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Efficacy of Selected Fungicides Against *Thielaviopsis paradoxa*, the Causal Agent of Neck Bending Disease in Oil Palm

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ABSTRACT

The oil palm (*Elaeis guineensis* Jacq.) is a vital tropical crop cultivated primarily for palm oil production. In Nigeria, the emerging *Thielaviopsis paradoxa*-induced neck bending disease poses a significant threat to oil palm yield. This study evaluated the efficacy of four fungicides (Z-force (80%), W-force (3%), Cabrio (3%), and Purudan (40 g/L)) against *T. paradoxa in vitro* and *in vivo*. Fungicides were tested *in vitro* at concentrations of 5, 10, 15, and 20 ppm against two *T. paradoxa* isolates from diseased oil palm trunks. Z-force (20 ppm) and W-force (20 ppm) exhibited the highest mycelial growth *in vitro*, while W-force demonstrated notable antifungal activity at 15 ppm. The most effective fungicide (W-force) was further tested *in vivo* using ring and center spraying methods to assess its impact on oil palm yield. The ring spray method significantly enhanced reproductive output, leading to increased inflorescence and fruit bunch production compared to center spear spraying. However, complete field control of *T. paradoxa* symptoms was not achieved, highlighting the need for integrated disease management approaches. These findings suggest that strategic fungicide application, particularly W-force (3%) via ring spraying, can improve oil palm productivity and contribute to more effective disease management in commercial plantations.

Keywords: *Elaeis guineensis* Jacq. *Thielaviopsis paradoxa,* Disease Management, Fungicide Application.

INTRODUCTION

The oil palm (*Elaeis guineensis*) is a crucial tropical crop belonging to the family Arecaceae and subfamily Cocoideae. It is primarily cultivated for its high-yield vegetable oil, which is widely used in the food, cosmetics, pharmaceuticals, and biofuels industries, making it one of the most significant agricultural commodities globally (Murphy, 2014). Large-scale plantations, typically spanning between 3,000 and 5,000 hectares, are established around major oil mills to facilitate efficient processing after harvest (Corley, 2009). In addition to industrial cultivation, oil palm is also grown on smallholder farms and in village gardens for local oil production. However, small-scale farmers often experience lower yields and oil quality due to limited access to improved planting materials, suboptimal farm management practices, and disease outbreaks.

Oil palm thrives in a warm, humid climate with stable high temperatures, deep well-drained soils, and continuous moisture throughout the year. Despite its adaptability, its productivity is often constrained by both abiotic and biotic stressors. Environmental challenges, such as drought, poor soil fertility, and climate change, can reduce yield (Ooi, 2016). Biotic factors, particularly insect pests and fungal pathogens, pose significant threats to oil palm cultivation. Among these, fungal diseases are especially damaging, leading to reduced fruit

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production and shortened palm lifespan. Common fungal diseases affecting oil palm include Ganoderma trunk rot, Fusarium wilt (Corley and Tinker, 2003), and oil palm bud rot (Paterson *et al*., 2019).

A recently emerging and highly destructive fungal disease, oil palm neck bending disease, is caused by *Thielaviopsis paradoxa*. Initially recorded in southern Nigeria, this disease primarily affects 2- to 3-year-old palms and has since spread to western Nigeria (Esiegbuya *et al*., 2022). The impact of this disease is profound, drastically reducing harvested fruit bunches from 12,000 to only 3,000 per month. Infected palms exhibit dry rot and necrotic lesions of various colors, which compromise the structural integrity of the trunk. As the disease progresses, the affected palm may collapse entirely, leading to total yield loss within a month. In addition to oil palm, *T. paradoxa* infects other economically important crops, such as coconut, banana, and date palm (Ayika *et al*., 2024). The versatility of *T. paradoxa* in causing disease at different growth stages of oil palm, ranging from seedling blight to stem rot and heart rot, makes it a formidable threat to palm cultivation (Flood *et al*., 2022).

