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# Study on Distribution of Teak Mistletoe (*Loranthus pulverulentus* Wall.) Control Measures and Teak Growth Assessment in Moeswe Teak Plantations

Tun Tun Win, Range Officer
Wai Wai Than, Deputy Director
Forest research Institute

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# ကျွန်းကိုင်းများတွင် ကပ်ပါးပင်ပေါက်ရောက်မှုကိုလေ့လာ၍ ကာကွယ်ခြင်းနည်းလမ်းများကိုစမ်းသပ်ခြင်းနှင့် ကျွန်းပင်၏ကြီးထွားမှုကိုအကဲဖြတ်ခြင်း

ထွန်းထွန်းဝင်း၊ တောအုပ်ကြီး
ဝေဝေသန်း၊ ဒုတိယညွှန်ကြားရေးမှူး
သစ်တောသုတေသနဌာန

## စာတမ်းအကျဉ်း

စိုက်ခင်းများတည်ထောင်ရာတွင် ကျွန်းကပ်ပါးပင်သည် များစွာသောဆုံးရှုံးမှုကိုဖြစ်စေတတ်သည့် ကပ်ပါးပင်တစ်မျိုးဖြစ်ပြီး ၎င်းကို ၁၈၆၇ ခုနှစ်ဝန်းကျင်တွင် တွေ့ရှိခဲ့သည်ဟု Dr. Cleghorn က မှတ်တမ်းတင်ထားရှိခဲ့သည်။ ကျွန်းကပ်ပါးပင်များသည် ကျွန်းပင်၏ အစာကြောရေကြောအပင်ဆဲလ်များထဲသို့ ထိုးဖောက်ဝင်ရောက်ဖျက်ဆီးတတ်နိုင်သဖြင့် အပင်ကြီးထွားမှုနှေးကွေးခြင်း၊ အပင်ပုံစံပျက်ခြင်း၊ အသီးအပွင့်ဖြစ်တည်မှုကျဆင်းစေခြင်းနှင့် တဖြည်းဖြည်းခြောက်သွေ့ သေဆုံးနိုင်စေခြင်းကို ဖြစ်ပေါ်စေပါသည်။ မြန်မာနိုင်ငံ၌ ကျွန်းကပ်ပါးပင်ကို ယခင်သဘာဝတောကြီးများတွင် အနည်းငယ်တွေ့ခဲ့ရသော်လည်း ယခုအခါစိုက်ခင်းများတိုးချဲ့တည်ထောင်လာခြင်းကြောင့် တွယ်ကပ်ပေါက်ရောက်ပျံ့ပွားမှုကို ပိုမိုတွေ့လာခဲ့ရပါသည်။ စမ်းသပ်လေ့လာမှုကို နေပြည်တော်တိုင်းဒေသကြီး၊ ဥတ္တရသီရိမြို့နယ်၊ မိုးစွေသုတေသန ကျွန်းစိုက်ခင်းများတွင် ဇွန်လ၊ ၂၀၁၃ ခုနှစ် မှ မတ်လ၊ ၂၀၁၅ အတွင်းအကွက် (၃) ကွက်ချ၍ ကိုင်းချိုင်ခြင်း၊ ဆေးဖြန်းခြင်း (Metribuzin) နည်းလမ်းများကို အသုံးပြုခဲ့ပြီး ကပ်ပါးကျရောက်မှုအရေအတွက် လစဉ်စာရင်းကောက်ယူခြင်း၊ လုံးပတ်တိုင်းတာခြင်းတို့ကို ဆောင်ရွက်ခဲ့ပါသည်။ ကျွန်းကပ်ပါးပင်များ ကျရောက်ခြင်းကြောင့် ကျွန်းပင်၏ကြီးထွားမှုတွင် ထူးခြားစွာသက်ရောက်မှုမရှိသည်ကို တွေ့ရှိခဲ့ရသည်။ ကိုင်းချိုင်ခြင်းသည် အထိရောက်ဆုံးနည်းလမ်းဖြစ်သည်။ စမ်းသပ်မှုအရကိုင်းချိုင်ခြင်းသည် ကျွန်းကပ်ပါးကျရောက်မှုကိုပထမနှစ်တွင် ၉၀ % ၊ ဒုတိယနှစ်တွင်၉၉% အထိ လျှော့ချပေးနိုင်ပြီး ဆေးဖြန်းခြင်းမှာ ကပ်ပါးကျရောက်မှုကို ပိုမိုပြန့်ပွားမှုမရှိစေရန် ထိန်းချုပ်ပေးနိုင်ရုံသာရှိကြောင်း လေ့လာတွေ့ရှိခဲ့ရပါသည်။ စိုက်ခင်းတည်ထောင်ရာတွင် သစ်မျိုး တစ်ခုတည်းဖြင့် တည်ထောင်ခြင်းထက် ကျွန်းနှင့် အရိပ်ကြိုက် အပင်မျိုးစိတ်များဖြင့် ရောနှောစိုက်ပျိုးခြင်း၊ စိုက်ကွက်အကြား ကြားခံသဘာဝတော ထားရှိခြင်းတို့ကို ကျင့်သုံးပါက ကပ်ပါးကျရောက်မှုကို အထိုက်အလျောက် ဟန့်တားနိုင်မည်ဖြစ်သည်။ ဓါတုဆေးဝါးများသုံးကာ ဆေးဖြန်းခြင်းသည် ကပ်ပါးပင်၏အမြစ်ဆုံကို ဖျက်ဆီးနိုင်ခြင်းမရှိသဖြင့် ကပ်ပါးပင်အသစ်များ ပြန်လည်ထွက်ပေါ်လာသည်ကိုတွေ့ရသည်။ ထို့ပြင် ကပ်ပါးသတ်ဆေးသည် ဈေးနှုန်းမြင့်မားခြင်း၊ နှစ်ကာလကြာရှည်စွာဆေးသုံးမှ ထိရောက်ခြင်း၊ သဘာဝပတ်ဝန်းကျင်ကို ထိခိုက်စေနိုင်ခြင်းတို့ကြောင့် ချင့်ချိန်ဆောင်ရွက်ပြီးမှ သုံးစွဲသင့်ကြောင်း အကြံပြုတင်ပြထားပါသည်။

