Forest Research Institute, Yezin, Nay Pyi Taw, Myanmar

Forestry Research Update

March, 2024

Research Findings on the Integrated Pest and Disease Management in Teak Plantations in Myanmar
Implementation by FD-AFoCO Cooperation

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Contents

Diversity of Insect Pests and Their Natural Enemies Infesting Teak (*Tectona grandis* L.f, Lamiaceae) in Bago Region, Myanmar

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Abstract

This survey was carried out to record the pests and their natural enemies associated with teak plantation in five townships namely, Paukkhaung, Padaung, Tharrawaddy, Minhla and Gyobingauk Township at Pyay and Tharyarwaddy Districts, Bago Region from August to December, 2022. In this experiment 23 pest species and 13 species of natural enemies were recorded by visual observation. 26 pest species and 11 species of natural enemies were recorded by using light trap. 30 pest species and 14 species of natural enemies were recorded by using yellow sticky trap. 27 pest species and 8 species of natural enemies were recorded by using insect net. The results revealed that teak is attacked by totally 46 species of pest. Out of them, 12 species were from Lepidoptera (26.1%), 12 species from Coleoptera (26.1%), 10 species from Hemiptera (21.7%), 7 species from Orthoptera (15.2%), 3 species from Homoptera (6.5%) and 2 species from Isoptera (4.4%). Out of the total reported species, leaf feeders are dominant (45.7%), sap feeders (26.1%) are moderate followed by stem borer (10.9%), root feeder (8.7%), flower and seed feeders (4.3 %) and bark feeders (4.3%) respectively. The results also revealed that totally 19 species of natural enemies were associated with pests. Out of 19 species of natural enemies, 5 species from Hymenoptera (26.3%), 5 species from Araneae (26.3%), 4 species from Coleoptera (21 %), 2 species from Odonata (10.5%), 1 species from Orthoptera (5.3%), 1 species from Hemiptera (5.3%) and 1 species from Neuroptera (5.3%) were recorded.

Keywords: Teak, *Tectona grandis,* diversity, pest, natural enemies, Bago region, Myanmar

ပဲခူးတိုင်းဒေသကြီးအတွင်း တည်ထောင်ကျွန်းစိုက်ခင်းများတွင် ကျရောက်တတ်သည့် အင်းဆက်ဖျက်ပိုးများနှင့် ၎င်းတို့၏သဘာဝရန်သူ အင်းဆက်များ

စာတမ်းအကျဉ်း

သာယာဝတီခရိုင်၊ သာယာဝတီ၊ မင်းလှ၊ ကြို့ပင်ကောက်မြို့နယ်များနှင့် ပြည်ခရိုင် ပေါက်ခေါင်းမြို့နယ်၊ ပန်းတောင်းမြို့နယ်များရှိ ကျွန်းစိုက်ခင်းများတွင် ကျရောက်တတ်သည့် အင်းဆက်ဖျက်ပိုးများနှင့် ၎င်းတို့၏ သဘာဝရန်သူအင်းဆက်များအား လေ့လာမှတ်တမ်း တင်နိုင်ရန် ဤသုတေသနလုပ်ငန်းအား ဆောင်ရွက်ခဲ့ခြင်းဖြစ်ပါသည်။ ၂၀၂၂ ခုနှစ် ဩဂုတ်မှ ဒီဇင်ဘာလအတွင်း ကွင်းဆင်းဆောင်ရွက်ခဲ့ခြင်းဖြစ်ပါသည်။ ဖျက်ပိုး (၂၃) မျိုးနှင့် ၎င်းတို့၏ သဘာဝရန်သူ (၁၃) မျိုးအား မျက်မြင်လေ့လာခြင်းဖြင့်လည်းကောင်း၊ ဖျက်ပိုး (၂၆) မျိုးနှင့် ၎င်းတို့၏ သဘာဝရန်သူ (၁၁) မျိုးအား မီးအိမ်ထောင်ခြောက်ဖြင့်လည်းကောင်း၊ ဖျက်ပိုး (၃၀) မျိုးနှင့် ၎င်းတို့၏သဘာဝရန်သူ (၁၄) မျိုးတို့အား အဝါရောင်ကော်ပြားဖြင့်လည်းကောင်း၊ မီးအိမ်ထောင်ခြောက်ဖြင့်လည်းကောင်း၊ ဖျက်ပိုး (၂၇) မျိုးနှင့် ၎င်းတို့၏သဘာဝရန်သူ (၈) မျိုးတို့အား အင်းဆက်ဖမ်းပိုက်ဖြင့်လည်းကောင်း ဖမ်းဆီး၍ မှတ်တမ်းတင်နိုင်ခဲ့ပါသည်။ ကျွန်းစိုက်ခင်းများတွင် ကျရောက်တတ်သည့် ဖျက်ပိုး စုစုပေါင်း (၄၆) မျိုးအား မှတ်တမ်း တင်နိုင်ခဲ့ပါသည်။ လေ့လာခဲ့သည့် ဖျက်ပိုးများအနက် Lepidoptera (၁၂) မျိုး၊ Coleoptera (၁၂) မျိုး၊ Hemiptera (၁၀) မျိုး၊ Orthoptera (၇) မျိုး၊ Homoptera (၃) မျိုး၊ Isoptera (၂) မျိုးတို့အား မှတ်တမ်းတင်နိုင်ခဲ့ပါသည်။ ၎င်းတို့အနက် ရွက်စားပိုး ၄၅.၇ %၊ စုတ်စားပိုး ၂၆.၁ % ၊ ပင်စည်ထိုးပိုး ၁၀.၉ %၊ အမြစ်ထိုးပိုး ၈.၇ %၊ အပွင့်နှင့် သစ်စေ့ဖျက်ပိုး ၄၃ % နှင့် အခေါက်ထိုးပိုး ၄.၃% ဖြစ်ကြောင်း လေ့လာသိရှိခဲ့ရပါသည်။ အဆိုပါ ဖျက်ပိုးများ၏ သဘာဝရန်သူ (၁၉) မျိုးအား လေ့လာမှတ်တမ်းတင်နိုင်ခဲ့ပါသည်။ သဘာဝရန်သူ များအနက် Hymenoptera (၅) မျိုး၊ Araneae (၅) မျိုး၊ Coleoptera (၄) မျိုး၊ Odonata (၂) မျိုး၊ Orthoptera (၁) မျိုး၊ Hemiptera (၁) မျိုး၊ Neuoptera (၁) မျိုးတို့အား မှတ်တမ်း တင်နိုင်ခဲ့ပါသည်။

Introduction

Teak (*Tectona grandis* L.f.) (Family Lamiaceae) is highly prized constructional and multipurpose timber species, found in the tropical and sub - tropical forests. Its natural distribution in India, Myanmar and Thailand ranges from sea level to 800m, even up to 1300m above sea level. The species has been planted in other tropical regions since the beginning of the 19th century, especially in Asia, Africa and Central America (Keogh, 1979; Dupuy, 1990). Teak, *Tectona grandis*, is a hardwood tree native to much of South and Southeast Asia, including Myanmar. Due to its natural water resistance, teak is sought out for a variety of uses including furniture-making and shipbuilding (Bryant, 1997).

Teak has been important to the economy of Myanmar since British Colonization. In Myanmar, large area of teak plantations have been establishing since 1980 and a total of 255,711 acres have been raised up to 1996 (Myint,1997). In Myanmar, it is naturally found in areas between the 25°30'N and 10°N lines of latitude. Teak mostly grows in hilly areas below 900 metres (3,000 ft) in elevation. Within the country, teak is most common in mixed deciduous forests as well as evergreen and semi evergreen forests (Gyi and Tint, 1995). In the south of Myanmar, major teak forests existed in the Bago and Tanintharyi Hills. Other notable areas of teak growth include the Arakan (Rakhine) Mountains in the west of the country and the Shan Hills in the East (Gyi and Tint, 1995).

Nearly 294 insects have been identified on teak, which includes 147 species from order Coleoptera, 94 species from Lepidoptera, 23 species from Orthoptera, 21 species from Hemiptera, 7 species from Isoptera, 1 species from Diptera and 1 species from Hymenoptera (Beeson, 1941; Mani 1959; Mathur, 1960; Mathur and Singh, 1960; Muttiah, 1967; Browne, 1968; Vastrad *et al*., 1989; Varma, 1991; Tewari, 1992; Chey, 1996; Roychoudhury et al., 2001). These insects attack all the stages of teak growth, from seed to mature trees. About 196 species of insects are associated with living teak, comprising mainly defoliators (141), sap suckers (17), stemborers (16), root feeders (12) and seed feeders (9) and gall former (1) (Shukla *et al*., 2001). Many of these insects are minor or occasional pests and very few are considered as insect pests of economic importance (Roychoudhury, 1998).

Teak plantations often suffer severe damage from insect attack and outbreak of infestation has been occasionally reported in Myanmar. Myint and Win (2016) earlier reported that shoot borer (*Zeuzea coffeae* Nietner), leaf feeder (*Eutectona machaeralis* Walker), sap sucking bug (*Tingis* sp.), stem borer (*Acalolepta cervinus* Hope), saplingborer (*Sahyadrassus malabaricus* Moore) and termite (*Copotermes curvignathus*) infested young teak plant from an experiment conducted in Nyaung Chae Thawk Reserve Forest, Oktwin Township, Bago Region and in Pa Lway Reserve Forest, Leway Township, Nay Pyi Taw, Myanmar.

In fact, the total number of insect pests infesting teak was not reported in forest trees protection in Myanmar. Hence, in the present investigation an attempt is being made for bringing out a systematic documentation of all the insect pests attacking teak in Bago Region as well as the occurrence of natural enemies of the major pests in this region with following objectives.

Objectives

The main objective of this research is to study the diversity of insect pests infesting teak plantations and their natural enemies. The main objectives are as follow;

1. To list the major insect pests found in young and old Teak plantations in Myanmar,
2. To observe the natural incidence as well as to formulate effective control measures
3. To list natural enemies of major insect pests infesting Teak

Materials and Methods

A survey was carried out to record the pests associated with teak plantation in Pyay and Tharyarwaddy Districts, Bago Region from August to December, 2022. Tharyarwaddy District is located in Bago Region of West Bago Yoma (between the latitude 17° 28' to 18° 48' N and longitude 95° 09' to 96° 05' E), Myanmar. It is 1,794,151ac (726,067 ha) in size and is composed of 8 Townships, namely; Tharyarwaddy, Letpadan, Minhla, Monyo, Okhpo, Gyobingauk, Zigon and Nattalin Townships. Pyay District is also located in Bago Region of West Bago Yoma (between the latitude 18° 20' to 19° 22' N and longitude 95° 06' to 97° 66' E), Myanmar. It is composed of 6 Townships, namely; Pyay, Paukkhaung, Padaung, Paungde, Thegon and Shwedaung Townships covering an area of 1,898,456 ac (768,278 ha). Among them survey areas were selected in Paukkhaung, Padaung, Tharrawaddy, Minhla and Gyobingauk Township. A total of 5 sample plots (100 acres) were selected from each township. One sample plot has an area of 20 acres. 5 subsample plots were laid out again within each sample plots in accordance sampling design.

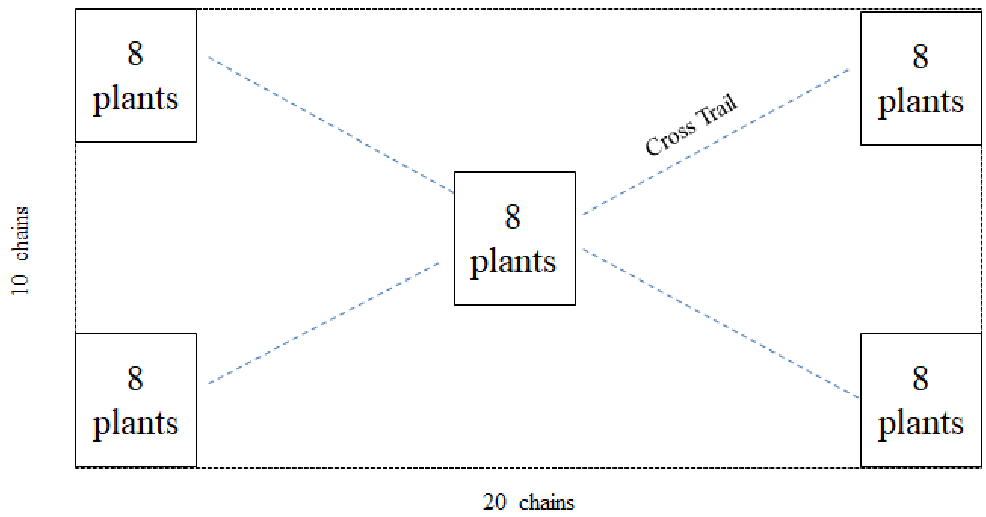

Figure 1: Layout design of sample plot

Table 1: List of representative teak plantations for pest survey

Sr.no.	Plantation No.	Year of Establishment	Location
1	2/1979	1979	Nawin (S) Reserve, Paukkhaung Township
2	2/1998	1998	Nawin (S) Reserve, Paukkhaung Township
3	2/2007	2007	Nawin (M) Reserve, Paukkhaung Township
4	3/2013	2013	Nawin (S) Reserve, Paukkhaung Township
5	2/2021	2021	Nawin (M) Reserve, Paukkhaung Township
6	1/2008	2008	Thayetan Reserve, Padaung Township
7	2/2010	2010	Thayetan Reserve, Padaung Township
8	2/2012	2012	Thanlaegyi Reserve, Padaung Township
9	1/2020	2020	Thani Reserve, Padaung Township
10	1/2021	2021	Thayetan Reserve, Padaung Township
11	1/2008	2008	Thonese Reserve, Thayarwaddy Township
12	1/2011	2011	Thonese Reserve, Thayarwaddy Township
13	1/2016	2016	Kanni Reserve, Thayarwaddy Township
14	1/2019	2019	Thonese Reserve, Thayarwaddy Township
15	1/2021	2021	Thonese Reserve, Thayarwaddy Township
16	1/2004	2004	Minhla Reserve, Minhla Township
17	2/2009	2009	Minhla Reserve, Minhla Township
18	1/2016	2016	Mokkha Reserve, Minhla Township
19	1/2017	2017	Mokkha Reserve, Minhla Township
20	1/2019	2019	Mokkha Reserve, Minhla Township
21	1/2008	2008	Bawbin Reserve, Gyobingauk Township
22	4/2010	2010	Bawbin Reserve, Gyobingauk Township
23	5/2010	2010	Bawbin Reserve, Gyobingauk Township
24	2/2011	2011	Bawbin Reserve, Gyobingauk Township
25	1/2021	2021	Bawbin Reserve, Gyobingauk Township

Methods of observations

The following methods were adapted to record observations;

1. Visual observation
2. Using light trap
3. Using yellow sticky trap
4. Using insect net

1. Visual observation

In each Township, 200 trees from 100 acres (over 45 ha) teak plantation were enumerated regarding the sample plot. A sub-sample-plot was collected in the four corners and in the middle of the teak plantation area in each 100 acres sample plot. Therefore, there will be 5 sub plots in each township to collect pest information. 40 trees were randomly marked permanently to record infestation of pests in one sub-sample plot at monthly interval (Figure 1.). The total number of larva, nymphs, adults of insects and natural enemies were counted at each observation on teak trees and classified. Not only Insect pests were counted but also damaged leaves were observed by visual observation (Figure 2 & 3).

Figure 2: Making marker number on teak tree

Figure 3: Visual counting in young teak plantations and old teak plantations

2. Using light trap

One light trap was set up in each sub-sample plot one night before recording. Light trap was lighting on from 6 pm to 6 am (Figure 4). Total number of individual pests and natural enemies trapped in light trap were counted and identified.

Figure 4: Setting light trap (up sight and lateral sight)

3. Using yellow sticky trap

Five yellow sticky traps were set up in each sub-sample plot at days 7 of individual pests and natural enemies sticked on yellow sticky traps were counted and identified.

Figure 5: Yellow sticky trap in young and old teak plantations

4. Using insect net

In each sub-sample plot, sweep net collection was done by walking in crossing before nine o' clock in the morning (Figure 7). Total number of individual pests and natural enemies collected in insect net were counted and identified.

Figure 6: Sweeping net collecting in teak plantation

Results and Discussion

1. Visual observation

Number of different species of pests and natural enemies recorded by visual observation in teak plantations are presented in Table 1 and 2. 23 pest species and 13 species of natural enemies are recorded in 5 townships (Table 1 and 2).

Table 2: Different species of pest recorded by visual observation in teak plantations of Pyay and Tharyarwaddy Districts, Bago Region (August - December, 2022)

No	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
1.	Aphid	*Aphis gossypii*	x	-	-	x	x
2.	Ash weevil	*Myllocerus viridanus*	x	-	x	-	-
3.	Cricket	*Tarbinskiellus portentosus*	x	-	x	x	x
4.	Chafer beetle	*Amphimallon majale*	-	-	x	-	-
5.	Teak Defoliator	*Hyblaea puera*	-	x	-	x	x
6.	Golden tortoise beetle	*Aspidimorpha sanctaecrucis*	-	-	x	-	-
7.	Green leaf hopper	*Bothrogonia ferruginea*	x	x	-	-	x
8.	Gundhi bug	*Leptocorisa oratoria*	x		x	-	x
9.	Horned shield bug	*Placosternum* sp.	-	-	-	x	-
10.	Lace bug	*Tingis* sp.	-	-	-	x	-
11.	Long horned grasshopper	*Conocephalus maculatus*	x	-	-	x	x
12.	Mealy bug	*Icerya* sp	x	-	-	x	-
13.	Mealy bug	*Pseudococcus* sp.	x	-	-	x	-
14.	Red borer	*Zeuzera coffeae*	-	-	-	x	-
15.	Scutellarid bug (Jewel bug)	*Chrysocoris purpureus*	-	-	-	x	-
16.	Short horned grasshopper	*Acrida turrita*	x	x	x	x	x
17.	Skeletoniser	*Eutectona machaeralis*	x	x		x	x
18.	Tawny coster	*Acraea violae*	-	-	x	x	x
19.	Teak canker grub	*Acalolepta cervinus*	-	-	-	x	-
20.	Fungus-growing Termite	*Odontotermes* sp.	x	x	x	x	x
21.	Rubber Termite	*Coptotermes curvignathus*	x	x	x	x	x
22.	Whitefly	*Bemisia tabaci*	-	-	-	x	-

No	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
23.	Yellow peach moth	*Conogethes punctiferalis*	-	-	-	x	-

Remark: Present x

Absent -

Table 3: Different species of natural enemies recorded by visual observation in teak plantations, Pyay and Tharyarwaddy Districts, Bago Region (August - December, 2022)

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
1.	Black ant	*Camponotus* sp.	x	x	x	x	x
2.	Red dragonfly	*Sympetrum fonscolombii*	-	x	-	-	x
3.	Green lace wing	*Chrysoperla* sp.	-	-	-	x	-
4.	Lady beetle	*Coccinella transversalis*	-	x		x	x
5.	Praying mantis	*Mantisa religiosa*	x	x	x	x	x
6.	Red ant	*Solenopsis* sp.	-	-	-	x	-
7.	Spider	*Lycosa pseudoanulata*	x	x	-	x	x
8.	Green lynx spider	*Peucetia viridans*	x	x	-	x	x
9.	Spider	*Oxyopes javanus*	x	x	-	x	x
10.	Spider	*Argiope* sp.	x	x	-	x	x
11.	Huntsman Spider	*Olios* sp.	x	x	-	x	x
12.	Wasp	*Bracon* sp.	-	x	-	x	-
13.	European paper wasp	*Polistes dominula*	-	-	x	x	x

Remark: Present x

Absent -

2. Using light trap

Number of different species of pests and natural enemies recorded by using light trap in teak plantations are presented in Table 3 and 4. 26 pest species and 11 species of natural enemies are recorded in 5 townships (Table 3 and 4).

