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Comparative antifungal efficacy of *Zinnia elegans* and *Tithonia diversifolia* extracts against *Fusarium verticillioides*: *In-vitro* study

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ABSTRACT

Fusarium verticillioides are broad-spectrum pathogens with extensive host ranges and represent a major constraint in agricultural production. Synthetic pesticides are commonly used by farmers to manage *Fusarium*-induced diseases; however, their intensive application poses serious risks to environmental sustainability and human health. Consequently, the development of eco-friendly disease management strategies is urgently required. Botanical pesticides derived from plant extracts represent a promising alternative. This study evaluated the antifungal effectiveness of Mexican sunflower (*Tithonia diversifolia*) and zinnia (*Zinnia elegans*) extracts at different concentrations against *Fusarium* wilt. The experiment was conducted from September to December 2024 using a completely randomized design (CRD) with six extract treatments (1800, 3600, and 5400 ppm for each plant species) and an untreated control. Antifungal activity was assessed based on the percentage of mycelial growth inhibition. The results demonstrated that both extract type and concentration significantly affected fungal inhibition ($p \leq 0.05$). Extract of *Z. elegans* at 5400 ppm exhibited the highest inhibitory effect, suppressing *Fusarium* growth by 32.0%, which was significantly higher than all other treatments. In contrast, *T. diversifolia* extract showed moderate inhibition, with a maximum of 16.5% inhibition at 5400 ppm. The increasing inhibition with higher concentrations indicates a clear dose-dependent response. These findings highlight the scientific significance of plant-based extracts as natural antifungal agents and demonstrate the superior efficacy of *Z. elegans* extract at higher concentrations. Overall, this study underscores the strong potential of zinnia-based extracts as eco-friendly biofungicide candidates for sustainable management of *Fusarium* wilt diseases.

Keywords: Botanical pesticide; *Fusarium* spp.; Plant extract; *Tithonia diversifolia*; *Zinnia elegans*

1. Introduction

Indonesia, an agricultural nation, boasts environmental conditions conducive to the growth of a wide variety of plants. This diversity extends to microorganisms, which often have the capacity to attack different plant groups as hosts. One such microorganism is the fungus *Fusarium* sp., which can infect plants from various families, including corn (Gabriel et al., 2021), tomatoes (Muslim et al., 2019), beans, and strawberries (Sampaio et al., 2021). *Fusarium* species produce conidia that can be dispersed through the air, rainwater splashes, and irrigation water. Some *Fusarium* species produce chlamydospores that can persist in soil and plant debris for extended periods, thereby acting as long-term sources of inoculum and contributing to recurrent disease outbreaks (Lin et al., 2013; Sampaio et al., 2021).In addition, most plant-pathogenic *Fusarium* species exhibit a hemibiotrophic infection strategy, in which the pathogen initially relies on a living host during the biotrophic phase before switching to a necrotrophic lifestyle that leads to host tissue destruction (Duba et al., 2018; Ma et al., 2013). These biological characteristics make *Fusarium* wilt particularly difficult to manage using conventional control measures, especially synthetic fungicides that often show limited efficacy against soilborne and persistent propagules.

Despite extensive research on chemical control and a growing number of studies on biological control agents, critical knowledge gaps remain regarding the effectiveness of locally available plant extracts as eco-friendly antifungal alternatives, particularly against *Fusarium* spp. (Schoss et al., 2022). Many previous studies have focused on single plant species or limited concentration ranges, without systematically comparing different botanical sources and dose-dependent responses under controlled conditions. Moreover, comparative evaluations between ornamental plants with known bioactive potential, such as *Tithonia diversifolia* (Dada et al., 2018) and *Zinnia elegans*, remain scarce, even though these plants are widely available and rich in secondary metabolites with potential antifungal activity (Mohammadi et al., 2024). Therefore, this study addresses these gaps by systematically assessing the

antifungal efficacy of two plant extracts at multiple concentrations against *Fusarium verticillioides*, providing quantitative inhibition data and statistically robust comparisons. By linking pathogen biology with extract performance, this research contributes to a better understanding of plant-based antifungal strategies and supports the development of sustainable, botanical-based biofungicides for managing *Fusarium* wilt diseases.

