

Ministry of Environmental
Conservation and Forestry
Forest Department
Forest Research Institute

**Comparison of the effectiveness of weeding methods to
control Forest Invasive Species, Pennisetum grass in Teak
plantation**

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**ကျွန်းစိုက်ခင်းများတွင် ပျံ့နှံ့နေသော Pennisetum ပေါင်းမြက် (Forest Invasive Species)
အား နှိမ်နင်းခြင်း နည်းလမ်းများကို နှိုင်းယှဉ်လေ့လာခြင်း**

ဝေဝေသန်း
သုတေသနအရာရှိ

သီတာဆွေ
သုတေသနလက်ထောက် - ၂
သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်း

မြန်မာနိုင်ငံတွင် ပုဂ္ဂလိက ကျွန်းစိုက်ခင်းများကို ၂၀၀၆-၂၀၀၇ ခုနှစ်များတွင် စတင် တည်ထောင်ခဲ့ပါသည်။ စိုက်ခင်းတည်ထောင်ခြင်းနှင့်အတူ ကျွဲနွားအစားအစာအတွက် ဩစတေးလျမှ တင်သွင်းခဲ့သော Pennisetum ပေါင်းမြက်သည်လည်း ပျံ့နှံ့ခဲ့ပါသည်။ ထိုပေါင်းမြက်များကို ဓါးဖြင့်ပေါင်းရှင်းရာ၌ ထိရောက်မှုမရှိသဖြင့် ပိုမိုထိရောက်သော ပေါင်းရှင်းခြင်းကို လေ့လာထား ပါသည်။ စမ်းသပ်မှုကို တိုက်ကြီးမြို့နယ် မြစ်ဝကျွန်းပေါ်မြို့နယ် ကျွန်းစိုက်ခင်းတွင် ၂၀၀၈ခုနှစ် စက်တင်ဘာလမှ ၂၀၀၉ခုနှစ် ဖေဖော်ဝါရီလအထိ ဆောင်ရွက်ရာ၌ ကျွန်းပင်အမြင့် များကို လစဉ်တိုင်းတာခြင်း၊ ဓါးဖြင့် ပေါင်းရှင်းခြင်း၊ မြက်ဖြတ်စက်ဖြင့်ပေါင်းရှင်းခြင်း၊ ပေါင်းသတ် ဆေး Glyphosate ၄၀% ဖြင့် ပေါင်းရှင်းခြင်းကို လစဉ်၊ နှစ်လခြား၊ သုံးလခြား၊ လေးလခြား ဆောင်ရွက်ခဲ့ပါသည်။ ပေါင်းမြက်လျော့ကျနှုန်းမှာ စမ်းသပ်မှုအားလုံး၌ ထူးခြားမှုရှိပါသည်။ လစဉ် ပေါင်းသတ်ဆေးဖြင့် ပေါင်းရှင်းခြင်းက အထိရောက်ဆုံးဖြစ်ပါသည်။ ပေါင်းသတ်ဆေးဖြင့် ပေါင်းရှင်း ခြင်းကြောင့် စိုက်ခင်းမြေထိခိုက်မှု ရှိ/မရှိ စမ်းသပ်ရာတွင် အော်ဂဲနစ်ပါဝင်မှု များလာသည်မှလွဲ၍ အခြားနိုက်ထရိုဂျင်၊ ဖေါ့စဖရပ်နှင့် မြေချဉ်ခါတ်များ ထူးခြားစွာ ပြောင်းလဲခြင်း မတွေ့ရပေ။ ကျွန်းပင်အမြင့်နှင့် ပေါင်းမြက်လျော့ကျမှု ဆက်စပ်မှုသည် လစဉ်ပေါင်းသတ်ဆေးဖြင့် ပေါင်းရှင်း ခြင်းတွင် တန်ဖိုး ၀.၆၇၄ ရှိ၍ လေးလခြားတွင် ၀.၅၅၈ ရှိကာ အခြား ပေါင်းသတ်ခြင်း နည်းလမ်း တို့ထက် ဆက်စပ်မှုအား ပိုမိုကြောင်း တွေ့ရှိရပါသည်။ ပေါင်းရှင်းခြင်း ထိရောက်မှု ရာခိုင်နှုန်းများမှာ လစဉ်ဆေးဖြန်းခြင်းတွင် ၈၂.၂၊ မြက်ဖြတ်စက်ဖြင့် ပေါင်းရှင်းခြင်းတွင် ၆၈.၈၊ ဓါးဖြင့် ပေါင်းရှင်း ခြင်းတွင် ၆၈.၁၊ နှစ်လခြား ဆေးဖြန်းခြင်းတွင် ၅၈၊ လေးလခြား ဆေးဖြန်းခြင်းတွင် ၅၈နှင့် သုံးလခြားဆေးဖြန်းခြင်းတွင် ၄၉ တို့ ဖြစ်ပါသည်။ ဓါးဖြင့် ပေါင်းရှင်းခြင်း ကုန်ကျစရိတ်မှာ အနည်းဆုံးဖြစ်သော်လည်း လက်တွေ့ ဆောင်ရွက်ရာ၌ အချိန်ကုန် ထိရောက်မှုမရှိသဖြင့် ပေါင်းသတ်ဆေးဖြင့် တွဲဖက်အသုံးပြုနိုင်လျှင် ပိုမိုထိရောက်နိုင်ပါသည်။ အကောင်းဆုံးနည်းလမ်းမှာ ရောနှော သစ်တောစိုက်ခင်း တည်ထောင်ခြင်း (အရိပ်ကြိုက်အပင် မျိုးစိတ်နှင့် အလင်းကြိုက် ကျွန်း ရောနှော စိုက်ပျိုးခြင်းဖြင့် အလင်းကြိုက်မြက်မျိုး ဝင်ရောက်ပေါက်ပွားခြင်းကို အထိုက်အလျောက် ဟန့်တားနိုင်ပါမည်)၊ နှင့် သဘာဝတောနှင့် စိုက်ခင်းအကွက်ခြား တည်ထောင်ခြင်းတို့ကို အားပေး၍ သဘာဝတောကို အပြောင်ရှင်းပြီး စိုက်ခင်းအမြောက်အများ တည်ထောင်ခြင်းကို ရှောင်ရှားသင့် ပါသည်။