Considering the increasing economic importance of oil palm and the destructive nature of *T. paradoxa*, developing effective disease management strategies is essential. Chemical control, particularly the use of fungicides, remains a primary approach for managing fungal diseases in oil palm plantations. However, there is limited research on the efficacy of various fungicides against *T. paradoxa*, underscoring the need to explore their potential for disease control. This study evaluates selected fungicides to assess their impact on *T. paradoxa* growth and their effectiveness in mitigating disease severity in oil palm. By identifying the most effective fungicide and application method, this research aims to contribute to sustainable management practices for the fungal disease.

MATERIALS AND METHODS

Fungal Isolation from Affected Oil Palm Trunks

Symptomatic oil palm trunks and fronds affected by neck bending disease were carefully cut into small pieces using a surface-sterilized razor blade. The samples were placed in sterile Petri dishes for microbiological analysis. Fungal isolation was performed using the direct plating method on Potato Dextrose Agar (PDA) and the plate were incubated at 25oC. Two morphologically and physiologically distinct isolates (OQ422128 and OQ422150), previously identified through ITS-PCR amplification in our study (Azeez *et al*., 2023) and were selected for this research.

Preparation of Selected Fungicide Stock Solutions and Dilutions

Four commercially available fungicides (Z-force 80%, W-force 3%, Cabrio 3%, and Purudan (40 g/L)) commonly used for controlling *T. paradoxa* were prepared as stock solutions and dilutions. Briefly, this was done by dissolving 100 g (for solid formulations) or 100 mL (for liquid formulations) of each fungicide in 1,000 mL of sterile distilled water to obtain a 1,000 ppm stock solution. From these stock solutions, working concentrations of 5, 10, 15, and 20 ppm were prepared following the method described by Smith *et al*. (1992).

Fungicide dilutions were achieved using the standard dilution formula:

$$C_1V_1 = C_2V_2, \text{ where:}$$

C_1 = Initial concentration of the fungicide, V_1= Initial volume of the fungicide, C_2 = Final concentration of the fungicide, V_2 = Final volume of the fungicide.

The prepared dilutions were then incorporated into PDA for further analysis.

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Evaluation of Fungicidal Efficacy against *T. paradoxa* and *In vivo* Application Methods

The efficacy of the different fungicides against *T. paradoxa* was assessed qualitatively based on fungal mycelial growth on PDA-amended plates. The Minimal Inhibitory Concentration (MIC) was determined as the lowest concentration that completely inhibited fungal growth. Plates with normal fungal growth were considered resistant to the fungicide, whereas plates with no visible growth indicated successful inhibition of *T. paradoxa*. The most effective fungicide from the *in vitro* trials was selected for *in vivo* evaluation. The *in vivo* experiment was conducted separately using ring spraying and center spear spraying methods and their impacts on oil palm yield were assessed.

Fungicide Preparation and Field Application Methods

Fungicides were prepared following the manufacturer's instructions by dissolving 100 g of each powdered fungicide in 16 liters of water to achieve the required concentration for field application.

The field trial was conducted at Okomu Extension 2, Field A10. Two fungicide application methods (ring spraying and center spear spraying) were employed. A total of 90 oil palm trees showing symptoms of bunch rot were selected and divided into three treatment groups.

In the ring spraying treatment, fungicides were applied around the base of the palms, covering the area where inflorescences and young fruit bunches develop. In the center spear spraying treatment, fungicides were sprayed directly onto the center spear of the palms. A control group was left untreated to serve as a reference for comparison. The number of fruit bunches, male inflorescences, female inflorescences, and total inflorescences were recorded before treatment application.

Evaluation of Treatment Efficacy

The effectiveness of each fungicide application method was assessed by monitoring key growth parameters, namely number of bud formations, male and female inflorescences, and fruit bunches. Data collection was conducted fortnightly following treatment application to evaluate the impact of fungicide treatments on oil palm recovery and yield improvement.

Statistical Analysis

Data obtained from the study were subjected to descriptive analysis, with results presented as Mean ± S.E. (standard error) in summary tables. One-way analysis of variance (ANOVA) was used to assess differences between treatments and controls. The significance level of $p < 0.05$ was considered statistically significant. Duncan's New Multiple Range Test (DMRT) was applied to compare significant differences among the means. Statistical analysis was performed using SPSS version 20, and graphical illustrations were created using MS Excel version 2016 (Ogbeibu, 2014).

