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Assessment of the Biological Efficacy of Biopesticides (Plantsain and Fertisain) Against Dieback of Mango in Burkina Faso

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Abstract

Dieback of Mango, primarily caused by *Lasiodiplodia theobromae*, poses a significant threat to mango production in Burkina Faso. This study evaluated the efficacy of biological and chemical treatments in controlling dieback and promoting tree recovery. Field trials were conducted in Koloko and Léo provinces across three mango orchards exhibiting varying disease incidences. Symptomatic tissues were collected for pathogen isolation and molecular confirmation via PCR, validating the presence of *L. theobromae*. Three biopesticide treatments (Plantsain, Fertisain, and their combination) were compared with a chemical reference (Azox + Manga Plus) and an untreated control, using a randomized complete block design with six replicates per treatment. Results indicated that Plantsain achieved the highest branch regeneration, with rates of 72.72% in Koloko and 60.49% in Léo, compared to 7.03% and 8.92% in untreated controls. Both disease incidence and severity decreased significantly with treatment, displaying a dose-dependent response. The combined Plantsain + Fertisain treatment at dose of 2 L/ha each also demonstrated high efficacy, comparable to the chemical Azox. These outcomes suggest that biopesticides not only significantly reduce the incidence and severity of the disease, the infection rate of *L. theobromae*, but can also promote the physiological regeneration of affected tissues. In conclusion, biological control strategies, taken individually or in combination, constitute sustainable and effective alternatives to chemical fungicides for the management of dieback in Burkina Faso.

Keywords: *L. theobromae*; Biopesticide; Mango dieback; Burkina Faso

1. Introduction

The mango tree (*Mangifera indica* L.) is one of the most important fruit trees in tropical and subtropical regions worldwide. In Burkina Faso, the mango sector represents a major economic activity, involving numerous producers and stakeholders along the value chain. In 2016, its added value was estimated at 30 billion FCFA, accounting for 0.5% of the national Gross Domestic Product (GDP) and providing approximately 27,800 direct jobs [1]. Despite these encouraging figures, the sector faces significant phytosanitary challenges, including mango dieback, a disease responsible for high tree mortality and substantial yield losses, potentially leading to the complete destruction of orchards. The disease is characterized by partial or total wilting of branches or the entire tree. The fungal species *L. theobromae* has been identified as the primary pathogen causing mango dieback in Burkina Faso [2].This fungus has also been reported in several other countries, including the United Arab Emirates, Peru, and Korea [3], [4], [5], as well as in West and North Africa, including Niger, Egypt, Ghana, and Togo [6], [7], [8]. In the context of climate change, this disease poses an increased threat to mango production in Burkina Faso, affecting numerous producers and other stakeholders who depend on mango cultivation and its derived products. In Burkina Faso, combinations of synthetic

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fungicides such as Nativo and Manga Plus, combined fertilizers and good agricultural practices have been used to recover mango trees affected by dieback [9]. While these control measures are effective, they have limitations related to pathogen resistance, environmental pollution, and potential risks to human health. The present study therefore aims to contribute to improved management of mango dieback through the application of sustainable, environmentally friendly biological compounds.

2. Material and methods

2.1. Experimental sites

The trials were established in two regions of Burkina Faso, namely Koloko and Léo. A total of three (3) orchards were selected across these localities. These sites are located in the provinces of Kénédougou and Sissili, respectively (Fig. 1). The Kénédougou province has a Sudano-Sahelian climate and contributes approximately 75% of the national fruit production [10]. Annual rainfall in this region ranges from 900 to 1,200 mm. In contrast, the Sissili province is located in the North Sudanian zone, with an annual rainfall ranging from 700 to 900 mm [11]. These provinces were selected due to their reported average incidences of mango dieback, ranging from 42.8% to 86% [2].