The pathogen from genus *Fusarium* causes plant diseases that spread through soil, seeds, and air. This fungus can also attach to plant debris. Infection in plants causes various diseases, including vascular wilt, root and stem rot, crown rot, damping-off, and canker (Torres-Cruz et al., 2022). The initial symptom of *Fusarium* wilt is the appearance of pale leaf veins, particularly in the upper leaves, followed by the curling of older leaves (epinasty) due to the drooping of the petioles, eventually leading to the complete wilting of the plant. In very young plants, the disease can cause sudden death by damaging the base of the stem. Infected mature plants often manage to survive and bear fruit, but the yield is significantly reduced and limited (Ali et al., 2024). To control pathogens such as *Fusarium* sp., which can infect a wide variety of plants, the use of synthetic pesticides is a control method widely used by farmers due to its simplicity. However, intensive application of synthetic pesticides can create new problems. Not only does it have an impact on environmental pollution (Mahmood et al., 2016),chemical pesticides also cause problems for human health (Poudel et al., 2020), a decrease in the population of non-target organisms, and the occurrence of pest resurgence (Akter et al., 2019).

Therefore, alternative control methods are needed that are easily implemented by farmers but do not have a negative impact on health and the environment. One such control method is using biofungicides made from plant extracts (Li et al., 2025).Biofungicides are fungicides derived from living organisms, either from plants, known as botanical fungicides (Cenobio-Galindo et al., 2024) or from microorganisms, commonly known as biological fungicides (Djaenuddin et al., 2025). The active ingredients in botanical biofungicides are derived from plant metabolites that can be toxic and inhibit the development of pests (Divekar et al., 2022). Plants synthesize a wide range of secondary metabolites that play a crucial role in plant defense, particularly against microbial pathogens (Chatri et al., 2022). Among these, phenolic compounds, flavonoids, and terpenoids have been extensively reported for their antifungal properties, including inhibition of mycelial growth and disruption of fungal cell membranes. *T. diversifolia* and *Z. elegans* were selected in this study due to their documented richness in bioactive secondary metabolites with potential antifungal activity. *T. diversifolia* is known to contain sesquiterpene lactones and diterpenoids that exhibit antimicrobial effects, while *Z. elegans* has been reported to possess high levels of phenolics and flavonoids associated with fungal growth suppression (Kerebba et al., 2019). Despite these reported bioactivities, comparative evaluations of their antifungal effectiveness at different concentrations remain limited. Therefore, focusing on these two species provides a targeted approach to assess their potential as botanical antifungal agents and to better understand how concentration influences their inhibitory performance against phytopathogenic fungi.

The Mexican sunflower, *T. diversifolia* (da Costa Inácio et al., 2020), and the zinnia, *Z. elegans* (Wahyuni et al., 2022),are known to contain metabolites with antioxidant, anti-allergic, anti-inflammatory, antimicrobial, and anticancer properties. However, no research has yet explored the use of these plant extracts to control the development of plant pathogens, particularly *Fusarium* spp. This gap in research underpins the investigation into the potential of these two plant extracts as biocontrol agents for *Fusarium* spp.

2. Materials and Methods

2.1. Experimental Design

This laboratory study used a completely randomized design (CRD) that included a control group and six different plant extract treatments. Each treatment was repeated four times, leading to a total of 28 treatment units. The treatments were as follows: P0: PDA without any plant extract/only distilled water (control) P1: 1800 ppm of Mexican sunflower extract; P2: 3600 ppm of Mexican sunflower extract; P3: 5400 of Mexican sunflower extract; P4: 1800 ppm of zinnia extract; P5: 3600 ppm of zinnia extract; P6: 5400 ppm of zinnia extract.

2.2. Purification of *Fusarium* spp. Isolate

This The pathogenic fungi *Fusarium verticillioides* used were collected from the Faculty of Agriculture, Makassar Islamic University. The collected fungi were purified using a 6mm cork borer and then grown in a petri dish containing PDA media, tightly sealed with plastic wrap. The growing *Fusarium* sp. fungi were incubated until 7 days before using for further test.

