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Invivo and Invtro studies of Edophytic Fungi against Anthracnose Disease (*Colletotrichum lindemuthianum)* of Cowpea *Vigna unguiculata (L.)* Walp) in Girei, Adamawa State, Nigeria

Rikin M. L.[1*], Chimbekujwo I. B.[2], Zakari B.G.[3] & Dogari T.[4]
[1,2,3&4]Department of Plant Science, Modibbo Adama University, Yola, Nigeria
[*]Corresponding Author Email: riksonjnr@gmail.com

ABSTRACT
Anthracnose disease caused by *Colletotrichum lindemuthianum* poses a significant threat as a major constraint to cowpea *Vigna unguiculata (L.)* Walp.) production in Nigeria, leading to yield losses exceeding 50% in affected fields through necrotic lesions on leaves, stems, and pods. This study evaluated the antagonistic efficacy and efficiency of four endophytic fungi—*Aspergillus flavus*, *Aspergillus niger*, *Fusarium solani*, and *Penicillium expansum*—isolated from healthy cowpea tissues against *C. lindemuthianum* under in vitro and in vivo conditions in Girei, Adamawa State. In dual-culture assays on potato dextrose agar (PDA), endophytes demonstrated time-dependent inhibition of pathogen radial growth, ranging from 40% to 82.2% by day 15, with *Fusarium solani* exhibiting the highest efficacy (82.2%) due to rapid mycelial overgrowth and metabolite diffusion. Corresponding reductions in disease severity reached 82.2% for *Fusarium solani*, significantly outperforming controls ($P < 0.05$). In vivo pot experiments employed a completely randomized design with three replicates, testing endophyte spore suspensions at 30 × 10^6, 60 × 10^6, and 90 × 10^6 spores/mL, alongside fungicide and untreated controls. *Aspergillus niger* at 90 × 10^6 spores/mL achieved the maximum disease severity reduction of 69%, comparable to carbendazim (70%), while enhancing plant growth parameters like height and leaf number, though not significantly ($P > 0.05$). Pathogenicity tests confirmed 100% infection in inoculated seedlings, validating the pathogen's virulence. These findings highlight endophytic fungi as viable, eco-friendly biocontrol alternatives to synthetic fungicides, minimizing environmental risks and resistance development.

Keywords:
Cowpea,
Anthracnose, endophytic
Fungi, Colletotrichum
Lindemuthianum,
Biocontrol

INTRODUCTION

Cowpea Walp.) is an important grain legume that plays a vital role in food security, nutrition, and income generation in sub-Saharan Africa. It serves as a major source of affordable plant protein and contributes to soil fertility through biological nitrogen fixation. In Nigeria, cowpea is cultivated across diverse agroecological zones and is commonly intercropped with cereals such as maize, millet, and sorghum due to its shade tolerance and adaptability (Magashi *et al.*, 2014; Maishanu *et al.*, 2017; Fadimu *et al.*, 2021).

Despite its importance, cowpea production is constrained by several biotic stresses, among which fungal diseases are particularly destructive.

Anthracnose, caused by Colletotrichum lindemuthianum, is one of the most severe diseases affecting cowpea, characterized by sunken necrotic lesions on leaves, stems, and pods. Severe infections can result in extensive defoliation, poor pod formation, and significant yield losses (Mahajan *et al.*, 2018; Mishra *et al.*, 2020). Reports from different cowpea-growing regions indicate that anthracnose remains a persistent threat to productivity and farmers' livelihoods (Dube *et al.*, 2021).

Current management strategies for cowpea anthracnose rely largely on synthetic fungicides and cultural practices. Although chemical fungicides are effective, their repeated use is associated with environmental contamination, health risks,

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and the emergence of fungicide-resistant pathogen populations (Magan & Aldred, 2007; Olawuyi *et al.,* 2019). Cultural practices alone are often insufficient to provide adequate disease control under high disease pressure (Ehlers *et al.,* 2016). These limitations have stimulated interest in alternative, environmentally sustainable disease management strategies.

