



Efficacy of Siam weed (*Chromolaena odorata* (L.) R.M. King & H. Rob.) extract in the management of *Fusarium* wilt of pepper (*Capsicum* sp.)

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ABSTRACT

Pepper is an important spice worldwide. Pepper is threatened by *Fusarium* spp. which cause wilt. The use of synthetic fungicides has raised concerns over the harmful threats they pose to man and the environment. The use of botanicals is a better and environmentally friendlier alternative for fungal disease management. *Chromolaena odorata* (siam weed) possesses secondary metabolites which have antimicrobial effects. This study aimed to assess the efficacy of siam weed in the management of *Fusarium* wilt *in vivo*. This study was conducted at the Nursery Section of the Crop Production Department, Prince Abubakar Audu University Anyigba (PAAU). *Fusarium* sp. was isolated from pepper rhizosphere at the Microbiology laboratory, PAAU, following standard procedures. Pathogenicity test was carried out using Koch's postulate. Sterilised soil (5 kg) was inoculated with *Fusarium* sp. (10^7 spores per mL) and left for 48 hours. Aqueous extract was prepared and applied at 0, 5, 10, 15 or 20 % concentrations using sterile needles. Three weeks old pepper seedlings were then transplanted and the experiment was arranged in a Randomized Completely Block Design (RCBD) with five treatments, each replicated four times in the screenhouse. Data were collected on the plant height, number of leaves, number of branches, stem girth and number of fruits. Similarly, disease incidence and severity were assessed. Data were analysed using statistical analysis of variance (ANOVA) and means were separated using the Duncan's Multiple Range Test (DMRT) at 5% level of probability. Results showed that soil treated with 20% w/v extract gave taller plants (30.75cm), higher number of leaves (170.50), higher number of branches (15.85), bigger stem girth (2.21 cm) and more fruits (15.69) compared to untreated soils. Untreated soils caused wilt in pepper seedlings at 6 Weeks After Transplanting (WAT). The highest incidence and severity were observed in untreated soils (65.25% and 6.00, respectively); at 20% w/v incidence (5.55) and severity (0.45) recorded the lowest diseases indices. In this study, 20% w/v aqueous extract of siam weed was the most efficient against *Fusarium* wilt. Preliminary agronomic practices, including the use of siam weed extract, as alternative to synthetic fungicides, can effectively manage this disease in pepper.

Keywords: Aqueous extract, *Capsicum* sp., *Fusarium* wilt, Siam weed, Soil treatment

1.0 INTRODUCTION

Pepper is a warm season, dicotyledonous flowery plant which is widely cultivated as a vegetable belonging to the family, Solanaceae, within the tribe, capsiceae (Barboza *et al.*, 2020). *Capsicum annum*, *Capsicum baccatum*, *Capsicum chinense*, *Capsicum frutescens*, and *Capsicum pubescens* are the most widely cultivated and they do well in a

wide range of soils especially in fertile loamy soils. Seeds are sown in nursery in preferably sterilized soils before transplanting (Grubben and El Tahir, 2004). Pepper is produced and consumed worldwide in many dishes either fresh or dried with its unique pungent characteristic due to the presence of capsaicinoids (Mustafa and Benjamin, 2017). Pepper is used as active ingredients in

cosmetics and pharmaceuticals. The extractable colour from pepper fruits is due to certain unique compounds such as capsanthin, capsorubin, and cryptocapsin which are used greatly in the food processing industry as natural colourant (Baenas *et al.*, 2019)

In spite of its importance, pepper production has been constrained by both biotic and abiotic stresses resulting in drastic reduction in the quality and quantity of production. A variety of fungal pathogens attack pepper, resulting in yield loss. *Fusarium* spp. cause wilting in pepper. Symptoms of *Fusarium* wilt involve wilting of upper leaves which gradually spread to all parts of plant and leaves that remain attached to plant are dark green in colour and red-brown discolouration of vascular tissue (Olowe *et al.*, 2018). As the disease progresses, it eventually results to the death of pepper plant. As with many fungal and bacterial diseases, *Fusarium* wilt is favoured by high soil moisture content (CABI, 2018; Jennifer *et al.*, 2023). There have been reports of 100 % loss of pepper plants when this disease is left unmanaged (Ikechi-Nwogu *et al.*, 2021). As a result, farmers rely heavily on synthetic fungicides to manage infection. However, these fungicides like all other synthetic pesticides are damaging to man's health and the ecosystem. Plant extracts are being increasingly explored for their antimicrobial effects against pests and have been confirmed to be environmentally friendly and risk-free on man's health. They are easily accessible, relatively cheap and better alternatives to the synthetic pesticides (Agbaji *et al.*, 2022). Siam weed (*Chromolaena odorata*) possesses phytochemicals such as phenols, methyl and hexadecanoic acid derivatives which have antimicrobial abilities and are not phytotoxic (Huang *et al.*, 2022). Both aqueous and solvent extracts of siam weed can suppress the growth of fungi responsible for diseases such as leaf spots, wilts, and rots, as well as bacteria that cause plant infections (Naruemon *et al.*, 2025)

