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Study on Effect of Overstorey Mixed Species Stands on Soil Enrichment, Tree Growth and Natural Regeneration

Dr. Chaw Chaw Sein, Staff Officer
Daw Ni Zin Phoo, Range Officer
Daw Khin Me MeAung, Research Assistant-3

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အပေါ်ယံလွှာတွင်သစ်မျိုးများ ရောနှောစိုက်ပျိုးခြင်းဖြင့် မြေဆီလွှာ၊ အပင်များကြီးထွားမှုနှင့် သဘာဝပေါက်ပင်များအပေါ်အကျိုးသက်ရောက်မှုအားလေ့လာဆန်းစစ်ခြင်း

ဒေါက်တာချောချောစိန်၊ ဦးစီးအရာရှိ
ဒေါ်နီဇင်ဖူး၊တောအုပ်ကြီး
ဒေါ်ခင်မီမီအောင်၊ သုတေသနလက်ထောက်-၃

စာတမ်းအကျဉ်း

အပူပိုင်းသစ်တော ဂေဟဗေဒစနစ်ကို ပြန်လည်ထူထောင်ရာတွင် သင့်တော်သော သစ်မျိုးများဖြင့် ရောနှောစိုက်ပျိုးခြင်းသည် အရေးပါသော အခန်းကဏ္ဍမှ ပါဝင်လျှက်ရှိပါသည်။ သစ်တောသစ်ပင်များ ရောနှောစိုက်ပျိုးခြင်းဖြင့် မြေဆီဩဇာပိုမိုကောင်းမွန်စေခြင်း၊ မူလရှိပြီး သဘာဝပေါက်ပင်များ ပြန်လည် ဖြစ်ထွန်းလာမှုကို နှိုးဆွပေးခြင်း၊ ရောနှောစိုက်ပျိုးသည့် သစ်ပင်များ၏ ကြီးထွားနှုန်းကို ပိုမိုကောင်းမွန် စေခြင်းတို့ ဖြစ်ပေါ်စေပါသည်။ ယခုစာတမ်းတွင် သစ်မကျီး၊ သင်းဝင်နှင့်ယမနေစသည့် သစ်မျိုးများ ရောနှောစိုက်ပျိုးခြင်း၊ ယင်းတိုက်၊ ပိတောက်နှင့်ပျဉ်းကတိုး စသည့် သစ်မျိုးများ ရောနှောစိုက်ပျိုးခြင်း နှင့် ကျွန်း၊ စစ်နှင့် ပျဉ်းကတိုးစသည့် သစ်မျိုးများ ရောနှောစိုက်ပျိုးထားသည့် (၃၆) နှစ်ရှိ စမ်းသပ်ကွက် (၃) ခု၏ ရောနှောစိုက်ပျိုးသည့် သစ်မျိုးများ ကွဲပြားမှုကြောင့် မြေဆီလွှာ၊ အပင်ကြီးထွားမှုနှင့် သဘာဝမျိုးဆက်ပင်များအပေါ် အကျိုးသက်ရောက်မှုများကို လေ့လာထားရာ ကျွန်း၊ စစ်နှင့် ပျဉ်းကတိုး ရောနှောစိုက်ခင်းသည် မြေဆီလွှာနှင့် အပင်ကြီးထွားမှု အကောင်းဆုံးဖြစ်ကြောင်း တွေ့ရှိရပါသည်။ အောက်လွှာအဖြစ် တွေ့ရှိရသည့် သဘာဝမျိုးဆက်ပင်များသည်လည်း ယခုလေ့လာသည့် ဒေသအတွင်း နောင်ဆက်လက်တည်ထောင်မည့် စိုက်ခင်းများအတွက် ရောနှောစိုက်ပျိုးသင့်သော သစ်မျိုးများအဖြစ် ဖော်ညွှန်းလျှက် ရှိသည်ကို လေ့လာတွေ့ရှိ ရပါ သည်။

Study on Effect of Overstorey Mixed Species Stands on Soil Enrichment, Tree Growth and Natural Regeneration

Dr. Chaw Chaw Sein, Staff Officer
Daw Ni Zin Phoo, Range Officer
Daw Khin Me Me Aung, Research Assistant-3

Abstract

Forest plantations, using appropriate tree and shrub species, can play an important role in the tropical ecosystem rehabilitation. The development of a mixed species plantation canopy can alter the under storey microclimate and the soil enrichment so as to facilitate recruitment, survival and growth of native forest species and proper mixed species selection could lead to better growth of the stands. The present study results indicate that the proper selection of over storey mixed species plantation can exert an influence on soil enrichment, tree growth and under storey regeneration. Among the (36) years old three mixed species stands, stand (1); mixture of *Albizia odoratissima, Millettia pendula, Gmelina arborea*, stand (2) ; mixture of *Dalbergia cultrata, Pterocarpus macrocarpus, Xylia xylocarpa*, stand(3); mixture of *Tectona grandis, xylia xylocarpa, Albizia procera*, stand (3) shows the best in soil enrichment and individual tree growth. The species of primary forest of the region were found in the understorey of the mixed species stands. These are promising indicators for the use of these plantations as accelerators of natural forest succession in the region.