Comparison of the effectiveness of weeding methods to control Forest Invasive Species, Pennisetum grass in Teak plantation

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Abstract

Large scale private teak plantations were initiated in 2006-2007. Consequently, introduced species *Pennisetum* grass for pasture followed and manual weeding was carried out four times per year during the juvenile stage. The practice was not effective and therefore, the study aimed to support better management among the weeding methods. Four blocks were selected randomly to compare the effectiveness of manual, mechanical, and chemical weeding. A plot size 6 m x 6 m with a total seven plots were staked in each block and containing two years old, four teak trees in a plot of height were measured monthly. Manual and mechanical practices were carried out every month. Herbicide, Glyphosate 48% was applied monthly (H₁), two month interval (H₂), three month interval (H₃) and four month interval (H₄). Un-weeded plots were included in every block. Grass samples were harvested from randomly selected (0.6 m x 0.6 m) two sub plots in each plot and weighted after oven dry at 70 °C for three days.. All experiments were conducted from September, 2008 to February, 2009 in the Mya Seinn Taung Nyo teak plantation. Weed Control Efficacy percentage assessed in H₁, mechanical, manual, H₂, H₄, and H₃ were 82.2, 68.8, 68.1, 58, 58 and 49 respectively. Over all weed weight reducing was observed highly significant in all treatments. The linear relationship between teak height and oven dry weight of weed in H₁ was higher correlated than other with r² value 0.674. There were no statistically differences among treatments and between the sampling times for all tested soil nutrients levels except organic matter content. Impact of herbicide application on soil nutrient levels was not found out in this study. The effect of herbicide on the applied area might depend on several factors like physical and chemical properties of the soil. Lower cost of manual weeding alone is not enough for timely and effect, therefore, sequential combination methods may be more effective in controlling *Pennisetum* grass if the plantation is a small area. Teak plantation should be established with limitation or mix plantation (shade bearer and light demander teak) or inter-blocking system with natural forest and plantation, and to avoid preparation of land widely for establishment of plantation from clear cut of natural forest.

Key Words: Blocking, Control, Herbicide, Manual, Mechanical, Mix Plantation, Organic matter, Pathogen, Pest, Weed.

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Introduction

Myanmar has diverse types of forest due to varied soil, rainfall and topography. Forests play an important role not only in the socio-economic sector, but also in the environment. About 50 percent of the total land area is still covered with forests. Thirty nine percent are Mixed Deciduous Forests, in which teak is considered to be the best species. Large scale plantation programs were started in 1977. Up to 2007, establishment of teak plantations was 383,967.62 hectares by Forest Department (Ko Ko Gyi & Zaw Win Myint, 2008). Private plantation programs for teak were initiated in 2006 - 2007 in East and West Bago Yoma and Upper Myanmar. Consequently, weeds problems followed and many other factors which affect the success of teak planting program include management.

Awareness, information, surveillance and research are necessary and also foresters and plantation managers need to practice in the biological, ecological and technologies to integrate into management of a targeted FIS (Forest Invasive Species) pennisetum grass in the study area.

Terminology Committee of the Weed Society of America defined weed as “A plant growing where it is not desired”, as their definition, undesirable pennisetum grass is existing in the teak plantation widely and aggressively in Myanmar. Pennisetum grass is noticed as invasive undergrowth, one of the main disturbances in weeding practice of teak plantation. However, it is not started yet to initiate research to control its distribution.

The most widely used herbicide in the world, glyphosate, has long been considered an ideal herbicide because of its rapid breakdown in the environment, low toxicity to animal species, and lack of carcinogenic or teratogenic effects (Baylis 2000; Borrgaard and Gimsing 2008; Duke and Powles 2008). A better understanding of the interactions between native plants, invasive species and the native soil community will help in developing more effective strategies in managing invasive species (Jeffrey, 2010). Therefore, the investigation on the effect of commonly used herbicides on soil conditions (changes of soil nutrient levels) will help in developing a better management system for successful plantation establishment.