Table 4: Different pest species recorded by light trap in teak plantations of Pyay and Tharyarwaddy Districts, Bago Region (August - December, 2022)

No.	Common Name	Scientific Name	Tharya r waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
1.	Aphid	*Aphis gossypii*	-	-	-	x	-
2.	Ash weevil	*Myllocerus viridanus*	x	-	x	-	-
3.	Black bug	unidentified	-	x	-	-	-
4.	Blister beetle	*Mylabris phalerata*	-	-	-	x	x
5.	Chafer beetle	*Amphimallon majale*	x	x	x	x	-
6.	Cricket	*Tarbinskiellus portentosus*	x	x	x	x	x
7.	Teak Defoliator	*Hyblaea puera*	x	-	-	x	x
8.	Dung beetle	*Heliocopris bucephalus*	x	-	-	-	-
9.	Green leaf hopper	*Bothrogonia ferruginea*	-	x	x	x	x
10.	Gundi bug	*Leptocorisa oratoria*	-	-	x	x	x
11.	Horned shield bug	*Placosternum* sp.	-	-	-	x	-
12.	Lace bug	*Tingis* sp.	x	-	-	x	-
13.	Leaf hopper	*Ptyclus praefractus*	x	-	-	x	x
14.	Long horned Grass Hopper	*Conocephalus maculatus*	x	x	-	-	-
15.	Bush cricket	*Mecopoda elongate*	-	-	-	-	-
16.	Red borer	*Zeuzera coffeae*	x	-	-	x	-
17.	Root borer	*Phassus signife*r		x		x	-
18.	S Grass Hopper	*Acrida turrita*	x	x	x	x	x
19.	Sapling borer	*Sahyadrassus malabaricus*	-	-	-	x	-
20.	Scutellaria bug (Jewel bug)	*Chrysocoris purpureus*	-	-	-	x	-
21.	Skeletoniser	*Eutectona machaeralis*	-	-	-	x	x
22.	Tawny coster	*Acraea violae*	-	-	-	x	-
23.	Teak canker grub	*Acalolepta cervinus*	-	-	-	x	-
24.	White fly	*Bemisia tabaci*	-	-	-	x	-
25.	White grub	*Holotrichia consanguinea*	-	-	-	x	-
26.	Yellow peach moth	*Conogethes punctiferalis*	-	-	-	x	-

Remark: Present x**,** Absent -

Table 5: Different species of natural enemies recorded by using light trap in teak plantations of Pyay and Tharyarwaddy Districts, Bago Region (August - December, 2022)

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
1.	Black ant	*Camponotus* sp.	x	-	x	-	x
2.	Red dragonfly	*Sympetrum fonscolombii*	-	-	-	x	-
3.	Ground beetle	*Nebria brevicollis*	x	x	-	x	-
4.	Lace wing	*Chrysoperla* sp.	-	x	-	x	-
5.	Lady beetle	*Coccinella transversalis*	-	x	-	x	-
6.	Praying mantis	*Mantisa religiosa*	x	-	x	-	x
7.	Red ant	*Solenopsis* sp.	-	-	-	x	-
8.	Spider	*Lycosa pseudoanulata*	x	-	x	x	x
9.	Wasp	*Bracon* sp.	-	x	-	-	-
10.	Wasp	*Polistes dominula*	-	-	-	x	x
11.	Wasp	*Apanteles* sp.	x	-	x	x	x

Remark: Present x

Absent -

3. Using yellow sticky trap

Number of different species of pests and natural enemies recorded by using yellow sticky trap in teak plantations are presented in Table 5 and 6. 30 pest species and 14 species of natural enemies are recorded in 5 townships (Table 5 and 6).

Table 6: Different pest species recorded by using yellow sticky trap in teak plantations of Pyay and Tharyarwaddy Districts, Bago Region (August – December, 2022)

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
1.	Aphid	*Aphis gossypii*	-	-	-	x	-
2.	Army worm	*Spodoptera litura*	-	-	-	x	-
3.	Black bug	unidentified	-	x	-	-	-
4.	Black pumpkin beetle	*Aulacophora nigripennis*	x	-	-	-	-
5.	Blister beetle	*Mylabris phalerata*	-	-	-	x	-
6.	Chafer beetle	*Amphimallon majale*	x	-	x	x	-

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
7.	Cicada	*Burmacicada protera*	-	-	-	x	-
8.	Common hairy caterpillar	*Spilosoma obliqua*	-	x	-	x	-
9.	Cotton stainer bug	*Dysdercus cingulatus*	-		-	x	-
10.	Cricket	*Tarbinskiellus portentosus*	x	x	x	x	x
11.	Teak Defoliator	*Hyblaea puera*	x	x	-	x	
12.	Green leaf hopper	*Bothrogonia ferruginea*	-	x	x	x	x
13.	Gundhi bug	*Leptocorisa oratoria*	x	-	x	x	-
14.	Horned shield bug	*Placosternum* sp.	-	x	-	x	-
15.	Lace bug	*Tingis* sp.	-	-	-	x	
16.	Leaf hopper	*Ptyclus praefractus*	x	-	-	x	x
17.	L grass hopper	*Conocephalus maculatus*	x	x	-	x	-
18.	Red borer	*Zeuzera coffeae*	x	x	-	x	-
19.	Red Pumpkin beetle	*Aulacophora foveicollis*	x	-	-	-	-
20.	Root borer	*Phassus signife*r	-	-	-	x	-
21.	Short horned Grasshopper	*Acrida turrita*	x	x	x	x	x
22.	Sapling borer	*Sahyadrassus malabaricus*		-	-	x	-
23.	Skeletoniser	*Eutectona machaeralis*	x	-	-	x	-
24.	Spider		x	x	x	x	x
25.	Sucking bug		-	x	-	-	-
26.	Teak canker grub	*Acalolepta cervinus*	-	-	-	x	-
27.	Trunk borer	*Alcterogystia cadambae*	-	-	-	x	-
28.	Tree hopper	*Leptocentrus Taurus*	x	-	-		-
29.	White fly	*Bemisia tabaci*	x	-	-	x	-
30.	Yellow peach moth	*Conogethes punctiferalis*	-	-	-	x	-

Remark: Present x
Absent -

Table 7: Different species of natural enemies recorded by using yellow sticky trap in teak plantations of Pyay and Tharyarwaddy Districts, Bago Region (August - December, 2022)

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
1.	**Assassin bug**	*Zelus renardii*	x	-	-	-	-
2.	Black ant	*Camponotus* sp.	x	x	x	x	x
3.	Red dragonfly	*Sympetrum fonscolombii*	x	x	-	x	x
4.	Damsel fly	Unidentified	x	x	x	x	x
5.	Ground beetle	*Nebria brevicollis*	x	x	-	x	
6.	Lace wing	*Chrysoperla* sp.	x	-	-	x	-
7.	Lady beetle orange	*Coccinella transversalis*	x	x	-	x	x
8.	Lady beetle	*Cycloneda munda*	x	-	-	-	-
9.	Lady beetle red	*Coccinella undecimpunctata*	x	-	-	-	-
10.	Mantis	*Mantisa religiosa*	-	x	x	x	-
11.	Spider	*Lycosa pseudoanulata*	x	x	x	x	x
12.	Wasp	*Bracon* sp.	x	x	x	x	
13.	Wasp	*Apanteles* sp.	x	x	x	x	x
14.	European Paper wasp	*Polistes dominula*	-	-	x	x	-

Remark: Present x

Absent -

4. Using insect net

Number of different species of pests and natural enemies recorded by using insect net in teak plantations are presented in Table 7 and 8. 27 pest species and 8 species of natural enemies are recorded in 5 townships (Table 7 and 8).

Total number of different species of pests and natural enemies recorded in teak plantations in five townships are presented in Table 9 and 10. 46 pest species and 19 species of natural enemies are recorded in 5 townships (Table 9 and 10).

Table 8: Different species of pest recorded by using insect net in teak plantations of Pyay and Tharyarwaddy Districts, Bago Region (August – December, 2022)

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
1.	Ash weevil	*Myllocerus viridanus*	x	-	x	-	-
2.	Black bug	unidentified	x	-	-	-	-
3.	Blue beetle	*Colasposoma* sp	-	-	-	x	-
4.	Black beetle	*Colasposoma* sp	-	-	-	x	-
5.	Butterfly	*Catopsilia pomona*	-	-	-	x	-
6.	Chafer beetle	*Amphimallon majale*	x	-	x	-	-
7.	Cricket	*Tarbinskiellus portentosus*	x	-	x	-	x
8.	Defoliator	*Hyblaea puera*	-	-	-	x	
9.	Green leaf hopper	*Bothrogonia ferruginea*	-	x	x	x	x
10.	Gundi bug	*Leptocorisa oratoria*	x	-	x	x	
11.	Horned shield bug	*Placosternum* sp.	x	-	-	-	-
12.	Jewel beetle		-	-	-	-	x
13.	Lace bug/ Sucking bug	*Tingis* sp.	-	-	-	x	-
14.	L Grass hopper	*Conocephalus maculatus*	x	x	-	x	x
15.	L Grass hopper	*Mecopoda elongate*	x	x	-	x	x
16.	L Grass hopper	*Pterophylla camellifolia*	x	x	-	x	x
17.	Red borer	*Zeuzera coffeae*	-	-	-	x	-
18.	Root borer	*Phassus signife*r	-	-	-	x	-
19.	S. Grass Hopper	*Acrida turrita*	x	x	x	x	x
20.	S. Grass Hopper	*Oxya chinensis*	x	x	x	x	x
21.	S. Grass Hopper	*Oxya yezoensis*	x	x	x	x	x
22.	Skeletoniser	*Eutectona machaeralis*	x	-	-	x	-
23.	Tawny coster	*Acraea violae*	-	x	-	-	-
24.	Teak canker grub	*Acalolepta cervinus*	-	-	-	x	-

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
25.	Trunk borer	*Alcterogystia cadambae*	-	-	-	x	-
26.	Tree hopper	*Leptocentrus Taurus*	x	-	-	-	-
27.	White fly	*Bemisia tabaci*	x	-	-	x	-

Remark: Present x
Absent -

Table 9: Different species of natural enemies recorded by using insect net in teak plantations of Pyay and Tharrawaddy Districts, Bago Region (August - December, 2022)

No.	Common Name	Scientific Name	Tharyar waddy	Minhla	Gyobin gauk	Pauk khaung	Pa daung
1.	Black ant	*Camponotus* sp.	x	-	x	x	x
2.	Red dragonfly	*Sympetrum fonscolombii*	x	x	x	x	x
3.	Lady beetle orange	*Coccinella transversalis*	x	x	-	x	x
4.	Praying mantis	*Mantisa religiosa*	x		x	x	x
5.	Spider	*Lycosa pseudoanulata*	x	x	x	x	x
6.	Wasp	*Bracon* sp.	-	x	x	-	-
7.	Wasp	*Apanteles* sp.	x	x	x	x	x
8.	European paper wasp	*Polistes dominula*	-	-	-	x	x

Remark: Present x
Absent -

Table 10: Total number of different pest species recorded in teak plantations in five townships, Pyay and Tharyarwaddy Districts, Bago Region (August - December, 2022)

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
1.	Aphid	*Aphis gossypii*	x	-	-	x	x
2.	Army worm	*Spodoptera litura*	-	-	-	x	-
3.	Ash weevil	*Myllocerus viridanus*	x	-	x	-	-
4.	Black beetle	*Colasposoma* sp	-	-		x	-

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
5.	Black Pumpkin beetle	*Aulacophora nigripennis*	x	-	-	-	-
6.	Blue beetle	*Colasposoma* sp	-		-	x	-
7.	Black bug	unidentified	x	x	-	-	-
8.	Blister beetle	*Mylabris phalerata*	-	-	-	x	x
9.	Butterfly	*Catopsilia pomona*	x	-	-	-	-
10.	Chafer beetle	*Amphimallon majale*	x	x	x	x	-
11.	Cicada	*Burmacicada protera*	-	-	-	x	-
12.	Common hairy caterpillar	*Spilosoma obliqua*	-	x	-	x	-
13.	Cotton stainer bug	*Dysdercus cingulatus*	-	-	-	x	-
14.	Cricket	*Tarbinskiellus portentosus*	x	x	x	x	x
15.	Defoliator	*Hyblaea puera*	x	x	-	x	x
16.	Dung beetle	*Heliocopris bucephalus*	x	-	-	-	-
17.	Golden tortoise beetle	*Aspidimorpha sanctaecrucis*	-	-	x	-	-
18.	Green leaf hopper	*Bothrogonia ferruginea*	x	x	x	x	x
19.	Gundi bug	*Leptocorisa oratoria*	x		x	x	x
20.	Horned shield bug	*Placosternum* sp.	x	x	-	x	-
21.	Jewel beetle	*Chrysochroa fulgidissima*	-	-	-	-	x
22.	Lace/ sucking bug	*Tingis* sp.	x	x	-	x	-
23.	Leaf miner	*Phyllocnistis tectonivora*	x	x	x	x	x
24.	L. Grass Hopper	*Conocephalus maculatus*	x	x	-	x	x
25.	L. Grass Hopper	*Pterophylla camellifolia*	x	x	-	x	x
26.	L. Grass Hopper	*Mecopoda elongate*	x	x	-	x	x
27.	Mealy bug	*Icerya* sp	-	-	-	x	-
28.	Mealy bug	*Pseudococcus* sp.	-	-	-	x	-
29.	Red borer	*Zeuzera coffeae*	x	x	-	x	-
30.	Red Pumpkin beetle	*Aulacophora foveicollis*	x	-	-	-	-
31.	Root borer	*Phassus signife*r	-	x	-	x	-
32.	S. Grass Hopper	*Acrida turrita*	x	x	x	x	x
33.	S. Grass Hopper	*Oxya chinensis*	x	x	x	x	x
34.	S. Grass Hopper	*Oxya yezoensis*	x	x	x	x	x

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobin gauk	Pauk khaung	Pa daung
35.	Sapling borer	*Sahyadrassus malabaricus*	-	-	-	x	-
36.	Skeletoniser	*Eutectona machaeralis*	x	x	-	x	x
37.	Scutellaria bug	*Chrysocoris purpureus*	-	-	-	x	-
38.	Tawny coster	*Acraea violae*	-	x	-	x	x
39.	Teak canker grub	*Acalolepta cervinus*	-	-	-	x	-
40.	Termite	*Odontotermes* sp.	x	x	x	x	x
41.	Termite	*Coptotermes curvignathus*	x	x	x	x	x
42.	Trunk borer	*Alcterogystia cadambae*	-	-	-	x	-
43.	Tree hopper	*Leptocentrus Taurus*	x	-	-	-	-
44.	White grub	*Holotrichia consanguinea*	-	-	-	x	-
45.	white fly	*Bemisia tabaci*	x	-	-	x	-
46.	Yellow peach moth	*Conogethes punctiferalis*	-	-	-	x	-

Remark: Present x
Absent -

Table 11: Total number of natural enemies species recorded in teak plantations in five townships, Pyay and Tharyarwaddy Districts, Bago Region (August – December, 2022)

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobi n gauk	Pauk khaung	Pa daung
1.	Assassin bug	Unidentified	x	-	-	-	-
2.	Black ant	*Camponotus* sp.	x	x	x	x	x
3.	Ground beetle	*Nebria brevicollis*	x	x	-	x	
4.	Red Dragonfly	*Sympetrum fonscolombii*	x	x	x	x	x
5.	Damsel fly	Unidentified	x	x	x	x	x
6.	Lace wing	*Chrysoperla* sp.	x	x	-	x	-
7.	Lady beetle orange	*Coccinella transversalis*	x	x	-	x	x
8.	Lady beetle	*Cycloneda munda*	x	-	-	-	-
9.	Lady beetle red	*Coccinella undecimpunctata*	x	-	-	-	-
10.	Mantis	*Mantisa religiosa*	x	x	x	x	x
11.	Red ant	*Solenopsis* sp.	-	-	-	x	-

No.	Common Name	Scientific Name	Tharyar waddy	Min hla	Gyobi n gauk	Pauk khaung	Pa daung
12.	Spider	*Lycosa pseudoanulata*	x	x	x	x	x
13.	Spider	*Oxyopes javanus*	x	-	x	-	-
14.	Spider	*Argiope* sp.	x	-	-	-	-
15.	Huntsman spider	*Olios* sp.	x	-	-	-	-
16.	Green lynx spider	*Peucetia viridans*	x	-	-	-	-
17.	Wasp	*Bracon* sp.	x	x	x	x	
18.	Wasp	*Apanteles* sp.	x	x	x	x	x
19.	Wasp	*Polistes dominula*			x	x	x

Remark: Present x
Absent -

Out of 46 species of insect pest, 12 species from Lepidoptera (26.1%), 12 species from Coleoptera (26.1%), 10 species from Hemiptera (21.7%), 7 species from Orthoptera (15.2%), 3 species from Homoptera (6.5%) and 2 species from Isoptera (4.4%) are shown in Table 11 and Fig. 6. Fig. 7 also indicate that leaf feeders are dominant (45.7%), sap feeders (26.1%) are moderate followed by stem borer (10.9%), root feeder (8.7%), flower and seed feeders (4.3 %) and bark feeders (4.3%) respectively.

Out of 19 species of natural enemies, 5 species from Hymenoptera (26.3%), 5 species from Araneae (26.3%), 4 species from Coleoptera (21 %), 2 species from Odonata (10.5%), 1 species from Orthoptera (5.3%), 1 species from Hemiptera (5.3%) and 1 species from Neuroptera (5.3%) are indicated in Table 12 and Fig. 8. Order Hymenoptera and Araneae are dominant order among the detected species of natural enemies. Order Coleoptera which includes lady beetles is moderately dominant followed by order Odonata (Red dragonfly and damsel fly), Orthoptera (prying mantid), Neuroptera (green lace wing) and Hemiptera (Assassin bug) respectively. Insect pests and natural enemies recorded are shown in Appendix. Shoot borer, *Hypsipyla robusta* and bark borer, *Indarbela tetraonis* were not found in this survey period.