Study on Effect of Overstorey Mixed Species Stands on Soil Enrichment, Tree Growth and Natural Regeneration

1. Introduction

Forest plantations, using appropriate tree and shrub species, can play an important role in the tropical ecosystem rehabilitation. A number of recent studies have demonstrated that plantations of native or exotic species adapted to the stressful conditions characteristic of degraded lands can reverse degradation processes by stabilizing soils through development of extensive root systems, increasing soil organic matter through enhancement of aboveground litter production (Lowry et al., 1988), fine root turnover and decomposition rates (Montagnini and Sancho, 1990), moderation of soil pH and improvement of soil nutrient status (Sanchez et al., 1985; Chakraborty and Chakrabony, 1989).

The development of a plantation canopy can alter the under storey microclimate and the soil physical and chemical environment so as to facilitate recruitment, survival and growth of native forest species which otherwise would only very slowly, if ever, regenerate on degraded sites (Uhl et al., 1982; Prasad and Pandey, 1989; Soni et al., 1989). Thus, plantations may act as
foster ecosystems' (Lugo, 1988), accelerating development of genetic and biochemical diversity on degraded sites and soil enrichment (Verma et al., 1982).

The choice of plantation species is likely to greatly influence both the rate and trajectory of rehabilitation processes. Among species that may be considered suitable for a given degraded
site, there may be considerable variations in their capacity to stabilize soils, increase soil organic matter and available soil nutrients (Gill et al., 1987; Sharma and Gupta, 1989) and facilitate understorey development (Somarriba, 1988; Pande et al., 1988).Nitrogen-fixing species inoculated with effective strains of *Rhizobium* or *Frankia* can have a dramatic effect on soil fertility through their production of readily decomposed, nitrogen-rich litter and turnover of fine roots and nodules (Bernhard-Reversat, 1988; Montagnini and Sancho, 1990). The present study results indicate that the proper selection of over storey mixed species plantation can exert an influence on soil enrichment, tree growth and under storey regeneration.

2. Objectives

The objectives of the study are:

(1) to analyse soil enrichment of the three different mixed species stands.
(2) to investigate under storey natural regeneration of the three different mixed species stands.
(3) to study growth of the three different mixed species stands.

3. Literature Review

3.1 Mixed stand in A/R: -

Under suitable management, all species can be grown in mixed stands. But, acceptable mixture should form and preserve a complete canopy and properly conserve the soil. Thin foliaged trees should usually be mixed with dense foliage ones. The mixture may be planned by single alternative trees, lines or groups. When a mixture is by groups, a member of trees of one species may form a group alternate with groups of the other species. Each of the groups will be regarded as a pure stand.

A mixture may be permanent or only temporary in character. All species may be sown or planted at the same time to result in an even-aged stand or at different times to form an unevenaged stand.

3.2. Rules for formation of mixed stands: -

The followings are the silvicultural principles involved in formation of mixed stands.

(1) The conditions and situations must be favourable for normal development of all species intended to be grown in mixture.
(2) A mixture of species must not ultimately endanger productive capacity of soil.
(3) Each species must have requisite amount of growing space. It must have light, air and warmth to its requirements throughout the entire period of rotation. What are the rules for the formation of mixed stands?

Hayer and Hess, 1982 have formulated the following rules.

(1) Predominant species must be capable of improving soil.
(2) Tolerant species may be grown in mixture with each other if the rate of growth is approximately the same or if the slower growing species is protected against the more rapidly growing species by planting or seeding it earlier or by loping, topping or otherwise holding back the more rapidly growing species.
(3) Tolerant species may be intermixed with tolerant (thin-foliage) species if the latter are of more rapid growth in height or if they started earlier in the mixture.
(4) Intolerant species should not, as a rule, be seeded or planted in mixture. But, it is advisable sometimes, on very good soil where there is no danger of soil deterioration.
(5) Intolerant species should be introduced into tolerant species individually and not in patches or groups. Exceptions for special condition are such as great variability in soil, more rapid growth in tolerant species and when standards are retained for the second rotation.

3.3 Advantages from mixed regeneration when correctly made: -

If the suitable species are mixed in proper proportion the mixed stands have the following advantages.

- Where a mixture is suitably arranged, the site is more completely utilized, resulting in an increasing production of wood.
- Shallow rooted species, when mixed with deep rooted ones, produce stands which suffer less damage from strong winds.
- Tender species suffer less damage from frost, snow, ice and excessive drought when grown in mixture with more hardy species.
- Fungi and insects are less harmful in stands composed of two or more species because the damage is usually confined to one of the species in a mixture.
- The risk of fire is usually much greater in a stand composed of a single species, particularly a conifer. The danger is much less of conifers are mixed with broad leave species.
- Mixed crop can be grown on sites too poor for pure stands. If a mixed stand, different species depend upon different depths of soil and make different demands upon the site.
- When early thinnings of a species in pure stand are of little economic value, more valuable thinnings may be realized by mixing it with one or more species, which are marketable in small sizes.
- Serious mistakes made in choice of species for A/R are more easily corrected in mixed than in pure stands because the least suitable species can be removed in the early thinnings.
- From an aesthetic point of view, mixed stand is desirable because of its increased beauty.
- A mixed stand can be easily transformed or modified to meet present or future demands of the market or to overcome as serious fungus or insect pest than pure stand.

3.4 Temporary mixture: -

In some instances, it is more advantages for a mixture to be temporary, all but one species being removed before maturity of the stand. Such mixtures are useful in the following cases: -

- When rapid growth and high value of one or more of the species make it economically advantages to remove them as thinning leaving the remaining species for the final crop.
- When original costs of the seeding or planting can be reduced by the use of so-called fillers, i.e., inexpensive species that serve to occupy a portion of the area, but are removed in the early thinning.