RESULTS

The efficacy of different fungicides in inhibiting *Thielaviopsis paradoxa* mycelial growth was evaluated over three days. The mean mycelial growth inhibition (mm) varied across fungicide treatments and concentrations. The antifungal efficacy of different fungicides against isolate OQ422128 was assessed based on mean mycelial growth inhibition over three days (Figure 1).

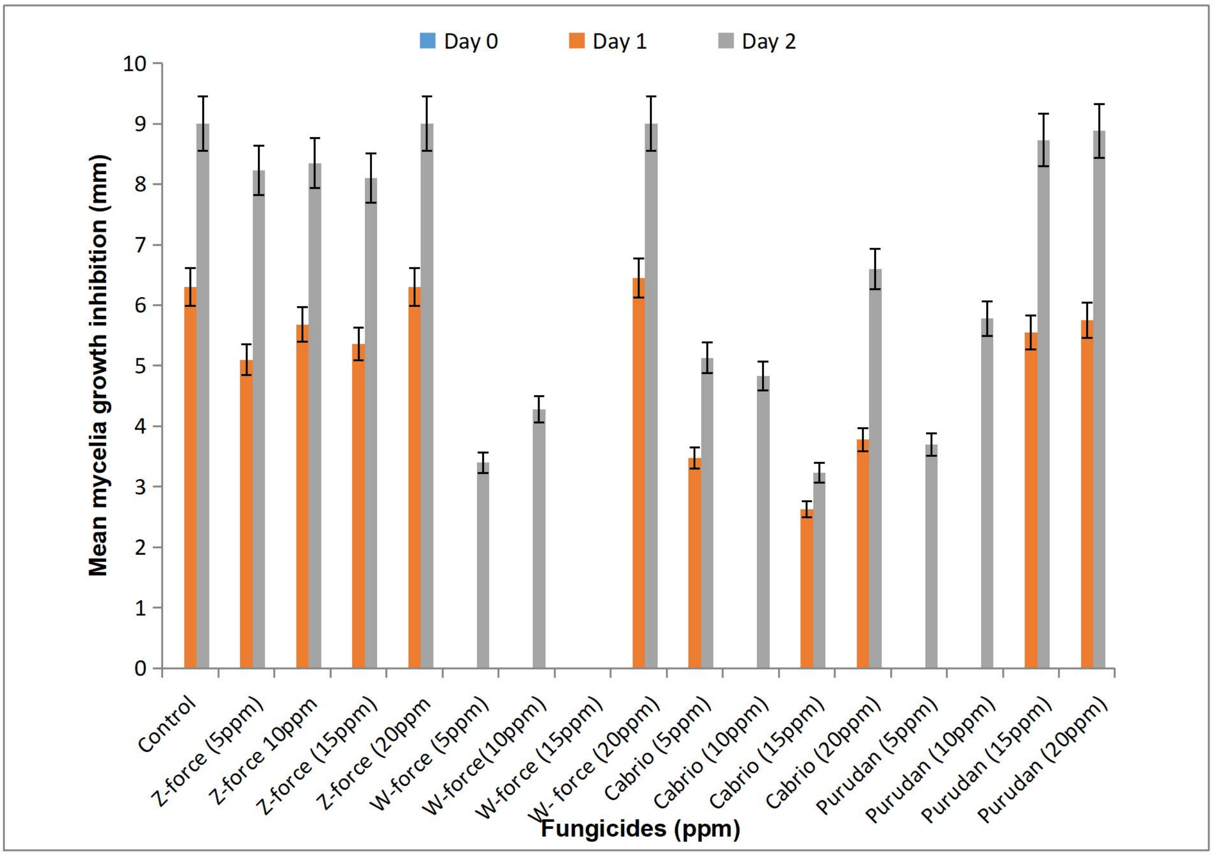

Figure 1: Mean mycelial growth inhibition (mm) of *T. paradoxa* isolate (OQ422128) treated with different fungicides at varying concentrations over three days. Error bars indicate standard error.