Table 12: Categories of different pests of *Tectona grandis* based on the nature of damage in Pyay and Tharyarwaddy Districts, Bago Region (August – December, 2022)

No.	Common Name	Scientific Name	Order	Family	Pest Category
1.	Army worm	*Spodoptera litura* Fabricius	Lepidoptera	Noctuidae	Defoliator
2.	Ash weevil	*Myllocerus viridanus*	Coleoptera	Curculionidae	Foliage Feeder
3.	Black beetle	*Colasposoma viridicoeruleum*	Coleoptera	Chrysomelidae	Foliage Feeder
4.	Black Pumpkin beetle	*Aulacophora nigripennis*	Coleoptera	Chrysomelidae	Foliage Feeder
5.	Blue beetle	*Colasposoma sp.*	Coleoptera	Chrysomelidae	Foliage Feeder
6.	Black bug	unidentified	Hemiptera		Foliage Feeder
7.	Butterfly	*Catopsilia pomona*	Lepidoptera	Pieridae	Foliage Feeder
8.	Common hairy caterpillar	*Spilosoma obliqua*	Lepidoptera	Erebidae	Foliage Feeder
9.	Cricket	*Tarbinskiellus portentosus*	Orthoptera	Gryllidae	Foliage Feeder
10.	Teak Defoliator	*Hyblaea puera*	Lepidoptera	Hyblaeidae	Defoliator
11.	Golden tortoise beetle	*Aspidimorpha sanctaecrucis*	Coleoptera	Chrysomelidae	Foliage Feeder
12.	Leaf miner	*Phyllocnistis tectonivora* Meyrick	Lepidoptera	Gracillariidae	Foliage Feeder
13.	Long horned Grass Hopper	*Conocephalus maculatus*	Orthoptera	Tettigoniidae	Foliage Feeder
14.	Rough-winged katydid	*Pterophylla camellifolia*	Orthoptera	Tettigoniidae	Foliage Feeder
15.	Bush cricket	*Mecopoda elongate*	Orthoptera	Tettigoniidae	Foliage Feeder
16.	Red Pumpkin beetle	*Aulacophora foveicollis*	Coleoptera	Chrysomelidae	Foliage Feeder
17.	Short horned grasshopper	*Acrida turrita*	Orthoptera	Acrididae	Foliage Feeder

No.	Common Name	Scientific Name	Order	Family	Pest Category
18.	Short horned grasshopper	*Oxya chinensis*	Orthoptera	Acrididae	Foliage Feeder
19.	Rice field grasshopper	*Oxya yezoensis*	Orthoptera	Acrididae	Foliage Feeder
20.	Skeletoniser	*Eutectona machaeralis* Walker	Lepidoptera	Pyralidae	Defoliator
21.	Tawny coster	*Acraea violae*	Lepidoptera	Nymphalidae	Foliage feeder
22.	Aphid	*Aphis gossypii* Glover	Hemiptera	Aphididae	Sap Feeder
23.	Cicada	*Burmacicada protera*	Homoptera	Cicadidae	Sap feeder
24.	Cotton stainer bug	*Dysdercus cingulatus*	Hemiptera	Pyrrhocoriidae	Sap Feeder
25.	Green leaf hopper	*Bothrogonia ferruginea*	Homoptera	Cicadallidae	Sap Feeder
26.	Gundhi Bug	*Leptocorisa oratoria*	Hemiptera	Alydidae	Sap Feeder
27.	Horned shield bug	*Placosternum* sp.	Hemiptera	Pentatonidae	Sap Feeder
28.	Lace bug	*Tingis* sp.	Hemiptera	Tingidae	Sap Feeder
29.	Mealy bug	*Icerya* sp.	Hemiptera	Coccidae	Sap Feeder
30.	Mealy bug	*Pseudococcus* sp.	Hemiptera	Pseudococcidae	Sap Feeder
31.	Scutellerid bug (Jewel bug)	*Chrysocoris purpureus*	Hemiptera	Scutelleridae	Sap Feeder
32.	Eggplant horned planthopper	*Leptocentrus Taurus* Fabricius	Hemiptera	Membracidae	Sap Feeder
33.	White fly	*Bemisia tabaci*	Hemiptera	Aleyrodidae	Sap Feeder
34.	Jewel beetle	*Chrysochroa fulgidissima*	Coleoptera	Buprestidae	Stem borer
35.	Sapling borer	*Sahyadrassus malabaricus* Moore	Lepidoptera	Hepialidae	Stem borer
36.	Redborer	*Zeuzera coffeae* Nietner	Lepidoptera	Cossidae	Stem borer
37.	Teak canker grub	*Acalolepta cervinus*	Coleoptera	Cerambycidae	Stem borer

No.	Common Name	Scientific Name	Order	Family	Pest Category
38.	Rubber Termites	*Coptotermes curvignathus* Holmgren	Isoptera	Rhinotermitidae	Bark Feeder
39.	Fungus-growing Termites	*Odontotermes* sp.	Isoptera	Termitidae	Bark Feeder
40.	Trunk borer, Carpenterworm	*Alcterogystia cadambae* Moore	Lepidoptera	Cossidae	Stem borer
41.	Blister beetle	*Mylabris phalerata*	Coleoptera	Meloidae	Flower and seed Feeder
42.	Yellow peach moth	*Conogethes punctiferalis*	Lepidoptera	Pyralidae	Flower and seed Feeder
43.	Chafer beetle	*Amphimallon majale*	Coleoptera	Scarabaeidae	Root Feeder
44.	White grub (Sugarcane Beetle)	*Holotrichia consanguinea*	Coleoptera	Scarabaeidae	Root Feeder
45.	Dung beetle	*Heliocopris bucephalus*	Coleoptera	Scarabaeidae	Root Feeder
46.	Root borer	*Phassus signife*r Walk.	Lepidoptera	Hepialidae	Root and stem borer

Table 13: Natural enemies of major pests of Teak Pyay and Tharyarwaddy District, Bago Region (August - December, 2022)

No.	Common Name	Species	Order	Family	Type of nature
1.	Wasp	*Apanteles* sp.	Hymenoptera	Braconidae	Parasite
2.	Wasp	*Bracon* sp.	Hymenoptera	Braconidae	Parasite
3.	European paper wasp	*Polistes dominula*	Hymenoptera	Polistinae	Parasite
4.	Black ant	*Camponotus* sp.	Hymenoptera	Formicidae	Predator
5.	Red ant	*Solenopsis* sp.	Hymenoptera	Formicidae	Predator
6.	Lady beetle	*Coccinella undecimpunctata*	Coleoptera	Coccinellidae	Predator
7.	Lady beetle	*Coccinella transversalis*	Coleoptera	Coccinellidae	Predator
8.	Lady beetle	*Cycloneda munda*	Coleoptera	Coccinellidae	Predator
9.	Spider	*Lycosa pseudoanulata*	Araneae	Lycosidae	Predator
10.	Green lynx spider	*Peucetia viridans*	Araneae	Oxyopidae	Predator
11.	Spider	*Oxyopes javanus*	Araneae	Oxyopidae	Predator
12.	Spider	*Argiope* sp.	Araneae	Papaveraceae	Predator
13.	Huntsman spider	*Olios* sp.	Araneae	Sparassidae	Predator
14.	Praying mantis	Mantisa religiosa	Orthoptera	Mantidae	Predator
15.	Green lace wing	*Chrysoperla* sp.	Neuroptera	Chrysopidae	Predator
16.	Red dragonfly	*Sympetrum fonscolombiii*	Odonata	Libellulidae	Predator
17.	Damsel fly	Unidentified	Odonata		Predator
18.	Ground beetle	*Nebria brevicollis*	Coleoptera	Carabidae	Predator
19.	Assassin bug	*Zelus renardii*	Hemiptera	Reduviidae	Predator

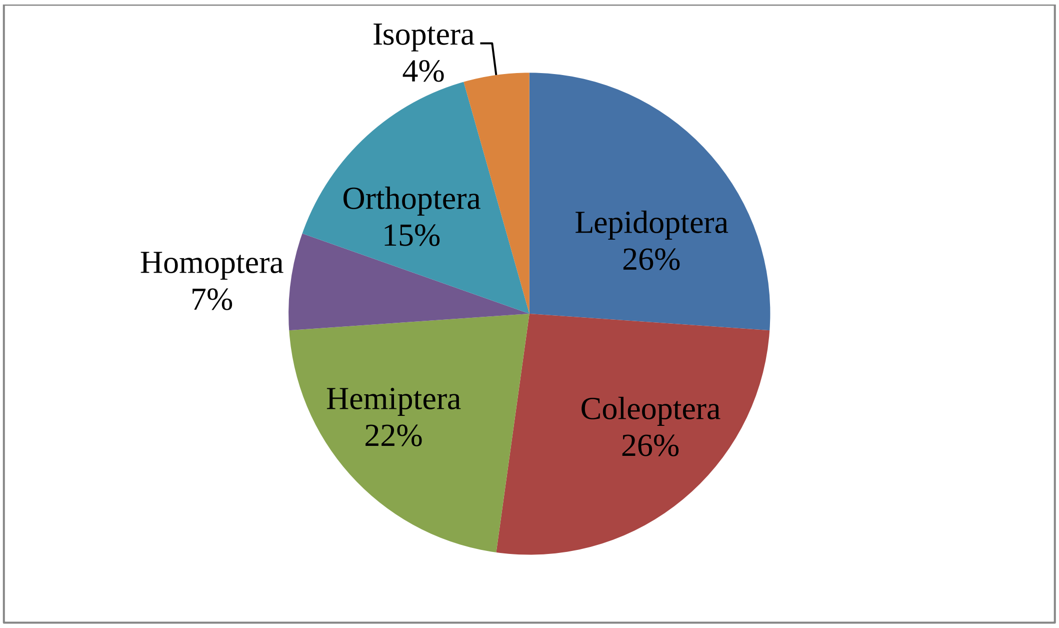

Figure 7: Percentage of different order of insect pests infesting Teak in Pyay and Tharyarwaddy Districts, Bago Region, August-December, 2022

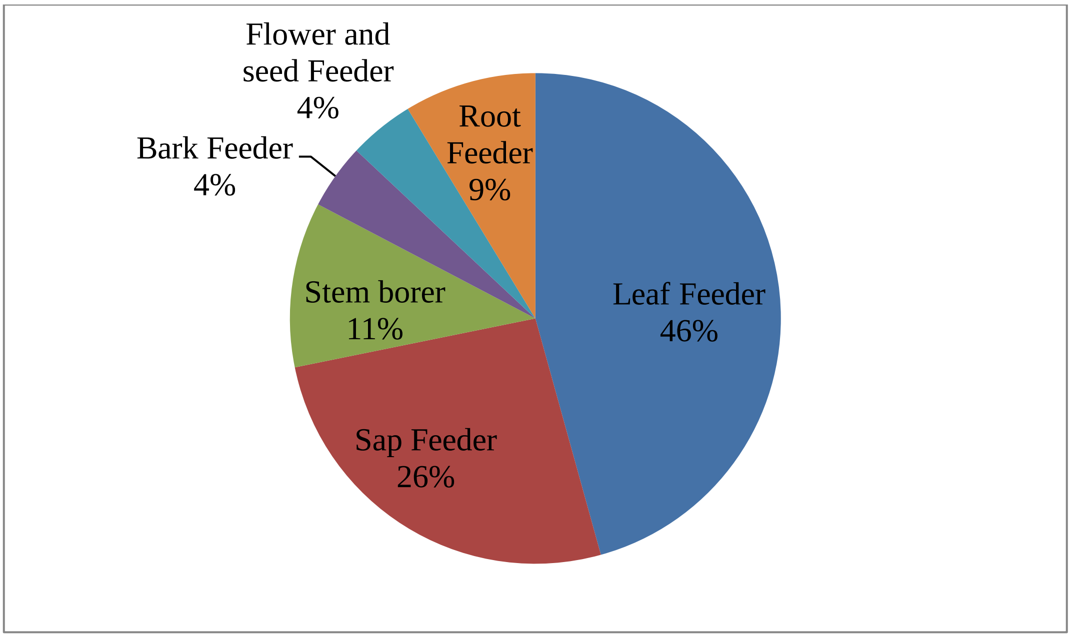

Figure 8: Percentage of different categories of insect pests infesting Teak in Pyay and Tharyarwaddy Districts, Bago Region, August-December, 2022

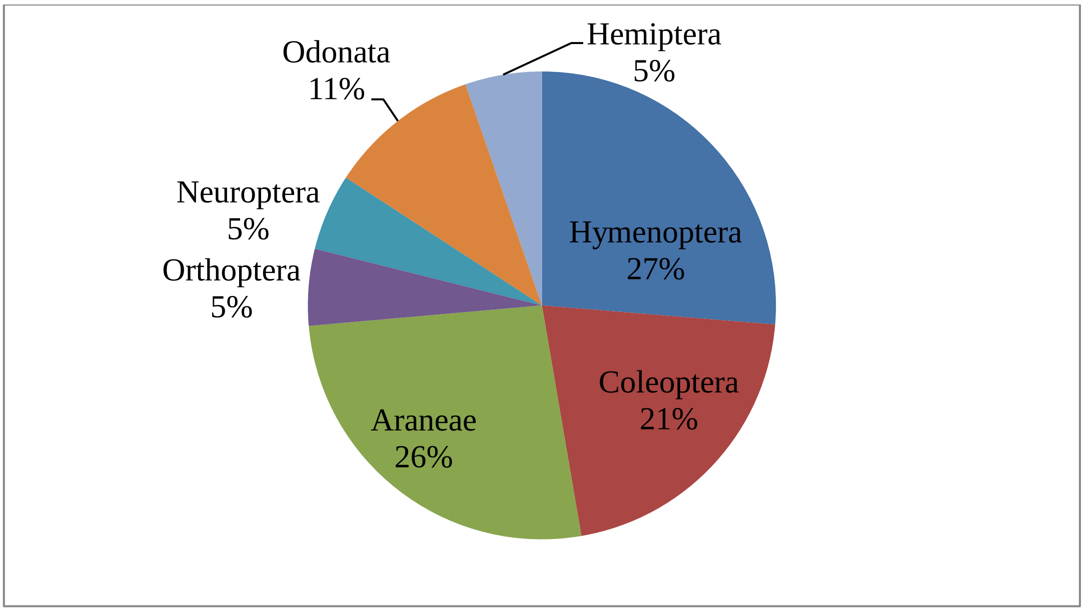

Figure 9: Percentage of different natural enemies attacked pest of Teak in Pyay and Tharyarwaddy Districts, Bago Region, August-December, 2022

Conclusions

On the whole results of the present study is hoped to be benefit to cultivators, by getting the awareness on what sort of insect pests infest the teak (*Tectona grandis*) and their prevalence on the specific parts of the tree. Therefore, necessary control measures would be taken to maintain the teak production in future. But the findings presented in this paper are only recorded from August to December, 2022 (5 months). It is monsoon season. So that it is not completed. Year-round incidence of pest on teak is needed to know. Therefore, this survey is being continued to post-monsoon (winter) and pre-monsoon (summer) season from January to November.

Acknowledgements

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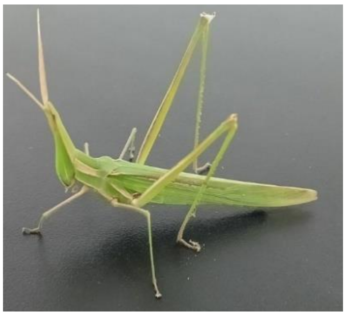
Appendix

Infesting Teak Pests

Hyblaea puera (Cramer)

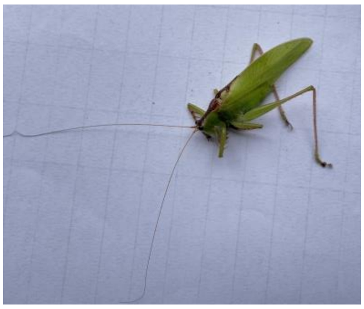
Eutectona machaeralis



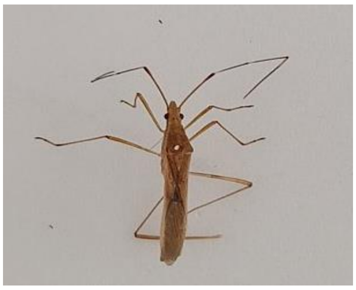
Acrida turrita

Myllocerus viridanus

Leptocentrus Taurus



Pterophylla camellifolia



Leptocorisa oratoria

Bemisia tabaci

Aphis gossypii

Mylabris phalerata

Pseudococcus sp

Tingis sp.

Infesting Teak Pests

Dysdercus cingulatus ***Chrysochroa fulgidissima*** ***Catopsilia pomona***

Acalolepta cervina ***Aspidimorpha sanctaecrucis*** ***Holotrichia consanguinea***

Natural Enemies Observed in Teak Plantations

Mantisa religiosa ***Chrysoperla sp.*** ***Zelus renardii***

Coccinella undecimpunctaa ***Cycloneda munda*** ***Coccinella transversalis***

Natural Enemies Observed in Teak Plantations

Sympetrum fonscolombii

Solenopsis sp.

Teak Diseases Assessment in Plantation Sites of West Bago Yoma Region, Myanmar

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Abstract

Disease survey was carried out in teak plantations of Pyay and Thayarwaddy Districts in West Bago Yoma Region, Myanmar in order to investigate diseases of teak and identify the causal organisms during August-November 2022. Different disease symptoms (foliage, stem and root) were observed. Foliage diseases were more prevalent than stem and root diseases. Foliage diseases showed leaf spot, rust, leaf blight and powdery mildew symptoms. Five pathogens namely *Cercospora tectonae*, *Olivea tectonae*, *Rhizoctonia bataticola*, *Curvularia* spp. and *Erysiphe tectonae* were identified from infected leaves. Disease severity index of leaf spot and leaf blight reached medium disease severity index range (1.1-2) in teak plantations of Thayarwaddy and Gyobingauk Townships. More rust and powdery mildew infection were observed in young plantations (2 - 17 years old) than old plantations (18 - 44 years old). The highest disease severity index of rust 0.57 was found in teak plantations of Minhla Township. Powdery mildew infection was highest in 2 – 7 years old teak plantations. Die back and mistletoe incidence were high in old plantations (18 - 44 years old).

