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Soil Characteristics of Tamalan (*Dalbergia oliveri* Gamble ex Prain) Habitat in Myanmar

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မြန်မာနိုင်ငံရှိတမလန်းသစ်မျိုးများပျံနှံ့ပေါက်လေ့ရှိသော မြေဆီလွှာအခြေအနေ

ဖြူဖြူဆွေ၊ လက်ထောက်သုတေသနအရာရှိ၊
ဆွေဆွေထွန်း၊ လက်ထောက်သုတေသနအရာရှိ
ထက်နှောင်းခန့်၊ သုတေသနလက်ထောက် - ၃
ရေမြေသားဌာန်နှင့်သစ်တောသယံဇာတဌာနစု၊ သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်းချုပ်

သစ်တောအဆင့်အတန်းကျဆင်းနေသော ဧရိယာများတွင် ဒေသဆိုင်ရာသစ်မျိုးများ စိုက်ပျိုးခြင်းသည် သဘာဝမျိုးဆက်ခြင်းကို ပိုမိုတိုးတက်စေပြီး ဇီဝမျိုးစုံမျိုးကွဲများကို ပြန်လည်ကောင်းမွန်လာစေရန် ထောက်ပံ့ပေးမှုလည်း ရရှိနိုင်မည်ဖြစ်ပါသည်။ သို့သော်လည်း အပင်စိုက်ပျိုးခြင်းမစတင်မီ စိုက်မည့်နေရာအခြေအနေနှင့် စိုက်ပျိုးမည့်သစ်မျိုးများ ကိုက်ညီရန် လိုအပ်ပါသည်။ ဤသုတေသနသည် သစ်တောအဆင့်အတန်းကျဆင်းသောဧရိယာများတွင် တမလန်းသစ်မျိုးများ ပြန်လည်ကောင်းမွန်လာစေရန် ရည်ရွယ်လျက် ထိုသစ်မျိုး ပေါက်ရောက်လေ့ရှိသည့် သဘာဝပတ်ဝန်းကျင် အကြောင်းအရာများကို အထူးသဖြင့် မြေဆီလွှာအခြေအနေကို လေ့လာခြင်းဖြစ်ပါသည်။ တမလန်းသစ်မျိုး ပေါက်ရောက်သည့် မြေဆီလွှာအခြေအနေကို ရဲရမန်းကြိုးဝိုင်း- ကျောက်ဆည်မြို့နယ်- မန္တလေးတိုင်းဒေသကြီး၊ နန့်ခေါင်ဟူးကြိုးဝိုင်း- ဗန်းမောက်မြို့နယ်- စစ်ကိုင်းတိုင်းဒေသကြီး နှင့် ကျောကြိုးဝိုင်း- ဂန့်ဂေါ်မြို့နယ်-မကွေးတိုင်းဒေသကြီး တို့တွင် ကောက်ယူဆန်းစစ် လေ့လာခဲ့ပါသည်။

တမလန်းပေါက်ရောက်နေသည့်အဆိုပါမြေဆီလွှာအမျိုးအစားများသည် တစ်နေရာနှင့် တစ်နေရာ သိသာစွာ ကွာခြားခြင်း မရှိကြောင်း လေ့လာသိရှိရပါသည်။ အများအားဖြင့် တမလန်းသစ်မျိုးများကို မြေသားထူသောနေရာများတွင် တွေ့နိုင်သကဲ့သို့ မြေသားပါး၍ ကျောက်သားနှင့် ရောနှောနေသည့်နေရာများတွင်လည်း တွေ့ရှိရပါသည်။ တမလန်းသစ်မျိုးများသည် ပူ၍စွတ်စိုသောဒေသများတွင် ပေါက်ရောက်ကြပြီး ကြီးထွားနှုန်းအရ လေ့လာခဲ့သည့်နေရာများတွင် သာလွန်စွာကောင်းမွန်သည့်နေရာဟူ၍ ကွဲပြားခြင်း မရှိခဲ့ပါ။ မြေဆီလွှာအာဟာရအနေနှင့် ကယ်လဆီယမ်ဓါတ်နှင့် ပိုတက်ဆီယမ်ဓါတ် ပါဝင်မှုများပြီး နိုက်ထရိုဂျင်ဓါတ်နှင့် ဖေါ့စဖေါ့ရပ်ဓါတ် ပါဝင်မှုနည်းပါးပါသည်။ မြေဆွေးဓါတ်ပါဝင်မှု အသင့်အတင့်ရှိပြီး သဲမြေကို အခြေခံသည့်မြေမျိုးများကို လေ့လာတွေ့ ရှိရပါသည်။ ထို့ကြောင့် သစ်တောများပြန်လည်ကောင်းမွန်ရန်၊ ဇီဝမျိုးစုံမျိုးကွဲများကို ထိန်းသိမ်းစောင့် ရှောက်နိုင်ရန် နှင့် စီးပွားရေးအရ ထုတ်လုပ်နိုင်ရန်တို့အတွက် တမလန်းသစ်မျိုးများကို ရွှေ့ပြောင်းရောနှောတော ရှိ သစ်တောအဆင့်အတန်းကျဆင်းသော ဒေသများတွင် စိုက်ပျိုးရန် သင့်တော်သော မျိုးစိတ်တစ်ခု ဖြစ်နိုင်ပါသည်။ လေ့လာတွက်ချက်မှုများအရ အကောင်းဆုံး စိုက်ပျိုးနိုင်သည့် မြေဆီလွှာချဉ်ငန်ဓါတ် မှာ ၆.၂ မှ ၆.၆ ၊ နိုက်ထရိုဂျင်ဓါတ် ၀.၀၃ မှ ၀.၀၃၉ % ၊