# Study on Distribution of Teak mistletoe (*Loranthuspulverulentus*Wall.), Control Measures and Teak Growth Assessment in Moeswe Teak Plantations

TunTun Win, Range Officer
WaiWai Than, Deputy Director
Forest Research Institute

## Abstract

Teak mistletoe was recorded by Dr. Cleghorn in 1867. It was one of the major pests of teak and infected with this parasite leading to a heavy loss in some plantations. They may cause damage to the plant reductions in vigor, growth, seed production, wood quality and even host mortality. Dead branches and trees in stands by mistletoe can become fire hazards. In Myanmar, teak mistletoe problems are gradually raising with planting of large scale monoculture teak trees. Therefore, Forest Research Institute urgently tried to find out effective control measures for that problem. This research aims to provide useful information on management of teak forests and plantations. This study was conducted in Compartment No. (72), Ngaleik Reserve Forest OttayaThiri Township, Nay Pyi Taw Region from June 2013 to March 2015. Over 20-year old teak plantations with mistletoe infection were selected and three blocks were named as B1, B2 and B3. Sixty infected teak trees were chosen for treatments in each block; 20 trees were for pruning (P), another 20 trees were for herbicide – Metribuzin (H) and the remaining 20 trees were marked as control (C). Mistletoe infection was occurred mostly in larger GBH (Girth at Breast Height) classes of teak trees. After applying different treatments, mistletoe infection of pruned trees were significantly decreased to nearly 90% in $1^{st}$year and around 99% in $2^{nd}$year than before. Mistletoe infection of chemical spraying was gradually decreased to nearly 20% in $1^{st}$ year and around 10% in $2^{nd}$year respectively. In assessing mistletoe control efficacy, pruning showed that it can be more reduced mistletoe infection than chemical spraying. To prevent the severe infestation of mistletoes, mix plantation (shade bearer species & light demander teak) should be more encouraged in future program. In addition, the use of shading to reduce the impacts of mistletoes on crop trees is possible because mistletoes do best in high light environment. Chemical control is time consuming and it does not kill the endophytic system and resprouting will occur. While using chemicals, environmental factors and potential harm to the host tree should consider for a long term.

**Key Words**: Teak, Mistletoe, Host, Parasite, Metribuzin (Sencor), Herbicide, Chemical, Pruning

## Contents

# Study on Distribution of Teak mistletoe (*Loranthuspulverulentus*Wall.), Control Measures and Teak Growth Assessment in Moeswe Teak Plantations

## 1.Introduction

Mistletoes, woody angiospermic parasite plants, infest trees throughout the world. In general, mistletoe is a parasitic flowering plant from sandalwood order (Santalales) that attaches to the above ground stem of another plant.The five families Loranthaceae, Viscaceae, Misodendraceae, Eremolepidaceae and Santalaceae include about 1400 species of mistletoes. Not all species within those families are mistletoes. Among them, Loranthaceae has the largest group of mistletoes by comprising about 900 species in 73 genera (David C. Shaw and Robert L. Mathiasen, 2013). Loranthus, members of the family Loranthaceae, are the most parasites in the tropics and they are partial stem parasites with green leaves, anchored to a host plant by means of modified adventitious roots called “sucker” “sinker” or “haustoria”. These suckers penetrate into the bark and wood to absorb nutrients from their host. So they may cause a considerable damage to the plant such as weakening trees by slowly removing water, minerals and phtosynthates (Hawksworth and Johnson 1993), causing reductions in vigour, growth, seed production, wood quality and even host mortality (Kimmey and Graham, 1960; Hawksworth and Wiens 1996). Dead tissues caused by mistletoes provide entry points for stain and decay fungi. Wood quality is reduced via witches’ brooms, branch swellings and stem infections with the end result being abnormal grain, spongy wood texture and increased number and size of knots (Hawksworth and Wiens 1996). Dead branches and trees in stands damaged by mistletoe can become fire hazards (Sinclair et al. 1987). In addition, mistletoe weakens, disfigures and kills landscape trees in plantations and residential areas.