- When nurse trees must be provided to protect a tender species during its juvenile stage (Hayer and Hess, 1982).

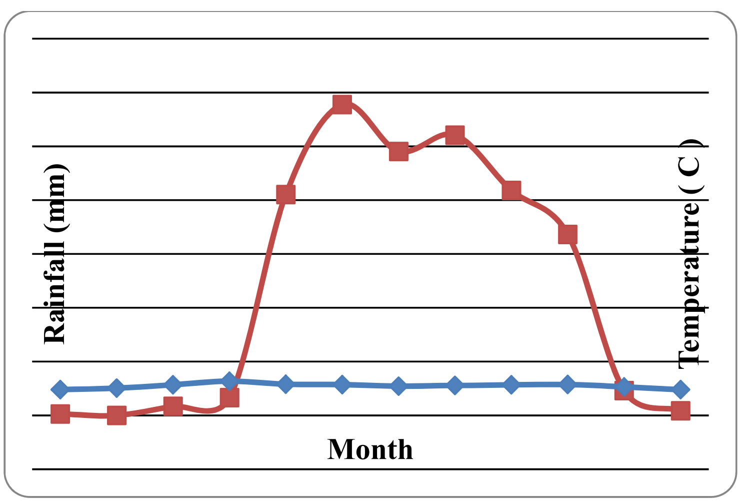
4. Materials and Methods

4.1 Study Area

The study site is situated in compartment No. 72 of Ngalaik Reserved Forest, Pyinmana Township. It is located on latitude of 19˚56' N and longitude of 95˚56' E, and 600 m above sea level. The topography consists of generally flat and the soil is buff to yellowish color, medium to thick bedded, coarse to gritty, poorly consolidated sand stone and is drained, and has a sandy loam texture with pH 6.3 (Kyi, 1991). The study site has a tropical savannah climate with a pronounced dry period between the monsoon rains. The raining season begins at the end of April or the first week of May and ends in October. The study area gets 6 months of more than 20 aridity index by DEMARTONNE's method (Swe, P. P.,2009).

Table (1) Climatic Data (monthly means) (2015)

Month	Temperature (˚C)	Rainfall (mm)
Jan	24.0	1.4
Feb	25.3	0
Mar	28.5	8.5
Apr	31.8	16.5
May	29.0	205.3
Jun	28.6	288.8
Jul	27.2	245.3
Aug	27.9	260.4
Sep	28.4	209.0
Oct	28.7	168.2
Nov	26.5	23.1
Dec	23.9	4.4



Monthly Climatic Data

Figure (1) Monthly mean climatic data

4.2 Methodology

A field survey was carried out in the 36 years old three mixed stands of Ngaleik reserved forest, compartment No.(72): the first mixed stand with *Albizia odoratissima, Millettia pendula, Gmelina arborea*, the second one with *Dalbergia cultrata, Pterocarpus macrocarpus, Xylia xylocarpa* and the third mixed stand with *Tectona grandis, xylia xylocarpa, Albizia procera*. In each mixed stand, the three temporary sample plots of 20mx 20 were selected only in places where stocking was full. The diameters (greater than 5cm) at breast height (dbh) - 1.3 m above ground and heights of all the standing trees were measured using diameter tape and clinometer respectively. Natural regeneration was counted within 5mx5m at the four corners of the mixed stands.

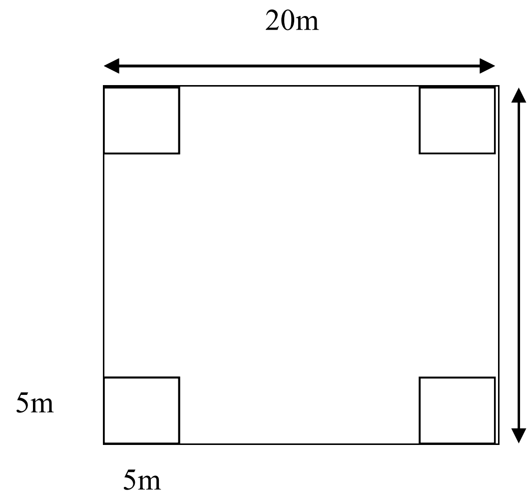


Figure (2) Layout of the sample plot

4.3 Soil Sampling

In each plot, three points as a triangle form are set to the north, southeast and southwest direction and 5m apart from the centre of plot and layout of sample plot was as shown in below, figure (3).

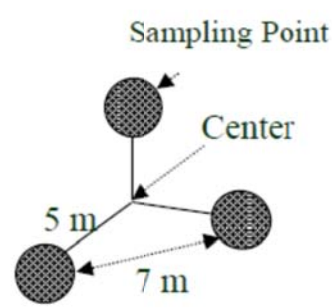


Figure (3) Design of soil sample collection under sample plot

4.4 Laboratory Analysis

Soil samples were dried in air and sieved. Total soil nitrogen (N_2) and organic carbon (OC) were determined on the 2 mm portion of the soil.

Total N_2 was analyzed by using Micro Kjedahal digestion and Pro nitro distillation unit and OC was tested by weight loss on ignition.

Available phosphorus was resolved with double acid extracting solution and molybdenum blue complex method by using Spectrophotometer Hach, 2000.