General objective

To control extensive distribution of pennisetum grass

Specific objectives

1. To assess the application of herbicide in reduction of distribution of pennisetum grass
2. To evaluate the effective and cost among the weeding methods
3. To investigate the effects of the herbicide application on soil nutrient levels e.g. pH, organic matter, Nitrogen and Phosphorous during the period of 3 and 6 month after herbicide application.

Grass (weed) invasion

Seeds of *Pennisetum* grass were introduced into Myanmar in 1976 from Australia by Livestock Department for pasture with good intention. The aim to help supply more animal feed for Animal Health Development and Artificial Insemination Project by World Bank. But, it happened unfortunately that the species was inversed as weed in forest plantations as well as in road-side and dry lands especially in Yangon and Bago divisions.

Problem Statement

Seeds dispersal from pennisetum grass were high and its threat level may be greater in the plantation. The grasses were not consequently before site preparation of the natural land to establish the plantations. Young teak plantation has no shade; therefore, grass is favored to grow widely. Manual weeding was carried out four times during the first year and second year, three times in third year of the plantation periods. The practice was not too much costly but it was not effective because carefully working could not be carried out where grass thickly distribution in the wide areas. The threats occurring now and will be for the future in the teak plantations.

- Pennisetum weed may become as a host for pathogen and insects
- Pennisetum weed influences other species. It may drive out native populations.
- It may cause heavy annual labor charges, waste of time and effort.
- Become fire hazard due to dried up in the dry season.

Literature Reviews

Climatic influences

Weather conditions e.g drought, excessive rains and temperature will favor growth and proliferation of weeds (Gupta, 1998).

Method and time of planting crops

Method and time of planting crop may affect the seed dispersion and distribution of weed. Close spacing is essential to minimize weed infestation and to obtain high yield in the concept of agricultural crops (Gupta, 1997).

Effect of Invasive Plants on Soils

Plants can affect soil structure by creating pores in soil, and plant growth promotes rapid wetting and drying cycles and cause shrinkage and strengthening of the soil (Angers and Caron 1998). Exotic invasive plant species also may alter nutrients cycles in ways that differ from native plants. Many invasive plant species have high specific leaf areas, growth rates, and leaf nutrient concentrations, relative to the natives at the same sites, and these traits have the potential to increase rates of decomposition and nutrient cycling (Allison and Vitousek 2004).

Rodgers *et al.* (2008) found that soils in North American temperate deciduous forest invaded by the European forb *Alliaria petiolata* were consistently and significantly higher in nitrogen, phosphorus, calcium, and magnesium availability, and soil pH. Sanon *et al.* (2009) also found that invasion by *Amaranthus viridis* increased concentrations of nitrogen, carbon, total phosphorus, and soluble phosphorus in the top 15 cm of soil. Total phosphorus was almost three times higher whereas soluble phosphorus was approximately twice as high in invaded soils. These increases were correlated with increases in bacterial abundance and soil microbial activity.

Lantana camara invasion in India is correlated with increases in soil available nitrogen, ammonification, nitrification rate, and nitrogen mineralization, which in turn is correlated with high nitrogen, low lignin, low lignin : nitrogen ratios, and low carbon : nitrogen ratios in *L. camara* litter (Sharma and Raghubanshi 2009). Blank (2008) found that invasion by *Bromus tectorum*, a Eurasian annual grass that has spread throughout western North America, increased the availability of manganese, nitrogen, phosphorus, copper, iron, calcium, and potassium.

Dassonville *et al.* (2008) examined the effects of seven invasive plant species in Europe on nutrient pools in the topsoil and found that the intensity of the impact and whether or not pools increased or decreased depended on the site. Strong increases in nutrient concentrations with invasion occurred primarily in sites that were initially nutrient poor, but decreases typically occurred in soils that initially were nutrient rich. However, in the nutrient-poor tropical forest of the Seychelles, Kueffer *et al.* (2008) did not find strong differences among ecosystem effects of native and invasive trees.

Impact of Glyphosate on Soil

Invasive plants also may indirectly alter soil chemistry through the synthetic herbicides used to control them. For example, the most widely used herbicide in the world, glyphosate, has long been considered an ideal herbicide because of its rapid breakdown in the environment, low toxicity to animal species, and lack of carcinogenic or teratogenic effects (Baylis 2000).

Araujo *et al.* (2003) found that in vitro application of glyphosate to two Brazilian soils resulted in increases of fungal and actinomycete populations, but very small decreases in the abundance of soil bacteria. Santos and Flores (1995) also evaluated the effect of glyphosate on nitrogen fixation by free-living *Azotobacter chroococum* and *A. vinelandii* and observed no effect at recommended applications rates of glyphosate. Busse *et al.* (2001) and Weaver *et al.* (2007) also found the same result. Long-term application (19 years) of glyphosate reduces C biomass in soil, but ammonification and nitrification are increased compared with untreated soil (Hart and Brookes, 1996).