Teak mistletoe was recorded as early as 1867 by Dr. Cleghorn from Nilambur (Lushington, 1896). It was one of the major pests of teak in Kerala and more than 80% of teak trees were infected with this parasite leading to a heavy loss in some plantations. In Nilambur, total failure of plantations was caused by heavy attack on young trees.The number of infested trees as well as mean number of the parasite clumps on individual trees increased with the age of plantation (M. Balasundaran and M.I Mohamed Ali 1997).

In Myanmar, a few number of mistletoe was found in natural teak forests only in last decades. But, that problem was increased significantly in recent years especiallyin teak plantations and natural teak trees as well. By mean this fact is that the planting of large scale monoculture teak tree is favoring for more easily distribution of mistletoe to everywhere. In addition, the obvious thing was many reports of mistletoe problem from some districts to FRI. Many severe attack of this parasite in teak plantations were found, therefore, FRI needs urgently to take into account this problem, and to conduct research on possible measures for management. This research aims to support better management of teak forests and plantations through consideration of mistletoe. The objectives of this study are;

(a) to collect the basic information of mistletoe species and record the distribution of teak mistletoe in tree size class

(b) to assess the growth of teak trees affected by teak mistletoe

(c) to find out the possible control measures on teak mistletoe
(d) to provide technical information forboth foresters and plantation managers in concerning with effective management of teak mistletoe

## 2. Literature Review

Mistletoes were one of the earliest parasites of plants recognized by Albertus Magnus around 1200 AD (Horsfall& Cowling 1977). They mostly attack dicotyledons and gymnosperms which include forest trees and horticultural plants.Sometimes, they cause problems for the horticulturists as well as the foresters. Despite the fact that the mistletoes take a heavy toll in horticulture and forestry, very little attention has been paid. Mistletoes are distributed all over the world and occur on all of the continents except for Antarctica. Although several species occur in temperate zones, they are most common and abundant in the tropical forests of Asia, Central America, South America and Africa (Kuijt, 1969; Calder and Bernhardt, 1983; Polhill and Wiens, 1998).

Mistletoes also parasitize a variety of fruit- and nut- producing trees throughout the world and cause economic losses by reducing the productivity of infected trees (Pundir, 2009). Most mistletoes attack hardwood forest and shade trees, gymnosperms (juniper, cypress) as well as coffee, cacao, rubber, apple, cherry and citrus (Agrios 1997). In Bangladesh, many of the important forest trees like teak (*Tectonagrandis*), Sal (*Shorearobusta*), etc. and several fruit trees like Mango (*Mangiferaindica*), Jack fruit (*Artocarpusheterophyllus*) are attacked by mistletoes.

Pollination of mistletoe flowers by biotic agents (primarily birds and insects) as well as by wind is essential for reproduction and therefore it is relevant to epidemiology. Mistletoes disperse their seeds by three distinct mechanisms: (i) animal dispersal; (ii) wind dispersal; and (iii) explosive discharge of seed (Shaw and Robert, 2013). Many tropical and subtropical types of mistletoe in the Loranthaceae have large, colorful flowers that produce large number of sugar-rich nectar that attract avian pollinators. The birds eat and digest the pulp of the berries, later excreting the living seeds, and it can stick tightly to any branch that they fall on.The mature fruits of mistletoes are brightly colored (usually white, yellow, red, blue or purple). In South America, a marsupial disperses seeds (Amico and Aizen, 2000), and in North America, squirrels and other mammals has been shown to rarely disperse dwarf mistletoe seeds adhering to their fur (Hawksworth and Wiens, 1996; Mathiasen, 1996). The Misodendraceae of temperate South America is the only group of mistletoes that have wind-dispersed seeds (David C. Shaw and Robert L. Mathiasen, 2013). Basically, mistletoe that occurred on ridge tops would spread further and wider than mistletoes in valley or from wind-protected sites. The dwarf mistletoes are primarily disseminated by an ‘explosive fruit’ system involving both hydrostatic and mechanical mechanisms (Hawksworth and Wiens, 1996; Hawksworth*et al*., 2002). Fire is a major factor that determines the distribution of dwarf mistletoe on a landscape bais (Alexander and Hawksworth 1975; Hawksworth and Wiens 1996).

*Dendrophthoefalcata*, mistletoe in growing teak plantations of Kerala can kill the trees. This parasite survives on trees irrespective of whether the trees are in full flushes or in the deciduous state. Photosynthesis measurements on the parasite leaves showed that they

were equally photosynthesizing in bright as well as in dim light conditions. This means that their survival is ensured in a deciduous tree like teak, both during the leafy and leafless stage. In addition, they maintain water potential much lower than the host tree, so it can suck water from the host using a gradient in pressure. During the dry season, teak is leafless and there is no mechanism to replenish the lost water in the wood tissue, thereby; the branches die due to local dryness (Peechii, 2005).