မြေဆွေးဓါတ် ၂.၅ မှ ၃ % ကြားတွင် အကောင်းဆုံး ဖြစ်နိုင်သည်ကို တွေ့ရှိရပြီး မြေအနုအကြမ်းအနေနှင့် သဲပါဝင်မှုများသည့် မြေမျိုးဖြစ်သည်ကို လေ့လာတွေ့ရှိရပါသည်။

Soil Characteristics of Tamalan (*Dalbergia oliveri* Gamble ex Prain) Habitat in Myanmar

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ABSTRACT

Accelerating of natural regeneration and supporting to recovery of biodiversity in degraded forests may be satisfied by planting of native trees. However, before planting trees we need to know species and specific site matching. Therefore this study investigates the site requirement emphasized on soil character where tamalan (*Dalbergia oliveri*) occurred for the purpose of restore in degraded forest area. We determined to obtain a correlation of the existing tamalan with soil conditions. The study were conducted in three sites: (1) Yeyaman reserved forest, Kyaukse township, Mandalay Region Region (2) Nankhaunghu reserved forest, Banmauk township, Sagaing Region Region (3)Kyaw reserved forest, Gangaw township, Magwe Region Region.

Soil types in three study area that determine what types of plants grow in that area are not completely different. Tamalan are found on deeper soils and also shallow soil with gravel and rock fragments and the hot and moist condition. D. oliveri had no direct differences in site suitability among these studied area. They have relatively fertile of high calcium (Ca), potassium (K), and lower amount of nitrogen (N) and phosphorus (P) and moderately amount organic matter (OM) contents and sandy based soil types. Therefore, planting or sowing D. oliveri degraded area under deciduous forest may be a suitable species for restoration of degraded forests, conservation of biodiversity and economic production. The best possible range for tamalan species is soil pH 6.2 - 6.6, concentration of nitrogen around 0.03 - 0.05 %, organic matter 2.5- 3%. Texture is predominantly sandy with different values of silt or clay. Temperature and elevation and other environment factors play important roles in limiting the distribution and growth pattern of the species.

Keywords: degraded forest area, Indaing forest, mixed deciduous forest, nutrient, soil pH

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1. Introduction

Due to the physiographic and climatic conditions, the major six forest types are occurred throughout the country. Among these types, deciduous forests are widely distributed over a large area and occupy 42. 5 % of forest area. They are the most important forests in Myanmar and supply the best timber and other forest products (Myanmar environment portal, 2003). In deciduous forest usually different deciduous species grow based on site conditions. Teak is the dominant species in mixed deciduous forest and Thitya, In and Ingyin are common species in deciduous Dipterocarp forest throughout the country. These forests have a distinct ecosystem, understory growth and complex soil dynamics. Several commercially important species such as pyinkado, padauk as well as Dalbergia species and Bamboo grew as the natural habitat in most deciduous forests.

Nowadays old growth of valuable commercial species is very rare and most deciduous forests are severely degraded because of over exploitation and agricultural expansion. In those degraded forests, however, several valuable deciduous species are found as usual. This means these areas are suitable for planting to restore and to expand the forests and assisting both conservation and production purposes.

Dalbergia oliveri Gamble ex Prain (Fabaceae), commercially known as tamalan or rosewood in Myanmar, is one of the most well known timbers in tropical hardwood sector. Populations of tamalan have been reduced intensely throughout their growth region because of the loss of habitat area and over exploitation. Mature and large sized trees remain a few number as individual. Seed production in mature trees is usually sufficient but natural regeneration is often poor due to low germination rates or disadvantageous weather and site conditions. Trees generally grow slowly in both natural and man-made forests (CTSP, 2001). Therefore this species is planted in reforestation projects to restore native woodland in Myanmar as a result of the rising

commercial interest and containing the IUCN Red List. However there is limited information known about that species.

We need to carefully evaluate soil fertility to prevent nutrients deficiencies before starting of plant. To achieve these conditions, the planting site must be suitable for the growth and development of planted trees. Since the growth and quality of plantations depends on site quality, this study attempts to describe some soil information which relate to the condition of tamalan growing areas.

2. Objectives

- To explain some soil characters which may be influencing tamalan species
- To describes as the view of research that we assess and conclude tamalan growth area

3. Literature Review

The forests of Myanmar which cover about 42.9 % of the total land area of the country (FRA 2015) play a vital role in national economic and social development and one of the major export commodities. Due to varying degrees of climatic and topographic conditions and a wide range of latitudes, the forest flora varies from alpine, deciduous, dry species to mangrove species. Forest resources of the country have been decreasing both extent and quality as increased population pressure and consequent rising demands for the forest land and its products. Therefore, Myanmar Forest Department has put in utmost efforts to fulfill a large scale planting scheme in order to increase the potential of the forests and also great demand both for export and local used. Plantings are done either to increase the proportion of commercially importance species and enrich the natural forests or restore and rehabilitate the degraded forest lands. Most of the planted species are indigenous mainly composed of Teak, Pyinkado, Padauk and Pinus spp. The main exotic species Eucalyptus spp. shares 10 % of the total plantation area and the other species occupy 36 % of the plantations. Now tamalan involved endanger species and it is needed to carry out gap planting, enrichment planting and natural regeneration in deteriorating natural forests and also

artificial regeneration in large scale planting program for the aim to promote the production of this species.