However, Feng and Thompson (1990) measured rapid initial degradation of glyphosate in soils, but detected residues of the herbicide and aminomethyl phosphoric acid (AMPA), the primary metabolite of glyphosate, for up to 360 days after application. Carbon dioxide

release from soil was increased and AMPA (aminomethyl phosphonic acid) was found in soils by glyphosate application, indicating that the herbicide was broken down by soil microorganisms.

Herbicides become incorporated in soil directly, during plant treatment, and indirectly, via water or residues of plant and animal origin. Rate of herbicide decomposition in soil depends on the properties of the preparation applied, herbicide dose (Schuster and Schröder, 1990;), physical and chemical soil properties, humidity, temperature, plant cover, soil cultivation technique and the types of the soil microorganisms present (Willems *et al.*, 1996).

Pesticide adsorption or desorption depends on the physical and chemical soil properties. The process of adsorption depends on the concentration and solubility of herbicides in soil solution, ion exchange capacity, organic matter content, pH, moisture and temperature of soil, etc. Therefore, understanding whether exotic invasive alter ecosystems differently from native species will help solve important questions in ecology, evolution, and conservation.

Phytotoxic effect

Phytotoxic effect of herbicide Diuron on cotton plants and adverse effect on fiber qualities were not found (Hla Hla Myint, 2000).

Cost of weeding

Leh Wah (1992) observed that rice field treated with Satunil 60 BC was more profitable than hand weeding because the cost of labor for hand weeding was higher than other practices. Application of Diuron (herbicide) alone was costly, but obtained higher yield in 1998 at the cotton field (Hla Hla Myint, 2000).

Materials and Methods

Study area

Study area is located in the Taik-kyi Township of the West Bago Yoma. Yangon Division.

Plantation:	Mya-sein-taung-nyo teak plantation
Location:	Oak-kan Reserved Forest,
Soil type:	Sandy loam, p ^H 4.9-5.7
Elevation:	180 ft (60 m)
Rainfall:	40- 100 inches (1016-2540 mm)
Temperature:	12-45°C
Establishment:	July, 2007
Planted area:	700 acres (283.4 ha)
Spacing:	9 ft (2.74 m)

Manual weeding tool

Long knife 2 ft (0.6 m).

Grass cutter machine

Honda UMK 4357 Thailand

Herbicide Glyphosate

- Common name: Glyphosate 480
- Organic herbicide compound
- Trade name: Maclinup
- Group: N-(phosphonomethyl) glycine
- Level of injury: Low
- Effective grade: 4
- Molecular structure: $C_3H_8NO_5P$
- Importer: Armo , Diamondstar Co.ltd , Yangon
- Producer: Map Pacific Pte.ltd, Singapore

Glyphosate is inactivated in soil and does not provide residual control of weeds. Glyphosate-based herbicides are among the most widely used broad-spectrum herbicides in the world because they are highly efficacious, cost effective, practically non-toxic, and degrade readily in the environment. Since glyphosate's development in the 1970's, there have been no documented cases of adverse effects on fish or aquatic invertebrates associated its use for the control of aquatic weeds (Giesy et al. 2000). Therefore, glyphosate was selected to apply in the research for treatments the grass.

Comparison of weeds reduction

Weed samples were harvested from randomly selected sub plots size 0.6 m x 0.6 m from September, 2008 to February 2009. The Pennisetum grass weed samples were dried in oven at 70° C for three days and weighed them.

Comparison of teak growth

In selected plots, 4 teak trees (3 m spacing) contain in each plot were measured monthly for their heights.

Comparison of effectiveness of weeding practices

RCBD (Randomize Complete Block Design) was laid out with 4 replications to compare the effectiveness among the manual, mechanical, and chemical weeding. Four blocks were selected with determination of the least differences in topography.

A plot size was 6 m x 6 m with a total number of 7 plots were staked randomly in each block.

Manual and mechanical weedings were carried out monthly in the study period. Herbicides were applied monthly (H₁), two month interval (H₂), three month interval (H₃) and four month interval (H₄). Un-weeded plots were existed in every experiment. Costs of every practice were recorded to compare in the study.

Investigation of soil value

Soil sampling

Four sampling points as shown in the following figure were selected in each plot where herbicide applications are carried out for two times (i.e., three month and six month after herbicide applications). Top soil samples (0-30 cm) from each point were collected and samples were reduced to one in each plot by mixing in equal amounts for analysis. The soil samples were sieved through a 2.0 mm width mesh to remove stones and plant debris. Soil texture, Organic Matter (OM), pH (soil reaction), Nitrogen (N) and Phosphorous (P) were analyzed to determine the changes of soil nutrient levels.

