

Research Article

Pest and disease inventory of ferns, *Rumohra adiantiformis* (G. Forst.) Ching and their control strategies

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ABSTRACT

Ferns are a floricultural commodity with high economic value, marketed for both domestic and export needs. However, production often declines due to pest and disease attacks. To date, information on pest types, diseases, and control strategies is still limited. This study aims to inventory pests and diseases in ferns and develop control strategies. The study was conducted from July 2024 to October 2025 at the farm of PT. Florex Farmino Sukabumi at elevations of 899 masl, 1081 masl, 1126 masl, and 1209 masl, as well as at the farm of PT. Florex Cita Respati Cianjur at an altitude of 1099 masl, 1106 masl, 1114 masl, and 1125 masl. Observation methods were adjusted to the types of pests and diseases, and used sweep net, yellow pan trap, and pitfall trap methods. Data were tabulated using Microsoft Office Excel and analyzed descriptively. Pests found in both locations were armyworms and grasshoppers that cause direct damage to plants due to feeding activities, planthoppers, mealybugs, stem borers, and anthracnose disease *Colletotrichum* spp., leaf tip rot *Fusarium* spp., and leaf blight *Pestalotiopsis* sp. causing gradual damage. The population of beneficial arthropods found was still relatively low. Based on the results of the inventory and the condition of the plants at the research location, a pest control strategy was developed that refers to the principles of IPM.

Keywords: anthracnose: arthropod; ornamental ferns: integrated pest management

INTRODUCTION

The fern *Rumohra adiantiformis* (G. Forst.) Ching (*Polypodiales: Dryopteridaceae*) is a high-value floricultural commodity widely traded to meet both domestic and export market demands. It is frequently used as a component in floral arrangements and decorations for celebratory events (Newman, 2019). This fern grows optimally at altitudes of 850–1,200 meters above sea level, with average temperatures of 19°C–27°C, relative humidity of 80%–90%, and light intensity of 3,000–5,000 candela (60%–70% under shade netting) (Wediyanto, 2009). Such agroclimatic conditions are prevalent in West Java, making the province a major center for fern cultivation in Indonesia. The resulting products are typically exported to various countries, including Japan and Australia.

Fern production reached 365.935 million stems in 2020 and 138.570 million stems in 2021, representing a production decline of approximately 62.13% (BPS, 2023). This decline was driven by various internal and external factors. Internal factors relate to the plant's resilience against biotic and abiotic stresses, while external factors include environmental conditions, cultivation techniques, and pest and disease infestations (Chen, 2022; Sinnarong et al., 2022). Such infestations not only reduce production volume but

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also increase production costs and diminish the product's marketability for both domestic and export markets (Lundstrom et al., 2017). Visual quality is a primary parameter in determining fern product quality, consequently pest and disease damage can compromise both the quality and aesthetic appeal of the product. As a result, the ferns risk failing sorting processes, falling short of quality standards, and becoming unmarketable—particularly in export markets that enforce strict quality requirements (Smith et al., 2018).

Various types of plant pests and diseases have been reported to affect ferns. Commonly encountered pests include mealybugs, while prevalent diseases include anthracnose and leaf blight (Hasibuan et al., 2025; Martins et al., 2024). Control measures implemented in the field are typically based on farmers' experience and assumptions regarding the specific pests or diseases present. A lack of information concerning these fern pests and diseases constitutes a major obstacle in addressing the issue. Currently, infestations are becoming more widespread and threaten to spread to unaffected areas of the farm, leading to escalating costs. Therefore, management strategies for fern pests and diseases are essential to curb their spread and proliferation within the farm and to minimize significant financial losses for farmers.

Research on fern pests and diseases has been reported in several countries. However, most of the information originates from studies conducted outside Indonesia. In Indonesia, such research remains limited and generally focuses on specific organisms or cultivation aspects, leaving a lack of comprehensive information regarding pests, diseases, infestation levels, and control strategies in commercial fern production centers. This study aims to inventory fern pests and diseases in the Sukabumi and Cianjur Regencies. The findings are expected to support fern cultivation efforts, particularly by identifying pest and disease types to assist in determining appropriate control strategies.

MATERIALS AND METHODS

Study Period and Location

The research was conducted from July 2024 to October 2025. Sampling of pests and diseases took place at the PT. Florex Farmino Sukabumi farm (6.856756°S, 106.975825°E) and the PT. Florex Cita Respati Cianjur farm (6.687143°S, 107.0416°E) in West Java (Table 1). Identification was performed at the Insect Pathology and Mycology Laboratory, Department of Plant Protection, Faculty of Agriculture, IPB University.

Table 1. Characteristics and environmental conditions in Sukabumi and Cianjur Regencies

Parameter	Sukabumi	Cianjur
Average Temperature (°C) ¹	23.46	26.10
Relative humidity (%) ¹	86.58	82.04
Average rainfall during the 4-week observation period (mm) ¹	2.91	5.85
Plant age (weeks) ²	3-7	3-7
Initial planting spacing (cm) ³	25x25	25x25
Irrigation frequency (times day ⁻¹)	5	5
Fertilization	Farmyard manure (no fertilization was applied during the observation period)	
Pest and disease management	Farm sanitation, rain shelter (plastic cover), and regular pesticide application	

¹Climate data were obtained from Nasa Power; ²Plant age refers to the age of the observed fern fronds; ³Initial planting spacing represents the spacing at planting, clump expansion due to the formation of new shoots resulted in non-uniform spacing during the observation period.

