У умовах *in vivo T. virens* та *T. harzianum* значно зменшили тяжкість та поширення бурої гнилі плодів какао, причому показники інгібування перевищували 80% залежно від методу інокуляції. **Висновки.** Дослідження *in vitro* та *in vivo* показали, що всі випробувані види грибів чинять значний інгібуючий вплив на розвиток збудника, хоча ефективність залежить від конкретного виду *Trichoderma*. Серед оцінених видів грибів *Trichoderma virens* виділився найсильнішою здатністю пригнічувати ріст міцелію *P. megakarya* та значним зниженням тяжкості захворювання на плодах какао як за умов інтенсивного, так і помірного зараження. Ці результати підтверджують значний потенціал видів грибів *Trichoderma*, зокрема *T. virens*, як ефективних засобів біологічного контролю проти *P. megakarya* та обґрунтовують їхнє включення до стратегій сталого управління щодо боротьби з бурою гниллю плодів какао, однак потрібні подальші польові дослідження.

Ключові слова: біологічний контроль; дерево какао; *Phytophthora megakarya*; бура гниль; *Trichoderma* spp.