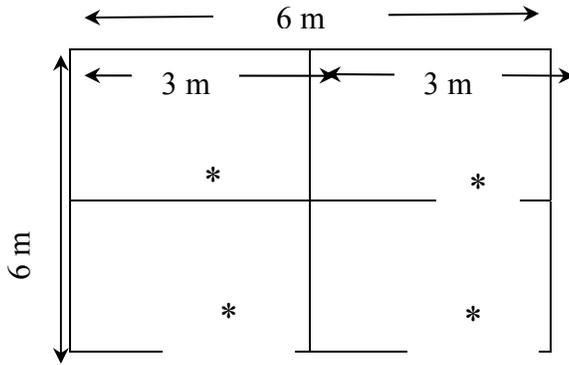


Figure (1) Soil san * = soil sampling point

Data Analysis

Data were analyzed by Genstat computer software program. Weed Control Efficacy (WCE) percentage was calculated by the formula $\% WCE = \frac{Wc - Wt}{Wc} \times 100$

Wc= Weed control

W t= Weed treatment

For the determination of soil value, data were analyzed by using STATISTIX released 8.0 (Analytical Software, Thallahassee, USA) and means were compared using the Tukey HSD (All-Pairwise Comparisns Test) among the treatments (H1, H2, H3, H4, Ma, Me and C) and sampling times (first and second times). All significance tests were conducted at the P=0.05 level.

Results

Three species of pennisetum were recorded in the teak plantation; *Pennisetum pedicellatum* Trin. (Tan); *Pennisetum polystachyon* (L.) Schult and *Pennisetum purpureum* (Schumach.).

Associated weed specie

Pennisetum grass were growing together with a few number of following species in some block. Thatch (*Imperata cylindrical*); Bizat (*Chromolaena odorata*); Kaing (*Sacharum sp.*) and Tamyetsipin (*Thysanolaena maxima*). However, pennisetum grass was more dominantly found in the whole study area.

Native plant feature

Teak has not a very large crown especially when grow in plantation except in some orchards and the species is deciduous which shed leaves in the dry season from December and February. That factors favor to grow pennisetum grass very well due to open land.

Phytotoxic effect In the all treatments, herbicide injury on teak was not observed.

Comparison of weeds reduction

Over all weed weight reduction was observed and found to be highly significant in all treatments.

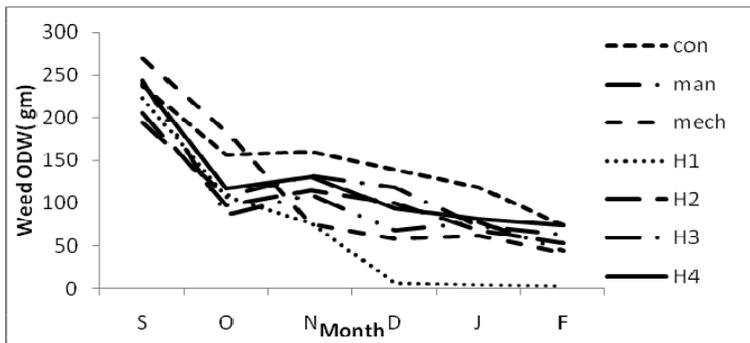


Figure 2. Monthly oven dry weight of grass in different control methods

Comparison of effectiveness of weeding practices

Weed Control Efficacy percentage assessed in H₁, mechanical, manual, H₄, H₂, and H₃ were 82.2, 68.8, 68.1, 58, 58 and 49 respectively.

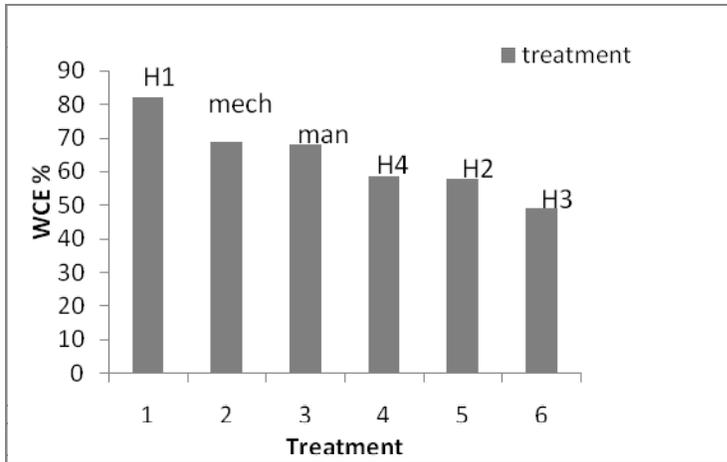


Figure 3. Comparison of grass (weed) control efficiency

Comparison of Teak growth

The linear relationship between teak height and weed oven dry weight in H₁ was higher correlated than other with r^2 value 0.674. The remaining r^2 values were 0.558 (H₄), 0.492 (manual), 0.451 (H₂), 0.33 (mechanical) and 0.263 (H₃) respectively.