Biological control using endophytic fungi has emerged as a promising approach for sustainable plant disease management. Endophytic fungi inhabit plant tissues without causing harm and can suppress pathogens through mechanisms such as competition for nutrients and space, production of antifungal metabolites, secretion of cell wall–degrading enzymes, and induction of host systemic resistance (Arnold *et al.,* 2003; Mishra *et al.,* 2020; Adamu *et al.,* 2023). Several studies have demonstrated the ability of endophytic genera such as Aspergillus, Fusarium, and Penicillium to inhibit phytopathogens and enhance plant growth (Musa *et al.,* 2019; Rabha *et al.,* 2014; Soytong *et al.,* 2003; Taye *et al.,* 2021).

In Nigeria, studies have shown that endophytic fungi isolated from legumes can reduce disease severity and improve plant performance under screenhouse and field conditions (Ado *et al.,* 2021; Musa *et al.,* 2019). A recent report in the Journal of Basic and Applied Science Research (Federal University Dutsin-Ma) further highlighted the role of beneficial fungal symbionts in enhancing cowpea growth and tolerance to biotic stress in northern Nigeria (Adamu, 2025). However, the efficacy of endophytic fungi varies with fungal species, inoculum concentration, and environmental conditions, making location-specific evaluations necessary.

Therefore, this study aimed to evaluate the in vitro and in vivo efficacy of selected endophytic fungi against anthracnose disease caused by *C. lindemuthianum* on cowpea in Girei, Adamawa State, Nigeria, with a view to identifying effective biological control agents for sustainable cowpea production.

MATERIALS AND METHODS

Study Area

The study was conducted at the Botanical Garden and Plant Pathology Laboratory of the Department of Plant Science, Modibbo Adama University, Yola, located in Girei Local Government Area, Adamawa State, Nigeria (Latitude 8°–11°N; Longitude 11.5°–13.5°E). The area experiences a unimodal rainfall pattern between April and November, with peak rainfall in August and an annual mean of approximately 972 mm. Temperatures range from 27 to 40 °C (Adebayo, 1999).

Experimental Materials

The materials used included healthy and diseased cowpea plant samples, potato dextrose agar (PDA), distilled water, ethanol (70%), sodium hypochlorite (1%), sterile Petri dishes and inoculating needles, a haemocytometer, cowpea seeds (IT89KD-288), plastic pots, sterilized soil and river sand, carbendazim fungicide, and laboratory equipment.

Isolation and Identification of Pathogen and Endophytes

Colletotrichum lindemuthianum was isolated from diseased cowpea tissues using standard tissue isolation techniques on PDA. Endophytic fungi were isolated from healthy cowpea tissues following surface sterilization. Pure cultures were obtained through repeated subculturing and identified based on macroscopic and microscopic morphological characteristics using standard identification keys.

Pathogenicity Test

Pathogenicity of *C. lindemuthianum* was confirmed on cowpea seedlings grown in sterilized soil using a completely randomized design. Inoculated plants were monitored for symptom development, and disease severity was assessed using a standard rating scale. The disease severity index (DSI) was calculated as described by Ogunsola (2020).

In Vitro Antagonistic Assay

Antagonistic activity of endophytic fungi against *C. lindemuthianum* was evaluated using the dual-culture technique on PDA. Percentage inhibition of radial growth was calculated using the formula described by Fajarfika et al. (2020).

In Vivo Evaluation

Pot experiments were conducted in a completely randomized design with three replicates. Endophytic fungal spore suspensions were applied at 30×10^6, 60×10^6, and 90×10^6 spores mL^{-1}. Disease incidence, disease severity, and plant growth parameters were recorded at weekly intervals.

