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UTILIZATION OF EXOPHYTIC AND ENDOPHYTIC FUNGI IN CONTROLLING ANTHRACNOSE DISEASE IN CHILI PEPPERS (*Capsicum frutescens* L.)

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Abstract

Anthracnose disease in cayenne pepper fruit is a very dangerous and detrimental disease for farmers in Bali Province. The results showed that the dominant exophytic fungus was *Aspergillus niger* in stems, fruits and leaves at 80%, 80% and 73.3%, respectively. The dominant endophytic fungus in stems, fruits and leaves was in the stems of *Rhizopus* sp., in the fruits of A. flavus and *A. niger* at 44.4%, 44.4% and 55.6%, respectively. The highest inhibitory power of exophytic fungi against pathogens (*Colletotrichum capsici*) was greatest from isolates of *A. niger* and *Neurospora* sp. at 80±0.4% and 80±0.3% respectively from leaves, while the highest inhibitory power of endophytic fungi from isolates of *A. flavus* and *Rhizopus* sp. at 80±0.6% respectively, which came from chili stems. The diversity index of exophytic fungi in stems, fruits and leaves is relatively small (<1) with less stable criteria with a fairly large dominance index (>0.5) this means that there is a dominant species, namely *A. niger*. The diversity index of endophytic fungi in stems, fruits and leaves ranges from 1.21-1.8 (quite stable) with a fairly large dominance index (>0.5) which is dominated by *Rhizopus* sp. in stems, while in fruits and leaves by *A. niger*. The best *in vivo* inhibition power was obtained from *A. niger* with an attack percentage of 0% (the same as the control without pathogens), followed by *A. niger* at 12.47±4.47%.

INTRODUCTION

Chili production in Bali Province was 34,948 tons in 2022, 27,606 tons in 2023, and 29,688 tons in 2024. One of the causes of the decline in chili production in Bali Province from 2022 to 2023 was anthracnose disease (Bali Provincial Statistics Agency, 2025) [1].

Anthracnose in chili fruit caused by *C. capsici* causes symptoms of ripe fruit turning red will be affected, small, black, and circular spots appear on the skin of the fruit, severely affected fruit will turn straw or pale white, and lose its spicy taste, affected fruit after being cut - the lower surface of the skin is covered with small, protruding sclerotia. Advanced stage - seeds are covered by a layer of fungal hyphae, turning rusty (Tnau Agritech Portal, 2015) [2].

The word anthracnose, derived from the Greek word meaning 'coal', is a common name for a plant disease characterized by very dark, sunken lesions containing fungal spores. Typical symptoms of anthracnose in chili peppers include dark, sunken necrotic spots with concentric rings of aservuli. In addition to fruit rot, the disease also causes leaf spots, stem dieback, seedling blight, or damping off. The disease not only affects fruit quality by the appearance of anthracnose lesions but also reduces fruit dry weight, as well as the amount of capsaicin and oleoresin (Kiran *et al*., 2020) [3].

Control of this disease still relies on chemical methods using fungicides. Many endophytic and exophytic fungi are useful as antagonistic fungi to control plant diseases. Exophytic and endophytic fungi can control plant diseases through various biological mechanisms, including direct antagonism, resource competition, and induced systemic resistance in host plants. Endophytes colonize plant tissues, while exophytes grow on plant surfaces. Both can be used as biological control agents, with endophytes providing benefits such as nutrient absorption and stress tolerance, while exophytes have the potential to act as physical barriers or antagonists (Sudarma *et al*., 2021; Sudarma and Darmiati, 2024) [4; 5].

Endophytes are microbes (mostly bacteria and fungi) that exist asymptomatically in plants. Endophytic microbes are often functional because they can transport nutrients from the soil into the plant, modulate plant development, increase plant tolerance to stress, suppress pathogen virulence, increase disease resistance in plants, and suppress the growth of competing plant species. Endophytic microbes have been shown to: (i) obtaining nutrients from the soil and transferring them to plants through rhizophagy and other nutrient transfer symbioses; (ii) enhancing plant growth and development; (iii) reducing oxidative stress in the host; (iv) protecting plants from disease; (v) preventing herbivores from consuming plants; and (vi) suppressing the growth of competing plant species. Due to the effective functions of endophytic microbes, we believe that endophytic microbes can significantly reduce the use of agricultural chemicals (fertilizers, fungicides, insecticides, and herbicides) in food crop cultivation. The loss of endophytic microbes from food crops during domestication and long-term cultivation can be overcome by transferring endophytes from wild relatives of food crops to food crop species. Increased atmospheric carbon dioxide levels can reduce the efficiency of the rhizophagy cycle due to the suppression of reactive oxygen species used to extract nutrients from microbes in the roots (White *et al*., 2019) [6].