Key Words: Bago Yoma, disease symptoms, disease severity index, teak

ပဲခူးရိုးမ (အနောက်) ဒေသအတွင်း တည်ထောင်ထားရှိသော ကျွန်းစိုက်ခင်းတွင် ကျရောက်သည့် ကျွန်းရောဂါများအား လေ့လာအကဲဖြတ်ခြင်း

စာတမ်းအကျဉ်း

ပဲခူးတိုင်းဒေသကြီး ပြည်ခရိုင်နှင့် သာယာဝတီခရိုင်အတွင်း တည်ထောင်ထားရှိသည့် ကျွန်းစိုက်ခင်းများတွင် ကျရောက်တတ်သော ရောဂါများနှင့် ရောဂါဖြစ်စေသည့် သက်ရှိများအား ရှာဖွေဖော်ထုတ်ရန်အတွက် ရောဂါကျရောက်မှုစာရင်းကောက်ယူခြင်းကို ၂၀၂၂ ခုနှစ် ဩဂုတ်လမှ နိုဝင်ဘာလအထိ ဆောင်ရွက်ခဲ့ပါသည်။ အရွက်၊ ပင်စည်နှင့် အမြစ်တို့တွင် ကျရောက်သောရောဂါလက္ခဏာများပေါ် မူတည်၍ ရောဂါစာရင်း ကောက်ယူခြင်းကို ပြုလုပ်ခဲ့ပါသည်။ ပင်စည်နှင့်အမြစ်တွင် ကျရောက်သောရောဂါလက္ခဏာများထက် အရွက်ရောဂါလက္ခဏာများသည် တွေ့ရှိရမှု အများဆုံးဖြစ်ပါသည်။ ကျွန်းပင်များတွင် ရွက်ပြောက်လက္ခဏာ၊ သံချေးလက္ခဏာ၊ ရွက်ခြောက်လက္ခဏာနှင့် ဖားဥမှိုလက္ခဏာ စသည့် အရွက်လက္ခဏာများ တွေ့ရှိခဲ့ရပါသည်။ အရွက်ရောဂါလက္ခဏာပြကျွန်းရွက်မှ ရောဂါဖြစ်စေသည့် သက်ရှိများဖြစ်သော *Cercospora tectonae*၊ *Olivea tectonae*၊ *Rhizoctonia bataticola*၊ *Curvularia* spp. နှင့် *Erysiphe tectonae* တို့ကို မွေးမြူရရှိခဲ့ပါသည်။ သာယာဝတီနှင့် ကြို့ပင်ကောက်မြို့နယ်များရှိ ကျွန်းစိုက်ခင်းများတွင် ကျရောက်နေသည့် ရွက်ပြောက်ရောဂါနှင့် ရွက်ခြောက်ရောဂါ၏ ရောဂါပြင်းထန်မှုညွှန်းကိန်းသည် အလယ်အလတ်အဆင့် (၁.၁-၂) သို့ ရောက်ရှိလျက်ရှိပါသည်။ (၂)နှစ်မှ (၁၇)နှစ် သက်တမ်းရှိ ကျွန်းစိုက်ခင်းများသည် (၁၈)နှစ်မှ (၄၄)နှစ်သက်တမ်းရှိ ကျွန်းစိုက်ခင်းများထက် သံချေးရောဂါနှင့် ဖားဥမှိုရောဂါ ကျရောက်မှု ပိုမိုမြင့်မားနေသည်ကို တွေ့ရှိရပါသည်။ ကျွန်းစိုက်ခင်းများထဲတွင် သံချေးရောဂါ၏ အမြင့်ဆုံးရောဂါပြင်းထန်မှုညွှန်းကိန်း (၀.၅၇)ကို မင်းလှမြို့နယ်၌ တွေ့ရှိရပါ သည်။ ဖားဥမှိုရောဂါကျရောက်မှုသည် သက်တမ်း (၂) နှစ်မှ (၇)နှစ်ရှိ ကျွန်းစိုက်ခင်းများတွင် အများဆုံးဖြစ်နေသည်ကို တွေ့ရှိရပါသည်။ Mistletoe ကပ်ပါးပင်နှင့် ကိုင်းခြောက်ရောဂါ ကျရောက်မှုသည် (၁၈) နှစ်မှ (၄၄) နှစ် သက်တမ်းရှိ ကျွန်းစိုက်ခင်းများတွင် ပိုမိုမြင့်မားနေသည်ကို လေ့လာတွေ့ရှိရပါသည်။

Introduction

Teak (*Tectona grandis* L.f.), tropical deciduous forest tree, inhabits naturally in Myanmar, India, Thailand and Laos. Teak is one of the most expensive timbers in tropical countries (Kaosa-ard, 1989) and it is a source of premium hardwoods for diverse applications (eg, furniture, construction, panel work, railway carriages (Keogh, 2009). The reputation of teak timber is due to its matchless combination of qualities: termite, fungus and weather resistance, strength, attractiveness, workability and seasoning capacity without splitting, cracking, warping or materially altering shapes (Hoe, 1969). Teak constitutes about 75% of the world's high quality tropical hardwood plantations. Teak is mostly used species for forest plantation establishments in Myanmar. Teak plantation area from 1981-1982 to 2018 was 395,492 ha covering 43.55 % of total plantation area of different species (FD 2020). In Myanmar, teak mainly occurs in dry and moist deciduous forests growing together with other deciduous trees species such as Legumes, *Lagerstroemia* species, *Terminalia* species and bamboo (Thein et al., 2007). Robertson (2002) reported that teak is susceptible to various kinds of pests and diseases. Different genera of various fungal groups are associated with cultivated plants and forestry species, such as teak (Nagadesi and Arya, 2014). In Myanmar, teak plantations often suffer severe damage from insect and disease attack and outbreak of infestation have been occasionally reported. The occurrence of teak rust has recorded by Common wealth Mycoligical Institute (CMI) (Mulder and Gibson, 1973). Teak rust incidence was also observed in nursery and plantations of Mandalay, Mawlamyine, Yezin, Yangon and Pathein (Than, 2000). Teak seedling blight caused by *Phytophthora* spp. occurred in East Bago Yoma teak nurseries (Saw, 1983). Teak mistletoe infection in Moeswe teak plantation was recorded by Win and Than, 2015. Investigation of reliable control measures against teak diseases is important. Therefore, Asian Forest Cooperation Organization (AFoCO) collaborated with Forest Department (FD) is implementing Integrated Pest and Disease Management (IPDM) Project in Teak Plantation in West Bago Region, Myanmar with the objectives to contribute to maintaining healthy forests and the vitality of the West Bago Yoma Region through exploring pest and disease lists, their possible control and prevention measures, and enhancing capacity building programs for all stakeholders.

Objective

The present investigation was undertaken to assess different teak disease problems on plantations in West Bago Yoma Region.

Materials and Methods

Study Sites and Sampling

The project site was West Bago Yoma Region which covers two main Districts; Tharyarwaddy and Pyay. Pyay District is located in Bago Region of West Bago Yoma (between the latitude 18° 20' to 19° 22' N and longitude 95° 06' to 97° 66' E), Myanmar. Tharyarwaddy District is also located in Bago Region of West Bago Yoma (between the latitude 17° 28' to 18° 48' N and longitude 95° 09' to 96° 05' E), Myanmar. The research was conducted in Paukkhaung, Padaung Townships of Pyay District and Thayarwaddy, Minhla and Gyobingauk Townships of Thayarwaddy District. The main criteria for selecting different plantation areas based on the age of plantations and spatial distribution. Five teak plantations from each township were selected for disease survey (Table 1). Each sample plot area was 20 acres and the coverage of sample plot area was equivalent to 100 acres of teak plantation. There were five sub-plots in each sample plot. In each sub-plot, eight trees were randomly selected for monthly disease survey (Figure 1).

Table 14. List of representative teak plantations area for disease survey

Sr.no.	Plantation No.	Year of Establishment	Location
1	2/1979	1979	Nawin (S) Reserve, Paukkhaung Township
2	2/1998	1998	Nawin (S) Reserve, Paukkhaung Township
3	2/2007	2007	Nawin (M) Reserve, Paukkhaung Township
4	3/2013	2013	Nawin (S) Reserve, Paukkhaung Township
5	2/2021	2021	Nawin (M) Reserve, Paukkhaung Township
6	1/2008	2008	Thayetan Reserve, Padaung Township
7	2/2010	2010	Thayetan Reserve, Padaung Township
8	2/2012	2012	Thanlaegyi Reserve, Padaung Township
9	1/2020	2020	Thani Reserve, Padaung Township
10	1/2021	2021	Thayetan Reserve, Padaung Township
11	1/2008	2008	Thonese Reserve, Thayarwaddy Township
12	1/2011	2011	Thonese Reserve, Thayarwaddy Township
13	1/2016	2016	Kanni Reserve, Thayarwaddy Township
14	1/2019	2019	Thonese Reserve, Thayarwaddy Township
15	1/2021	2021	Thonese Reserve, Thayarwaddy Township
16	1/2004	2004	Minhla Reserve, Minhla Township
17	2/2009	2009	Minhla Reserve, Minhla Township
18	1/2016	2016	Mokkha Reserve, Minhla Township
19	1/2017	2017	Mokkha Reserve, Minhla Township
20	1/2019	2019	Mokkha Reserve, Minhla Township
21	1/2008	2008	Bawbin Reserve, Gyobingauk Township
22	4/2010	2010	Bawbin Reserve, Gyobingauk Township
23	5/2010	2010	Bawbin Reserve, Gyobingauk Township
24	2/2011	2011	Bawbin Reserve, Gyobingauk Township
25	1/2021	2021	Bawbin Reserve, Gyobingauk Township

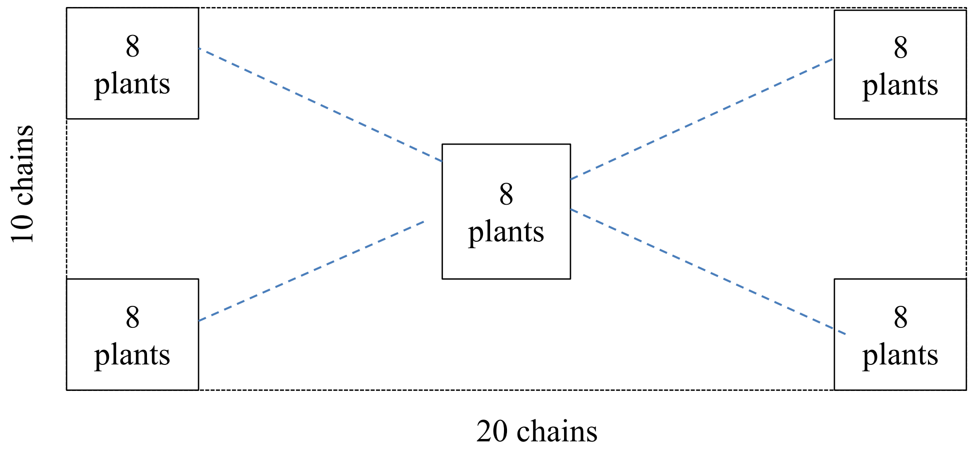

Figure 10. Layout design of sample plot

Study Period

Disease surveys were conducted during August-November 2022 and observation recorded on disease (Plate 1).

Plate 1. Teak disease survey during August-November 2022

Assessment of Disease Incidence and Disease Severity

Assessment of disease was designed to be able to conduct in different seasons (summer, monsoon and winter). Diseases were classified based on the symptoms of tree parts (foliage, stem and root). Disease severity assessment was rated on numerical scale (0-3) of disease severity index by using Sharma et al., (1985) (Table 2). The rating system of teak mistletoe infection was calculated by Win and Than, 2015.

Table 15. Disease scoring scale to access the severity of foliage infection, stem canker and root disease in plantation

Disease Severity	Foliage Infection	Main Stem Canker	Branch Canker	Root Disease	Disease Severity Index (1-3)
Nil	Nil	Nil	Nil	Nil	0
Low (L)	Up to 25% of the foliage infected	1 canker, no apparent harm to tree	Up to 25% of the shoots of tree affected	Die back of branches(.25%) in the crown	1(0.1-1)
Medium (M)	> 25-50% of the foliage infected; >10% defoliated prematurely	1-2 cankers, epicormic shoots present	> 25-50% of the shoots of tree affected	Die back of branches(>50%), thinning of crown	2(1.1-2)
Severe (S)	50-70% or more foliage infected; >25 defoliated prematurely	1-2 or more cankers, epicormic shoots present, apical shoot dead due to girdling	> 50-70% of the trees affected	Foliage of pale yellow accompanied by premature defoliation, extensive die-back, death of tree	3(2.1-3)

Disease incidence percentage was calculated by using the formula.

$$\textbf{Percent Disease Incidence} = \frac{nd}{N} \times 100$$

nd = total number of plants affected

N = total number of plants observed in all the plots (Karnataka, 2010)

Disease severity index (DSI) was calculated by using the formula.

$$\textbf{Disease Severity Index (DSI)} = \frac{nL \times 1 + nM \times 2 + nS \times 3}{N}$$

nL. = number of plant with low
nM = number of plant with medium
nS = number of plant with severe
N = total number of tree accessed in all observation plots (Sharma et al., 1985)

Collection, Isolation and Identification

Infected plant parts showing various symptoms were collected and kept into sterile polyethylene bags and plastic bottle (containing cotton and silica gel for moisture control purpose). Leaves showing same symptoms were collected together in the same polyethylene bag. Place of collection, locality, date of collections and weather conditions were noted. Rust and powdery mildew disease observations were recorded based on occurrence.

Isolation of collected samples was carried out at the Laboratory of Plant Pathology Research Section, Department of Agricultural Research (DAR). The infected plant parts were cut into small piece (3mm) and surface-sterilized in 70% sodium hypochloride solution (NaOCl) for 3 minutes and rinsed 3 times in sterile distilled water. The cut pieces were inoculated aseptically on potato dextrose agar (PDA) in sterile Petri dishes. The plates were incubated at room temperature for the growth of associated organisms. Slides were prepared and observations were made by using compound microscope. Observed growths were sub-cultured several times to obtain pure cultures. Pathogens were identified based on disease symptoms, colony morphology and spores identification by using standard literature (CMI, 1966).

Pathogenicity Test

In order to determine the related organisms isolated from the teak leaves, a pathogenicity test was carried out separately with each of the isolates. Artificial inoculation experiments were conducted using detached leaf method (Amadi, 2003). Healthy mature leaves were collected from the teak plantations in sterile polyethylene bags and used for artificial inoculation. Samples were surface-sterilized in 70 % ethanol for 3 minutes and rinsed 3 times in sterile distilled water. The leaves were injured at four points with sterile needle and then placed on layers of moist filter papers in sterile Petri dishes. Spore suspension was inoculated into each test leaf (Plate 2). Inoculated leaves were incubated at room temperature and observed frequently for symptom development. Re-isolations were carried out from inoculated leaves showing symptoms. Control plates were inoculated with sterile distilled water and incubated at room temperature.

Plate 2. Pathogenicity test

Results and Discussion

Disease Incidence and Disease Severity Index

During disease survey, it was found that foliage diseases was more prevalent than stem and root diseases. Among foliage diseases, leaf spot, rust and leaf blight infection were found in all survey areas. Powdery mildew and stem disease infections were not detected in survey areas of Gyobingauk. Only stem disease symptom was observed particularly dieback in Padaung and canker in Minhla. Both dieback and canker disease symptoms were found in Paukkhaung and Thayarwaddy. Mistletoe infection was occurred only in Paukkhaung. The root disease symptoms were not detected in survey area (Table 3).

Table 16. Disease occurrence in surveyed teak plantations during August-November 2022

Tree Part	Name of disease	Township				
		Paukkhaung	Padaung	Thayarwaddy	Minhla	Gyobingauk
Foliage	Leaf Spot	√	√	√	√	√
	Rust	√	√	√	√	√
	Leaf Blight	√	√	√	√	√
	Powdery Mildew	√	√	√	√	-
Stem	Dieback	√	√	√	-	-
	Canker	√	-	√	√	-
	Mistletoe	√	-	-	-	-
Root	Wilt	-	-	-	-	-
	Root Rot	-	-	-	-	-
	Damping Off	-	-	-	-	-

√ = Detected, - = Not Detected

In 25 teak plantations, mean disease incidence and disease severity index of foliage diseases (except powdery mildew) was higher than those of stem diseases. Ashajyothi et al., (2021) similarly reported that among various diseases, foliage diseases mainly leaf rust, leaf spot and leaf blight are the most common diseases in many areas of India. The occurrence of leaf spot was maximum with a mean of 64.83 %, followed by leaf bight (58.10%) and least mean disease incidence was observed for canker (0.85%). Maximum disease severity index was recorded for leaf spot (0.76) and least severity index was recorded for canker (0.01) (Table 4). Soni and Nag, (2021) revealed that the major tree disease in *Tectona grandis* was leaf spot that compared with leaf blight, leaf gull and stem canker.

Table 17. Teak diseases incidence and disease severity index at survey area during August-November 2022

Sr. no.	Diseases	Mean Disease Incidence (%)	Mean Disease Severity Index
1	Leaf Spot	64.83	0.76
2	Rust	26.13	0.36
3	Leaf Blight	58.10	0.73
4	Powdery Mildew	2.93	0.03
5	Dieback	8.95	0.09
6	Canker	0.85	0.01
7	Mistletoe	1.03	0.02

In Paukkhaung teak plantations, the disease severity index was highest in leaf blight (0.52%) followed by leaf spot (0.43%), rust (0.05%) and least in powdery mildew (0.008%) (Figure 2). The disease severity index was found maximum in leaf blight, leaf spot, rust and powdery 0.66, 0.65, 0.14 and 0.003 respectively in Padaung teak plantations (Figure 3). Maximum disease severity index was recorded for leaf spot (1.01) and least severity index in powdery mildew disease (0.14) that found in Thayarwaddy teak plantations (Figure 4). In Minhla teak plantations, disease severity index of rust (0.57) was highest, followed by leaf spot (0.29), leaf blight (0.15) and powdery mildew (0.008) (Figure 5). Disease severity index of leaf spot and leaf blight in Gyobingauk teak plantations reached 1.41 and 1.56 respectively (Figure 6).