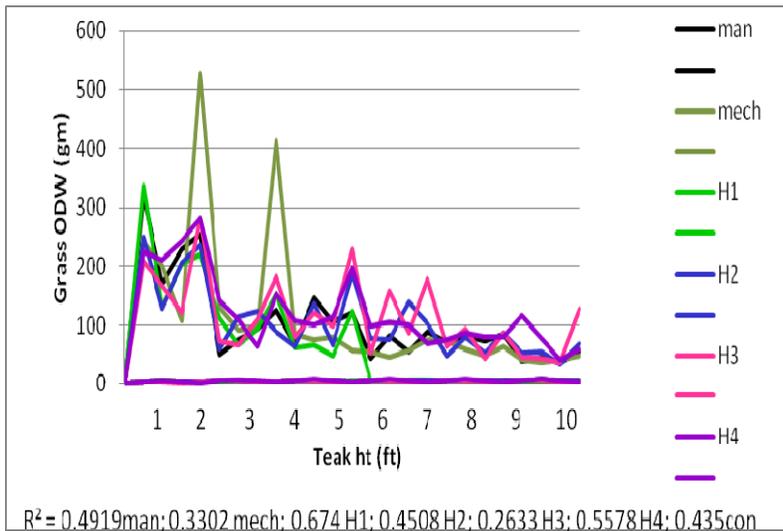


Figure 4. Linear relationship between teak height and grass oven dry weight

Table (1) Actual weeding cost of different control for one hectare/labor/ ½ year, from September to February, 2008-09 (Kyats)

Item	Control	Manual	Mechanical	H ₁	H ₂	H ₃	H ₄
Labor	-	11250 ks	11250 ks	7000 ks	7000 ks	7000 ks	7000 ks
Tools:							
-Long knife	-	5000	-	-	-	-	-
-grass cutter machine	-	-	-	-	-	-	-
-sprayer	-	-	350000	-	-	-	-
			-	15000	15000	15000	15000
Petrol	-	-	3000 ks x 10 gal	-	-	-	-
Herbicide				10000	10000	10000	10000
Sequence	-	2 / 6	2/ 6	6	3	2	2
Total	-	22500/67500	82500/247500	102000	51000	34000	34000

Manual wage rate = 11250 kyats/ha; herbicide wage rate = 7000 ks
 Cost of glyphosate = 10000 ks/liter (2008-09). 5000 ks/liter (2010)
 Petrol = 3000 kyats/gallon (2008-2009)

Investments of tools were omitted in the comparison of cost because the instruments will be used as permanent in the plantation.

Investigation of soil value

The soil in Mya-sein-taung-nyo plantation is generally sandy loam with slightly acidic condition. Low nutrient contents in Nitrogen and Phosphorous are found. Fairly amount of organic matter is contained in the soil.

Organic Matter (OM%)

The following figure shows the changes of organic matter (OM%) contents in every plot treated with herbicides at every month, two, three and four month intervals, and monthly manual and mechanical weeding techniques.

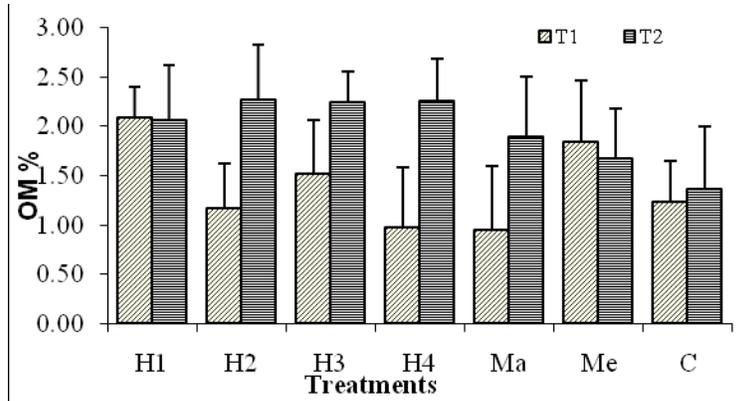


Figure (5) Changes of Organic Matter (OM) contents after the application of herbicide, manual and mechanical weedings at time 1 and 2

Table (2) Tukey HSD All-Pairwise Comparisons Test of OM for Times*Treatments

Times	Treat	Mean	Homogeneous Groups
2	2	2.2750	A
2	4	2.2675	A
2	3	2.2425	A
1	1	2.0875	A
2	1	2.0650	A
1	6	1.8991	A
2	5	1.8950	A
2	6	1.6750	A
2	7	1.5725	A
1	3	1.5200	A
1	7	1.2425	A
1	2	1.1675	A
1	5	1.0139	A
1	4	0.9800	A

Means followed by a common letter are not significantly different at the 5% level

As shown in the figure, increased organic matter contents were found in every plot at time 6 month after herbicide application. Increased organic matter contents may be accompanied with increased dried invasive grasses incorporated with soil when these grasses die. According to the statistical analysis, it is found that significant changes of organic matter contents were found between two sampling times (3 month and 6 month after herbicide

application) at 0.05 % level. However, mean comparison by Turkey HSD shown no significant differences among treatments at every sampling time (Table 2).

Nitrogen (N %)

As shown in the figure, slightly increased nitrogen contents at second sampling time in two and tree interval herbicide application plots were found. However, no significant changes were observed among treatments according to the statistical analysis and mean comparisons.