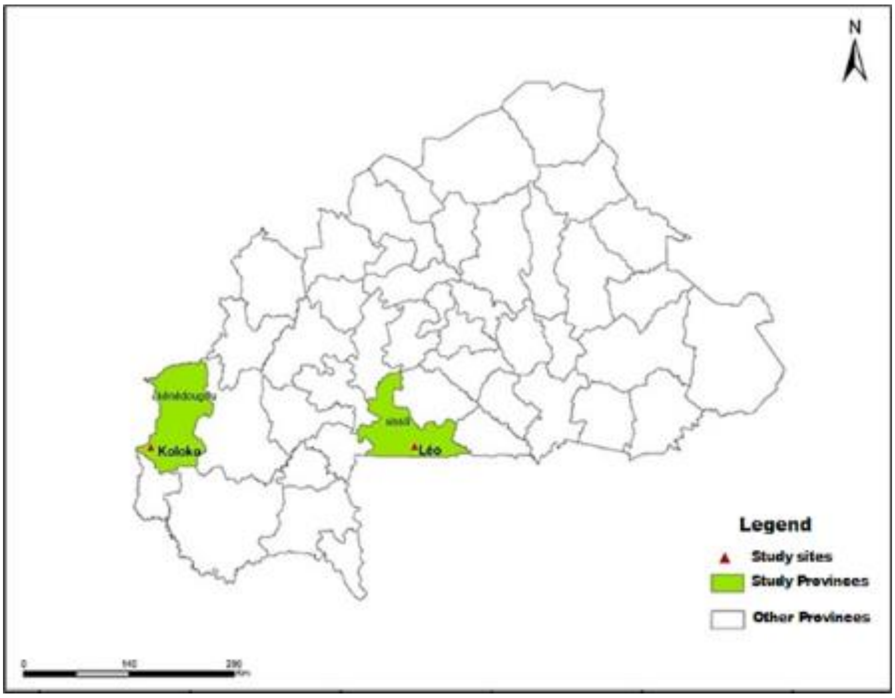

Figure 1 Geographical Location of the Experimental Sites

2.2. Identification of *L. theobromae*, pathogen of mango dieback at experimental sites

This activity aimed to confirm the presence of *L. theobromae*, a pathogen of mango tree decline, on the experimental sites. Surveys were conducted in the selected orchards to identify mango trees showing characteristic dieback symptoms. Infected leaves and twigs were collected, placed in a cooler, and transported to the laboratory. The samples were incubated using the moist blotting paper method [2]. Fragments of 2–4 cm, successively disinfected in 70% ethanol (30 s), 1% sodium hypochlorite (1 min), and rinsed with sterile distilled water, were placed on moist blotting paper in sterile Petri dishes. Incubation was carried out for seven days at 25–28 °C under a 12h UV light / 12h dark cycle. Fungal structures, including pycnidia, acervuli, and conidia, observed under a stereomicroscope and light microscope, allowed the identification of *L. theobromae*. Isolates were purified on Potato Dextrose Agar (PDA), and the pathogen's identity was confirmed by PCR using the specific primers Lt347-F (AACGTACCTCTGTTGCTTTGGC) and Lt347-R (TACTACGCTTGAGGGCTGAACA) [12].

2.3. Selection of treatments and experimental design

Three biological treatments (T1, T2, and T3) were tested to evaluate their effectiveness in recovering partially dieback-affected mango trees (Table 1). These treatments were compared to an untreated control (T5) and a reference treatment (T4), composed of synthetic products known for their efficacy against the disease in Burkina Faso [9]. The experiment was conducted using a completely randomized block design with six replicates per treatment corresponding to six mango trees per modality. To prevent cross-contamination between treatments, an untreated tree was retained between two trees receiving different treatments. Applications were performed on mango trees showing partial dieback symptoms. Biopesticides (Plantsain and Fertisain) as well as BF2 fertilizer were made available by Biotech service Senegal.

Table 1 Composition of treatments

Treatments	Composition of Inputs and Agricultural Practices
T1	Plantsain + Basin + BF2
T2	Fertisain + Basin + BF2
T3	Plantsain + Fertisain + Basin + BF2
T4	Azox + Manga plus + Basin + NPK
T5	Control without product application or agricultural practices

2.4. Application of treatments

The treatments were applied at two levels of the mango tree: aerial and subterranean. For the aerial level, the spray mixture was prepared according to three specific doses for each biopesticide tested (Plantsain and Fertisain), namely Dose 1 = 1.2 L/ha, Dose 2 = 1.6 L/ha, and Dose 3 = 2 L/ha. The reference treatment, consisting of synthetic fungicides (Azox, 2 L/ha, and Manga Plus, 2 kg/ha), was applied at the manufacturer's recommended doses. Spraying was carried out early in the morning or late in the afternoon, avoiding strong winds and high temperatures. In the event of rainfall that could wash away the product, the treatment was repeated. A total of six applications were performed at 15-day intervals. At the subterranean level, fertilizers were applied to enhance the nutrition of treated mango trees. BF2 was applied at a rate of 1.5 t/ha, while NPK was supplied at 500 g per tree, according to the experimental design.