Mistletoes have a serious impact on the host tress in terms of quantity and quality as well. The degree of damage is upon the species of the parasite, host susceptibility, age of the host, life-cycle, longevity of the parasite and etc.(S.K.Gosh*et al.,* 1984). Economic impacts of mistletoes include reduction in tree vigour and growth increment, poor fruit and seed setting, drying of branches and even the death of the host tree. Reduction in timber quality including strength property is another serious damage caused by mistletoes. Tests of physical properties of wood from mistletoe infested trees showed reduction in timber quality; 16% higher MOR (Modulus of rupture) values and 63% higher Wmax (Work to maximum load) values over the respective values of wood from infested teak trees (Gnanharan*et al.,* 1983). If the history of mistletoe infestation in the plantations were unknown, it was not possible to assess the exact volume loss of timber.

In India, several mistletoe species have been recorded on various forest and fruit trees (Brandis 1906; Rao 1923; Fischer 1926; De 1945; Koppikar 1948; Bagchee 1952; Singh 1962). Teak is the major hardwood species in the state and Kerala Forest Research Institute has recognized the problem of mistletoe as the most important pathological challenge. In horticultural plantations, mistletoes are removed periodically with the annual tree pruning or sometimes under the "tree clearing" programmes(S.K.Gosh*et al.,* 1984). Koppikar (1848) advocated the public consensus with the popular slogan "**killloranthus and save trees**" with cooperation of various public departments to remove mistletoes. Removal of the parasite was being practiced in teak since it was noticed in the Nilambur plantations (Lushiongton 1896; Brand 1941). The previous study showed that in Nilambur Division, almost all plantations above the age of seven years were being attacked by mistletoes and in some plantations more than 85% of trees were infested with the parasite.

Dwarf mistletoes (*Arceuthobium*) are smaller plants than broadleaf mistletoes. Their shoots are non-woody, segmented, and have small scale like leaves. While broadleaf mistletoe seeds are dispersed by birds, dwarf mistletoe seeds are spread mostly by their forcible discharge from fruit. Dwarf mistletoes have long been understood as one of the most damaging disease of confiers in USA and Canada. It kills by slowly robbing the tree of food and water. The estimated annual loss due to mistletoes was 7.5 million of timber (Stewart 1978). Genetic resistance to infection resulting from co-evolution of the forest trees and their pathogens has been the main principles of disease control in the natural ecosystem (van der Plank 1875). The possibilities of breeding and selection of dwarf mistletoe resistant trees have gained some recognition lately in USA (Roth 1978). In concerning with epidemiology, a number of biological entities which can destroy the parasite clumps has been listed, but present knowledge on this parasites are insufficient to use them for biological control.

Chemical control of mistletoes has been investigated since before the 1930s (Parker and Riches, 1993; Shamoun and DeWald, 2002; Pundir, 2009; Reid and Shamoun, 2009). In India and Australia, limited attempts have been made to control tree mistletoes in chemically.

Chemicals have been sprayed directly on the parasites or have been infused to the host by injection or drill girdling.2, 4-0 formulations were sprayed successfully in Australia for killing mistletoes on eucalypts (Hartigen 1949; Greenham*et al.* 1951). In India, phytotoxic effect on mistletoes was noticed accidentally by Kadambi 1954. While injecting sandal trees with mercury and copper compounds to combat spike disease in Kamata, he observed that copper sulphate had no effect on the spike symptoms but killed the mistletoe clumps. LaterCopper sulphate and Fernoxone were injected into *Dalbergiasissoo*to kill*Scurrulapulverulenta*, and he found that these chemicals were highly toxic to some of the host trees. Kerala Forest Department failed to eradicate teak mistletoe by injecting Copper sulphate and Fernoxone in Nilambur (Anonymous 1962). Several methods of tree injection using pressure have been developed in USA, Canada and South Africa to combat tree diseases (Pinkas*et al.* 1973; Schwarz *et al.* 1978; van Alfen& Walton 1974; Prasad 1975; Nair 1981).

Mistletoe management is dependent on the nature of the mistletoe and the situation (Reid and Shamoun, 2009). A clear understanding of the ecology, population dynamics and spatial patterns of mistletoe will be important to sustain the function of forests and provide necessary scientific basis for the management of these valuable resources (Hawksworth and Weins, 1996).

## 3.Materials and Methods

This study was conducted in Compartment No. (72), Ngaleik Reserve Forest under the areas of Moeswe Research Station No.(5) in OttayaThiri Township in Nay Pyi Taw Region. Over 20-yearold teak plantations with mistletoe infection were selected and three blocks, namely; B1, B2, B3, were chosen from those plantations for experiments. B1 is located at 19˚55′ 38″ N and 95˚59′ 0″ E with the elevation of 695 ft, B2 is located at 19˚55′ 30″ N and 95˚58′ 49″ E with the elevation of 660 ft, and B3 is located at 19˚55′ 37″ N and 95˚58′ 14″ E with the elevation of 600 ft respectively.