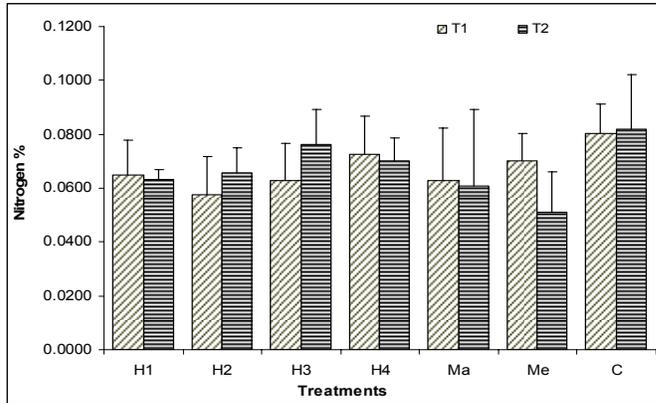


Figure (6) Changes of Nitrogen (N) contents after the application of herbicide, manual and mechanical weedings at time 1 and 2

Table (3) Tukey HSD All-Pairwise Comparisons Test of N for Times*Treatments

Times	Treat	Mean	Homogeneous Groups
2	7	0.2113	A
1	7	0.0801	A
2	3	0.0761	A
2	1	0.0731	A
1	4	0.0726	A
1	5	0.0717	A
2	4	0.0703	A
1	6	0.0686	A
2	2	0.0656	A
1	1	0.0648	A
1	3	0.0629	A
2	5	0.0608	A
1	2	0.0575	A
2	6	0.0510	A

(Means followed by a common letter are not significantly different at the 5% level)

Phosphorous (Ava. P %)

Unlike the nitrogen content, decreasing phosphorous contents from first sampling time to second sampling time were found as shown in the figure (7) but not statistically significant difference.

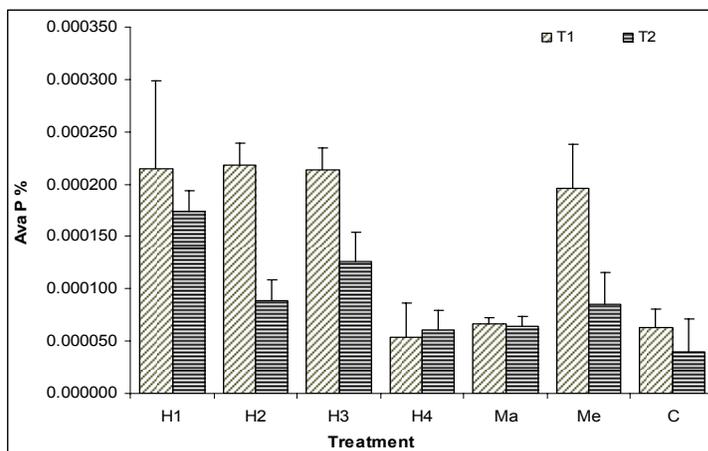


Figure (7) Changes of Phosphorous (Ava. P%) contents after the application of herbicide, manual and mechanical weedings at time 1 and 2

Table (4) Tukey HSD All-Pairwise Comparisons Test of P for Times*Treatments

Times	Treat	Mean	Homogeneous Groups
1	3	5.12E-04	A
1	2	3.07E-04	A
2	1	2.15E-04	A
2	6	1.77E-04	A
1	1	1.72E-04	A
1	5	7.37E-05	A
2	2	7.06E-05	A
1	7	6.25E-05	A
1	4	5.50E-05	A
1	6	4.16E-05	A
2	4	7.98E-06	A
2	7	-1.72E-06	A
2	3	-1.50E-05	A
2	5	-1.02E-04	A

(Means followed by a common letter are not significantly different at the 5% level)

Soil Reaction (pH)

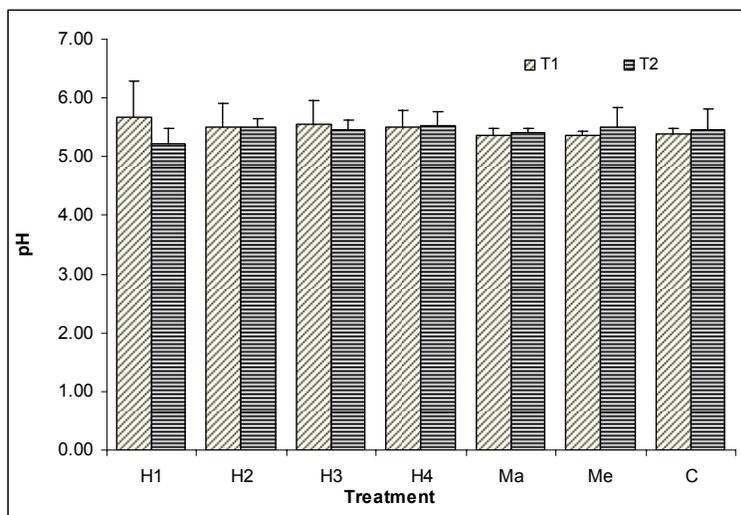


Figure (8) Changes of soil pH contents after the application of herbicide, manual and mechanical weedings at time 1 and 2

The effect of herbicide treatments on soil pH is presented with the statistical test of significance in figure (8) and table (8). As a result, Glyphosate treatment resulted in any significant changes in soil pH ($p < 0.05$).