Tamalan scattered throughout the country as two types of species. These are D. oliva and D. Hemsleyi based a large diversity in bark characteristics and heartwood color. Tamalan are found from the dry zone to Upper Myanmar. It grows usually on hilly ground in localities but also in the indaing (dry dipterocarpus) forest in laterite (Troup, R.S, 1921). A medium to large tree, they reach from 25-30 m high and produces boles from 70-90 cm in diameter at beast height (Troup, R.S, 1921 & CTSP, 2001). The wood is durable, medium-textured, and has a density of 0.85(FIPI. 1996). Tamalan grows naturally over a wide range of climatic condition, from the very dry (500 mm/year) to the very moist (up to 5,000 mm/year). It is noted that the tamalan distribution pattern in its natural range is of discontinuous (Troup, 1921). Size, quality, density, and form of tamalan trees vary from one location to another. There are several factors which control the distribution and growth pattern of the species. The major factors include the amount and distribution of rainfall and moisture, soil and light. This species can be found at elevations up to 850 meters. It grows best in areas where the mean annual temperature falls within the range 24 - 34°c, but can tolerate 8 - 44°c. Suitable habitat across their natural range is now limited for these species due to deforestation, forest conversion and legal and illegal logging to supply market demands. These species have been assessed by the IUCN Red List. Local names in Myanmar used for the species were red tamalan/ tamalan ni or yellow tamalan/ tamalan war or white tamalan/ tamalan byu. The wood is hard and heavy, resistant to termites and the color of wood varies– commercial timber is rose-yellow, brown veined red with black veins, or purple streaked with yellow. The wood is easy to polish and is widely used for making high quality and luxury products (CTSP et al., 2003). The distinguishing feature of this species is the color of the wood. The trunk is straight and cylindrical, and the bark is dark brown and longitudinally fissured. On local markets it is sought for manufacturing traditional instruments (Rujinirun et al., 2005). Tamalan like padauk are valued for their toughness, stability in use, and decorativeness, most having a reddish wood. Its color makes it a favorite among demanders. It is sometimes used to make

xylophone and marimba keys, and guitars and an important material in traditional Chinese furniture (https:// en.wikipedia. org/ wiki). Tamalan and has been subject the main target for the trade over the past decade, mostly by China, but also in Vietnam. In the Philippines in recent years, the tree has become a source of popular herbal remedies for such diverse health problems as headaches, rheumatoid arthritis, leprosy, T.B., menstrual cramps, diabetes and flu. As the bark and wood are employed in herbal remedies this growth in popularity may cause further depletion of these trees (https:// Buemese rosewood tree/).

4. Material and Methods

Tamalan is mostly found in Sagaing Region, and to a lesser extent in Shan and Kachin states and also Mandalay Region (planning and statistic Region, FD). Therefore, as studied area, three different locations were selected seen in Fig.1, namely; (1) Site-1: Yeyaman reserved forest, Kyaukse township, Mandalay Region (2) Site-2: Nankhaunghu reserved forest, Banmauk township, Sagaing Region (3) Site-3:Kyaw reserved forest, Gangaw township, Magwe Region.

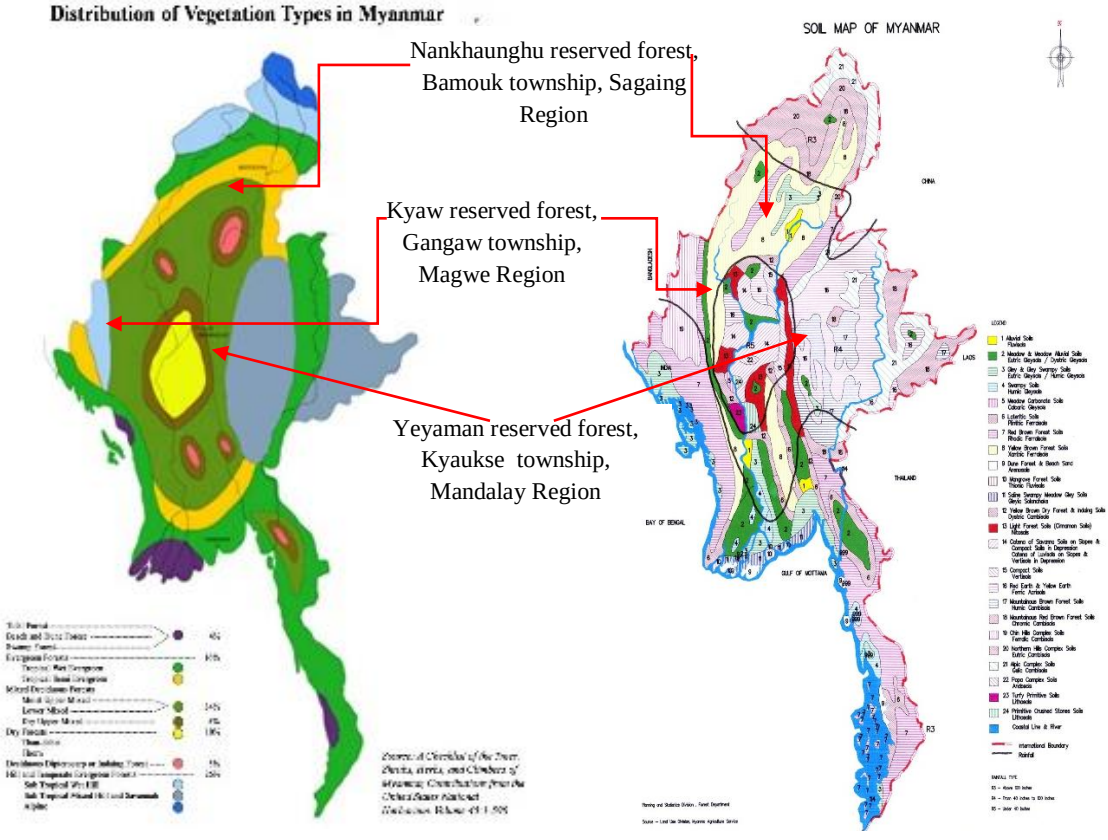

Fig. 1. Location of study area

Most of the annual precipitation occurs during the end of April or the first week of May and end in September and average annual rainfall in 60 - 80 inches based on statistical and climate map of Myanmar and a distinct dry period of 6 – 8 months. These studies were performed in a patch of tamalan occurring region. The dominant types of forest in these regions are mixed deciduous and deciduous Dipterocarpus forests. The slope of studied area is from 35º - 40º to 50º - 60º. The soils are mostly yellow brown forest soils (xanthic ferralsols) and Mountain brown forest soil (humic cambisol).