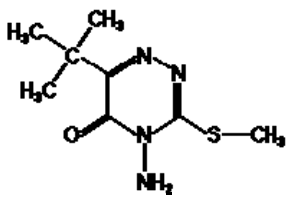
This research was conducted within 2 years from 2013-14 to 2014-15 and three kinds of treatments; pruning, herbicide and control trees were used in each block. Sixty infected teak trees were marked for each treatment in each block. 20 trees for pruning (P), another 20 trees for herbicide (H) and the remaining 20 trees were marked as controls (C).

According to agro-care Chemical Industry Group limited, the details of herbicide used in this paper can see as follows;

Chemical name: Metribuzin

Chemical name: 4-amino-6-tert-buytl-4,5-dihydro-3-methylthio-1,2,3-triazin-5-on

Structure:



| | |
|---|---|
| Physical Chemistry: | Metribuzin is a white, crystalline solid with a slightly sharp, sulfurous odor. Water solubility: 1050 mg/L. Melting Point: 125-126.5 C. |
| Toxicity: | Metribuzin has been shown not to irritate the skin or eyes of rats, rabbits, guinea pigs, or human volunteers. |
| Application: | Metribuzin is a selective triazine herbicide which inhibits photosynthesis of susceptible plant species. It is used for control of annual grasses and numerous broadleaf weeds in field and vegetables crops, in turf grass and on fallow lands. |

In the first year of research, the growth of all 60 teak trees was measured in terms of girth. And then, to classify the species of mistletoe, leaves, flowers and fruits of mistletoe's were collected and sent to the Herbarium, Forest Research Institute. Two times of pruning and spraying herbicide were carried out at the same time in each year. In spraying herbicide, two different concentration of Metribuzin were used; 2500 mg/l of Metribuzin mixed with 1 liter of water was used in first year and 5000 mg was used in last year respectively. After pruning, the pruned areas of teak trees were covered with thit-si (*Melanorrhoeausitata*), one of local gums, to prevent from the infestation of insect and other fungus attacks. In spraying herbicide, Sencor 70 WP (Metribuzin) 1,2,4-triazinone was appliedto all selected trees by using a hydraulic sprayer. Checking and counting the numbers of the mistletoe clumps on all selected teak trees were done one time per month, and recorded the decreasing and increasing numbers of it.

In the second year, measurement of teak growth, another two times of pruning and spraying metribuzin, monthly checking and counting the number of mistletoe clumps were conducted to complete the objectives of this research.

In concerning with data analysis, the collected data was sorted by Microsoft office Excel 2010, analyzed with Statistix8.0 (Analytical Software, Thallahassee, USA) and means were compared using the Tukey HSD (All-Pairwise Comparisons Test) to assess the performance of trees' growth affected by mistletoe. All significance tests were conducted at the P=0.05 level. For mistletoe control efficacy (MCE) percentage, it was calculated by the formula of % MCE = $M_c – M_t / M_c \times 100$ where $M_c$ = Mistletoe control and $M_t$ = Mistletoe treatment.

## 4. Results

The basic information of mistletoe species and distribution of teak mistletoe in tress size classes were assessed; then, the growth of teak affected by teak mistletoe wasanalyzed, and the effective control measure on this parasite wasrecommended.

### 4.1 Basic information of teak mistletoe in study site

According to the classification of this mistletoe species from Herbarium (FRI), the botanical name of teak mistletoe in the study area was:

Kingdom – Plantae
Order – Santalales
Family – Loranthaceae
Genus – *Loranthus*
Species – *pulverulentus*
Botanical name: *Loranthuspulverulentus* Wall.

The main flowering and fruiting season is from November to March and this period coincides with defoliation of teak. During this period, plenty and strong white, some orange colored ripe fruits can be clearly seen on trees and flower-peckerbirds feed on the fruits and disperse the seeds. When feeding the fruits, the sticky seeds stick to beaks of birds and then when these birds visit other branches of trees and the seeds get stuck to the branches of the host, germinate new mistletoe clumps. In March, re-sprouting of new regeneration of mistletoe clumps on teak trees was observed.

**4.2 Distribution of teak mistletoe in trees size classes**

In considering the rating system of teak mistletoe infection, different classes were divided by depending on the number of mistletoe clumps attached on teak branches; namely

| | |
|---|---|
| 0 | = no visible infection |
| Light (L) | = 1 to 2 branches infected |
| Moderate (M) | = 3 to 4 braches infected |
| High (H) | = 5 to 6 branches infected |
| Very High (VH) | = more than 6 branches infected and |
| D | = dead tree |

Table 1. Frequency distribution by girthat breast height (GBH) class of infected teak trees with different mistletoe rating L, M, H and VH within selected 3 blocks in Moeswe.