MATERIALS AND METHODS

Research Location and Time

The research was conducted in two locations: 1) collecting diseased and healthy panicle specimens from the Faculty of Agriculture, Udayana University Plantation in Pegok, and 2) the Plant Pathology Laboratory and Agricultural Biotechnology Laboratory, Faculty of Agriculture, Udayana University. The research was conducted from April to August 2025.

Isolation of Endophytic and Exophytic Fungi

To isolate endophytic fungi, plant parts such as fruit, leaves, and stems were washed with sterile running water. Then, they were sterilized with 0.525% sodium hypochlorite for 3 minutes and 70% alcohol for 2 minutes. Then, they were rinsed with sterile water for 1 minute and placed on PDA media (pre-treated with the antibacterial antibiotic livoploxacin at a concentration of 0.1% (w/v). The fungi that emerged from the leaf pieces were transferred to test tubes containing PDA for storage and morphospecies classification. Meanwhile, exophytic fungi were isolated by spraying plant parts (fruit, leaves, and stems). The washing water was collected in a tube, and 1 ml of the tube was then grown on PDA media previously filled with livoploxacin at a concentration of 0.1% (w/v).

Identification of Endophytic and Exophytic Fungi

The stored endophytic and exophytic fungi were then grown in Petri dishes containing PDA, and the experiment was repeated five times. The cultures were incubated in the dark at room temperature (±27°C). Isolates were identified macroscopically after 3 days to determine colony color and growth rate, and microscopically to identify hyphal septa, spore/conidia shape, and sporangiophores. Fungal identification was carried out using reference books [7, 8, 9, 10, 11].

Endophytic and Exophytic Fungal Inhibitory Tests Against Pathogens

The endophytic and exophytic fungi found were each tested for their inhibitory activity against the growth of pathogenic fungi using the dual culture technique (one pathogenic fungus was grown in a Petri dish flanked by two endophytic fungi). The inhibitory activity can be calculated as follows [12, 13]:

$$\text{Inhibitory activity (\%)} = \frac{A - B}{A} \quad x\ 100$$

Where:

A = Pathogen colony diameter in single culture (mm)

B = Pathogen colony diameter in dual culture (mm)

Prevalence of Endophytic and Exophytic Fungi

Determining the prevalence of endophytic and exophytic fungi is based on the frequency of endophytic and exophytic fungal isolates found in healthy fruit per Petri dish, divided by the total number of isolates found, multiplied by 100%. The prevalence of isolates determines the dominance of endophytic fungi in healthy fruit.

Determining Diversity and Dominance Index

The diversity and dominance of contaminant fungi can be determined by calculating the Shannon-Wiener diversity index [14] and soil microbial dominance can be calculated by calculating the Simpson index [15].

(1) Microbial Diversity Index

The soil microbial diversity index is determined using the Shannon-Wiener diversity index, which is based on the formula [14]:

$$H' = -\sum_{i=1}^{s} Pi \ln Pi.$$

Where:
H’ = Shannon-Wiener diversity index S = Number of genera
Pi = ni/N as a proportion of species i (ni = Total number of individuals of microbial species i, N = Total number of individuals in a total of n)

The criteria used to interpret Shannon-Wiener diversity [16] are: H' value < 1, meaning low diversity, H' value 1 - 3 meaning moderate diversity and H' value > 3 meaning high diversity or (Table 1).

Table 1. Criteria for assessing environmental quality weighting [17]

Diversity index	Community structure conditions	Category	Scale
>2.41	Very stable	Very good	5
-2.4	More stable	Good	4
1.21-1.8	Quite stable	Average	3
0.61-1.2	Less stable	Bad	2
<0.6	Unstable	Very bad	1

Dominance Index

The dominance index for pests and natural enemies is calculated using the Simpson index [15], using the following formula.

$$C = \sum_{i=1}^{s} Pi2$$

Where:
C = Simpson index
S = Number of genera
Pi = ni/N, i.e., the proportion of individuals of species i to all individuals (ni = Total number of individuals of species i, N = Total number of individuals in a total of n)

Furthermore, the species dominance index (D) can be calculated using the formula 1-C [18]. The criteria used to interpret the dominance of soil microbial species are: approaching 0 = low index or increasingly low dominance by one microbial species or there is no species that extremely dominates other species, approaching 1 = large index or tends to be dominated by several microbial species [15].