We selected 9 focal tree plots in each site to determine plant communities and soil characteristics where tamalan occurs. For Vegetation data, each focal tree plot was a circular sample plot (r = 10 m) laid out around a tamalan (Fig. 2) and generally three positions at top, middle, lower position along the slope. In each plot, all woody species names with exceeding a diameter at breast height 5 cm were collected.

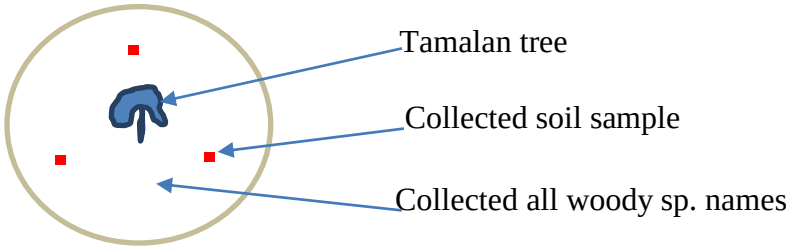

Fig. 2. Layout of tree and soil samples

For soil information, three points as a triangle form were collected to the north, southeast and southwest direction with 5 m apart from the focal tree plot and mixed as one soil sample for each focal tree as seen in fig.2.

Collected soil sample consist of three layers (0-10 cm, 40-50 cm and 80-90 cm). Totally 81 soil samples were collected in the studied forest. The soil tests were conducted at Forest Research Institute of Yezin. Each sample was then analyzed for the following chemical components, Soil acidity pH Determined by water 1: 2.5, Sand , Silt and Clay by Pipeting, Organic matter by Ignition, Total nitrogen by Kjeldahl method, Av. Phosphorus by Blue Method, Exchangeable Ca and K by Atomic Absorption spectrophotometer method. The depth of a compact gravel layer in the subsoil was measured by digging auger and used as an estimator for effective soil depth.

One-way analysis of variance (ANOVA) was used to test differences in soil physical and chemical properties across different study sites and carried out by using the SPSS 20 program for windows. Duncan's significance test was used for mean separation when the analysis of variance showed a statistically significant difference ($p < 0.05$).

5 Results

5.1. vegetation data

In the focal tree plots 19 species in site-1, 36species in site- 2 and 32 tree species in Site-3 were recorded in the study area in appendix-I. Tamalan spp. is usually found in this studied area. Other majority of important trees species such as kyun, pyinkado, padauk, In, Ingyin, Thityar, Taukkyun, Zaungbale, Thadi and some lesser-used species are found in study area. Tamalan and various deciduous species are more observed on ridge top and hot aspect and also in lower part alluvial soil.

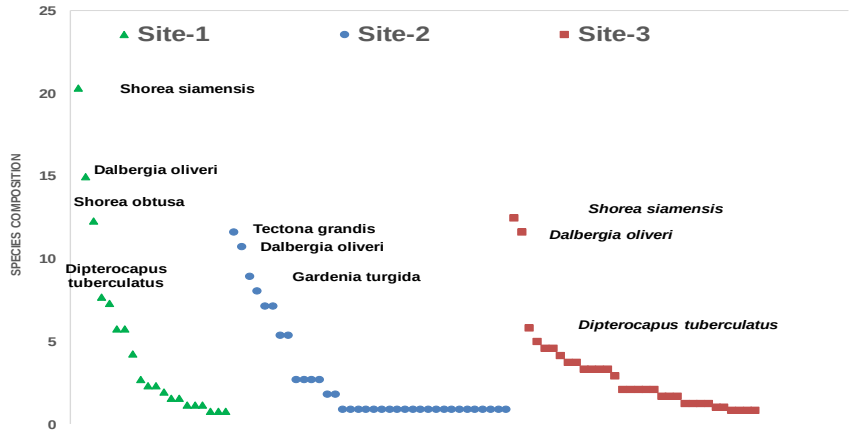

Fig.3- Tree composition in studied area

5.2 soil information

Soil types in three study area that determine what types of plants grow in that area are not completely different. Based on Myanmar rock types, the studied area are found under maily soft rocks, which consist of sandstone, shale, limestones and conglomerate. Usually these soils texture varies from sandy clay loam to sand clay or sandy loam. Sand content ranges between 35 – 90 %but generally optimal contents are 65 – 70%. Partical site distribution is significant with various content of silt and clay .

The soil is slightly acid to neutral condition with the pH value ranging from 5.1 to 7.7. There are no significant differences with mean values among three sites but also layers. The soils contain moderate amount of plant available nutrients. The distribution patterns of nutrients based on soil depth and studied area under each site could be seen in Table.1.