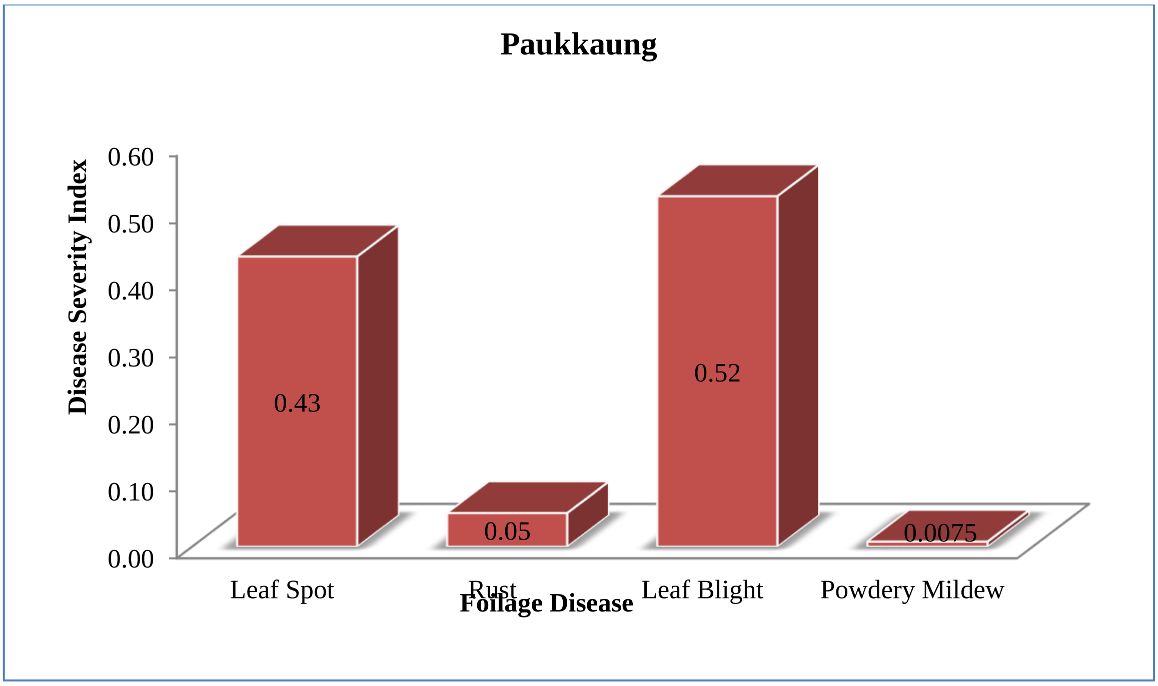

Figure 11. Disease severity index of foliage diseases in Paukkhaung Township during August-November 2022

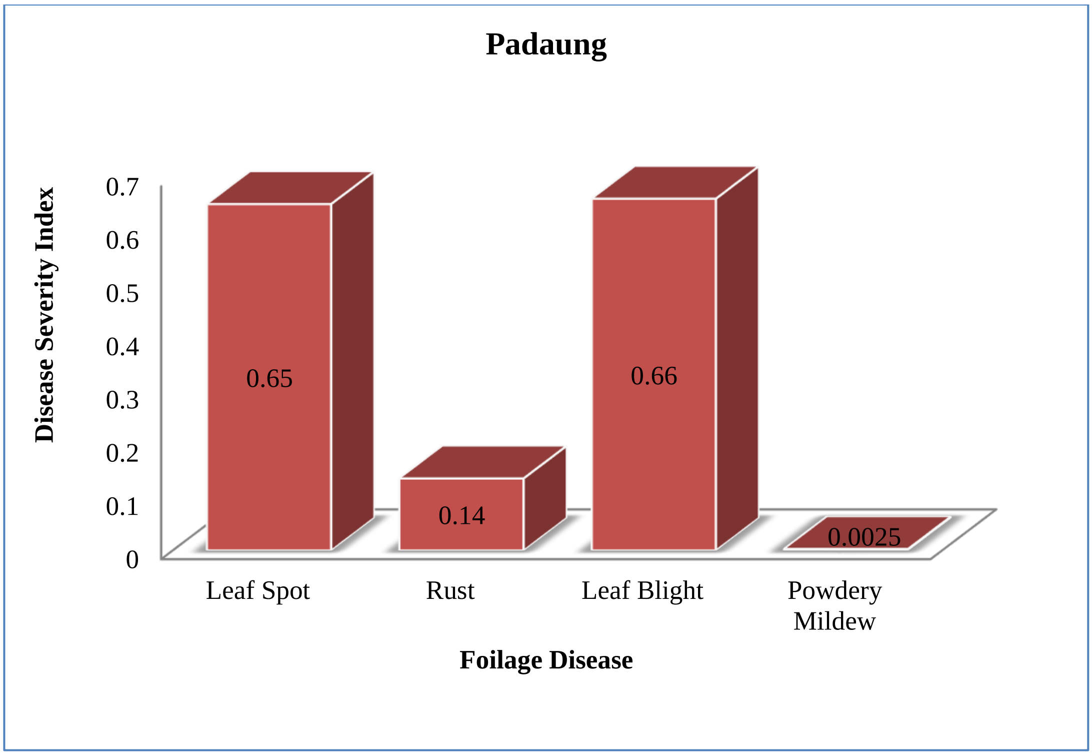

Figure 12. Disease severity index of foliage diseases in Padaung Township during August-November 2022

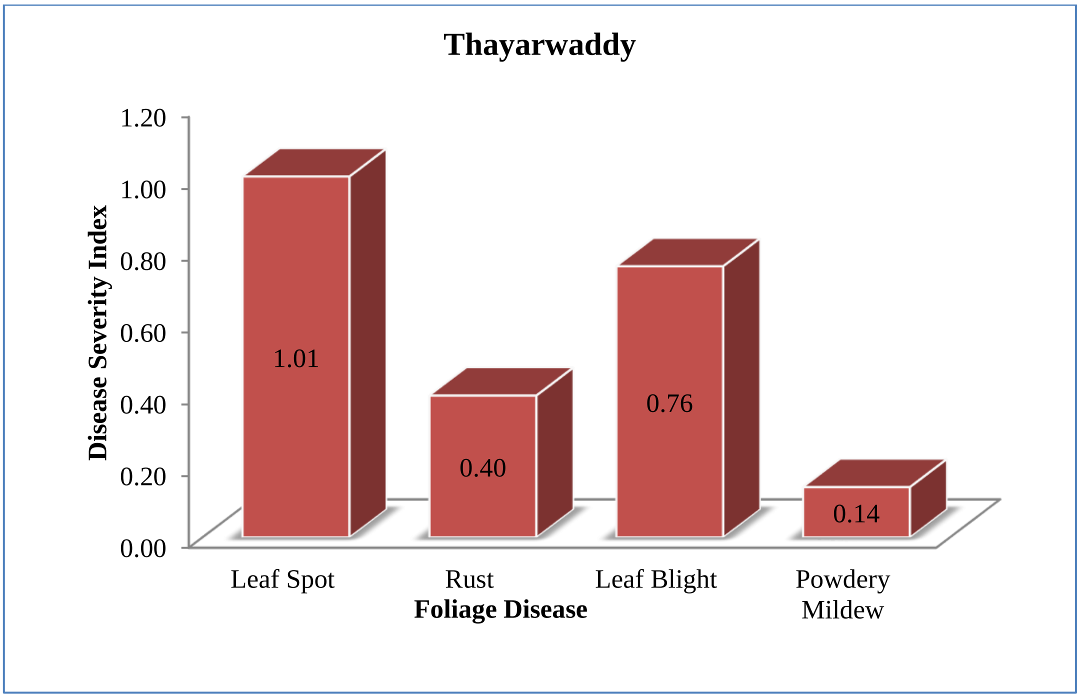

Figure 13. Disease severity index of foliage diseases in Thayarwaddy Township during August-November 2022

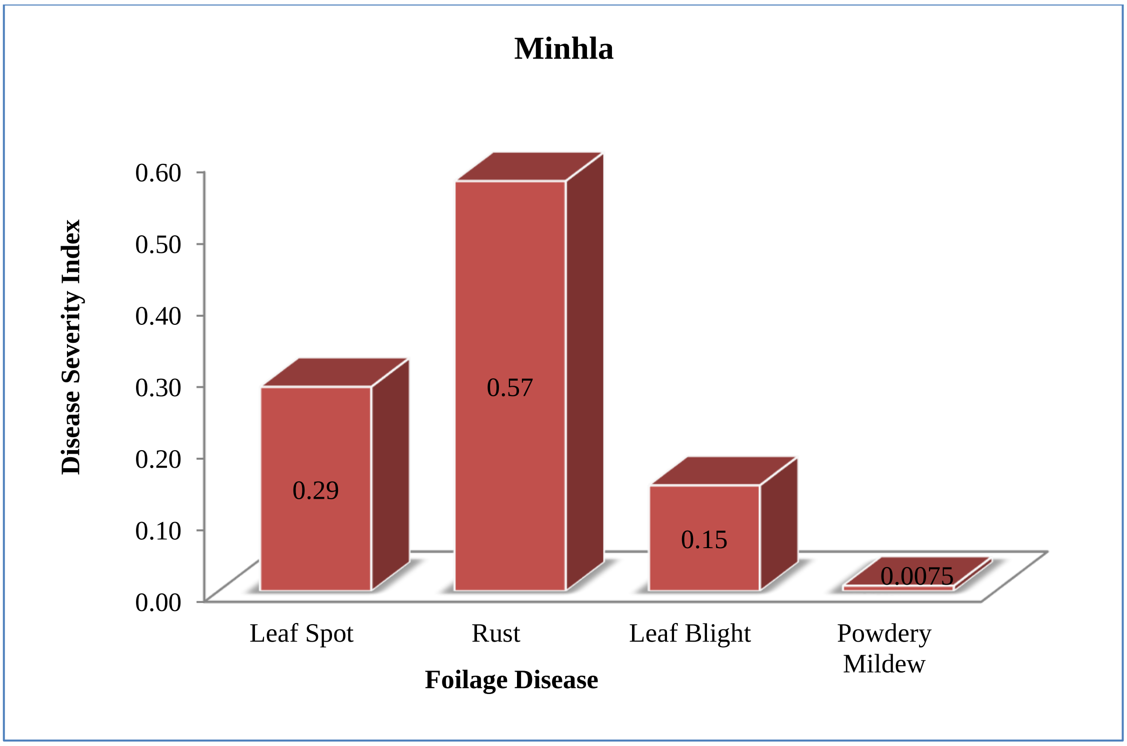

Figure 14. Disease severity index of foliage diseases in Minhla Township during August-November 2022

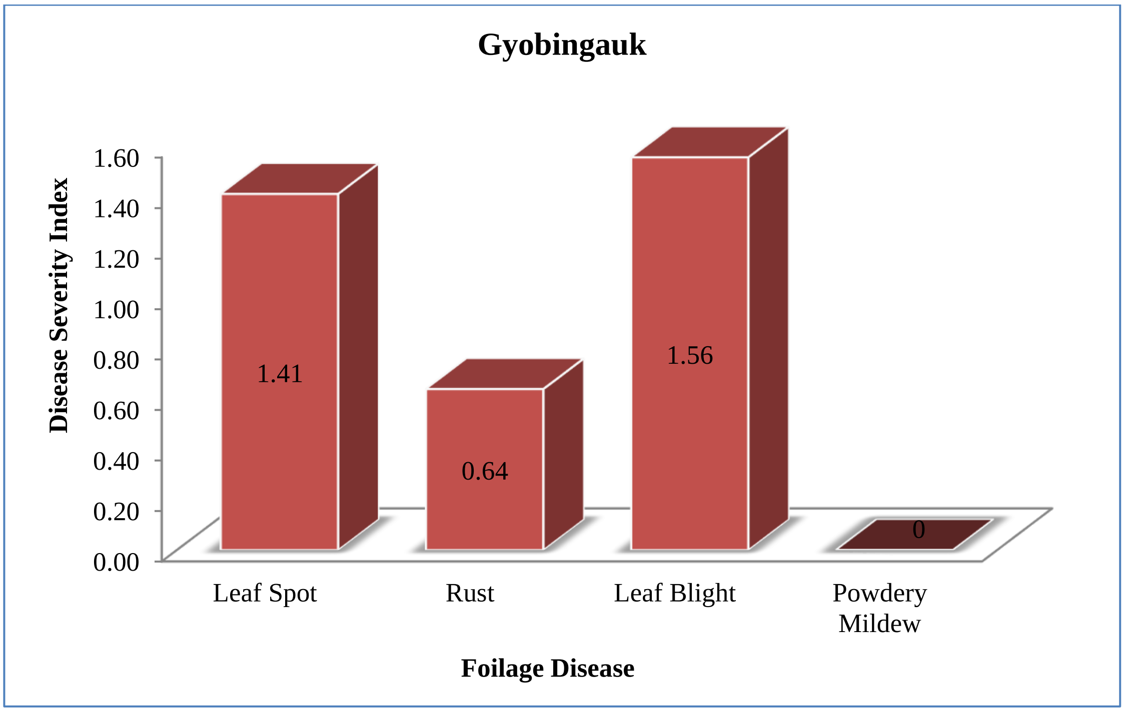

Figure 15. Disease severity index of foliage diseases in Gyobingauk Township during August-November 2022

Teak trees were categorized into four groups according to year of establishment. The teak trees with the year of establishment from 1979-2005 were categorized in Group 1, 2006-2010 in Group 2, 2011-2015 in Group 3 and 2016 – 2021 in Group 4. It was found that foliage disease incidence was higher in young plantations (Group 2, Group 3 and Group 4) than old plantations (Group 1). Rust and powdery mildew infection was highest in young plantations (Group 4) (Figure 7). Sharma et al., (1984) found that the severity of rust was relatively higher in nurseries and younger plantations (<10 years old) than in older ones. In this study, percent disease incidence of dieback was lowest in young plantations (Group 1) compared with old plantations (Group 1). Sharma et al., (1984) also found that dieback of teak in a 40 years old plantations and dieback were only infected in more than 10 years old plantations. Mistletoe infection was found in old plantations Group 1 (Figure 8).

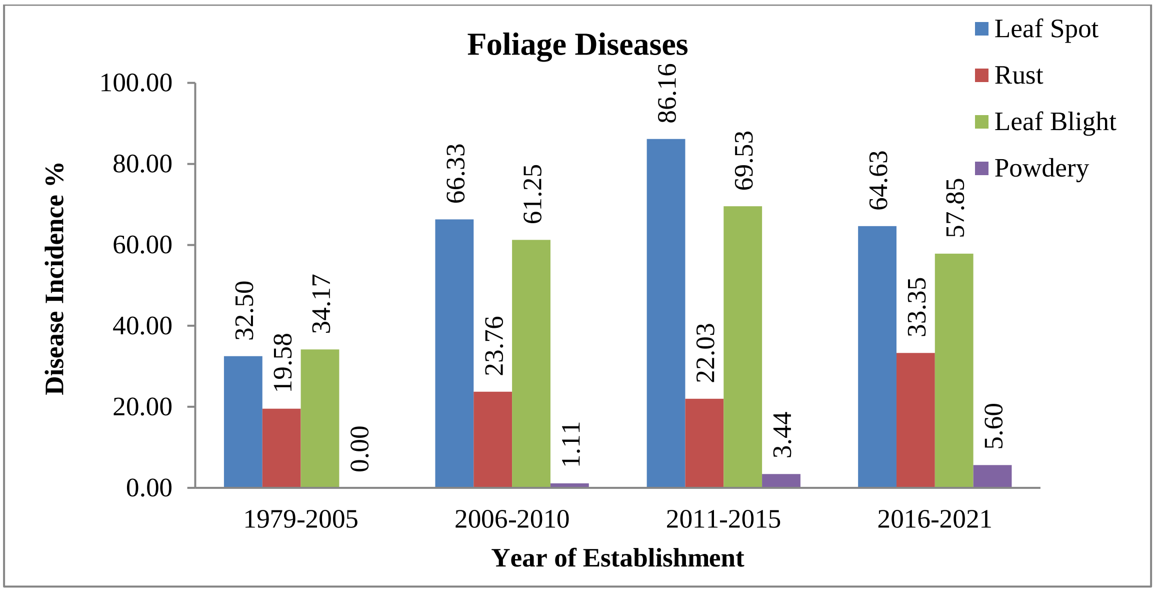

Figure 16. Percent disease incidence of foliage diseases based on year of establishment

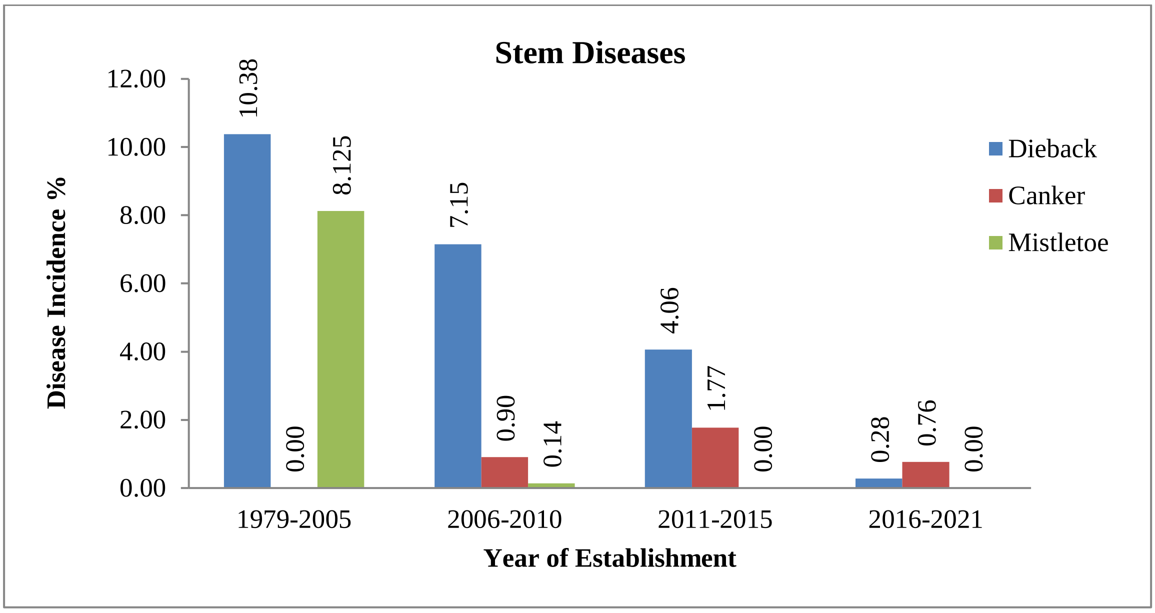

Figure 17. Percent disease incidence of stem diseases based on year of establishment

Identification of Pathogen

During disease survey from August-November 2022, the major teak disease was foliage disease. Foliage diseases of teak plantations area of Paukkhaung, Padaung, Thayarwaddy, Minhla and Gyobingauk Townships were presented in Table 5. Five pathogens i.e *Cercospora tectonae*, *Olivea tectonae*, *Rhizoctonia bataticola*, *Curvularia* spp. and *Erysiphe tectonae* were identified.

Table 18. Foliage disease occurrence in survey teak plantation area

Sr.no.	Name of Disease	Name of Pathogen	Disease Symptom
1	Leaf Spot	*Cercospora tectonae* Conidiophores are in loose fascicules, 1–5–septate, straight to decumbent, light brown to medium brown, paler towards the apex, geniculate at the apex. Conidia are hyaline, acicular to obclavate–cylindric, 4–13–septate, straight to curved, truncate or obconically truncate at the base, with subacute apex, thickened and darkened (Meeboon, 2009).	The symptoms are angular or sub-orbicular leaf spots, brown to grayish brown at the center with a dark margin, which develop near the tip and along the margin of the leaves (Plate 3).
2	Rust	*Olivea tectonae* Hyaline to pale brown incurved uredinial paraphyses are observed. Only uredinial stage is observed. Urediniospores are subglobose, ellipsoid and produced singly on a short pedicel. Urediniospores are pale brown or yellow, echinulate with spines. Teliospores are not observed (Daly et al., 2006).	Infected leaves showed angular brown to grey necrotic areas on the upper leaf surfaces due to the formation of flecks. As lesions coalesced, large necrotic areas were evident. The necrotic areas corresponded to numerous subepidermally erumpent orange yellow uredinia on the lower leaf surfaces (Plate 4).
3	Leaf Blight	*Rhizoctonia bataticola* The dark brown, globes and ostiolated pycnidia are often produced on host tissues. Pycnidiospores are ellipitica, thin walled, single-celled, hyaline. The young hyphae typically branch at 45 or 90 angles, with constrictions at the point of origin of hyphal branches and septate near hyphal branches (Plate 5).	Infected leaves showed wedge shape lesions which develop near the tip and enlarge rapidly to the middle vein. These patches turn brown. Infected leaves dry up and are eventually shed (Plate 5).