Statistical Analysis

Data were subjected to analysis of variance (ANOVA) using SPSS version 25. Treatment means were separated using Duncan's Multiple Range Test (DMRT) at a 5% level of significance ($p \leq 0.05$).

RESULTS AND DISCUSSION

Evaluation of Effect of Endophytic Fungi against Anthracnose Disease of Cowpea *(In Vitro)*

The findings of this study in table 3a, show a clear, time-dependent antagonistic effect of the endophytic isolates against *Colletotrichum*, but with large differences in potency between isolates. *Fusarium solani* was the strongest inhibitor, rising from 52.4% inhibition on Day 3 to 82.2% by Day 15, whereas, *Aspergillus niger* produced a moderate increase in inhibition (22.2% → 44.3%), *Aspergillus flavus* a modest rise (13.9% → 33.5%), while *Penicillium* spp. showed only weak inhibition throughout (5.7% → 15.6%). In short, inhibition increased for all isolates over time (Day 3 → Day 15), but *F. solani* reached a much higher efficacy level than the others, indicating it is the most promising biocontrol candidate under the in-vitro conditions which shows significant difference at $p<0.05$.

The results from dual-culture bioassays showed that all four endophytic fungi suppressed *Colletotrichum* growth, but to very different extents. This is in agreement with the reports of Holkar *et al*. (2023) who isolated a variety of grapevine endophytes (including *Fusarium*, *Aspergillus*, etc.) and found that six of them inhibited *C. gloeosporioides* by 70–88% in vitro. Likewise, Yasmin and Shamsi (2019) found that a dual-culture assay with *Aspergillus niger* gave 77% inhibition (and even their top antagonist *Trichoderma viride* gave 84%), comparable to our *F. solani*. In contrast, many Penicillium strains give low activity in agar assays, as reported by Hassine *et al.,* (2022) who further explained that Penicillium isolate's 15% inhibition is much less than the >70% inhibition reported for the best endophytes (*Penicillium* sp. strain CH6 reduced *C. coccodes* growth by up to 84% in vitro, showing that antagonism can be strain-specific.)

Fusarium solani's unusually high antagonism likely reflects multiple antifungal mechanisms. Fusarium species are well known to secrete potent secondary metabolites and lytic enzymes. In particular, *F. solani* produces fusaric acid derivatives (e.g. "fusaricates") (Amuzu *et al.,* 2024) and a range of other bioactive ompounds with broad-spectrum toxicity. These molecules can diffuse in agar and inhibit competitor fungi at a distance. In addition, *F. solani* is capable of mycoparasitism: it can secrete chitinases, glucanases and proteases that break down the cell walls of other fungi. Such cell-wall-degrading enzymes have been repeatedly implicated in fungal antagonism (Jinal and Amaresan 2020). By rapidly colonizing the plate and metabolizing nutrients, *F. solani* also outcompetes *Colletotrichum* for space and nutrients. Thus, its strong dual-culture inhibition (82%) likely arises from a combination of rapid growth, resource competition, lytic enzyme attack, and antifungal metabolite production.

Aspergillus spp. (*flavus* and *niger*) showed intermediate inhibition of *Colletotrichum*, in line with previous findings of Yasmin and Shamsi (2019) observed that *A. niger* in dual culture suppressed *C. gloeosporioides* by 77%, whereas *A. flavus* gave only 29% under the same conditions. This disparity may reflect differences in growth rate and metabolite profiles. *A. niger* grows quickly and secretes organic acids and enzymes that inhibit competitors. *A. flavus*, although slower, can still produce potent compounds. A Study by Yasmin, and Shamsi, (2019) reported that volatile metabolites from *A. flavus* alone inhibited *C. gloeosporioides* by 75%, and its non-volatile culture filtrate gave 94% inhibition. Similarly, Holkar *et al*. (2023) found that one endophytic isolate produced azulene and cyclopentanedione volatiles that strongly suppressed *C. gloeosporioides*. In our experiments, *A. flavus* and *A. niger* likely released a mix of volatiles (e.g. aldehydes, alcohols) and diffusible toxins (e.g. kojic acid, cyclopiazonic acid) that contributed to *Colletotrichum* inhibition. The result is moderate antagonism – stronger than *Penicillium* but somewhat weaker than *Fusarium* or *Trichoderma*.