In Vivo Inhibitory Testing

In vivo antagonistic testing of endophytic and exophytic fungi with the best inhibitory activity was performed by dipping them into a spore suspension of the antagonistic fungi (each treatment corresponding to the desired treatment). The best endophytic and exophytic fungal treatments were found to be:
A = control (without antagonist treatment) + pathogen
B = Antagonist treatment 1 (250 ml of water (10% sugar solution) + spore suspension in 1 Petri dish) + pathogen
C = Antagonist treatment 2 (250 ml of water (10% sugar solution) + spore suspension in 1 Petri dish) + pathogen
D = Antagonist treatment 3 (250 ml of water (10% sugar solution) + spore suspension in 1 Petri dish) + pathogen
E = Antagonist treatment 4 (250 ml of water (10% sugar solution) + spore suspension in 1 Petri dish) + pathogen
F = Antagonist treatment 5 (250 ml of water (10% sugar solution) + spore suspension in 1 Petri dish) + pathogen
G = No treatment.

The percentage of infection was calculated by dividing the number of infected needle punctures by the total number of punctures (10 punctures) by 100%.

All treatments were repeated 5 times. The experiment was designed using a completely randomized design (CRD), and after analysis of variance (ANOVA) was carried out, it was continued with the least significant difference (LSD) test at the 5% level. The attack parameter was measured using the formula: diseased fruit divided by the total number of observed fruit times 100%.

RESULTS AND DISCUSSION

Exophytic Fungal Population

The stem exophytic fungal population was dominated by A. *niger* at 36 x 10^3 cfu (80%), followed by *A. flavus* at 6 x 10^3 cfu (13.3%), and *Aspergillus* sp. at 3 x 10^3 cfu (6.7%). The fruit exophytic population was dominated by *A. niger* at 36 x 10^3 cfu (80%), followed by *Rhizopus* sp. at 6 x 10^3 cfu (13.3%), and *Monomicrospora* sp. (Actinomycetes) at 3 x 10^3 cfu (6.7%). The leaf exophytic population was dominated by *A. niger* at 33 x 10^3 cfu (73.3%), followed by *Stephanoma* sp. and *Neurospora* sp. at 6 x 10^3 cfu (13.3%) each (Table 2, Figure 1).

Table 2. Exophytic microbes found on healthy stems, fruits and leaves of chili plants

No.	**Stem (10^3 cfu)**		**Fruit (10^3 cfu)**		**Leaves (10^3 cfu)**	
	Microbe type	Number isolates	Microbe type	Number isolate	Microbe type	Number isolates
1	*A. niger*	36 (80%)*	*A. niger*	36 (80%)	*A. niger*	33 (73.3%)
2	*A. flavus*	6 (13.3%)	*Monomicrospora* sp.	3 (6.7%)	*Neurospora* sp.	6 (13.3%)
3	*Aspergillus* sp.	3 (6.7%)	*Rhizopus* sp.	6 (13.3%)	*Stephanoma* sp.	6 (13.3%)