Sr.no.	Name of Disease	Name of Pathogen	Disease Symptom
4	Leaf Blight	*Curvularia* spp. Dark brown, unbranched, septic conidiophores were found. The formed numerous conidia were dark brown, curved to varying degrees, tapering at both ends, with three to four septa, with one or two central cells larger and darker than the terminal ones (Plate 6).	Irregular brown necrotic patches can be seen between the veins of leaves at close distance to each other; two or more patches may be fused into a larger size and the border between infected and healthy was reddish brown (Plate 6).
5	Powdery Mildew	*Erysiphe tectonae* Mycelium epiphyllous, effuse or in irregular patches, almost persistent. Hyphal appressoria lobed to multilobed, solitary or in opposite pairs. Conidiophores are mostly arising laterally from the mother cells. Conidia are ellipsoid-ovoid to sub-cylindrical. Ascospores are ellipsoid-oviid, colorless (Jamjan and Takamatsu, 2017).	Irregular white patches appeared on the upper surface. As disease progressed, these patches coalesced and developed greyish-white powdery appearance (Plate 7).

Plate 3. Leaf spot symptom (a) and its causal organism *Cercospora tectonae* 40x (b)

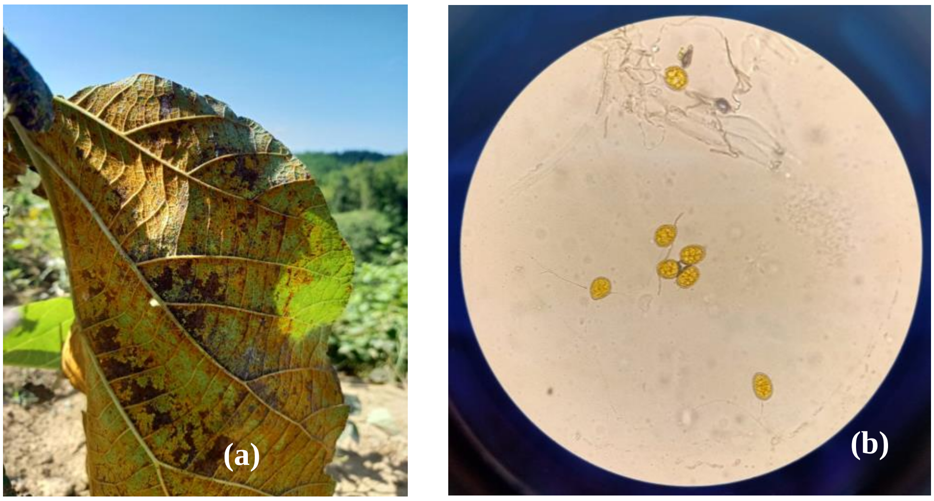

Plate 4. Teak Rust symptom (a) and its causal organism *Olivea tectonae* 40x (b)

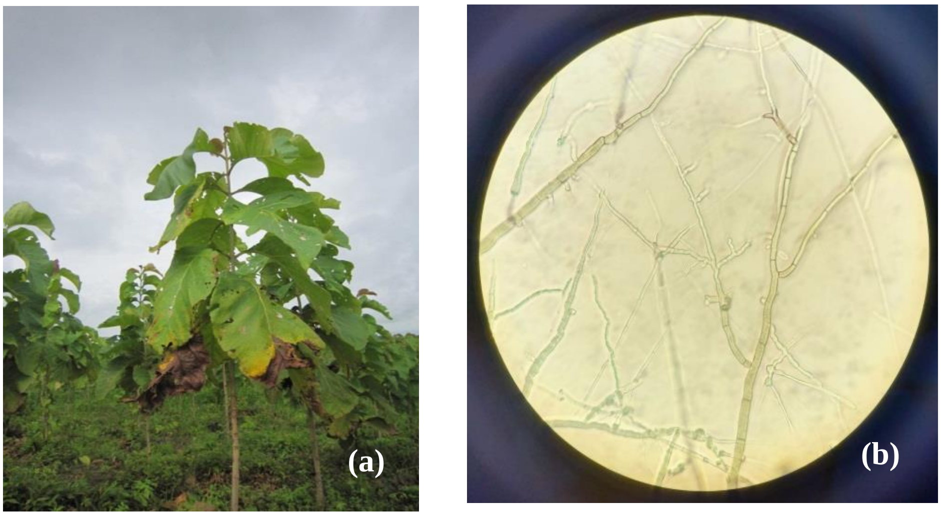

Plate 5. Leaf blight symptom (a) and its causal organism *Rhizoctonia bataticola* 40x(b)

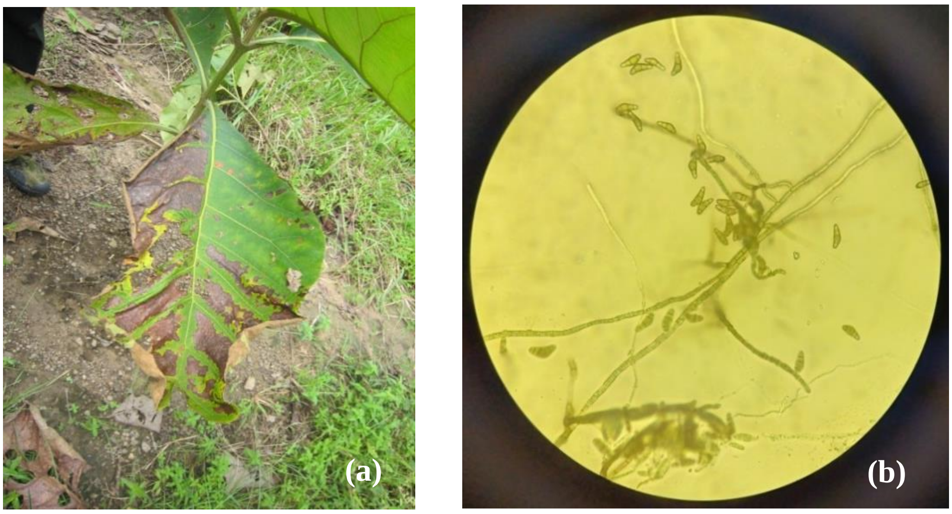

Plate 6. Leaf blight symptom (a) and its causal organism *Curvularia* spp. 40x (b)

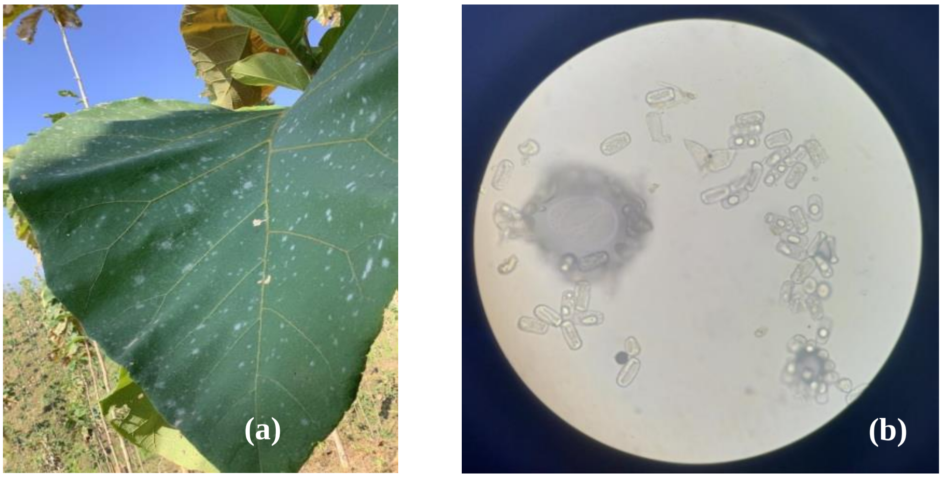

Plate 7. Powdery mildew symptom (a) and its causal organism *Erysiphe tectonae* 40x (b)

Pathogenicity Test

This study revealed that three isolates produced symptoms on artificially inoculated leaves under the conditions of this study. The three isolates are *Cercospora tectonae, Rhizoctonia bataticola* and *Curvularia* spp. Inoculated leaves showed soaked brown lesions (Plate 8). Symptoms started from the injured portions of leaves and spread throughout the leaf surface. The artificially inoculated organisms were re-isolated from the inoculated teak leaves.

(a) (b)

(c) (d)

Plate 8. Leaf inoculation of *Tectona grandis* with sterilized water (a), *Cercospora tectonae* (b), *Rhizoctonia bataticola* (c) and *Curvularia* spp. (d)

Conclusion

The study revealed that various types of disease present in survey teak plantation area of West Bago Yoma Region, Myanmar. Foliage disease was more prevalent than stem and root diseases. The causal organisms causing foliage diseases (leaf spot, rust, leaf blight and powdery mildew) were *Cercospora tectonae*, *Olivea tectonae*, *Rhizoctonia bataticola*, *Curvularia* spp. and *Erysiphe tectonae*. Among foliage diseases, leaf spot and leaf blight diseases commonly found in all survey area of teak plantations. Disease severity index of leaf spot and leaf blight reached medium disease score range (1.1-2) in teak plantations area of Thayarwaddy and Gyobingauk Townships. Young plantations had more rust and powdery mildew infection than old plantations. Disease severity index of rust 0.57 was highest in Minhla teak plantations area. Die back and mistletoe incidence were high in old plantations. This disease survey results can be useful in identification of disease symptom and causal organism. The appropriate control measures can be developed, and then, it will be helpful for reducing the risk of teak diseases infection in West Bago Region.

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In-vitro Efficacy of Different Fungicides on *Alternaria* spp. Causing Alternaria Leaf Blight of *Tectona grandis* L. f. Lamiaceae

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Abstract

The incidence of foliage diseases (leaf rust, leaf spot, powdery mildew and leaf blight) was observed in teak plantation area of West Bago Yoma Region. Alternaria leaf blight is one of the most common diseases. Alternaria leaf blight is difficult to control because the fungus persists in plant debris and soil. One of the most effective methods is the use of fungicides. The present study was conducted to evaluate the efficacy of six fungicides (Mancozeb 80%WP, Chlorothalonil 72% SC, Hexaconazole 5% SC, Difenoconazole 25% EC, Propiconazole 15% + Difenoconazole 15% EC, Azoxystrobin 20% + Difenoconazole 12.5% SC) with four concentrations (at 250 ppm, 500 ppm, 750 ppm and 1000 ppm) *in-vitro* conditions against the pathogen by using poisoned food technique. Results indicated that mean mycelial growth inhibition ranged from 46.76 to 97.78 percent among tested fungicides. Hexaconazole 5% SC (at 500 ppm), Propiconazole 15% + Difenoconazole 15% EC (at 750 ppm) and Mancozeb 80% WP (at 1000 ppm) showed 100% mycelial growth inhibition. The least inhibition rate percent 34.07 is shown by chlorothalonil 72% SC (at 250 ppm). Therefore, Mancozeb 80% WP, Hexaconazole 5% SC, Difenoconazole 25% EC, Propiconazole 15% + Difenoconazole 15% EC and Azoxystrobin 20% + Difenoconazole 12.5% SC would be effective fungicides to control Alternaria leaf blight of *Tectona grandis*.

Keywords: Foliage, Teak, *Alternaria* spp., Efficacy, Poisoned Food Technique, Fungicides, Mycelial Growth Inhibition

ဓာတ်ခွဲခန်းတွင် မှိုသတ်ဆေးအမျိုးမျိုးအသုံးပြုပြီး ကျွန်းရွက်ခြောက်ရောဂါဖြစ်စေသောက်ရှိမှို (*Alternaria* spp.) ကြီးထွားမှုအပေါ် ဟန့်တားနိုင်မှုစွမ်းရည်ကို လေ့လာအကဲဖြတ်ခြင်း

စာတမ်းအကျဉ်း

ပဲခူးတိုင်းဒေသကြီး၊ ပြည်ခရိုင်နှင့်သာယာဝတီခရိုင်အတွင်း တည်ထောင်ထားရှိသည့် ကျွန်းစိုက်ခင်းများတွင် သံချေးရောဂါ၊ ဖားဥမှိုရောဂါ၊ ရွက်ခြောက်ရောဂါနှင့် ရွက်ပြောက်ရောဂါများ ကျရောက်လျက်ရှိပါသည်။ ရွက်ခြောက်ရောဂါများအနက် ရောဂါဖြစ်စေသောက်ရှိ Alternaria ကြောင့်ဖြစ်သော ရွက်ခြောက်ရောဂါသည် ကျရောက်မှုအများဆုံး ရောဂါတစ်ခုဖြစ်ပါသည်။ ရောဂါဖြစ်စေသောက်ရှိ Alternariaမှိုသည် မြေဆီလွှာနှင့် သစ်ပင်အကြွင်းအကျန်များထဲတွင် အချိန်ကြာမြင့်စွာ နေထိုင်နိုင်သောကြောင့် ဓာတုမှိုသတ်ဆေးများဖြင့် ကာကွယ်နှိမ်နင်းခြင်းသည် ထိရောက်သော ကာကွယ်နှိမ်နင်းနည်းတစ်ခုဖြစ်ပါသည်။ ထို့ကြောင့် မှိုသတ်ဆေးအမျိုးမျိုး (Mancozeb 80% WP, Chlorothalonil 72% SC, Hexaconazole 5% SC, Difenoconazole 25% EC, Propiconazole 15% + Difenoconazole 15% EC, Azoxystrobin 20% + Difenoconazole 12.5% SC) ၏ ပြင်းအားများ (၂၅၀ပီပီအမ်၊ ၅၀၀ပီပီအမ်၊ ၇၅၀ပီပီအမ်နှင့် ၁၀၀၀ပီပီအမ်) ကို အသုံးပြုပြီး မှိုသတ်ဆေးများ၏ ရောဂါဖြစ်စေသောက်ရှိကြီးထွားမှုအပေါ် ဟန့်တားနိုင်မှုစွမ်းရည်စမ်းသပ်ခြင်း ဓာတ်ခွဲခန်းသုတေသနကို Poisoned Food Technique ကို အသုံးပြု၍ ဆောင်ရွက်ခဲ့ပါသည်။ မှိုသတ်ဆေးများ၏ ရောဂါဖြစ်စေသောက်ရှိကြီးထွားမှုအပေါ် ဟန့်တားနိုင်မှုသည် ၄၆.၇၆ မှ၉၇.၇၈ ရာခိုင်နှုန်းရှိသည်ကို တွေ့ရှိရပါသည်။ Hexaconazole 5%SC (ပြင်းအား ၅၀၀ ပီပီအမ်)၊ Propiconazole 15%+Difenoconazole 15% EC (ပြင်းအား ၇၅၀ ပီပီ အမ်)နှင့် Mancozeb80% WP (ပြင်းအား ၁၀၀၀ပီပီအမ်)သည် ရောဂါဖြစ်စေသောက်ရှိကြီးထွားမှုအပေါ် (၁၀၀) ရာခိုင်နှုန်း ဟန့်တားနိုင်သည်ကို တွေ့ရှိရပါသည်။ ရောဂါဖြစ်စေသောက်ရှိကြီးထွားမှုအပေါ် ဟန့်တားနိုင်မှု အနည်းဆုံး ၃၄.၀၇ ရာခိုင်နှုန်းကို Chlorothalonil 72% SC (ပြင်းအား ၂၅၀ ပီပီအမ်) မှ တွေ့ရှိရပါသည်။ ထို့ကြောင့် Mancozeb၊ Hexaconazole၊ Difenoconazole ၊ Propiconazole +Difenoconazole နှင့် Azoxystrobin+ Difenoconazole မှိုသတ်ဆေးများသည် ကျွန်း Alternaria ရွက်ခြောက်ရောဂါ ကာကွယ်နှိမ်နင်းရန်အတွက် ထိရောက်မှုရှိသော မှိုသတ်ဆေးများ ဖြစ်ပါသည်။

Introduction

Teak (*Tectona grandis* L. f.) is a deciduous tree, which is native from India, Myanmar, Laos and Thailand. The natural populations of teak remain an important source from the economic, ecological and environmental perspectives (Venkatesh et al., 2023). Teak is suitable species for agroforestry due to its pleasant appearance, superior timber quality and timber durability (Ashajyothi et al., 2021). In Myanmar, teak plantation area was 395,492 ha covering 43.55% of total plantation area of different species (FD 2020). The teak associated fungal pathogens include *Olivia* spp., *Rhizoctonia* spp., *Alternaria* spp., *Cercospora* spp., *Phomopsis* spp., *Fusarium* spp., *Phytophthora* spp. etc. Among various diseases reported, foliage diseases mainly leaf rust, leaf blight and leaf spot were the most common ones in many areas (Ashajyothi et al., 2021). In Myanmar, the incidence of foliage diseases such as rust (*Olivea* spp.), powdery mildew (*Erysiphe* spp.), leaf spot (*Cercospora* spp.) and leaf blight (*Rhizoctonia* spp., *Alternaria* spp., *Curvularia* spp.) were observed in teak plantation area of West Bago Yoma Region. Alternaria leaf blight disease is one of the common diseases in teak plantation (Aye et al., 2023). Alternaria leaf blight is difficult to control because the fungus persists in plant debris and soil. One of the most effective methods for disease control is the use of fungicides (Bangar et al., 2019).

Objectives

To investigate the efficacy of six fungicides at four concentrations (250, 500, 750 and 1000 ppm) on the mycelial growth of *Alternaria* spp. in laboratory condition.

Materials and Methods

Collection of diseased samples

Infected leaves showing Alternaria blight symptom were collected during survey (August 2022 - July 2023) from FD-AFoCO project site of West Bago Yoma Region, Myanmar. Infected leaves were kept into polyethylene bags. Samples were brought to Pathology Laboratory, Forest Protection Section, Forest Research Institute (FRI), Yezin. Alternaria disease symptom on leaves initially appeared as round dark brown necrotic lesions which were surrounded by yellow haloes. When disease infection increased, these lesions coalesced and developed into larger circular or irregular spots (Plate 1). In severe infections, infected leaves dried and eventually dropped.