Table (5) Tukey HSD All-Pairwise Comparisons Test of pH for Times*Treatments

Times	Treat	Mean	Homogeneous Groups
1	1	5.6750	A
2	7	5.6000	A
1	3	5.5500	A
2	4	5.5250	A
1	2	5.5000	A
1	4	5.5000	A
2	2	5.5000	A
2	6	5.5000	A
2	3	5.4500	A
1	5	5.4248	A
2	5	5.4000	A
1	7	5.3750	A
1	6	5.3327	A
2	1	5.2250	A

Means followed by a common letter are not significantly different at the 5% level

Rankings are shown above with mean values following common letter are not significant different. Therefore, it can be said that there is no statistically difference among the treatments or sampling times.

Discussion

Associated weeds were very few in the teak plantation. It refers to pennisetum grass as aggressive, competitor and it has high natural reproduction.

Time of site preparation for teak plantation establishment is in winter, that time is coincided with mature flowering and seed dispersing of pennisetum grass. Therefore, the prepared site is ready for receiving and growing for the grass. In general, annually weeds reproduce abundant seed production (Gupta, 1998). Such weeds must be destroyed just after started growing and before flowering, it can reduce gradually grass population.

In the teak plantations of study area, fertilizer was applied in the rainy season. Their fertilizer application was spot feeding around the base of teak, nevertheless the affect may be encourage to develop the grass according to Moody's (1978) description that growth is usually stimulated by fertilizer applications to favor weed rather than crop growth.

Hla Hla Myint (2000) mentioned that phytotoxic effect of herbicide Diuron on cotton was not found. In the treatments, herbicide Glyphosate injury was not also observed on teak. However, authors have described their different observations that would be confused for users there are recommendations and objections to apply the herbicide.

Leh Wah (1992) observed that herbicide weeding in rice field was more profitable than hand weeding because the cost of labor for hand weeding was higher than other practices. In this experiment, manual was cheaper than other practices. However, herbicides are specific regarding their toxic level, the application of several chemicals may lead to synergy and development of toxic effects hazardous for humans and the ecosystem (Michaelidou [et.al](#), 2000). Therefore, should be considered the level of injury and effective grade (WHO) of the herbicides to apply systematically.

Sequential combination methods (manual plus herbicide) may be more effective in controlling the grass, two times of manual and herbicide weeding per year after grass start growing and before seeding in a hectare would cost 56500 kyats in the first year period that will be decreased next year and the weed gradually disappeared in the future. Research activities were implemented carefully in small areas, thereby, practical and research differences in the output of effectiveness made clear.

Growth of teak was measured by its height only, diameter of stem was too small to measure therefore yield could not be made in the study. But linear relationship between growth (teak height) and grass reduction of all treatments was shown no more correlation except H₁ had R² value 0.67.

The impact of glyphosate on soil microbial communities has also been widely studied in both agricultural and non-agricultural communities, and most studies have shown little to no lasting effects (Wardle and Parkinson 1991; Haney et al. 2000; Busse et al., 2001; Ratcliff et al. 2006; Weaver et al. 2007). Weaver et al. (2007) concluded that the effects of glyphosate on soil microbes were “small” and “transient”. This study shows that there were no statistically differences among treatments and between the sampling times for all tested soil nutrients levels except organic matter (OM). According to the statistical analysis, only the difference organic matter contents were found between the sampling times at 0.05 % level. It can be said that no impact of herbicide application on soil nutrient levels. The effect of herbicide on the intended application area might be influenced by its particular chemical properties: binding to soil, its vapor pressure, its water solubility, and its resistance to being broken down over time. Moreover, it may depend on the soils of the area, such as texture, its ability to retain water, and the amount of organic matter. Therefore, additional experimental analyses on soil microbial activities are certainly needed.

Conclusion

In forestry of Myanmar, manual weeding is a common practice using long knife and that is effective since long ago and still herbicides in plantations to reduce the noxious weed are not. Increasing teak plantations is generally considered to be minimized invasion of the pennisetum grass weed that would be solved to establish teak plantation with limitation and also to avoid preparation of land widely by clear fell of natural forest.

Many indicators remain in estimating the environmental quality but except only investigation on soil value. However, the herbicide application in this study, the effect or impact on environmental are not observable immediately. Therefore, continue monitoring and observations are needed.

But no data can be cited for the research due to lack of previous studies in this field. However it can be said surely that the threats will be greater than before because pennisetum grass is aggressive, tough, widely distribution by wind, rapid regeneration, costs of control and fire hazard would be problems in the future. Lower cost of manual weeding alone is not enough for timely and effect, therefore, sequential combination methods may be more effective in controlling Pennisetum grass if the plantation is a small area. Advantages and disadvantages must be considered with balancing based on the situations of weed distribution and their environment.

Recommendation

Before introducing a new species, should not be considered only its advantages but also susceptibility in health and environmental impacts also should be determined with precaution prior to introducing. Surveillance activities for early detection must be practiced to minimize the widely spread. Mix plantation (shade bearer species & light demander teak) should be encouraged in the future program. Another solution method is to establish inter blocking system with natural forest and plantation (buffer zone).

Better techniques and experts are beneficial to separate out the effects (e.g. air, water pollution, soil microorganisms, insect population, small animals, birds, etc.) of environmental consequences from the experiments.

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