1.1 Objective of the study

The objective of this study was to assess the efficacy of siam weed (*Chromolaena odorata*) in the management of *Fusarium* wilt in pepper

2.0 MATERIALS AND METHODS

2.1 Experimental location

The experiment was carried out at the Nursery section, Faculty of Agriculture, Prince Abubakar Audu, University Anyigba.

2.2 Sources of experimental materials

Chromolaena odorata was obtained from the Students Research and Demonstration Farm and was confirmed at the department of Botany Prince Abubakar Audu, University Anyigba by comparing the botanical available in the International Plant Names Index (IPNI) database with ID number (57443-2). Pepper seeds (NHP1008) were obtained from the Nigerian Institute of Horticulture (NIHORT) Research Station Jericho, Ibadan, Oyo State.

2.3 Experimental design and treatment

The experiment was laid out in a Randomised Complete Block Design (RCBD) with five treatment levels (0%, 5%, 10%, 15%, and 20%) and replicated four times

2.4 Preparation of *Fusarium* spore solution

The spore suspension of the fungus was prepared following standard protocol (Akinbode, 2013). The mycelial mass of the fungus growth culture was scooped into a sterile flask, filtered, and counted using a haemocytometer. The suspension was pipetted into counting chambers and counted in four corner squares. The spore concentration was calculated using the equation $\text{Spores/mL} = (n) \times 10^4$ where: n = the average cell count per square of the four corner squares counted. The final spore count and desired inoculum concentration were determined (Berkane *et al.*, 2002). Sterilized soil (5 kg) was inoculated with *Fusarium solani* (10^7 spores per mL) and left for 48 hours.

2.5 Plant extract and soil sample preparation

Aqueous solution of the sample was prepared by rinsing freshly harvested *Chromolaena odorata* in four changes of sterile distilled water, air-dried, and

finely ground into smooth particles using an electrical grinding machine (GX160 Petrol Engine). The extract was measured into different conical flasks using a weighing scale (Model WS 1700CB). Sterile distilled water (100 mL) was added to thoroughly ground *Chromolaena odorata* in order to obtain varying percentage concentrations (0%, 5%, 10%, 15%, or 20%). The solutions were each homogenised carefully and thoroughly using an electric shaker (USBC Rechargeable 7000rpm Mixer). The mixtures were then added to the soil already inoculated with spores of the fungal isolate (Engalycheva *et al.*, 2024). The soil samples collected were sterilized, air-dried and analyzed and then filled into polythene bags (5 Kg).

2.6. Sowing and Seed rate

Pepper seeds (NHP1008) were raised in the nursery and then transplanted into the polythene bag. The seeds were sown at two stands per pot and correspondingly tagged.

2.7. Data Collection

Data were collected at 2, 4, 6, 8, and 10 weeks after sowing on plant height, number of leaves, number of branches, and stem girth, for varying concentrations (0 g, 5 g, 10 g, 15 g, 20 g) of *Chromolaena odorata* extract

2.7.1 Growth parameters measured

Plant height: This was determined by measuring the height of the plant from the ground level to the

apical tip of the plant using the meter rule.

Number of branches per plant: This was determined by visually counting the number of branches of each plant at 2, 4, 6, 8, and 10 weeks.

Number of leaves per plant: This was obtained by physical counting of leaves at 2, 4, 6, 8 and 10 weeks

Stem girth. This was obtained by measuring the stem girth using a Vernier caliper

2.8. Effect of varying percentage concentrations of siam weed extracts on incidence and severity of *Fusarium* wilt in pepper

Disease incidence and severity were symptomatically observed among pepper plants. Visual observations were made and comparisons were made (Agrios. 2005). Disease incidence was determined as reported by Popoola *et al.* (2015)

$$DI = (n / N) \times 100$$

Where, DI = Disease Incidence
n = Number of diseased plants
N = Total number of plants observed.