2.5. Evaluation of treatment effectiveness

The effectiveness of the different treatments was evaluated based on three parameters: regeneration rate, disease incidence, and disease severity. Regeneration rate (Tr) corresponds to the percentage of partially wilted branches that recovered normal foliage and was calculated as: $Tr = (nr/N) \times 100$ where nr is the number of regenerated branches and N is the total number of branches per tree. Disease incidence (Inc) represents the percentage of branches showing dieback symptoms and was calculated as: $Inc = (ni/N) \times 100$ where ni is the number of infected branches and N the total number of branches observed. Disease severity (S) was assessed using the formula: $S=\sum(xini)/n$ where x_i is the disease severity score according to the scale of [13], n_i is the number of trees with score i, and n is the total number of trees per treatment.

2.6. Statistical analysis

All statistical analyses were performed using RStudio software (version 2025.05.1.513). Data normality and homogeneity of variances were verified using the Shapiro–Wilk and Levene tests, respectively. When the data met the assumptions for parametric testing, analysis of variance (ANOVA) was conducted to compare treatment effects. Significant differences among means were determined using Tukey's test at a significance level of $\alpha = 0.05$.

3. Results

3.1. Occurrence of dieback in the experimental sites

Field surveys conducted in the mango orchards revealed the presence of typical dieback symptoms, characterized by partial or total drying of the trees (Fig. 2). The observed incidence rates ranged from 20% to 90%, while disease severity levels varied between 20% and 80%.

Figure 2 Characteristic dieback symptoms observed in mango orchards (A) Partial branch dieback; (B) Complete tree dieback)

Incubation of samples collected from symptomatic trees allowed the isolation of *L. theobromae*, identified as the main pathogen associated with mango dieback in Burkina Faso. In addition, conventional PCR analysis using specific primers confirmed the presence of *L. theobromae* through the amplification of a 350 bp fragment (Fig. 3).

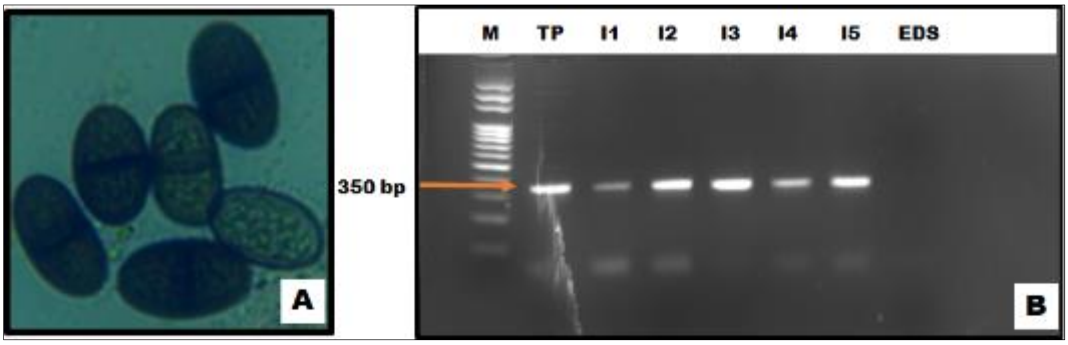

Figure 3 Identification of *L. theobromae* from samples collected on treated mango trees (A: Fungal conidia observed under the microscope; B: 350 bp amplicons obtained after PCR amplification of isolates; M: 100 bp molecular marker; TP: positive conrol; I1–I5: isolates obtained from dieback symptoms; EDS: sterile distilled water)

3.2. Effect of treatments on mango branch regeneration

Branch regeneration was observed on mango trees during the different observation periods (Fig. 4). Overall, the treatments applied induced similar effects on the regeneration of dieback-affected trees. The highest average regeneration rate (72.72%) was recorded in Koloko twelve months after the application of the Plantsain-based treatment (Fig. 5). During the same period and at the same site, this rate was markedly higher than that observed in untreated control trees (7.03%). Although the regeneration rate obtained in Léo was slightly lower than that in Koloko, the Plantsain product also showed notable effectiveness there, with an optimal average rate of 60.49% twelve months after treatment, compared to 8.92% in untreated controls.