* Numbers in brackets indicate prevalence

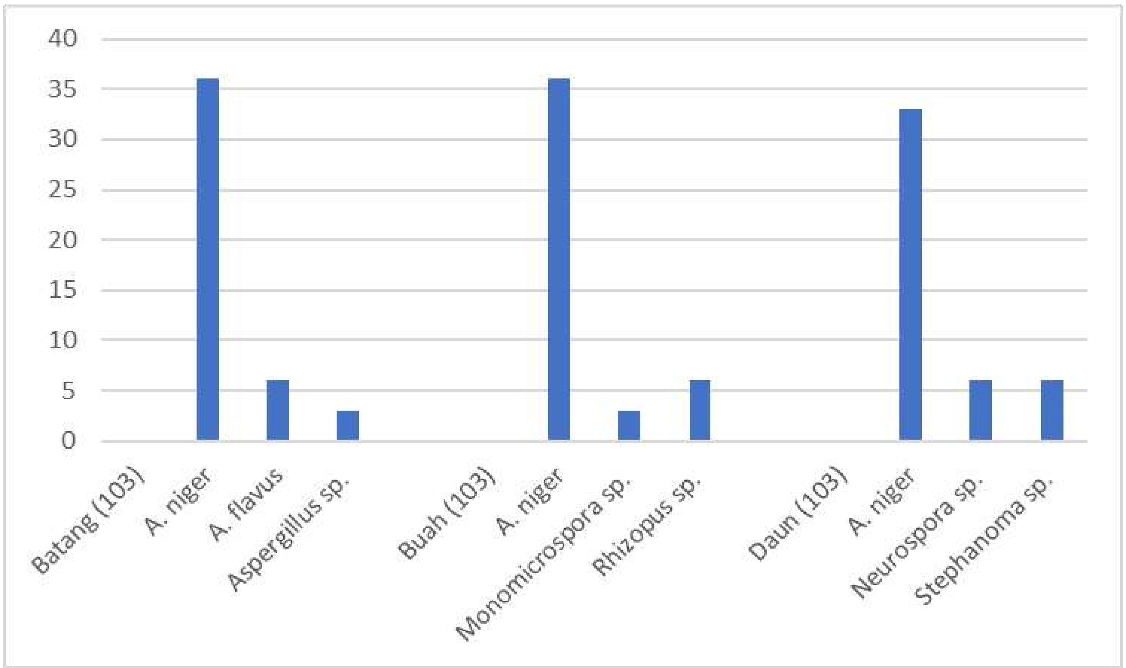

Figure 1. Population of exophytic fungi on stems, fruit and leaves

Endophytic Fungal Population

The endophytic fungal population in healthy chili plant stems was dominated by *Rhizopus* sp. with 12 isolates (44.4%), followed by *A. niger* with 9 isolates (33.3%), and the smallest by *A. flavus* with 6 isolates (22.2%). Fruit endophytes were dominated by *A. niger* with 12 isolates (44.4%), followed by A. flavus with 9 isolates (33.3%), and the smallest by *Rhizopus* sp. with 6 isolates (22.2%). Leaf endophytes were dominated by *A. niger* with 15 isolates (55.6%), followed by *A. flavus*, Miselia sterilia, *Rhizopus* sp., and *Trichoderma* sp. with 3 isolates each (11.1%) (Table 3, Figure 2).

Table 3. Endophytic microbes found in healthy stems, fruits and leaves of chili plants

No.	Stem (10^3 cfu)		Fruit (10^3 cfu)		Leaves (10^3 cfu)	
	Microbe type	**Number isolates**	**Microbe type**	**Number isolate**	**Microbe type**	**Number isolates**
1	*B. niger*	9 (33.3%)*	*A. niger*	36 (44.4%)	*A. niger*	15 (55.6%)
2	*A. flavus*	6 (22.2%)	*A. flavus*	9 (33.3%)	*A. flavus*	3 (11.1%)
3	*Rhizopus* sp.	12 (44.4%)	*Rhizopus* sp.	6 (22.2%)	*Miselia sterilia*	3 (11.1%)
					Trichoderma sp.	3 (11.1%)