Sampling Method

Sampling was conducted in fern farm across Sukabumi and Cianjur Regencies. Four farm were selected for observation in each regency to represent the varying altitudes of fern cultivation sites (Table 2). Three observation blocks were designated within each farm. From each block, five planting beds were selected systematically to represent the

crop conditions. For pest and disease assessment, 20 plants per bed were chosen via systematic random sampling to represent the condition of each bed, while disease incidence was assessed by examining all plants within the bed.

Table 2. Elevation of the study sites in Sukabumi and Cianjur Regencies

Study site	Elevation (m above sea level)	
	Sukabumi	Cianjur
A	899	1099
B	1081	1106
C	1126	1114
C	1209	1125

Observation methods were conducted according to the type of pest (Table 3). Pest identification was based on morphological characteristics using a stereo microscope, referencing Borror & White (1970) and other relevant identification keys.

Table 3. Methods for pest assessment

Pest	Assessment method
Mealybugs	Direct observation (counting the number of individuals per sampled plant)
Leafhoppers	Direct observation
Armyworm	Direct observation
Grasshoppers	Direct observation
Fern stem borer	Damage incidence was calculated using the following formula: $I = \frac{a}{a+b} \times 100\%$ I = stem borer incidence (%) a = number of plants infested by the stem borer b = number of healthy plants

Sampling Using Trap

Insect sampling was conducted at weekly intervals over a four-week period, starting at 07:00 Western Indonesia Time (WIB). Samples were collected and identified using the references of Goulet & Huber (1993) and other relevant identification keys. A sweep net was used by swinging it back and forth-left to right-ten times across each designated planting bed, additionally yellow pan trap and pitfall trap were placed on each bed (Figure 1), resulting in a total of 60 traps per study site. Observations were made 24 hours after trap deployment. Trapped insects were sorted and then collected using a brush.

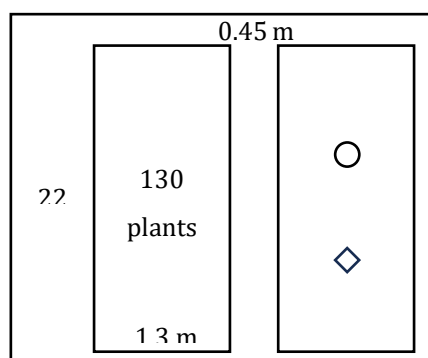


Figure 1. The size of the fern plot and the location of the traps (○ yellow pan trap, ◇ pitfall trap).

Disease Observation in Fern

Observations were conducted by collecting samples of symptomatic plant parts, placing them in paper bags and boxes, and transporting them to the laboratory for identification. The identification method employed was the moist chamber technique.

This involved moistening the symptomatic leaf sections, placing them in petri dishes, and observing them after a three day incubation period. Pathogen observation focused on the conidia using a binocular light microscope on prepared slides. Identification was based on the references of Barnett & Hunter (1998) and other relevant identification keys.

Calculation of plant incidence based on the formula by Cooke et al., (2006):

$$I = \frac{n}{N} \times 100\%$$

Formula description:

I = disease Incidence (%)

n = number of affected plants

N = total number of sample plants observed

Disease severity was calculated based on the formula of Townsend & Heuberger (1943):

$$Kp = \frac{\sum(n \times v)}{N \times V} \times 100\%$$

Formula description:

Kp = disease severity (%)

v = score for each symptom category

N = number of plants observed

V = highest score among symptom categories

Determination of disease severity score based on Sumardiyono et al., (2011):

Table 4. Determination of disease attack severity scores

Disease score	Attack symptoms
0	Healthy plants (no infection)
1	0 < x ≤ 10
2	10 < x ≤ 20
3	20 < x ≤ 40
4	40 < x ≤ 60
5	X > 60

Pest and Disease Management Strategies in Fern

The control strategies in this study were not experimentally tested but were formulated as recommendations based on the inventory of pests and diseases and the cultivation techniques observed at the study site. These strategies were developed according to cultivation stages drawing on literature reviews and adhering to Integrated Pest Management (IPM) principles and incorporate cultural, physical or mechanical, biological, and chemical approaches at each stage.

Data Analysis

Data were tabulated using Microsoft Office Excel and analyzed descriptively. Pest population data, as well as disease incidence and severity, were calculated as mean values to characterize the infestation and infection status at each study site. The results of pest and disease identification are presented in tables and interpreted based on morphological characteristics, infestation/infection levels, and orchard conditions to inform the formulation of control strategies. Supplementary data regarding climatic factors, such as temperature, rainfall, and humidity were obtained from Nasa Power (<https://power.larc.nasa.gov/data-access-viewer/>).

RESULTS AND DISCUSSION

Pests of Fern

Several types of pests were found at both observation sites, mealybugs, planthoppers, armyworms, grasshoppers, and stem borers. Each pest has a different mode of attack. Armyworms and grasshoppers cause direct damage to the plants through feeding activity, whereas planthoppers, mealybugs, and stem borers cause gradual damage.

Mealybug pests (Hemiptera: Pseudococcidae) form colonies on the undersides of leaves and feed on plant sap (Figure 2 A). In Sukabumi, the highest population was recorded in Farm D during the first week, at approximately 0.06 individuals per clump (Table 2 D), while in Cianjur, the peak occurred in Farm C during the fourth week, at approximately 0.05 individuals per clump (Table 3). Weeds growing within the crop area can increase humidity and promote mealybug proliferation (Sun et al., 2025). These conditions likely contribute to mealybug populations, as weeds not only elevate micro-humidity levels but can also serve as alternative host plants. Mealybug populations tend to develop in colonies and have the potential to increase if garden sanitation and weed control are not carried out regularly.