Table. 1- Mean of soil Nutrients among the study sites

		pH	Nitrogen (%)	Phosphorous (%)	Potassium (%)	Calcium (%)	Organic Matter (%)	Sand (%)	Silt (%)	Clay (%)
Locations	Site - 1	65 ^{a}	0.03 ^{a}	0.0018 ^{b}	0.011^{a}	0.15 ^{b}	2.7^{a}	69^{a}	7^{b}	22^{a}
	Site - 2	6.2 ^{a}	0.05 ^{a}	0.0016^{b}	0.007^{b}	0.07^{c}	2.8 ^{a}	60 ^{a}	25^{a}	15 ^{a}
	Site-3	6.3 ^{a}	0.03 ^{a}	0.0045 ^{a}	0.0034 ^{c}	0.23^{a}	2.7^{a}	72 ^{a}	10^{b}	14 ^{b}
Soil depth 0-10(cm)	Site - 1	6.03 ^{a}	0.045 ^{a}	0.0036 ^{a}	0.008 ^{a}	0.06^{b}	3.4 ^{a}	67 ^{a}	20 ^{a}	11 ^{a}
	Site - 2	6.8 ^{a}	0.037 ^{a}	0.0021 ^{a}	0.012 ^{a}	0.20 ^{a}	3.4^{a}	71^{a}	7^{b}	20 ^{a}
	Site-3	6.2 ^{a}	0.034 ^{a}	0.0021^{a}	0.004 ^{b}	0.21^{a}	3.4^{a}	74 ^{a}	9 ^{b}	14 ^{b}
Soil depth 40-50(cm)	Site - 1	6.4 ^{a}	0.039 ^{a}	0.0006^{b}	0.0062^{ab}	0.084 ^{ab}	2.4 ^{a}	56 ^{c}	6 ^{a}	20 ^{a}
	Site - 2	6.5 ^{a}	0.032 ^{a}	0.0018^{b}	0.009 ^{a}	0.15^{b}	2.6^{a}	70^{b}	13^{b}	16 ^{a}
	Site-3	6.2 ^{a}	0.024 ^{a}	0.0036^{a}	0.0027 ^{b}	0.19^{a}	2.3^{a}	80 ^{a}	27 ^{b}	16 ^{b}
Soil depth 80-90(cm)	Site - 1	5.9 ^{a}	0.0412^{a}	0.0007^{b}	0.008 ^{a}	0.06^{b}	2.5 ^{a}	55 ^{b}	29 ^{a}	15 ^{a}
	Site - 2	6.5 ^{a}	0.0416^{a}	0.0016^{b}	0.010 ^{a}	0.12^{b}	2.3 ^{b}	67^{a}	7^{b}	23 ^{a}
	Site-3	6.3 ^{a}	0.0232 ^{a}	0.0044^{a}	0.003 ^{b}	0.25^{a}	2.3 ^{b}	69a	12 ^{b}	18^{a}

Different alphabet shows different significant levels at ($p < 0.05$)

The values of total N that contains 0.02 to 0.12 % was not significantly in different studied sites. We found significantly differences in the concentration phosphorous (0.0001 – 0.0112) with high upper layer than lower. Comparisons in potassium and calcium showed significantly differences. Usually, potassium in these studied area are found a few higher amount with large variation. Exchangeable K in soil largely depends on locally fire or leaching and drainage and the composition of parent rock material at different altitudes.

The ANOVA results of Ca (0.01- 0.65%) show that there is significant differences among the studied area. Because the Ca content of the soils in the site -2is significantly lower than others. Organic matter contains in 2 - 5 %

with higher in upper layers. It attributed to the addition of leaf litter annually and high decomposition rates of organic residues. Mean values found for all properties are shown in appendices.