* Numbers in brackets indicate prevalence

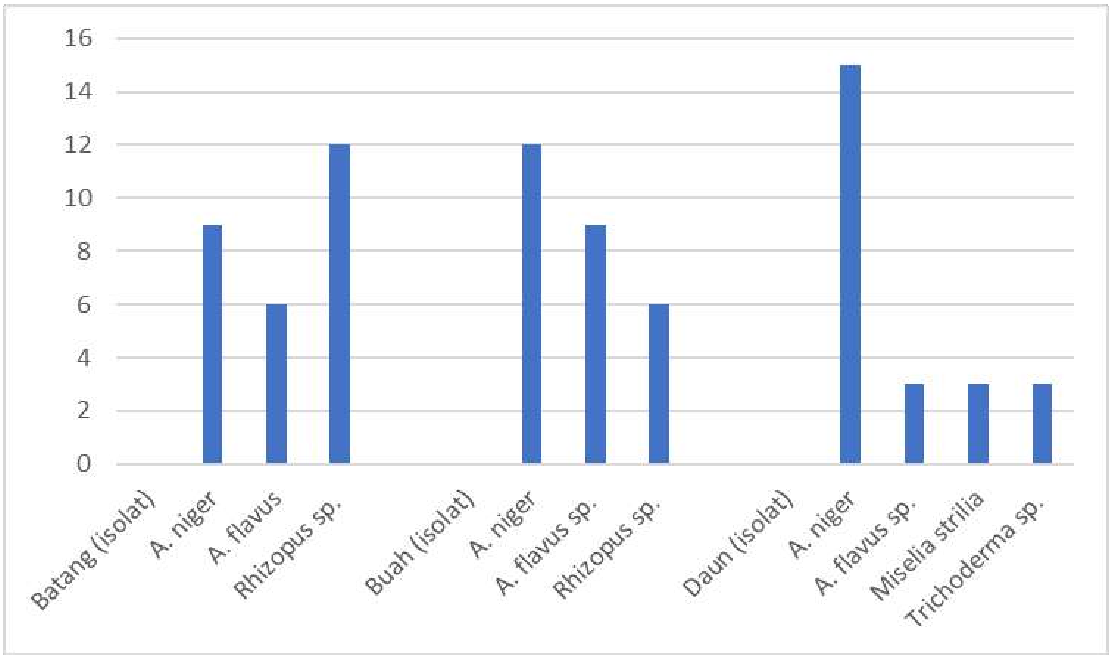

Figure 2. Endophytic fungi on healthy stems, fruit and leaves of chili plants

Plants harbor diverse fungal communities on their surfaces (exophytes) and within their tissues (endophytes). They are essential for plant health and the environment. The diversity of fungal associations with medicinal plants remains largely unexplored. *Catharanthus roseus*, a medicinal plant, plays a crucial role in global healthcare. A total of 153 fungal isolates were isolated from thirty leaves of *C. roseus* plants, including 11 endophytic isolates and 142 exophytic isolates. Based on morphological characteristics, the isolates were classified into six genera and 11 species of endophytic fungi, and 12 genera and 33 species of exophytic fungi. Endophytes have significantly lower fungal diversity than epiphytes. By sequencing the ITS region of rDNA, five epiphytic and three endophytic fungal species were molecularly identified. The isolates were *Aspergillus caespitosus, A. elegans, A. flavus, A. nidulans*, *Penicillium chrysogenum, P. commune*, *and Talaromyces purpurogenus*. *Aspergillus* was the most abundant fungal genus isolated, with four endophytic species from eleven species and nine exophytic species from thirty-three species. *A. niger* was the most common exophytic species, with 28 isolates, a colonization frequency of 18.6%, and a relative frequency of 19.7%. In addition, *A. caespitosus* was the most common endophyte, accounting for 1.3% of the CF (colonization frequency) and 18.18% of the RF (relative frequency) [19].

Fruit rot disease in soursop (*Annona squamosa* L.) plants caused *by Lesiodiplodia theobromae*, has been tested with exophytic fungi found on leaves, fruit, and twigs are *Aspergillus* sp. *A. niger, Fusarium* sp., Mycelia sterillia, *Neurospora* sp., and *Rhizopus* sp., while endophytic fungi on leaves, fruit, and twigs are *Fusarium* sp., *Penicillium* sp., *Neurosporas* sp., and Mycelia sterillia [20].

In Vitro Inhibitory Power of Exophytic and Endophytic Fungi

The highest inhibition power of exophytic fungi on stems, fruits, and leaves was achieved by *A. niger* at 70 ± 0.6%, 70 ± 0.6%, and 80 ± 0.4%, respectively (Table 4). Meanwhile, the in vitro inhibition power of endophytic fungi against pathogens was as follows: the highest in stems was achieved by *A. flavus* and *Rhizopus* sp. at 80 ± 0.6%, respectively; in fruit, by *A. flavus* at 70 ± 0.6%, and in leaves, by *A. niger* and *Rhizopus* sp. at 80 ± 0.4%, respectively (Table 5).

The results of research by Sudarma *et al.* (2021) [21] showed that the microbe that dominates the exophyte and has the highest inhibitory power against the pathogen (*Lasiodiplodia theobromae*) is *Rhizopus* sp. on papaya fruit, as well as the highest endophyte has inhibitory power and dominates in suppressing the papaya fruit rot pathogen. Likewise, the results of research by Sudarma *et al.* (2024) [22] showed that in vitro the antagonist fungus that has the highest inhibition of the anthracnose pathogen (*Colletotrichum fructicola*) is *A. niger* on rambutan fruit at 92.22 ± 0.3%.