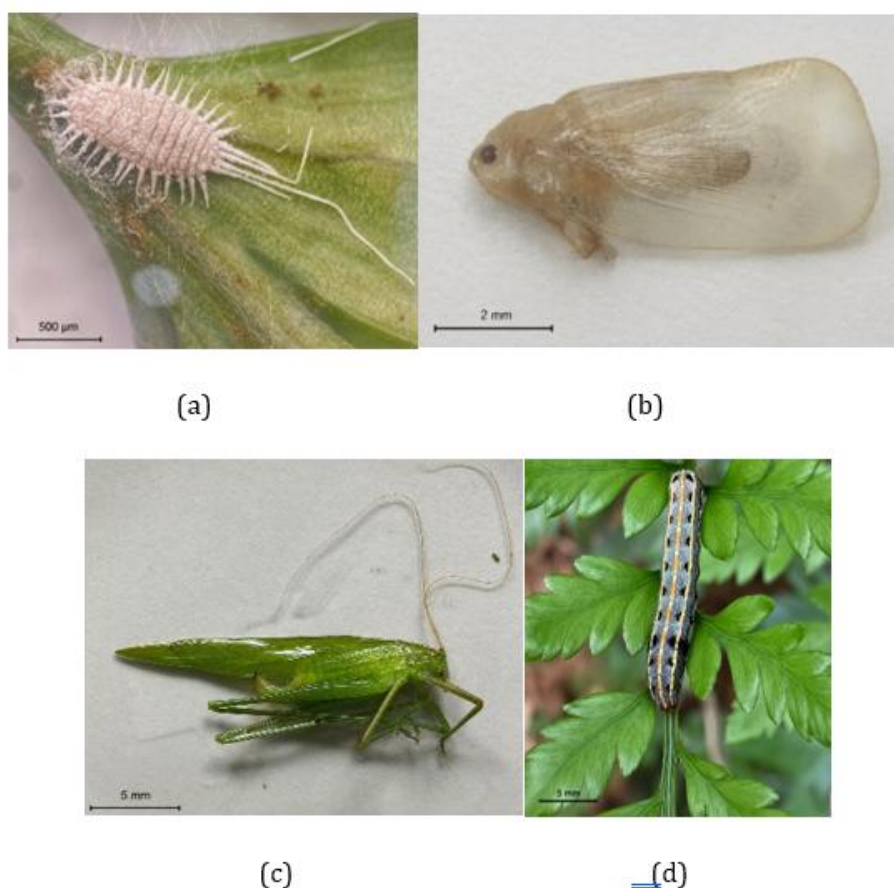


Figure 2. Pest on ferns: (a) Mealybug; (b) Leafhopper; (c) *Spodoptera* spp ; (d) *Phaneroptera* spp.

Planthoppers (Hemiptera: Flatidae) were also frequently found at the research sites (Figure 2 B). These pests cause damage by sucking sap from plant cells. In Sukabumi, the highest population was recorded in Farm D during the first week at approximately 0.09 individuals per clump (Table 2 D), while in Cianjur, the peak occurred in Farm C during the third week at approximately 0.04 individuals per clump (Table 3). The growth of new branches can lead to irregular plant spacing, resulting in relatively stable temperatures

and higher humidity conditions that favor planthopper proliferation. Furthermore, planthoppers prefer shoots or young leaves because the tissues are soft and nutrient rich. Denser foliage can also restrict air circulation, creating a microclimate more conducive to this pest development. Therefore, regular branch pruning and the maintenance of airflow within the planting area are crucial for suppressing planthopper population growth.

Another pest found was the armyworm *Spodoptera* spp. (Lepidoptera: Noctuidae) (Figure 2 C). The larvae attack by eating the leaves, leaving the leaf veins behind. The armyworm population per farm in each location is relatively low and tends to fluctuate (Tables 2 D and 3). This condition is thought to be related to the relatively stable planting microclimate due to the use of plastic covers (Holcman et al., 2017). The next pest is the grasshopper *Phaneroptera* spp. (Orthoptera: Tettigoniidae) (Figure 2 D). These grasshoppers feed by biting the edges of the leaves. In Sukabumi, the highest populations were recorded in Farm A and C during the first week, at 0.03 individuals per clump (Table 2 D), whereas in Cianjur, the highest population was found in Farm C at 0.02 individuals per clump during the second and third weeks (Table 2 B). These grasshoppers inhabit forest ecosystems or areas with dense shrubbery. Consequently, the presence of shrubs and vegetation surrounding the cultivation area could serve as a source of pest infestation, necessitating regular monitoring.

Another pest attacking ferns is the stem borer (Coleoptera: Curculionidae) (Figure 3 C). This pest typically attacks young plants, causing the section above the bore site or the tip to appear wilted, while the portion below remains healthy (Figure 3 B). The adult insect emerges from the stem, leaving behind a bore hole (Figure 3 A).