2.3. Plant Extraction

Mexican sunflower (*Tithonia diversifolia*) and zinnia plants (*Zinnia elegans*) were extracted using the maceration method. The extraction process begins with cleaning dirt and dust using running water. The chopping process is carried out on fresh plants (without going through a drying process). Each plant is chopped at the stem, leaf, and flower sections. Then weighed to 200 grams. The plants are then immersed in a closed container containing 200 mL of 90% ethanol solvent (1:1) and stored at room temperature (27–28 °C) for 24 hours. The extract solution is then filtered. The filtered dregs are re-macerated twice with the same volume of solvent to obtain maximum results. After the extraction process, all the filtrate solutions obtained are mixed and evaporated using a rotary evaporator at a temperature of 40–45 °C until a thick extract in the form of a paste is obtained.

2.4. Preparation of Plant Extract Concetration

The preparation of plant extract solutions was conducted using the extracted paste as the primary component. Precisely 0.2, 0.4, and 0.6 g were accurately weighted and dissolved in 10 mL of sterile distilled water, resulting in stock solutions with concetntration of 20.000, 40.000, and 60.000 ppm, repectively. Each solutions was homogenized using a vortex mixer to ensure complete dissolution. Subsequently, 10 mL of each stock solution was added to

100 mL of molten Potato Dextrose Agar (PDA) maintained at 45–50 °C, resulting in final extract concentrations of 1800, 3600, and 5400 ppm in the culture medium. These concentrations were used for antifungal activity assessment.

2.5. *In-Vitro* Test of *Fusarium* spp. Inhibition

In-vitro experiments were performed by introducing 10 mL of plant extract from each treatment into 100 mL of potato dextrose agar (PDA) within an Erlenmeyer flask, followed by homogenization. The homogenized mixture was subsequently poured into a Petri dish and allowed to solidify. Mycelium from the *Fusarium* spp. fungal colony was taken using a cork borer with an 8 mm diameter and inoculated at the center of the Petri dish containing the PDA medium and plant extracts from each treatment. The setup was incubated at room temperature (27–28 °C) and subsequently observed.

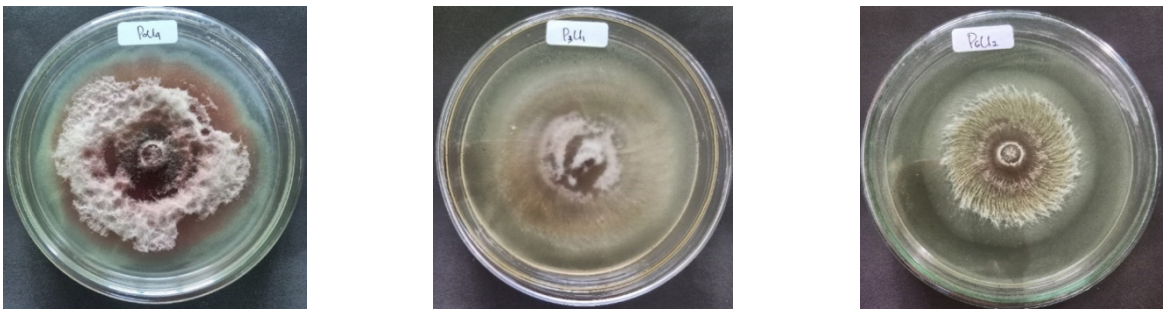
2.6. Observation Parameters

Observations were conducted on the growth diameter of *Fusarium* spp. fungal colonies subjected to extracts of varying types and concentrations. These observations were performed four times, with a 48-hour interval between each observation. The initial observation occurred 1 day post-inoculation. Subsequently, the inhibition of *Fusarium* spp. pathogen development was calculated using the following formula (1):

$$I\ (\%) = \frac{C - T}{C} \times 100\% \quad (1)$$

Where: I = Percentage of inhibition; C = Diameter of pathogen colony at the control; T = Diameter of pathogen colony at the treatment

Data were subjected to two-way analysis of variance (ANOVA) to evaluate the effects of extract type, concentration, and their interaction. Prior to analysis, data were examined for normality and homogeneity of variance, and no data transformation was required. When the ANOVA indicated significant differences ($p \leq 0.05$), mean separation was performed using the Least Significant Difference (LSD) test at the 5% probability level. All statistical analyses were conducted using standard statistical procedures appropriate for factorial experiments.



(a) (b) (c)

Figure 1. Mycelium growth of pathogenic fungi of *Fusarium* spp. isolate in (a) Control (b) Plant extract of *Tithonia diversifolia*, and (c) Plant extract of *Zinnia elegans*.