Table 4. Inhibitory power of exophytic microbes on the growth of *C. capsici in vitro*

Microbe type	Stem (IA %)*	Microbe type	Fruit (IA%)	Microbe type	Leaves (IA%)
1. *A. niger*	70 ± 0.4	1. *A. niger*	70 ± 0.5	1. *A. niger*	70 ± 0.3
2. *Aspergillus* sp.	50 ± 0.3	2. *A. niger*	70 ± 0.5	2. *A. niger*	80 ± 0.3
3. *A. niger*	60 ± 0.5	3. *Micromonospora* sp. (Actinomycetes)	–	3. *A. niger*	80 ± 0.4
4. *A. niger*	60 ± 0.6	4. *A. niger*	70 ± 0.4	4. *Stephanoma* sp.	–
5. *A. niger*	60 ± 0.3	5. *A. niger*	70 ± 0.3	5. *A. niger*	70 ± 0.3
6. *A. niger*	70 ± 0.2	6. *A. niger*	70 ± 0.5	6. *A. niger*	80 ± 0.3

7. *A. niger*	60 ± 0.5	7. *A. niger*	70 ± 0.6	7. *A. niger*	70 ± 0.3
8. *A. niger*	56 ± 0.6	8. *A. niger*	70 ± 0.5	8. *A. niger*	80 ± 0.4
9. *A. niger*	70 ± 0.4	9. *A. niger*	70 ± 0.5	9. *A. niger*	80 ± 0.3
10. *A. niger*	60 ± 0.4	10. *A. niger*	70 ± 0.3	10. *A. niger*	80 ± 0.3
11. *A. niger*	60 ± 0.4	11. *A. niger*	70 ± 0.5	11. *Neurospora* sp.	80 ± 0.2
12. *A. niger*	60 ± 0.5	12. *A. niger*	70 ± 0.5	12. *A. niger*	80 ± 0.3
13. *A. flavus*	60 ± 0.3	13. *A. niger*	70 ± 0.5	13. *Neurospora* sp.	80 ± 0.3
14. *A. flavus*	76 ± 0.3	14. *Rhizopus* sp.	70 ± 0.2	14. *Stephanoma* sp.	–
15. *A. niger*	76 ± 0.6	15. *Rhizopus* sp.	70 ± 0.4	15. *A. niger*	80 ± 0.3

*IA= Inhibitory ability

Table 5. Inhibitory power of endophytic microbes on the growth of *C. capsici in vitro*

Microbe type	**Stem (IA %)***	**Microbe type**	**Fruit (IA %)**	**Microbe type**	**Leaves (IA %)**
1. *A. niger*	80 ± 0.4	1. *A. niger*	70 ± 0.5	1. *A. niger*	80 ± 0.3
2. *A. niger*	78 ± 0.3	2. *A. niger*	70 ± 0.5	2. *A. niger*	80 ± 0.3
3. *A. niger*	60 ± 0.5	3. *A. niger*	–	3. *A. niger*	80 ± 0.4
4. *A. flavus*	80 ± 0.6	4. *A. niger*	70 ± 0.4	4. *A. niger*	–
5. *A. flavus*	80 ± 0.3	5. *A. flavus*	70 ± 0.3	5. *A. niger*	70 ± 0.3
6. *Rhizopus* sp.	70 ± 0.2	6. *A. niger*	70 ± 0.5	6. *A. flavus*	60 ± 0.3
7. *Rhizopus* sp.	72 ± 0.5	7. *A. flavus*	70 ± 0.6	7. *Miselia sterilia*	–
8. *Rhizopus* sp.	80 ± 0.6	8. *A. flavus*	70 ± 0.5	8. *Rhizopus* sp.	80 ± 0.4
9. *Rhizopus* sp.	76 ± 0.4	9. *Rhizopus* sp.	70 ± 0.5	9. *Trichoderma* sp.	76 ± 0.3

*IA = Inhibitory ability

Inhibitory Power of Exophytic and Endophytic Fungi in Vivo

The results showed that the treatments were significantly different from the control. The exophytic and endophytic fungi tested showed that the highest percentage of pathogen attack was in the control treatment with pathogen (A+K) at 80±22.8%, followed by the

Trichoderma sp. (E) treatment at 94.4±5.18%, then by the *Rhizopus* sp. (D) treatment at 64±8.94%, then by the *Neurospora* sp. (C) treatment at 52±10.95%, then by *A. flavus* (A) at 12±12.25%, and the smallest was by the antagonistic fungus *A. niger* (B) at 12±4.47% (Table 6).