Disease severity was calculated using;
Disease severity (%) = $\sum [(n \times V) / (6 \times N)] \times 100$

Where, n: number of diseased plants, V: numerical grade of diseased plants, N= total number of plants examined in each treatment, 6= the highest grade of infection category (Popoola *et al.*, 2015). Disease severity was determined using the rating scale presented in Table 1 below.

Table 1: *Fusarium* wilt rating scale for pepper plants

1.	Symptomless
2.	5% leaves showing yellowing and wilting
3.	6-10% wilting and yellowing of leaves
4.	11-12% leaves showing symptoms
5	21-50% leaves wilting with yellow-brown bicolouration
6.	50% leaves dying and drying of plant

2.10 Statistical Analysis

All the data collected during the experiment were subjected to analysis of variance (ANOVA) and the means were separated using Least Significant Difference at 5% level of probability ($LSD_{0.05}$)

3.0 RESULTS

3.1. Morphological identification of *Fusarium* sp.

Plate 1. shows the morphological identification of *Fusarium* sp. in this experiment. The isolate was septate, and possessed hyaline hyphae that formed a well-developed mycelium. Mycelia were white, and fairly dense and cottony. The cultures grew fast on PDA (3- 4 days) with mycelia up to 3-4 cm. Spores were canoe- or sickle-shaped with pointed ends.

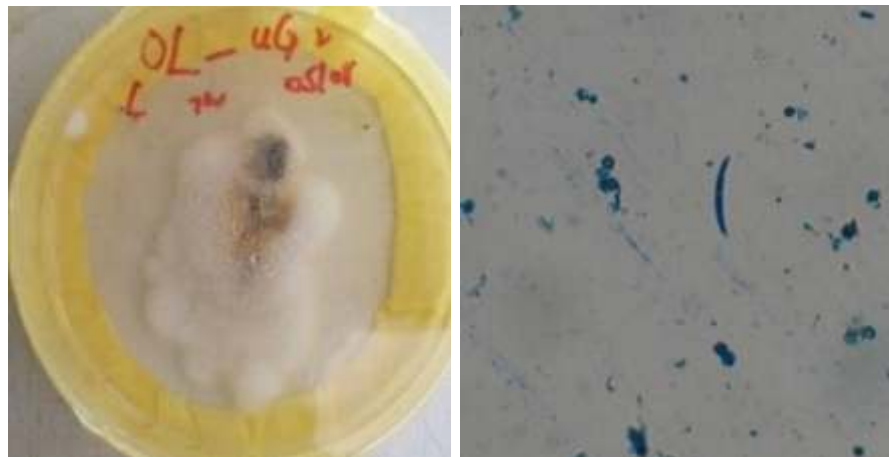


Plate 1. Pure culture and photomicrograph of *Fusarium* sp.

3.2 Impact of siam weed extract against *Fusarium* sp. on the plant height of pepper

The impact of siam weed extract on the height of pepper plants in response to *Fusarium* wilt is shown in Figure 1. There were significant differences from 4 weeks after transplanting (WAT), soils treated with 5% w/v extract produced taller plants (11.50 cm) compared with control (1.7 cm) and at 20% w/v, the tallest plants (13.00 cm) was recorded. At 10 WAI, the highest plant height (30.75 cm) was recorded at 20% w/v concentration.