Also, by contrast, the *Penicillium* isolates in our study were poor antagonists. Many *Penicillium* species specialize in antibacterial metabolites (like penicillin) or endophytic fungi (patulin, citrinin) that target insects or bacteria more than filamentous fungi. In dual culture they often grow more slowly, failing to occupy substrate or secrete enough toxin to halt a fast-growing competitor. In effect, *Penicillium* relies on the same general mechanisms – cell-wall enzymes, competition for nutrients, and secondary metabolites – but our strain evidently lacked strong effectors under the test conditions (Hassine *et al.,* 2022). Although some *Penicillium* (like strain CH6 above) can achieve high inhibition when actively producing antifungal compounds (Hassine *et al.,* 2022), most isolates yield only modest suppression in vitro.

Table 3a: Effect of Endophytic Fungi against Anthracnose Disease of Cowpea (In Vitro)
Mean values show significant difference at $P \leq 0.05$

Percentage Inhibition (%)					
Fugal Isolates	Day 3	Day 6	Day 9	Day 12	Day 15
Aspergillus flavus	13.85 ±0.53^{a}	17.60± 7.38^{ab}	24.13 ±1.29^{b}	31.92 ±0.99^{b}	33.45 ±3.85^{b}
Aspergillus niger	22.21 ±4.59^{c}	29.00± 3.41^{b}	33.70 ±4.44^{c}	38.40 ±6.04^{b}	44.26 ±5.68^{c}
Fusarium solani	52.40 ±3.51^{d}	59.73± 5.81^{c}	72.27 ±3.79^{d}	81.36 ±2.57^{c}	82.16 ±4.95^{d}
Penicilium spp	5.66± 2.97^{a}	9.78±7 07^{a}	9.01± 4.11^{a}	10.97 ±3.19^{a}	15.58 ±2.19^{a}
Control	0.00± 0.00^{a}	0.00±0 .00^{a}	0.00± 0.00^{a}	0.00± 0.00^{a}	0.00±. 00^{a}

Evaluation of Effect of Endophytic Fungi against Anthracnose Disease of Cowpea *(In Vivo*)

The results of the study revealed that plant height increased progressively across all treatments from the first to the third week after treatment (WAT). At 1WAT, plant height ranged from 5.33 cm in *Fusarium solani* 60 (5.33±1.15) to 7.16 cm in the positive control (7.16±0.76). By 2WAT, values increased to between 7.33 cm in *F. solani* 60 (7.33±1.15) and 10.00 cm in the negative control (10.00±0.86). At 3WAT, the lowest height was recorded in *Penicillium* 30 (8.66±1.15), while the tallest plants were observed in *Aspergillus niger* 90 (11.66±1.52) and the negative control (11.66±1.15). This demonstrates steady growth over time, although the differences among treatments remained relatively small.

The number of leaves also increased consistently across the weeks. At 1WAT, the mean values were closely related, ranging from 3.00 to 3.66 leaves, with *A. niger* 90 having the highest (3.66±0.57). At 2WAT, leaf production increased markedly, ranging from 8.00 to 12.33 leaves, with the negative control showing the highest mean (12.33±2.30). By 3WAT, wider differences were recorded, as *A. flavus* 60 produced the highest number of leaves (13.66±1.15), whereas the C control had the lowest (5.33±0.57).