Extractable potassium content in soil was assessed with double acid extracting solution by using GBC, Atomic Absorption Spectrophotometer.

Soil organic matter was detected by using Loss-on-ignition (L-O-I) method.The principle of which method is simple; the organic matter in a weighed quantity of soil is destroyed completely by heat, the sample reweighed and the loss in weight represents the organic matter.

5 Results and Discussions

5.1 Effect of Soil on Three Mixed Stands

Table (2) Chemical properties of soil in the three mixed stands

Property	**Stand (1)**	**Stand (2**	**Stand(3)**
Total N %	0.037	0.041	0.076
Ava. P %	0.00073	0.00021	0.00019
Ext- K(%)	0.007	0.008	0.017
OM %	1.6	3.0	3.7

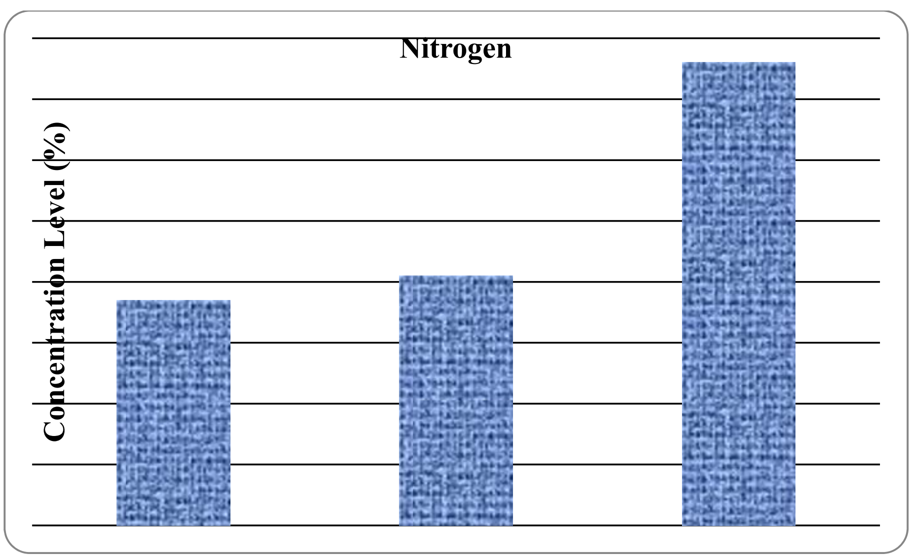


Figure (4) The concentration level of total nitrogen in the three mixed species stands.

The nitrogen contents range from 0.09% to 0.14% in most forest soils. Wilde et al 1972 stated that species of low nitrogen requirement might grow properly in soils of total nitrogen content as low as 0.07%. Mean nitrogen content in the mixed plantation stand (3) is (00.076%) is near to the natural forest soil and the other two have low nitrogen content.

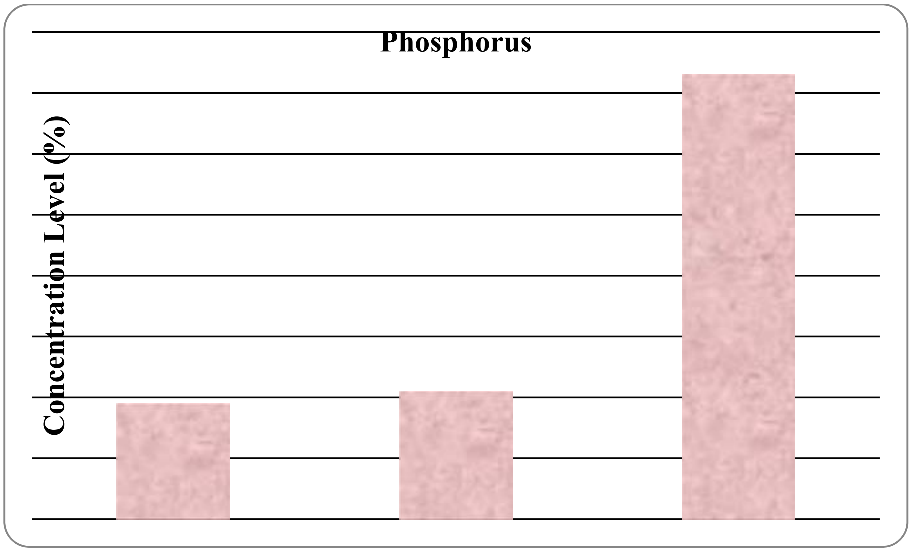
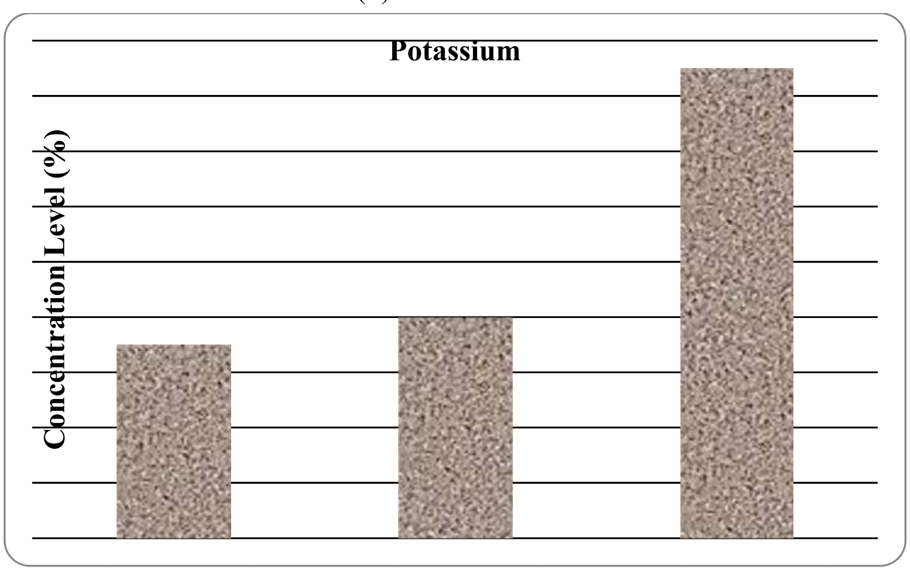