Plate 9. Leaf blight symptom of *Tectona grandis*

Isolation and identification of pathogen

The diseased samples were cut into small pieces along with growing margins of disease. These pieces were surface sterilized with 70% sodium hypo chloride for 3 minutes and cleaned with sterilized distilled water for 1 minute for 2-3 times to remove the traces of surface sterilant. Then sterilized pieces were blotted dry on sterile filter paper and aseptically transferred to sterilized potato dextrose agar (PDA) plates. These plates were incubated at room temperature for 3-5 days for mycelial growth formation. Observed growths were sub-cultured by single spore technique to obtain pure culture. Identification of *Alternaria* spp. was carried out by its morphological features (Woudenberg et al., 2013).

***In-vitro* Evaluation of different fungicides against *Alternaria* spp.**

Two systemic (Hexaconazole, Difenoconazole), two non-systemic (Mancozeb, Chlorothalonil) and combi-product (Propiconazole + Difenoconazole, Azoxystrobin + Difenoconazole) fungicides were used in evaluating the efficacy on mycelial growth of *Alternaria* spp. Poisoned food technique was used for assessing these fungicides on *Alternaria* spp. by using PDA as the medium. The principle involved in poisoned food technique is to poison the nutrient medium with a fungi-toxicant and then allowing the test fungus to grow on it and finally recording the extent of growth (Nene and Thapliyal 1997). Four concentrations i.e 250ppm, 500ppm, 750ppm and 1000ppm were used for each fungicide (Table 1). Required quantities of individual fungicides based on active ingredients were added separately into potato dextrose agar so as to get desired concentration of fungicides. To avoid bacterial contamination, Streptomycin (15 mg L^{-1}) was added to each flask before pouring. Twenty ml of poisoned medium was poured into sterile petri dishes.

Table 19. List of fungicides and their concentrations

Sr. no.	Fungicides	Trade Name	Concentration (ppm)
1.	Mancozeb 80% WP	Dicozeb	250, 500, 750 & 1000
2.	Chlorothalonil 72% SC	Cleaner	250, 500, 750 & 1000
3.	Hexaconazole 5% SC	Hezagon	250, 500, 750 & 1000
4.	Difenoconazole 25% EC	Zolar	250, 500, 750 & 1000
5.	Propiconazole 15% + Difenoconazole 15% EC	Tiger	250, 500, 750 & 1000
6.	Azoxystrobin 20% + Difenoconazole 12.5% SC	Dize	250, 500, 750 & 1000

Mycelial discs of 5 mm diameter were cut from actively growing culture of fungus with the help of a sterilized cork-borer. A single disc was aseptically placed at the center of each PDA plate that already poured with poisoned medium. Control was maintained without adding any fungicides to the medium. Factorial experiment was laid out in a Completely Randomized Design (CRD) with three replications. There were two factors involving six fungicides and control as the first factor and four concentrations as the second factor. Plates were incubated at room temperature. Observation on colony diameter (mm) of pathogen was recorded when control treatment was fully covered with mycelial growth. The efficacy of a fungicide was expressed as percent inhibition of mycelia growth over control which was calculated by using the following formula (Vincent, 1927).

$$\text{Percent Inhibition (I)} = \frac{(C - T)}{C} \times 100$$

Where,
C = Growth (mm) of the fungus in untreated control plates
T = Growth (mm) of the fungus in treated plates

Analysis of variance was performed by using Statistix Version 8.0 program and means were separated by Least Significant Difference (LSD) test at 5% probability level.

Results and Discussion

Identification of Pathogen

The colonies were initially light grey in color and turned olive green to dark brown with whitish margin. When the medium was completely covered by fungi, the whole surface of the colony turned dark green or black with numerous sporulation (Plate 2). The fungus produces long chains conidia. Mycelia were light brown with brown conidiophores. Conidiophores have septa, straight to geniculate and prominent conidial scars. Conidia were brown in color and obclavate. Conidia have short beak with 3-5 transverse septa and 0-3 longitudinal septa (Plate 3). Conidial morphology of the fungus was similar with characteristics of Alternaria on teak (Ai et al., 2015) and description of Alternaria (Woudenberg et al., 2013).

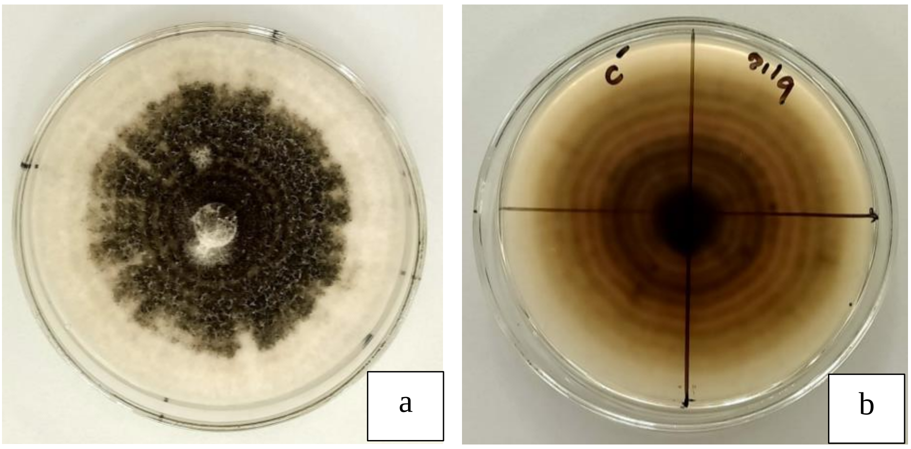

Plate 10. Front view (a) and back view (b) of colony morphology of *Alternaria* spp.

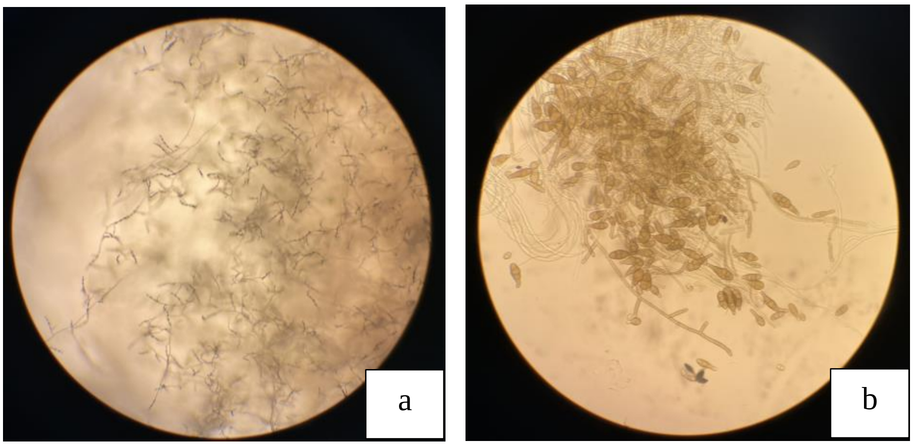

Plate 11. Conidia and conidiophores of *Alternaria* spp. 10x (a) and 40x (b)

***In-vitro* Evaluation of different fungicides on mycelial growth of *Alternaria* spp.**

Table 20. In-vitro Effect of different fungicides on mycelial growth of Alternaria spp.

Fungicides	Colony Diameter (mm)			
	C1: 250ppm	C2: 500ppm	C3: 750ppm	C4: 1000ppm
T1: Mancozeb 80% WP	19.33	12.67	4.00	0.00
T2: Chlorothalonil 72% SC	59.33	58.50	37.67	36.17
T3: Hexaconazole 5% SC	8.00	0.00	0.00	0.00
T4: Difenoconazole 25% EC	16.00	11.67	10.33	10.00
T5: Propiconazole 15% + Difenoconazole 15% EC	9.67	9.00	0.00	0.00
T6: Azoxystrobin 20% + Difenoconazole 12.5% SC	16.17	13.50	12.33	12.33
T7: Control	90.00	90.00	90.00	90.00
P value	0.0000			
CV %	17.78			
LSD $_{0.05}$	4.34			

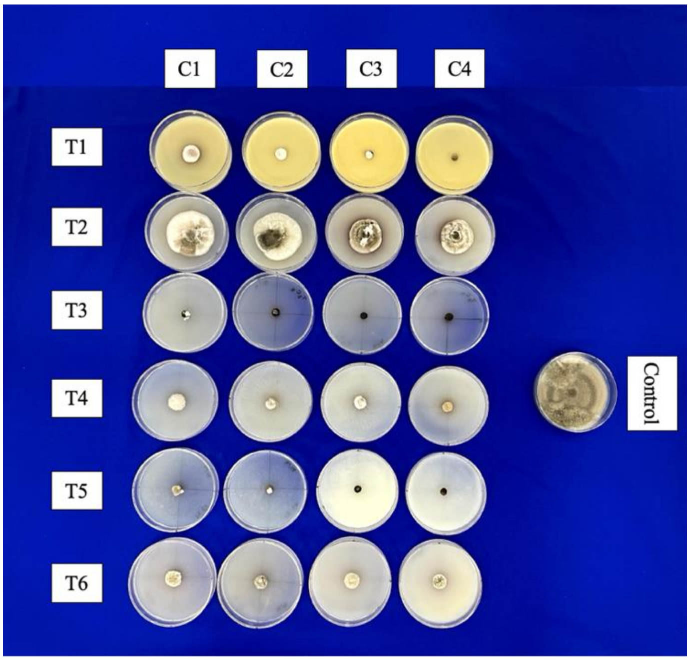

Plate 12. Efficacy of six fungicides on the mycelial growth of *Alternaria* spp. at four concentrations

Six fungicides viz., Mancozeb, Chlorothalonil, Hexaconazole, Difenoconazole, Propiconazole + Difenoconazole, Azoxystrobin + Difenoconazole were evaluated against the mycelial growth of *Alternaria* spp. at four concentrations viz., 250, 500, 750 and 1000 parts per million (ppm) by poisoned food technique at 10 days after inoculation (DAI). Result (Table 2, Plate 4) revealed that test fungicides exhibited a wide range of mycelial growth of *Alternaria* spp., which was found to be decreased drastically with increase in concentrations of different fungicides. At 250 ppm, mycelial growth of *Alternaria* spp. ranged from 8.00 to 59.33 mm. However, it was least with Hexaconazole 5% SC (8.00 mm), followed by Propiconazole 15% + Difenoconazole 15% EC (9.67 mm), Difenoconazole 25% EC (16.00 mm), Azoxystrobin 20% + Difenoconazole 12.5% SC (16.17 mm), Mancozeb 80% WP (19.33 mm) and Chlorothalonil 72% SC (59.33 mm). At 500 ppm, mycelial growth ranged from 0.00 to 58.50 mm. However, Hexaconazole 5% SC completely inhibited the growth of the pathogen. It was followed by Propiconazole 15% + Difenoconazole 15% EC (9.00 mm), Difenoconazole 25% EC (11.67 mm), Mancozeb 80% WP (12.67 mm), Azoxystrobin 20% + Difenoconazole 12.5% SC (13.50 mm) and Chlorothalonil 72% SC (58.50 mm). At 750 ppm, mycelial growth was between 0.00 to 37.67 mm. However, Hexaconazole 5% SC and Propiconazole 15% + Difenoconazole 15% EC entirely inhibited the pathogen growth. The highest mycelial growth (37.67 mm) observed from Chlorothalonil 72% SC. At 1000 ppm, mycelial growth ranged from 0.00 to 36.17 mm. However, Hexaconazole 5% SC, Propiconazole 15% + Difenoconazole 15% EC and Mancozeb 80% WP inhibited the growth of the fungus.

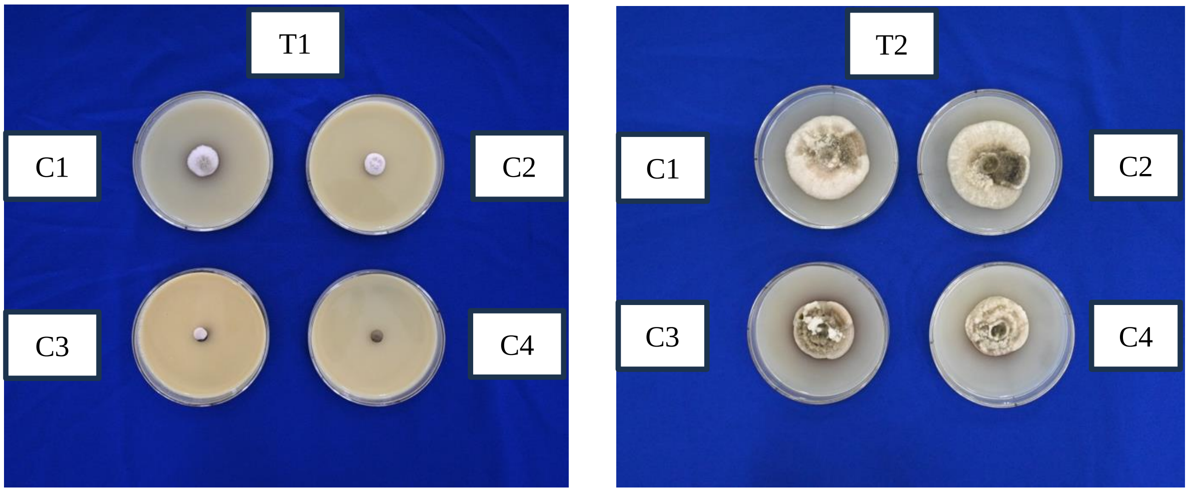

Plate 13. Inhibition effect of Mancozeb (T1) and Chlorothalonil (T2) on mycelial growth of *Alternaria* spp. at four different concentrations

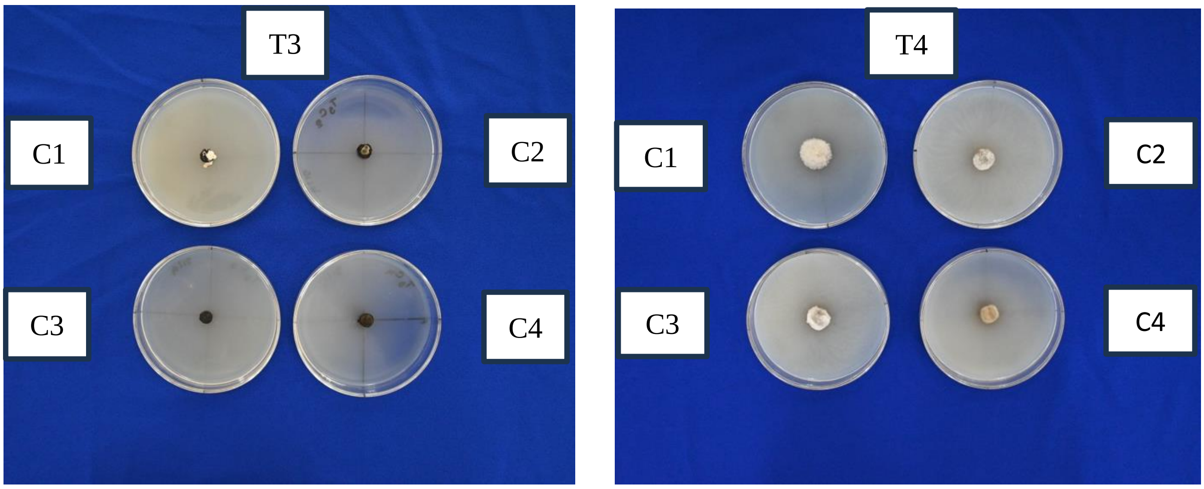

Plate 14. Inhibition effect of Hexaconazole (T3) and Difenoconazole (T4) on mycelial growth of *Alternaria* spp. at four different concentrations

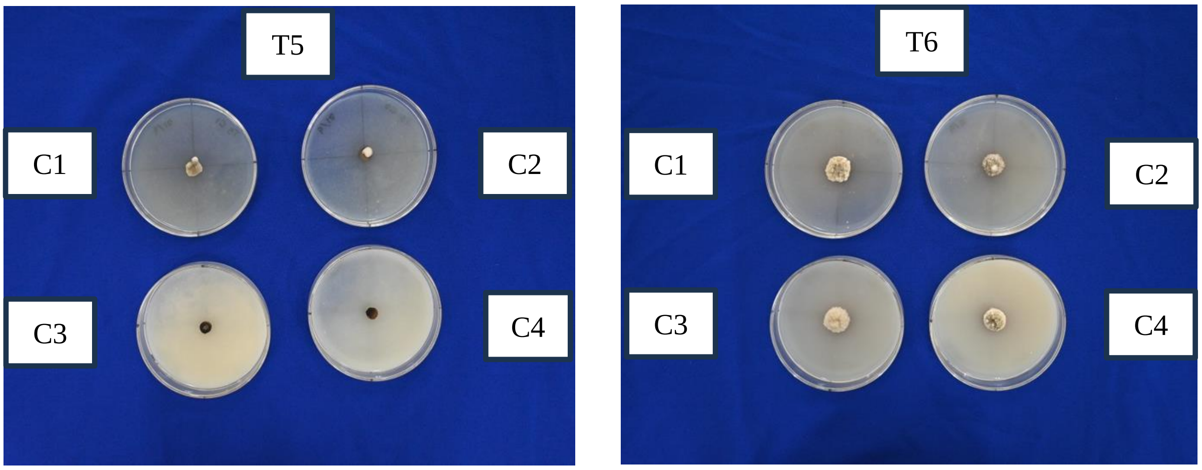

Plate 15. Inhibition effect of Propiconazole + Difenoconazole (T5) and Azoxystrobin + Difenoconazole (T6) on mycelial growth of *Alternaria* spp. at four different concentrations

Table 21. Inhibition percent of six fungicides on mycelial growth of *Alternaria* spp.

Fungicides	Mycelial growth inhibition (%)
T1: Mancozeb 80% WP	90.00 C
T2: Chlorothalonil 72% SC	46.76 E
T3: Hexaconazole 5% SC	97.78 A
T4: Difenoconazole 25% EC	86.67 D
T5: Propiconazole 15% + Difenoconazole 15% EC	94.81 B
T6: Azoxystrobin 20% + Difenoconazole 12.5% SC	84.91 D
P value	0.0000
CV %	3.52
$LSD_{0.05}$	2.41

All tested fungicides are capable of inhibiting the growth of *Alternaria* spp. at all the concentrations. A progressive increase in inhibition on mycelial growth of pathogen was observed with increase in concentration of fungicides (Plate 5, Plate 6, Plate 7). The percent inhibition of mycelial growth ranged from the minimum of 46.76 to the maximum of 97.78. Among these fungicides, Hexaconazole 5% SC was found superior in inhibiting the growth of *Alternaria* spp. with a mean percent inhibition of 97.78 % and was significantly different as compared to the other fungicides. Propiconazole 15% + Difenoconazole 15% EC (94.81%) was second best followed by Mancozeb 80% WP (90.00%). Difenoconazole 25% EC (86.67%) and Azoxystrobin 20% + Difenoconazole 12.5% SC (84.91%) were the next best chemicals in that order. However, Chlorothalonil 72% SC recorded least percent inhibition of mycelial growth at all concentration with a mean 46.76 percent growth inhibition (Table 3).