3. Results

3.1. Inhibition of *Fusarium* spp. Mycelium

As illustrated in Figure 1, the extracts from Mexican Sunflower and zinnia plants demonstrated an ability to inhibit the growth of *Fusarium* spp. fungal colonies. This is evidenced by the observed differences in the development of *Fusarium* spp. fungal mycelium colonies between the control and treatment groups. The observations indicate that each plant extract employed in this study possesses antimicrobial potential. In the control group, the *Fusarium* spp. fungal mycelium appeared to have completely covered the Petri dish at seven days post-inoculation, whereas the fungi in each treatment group had not achieved similar coverage.

The measurement of the growth diameter of the fungus *Fusarium* sp. revealed distinct outcomes for each treatment, as illustrated in Figure 2. The following data represent the average growth measurements of *Fusarium* sp. isolates. On the seventh day, the control group (P0) exhibited the largest average diameter, measuring 8.3 cm. This was followed by treatments P1, P2, P3, P4, and P5, with diameters of 8, 7.2, 6.9, 6.3, 6.2, and 5.6 cm, respectively. The smallest diameter at 7 days post-inoculation (DPI) was observed in the treatment with 60% zinnia flower extract (P6), measuring 5.6 cm.

The graph (Figure 2) illustrates the dynamics of pathogen colony growth from 1 to 7 days post-inoculation (DPI) across seven distinct treatments (P0–P6). Overall, all treatments exhibited an upward growth trajectory with prolonged incubation time; however, notable differences were observed between the control group (P0) and the extract treatments (P1–P6). At 1 DPI, variations in colony diameter among treatments were already apparent, with P0 showing the largest initial diameter, suggesting that in the absence of inhibitor treatment, the fungus could rapidly commence its growth. Treatments P1, P2, and P3 demonstrated relatively mild inhibition during the early phase, whereas P4, P5, and particularly P6 exhibited more pronounced initial suppression of colony growth.

3.2. Inhibition Percentage of Plant Extract Treatment

The results (Table 1) showed that plant type and extract concentration significantly influenced the percentage of pathogen growth inhibition. *Z. elegans* extract consistently provided higher inhibition than *T. diversifolia*, as indicated by significantly different average inhibition values (32% compared to 16.5%). This indicates that *Z. elegans* contains

active compounds that are more effective in suppressing pathogen growth across the tested concentration range. The extract concentration also had a significant effect. Increasing the concentration from 1800 ppm to 5400 ppm increased the inhibition percentage from 13.5% to 24.25%, indicating that inhibition is dose-dependent. The highest concentration (5400 ppm) provided the most effective inhibition, while 1800 ppm was the least effective.

The inhibition percentage graph (Figure 3) illustrates that all treatments successfully suppressed pathogen growth during the initial phase of incubation, as evidenced by the relatively high inhibition values at 1 DPI. Nevertheless, the efficacy of the extracts appeared to diminish over time, as indicated by a marked decrease in the inhibition percentage between 3 and 5 DPI. Treatment P6 exhibited the highest level of inhibition throughout the observation period, achieving approximately 70% inhibition at 1 DPI and maintaining inhibition above 30% at 7 DPI. This finding confirmed that P6 exhibited the most potent antifungal activity among all treatments. In contrast, P1 demonstrated the lowest effectiveness. Meanwhile, P2, P3, P4, and P5 exhibited moderate levels of inhibition, characterized by a gradual decline and some stabilization at 7 DPI. Overall, this pattern suggests that the plant extracts were most effective during the early phase of contact with the pathogen, with their effectiveness decreasing as the fungus entered its rapid growth phase. However, high-concentration treatments such as P6 continued to suppress pathogen growth until the end of the observation period.

Table 1. The inhibitory efficacy of *Fusarium* sp. against fusarium wilt disease was assessed using extracts from *Tithonia diversifolia* and *Zinnia elegans* at varying concentrations (%).

Plant extract	Concentration		
	1800 ppm	3600 ppm	5400 ppm
T. diversifolia	3.0 e	12.8 d	16.5 c
Z. elegans	24.0 b	25.0 b	32.0 a

Two-way ANOVA revealed that extract type significantly affected inhibition percentage ($F = 551.09$; $p < 0.0001$). Concentration also showed a highly significant effect ($F = 80.39$; $p < 0.0001$). Moreover, a significant interaction between extract type and concentration was observed ($F = 13.61$; $p = 0.00025$), indicating that the inhibitory response depended on the combination of both factors. In the Least Significant Difference test at $\alpha = 0.05$, average values followed by the same letter are significantly different, whereas those followed by different letters are significantly different. DPI = Days Post-Inoculation.