Figure (5) The concentration level of available phosphorus in the three mixed species stands

In most soils, the amount of phosphorus in the available form at any one time is very low, seldom exceeding about 0.01% of the total phosphorus levels. (Wilde *et al* , 1972) claimed that for most of the plants, the minimum requirement of phosphorous for normal growth was about 0.002%. The phosphorous concentration level in the surface soil of natural forest is much lower than that requirement. Low available phosphorous may be due to the high nitrogen content in the mixed stand (3).



Figure(6) The concentration level of extractable potassium in the three mixed species stands

Available potassium concentration in soils for normal growth was 0.00025% and above (Wilde *et al* , 1972). The amount of extractable potassium lies within a range of .001 to

.01% in most forest soils. Therefore, the surface soils of the three mixed stands under study have quite sufficient concentration of potassium.

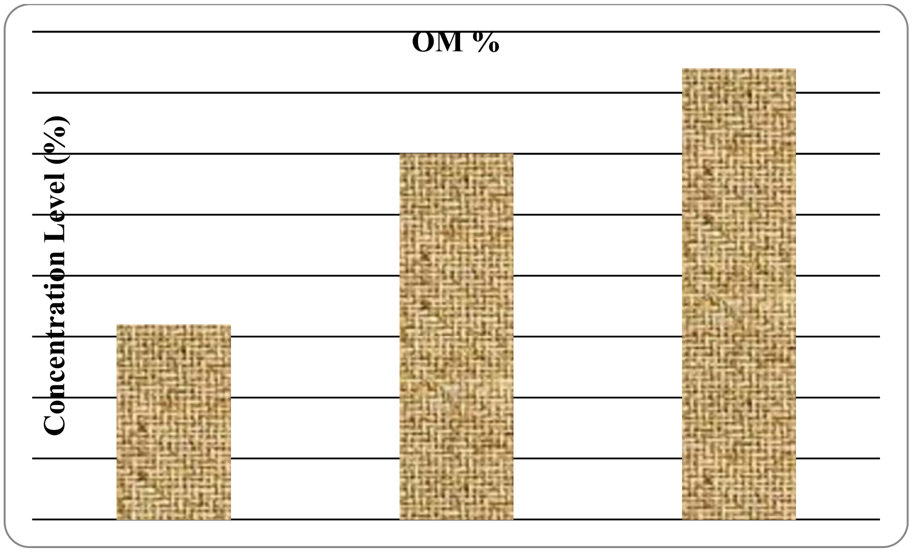


Figure (7) The concentration level of organic matter in the three mixed species stands

The organic matter contents of the surface soils range from 1.5 to 4.0% in most soils. The OM% is quite high in mixed plantation of stand (3), the amount of OM is (3.7%) due to high organic residues.OM content (%) ranges from 2.5 to 8.0 in the forest soils of the Bago Yomas, the representative concentration being 4.75.

5.2 Stand Growth

5.2.1 Stand Basal Area

Stand basal area (SBA) is simply the cross-sectional area of all trees at breast height per hectare of forest or plantation (m^2/ha). Stand basal area can be used to estimate stand volume and is a useful measure of stand density, as it is simple to measure. Stand basal area values not only depend on the number of trees, but also on the size of trees. The relationship between stand density and average tree size is important to compare different thinning regimes for industrial plantation. Von Gadow and Bredenkamp (1992) concluded that sawn timber necessitates larger diameter trees, whereas a large stand basal area is needed for pulpwood.

The approximate average stand basal area in a moist evergreen forest is about 30 m2 per hectare (Weidelt, 1998). The un-thinned 67-year-old stand of *Flindersia brayleyana* on basaltic soil carried a stem basal area of 78 m2 /ha (Brown *et al*., 2004). This is similar to the basal area recorded in the Monteverde forests of Costa Rica (Nadkarni *et al.,* 2000), of which 70% was contributed by *Flindersia brayleyana*. Stand basal area may be up to 80-85 m^2/ha in a Eucalypts plantation at a productive site. The stand basal area is a suitable parameter to compare un-thinned even-aged stands of a given age and site. Hui and von Gadow (1993) developed a model that includes the stem number and top height to calculate the basal area. A modified version of this model was applied to determine basal area in this study. This model includes the varying age and is as follows:

$$G=a*H^{\alpha*}N^{\beta*}t^{\gamma}$$

Where,

G = Stand basal area (m^2)

N = Number of stems (per ha)

H_d = Top height (m)

t = Age (years)

a, α, β and δ = Model parameters

Table (3) Parameters for the estimation of the basal area of the Stands

Stand	**Model Parameters**				**R^2**
	A	**A**	**β**	**γ**	
Stand (1)	0.003085	0.769117	1.262451	0.275437	0.92
Stand (2)	0.008296	0.675408	1.056497	0.358526	0.78
Stand (3)	0.000319	0.874257	1.863192	0.085587	0.86