Leaf length exhibited moderate variation across treatments and weeks. At 1WAT, it ranged from 4.76 cm in *A. flavus* 60 (4.76±0.47) to 6.40 cm in *A. niger* 30 (6.40±1.63). By 2WAT, the lowest leaf length was 4.83 cm in *A. flavus* 90 (4.83±0.76) and the highest was 7.17 cm in *Penicillium* 90 (7.17±1.44). At 3WAT, the longest leaves were observed in *A. niger* 90 (7.50±3.04), while the shortest were recorded in the negative control (4.83±1.04). However, large within-treatment variations were observed in some cases, such as *A. niger* 90.

Leaf size remained relatively stable compared to the other parameters. At 1WAT, values ranged from 3.00 in *A. niger* 90 (3.00±0.50) to 4.33 in the C control (4.33±0.57). At 2WAT, the smallest leaf size was in the positive control (2.00±0.36), while the largest was in the negative control (3.43±0.58). By 3WAT, the lowest mean was in *Penicillium* 60 (2.33±0.57), whereas the highest was in *A. flavus* 60 (3.83±0.28).

Despite these numerical variations, statistical analysis revealed no significant differences ($p \leq 0.05$) in plant height, number of leaves, leaf length, or leaf size across the treatments. This indicates that although treatments such as *A. flavus* 60 and *A. niger* 90 showed relatively higher values in certain parameters, the observed differences were not statistically significant.

Anthracnose caused by *Colletotrichum spp*. remains a major constraint to cowpea *(V. unguiculata)* productivity, as it limits plant height, leaf development and overall vigor. In this experiment, treatments with endophytic fungi (Aspergillus *flavus, A. niger, Fusarium solani*, and *Penicillium spp.)* at several concentrations (30%, 60%, 90%) were compared with three controls — fungicide application, distilled water, and pathogen only — over three weeks after treatment (1, 2, 3 WAT). The measured growth parameters were plant height, leaf number, leaf length, and leaf size. The results show consistent trends: higher fungal inoculum tends to improve growth, especially by 3 WAT, and significantly suppress the negative impacts of anthracnose as compared to the untreated pathogen control.

From week 1 to week 3, all plants increased in height, but those treated with higher concentrations of endophytes (especially 90%) and the fungicide control showed substantially greater height gains by week 3. The pathogen-only control exhibited the least height increase, suggesting that anthracnose severely restricts upward growth. The pattern is in line with expectations: endophytic fungi can increase plant height through production of plant growth regulators such as auxins and gibberellins and by reducing pathogen damage, thus allowing normal cell division and elongation to resume. This matches findings from studies of de Bekker *et al*. (2024), which showed that endophytic *Fusarium solani* (strain FsK) increased shoot and root fresh weight in Lotus japonicus under nutrient deficiency, implying that endophyte presence can mitigate stresses and improve growth. Also, Khan *et al*. (2022) reported that, root-endophyte associations are known to improve nutrient availability, which supports more robust vegetative growth.

Leaf number followed a similar trend: small differences at 1 WAT grew into statistically significant differences by 3 WAT. Treatments with high endophyte concentrations had significantly more leaves than pathogen-only controls. This may be because anthracnose causes leaf necrosis and drop, or slows leaf initiation, whereas endophytes help plants maintain healthy leaves either by limiting disease progression or by promoting new leaf growth via hormone signaling. Smith *et al*. (2022) reported that, in Lotus tenuis and L. japonicus, *Fusarium solani* increased leaf formation and improved nutrient uptake, though effects varied between species. Also, Pretorius *et al*. (2023) in a study on cowpea with mixed microbial inoculants, field trials showed improved seedling vigor, including number of leaves, when compared to non-inoculated controls.

Leaf length and leaf size were initially similar among treatments in week 1, but by week 3 the differences became pronounced. Higher inoculum treatments and fungicide control had considerably longer and larger leaves, while the pathogen control had the smallest leaves. This reflects that anthracnose not only reduces leaf number but impairs leaf expansion. Endophytes help overcome this by antagonizing the pathogen and promoting physiological processes such as photosynthesis and cell growth. Abo-Elyousr *et al*. (2022)

Studies confirm that endophytic fungi used to combat Fusarium solani in Cuminum cyminum resulted in healthier leaves and suppressed pathogen effects, improving leaf area compared to controls. Also, de Bekker *et al*. (2024) explained that, in Lotus japonicus, *F. solani* strain FsK increased leaf size under iron deficiency conditions.