Table 6. *In vivo* tests of exophytic and endophytic fungi

Treatment	Treatment code	DMRT 5%	DMRT 1%
Control (without treatment	K-P	0 ± 00 a	a
Control (with treatment)	K+P	80 ± 22,8 e	e
A. flavus	A	12,25 ± 12,25 b	b
A.niger	B	12,47 ± 4,47 b	b
Neurospora sp.	C	52 ± 10,95 c	c
Rhizopus sp.	D	64 ± 8,94 d	c
Trichoderma sp.	E	94,4 ± 5,18 e	d

Secondary metabolites such as mycotoxins can be produced by fungi on agricultural commodities in the field. These fungi can colonize medicinal plants, such as *Catharanthus roseus.* On PDA media, 18 exophytic and endophytic fungal isolates isolated from *C. roseus,* including *Aspergillus, Penicillium*, and *Talaromyces* species, were tested for mycotoxin production. Thin layer chromatography showed the formation of six mycotoxins from six isolates, including aflatoxin G1, aflatoxin B1, sterigmatocystin, citrinin, aflatoxin B2, and penicillic acid. It was found that enriched PDA media could increase the formation of certain mycotoxins. Toxicity was carried out on Artemia salina brine shrimp larvae for fungal mycotoxin extraction and C. roseus leaf extract. Selected fungal extracts at a concentration of 10 µg/ml were also harmful to brine shrimp larvae, while leaf extracts at a concentration of 6.25-200 µg/ml were highly toxic [23].

Diversity, Dominance, and Uniformity Index of Exophytic and Endophytic Fungi

The diversity (H), dominance (D), and uniformity (E) indices of exophytic microbial fungi in healthy plants showed that in the stems, H = 0.6277 (less stable), D = 0.6622, and E = 0.1269 were dominated by *A. niger* fungi. However, in the fruits, H = 0.7077 (less stable), D =0.7916, and E = 0.1768 were dominated by *A. niger* fungi. Meanwhile, in the leaves, H = 0.7648 (less stable), D = 0.5733, and E = 0.1762 were dominated by *A. niger* (Table 7).

Table 7. Diversity, dominance and uniformity index of exophytic microbes in healthy plants

Plant parts	Diversity index (H)	Dominance/Simpson index (D/C)	Uniformity index (E)	Dominant species
Stem	0.6277 (less stable)	0.6622	0,1269	*A. niger*
Fruit	0.7077 (less stable)	0.7916	0,1768	*A. niger*
Leaves	0.7648 (less stable)	0.5733	0,1762	*A. niger*

The diversity index (H), dominance (D) and uniformity (E) of endophytic microbial fungi in healthy plants showed that in the stem the value of H = 1.0609 (quite stable), D = 0.642, and E = 0.3108 was dominated by *Rhizopus* sp. fungi, but in the fruit the value of H = 1.0609 (quite stable), D = 0.642 and E = 0.31078 was dominated by *A. niger* fungi, while in the leaves the value of H = 1.3031 (quite stable), D = 0.462, and E = 0.1390 was dominated by *A. niger* fungi (Table 8).

Table 8. Diversity, dominance and uniformity index of endophytic microbes in healthy plants

Plant parts	Diversity index (H)	Dominance/Simpson index (D/C)	Uniformity index (E)	Dominant species
Batang	1.0609 (quite stable)	0.642	0.3108	*Rhizopus sp.*
Buah	1.0609 (quite stable)	0.642	0.3108	*A.niger*
Daun	1.3031 (quite stable)	0.642	0.1390	*A.niger*

The isolates isolated were *Aspergillus caespitosus, A. elegans, A. flavus, A. nidulans*, *Penicillium chrysogenum, P. commune* and *Talaromyces purpurogenus. Aspergillus* was the most frequently isolated fungal genus, with four endophytic species out of eleven and nine exophytic species out of thirty-three. *A. niger* was the most common exophytic species, with 28 isolates, a colonization frequency of 18.6%, and a relative frequency of 19.7%. In addition *A. caespitosus* was the most common endophyte, contributing 1.3% of the CF (colonization frequency) and 18.18% of the RF (relative frequency). This study aimed to compare the diversity of epiphytes and endophytes that perform poorly on medicinal plants. This finding may provide new perspectives and opportunities for compounds and mycotoxins with medicinal value [24].

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