5.2.2 Volume Production

In forestry, it is indispensable to estimate the volume of a stand based on variables measured in the field. Since volume production is usually the growth parameter of greatest interest to the forest manager, an evaluation of site productivity in terms of volume is desirable (Sammi, 1965). There are a number of practical approaches to determine stand volume. It can be calculated by means of other correlated variables such as basal area, tree height, form factor and sometimes stand age. The measurement of volume production as a guide to site productivity in plantations is used in Germany (Shrivasta and Ulrich, 1976), Sweden (Johnston *et al*., 1967) and Britain (Johnston and Bradley 1963, Bradley *et al*., 1966) as well as in a number of other countries (e. g. France, Finland, Norway). Estimates of volume production are helpful in planning when to harvest or how much to remove in a thinning operation. These estimates can also assist with financial analysis and the tax implications of a timber harvest. There are two main approaches to estimate volume production. The first one is by stem analysis, wherein calculations are derived from the segmented stems and the second one is by estimation via obtainable volume equations or volume tables.

The dbh, height and form factor are the parameters required for the basic volume estimation of a single tree. The stem mass can be stated either in volume or in weight, depending on the final product. Likewise, there are two options for measurement of tree height: total height and merchantable height. The normally used measures of stem form

(form factor) are fractions of volume of a tree related to a pillar with diameter equal to tree dbh. The volume equation may be commonly written as follows:

$$V = f(D, H, F)$$

Where:

V= Stem Volume
D= Stem diameter at breast height
H= Stem Height
F= Stem Form factor

5.2.3 Relationship between single tree volume and basal area

The relationship between volume and basal area enables the estimation of individual tree volume by measuring only the dbh (basal area). It is impossible to assess all variables for every tree in each sample plot due to the limitation of time and money. In both natural forests and plantations, dbh measurements can be attained at low cost. It is difficult to measure the heights of large dense stands. In forest management, dbh measurement is a regular practice, particularly in plantations. The allometric regression was applied to fit the following equation for selected mixed species stands.

$$V=\alpha*G^{\beta}$$

Where

V= Individual tree volume, up to top diameter 5 cm (m^3)
g= Individual tree basal area (m^2)
α and β= Intercept and regression coefficient

The relationship between volume and basal area of individual trees using the above equation are shown in below and the parameters are given in table ( ) for each stands.

Table (4) Parameter values for the relationship between volume and basal area of the three mixed stands

Stand	**Parameter Values**		**R^2**
	A	β	
Stand (1)	22.93	1.281	0.87
Stand (2)	21.611	1.319	0.95
Stand (3)	15.809	1.215	0.91

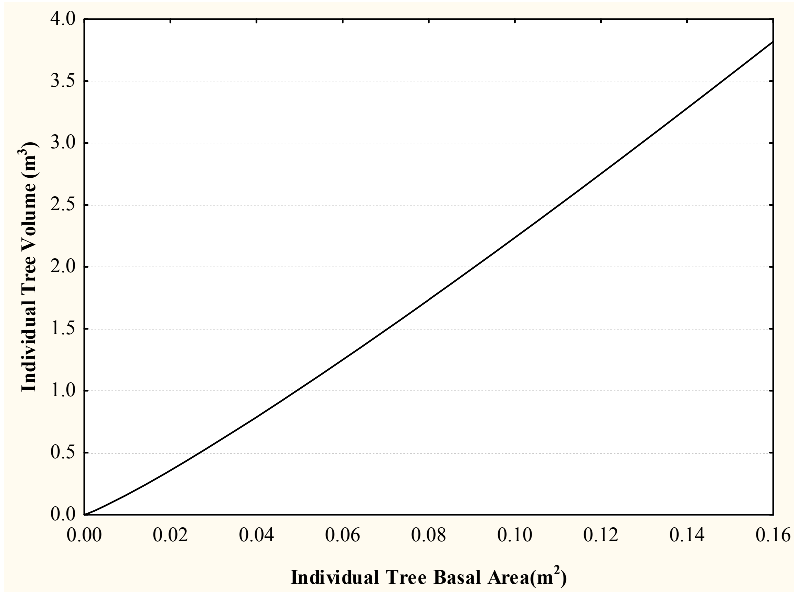


Figure (8)The relationship between volume and basal area of mixed species stand (1).