[

| GBH class | All infected stems | VH% | H% | M% | L% |
|---|---|---|---|---|---|
| 1′ 0″ - 1′ 6″ | 18 (10.0%) | 2 (10.0) | 1 (3.4) | 2 (7.4) | 13 (12.5) |
| 1′ 7″ - 2′ 0″ | 49 (27.2%) | 4 (20.0) | 6 (20.7) | 8 (29.6) | 31 (29.8) |
| 2′ 1″ - 2′ 6″ | 67 (37.2%) | 8 (40.0) | 9 (31.0) | 11 (40.7) | 39 (37.5) |
| 2′ 7″ - 3′ 0″ | 36 (20.0%) | 6 (30.0) | 9 (31.0) | 4 (14.8) | 17 (16.3) |
| > 3′ 1″ | 10 (5.5%) | - | 4 (13.8) | 2 (7.4) | 4 (3.8) |
| **Total** | 180 | 20 | 29 | 27 | 104 |

Note: Values are relative (%) to total (number at bottom of each column).

Of 180 infected teak trees, the infected stems were evenly split except in L rating system; 20 were very highly, 29 were highly, 27 were moderate and 104 were lightly infected which showed significantly large amount of proportion in Table 2. But, the severe increasing rate of mistletoe distribution was found in accordance with larger DBH classes of infected teak trees. It means that in smaller GBH classes of 1′ 0″ - 1′ 6″and 1′ 7″ - 2′ 0″, large amount of mistletoe clumps were found as 12.5% and 29.8% in L rating system. However, there was noticeably pointed out that 2′ 1″ - 2′ 6″GBH class was grown to a high of 40.7% mistletoe attachment in M rating system. In the remaining groups of GBH classes, the large amount of

mistletoe infection was significantly reached to a peak of 31% and 13.8% in H rating system. This indicates that the infected trees tend to be larger. The average DBH of VH, H, M and L infected trees were 26.85 inches (68.30cm), 29.34 inches (74.40cm), 26.57 inches (67.38cm) and 25.59 inches (64.94cm) respectively. There was no significant difference on average DBH of all rating systems.

**4.3 Growth (GBH)of teaktrees affected by teak mistletoe infection**

In assessing the growth of teak trees, only girth measurement was conducted and excluded measurement of height because some infected trees were done with topping, so it was difficult to compare other trees in height.

Table 2.Tukey HSD all – pairwise comparisons test of GBH for mistletoe infected trees

| Times | Treatment | Mean(inches) | Homogenous Groups |
|---|---|---|---|
| **3** | Control | 25.700 | A |
| **2** | Control | 25.667 | A |
| **1** | Control | 25.500 | A |
| **3** | Pruning | 29.000 | A |
| **2** | Pruning | 28.900 | A |
| **1** | Pruning | 28.767 | A |
| **3** | Herbicide | 26.367 | A |
| **2** | Herbicide | 26.167 | A |
| **1** | Herbicide | 25.500 | A |

Means followed by a common letter(A) are not significantly different at the 0.05% level.

As shown in Table 2, it is meant that changes of growth (GBH) of infected teak trees were found three times measurement (2013, 2014 and 2015) at 0.05 %. However, mean comparison by Tukey HSD shown no significant differences among treatments at every sampling time.

**4.4 Finding out the effective control measures on teak mistletoe**

The degree of mistletoe infection and mistletoe control efficacy can be found as follows;

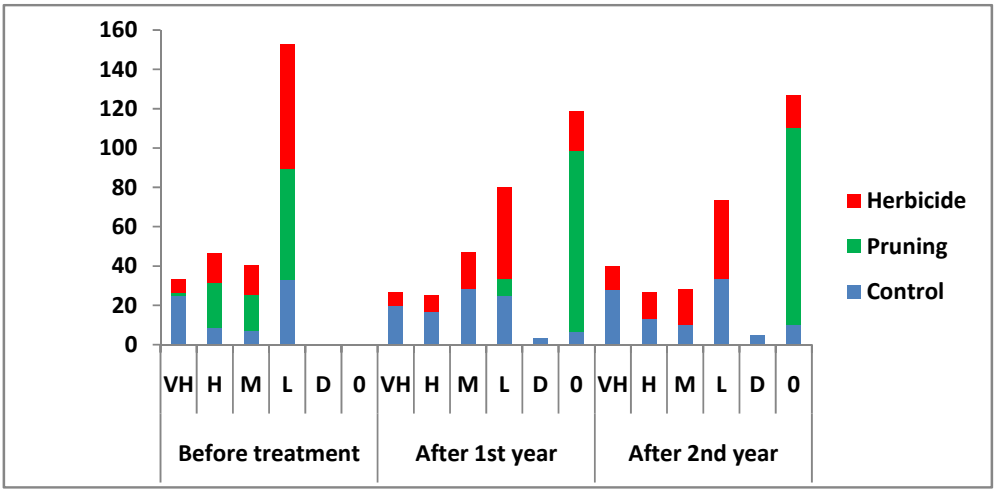


Figure1. Conditions of before and after treatments on teak mistletoe

Before carrying out treatments, all stands were covered with mistletoes but different degree as shown in Figure 1. Mostly, they were fallen in rating system of L. After treating control measures, mistletoe infection of pruned trees were significantly decreased to nearly 90% in 1st year and around 99% in 2nd year than before. While pruning treatment showed good progress, chemical sprayed trees indicated to some extent in succeed. That is to say chemical spraying was gradually decreased to nearly 20% in 1st year and nearly 10% in 2nd year respectively. But in control trees, natural dying and decreasing of mistletoe infection were found in Fig 1.