On Day 0, there was no significant inhibition across all treatments, as expected. By Day 1, fungicides exhibited varying degrees of mycelial growth inhibition, with higher concentrations generally resulting in greater inhibition. Among the tested fungicides, Z-force (20 ppm) and W-force (20 ppm) demonstrated the highest inhibition, significantly ($p < 0.05$) reducing fungal growth compared to the control. Cabrio (5–20 ppm) and Purudan (5–20 ppm) also showed notable inhibitory effects, though their efficacy varied with concentration.

By Day 2, mycelial growth inhibition was more pronounced, with all fungicide treatments significantly restricting fungal growth compared to the untreated control. Z-force (15 and 20 ppm) and W-force (20 ppm) completely inhibited mycelial growth, suggesting strong antifungal activity. Lower concentrations of fungicides exhibited moderate inhibition, with Cabrio and Purudan maintaining their suppressive effects in a dose-dependent manner.

Similarly, for isolate OQ422150, on Day 0, there was no inhibition across all treatments, as expected (Figure 2).

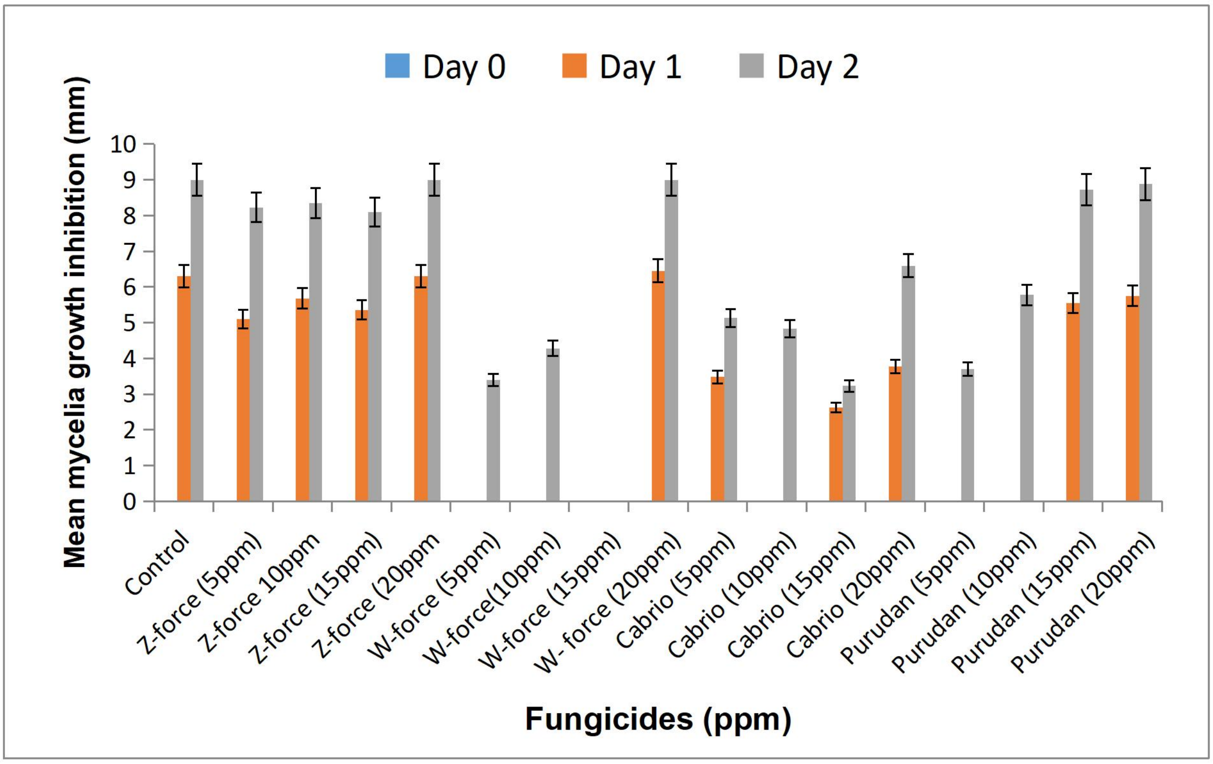

Figure 2: Mean mycelial growth inhibition (mm) of *T. paradoxa* isolate (OQ422150) treated with different fungicides at varying concentrations over three days. Error bars indicate standard error.