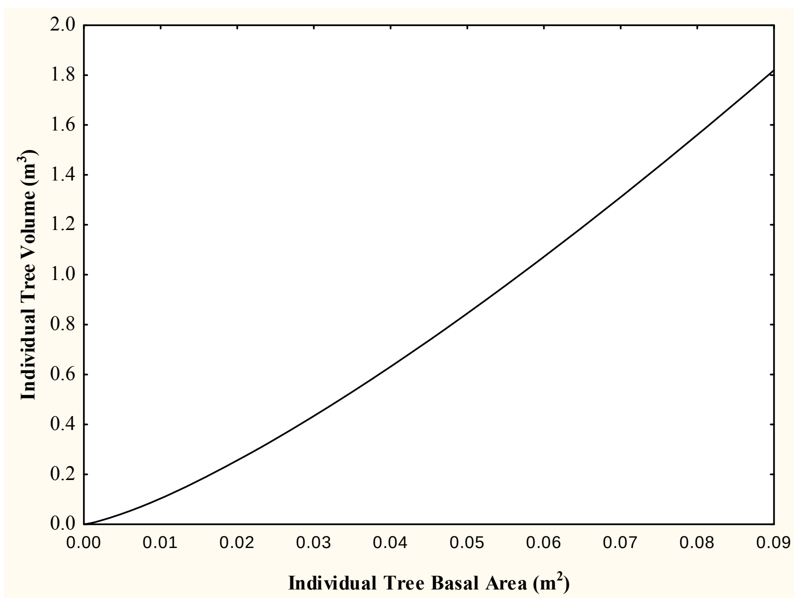
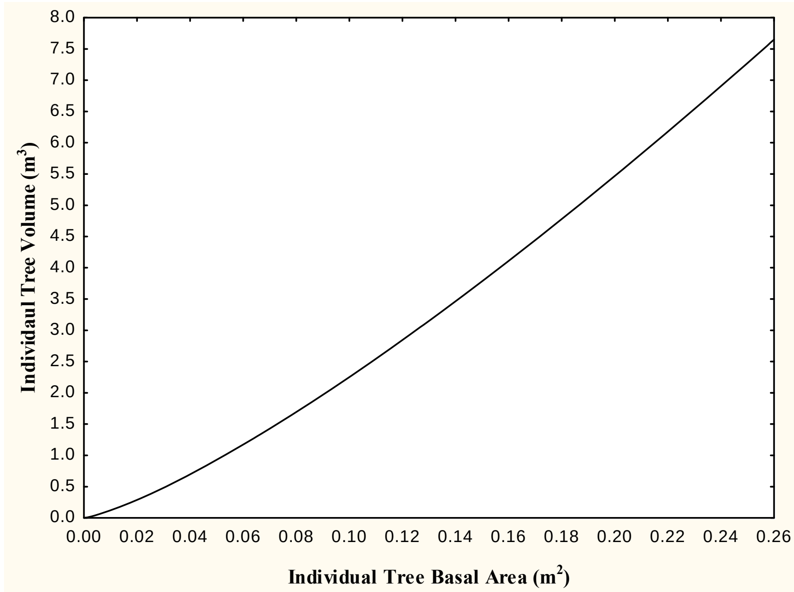


Figure (9)The relationship between volume and basal area of mixed species stand (2).



Figure(10)The relationship between volume and basal area of mixed species stand (3).

5.3 Effect on Natural Regeneration

The establishment of mixed species plantations can facilitate the regeneration of native species that could not otherwise grow in open micro sites or in competetion by herbaceous species. The present research investigated that tree regeneration under three mixed species stands.

Smilax griffithii was found the highest abundance of regenarating species in the understorey of mixed species stand(1), follwed by *Holarrhena pubescens* and *Polyalthia simiarum*. In mixed species stand (2), *Cephalostachyum pergracile* was found as the main dominance regenerating species, followed by *Harrisonia perforata* and *Uncaria pilosa.*The most dominated understorey species under mixed species stand (3) was *Schleichera oleosa* and followed by *Cratoxylum ligustrinum* and *Pterocarpus macrocarpus.*

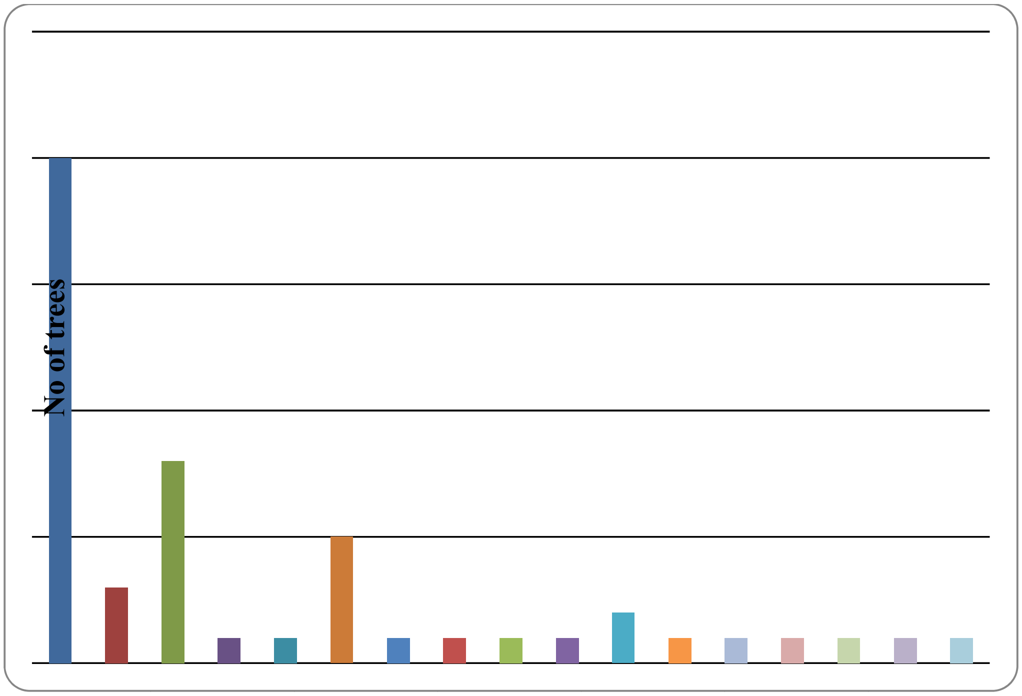


Figure (11) The abundance of regenerating species in the understorey of mixed species stand(1).