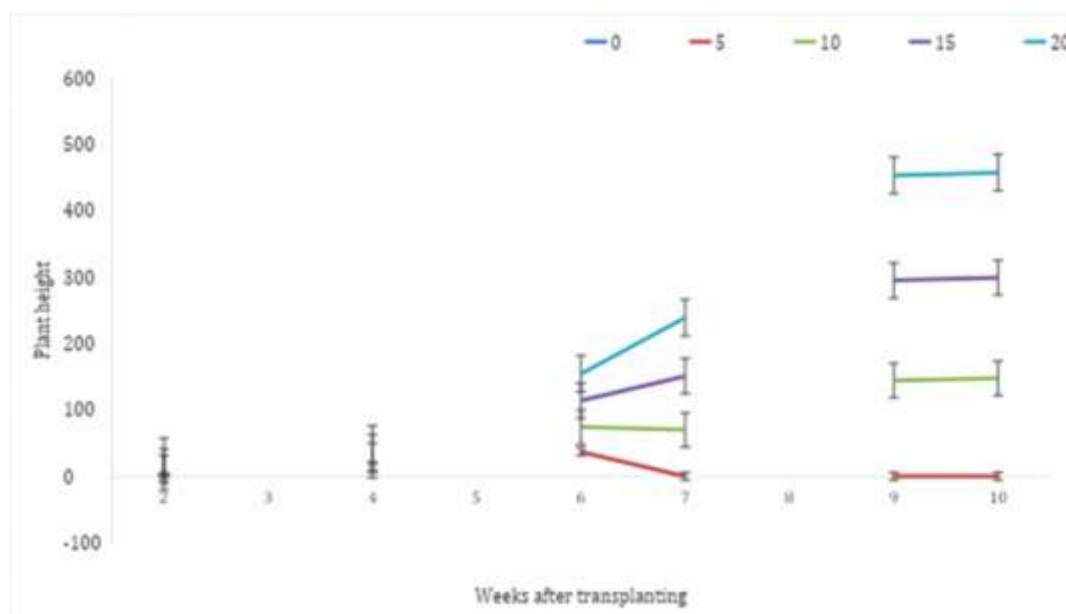


Figure 1. Plant height of pepper (*Capsicum* sp.) as influenced by siam weed extract against *Fusarium* sp.

3.3. Number of leaves of pepper (*Capsicum* sp.) as influenced by siam weed extract against *Fusarium* sp.

The effect of siam weed extract in the management of pepper plant on the number of leaves is shown in Figure 2. Number of leaves in pepper plants significantly increased, especially at higher concentrations. At 20 % w/v, the number of leaves of pepper significantly increased (14.00) at 4 WAT compared with the control. At 20% w/v, number of leaves significantly increased (170.5) At 10 WAT.



Fig 2. Number of leaves of pepper (*Capsicum* sp.) as influenced by siam weed extract against *Fusarium* sp.

3.4. Number of branches of pepper (*Capsicum* sp.) as influenced by siam weed extract against *Fusarium* sp.

The influence of siam weed extract in the control of fusarium wilt of pepper on the number of branches is shown in Figure 3. At 20 % w/v, the number of branches (15.15 and 15.85) was significantly higher compared with the controls (4.13 and 5.71) at 8 and 10 WAT, respectively.

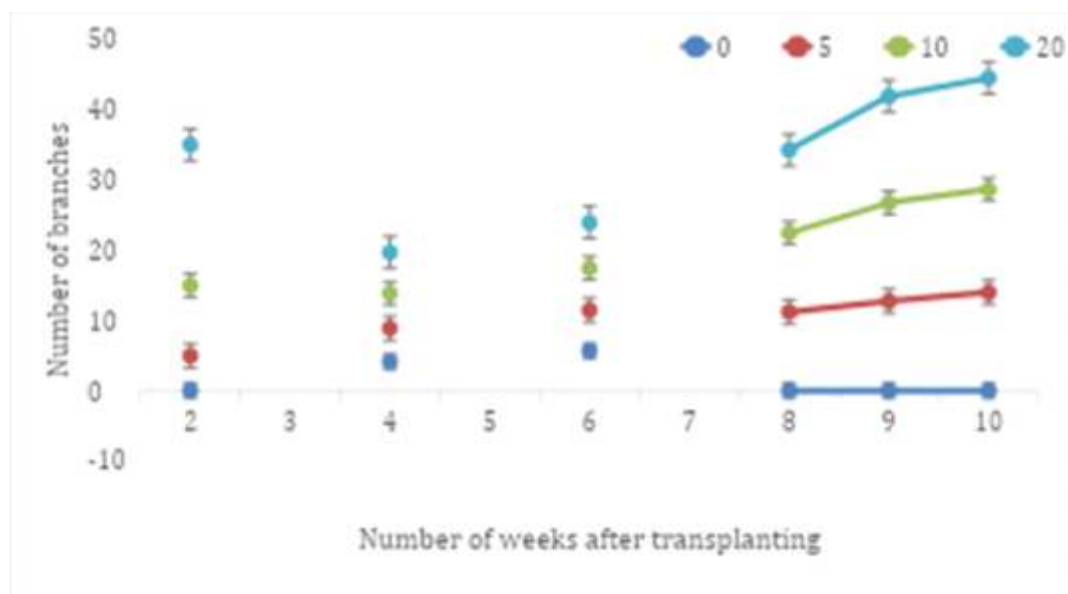


Fig 3. Number of branches of pepper (*Capsicum* sp.) as influenced by siam weed extract against *Fusarium* sp.