By Day 1, varying degrees of mycelial growth inhibition were observed among the fungicide treatments, with higher concentrations generally exhibiting greater inhibitory effects. Z-force (20 ppm) and W-force (20 ppm) showed the highest inhibition, significantly suppressing fungal growth compared to the control. Cabrio and Purudan (5–20 ppm) also demonstrated moderate inhibition, with increasing efficacy at higher concentrations.

By Day 2, all fungicide treatments exhibited a more pronounced inhibition of mycelial growth. Z-force (15 and 20 ppm) and W-force (20 ppm) achieved the highest suppression, with near-complete inhibition at the highest concentrations. Lower concentrations of the fungicides displayed moderate inhibition, while Cabrio and Purudan continued to suppress mycelial growth in a dose-dependent manner.

Effect of Fungicide Treatment on Inflorescence and Fruit Bunch Production in Oil Palm

The application of fungicide significantly influenced the production of male inflorescence (MI), female inflorescence (FI), total inflorescence (I), and fruit bunch (FB) in oil palm trees.

Table 1: Population (n) and frequency (%) of male inflorescence (MI), female inflorescence (FI), inflorescence (I) and fruit bunch (FB) in different palm trees treated with fungicide (Carbofuran 3%).

Treatment setup	Duration	MI n (%)	FI n (%)	I n (%)	FB n (%)
Line11 (Ring spray)	Week 2	15 (15.31)	11 (22.45)	13 (6.34)	11 (5.91)
	Week 4	16 (16.33)	15 (30.61)	66 (32.19)	30 (16.13)
	Week 6	27 (27.55)	16 (32.65)	58 (28.29)	59 (31.72)
	Week 8	40 (40.82)	7 (14.29)	68 (33.17)	86 (46.24)
	Total	98	49	205	186
	p value	0.217	0.412	0.000*	0.000*
Line12 (Centre spray)	Week 2	8 (8.79)	3 (8.79)	28 (16.37)	7 (6.09)
	Week 4	16 (17.58)	2 (17.58)	33 (19.29)	16 (13.91)
	Week 6	27 (29.67)	9 (29.67)	52 (30.41)	28 (24.34)
	Week 8	40 (43.96)	4 (43.96)	58 (33.92)	64 (55.65)
	Total	91	18	171	115
	p value	0.054	0.218	0.009*	0.000*
Line13 Control	Week 2	6 (8.82)	8 (21.62)	26 (15.66)	13 (7.69)
	Week 4	15 (22.06)	8 (21.62)	41 (24.69)	25 (14.79)
	Week 6	16 (23.53)	13 (35.14)	36 (21.69)	49 (28.99)
	Week 8	31 (45.59)	8 (21.62)	63 (37.95)	82 (48.52)
	Total	68	37	166	169
	p value	0.063	0.581	0.004*	0.000*

MI= Male inflorescence, FI= Female inflorescence, I= inflorescence, Line 11 = Palm trees treated with fungicide using Ring spray method, Line 12 = Palm trees treated with fungicide using Centre spear method, Line 13 = Palm trees without fungicide treatment (control). P≤0.05 = significant difference, P≥0.05 = no significant difference.

Among the treatment methods, the Ring spray method (Line 11) resulted in the highest production of all reproductive structures, followed by the Centre spray method (Line 12), while the Control (Line 13) recorded the lowest values.

Male and Female Inflorescence Production

The number of male inflorescences was highest in trees treated with the Ring spray method (n = 98), followed by the Centre spray method (n = 91), while the Control trees produced the lowest count (n = 68). However, no significant difference was observed among the treatments ($p > 0.05$). Similarly, the female inflorescence count was highest in the Ring spray treatment (n = 49), followed by the Control (n = 37), while the Centre spray treatment recorded the lowest count (n = 18), with no statistically significant difference ($p > 0.05$).