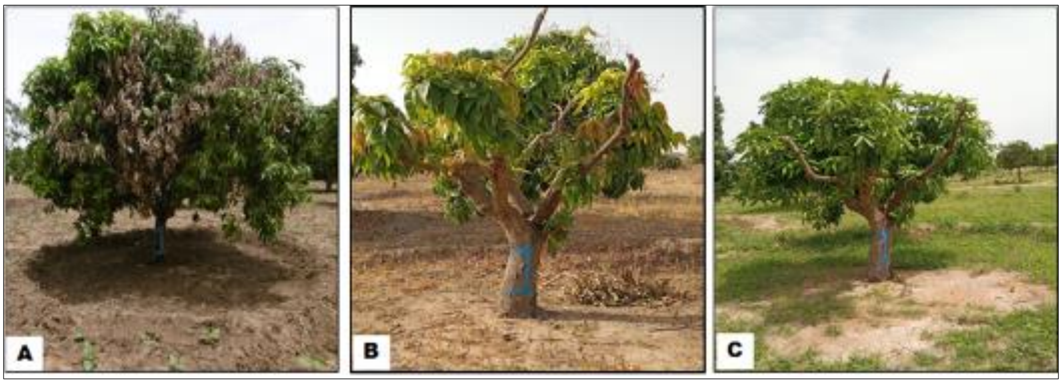

Figure 4 Branch regeneration on a mango tree treated with *Plantsain* (A: tree before treatment; B: tree after 6 months; C: tree after 12 months)

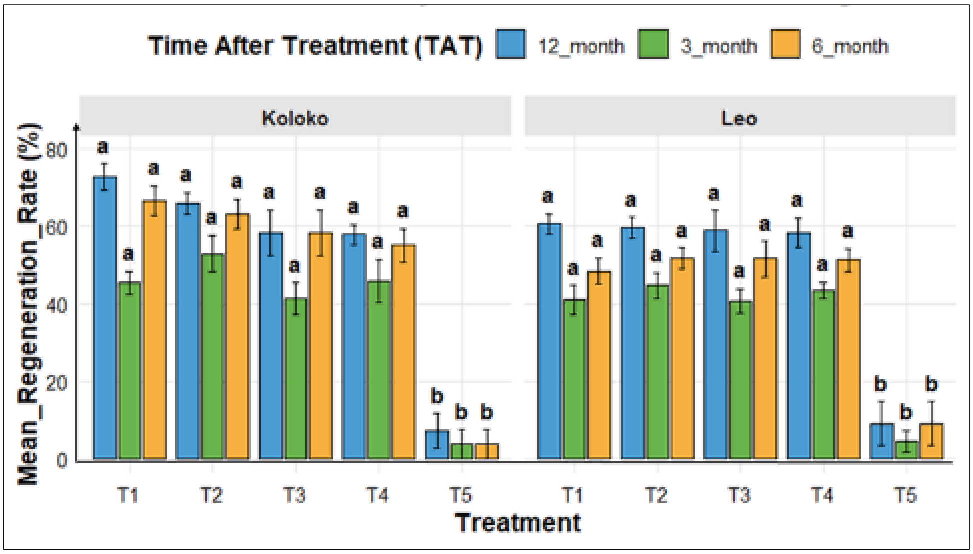

Figure 5 Effect of treatment on tree regeneration rate at different periods after treatment (3, 6, and 12 months) in each locality (Koloko and Leo). Bars represent means ± standard error. Different letters above the bars indicate significant differences according to Tukey's test ($p < 0.05$)

3.3. Effectiveness of treatments on the incidence and severity of dieback

Analysis of disease incidence revealed highly significant differences between treatments across all sites and doses tested ($p < 0.01$) (Fig. 6). In Koloko, the average incidence of mango dieback ranged from 19.9% to 86.9%, depending on the type of treatment and applied dose. At dose 1 (1.2 L/ha), trees treated with *Plantsain* exhibited the lowest incidence rate (19.9%), followed by those treated with the chemical fungicide (27.27%), while untreated control trees showed a markedly higher average incidence (86.9%). At the same dose, the biopesticide *Fertisain* had an effect comparable to that of *Plantsain*, with an average incidence of 34.17%.