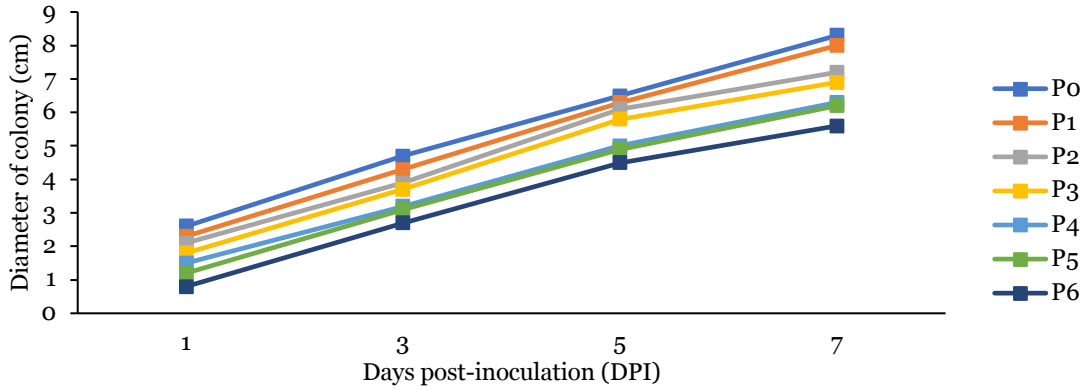


Figure 2. Colony growth of *Fusarium* spp. for each treatment (P0: PDA without any plant extract/only distilled water (control) P1: 1800 ppm of *T. diversifolia* extract; P2: 3600 ppm of *T. diversifolia* extract; P3: 5400 of *T. diversifolia* extract; P4: 1800 ppm of *Z. elegans* extract; P5: 3600 ppm of *Z. elegans* extract; P6: 5400 ppm of *Z. elegans* extract).

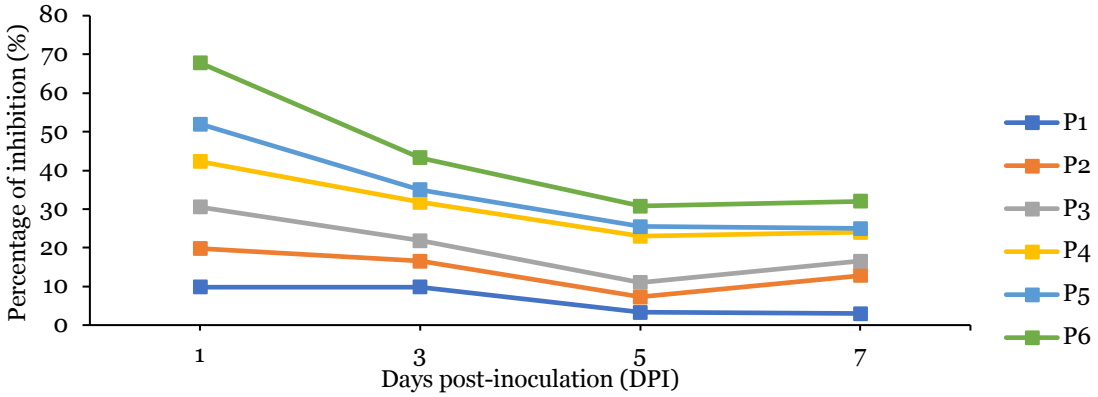


Figure 3. Inhibition percentage of each treatment (P1: 1800 ppm of *T. diversifolia* extract; P2: 3600 ppm of *T. diversifolia* extract; P3: 5400 of *T. diversifolia* extract; P4: 1800 ppm of *Z. elegans* extract; P5: 3600 ppm of *Z. elegans* extract; P6: 5400 ppm of *Z. elegans* extract).