Total Inflorescence Production

A significant difference ($p < 0.05$) was observed in total inflorescence production among the treatments. Trees treated using the Ring spray method recorded the highest total inflorescence count (n = 205), followed by the Centre spray method (n = 171), while the Control recorded the lowest count (n = 166).

This suggests that fungicide application, particularly through the Ring spray method, enhances inflorescence production.

Fruit Bunch Production

Fruit bunch (FB) production was significantly influenced by fungicide application ($p < 0.05$). Trees treated using the Ring spray method produced the highest number of fruit bunches (n = 186), followed by those treated with the Centre spray method (n = 115), while the Control trees recorded the lowest fruit bunch count (n = 169).

DISCUSSION

This study demonstrates that fungicide application enhances reproductive output in oil palm, with the ring spray method being the most effective in promoting both inflorescence and fruit bunch production. This suggests that strategic fungicide application can improve oil palm yield by stimulating reproductive development, potentially contributing to increased fruit production in commercial plantations.

The *in vitro* evaluation of fungicides against *Thielaviopsis paradoxa* revealed significant differences in their efficacy. Z-force (20 ppm) and W-force (20 ppm) exhibited the highest levels of mycelial growth inhibition, suggesting their strong antifungal activity. The dose-dependent response observed in Cabrio and Purudan treatments further underscores the importance of concentration in determining fungicidal effectiveness. Similar patterns of inhibition were observed for isolate OQ422150, reinforcing the efficacy of these fungicides in restricting *T. paradoxa* growth. These results align with previous findings that highlight the effectiveness of systemic fungicides in controlling fungal pathogens in crops (Agrios, 2005; Irabi *et al*., 2018).

Despite the promising *in vitro* results, the field application of W-force 3% failed to completely manage fruit bunch rot symptoms in oil palm. Carbofuran which is the active ingredient in W-force, is a systemic fungicide that is selectively toxic to microorganisms and invertebrates, functioning by interfering with meiosis and intracellular transportation (Cinar *et al*., 2015). Therefore, its limited efficacy in controlling *T. paradoxa in vivo* suggests that environmental factors, such as humidity, temperature fluctuations, and pathogen adaptability, may have influenced its performance. The variation in inflorescence and fruit bunch production across different application methods also indicates that the mode of fungicide delivery plays a crucial role in its effectiveness.

The significant increase in total inflorescence and fruit bunch production in fungicide-treated trees, particularly with the Ring spray method, suggests that fungicide application indirectly enhances reproductive success in oil palm. This could be attributed to improved plant health, reduced pathogen load, and a subsequent allocation of resources toward reproductive development. Similar findings have been reported in other crop systems, where disease management through fungicide application resulted in improved yield and fruit quality (Schumann and D'Arcy, 2012; Uppala *et al*., 2025)

However, the limitations of fungicide use must be considered. The high risks associated with fungicides, ranging from environmental toxicity to the emergence of resistant pathogen strains, necessitate the development of an integrated disease management approach. Combining fungicide application with biological control strategies, cultural practices, and resistant cultivars could provide a more sustainable solution for managing *T. paradoxa* in oil palm plantations (Alizadeh *et* *al*., 2020; Azeez *et al*., 2023). Further studies should explore alternative control measures, including biocontrol agents and genetic resistance, to mitigate the risks associated with chemical fungicides.

CONCLUSION

This study highlights the potential of fungicide application, particularly through the ring spray method, in enhancing oil palm productivity. While fungicides demonstrated strong *in vitro* efficacy, their field application showed variable success, emphasizing the need for an integrated approach to managing *T. paradoxa*. Apart from focusing on optimizing fungicide application methods and exploring environmentally sustainable disease control strategies, the most effective fungicide with the application method (W-force 3% and ring spray method) from this study can serve as a selective and effective control measure for managing *T. paradoxa* in oil palm cultivation. Additionally, future research should focus on long-term field trials and integrated disease management strategies to improve the sustainable production of oil palm.

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