3.5. Stem girth of pepper (*Capsicum* sp.) as influenced by siam weed extract against *Fusarium* sp.

The effect of siam extract on stem girth in pepper plants is represented in Figure 4. At 20 % w/v, there were significant increases in stem girth compared with controls across the weeks. At 8 WAT (1.93 cm) and 10 WAT (2.21 cm) there were significant increases compared with controls (0.75 cm) and (1.45 cm), respectively.

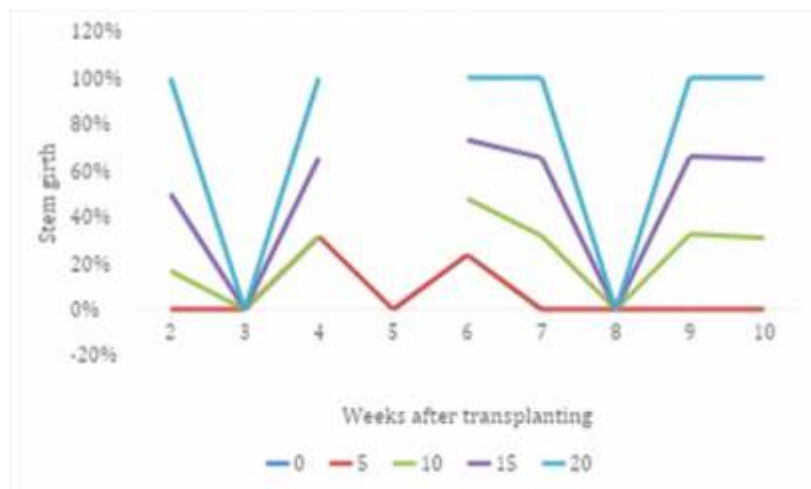


Fig 4. Stem girth of pepper (*Capsicum* sp.) as influenced by siam weed extract against *Fusarium* sp.

3.6. Number of fruits of pepper (*Capsicum* sp.) as influenced by siam weed extract against *Fusarium* sp.

The impact of siam extract in the management of *Fusarium* wilt on the number of fruits of pepper is shown in Table 5. The study demonstrated at 20 % w/v, at 8 WAT (10.68) and 10 WAT (15.69) there were significantly higher number of fruits produced compared with controls (3.71) and (4.82), respectively.

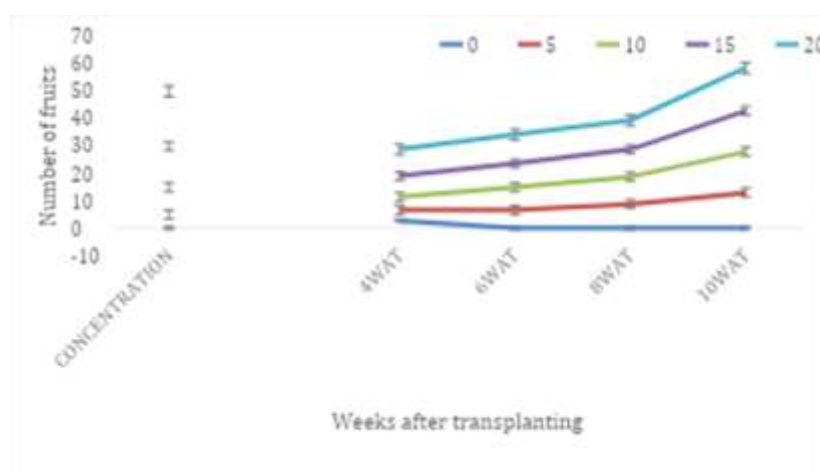


Fig 5. Number of fruits of pepper (*Capsicum* sp.) as influenced by siam weed extract against *Fusarium* sp.

3.7. Incidence and severity of *Fusarium* wilt infecting pepper under varying siam weed concentrations

The Incidence and severity of *Fusarium* wilt infecting pepper under varying soil concentrations of siam weed is shown in Table 2. At 5% w/v, the incidence (40.90 %) and severity (4.86) were recorded. At 10 % w/v incidence (28.73%) and severity (4.14) were observed. At 15 % w/v, incidence (20.12%) and severity (3.10) were reported while at 20 % w/v, incidence (5.5%) and severity (0.4) showed the most significant reductions among the concentrations.