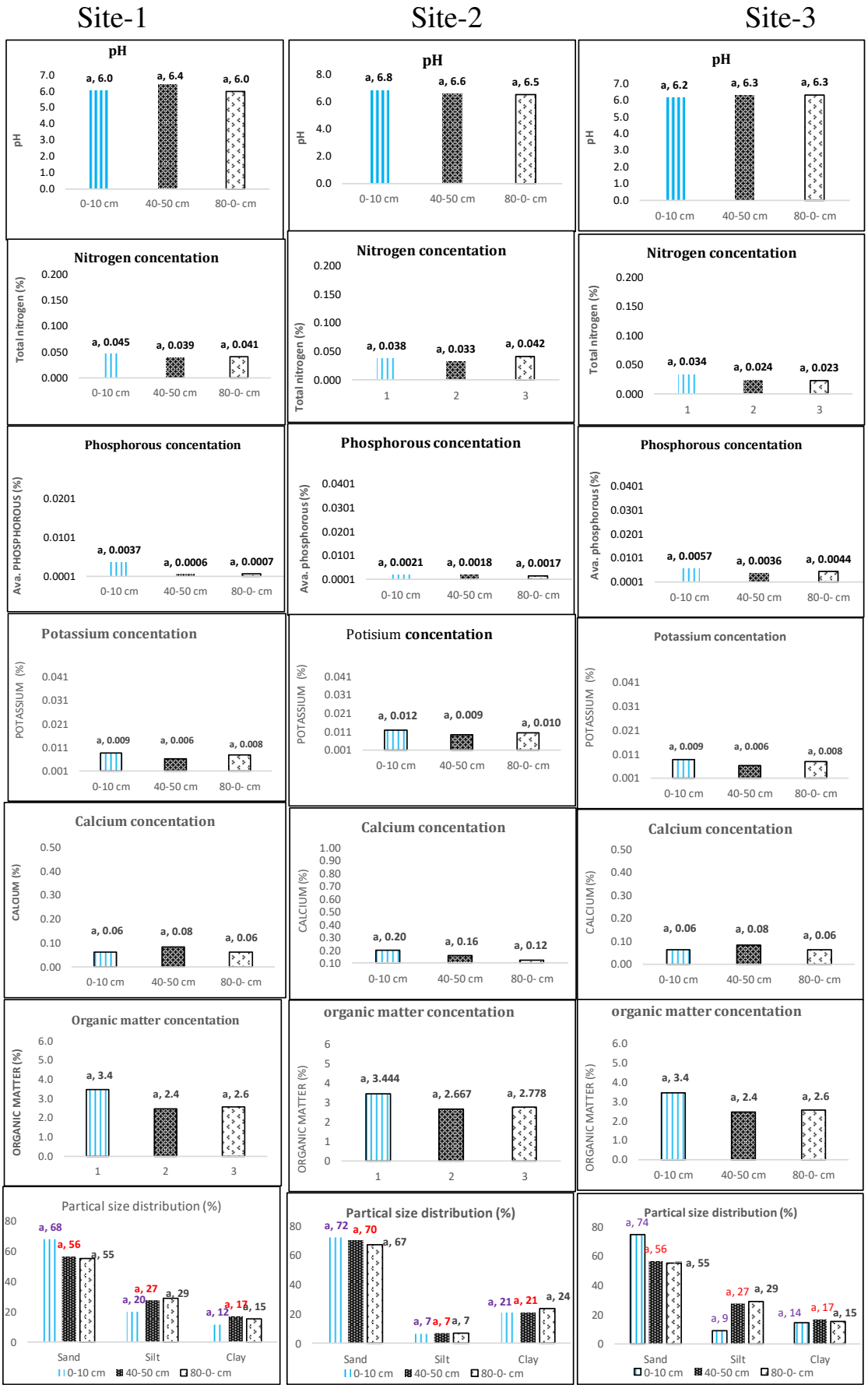

Fig-4 Mean Comparison of soil depths among three studied area

6. Discussions

Tamalan species occurred on deeper soils of the foothills, on ridge tops and on the steepest slopes with shallow soil. Based on soil map of Myanmar Yellow Brown Forest Soils are dominant in most of the study area which were deeper and had higher sand and silt content. The soils are well structured and have a good drainage. They have occurred in site-2 and site-3. Mountain brown forest soil are also occurred in site-1 that deep or shallow and had a higher sand and clay content in well-drained hill sides with the presence of gravel and rock fragments.

Within the study area, out of seven properties of soil tested, only three properties namely pH, nitrogen and organic matter levels were not significantly different among layers to layers, plots area within site and also studied sites. Raf Aertsa, et.al., (2009) mention that *Dalbergia oliveri* in northern Thailand occurred in pH value around (5.2 to 5.5) and elevated values of exchangeable Ca and higher values of exchangeable P. Compared our result that the range of soil pH in study area is (5.0 - 7.7) and the optimum pH range is between 6.2 - 6.6, seen in appendix II. Therefore, soil pH for tamalan species is suitable slightly acid condition to neutral. In Myanmar the soil pH value in lower part of the country is strongly acid conditions under heavy rain and soil pH in central part is strongly alkali condition under dry and high evaporation. These extreme conditions are not suitable to plant tamalan species. Concentration of Nitrogen around 0.03-0.05 %, organic matter 2.5- 3 % are the best range for tamalan species. Texture is predominantly sandy with different values of silt or clay. Phosphorous, Potassium and calcium are dynamic among the studied area. Our results show that studied species has been found low soil nutrient requirements compared with teak, except potassium and calcium.

7. Conclusions

Our studied area have the well drained hill slopes and relatively fertile with high calcium (Ca), potassium (K), and lower amount of nitrogen(N) and phosphorus (P), and moderately amount organic matter (OM) contents and sandy based soil types. Almost all of the study area have lower amount of phosphorous and some are required nitrogen for tree species. However,

Tamalan can adapt to these conditions. It prefers soil pH 6.2 - 6.6, tolerating 5.1 – 7.7. Therefore this plant is not tolerant of salinity. This species is considered to be planted in a wide variety of soils, including many with fertility problems or with difficulties of their physical properties. However this species are suitable for well drained, medium textured and deep soil and little humus. Soil depth up to the C horizon usually should be more than a meter with soil color yellowish brown. Tamalan species is a leguminous tree and is likely to form symbiotic associations with nitrogen fixing bacteria. It may be able to ameliorate the soil chemical properties in degraded sites as its fast decomposing litter is rich in nitrogen, phosphorus and organic carbon. Under the site of nitrogen requirement this species can be added. Based on studied region tamalan grows well under hot and moist conditions on hill sides but also lower part of alluvial soil. Important roles in limiting the distribution and growth pattern of the species are temperature and elevation and other environment factors.

8. Recommendation

All plants require healthy soil in order to thrive, but tamalan species have some different requirements. Most importantly, tamalan species can be planted deep or shallow soil with excellent drainage. Therefore tamalna can be planted in degraded woodland and open areas with various other species under mixed deciduous forest.

Acknowledgement

The authors wish to thank the forest staff from Banmauk, Kyaukse and Gangwe townships in the study areas and our soil lab staff for their kind helps. Appreciation is also extended to our colleagues for their assistances in the various stages of our studies. We are also grateful to our Director of Forest Research Institute, Yezin, for his kind permission to undertake this study. Special thanks go to our teacher Sayar U Sein Thet and sayarma Daw Tin Tin Ohn for their valuable suggestions and comments on the manuscript and encouraging us to conduct our research work.

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Appendix- I

Species composition in three studied sites

Sample unit	No.	Common name	Scientific name	species composition
Site-1	1	Gyo	*Lagerstroemia macrocarpa Kurz.*	1
	2	In	*Dipterocapus tuberculatus Roxb.*	8
	3	Ingyin	*Shorea siamensis (Kurz)Miq.*	20
	4	kyun	*Tectona grandis L.f*	6
	5	Nabe	*Lannea coromandelica(Houtt). Merr.*	2
	6	Padauk	*Pterocarpus macrocarpus Kurz*	6
	7	Pankha	*Terminalia chebula Retz*	1
	8	Pyinkado	*Xylia xylocarpa (Roxb.)Toub.*	7
	9	shitshar	*Phyllanthus pomiferus Hk.f.*	4
	10	Shwephyu	*Sterculiaceae*	2
	11	Tamalan	*Dalbergia oliveri*	15
	12	Taukkyan	*Terminalia crenulata (Heyne)Roth*	2
	13	Tayaw	*Grewia tiliifolia Vahal.*	3
	14	Te	*Diospyros burmanica Kurz*	1
	15	Thit-ni	*Wendlandia tinctoria DC.*	1
	16	Thit-pagan	*Millettia brandisiana Kurz*	1
	17	Thitya	*Shorea obtusa Wall.*	12
	18	Yindaik	*Dalbergia cultrate Grah.*	1
	19	Zeephyu	*Emblica officinalis Gaertn.*	2
Site-2	1	Auchinsa	*Diospyros ehretioides* Wall.	1
	2	Bambwe	*Careya arborea Roxb.*	3
	3	Bebya	*Cratoxylum nerii foliam Kurz*	2
	4	Binga	*Mitragyna rotundifolia (Roxb.) Kuntze*	7
	5	Hman-byu	*Gardenia turgida Roxb.*	9
	6	Hman-ni	*Gardenia erythroelada Kurz.*	3
	7	In	*Dipterocapus tuberculatus Roxb.*	1
	8	Ingyin	*Shorea siamensis (Kurz)Miq.*	1
	9	Kabaung	*Strychnos nux-blanda A.W. Hill*	8
	10	Kokko	*Albizzia lebbek (L.) Benth*	3
	11	Kyaungsha	*Oroxylum indicum (L.)Kun*	1
	12	Kyetyo	*Vitex peduncularis Wall.*	1
	13	kyun	*Tectona grandis L.f*	12
	14	Kyun-gauk-new	*Vitex limnifolia Wall.*	1
	15	Kyun-nalin	*Premna pyramidata Wall.*	1
	16	Nabe	*Lannea coromandelica (Houtt).Merr.*	1