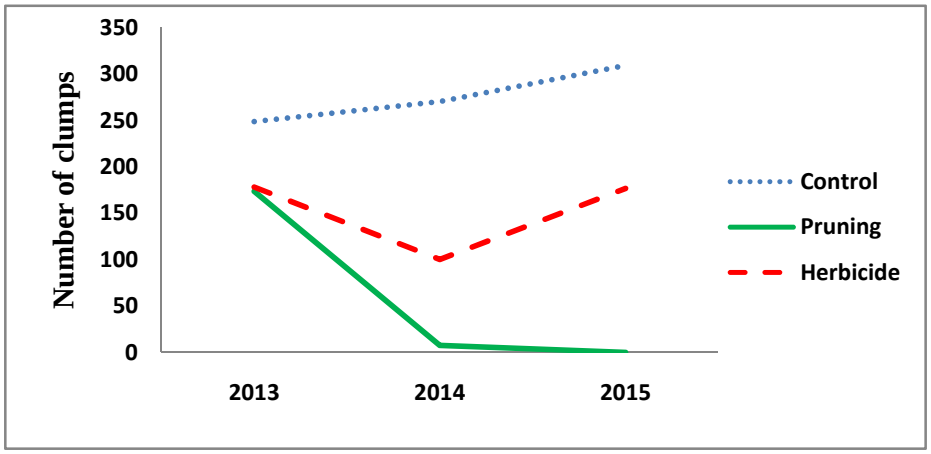
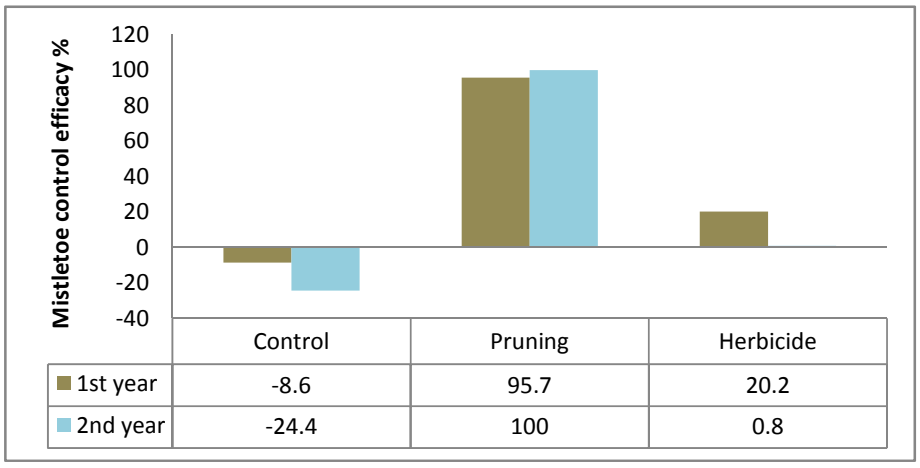



Figure 2.Annually degree of mistletoe clumps attachment in different treatments

The degree of decreasing and increasing mistletoe clumps during 2 years period is shown in Fig 2. At the beginning, number of mistletoe clumps in control trees was totally about 250 and continued to over 250 in 2014 and nearly 300 in 2015. But in spraying chemical, although mistletoe clumps were sharply decreased from around 200 to nearly 100 in 2014, it was increased again to nearly 200. Conversely, mistletoe clumps of around 200 were fallen down to nearly 0 in the following years of 2014 and 2015 in pruning.

In assessing mistletoe control efficacy, pruning showed that it can be more reduced mistletoe infection than chemical spraying in Fig 3. But the degree of infection in control stands was severe from (-8.6) to (-24.4) in last two years.




| | Control | Pruning | Herbicide |
|---|---|---|---|
| 1st year | -8.6 | 95.7 | 20.2 |
| 2nd year | -24.4 | 100 | 0.8 |

Figure 3. Comparison of effectiveness of treatments

## 5. Discussions

Among all studied trees, it can be found that the greater GBH class, the more mistletoe infection had been severed. Within the smaller GBH classes, mistletoe infection was mostly found in low rating systems (L and M) when heavily infected trees were found in H and VH rating systems respectively. According to investigation of David C. Shaw *et al*., 2005 on the distribution and severity of trees infected with western dwarf mistletoe in an old-growth Douglas fir, infected trees were smaller than uninfected trees, on average, and within the infected tree population, the severely infected trees averaged larger than lightly infected trees.