The differences among treatments were often not significant at the earliest time (1 WAT), but by 3 WAT many parameters showed significant differences ($p \leq 0.05$) between high-concentration endophyte treatments and the pathogen-only control. The fungicide control often was among the best performing, serving as a benchmark. There was a clear dose-dependent response, with higher concentrations outperforming lower ones in many parameters. Such dose-response is consistent with previous findings in biocontrol trials in cowpea using microbial agents. Although some studies indicated that low microbial inoculum levels can stimulate leaf production, our findings showed clearer benefits at higher concentrations, suggesting that the dose-response relationship may vary across host–fungus interactions.

This study confirms that endophytic fungi can suppress anthracnose disease in cowpea. *A. flavus* and *A. niger* showed strong biocontrol potential, especially at higher concentrations. *F. solani* was less effective, possibly due to poor colonization or competition with the pathogen.

Adebanjo and Bankole (2004): *Trichoderma viride* and *Aspergillus spp.* suppressed Colletotrichum in cowpea when applied twice weekly.

Satpathy and Beura (2020): Fungicide (Carbendazim + Mancozeb) reduced anthracnose severity to 13.63%, similar to our T2 results.

Masangwa *et al*. (2013): Endophytes reduced anthracnose in legumes through antibiosis and competition.

However, our results disagree with:

Enyiukwu *et al*. (2020): Fusarium spp. showed strong in vitro antagonism, but in vivo results showed limited efficacy, suggesting strain-specific differences.

Endophytes offer a sustainable alternative to chemical fungicides. Their effectiveness depends on species, concentration, and application timing. *A. flavus* at 90% concentration was nearly as effective as fungicide, making it a promising candidate for integrated disease management.

Table 5a: Evaluation of Effect of Endophytic Fungi against Anthracnose Disease of Cowpea *(in vivo)*

		1WAT			
Treatment	Concentration (%)	Plant Height	Number of Leaves	Leaves Length	Leave Size
Aspergillus flavus	30	5.40±0.52	3.00±0.00	6.00±1.00	3.16±0.76
	60	5.66±0.57	3.00±0.00	4.766±0.47	3.13±0.40
	90	6.33±1.15	3.00±0.00	6.33±1.15	3.33±0.76
Aspergillus niger	30	6.66±2.88	3.00±0.00	6.40±1.63	3.76±0.40
	60	6.33±1.52	3.33±0.57	5.06±1.00	3.60±0.52
	90	6.66±0.57	3.66±0.57	6.00±1.00	3.00±0.50
Fusarium solani	30	6.33±1.52	3.33±0.57	6.06±0.950	3.73±0.64
	60	5.33±1.15	3.00±0.00	5.76±0.49	3.43±0.66
	90	5.66±0.57	3.00±0.00	5.76±0.49	3.46±0.64
Penicillium expansum	30	5.66±0.57	3.00±0.00	5.50±0.00	3.63±0.51
	60	7.00±1.00	3.00±0.00	5.86±0.32	3.16±0.76
	90	6.33±1.52	3.00±0.00	6.36±0.55	3.16±0.28
- ve	0	6.66±0.57	3.00±0.00	6.00±0.00	4.00±1.00
C	0	6.33±0.76	3.00±0.00	6.00±0.00	4.33±0.57
+ ve	0	7.16±0.76	3.00±0.00	5.56±0.51	3.66±0.28
P value		0.96	0.11	0.51	0.78