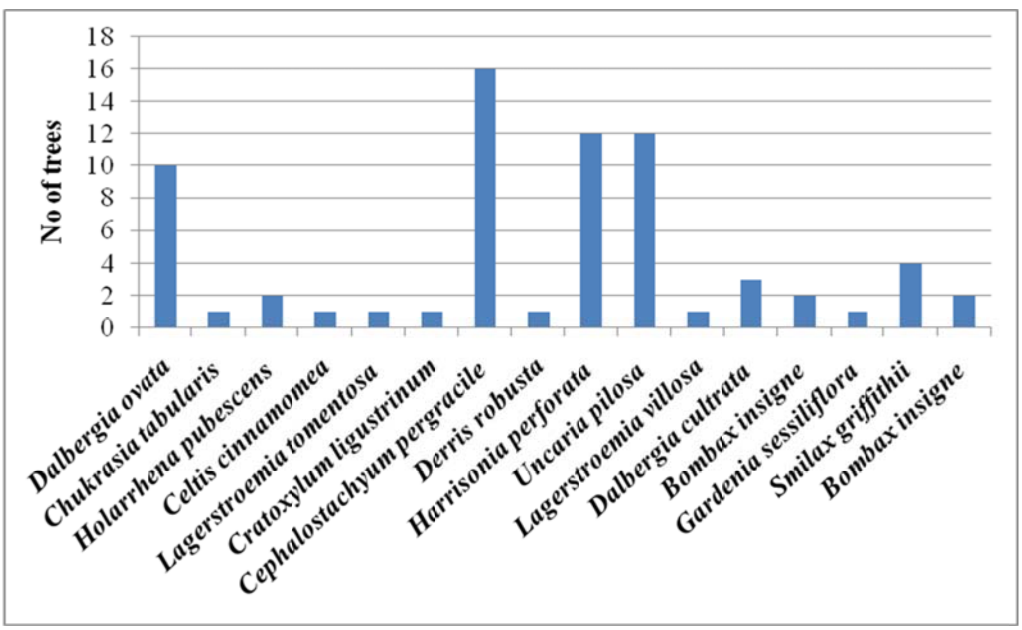


Figure (12) The abundance of regenerating species in the understorey of mixed species stand(2).

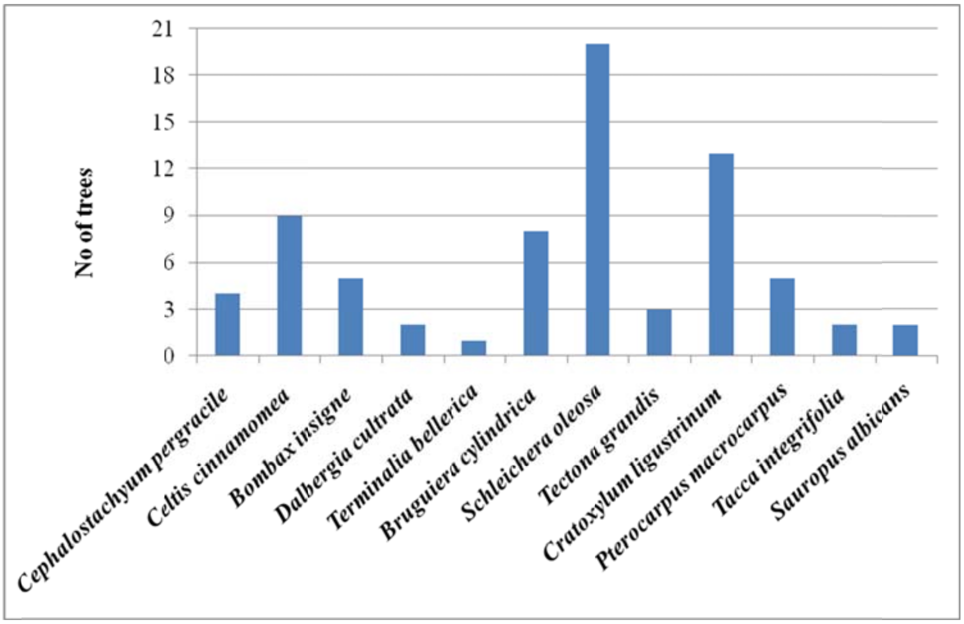


Figure (13) The abundance of regenerating species in the understorey of mixed species stand(3).

6. Conclusions and Recommendations

Mixed plantations are promoted regeneration in the understorey by shading out grasses, increasing soil nutrients (through uptake by deep roots and litter fall), improving micro-climate, and generally increasing the chance for seed germination and establishment. According to the results of the chemical properties of the three mixed stands, the stand (3) had the best soil enrichment comparing the rest two stands. It showed that the specie mixture is one of the overwhelming factors to soil enrichment. Moreover, the behavior of the horizontal and vertical growth pattern showed that stand (3) is the best one followed by stand (1) and stand (2).

Mixed plantations could promote the regeneration of a greater diversity of species in their understory than pure species plantations by creating a greater variability of habitat conditions that may favor seed dispersers and germination and growth of tree species. In addition, the species of primary forest of the region were found in the understorey of the mixed plantation. These are promising indicators for the use of these plantations as accelerators of natural forest succession in the region.

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