	17	Nagye	*Pterospermum semisagittatum Buch-Ham.*	1
	18	Padauk	*Pterocarpus macrocarpusKurz*	3
	19	Pauk	*Butea monosperma(Lam.)Kuntze*	1
	20	Tabauk	*DalbergiapaniculataRoxb.*	1
	21	Tamalan	*Dalbergiaoliveri*	11
	22	Taukkyan	*Terminalia crenulata (Heyne)Roth*	1
	23	Tawthidin	*Mallotus philipinensis(Lam) .Muell.Arg.*	1
	24	Tayaw	*Grewia tiliifoliaVahal.*	7
	25	Te	*Diospyros burmanica Kurz*	5
	26	Thabut-gyi	*Milius velutina Hool.f. & Thomson*	1
	27	Thadi	*Protium serratum Engl.*	1
	28	Thaminsa	*Randia dumetorum Lam.*	1
	29	Thetyin-gyi	*Croton roxburghianus.N.P.Balakr*	2
	30	Thit-ni	*Wendlandia tinctoria DC.*	1
	31	Thit-pagan	*Millettia brandisiana Kurz*	1
	32	Yindaik	*Dalbergia cultrate Grah.*	1
	33	Yingat-gyi	*Gardenia coronaria Buch-Ham.*	1
	34	Yinzat	*Dalbergia fusca Pierre*	1
	35	Zibyu	*Emblica officinalis Gaertn.*	1
	36	Zinbyun	*Dillenia pentagyna Roxb.*	5
Site-3	1	Binga	*Mitragyna rotundifolia (Roxb.) Kuntze*	1
	2	Chinyoke	*Garuga pinnataRoxb.*	1
	3	Tamalan	Dalbergia oliveri	12
	4	Didu	*Bombax insigne Wall.*	1
	5	Hmanbyu	*Gardenia turgidaRoxb.*	3
	6	In	*Dipterocapus tuberculatus Roxb.*	6
	7	Ingyin	*Shorea siamensis(Kurz)Miq.*	12
	8	Khabaung	*Strychnoxnux-blunda A.W. Hill*	2
	9	Kuthan	*Hymenodictyon orixense (Roxb.) Mabb.*	1
	10	Kyetyo	*Vitex peduncularis Wall.*	4
	11	kyun	*Tectona grandisL.f*	1
	12	Lunbo	*Buchania lanzan Spreng.*	2
	13	Madama	*Dalbergia ovata Grah.*	2
	14	Nabe	*Lannea coromandelica (Houtt).Merr.*	1
	15	Nibase	*Moninda tinctoria Roxb.*	1

Sample Unit	N0.	Common Names	*Scientific names*	species composition
	16	Pankha	*Terminalia chebula Retz.*	2
	17	Pyinkado	*Xylia xylocarpa (Roxb.)Toub.*	3
	18	Seikche	*Bridelia retusa (L.)A.Juss.*	2
	19	Suhtanlayat	-	5
	20	Taukkyan	*Terminalia crenulata (Heyne)Roth*	4
	21	Taungsagwar	*Lagertroemia villosa Wall.ex.Kurz*	1
	22	Tawthidin	*Terminalia crenulata (Heyne)Roth*	5
	23	Tayaw	*Grewia tiliifoliaVahal.*	3
	24	Te	*Diospyros burmanica Kurz*	1
	25	Thabye	*Syzygium cumini (L.) skeels*	2
	26	Thadi	*Protium serratum Engl.*	2
	27	Thatyinkyi	*Diospyros burmanicaKurz*	2
	28	Thitpagan	*Croton roxburghianus.N.P.Balakr*	3
	29	Thitya	*Shorea obtusa Wall.*	5
	30	Yingat-gyi	*Gardenia coronaria Buch-Ham.*	4
	31	Zamani	*Hiptage candicans Hk.f*	1
	32	Zeephyu	*Hiptage candicansHk.f.*	3

Appendix- II

ANOVA for comparison of three sites

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
pH	Between Groups	3.505	2	1.753	3.926	.024
	Within Groups	34.817	78	.446		
	Total	38.322	80			
N	Between Groups	.003	2	.002	4.425	.015
	Within Groups	.028	78	.000		
	Total	.031	80			
P	Between Groups	.000	2	.000	12.350	.000
	Within Groups	.000	78	.000		
	Total	.001	80			
K	Between Groups	.001	2	.000	17.025	.000
	Within Groups	.002	78	.000		
	Total	.002	80			
Ca	Between Groups	.308	2	.154	14.582	.000
	Within Groups	.824	78	.011		
	Total	1.132	80			
OM	Between Groups	.914	2	.457	.411	.664
	Within Groups	86.667	78	1.111		
	Total	87.580	80			
Sand	Between Groups	3116.765	2	1558.383	16.006	.000
	Within Groups	7594.222	78	97.362		
	Total	10710.988	80			
Silt	Between Groups	5345.852	2	2672.926	46.904	.000
	Within Groups	4445.037	78	56.988		
	Total	9790.889	80			
Clay	Between Groups	910.296	2	455.148	7.365	.02
	Within Groups	4820.593	78	61.802		
	Total	5730.889	80			