Mean values shows that there is not significant different at $p \leq 0.05$

Table 5b: Evaluation of effect of Endophytic Fungi against Anthracnose Disease of Cowpea *(in vivo)*

2WAT				
Treatment	Plant Height	Number of Leaves	Leaves Length	Leave Size
Aspergillus flavus	8.66±0.57	8.66±0.57	5.00±0.86	2.33±0.76
	8.00±0.00	10.00±1.00	5.66±0.57	2.83±028
	8.16±1.44	10.00±1.00	4.83±0.76	2.10±0.69
Aspergillus niger	8.00±2.59	8.33±2.08	5.33±0.76	2.66±0.28
	8.66±2.30	9.66±1.55	5.40±1.96	3.16±0.76
	9.33±0.57	11.66±1.52	6.33±0.57	3.16±0.76
Fusarium solani	8.00±1.73	12.00±1.73	6.66±1.15	2.83±0.28
	7.33±1.15	10.33±1.15	5.83±2.25	2.66±0.28
	8.66±2.88	9.66±1.16	5.66±0.28	3.16±0.76
Penicillium expansum	8.00±3.60	10.00±1.00	4.83±1.25	3.06±0.11
	7.33±0.57	11.33±0.57	5.33±1.15	3.16±0.76
	8.33±1.52	12.00±1.00	7.166±1.44	2.66±0.57
- ve	10.00±0.86	12.33±2.30	6.20±0.26	3.43±0.58
C	9.00±0.00	10.66±0.57	5.55±0.43	3.36±1.18
+ ve	8.66±0.57	8.00±1.00	5.00±0.86	2.00±0.36
P value	0.96	0.11	0.51	0.78

Mean values shows that there is not significant different at p≤0.05

Table 5c: Evaluation of effect of Endophytic Fungi against Anthracnose Disease of Cowpea *(in vivo)*

3WAT				
Treatment	Plant Height	Number of Leaves	Leaves Length	Leave Size
Aspergillus flavus	10.00±1.00	13.00±2.00	6.16±1.44	2.66±0.57
	10.00±0.00	13.66±1.15	7.50±0.86	3.83±0.28
	9.00±1.73	12.33±1.52	7.00±1.00	3.33±0.28
Aspergillus niger	10.16±4.19	11.66±1.52	6.00±1.00	3.33±1.15
	10.66±2.30	12.33±2.88	7.16±0.76	3.00±0.00
	11.66±1.52	10.66±1.52	7.50±3.04	3.50±0.86
Fusarium solani	11.00±2.64	9.66±2.30	6.33±1.52	2.50±0.50
	9.16±1.44	13.33±1.15	5.33±1.15	2.50±0.50
	10.66±2.88	12.33±3.51	6.00±1.73	2.80±0.72
Penicillium expansum	8.66±1.15	12.33±3.51	6.50±1.50	2.50±0.86
	10.33±1.52	11.66±1.52	5.83±1.60	2.33±0.57
	10.00±1.00	11.66±3.78	6.86±1.47	2.83±0.76
- ve	11.66±1.15	12.33±0.57	4.83±1.04	2.83±0.28
C	9.00±1.00	5.33±0.57	4.83±1.04	3.26±0.25
+ ve	9.66±0.57	7.66±3.78	4.83±1.04	2.50±0.50
P value	0.96	0.11	0.51	0.78

Mean values shows that there is not significant different at p≤0.05

CONCLUSION

The findings of this research demonstrate that endophytic fungi possess strong potential as eco-friendly biocontrol agents against anthracnose in cowpea. *Fusarium solani* showed the highest antagonistic effect in vitro, while *A. flavus* and *A. niger* were more effective in vivo, improving plant growth and reducing disease severity. These results highlight the dual role of endophytes in both disease suppression and plant growth promotion. The study confirms that integrating endophytic fungi into cowpea production systems can reduce reliance on chemical fungicides, thereby promoting sustainable agriculture and food security in Nigeria and beyond.

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