Similar trends were observed in Leo, where the average incidence ranged from 25.87% for trees treated with the chemical fungicide Azox to 36.23% for those treated with *Fertisain*. Overall, a progressive decrease in the average disease incidence was observed with increasing application doses for all treatments. The lowest mean incidence rate (4.76%) was recorded for trees treated with *Plantsain* at 2 L/ha. In contrast, untreated control trees maintained significantly higher incidence rates (92.2% and 77.3% at Koloko and Léo, respectively; Kruskal–Wallis test, $p = 0.0018$ and 0.0021).

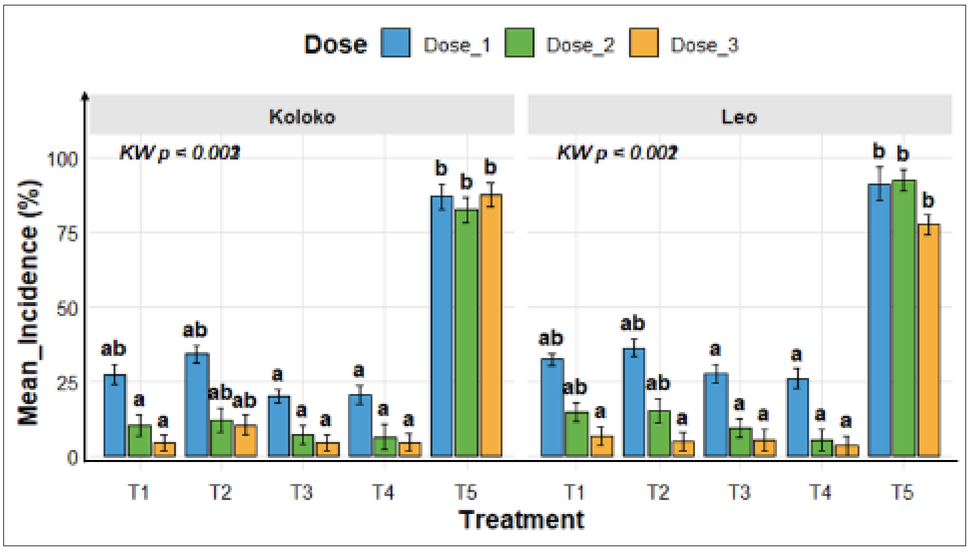

Figure 6 Effect of treatment on disease Incidence at different Dose (Dose_1: 1.2 L/ha, Dose 2: 1.6 L/ha and Dose 3: 2 L/ha) in each locality (Koloko and Leo). Letters above the bars correspond to statistically distinct groups, determined by a Kruskal-Wallis (KW) test followed by pairwise comparisons with Bonferroni correction (significance level α = 0.05)

Analysis of disease severity revealed highly significant differences between treatments across all sites and doses tested ($p < 0.01$) (Fig. 7). In Koloko, at dose 1 (1.2 L/ha), the lowest mean severity (25%) was observed in trees treated with either the *Plantsain + Fertisain* combination (T3) or Azox (T4), whereas untreated control trees exhibited a significantly higher mean severity of 79.16% compared to all other treatments (Kruskal–Walli's test, p = 0.00015). Similarly, in Leo, at the same dose, the mean severity observed was 29.16% for treatments T3 and T4, compared to 87.5% for untreated controls. As observed for disease incidence, severity progressively decreased with increasing application doses. The lowest mean severity (4.16%) was recorded in trees treated with the *Plantsain + Fertisain* combination at 2 L/ha.