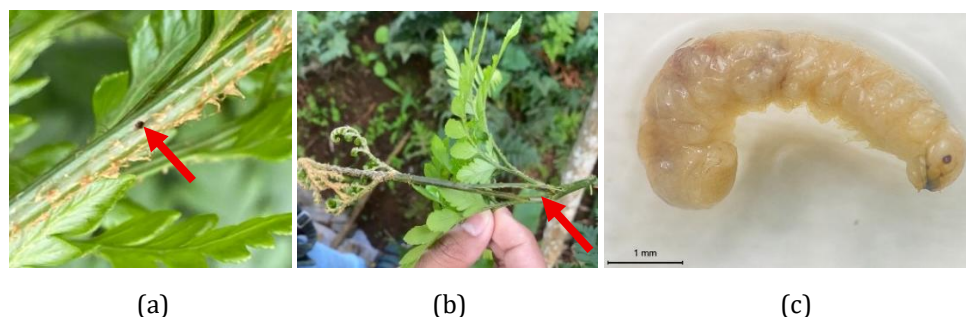


Figure 3. Borer larvae and attack symptoms. (a) drill hole; (b) larvae in the stem; (c) larvae outside the stem.

The intensity of fern stem borer infestations in Sukabumi remains low across all farm (Table 5), whereas in Cianjur, the highest intensity was recorded at Farm C during the fourth week, reaching 2.33% (Table 6). Stem borers typically damage young plants particularly under conditions of high humidity and poor drainage because the stems become softer (Ranger et al., 2016). However, it is possible for these pests to attack older plants as well when environmental conditions are favorable. Although the infestation intensity is relatively low, the presence of stem borers warrants attention because the resulting damage is permanent. Therefore, early detection of infestation symptoms and the sanitation of symptomatic plants are crucial measures for preventing the spread of the pest within the plantation.

Table 5. Pest population in Sukabumi Regency (individuals/plots)

Types of pests	Garden	Observation at week -			
		1	2	3	4
Mealybugs (per clump)	A	0.02	0.01	0	0.01
	B	0.02	0.03	0.02	0.02
	C	0.02	0.01	0	0.01
	D	0.06	0.04	0.05	0.05
Planthoppers (per clump)	A	0.04	0.02	0.02	0.01
	B	0.02	0.03	0.01	0.02
	C	0.01	0.02	0.01	0.02
	D	0.09	0.07	0.07	0.05
Armyworms (per clump)	A	0.01	0	0	0.01
	B	0.01	0	0	0.01
	C	0	0	0	0.01
	D	0.01	0.01	0.01	0.01
Grasshoppers (per clump)	A	0.03	0.02	0.02	0.01
	B	0.02	0.01	0.01	0.01
	C	0.03	0.01	0.01	0.01
	D	0.02	0.01	0.02	0.01
Fern stem borers (%)	A	0.33	1.00	1.33	1.33
	B	0.33	0.67	1.33	1.33
	C	0	0.67	0.33	0
	D	0.67	0.67	1.33	1.33

Table 6. Pest population in Cianjur Regency (individuals/plots)

Types of pests	Garden	Observation at week -			
		1	2	3	4
Mealybugs (per clump)	A	0.03	0.03	0.04	0.04
	B	0.02	0.02	0.02	0.03
	C	0.03	0.05	0.05	0.05
	D	0.03	0.01	0.03	0.04
Planthoppers (per clump)	A	0.47	0.20	0.53	0.53
	B	0.27	0.27	0.53	0.33
	C	0.27	0.53	0.80	0.73
	D	0.33	0.27	0.47	0.53
Armyworms (per clump)	A	0.01	0.01	0.01	0.02
	B	0.01	0.01	0.01	0.02
	C	0	0.01	0.01	0.02
	D	0	0.01	0.01	0.02
Grasshoppers (per clump)	A	0.01	0.01	0	0.02
	B	0	0.01	0.01	0.01
	C	0.01	0.02	0.02	0.01
	D	0.01	0	0.01	0.01
Fern stem borers (%)	A	0.67	1.00	0.67	0.33
	B	1.00	1.00	1.67	0.67
	C	0.33	0.67	1.33	2.33
	D	0	0.67	0.33	0.33

Diseases of Fern

Observations revealed three types of diseases at both study sites anthracnose, leaf tip rot, and leaf blight. The incidence and severity percentages for each disease varied by location. Anthracnose was the primary disease in both Sukabumi and Cianjur.

The initial symptoms of fern anthracnose involve necrosis at the leaf tips, turning them brown; the leaves gradually turn black and appear burnt or scorched, with young leaves being more susceptible (Figure 4 A). This disease is caused by the pathogen *Colletotrichum* spp. (Figure 4 B). In Sukabumi, the highest incidence and severity occurred in Farm D, at 3.79% and 12.93% respectively, during the third week (Table 7). In Cianjur,

the highest incidence and severity were observed in Farm A, at 2.26% and 6.40% respectively, during the first week (Table 8).

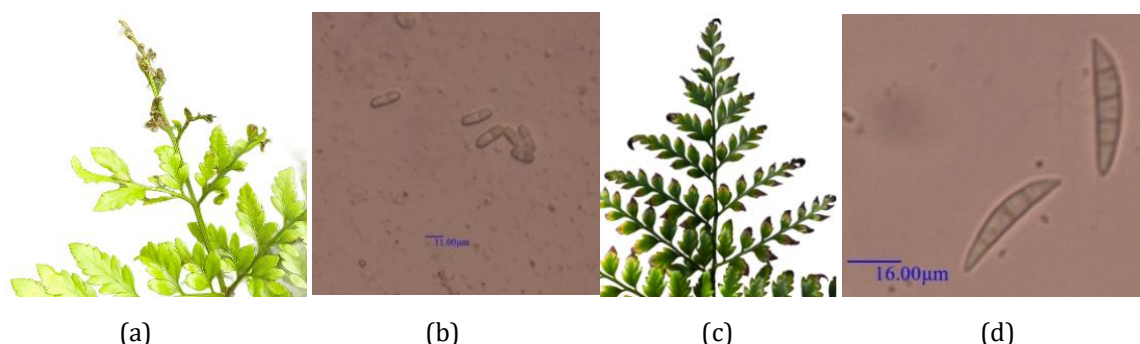


Figure 4. Anthracnose disease in ferns. (a) disease symptoms at the tip of the fern stalk; (b) Microscopically, the conidia of *Colletotrichum* spp. were cylindrical and hyaline; (c) disease symptoms on fern leaf tips; (d) microscopically, the macrokonidia of *Fusarium* spp. were sickle-shaped.