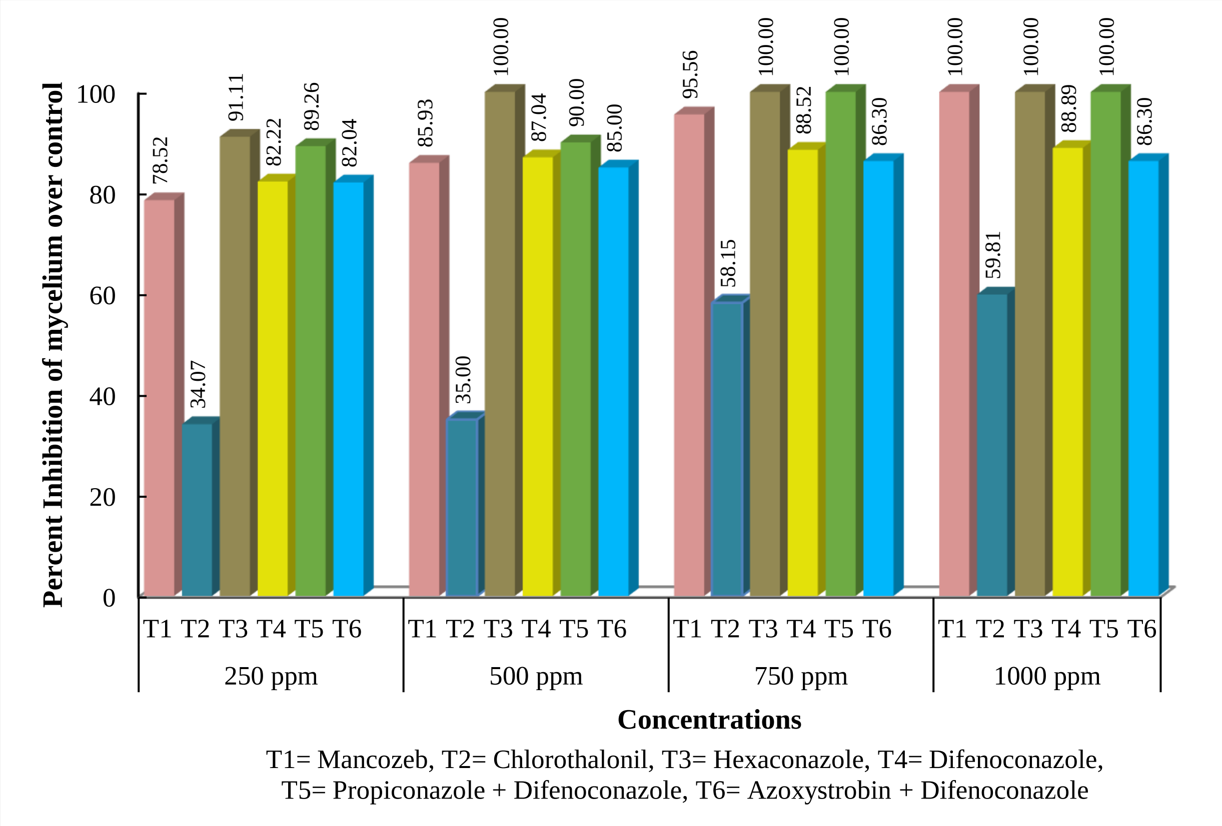

Figure 18. *In-vitro* efficacy of six fungicides against *Alternaria* spp. at four concentrations ($LSD_{0.05}$ = 4.83, CV = 3.52)

At 250 ppm, Hexaconazole 5% SC showed maximum percent inhibition (91.11%) followed by Propiconazole 15% + Difenoconazole 15% EC (89.26%) and least percent inhibition was recorded by Chlorothalonil 72% SC (34.07%). At 500 ppm, Hexaconazole 5% SC resulted with highest inhibition (100%), followed by Propiconazole 15% + Difenoconazole 15% EC (90.00%). Least inhibition was observed in Chlorothalonil 72% SC (35.00%). At 750 ppm, 100% inhibition of pathogen was achieved from the treatments of Hexaconazole 5% SC and Propiconazole 15% + Difenoconazole 15% EC. Chlorothalonil 72% SC was appeared as least effective fungicide which showed only 58.15% inhibition of pathogen. At 1000 ppm, Mancozeb 80% WP, Hexaconazole 5% SC and Propiconazole 15% + Difenoconazole 15% EC showed 100% inhibition of mycelial growth followed by Difenoconazole 25% EC with 88.89% inhibition. Least percent inhibition was recorded by Chlorothalonil 72% SC (59.81%) (Figure 1).

These results were in conformity with the findings of several earlier researchers. Bangar et al., (2019) reported that Mancozeb 75% WP (0.25%) was completely inhibited the growth of *Alternaria brassicae* causing Alternaria leaf spot of cauliflower. Babhare et al., (2023) showed that significantly highest and percent (100%) inhibition against *Alternaria cucumerina*, causing leaf blight of bottle gourd was recorded from Propiconazole 25% EC and Tebuconazole 25.9% EC, followed by Hexaconazole 5% SC (96.36%). Jewaliya et al., (2021) reported that Hexaconazole was the most effective against *Alternaria alternata* which showed 97.96% inhibition of mycelial growth.

Conclusion

Based on the results of current experiment, it can be concluded that Mancozeb 80% WP, Hexaconazole 5% SC, Difenoconazole 25% EC, Propiconazole 15% + Difenoconazole 15% EC and Azoxystrobin 20% + Difenoconazole 12.5% SC would be effective fungicides to control Alternaria leaf blight of *Tectona grandis* in Laboratory. However, these findings need to be studied under field conditions.

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Field-based First Observation of *Euplatypus parallelus* (F.) (Coleoptera: Curculionidae: Platypodinae) which might cause Fatal Impacts on the Padauk (*Pterocarpus indicus* Willd.) Trees in Myanmar

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Abstract

An ambrosia beetle, *Euplatypus parallelus* (F.) was collected from infested padauk *Pterocarpus indicus* Willd in Nay Pyi Taw, Myanmar. Larvae and eggs were found in the holes and the galleries of infested padauk wood cuttings. The adults come out from the holes to the mesh that covers the infested padauk wood cuttings. Half of these infested trees were previously pruned while some of them appeared to be healthy. Findings of this study indicated that mass attacked and damaged by a large population of this beetle might be a cause of sudden decline or death of *P.indicus*. Aluminium phosphide and carbaryl insecticide had effect on the attack of ambrosia beetle to padauk.

Keywords: ambrosia beetle, aluminium phosphide, carbaryl, Platypodinae, padauk.

ပိတောက်ပင်များအားသေစေနိုင်သည့်သစ်ထိုးပိုး *Euplatypus parallelus* (F.)

စာတမ်းအကျဉ်း

Ambrosia beetle *Euplatypus parallelus* (F.) အား မြန်မာနိုင်ငံ၊ နေပြည်တော်ဧရိယာရှိ ပိုးကျရောက်ဖျက်ဆီးသော ပိတောက်ပင်များမှ စုဆောင်းခဲ့ပါသည်။ ပိုးကျရောက် ဖျက်ဆီးသော ပိတောက်သားဖြတ်စများ၏ ပိုးပေါက်နှင့် ဥမှင်လမ်းကြောင်းများတွင် ကျိုင်းကောင်၏ ဥအဆင့်နှင့် သားလောင်းအဆင့်များအား တွေ့ရှိခဲ့ပါသည်။ ပိုးကျရောက် ဖျက်ဆီးသော ပိတောက်သားဖြတ်စအား ဖုံးအုပ်ထားသော ခြင်ထောင်ဇာအတွင်းသို့ အရွယ်ရောက်ကောင်များသည် ပိုးပေါက်များမှ ထွက်ရှိလာသည်ကို တွေ့ရှိခဲ့ရပါသည်။ ပိုးကျရောက်ဖျက်ဆီးသော ပိတောက်ပင်ထက်ဝက်သည် ယခင်က အကိုင်းချိုင်ခြင်းများ ပြုလုပ်ထားရှိပြီး အချို့အပင်များသည် ကျန်းမာနေသည်ကို တွေ့ရှိခဲ့ပါသည်။ ဤလေ့လာမှုတွင် ကျိုင်းကောင် အရေအတွက်များစွာသည် အပင်တွင် အုပ်စုလိုက်ကျရောက်ကာ ဖျက်ဆီးမှုကြောင့် ပိတောက်ပင်သေဆုံးရခြင်း ဖြစ်နိုင်ကြောင်း လေ့လာတွေ့ရှိခဲ့ရပါသည်။ Aluminium phosphide နှင့် Carbaryl ပိုးသတ်ဆေးသည် ပိတောက်ပင်တွင် ၎င်းကျိုင်းကောင် ကျရောက်မှုအပေါ် ထိရောက်မှုရှိကြောင်း တွေ့ရှိခဲ့ရပါသည်။

Introduction

Ambrosia beetles are one of the wood-boring insects. Invasive bark and ambrosia beetles (Curculionidae: Scolytinae and Platypodinae) are increasingly responsible for major economic damage to forests, planations and orchards worldwide (Hulcr & Dunn, 2011). Platypodinae occurs in the tropical and subtropical areas where some species are important pest for forest and tree plantation (Browne, 1968). *Euplatypus parallelus* (F.) (Platypodinae) is native to tropical America, but has been widespread to Africa, Madagascar, Australia and Southeast Asia (Beaver, 1999; Gümüş & Ergün 2015). This species is highly polyphagous, attacking conifers and broadleaf trees of over 80 species from about 25 botanical families (Gümüş & Ergün, 2015). Most platypodine species infest only freshly dead or dying trees. But, E. parallelus is one of the few species of colonizing to standing trees which is stressed by drought, disease, or flooding (Boa & Kirkendall, 2004). These beetles live in symbiosis with fungi which may be pathogenic causing tree mortality (Harrington et al., 2011).

Padauk *Pterocarpus indicus* Willd. is a native tree to Southeast Asia distributed from southern Myanmar to the Philippines (Carandang, 2007). Padauk is mainly planted as ornamental or shade trees along roads, walkways, in parks and residential areas in Myanmar and it can fast growing, evergreen, and attractive flowering period. In the study area, this tree has been usually grown more than 5 years with other forest trees and has been pruned before rainy season.

It is difficult to control this pest because its life cycle takes place within wood (Manohara et al., 2023). Carbaryl and cypermethrin has proved to be highly effective against ambrosia beetle such as *Megaplatypus mutatus* (Bascialli et al., 1996). To control M. mutates, early detection and destruction of infested trees is firstly conducted (Santoro, 1967; Toscani, 1990). Secondly, the insecticide is injected into the galleries or sprayed to the trunk during the adult emergence in spring (Santoro, 1967). Phosphine fumigation can be adopted to protect the infestation of wood pest pest S*inoxylon anale* (coleoptera: bostrychidae) in wooden logs and products (Remadevi & Deepthi, 2018). Fumigation of wood with aluminium phosphide gave more than 90 % protection against wood decaying white and brown rot fungi (Pant & Tripathi, 2011). There is no previous information on E. parallelus attacking padauk in this area.

Objectives

- To report the presence of infestation by Ambrosia beetles *E. parallelus* on padauk in Myanmar
- To explore the proper chemical control for the ambrosia beetle infestation on padauk.

Materials and Methods

Study site

The study area is located in Nay Pyi Taw, Myanmar. Padauk and other forest trees were planted as shade trees along the road. The study period was from July, 2023 to December, 2023.

Collection and identification

Samples were collected from the recently dead and partly dead tree with signs of infestation by insects. One major branch from each infested tree was cut with a wood cutter to get about 0.5 m wood pieces as sample. Samples were brought to Entomology laboratory, Forest Protection Division, Forest Research Institutes to identify the pest. The samples from partly dead tree were covered with fine cloth mesh to monitor the adult beetle. The adults come out from the wood cutting were collected. Samples from recentely dead tree were cut vertically to observe larva, pupa, adult and their gallery system. The adults were identified by comparing the external morphological features with *E. parallelus* (F.) from published articles.

Effect of different pesticide methods on the incidence of ambrosia beetles on padauk

Insecticides selected for this study were those commonly used by the farmers and readily available in the market. Lime and pesticides; carbaryl 85% WP and aluminium phosphide tablet were applied at manufacturer's recommended rates. Three methods of application were conducted to nine plants and no pesticide to one plant as follow.

Method (1) Lime 1kg and carbaryl 85% WP (50 g) were mixed with 10 liters of water. The mixture was applied to the stem of the plant.
Method (2) Lime 1kg and carbaryl 85% WP (50 g) were mixed with 10 liters of water. The mixture was applied to the stem of the plant. One aluminium phosphide tablet was put into the stem with the help of nail. After putting, the hole was covered with tape.
Method (3) Lime 1kg and carbaryl 85% WP (50 g) were mixed with 10 liters of water. The mixture was applied to the stem of the plant. One aluminium phosphide tablet was put into the stem with the help of nail. After putting, the hole was covered with tape. One aluminium phosphide tablet was buried into the soil which is near the stem. No pesticide was applied to one plant as control plant.

Results and Discussion

Identification of beetle

Larvae and eggs were found in the holes and in the galleries of recently dead tree (Plate 1). Egg mass was found both with and without larvae in some galleries. Larvae of *E. parallelus* are creamy white and curved (Plate 2). The adult from the gallery systems in the wood and come out into the mesh are slender body, about 4 mm length, brown with hairs. Male elytra striae deeply impressed, subequal in width to interstriae at base of declivity. The beetles were identified by comparing the external morphological characteristic with *E. parallelus* (F.) of published articles (Atkinson, 1989), (Tarno et al., 2014) and (Manohara et., 2023). (Manohara, 2023) reported that Larval galleries were 1.3- 1.5 mm wide. In a single gallery system, larvae, pupae and adults coexisted (overlapping generations). Adult beetles are slender, 3.8- 4.2 mm long and brownish and hairy.

Plate 1. Larvae and eggs from the holes

Plate 2. Creamy white and curved larvae from the holes and the galleries

Plate 3. Cylinder of frass on the trunk of partly dead tree

Plate 4. Cylinder of frass at the opening of holes on the branch of partly dead tree

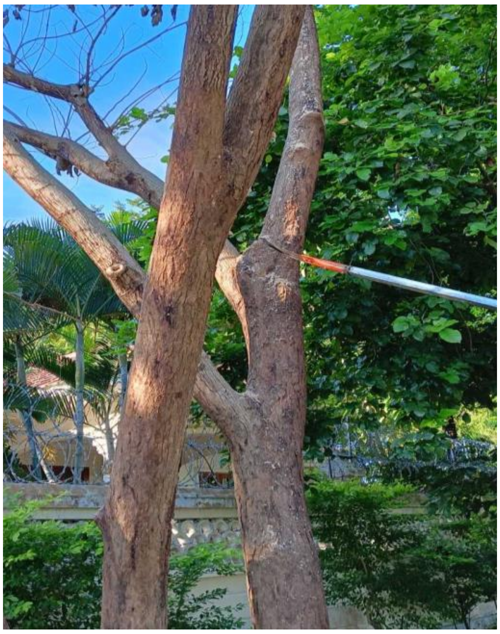

Plate 5. Fine dust of frass on the branches of recently dead tree

Plate 6. Fine dust of frass at the base of recently dead tree

Plate 7. dark-stained galleries

Plate 8. Galleries of infested wood sample

Regarding with the characteristic of tree's damage, a number of small holes (about 1 mm in diameter) and cylinders of frass (2-3 cm long) were observed on the major branches and stem of partly dead tree (Plate 3 and 4). In recently dead tree, fine dust of frass was observed on the major branches, stem and on the ground (Plate 5 and 6). One to sixty galleries were found from each sample. The holes inside the stem were shown with a black color. Some of the gallery walls were dark-stained with fungal mycelia (Plate 7) (Plate 8). The gallery was simple, straight and about 1 mm in diameter. Some galleries were not particularly straight with a single branch. Symptom of tree's damage was observed as fallen leaves, wilting and drying.

The findings of larva and adult of this beetle, gallery system, sign and symptom of attacked tree are similar to *E. parallelus* (F.) infested on padauk from Malang Indonesia, Southern Thailand and on rubber in Brazil. The result in this research coincided with the previous research findings observed by other authors (Tarno et al., 2014), (Manohara et., 2023), (Silva et al., 2013) regarding with E. parallelus (F.).

Effect of pesticide application methods on the incidence of ambrosia beetles on padauk

Three methods of pesticides application were observed the effectiveness on this beetle infestation. Among the three methods of pesticide application, method (2) and method (3) were observed more effect on the beetle infestation to padauk than method (1). Method (3) had more effect on the partly infested or partly died branches of trees than method (2). But, Method (3) had bad effect on the young plant (under one year old plant which is grown by wood cutting) as died. Untreated plant had severely infestation of beetle and finally result tree mortality. The comparison of effectiveness among the pesticide application methods were measured based on plant healthy, no sign of beetle attacking (frass, holes) , no fallen leaves, no wilting and dying by visual observation.

Carbaryl and aluminium phosphide tablet would be effective pesticides on ambrosia beetle attack to this tree. (Bascialli et al., 1996) mentioned that Carbaryl has proved to be highly effective against ambrosia beetle *Megaplatypus mutates.* (Zhang et al., 2004) reported that phosphine has the potential to control the pests in export logs before they arrive in the other countries. According to the Report of the Methyl Bromide Technical Options Committee by United Nations Programme, fumigation of logs using phosphine is effective in controlling bark beetles, wood wasps, long horn beetles and platypodids. (Montreal Protocol On Substances that Deplete Ozone Layer, 1998).

On the other hand, treated plants were found the effectiveness on the beetle attack as it may be no odor of fermentation from the tree. Healthy trees do not emit fermentation odors and that tree is unattractive to beetle. Half of these infested trees in this area were previously pruned and it can emit odor of fermentation. In this research area, most of the padauk was planted by vegetative propagation method and this species may be involved within that wood cuttings. (Alfaro et al., 2007) indicated that this beetle was likely to be transported with host material as it spends its life within the host tree for planting. Mass attacked and damaged by a large population of this beetle might be a cause of sudden decline or death of padauk.

Conclusion

Since ambrosia beetles rarely attack healthy vigorous trees. Good cultural practice should be conducted for the vigorous growth of tree. Weakened or stressed trees apparently emit fermenting-like odors that attract ambrosia beetles. To prevent severely infestation of this beetle, early detection and destruction of infested trees should be conduct as first approach. As second approach, chemical control can be conducted by applying insecticides into the galleries or on the trunks and branches during adult emergence. The findings presented in this paper showed carbaryl and aluminium phosphide are effective against this beetle. However, chemical control is costly and potentially harmful to the environment, people and animals. Chemical control may be needed occasionally and it should be carried out in high-value trees and in small defined areas. On the other hand, mass testing of different kind of traps in monitoring population peaks could be a valuable help in the control of this beetle and Integrated Pest Management should be conducted for safety environment.

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