The environmental factors affecting the occurrence and intensity of mistletoe infestation are poorly understood. Usually the clumps of the parasite establish well in drier areas (comparatively) in open sunny places, on the trees tops in plantationsespecially at the edges of the dense forests (Troup 1921; Fischer 1926; Gill &Hawksworth 1961).In tropical regions, mistletoe plants are much more difficult to observe, particularly because birds, one of seed dispersal vectors, often perchat the tops of the larger trees, thus depositing mistletoes seed high in the canopy.A few mistletoes canmimic the leaves of their hosts, making them very difficult to observe by humans as well as potential herbivores that may prefer parasite leaves to host leaves. High occurrence of host mimicry by mistletoes in Australia has been suggested (Attsat, P. R. 1983).

When numbers of mistletoes are counted, need to look with careful observations especially in rainy season because they are covered with large green leaves. Severe infection by mistletoes is often associated with premature mortality of host trees. In addition, severely infected trees are often predisposed to infection by other pathogenic agents and attack by insects, which lead to the death of the infected plant (Kolb, T. E. 2002). During droughts, mistletoe plants distal to other plants often die as well.

Measures to combat mistletoes are under the broad outlines of silvicultural, biological and chemical control. Practically, pruning and spraying chemicals are too expensive in large scale plantation management. In addition, many problems such as need of skillful climber, difficult to spray and prune mistletoe clumps attached edge of branches were also found. It is impossible to control the pollinator birds for mistletoe management because of limitations of our present knowledge on the biology and ecology of these birds. Although Sencor (Metribuzin) affected the parasite, its clumps sprouted again after sometime. During hot season, Sencor produced some blotching symptoms in the young leaves and shoots of the host in higher concentration. No drastic harmful effects on the host tree were noted. (S.K. Gosh et.al., 1984)

According to research findings of Kerala Forest Research Institute during the period of 1880-83, there is about 41.64% increment loss in a 12 year plantation whereas in 34 year old plantation it is about 37.18 increment loss. It was shown that mortality was none in both plantations after lopping off the clumps from the plants. It was noted that clumps of the parasite reappear due to fresh infestation during flowering and fruiting period of the parasite. Therefore, eradication of the parasite was impossible. During studied period, there was no significant different on growth of trees (girth) affected by mistletoe after pruning and spraying chemicals. Any regularly and annuallycollected data on selected 20-year old teak

plantations were unavailable and thus, it was difficult to compare the original annual increment of those plantations and GBH measurements in this paper. But, with the passage of time, increment loss of those plantations could be more severe in terms of vigor, deformation, volume loss.

The International Union for the Conservation of Nature (IUCN) has listed four species of Loranthaceae and 15 species of Visaceae on the official IUCN Red List of Threatened Species. In New Zealand, several loranthus are considered endangered species and are managed for preservation (de Lange, P. J., and Norton, D. A., eds. 1997).*Viscum album* was used in the pharmaceutical industry and was cultivated commercially (Biisainf, A., ed. 2000) including cancer treatments. The mistletoes associated with Christmas folklore and decorations come to the forefront every December in many regions of the world.

## 6. Conclusion and Recommendations

Forest stand structure and species composition are the primary controls on the spread and intensification of mistletoes.In forestry of Myanmar, although silvicultural control methods include clear-cuts, elimination of residual trees, sanitation, thinning in young infected stands, the principle control of these mistletoes is pruning and it must be continually done to maintain low populations of mistletoes.To prevent the severe infestation of mistletoes, mix plantation (shade bearer species & light demander teak) should be more encouraged in establishing plantations. In addition, the use of shading to reduce the impacts of mistletoes on crop trees is possible because mistletoes do best in high light environment. Chemical control is time consuming and it does not kill the endophytic system and resprouting will occur. While using chemicals, environmental factors and potential harm to the host tree should consider carefully.

All aspects of integrated mistletoe management should be studied thoroughly by adopting tree injection, proper pruning, using effective weedicides and biological control on a large number of trees. In biological control with fungi, there are 29 known fungal parasites of dwarf mistletoe and 18 of these are already found in Canada. The effects or impact of treatments on environmental was not observable yet. Therefore, continue monitoring and observations are needed.

Nowadays, mistletoe problems are gradually increasing not only in teak plantations but also in natural forests on different ecological zones of Myanmar. To monitor the long-term conservation of mistletoe, we need to survey on host and mistletoe species, future research plan and public awareness program.

Mistletoes should not be only considered detrimental to the forest ecosystem, but also as their distribution for wildlife and biodiversity is very important. That means the groups of Viscaceae and Loranthaceae can provide nesting resources for a range of birds and mammals, and nutritional resources for a diverse assemblage of species.

Finally, more research is clearly necessary on several components of mistletoe- host interaction, host range, explorations of the role of birds or seed vectors- and also on interactions between mistletoe and wildlife with the support of advanced technology and tools.

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