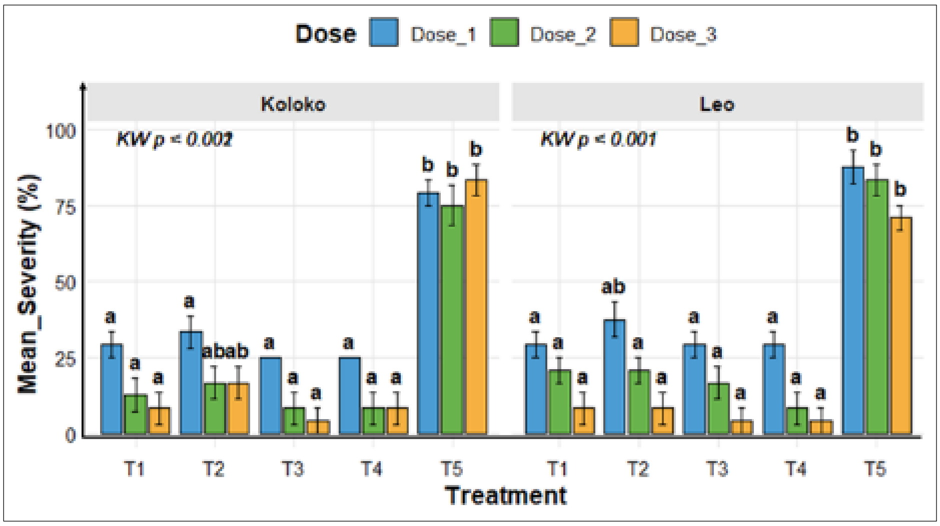

Figure 7 Effect of treatment on disease severity at different Dose (Dose_1: 1.2 L/ha, Dose_2: 1.6 L/ha and Dose_3: 2 L/ha) in each locality (Koloko and Leo). Letters above the bars correspond to statistically distinct groups, determined by a Kruskal-Wallis (KW) test followed by pairwise comparisons with Bonferroni correction (significance level α = 0.05)

4. Discussion

Field surveys, supported by laboratory analyses, established a strong association between dieback of mango observed in Burkina Faso and the presence of *L. theobromae*. Isolation of the fungus from symptomatic tissues, followed by molecular identification via PCR (yielding an approximately 350 bp amplicon), confirms its probable involvement in the disease etiology. These findings are consistent with previous studies identifying *L. theobromae* as a major causal agent of dieback of mango in various tropical regions [14]. This confirms that, in the context of Burkina Faso, *L. theobromae* represents a major phytopathological threat to mango production [15]. In Koloko, treatment induced an average branch regeneration rate of 72.72% twelve months post-application, compared to only 7.03% in untreated controls, demonstrating a clear and durable therapeutic effect. In Leo, although the regeneration rate was slightly lower (60.49% versus 8.92% in controls), treatment efficacy remained statistically significant, confirming the reproducibility of the physiological response under contrasting conditions. The consistency of results across sites suggests that the product maintains its effectiveness despite local variations in pedoclimatic conditions and pathogen pressure. These results indicate that the use of biopesticides such as *Plantsain* and *Fertisain* may extend beyond pathogen control, potentially stimulating physiological regeneration of damaged tissues, likely through reduction of oxidative stress and restoration of tree metabolic functions. Previous studies have shown that certain biological formulations can induce systemic defense mechanisms and promote post-infection growth [16], [17]. In dieback of mango, *L. theobromae* is known to cause severe physiological disturbances, including inhibition of photosynthesis, vascular tissue degradation, and disruption of nutrient translocation [6], [18]. The ability of the applied treatments to mitigate these effects may explain the observed recovery. Results related to disease incidence and severity further confirm the significant effectiveness of the applied treatments, particularly the *Plantsain* biopesticide, followed by the combined formulations (*Plantsain* + *Fertisain*) and the chemical fungicide Azox. This demonstrates that the two biopesticides, composed of peptides isolated from *T. harzianum*, may produce volatile and non-volatile antibiotics capable of combating these microorganisms [19]; [20] ; [21]. Moreover, *L. theobromae* exhibits high plasticity and strong virulence, highlighting the need for combined agents or optimized formulations to ensure a lasting effect [22]. The general trend of progressively reduced incidence and severity with increasing application doses indicates a dose-dependent effect of the treatments. The potential of various biocontrol agents against *L. theobromae*, particularly for the prevention of post-harvest mango rots, has been demonstrated [23]. Overall, these findings underscore the effectiveness of both biological and chemical agents in managing mango dieback, while emphasizing the importance of optimizing application doses to maximize protective effects.

5. Conclusion

Our study confirmed the predominant role of *L. theobromae* in dieback of mango in Burkina Faso. However, treatments based on the biopesticides *Plantsain* and *Fertisain*, as well as their combination and the chemical fungicide Azox, demonstrated significant efficacy in both promoting regeneration of affected trees and reducing disease incidence and severity. The observed dose-dependent effect and the reproducibility of results across sites suggest that these treatments remain effective despite local variations in pedoclimatic conditions and pathogen pressure. These findings highlight the potential of biocontrol strategies, alone or in combination, as a sustainable solution for managing of dieback of mango.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Contributions of authors

ZOD : followed the field trial, collected the data and participated in the analysis and writing of the manuscript. NES and BO oversaw the data analysis and manuscript write an review. TCZ & IW reviewed the manuscript.

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