4. Discussion

When the two graphs are analyzed simultaneously, it appears that the pattern of decreasing inhibition percentages is directly related to the increase in fungal colony diameter. The first graph shows a steady increase in fungal colony diameter across all treatments from 1 to 7 DPI, while the inhibition graph shows a decrease in inhibition percentage over the same period. This counterintuitive trend is a common characteristic of

antifungal assays: the larger the colony diameter, the lower the inhibition value. Therefore, both graphs provide strong evidence that the effectiveness of the plant extracts decreases over time, even though treatments with strong antifungal concentrations or potency (*e.g.*, P6) still significantly suppress pathogen growth until the end of the observation period. Treatment P6 consistently provides the highest inhibition and the lowest colony diameter in the previous graphs, indicating that it has the most stable antifungal potency. Conversely, treatments such as P1 show an increase in colony diameter nearly equivalent to the control, and this is reflected in the inhibition graphs, which show percentages approaching zero at 5 and 7 DPI. The similarity in the patterns between the two graphs reinforces the consistency of the data and supports the interpretation that the plant extracts are effective only in the initial phase before their effectiveness wanes.

Observations of the diameter of *Fusarium* sp. fungi under various treatments, including 1800 ppm of Mexican sunflower extract (P1), 3600 ppm of Mexican sunflower extract (P2), 5400 ppm of Mexican sunflower extract (P3), 1800 ppm of zinnia plant extract (P4), 3600 ppm of zinnia plant extract (P5), and 5400 ppm of zinnia plant extract (P6), revealed notable differences compared to the control (P0). These findings suggest that the constituents of Mexican sunflower and zinnia plant extract effectively suppress the growth of *Fusarium* sp. fungi. Secondary metabolites, particularly tannins, found in plants or extracts derived from these parts, demonstrate diverse inhibitory mechanisms against fungal growth (Djaenuddin et al., 2025). The antifungal efficacy of tannins in plants has been extensively documented by several researchers. Studies conducted by Fatma et al. (2021) and Marisa et al. (2022) on papaya leaf extract and sungkai leaf, which contain several secondary metabolites including tannin, have shown that tannin inhibits the growth of the fungus *F. oxysporum in-vitro*. The mechanism of action involves tannin's inhibition of the chitin synthesis process, which is utilized by fungi in the formation of cell walls, and its ability to damage the fungal cell membrane, thereby impeding fungal growth. The defense mechanism against fungi is attributed to a secondary metabolite compound known as tannin. Tannins exhibit antifungal properties by inhibiting the biosynthesis of ergosterol, which is the primary sterol produced by fungi and a crucial component of fungal cell walls (Agidew, 2022). Tannins are ubiquitously present in various parts of plants, including leaves, stems, bark, and fruit (Kato-Noguchi & Kato, 2025).

The findings of this research suggest that plant extracts can effectively suppress pathogen growth during the initial incubation stage, as evidenced by the high inhibition percentage at 1 DPI and the small colony diameter shown in the growth chart. Nevertheless, this effectiveness diminished over time, as indicated by a steady decline in the percentage of inhibition at 3, 5, and 7 DPI. This trend corresponds with the increase in fungal colony size observed in the earlier graph, demonstrating a supportive relationship between the two graphs. Among the treatments, P6 proved to be the most effective in curbing fungal growth, as it consistently showed the highest inhibition percentage and the smallest colony diameter throughout the incubation period. This suggests that P6 (*Z. elegans*) either contains a higher concentration of antifungal agents or possesses a more synergistic blend of bioactive compounds compared to the other treatments. This suggests that the zinnia flower extract is capable of suppressing the growth of *Fusarium* sp. Certain species within the *Zinnia* genus demonstrate potential biological activities, including antifungal compounds. According to research by Samy et al. (2022), zinnia flower extract can produce some flavonoid known as antifungal compounds. Furthermore, research by Wahyuni et al. (2022) indicates that phytochemical analyses of zinnia flowers reveal the presence of secondary metabolites such as flavonoids, saponins, and tannins. Secondary metabolites in plants serve several functions, including: 1) defense against fungi, viruses, bacteria, competing plants, and herbivores; 2) acting as attractants (taste, smell, color) for pollinators and seed-dispersing animals; and 3) providing protection against ultraviolet light and serving as nutrient storage (Divekar et al., 2022).