The high incidence and severity are thought to be influenced by conditions of high micro-humidity. During observation, the densening of fern clumps due to the growth of offshoots, combined with the presence of weeds in some beds, potentially restricted air circulation, this kept leaf surfaces moist, thereby facilitating infection by *Colletotrichum* spp. As this fungus is saprophytic and spreads rapidly, immediate sanitation of infected plant parts is required (Guarnaccia et al., 2021).

Leaf tip rot disease is characterized by symptoms of the leaf tips turning black and wilting (Figure 4 A). This disease is caused by *Fusarium* spp. (Figure 4 B). In Sukabumi, the highest incidence occurred in Farm A (0.49%) in the fourth week, while the highest severity was observed in Farm D (5.87%) in the third week (Table 7). In Cianjur, the highest incidence and severity occurred in Farm C, at 0.62% in the fourth week and 7.93% in the third week, respectively (Table 8).

Fusarium sp. is a soil borne fungus that causes significant damage to perennial plants such as ferns (Joshi, 2018). The presence of this fungus is believed to be influenced by moist soil conditions and poor drainage in certain planting beds, which facilitate pathogen survival and plant infection. Therefore, improving drainage and sanitizing infected plants are crucial measures for suppressing disease progression.

Leaf blight is characterized by reddish brown lesions on the leaves that spread from the leaf margins across the entire leaf surface until the leaf dries out (Figure 5 A). This disease is caused by the pathogen *Pestalotiopsis* sp. (Figure 5 B). In Sukabumi, the highest incidence and severity were recorded in Farm D, at 0.21% and 4.2% during the third and fourth weeks, respectively (Table 7). In Cianjur, the highest incidence and severity occurred in Farm C during the fourth week, at 1.18% and 17.53%, respectively (Table 8).

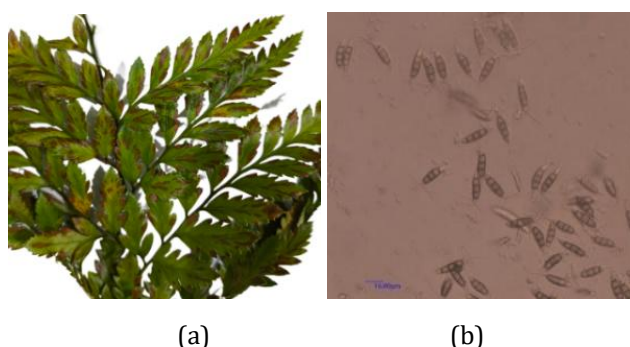


Figure 5. Leaf blight disease in ferns. (a) disease symptoms on each edge of the fern leaf; (b) microscopically, the conidia of *Pestalotiopsis* sp. were septate and appendaged.

Pestalotiopsis sp. typically attacks plants that are wounded or already infected by other pathogens, such as *Colletotrichum* spp., leading to secondary infection and increased disease severity (Aliya et al., 2022). In addition to tissue wounds, high humidity and poor air circulation within dense fern clumps are thought to facilitate the development of this disease. High severity scores indicate that symptoms on affected plants are widespread. Therefore, pruning infected parts and practicing routine sanitation are necessary to limit the spread of the pathogen.

Table 7. Incidence and severity of disease in Sukabumi Regency (%)

Type of disease	Garden	Observation at week -							
		1		2		3		4	
		I	KP	I	KP	I	KP	I	KP
Anthracnose	A	2.21	4.33	2.31	6.47	2.77	8.07	1.54	2.47
	B	1.59	2.53	1.69	4.33	2.26	6.73	1.38	3.93
	C	0.97	1.60	1.03	2.67	1.23	4.00	0.92	1.80
	D	3.13	6.53	3.28	9.73	3.79	1.93	2.26	7.27
Leaf tip rot	A	0.26	3.27	0.15	2.40	0.31	4.13	0.49	4.47
	B	0.10	1.33	0.21	2.40	0.21	2.07	0.40	2.73
	C	0	0	0	0	0.10	0.67	0.18	1.67
	D	0.39	4.67	0.26	3.27	0.41	5.87	0.41	5.73
Leaf blight	A	0.10	2.33	0.10	2.67	0.15	2.80	0.15	3.53
	B	0	0	0	0	0.10	0.67	0.10	0.73
	C	0.05	1.33	0	0	0	0	0.05	0.33
	D	0.15	2.80	0.15	3.13	0.21	4.20	0.21	4.20

I: incidence, KP: severity of disease.