Table 2. Incidence and Severity for *Fusarium* wilt of pepper treated with siam weed extract

Siam weed concentrations. (%)	Disease incidence	Disease severity
0	65.25 ^a	6.00 ^a
5	40.90 ^b	4.86 ^b
10	28.73 ^b	4.14 ^b
15	20.12 ^b	3.10 ^b
20	5.55 ^c	0.45 ^c

Means with the same alphabet are not significantly different from each other in the same column (P ≥ 0.05)

4.0 Discussion

Fusarium wilt is a great threat to pepper production in Nigeria (Agbaji and Aduramigba, 2025). The findings of this study are generally consistent with earlier reports on the antifungal potential of *Chromolaena odorata* and its role in plant disease management (Odutayo *et al.*, 2017; Okhonlaye Ojokoh *et al.*, 2022). The significant reduction in disease incidence and severity of *Fusarium* wilt observed in treated soils aligns with previous studies that have demonstrated the inhibitory effects of plant-derived extracts on *Fusarium* spp (Othman *et al.*, 2019; Naruemon *et al.*, 2025) This antifungal activity of the botanical is attributed to the presence of bioactive compounds such as flavonoids, phenolics, and terpenoids (Aadil, 2020), which interfere with fungal growth and pathogenicity (Chaachouay and Zidane, 2024; Kiri *et al.*, 2024). Botanicals can serve as viable alternatives to synthetic fungicides (Agbaji *et al.*, 2020). This study corroborates these findings as it demonstrated the efficacy of *C. odorata*.

It was observed in this experiment that the plots that were not treated with siam weed extract wilted before fruit emergence. This study demonstrated the importance of *Fusarium* wilt management

before pepper transplanting. This agrees with earlier reports that late control of wilt in pepper resulted in a 100% destruction of pepper plants (El-Kazzaz *et al.*, 2022). The virulence of the fungus is as a result of toxin production, cell wall-degrading enzymes, and effector proteins that suppress plant immunity (Tilahun *et al.*, 2026)

The concentration rate of 20% (w/v) extract produced the most significant disease suppression and thereby, improved plant growth. This is in agreement with earlier findings that higher concentrations of plant extracts generally exhibit stronger antimicrobial effects (Patrick *et al.*, 2018; Fotsing *et al.*, 2022). However, while many previous studies have focused primarily on in vitro inhibition (Allemailem, K. 2021; Garba *et al.*, 2022; Kamila and Klaudia, 2025), this study demonstrated the *in vivo* effectiveness of siam weed under greenhouse conditions. The observed improvement in agronomic parameters such as plant height, leaf number, and fruit yield in soils treated with this extract also agrees with reports suggesting that reduction in pathogen load often translates into better plant performance (Agbaji *et al.* 2022; Hilal *et al.*, 2024). Some earlier studies have even suggested that in addition to its microbial effect, *C. odorata* may exhibit mild growth-promoting properties due to its

phytochemical composition (Thanatsan *et al.*, 2021; Kato-Noguchi and Kato, 2023; Sookying *et al.*, 2026)

While the present results show very low disease incidence and severity at 20% concentration, some earlier studies have recorded less pronounced effects, particularly under variable environmental conditions obtainable on the field (Otabor *et al.*, 2025; Vo *et al.*, 2025). This discrepancy may be due to differences in extraction methods pathogen strain variability, environmental factors, or application techniques.

Furthermore, unlike some studies that highlight potential phytotoxic effects of high botanical concentrations (Nirgundikar *et al.*, 2021; Poonpaiboonpipat *et al.*, 2021), no adverse effects on pepper growth were observed even at 20% (w/v) in this experiment. This suggests that siam weed extract is relatively safe for *Capsicum* spp. at the tested concentrations reported in this experiment. In contrast to synthetic fungicides, whose environmental and health risks are well documented (Muñoz-Bautista *et al.*, 2025; Verdadero *et al.*, 2025), the findings of this study corroborate previous studies that plant-based extracts offer a more sustainable and eco-friendly approach to disease management.

5.0 Conclusion

Fusarium spp. significantly threaten pepper production in Nigeria. The *in vivo* effectiveness of *C. odorata* was confirmed in this study. At 20 % (w/v), siam extract effectively managed the effect of *Fusarium* wilt in pepper. The efficacy of this botanical was confirmed in the low disease incidence and severity as well enhanced growth and yield recorded in soils treated with the extract. Botanicals are safer and better alternatives to synthetic pesticides.

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