The significant differences in inhibition between *T. diversifolia* and *Z. elegans* extracts can be explained by the variation in biochemical compounds present in each plant. Han et al. (2024) have identified secondary metabolites, such as alkaloids and flavonoids, in Mexican sunflower plants through phytochemical analyses. Additionally, Kato-Noguchi & Kato, (2025) reported that phytochemical screening of Mexican sunflower extract revealed the presence of flavonoids, tannins, glycosides, terpenoids, and phenols. Further testing with methanol confirmed the presence of saponins and alkaloids in the Mexican sunflower extract. The notably lower inhibition values observed in *T. diversifolia* treatments suggest that its active compounds may necessitate higher purity or synergistic interactions with other components to achieve more effective fungal suppression. Optimization through purification or fractionation may be required to enhance its inhibitory efficacy. Meanwhile, the modest performance of *T. diversifolia* indicates that additional extraction methods or enhancement strategies may be necessary to fully realize its antifungal potential.

Several studies have reported the antifungal potential of plant-derived extracts against *Fusarium* species, including *F. oxysporum* and *F. solani*, with inhibition levels generally ranging from moderate to high depending on plant source and concentration. Previous reports have shown that extracts from medicinal and ornamental plants can suppress *Fusarium* mycelial growth through disruption of cell membrane integrity, inhibition of spore germination, and interference with fungal enzymatic activity. In this context, the markedly higher inhibitory effect observed for *Z. elegans* extract in the present study may be attributed to its richer and more diverse composition of bioactive secondary metabolites, such as phenolic compounds, flavonoids, terpenoids, and other lipophilic constituents known for strong antifungal properties. These compounds are likely to act synergistically, enhancing membrane permeability and impairing essential metabolic processes in *Fusarium* spp., thereby resulting in greater growth suppression compared with *T. diversifolia*. From an applied perspective, the strong in vitro antifungal activity of *Z. elegans* extract highlights its promising potential as a botanical

biofungicide for sustainable disease management. However, the present findings are limited to laboratory conditions, and further studies are required to evaluate its effectiveness under field conditions, assess formulation stability, and determine possible phytotoxic effects on host plants before practical agricultural application can be recommended (Cenobio-Galindo et al., 2024).

The interaction between plant species and concentration was statistically significant, indicating that the enhancement of antifungal activity with increasing concentration varied among species. This interaction highlights the complexity of plant extract behavior, as crude extracts comprise heterogeneous mixtures of active and inactive compounds. While *Z. elegans* demonstrated a substantial increase in inhibition at higher concentrations, *T. diversifolia* exhibited only a moderate improvement, suggesting that its antifungal compounds may be less abundant, less bioavailable, or less synergistic compared to those of *Z. elegans*. These findings underscore the potential of *Z. elegans* as a candidate for further development into plant-based antifungal formulations. Overall, this study contributes to the expanding body of literature on botanical antifungal agents and emphasizes the importance of phytochemical composition in determining extract efficacy. Future studies should incorporate chromatographic profiling (*e.g.*, GC–MS, LC–MS, HPLC) to identify the specific compounds responsible for antifungal activity and explore potential synergistic interactions among phytochemicals.

4. Conclusion

Based on the findings of this study, it can be concluded that extract type and concentration significantly influence the inhibition of *F. verticillioides* growth. *Z. elegans* extract exhibited superior antifungal activity compared to *T. diversifolia*, achieving a maximum inhibition of 32.0% at a concentration of 5400 ppm, while the highest inhibition recorded for *T. diversifolia* was 16.5% at the same concentration. The concentration-dependent increase in inhibition observed for both extracts indicates that higher doses enhance antifungal efficacy, reflecting a clear dose–response relationship.

To strengthen the practical applicability of these findings, further research is recommended to isolate and characterize the active antifungal compounds through fractionation and GC–MS analysis, as well as to elucidate their modes of action. In addition, in vivo and greenhouse evaluations are necessary to confirm efficacy under more realistic conditions and to assess potential phytotoxic effects on host plants. Future studies should also focus on formulation development, including stability testing and delivery methods, to support the potential development of *Z. elegans*-based biofungicide products for sustainable management of *Fusarium*-induced diseases.

Author Contributions: **Asmila Asmila:** Writing—original draft preparation, Methodology, Data curation, Software, Resources, Visualization; **Asti Irawanti Azis:** Conceptualization, Supervision, Methodology, Visualization, Investigation, Writing—review and editing, Formal analysis; **Eka Lestari Ariyanti:** Methodology, Supervision, Project administration, Validation, Funding acquisition; **Ade Sugiarti:** Writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflicts of interest.

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