Table 8. Incidence and severity of disease in Cianjur Regency (%)

Type of disease	Garden	Observation at week -							
		1		2		3		4	
		I	KP	I	KP	I	KP	I	KP
Anthracnose	A	2.26	6.40	1.90	5.60	1.54	4.47	1.23	3.27
	B	1.38	4.27	1.13	2.60	0.82	1.93	0.87	2.27
	C	1.64	5.60	1.38	4.40	1.18	3.13	1.03	2.27
	D	0.97	1.87	0.77	1.53	0.77	1.93	0.72	1.67
Leaf tip rot	A	0.31	6.53	0.21	2.07	0.26	3.47	0.26	4.40
	B	0.15	2.47	0.15	2.53	0.21	3.20	0.21	3.87
	C	0.36	6.80	0.46	5.07	0.56	7.93	0.62	6.07
	D	0.10	0.73	0.15	1.67	0.10	1.13	0.10	1.87
Leaf blight	A	0.37	4.53	0.41	8.33	0.51	7.60	0.62	11.00
	B	0.05	1.00	0.21	1.73	0.26	1.93	0.26	3.47
	C	0.67	10.93	0.82	10.40	1.03	16.67	1.18	17.53
	D	0.15	1.47	0.15	2.67	0.15	2.20	0.31	2.73

I: incidence, KP: severity of disease.

The inventory identified several types of pests and diseases affecting ferns. A summary ranging from the types of pests and diseases to control strategies based on Integrated Pest Management (IPM) principles was compiled to facilitate the interpretation of the research results (Table 9).

Table 9. Summary of pest and disease inventory results, as well as control strategies for ferns

Pest	Main symptoms	Causal agent	Occurrence level	Management strategy
Mealybug	White cottony colonies on fronds and petioles, sap-sucking damage	Hemiptera: Pseudococcidae	Moderate population	Weed sanitation, conservation of natural enemies
Planthopper	Sap-sucking damage causing chlorosis	Hemiptera: Flatidae	Moderate population	Maintain proper plant spacing, remove weeds regularly
Armyworm	Irregular holes on fronds, severe feeding may leave only leaf veins	<i>Spodoptera</i> spp. (Lepidoptera: Noctuidae)	Low population	Monitoring, manually remove larvae
Grasshopper	Chewing damage along leaf veins	<i>Phaneroptera</i> spp. (Orthoptera: Tettigoniidae)	Low population	Weeds sanitation
Fern stem borer	Boring holes in rhizomes/stems, causing wilting and frond damage	Coleoptera: Curculionidae	Low population	Use healthy rhizomes, remove and destroy infested plants
Disease				
Anthracnose	Dark brown to black necrotic lesions on fronds	<i>Colletotrichum</i> spp.	Highest disease incidence and severity	Use disease-free planting materials, improve drainage and air circulation, prune and destroy infected fronds, sanitation
Leaf tip rot	Necrosis beginning at the leaf tip and progressing downward	<i>Fusarium</i> spp.	Low incidence and severity	Use healthy planting materials, improve drainage, avoid excessive soil moisture, remove infected plants
Leaf blight	Brown lesions expanding over the frond, leading to blighting	<i>Pestalotiopsis</i> sp.	Moderate incidence with relatively high severity	Field sanitation, remove infected fronds

Arthropod Natural Enemies of Fern

Observations at each location identified *Oxyopes* spp. (Araneae: Oxyopidae) as the most abundant predator. This generalist predator is typically nocturnal and capable of preying on pests belonging to the orders Diptera and Hymenoptera.

The most abundant parasitoid group in Sukabumi specifically in Farm C was the Diapriidae (Hymenoptera), whereas almost no parasitoid insects were found in Cianjur. However, the findings regarding these parasitoids bear no direct relationship to the pests identified in the study, as they typically function as biocontrol agents against *Drosophila* sp. (Diptera: Drosophilidae).

The decomposers found at each location were *Hermetia illucens* (Black Soldier Fly/BSF) and *Aponedyopus* sp. Each acts as a natural decomposer or detritivore, breaking

down fallen fern fronds and other plant litter, thereby increasing the availability of soil nutrients beneficial for plant growth.

Management Strategies

The first stage is seeding. Seedling selection in the research garden was carried out by breaking up clumps from approximately 2 year old broodstock that were still productive and healthy. These seedlings can be infested with pests such as stem borers and infected with latent pathogens such as *Colletotrichum* spp. and *Fusarium* spp, so it has the potential to be a source of spread of pests to new plantings. Therefore, seed selection can be done more selectively or checked and cleaned before planting. and can use tissue culture seeds (Bhardwaj et al., 2025).

The second stage is land preparation, which encompasses soil tillage and the construction of planting beds and drainage systems. Observations revealed that some beds and drainage channels were poorly maintained and overgrown with weeds, impeding water flow particularly during the rainy season. These conditions increased humidity around the crops, creating an environment conducive to the proliferation of plant pests and diseases. Consequently, routine weed management and drainage system maintenance are essential to prevent water stagnation. Improving drainage and controlling weeds also help reduce humidity levels that favor the development of anthracnose, leaf tip rot, and leaf blight, while simultaneously limiting alternative habitats for mealybugs, planthoppers, and grasshoppers.

The third stage is planting. An initial spacing of 25x25 cm is appropriate at the time of planting. However, as the plants grow, they produce numerous tillers, causing the clumps to become increasingly dense and reducing air circulation. Consequently, periodic pruning of tillers is necessary to maintain aeration and reduce the micro humidity levels that foster the development of pests and diseases (Douma & Noordhoek, 2025). Improved air circulation also helps suppress the development of foliar diseases particularly anthracnose, leaf tip rot, and leaf blight while creating conditions less favorable for mealybug and planthopper populations.

The fourth stage involves watering and fertilization. During the study, watering was carried out every five days to maintain stable soil moisture without causing waterlogging. Ideally, watering should be performed in the morning and directed at the growing medium to avoid wetting the foliage, which can increase the risk of disease development, if large scale implementation is not yet feasible, manual watering using a hose can be done after the field has been cleared of diseased plant debris (Zhang et al., 2025). Fertilization was not performed during the observation period, however periodic application of manure outside this period is necessary to maintain soil fertility, enhance plant vigor, and activate soil borne biological agents (Yulianti et al., 2016). Plant vigor is linked to resistance against pests and diseases, while proper watering helps mitigate the risk of diseases triggered by high humidity, such as anthracnose, leaf tip rot, and leaf blight.

The fifth stage involves the control of plant pests and diseases. Control measures at the research site included farm sanitation, the installation of plastic covers, and periodic pesticide application. However, populations of mealybugs and planthoppers, as well as instances of certain diseases, were still observed. Therefore, control efforts need to be optimized through routine monitoring, sanitation of weeds and infected plants, rotation of pesticide active ingredients to prevent resistance, and the conservation of natural enemies (Paini et al., 2016; Zuhra et al., 2021). The selection of pesticide active ingredients is tailored to the specific pests and diseases present, with applications based on recommended dosages and field monitoring results. Weed sanitation, pruning of infested plants, and the conservation of natural enemies serve as initial measures against mealybugs and planthoppers prior to pesticide use. Meanwhile, improving drainage and sanitizing weeds and infected plants are the primary measures for suppressing inoculum sources associated with anthracnose, blossom-end rot, and leaf blight.

The sixth stage is harvesting. Harvesting is carried out by cutting the fronds using harvesting shears. However, the cut surfaces can serve as entry points for pathogens, and

since harvesting tools are typically reused, there is a risk of transferring pathogens from infected plants to healthy ones. Therefore, it is recommended to disinfect or clean the tools both before and after harvesting to ensure they remain free from dirt and pathogen contamination. In addition to maintaining tool hygiene, the harvesting process serves as a final monitoring stage, allowing for the observation of symptoms caused by plant pests and diseases. Plants exhibiting such symptoms are separated from the rest of the harvest to prevent them from becoming sources of pathogen spread during handling and storage.

CONCLUSION

Pests identified at both locations included planthoppers, mealybugs, armyworms (*Spodoptera* spp), grasshoppers (*Phaneroptera* spp.), and stem borers, while diseases included anthracnose *Colletotrichum* spp., leaf tip rot *Fusarium* spp., and leaf blight *Pestalotiopsis* sp. Armyworms and grasshoppers caused direct damage to the plants through feeding, whereas planthoppers, mealybugs, stem borers, and diseases caused gradual damage. Populations of beneficial arthropods remained relatively low. These findings can serve as a basis for developing an integrated pest and disease management strategy tailored to the specific conditions of the fern crops at the study sites, thereby supporting plant health and maintaining the quality of the harvested ferns.

REFERENCES

- Aliya, S., Sa, N., Mahyudin, M. M., Wong, M. Y., & Yusop, M. R. (2022). *Colletotrichum siamense* and *Pestalotiopsis jesteri* as potential pathogens of new rubber leaf spot disease via detached leaf assay. *Rubber Research Journal*, 25(6), 195-212. <https://doi.org/10.1007/s42464-022-00157-4>.
- Barnet, H. L., & Hunter, B. B. (1998). *Illustrated genera of imperfect fungi* (4th ed). APS Press, St. Paul Minnesota, USA.
- Badan Pusat Statistik. (2023). *Provinsi Jawa Barat dalam angka*. BPS Provinsi Jawa Barat, Bandung.
- Bhardwaj, S., Kumari, M., Chethan, T., Hosamani, M., Paul, M., Moirangthem, A., Dash, A. P., & Verma, S. (2025). Advances in micropropagation and tissue culture for horticultural crops: a review. *Plant Cell Biotechnology Molecular Biology Journal*, 26(11-12), 166-182. <https://doi.org/10.56557/pcbmb/2025/v26i11-1210039>.
- Borror, D. J., & White, R. E.. (1970). *A field guide to the insect America North of Mexico*. Houghton Mifflin Company, New York.
- Chen, Z. H. (2022). Unveiling novel genes in fern genomes for the design of stress tolerant crops. *Crop Design Journal*, 1, 1-6. <https://doi.org/10.1016/j.crope.2022.100013>.
- Cooke, B. M., Jones, D. G., & Kaye, B. (2006). *The epidemiology of plant diseases* (2nd ed). Springer, Dordrecht, Netherlands.
- Douma, J. C., & Noordhoek, R. (2025). The effect of plant host density on disease incidence: a meta-analysis. *Plant Cell & Environment Journal*, 48(9), 6632-6644. <https://doi.org/10.1111/pce.15634>.
- Goulet, H., & Huber, J. T. (1993). *Hymenoptera of the world: an identification guide to families*. Canada Communication Group, Ottawa, Canada.
- Guarnaccia, V., Martino, I., Gilardi, G., Garibaldi, A., & Gullino, M. L. (2021). *Colletotrichum* spp. causing anthracnose on ornamental plants in Northern Italy. *Plant Pathology Journal*, 103, 127-137. <https://doi.org/10.1007/s42161-020-00684-2>.
- Hasibuan, F. R., Khotizah, L. N., Butar, M. K. B., Hariyanti, M., Putri, R. S. A., Veraresa, R. H., Syahfitri, W., Ilmi, A. N., & Pujiyanti, A. S. (2025). Karakterisasi morfologi dan analisis literatur peran vektor kutu putih (*Pseudococcidae*) pada tanaman hias di lingkungan kampus Universitas Mulawarman. *Jurnal Hama dan Penyakit Tumbuhan*, 13(3), 142-149. <https://doi.org/10.21776/ub.jurnalhpt.2025.013.3.2>.
- Holcman, E., Sentelhas, P. C., Conceicao, M. A. F., & Couto, H. T. Z. (2017). Vineyard microclimate and yield under different plastic covers. *Biometeorology*, 62, 925-937. <https://doi.org/10.1007/s00484-017-1494-y>.
- Joshi, R. (2018). A review of *Fusarium oxysporum* on its plant interaction and industrial use. *Medicinal Plants Studies Journal*, 6(3), 112-115. <https://doi.org/10.22271/plants.2018.v6.i3b.07>.
- Lundstrom, N. L. P., Zhang, H., & Brannstrom, A. (2017). Pareto-efficient biological pest control enable high efficacy at small cost. *Ecological Modelling*, 364, 89-97. <https://doi.org/10.1016/j.ecolmodel.2017.08.015>.

- Martins, S. S., Souza, G. J. T., Netto, M. S. B., Vieira, W. A. S., Assuncao, I. P., Neto, F. A., Filho, F. A. C. R., & Melo, M. P. 2024. *Colletotrichum truncatum* causing anthracnose of *Catharanthus roseus* in Brazil. *Crop protection Journal*, 175, 1-8. <https://doi.org/10.1016/j.cropro.2023.106449>.
- Nasa Power. (2024). Powering the future of energy, infrastructure, and agroclimatology. <https://power.larc.nasa.gov/data-access-viewer/>.
- Newman, S. E. (2019). Floriculture: *Encyclopedia of Environment Health Journal*, 2(3), 19-33. <https://doi.org/10.1016/B978-0-12-409548-9.11830-5>.
- Paini, D. R., Sheppard, A. W., Cook, D. C., Barro, P. J. D., Worner, S. P., & Thomas, M. B. (2016). Global threat to agriculture from invasive species. *Proceedings of the National Academy of Science Journal*, 113(27), 7575–7579. <https://doi.org/10.1073/pnas.1602205113>.
- Ranger, C. M., Reding, M. E., Schultz, P. B., Oliver, J. B., Frank, S. D., Adesso, K. M., Ching, J. H., Sampson, B., Werie, C., Gill, S., & Krause, C. (2016). Biology, ecology, and management of nonnative ambrosia beetles (*Coleoptera: Curculionidae: Scolytinae*) in ornamental plant nurseries. *Integrated Pest Management Journal*, 7(1), 1-23. <https://doi.org/10.1093/jipm/pmw005>.
- Sinnarong, N., Siwarat, K., Waraporn, N., Sasiwimon, P., & Vannasinh, S. (2022). The potential risks of climate change and weather index insurance scheme for Thailand's economic crop production. *Environmental Challenges*, 8, 1-8. <https://doi.org/10.1016/j.envc.2022.100575>.
- Smith, G. H., Roberts, J. M., & Pope, T. W. 2018. Terpene based biopesticides as potential alternatives to synthetic insecticides for control of aphid pests on protected ornamentals. *Crop Protection*, 110, 125-130. <https://doi.org/10.1016/j.cropro.2018.04.011>.
- Sumardiyono, C., Joko, T., Kristiawati, Y., & Chinta, Y. D. (2011). Diagnosis dan pengendalian penyakit antraknosa pada pakis dengan fungisida. *Jurnal Hama dan Penyakit Tropika*, 11(2), 194-200. <https://doi.org/10.23960/j.hptt.211194-200>.
- Sun, W., Guo, Y., Wang, H., Sun, Y., Xu, J., Zhang, K., & Jin, H. (2025). Impact of airflow-assisted spraying technology on droplet drift: a solution for reducing pesticide drift under multidirectional strong wind conditions. *Pest Management Science*, 81(6), 3312-3327. <https://doi.org/10.1002/ps.8702>.
- Townsend, G. R., & Heuberger, J. W. (1943). Methods for estimating losses caused by diseases in fungicide experiment. *Plant Disease Report*, 27(17), 340-343.
- Wedyanto, A. (2009). Standar Operasional Prosedur Budidaya Leatherleaf. Direktorat Jenderal Hortikultura, Jakarta.
- Yulianti, Y., Aisyah, S. I., & Sukma, D. (2016). Pengaruh bahan organik nabati dan hewani terhadap pertumbuhan Protocorm Like Bodies *Phalaenopsis amabilis* (L.) Blume. *Jurnal Hortikultura Indonesia*, 7(3), 176-186. <https://doi.org/10.29244/jhi.7.3.176-186>.
- Zhang, H., Cao, H., Zhao, Z., Dou, Z., Liao, Z., Bai, Z., Li, S., Zhang, F., & Fan, J. (2025). Effects of irrigation interval and irrigation level on growth, photosynthesis, fruit yield, quality, and water-nitrogen use efficiency of drip-fertigated greenhouse tomatoes (*Solanum lycopersicum* L.). *Agronomy*, 15(5), 1068. <https://doi.org/10.3390/agronomy15051068>.
- Zuhran, M., Mudjiono, G., & Puspitarini, R. D. (2021). Pengaruh praktik budidaya jeruk terhadap intensitas penyakit Huanglongbing (HLB) di Kabupaten Sambas, Kalimantan Barat. *Jurnal Hortikultura Indonesia*, 12(2), 108-116. <http://dx.doi.org/10.29244/jhi.12.2.108-116>.

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