Mean comparison of soil properties in each study area

	No.	pH		Nitrogen(%)		Phosphorous (%)		Potassium(%)		Calcium(%)		Organic matter (%)		Sand (%)		Silt(%0		Clay(%)	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Site-1	3	6.5[a]	0.1	0.042[a]	0.010	0.0024[a]	0.0005	0.008[a]	0.001	0.16[a]	0.09	3.3[a]	0.9	70[a]	3	4[a]	1	24[a]	4
	3	5.8[a]	0.2	0.034[a]	0.008	0.0008[a]	0.0004	0.009[a]	0.002	0.10[a]	0.07	3.0[a]	0.6	69[a]	3	11[a]	3	18[a]	2
	3	7.0[a]	0.3	0.045[a]	0.003	0.0027[a]	0.0013	0.011[a]	0.001	0.26[a]	0.09	3.3[a]	0.7	72[a]	5	7[a]	2	19[a]	4
	3	6.2[a]	0.3	0.027[a]	0.001	0.0009[a]	0.0007	0.008[a]	0.002	0.06[a]	0.01	2.0[a]	0.0	74[a]	6	4[a]	1	19[a]	6
	3	6.8[a]	0.4	0.036[a]	0.016	0.0015[a]	0.0008	0.015[a]	0.003	0.22[a]	0.09	3.7[a]	0.9	74[a]	1	7[a]	1	17[a]	2
	3	6.7[a]	0.2	0.030[a]	0.005	0.0011[a]	0.0004	0.010[a]	0.003	0.12[a]	0.07	2.7[a]	0.7	65[a]	2	8[a]	1	25[a]	3
	3	6.6[a]	0.3	0.061[a]	0.016	0.0030[a]	0.0016	0.011[a]	0.005	0.23[a]	0.10	3.3[a]	0.7	64[a]	2	5[a]	1	31[a]	1
	3	6.7[a]	0.3	0.024[a]	0.003	0.0018[a]	0.0009	0.011[a]	0.005	0.17[a]	0.11	2.7[a]	0.7	78[a]	3	4[a]	1	16[a]	3
	3	6.3[a]	0.1	0.037[a]	0.014	0.0027[a]	0.0011	0.011[a]	0.003	0.11[a]	0.05	2.7[a]	0.7	61[a]	3	11[a]	3	25[a]	6
Site-2	3	6.1[a]	0.4	0.034[a]	0.016	0.0045[a]	0.0029	0.007[a]	0.002	0.09[a]	0.06	3.3[a]	0.7	61[a]	3	15[a]	7	23[a]	8
	3	5.7[a]	0.3	0.051[a]	0.006	0.0014[a]	0.0009	0.010[a]	0.001	0.05[a]	0.01	2.7[a]	0.3	62[a]	8	30[a]	11	5[a]	1
	3	5.5[a]	0.3	0.028[a]	0.006	0.0014[a]	0.0006	0.007[a]	0.001	0.05[a]	0.01	3.3[a]	0.9	63[a]	8	18[a]	2	20[a]	7
	3	6.8[a]	0.4	0.025[a]	0.007	0.0012[a]	0.0010	0.004[a]	0.001	0.08[a]	0.01	3.7[a]	0.7	53[a]	9	39[a]	9	8[a]	4
	3	7.3[a]	0.0	0.033[a]	0.004	0.0007[a]	0.0005	0.003[a]	0.000	0.11[a]	0.02	2.7[a]	0.7	50[a]	2	29[a]	5	21[a]	4
	3	6.6[a]	0.7	0.027[a]	0.006	0.0009[a]	0.0007	0.007[a]	0.005	0.10[a]	0.04	2.0[a]	0.0	59[a]	3	26[a]	8	17[a]	5
	3	5.5[a]	0.2	0.038[a]	0.000	0.0028[a]	0.0013	0.019[a]	0.003	0.02[a]	0.00	3.0[a]	1.0	57[a]	5	22[a]	0	19[a]	5
	3	5.7[a]	0.1	0.083[a]	0.023	0.0018[a]	0.0003	0.006[a]	0.000	0.06[a]	0.02	2.7[a]	0.7	68[a]	5	22[a]	8	10[a]	4
	3	6.1[a]	0.6	0.058[a]	0.018	0.0011[a]	0.0006	0.006[a]	0.002	0.09[a]	0.03	2.7[a]	0.7	65[a]	6	18[a]	5	16[a]	4
Site-3	3	6.0[a]	0.7	0.041[a]	0.014	0.0028[a]	0.0023	0.007[a]	0.002	0.08[a]	0.03	2.7[a]	0.7	65[a]	6	18[a]	5	16[a]	4
	3	5.9[a]	0.5	0.028[a]	0.009	0.0035[a]	0.0025	0.003[a]	0.000	0.21[a]	0.12	2.7[a]	0.7	84[a]	4	6[a]	1	7[a]	1
	3	6.8[a]	0.3	0.035[a]	0.010	0.0035[a]	0.0016	0.004[a]	0.001	0.34[a]	0.04	2.7[a]	0.7	80[a]	5	5[a]	1	15[a]	5
	3	6.6[a]	0.0	0.034[a]	0.005	0.0069[a]	0.0023	0.003[a]	0.001	0.24[a]	0.01	3.3[a]	0.7	79[a]	1	9[a]	1	11[a]	2
	3	6.3[a]	0.1	0.035[a]	0.006	0.0030[a]	0.0008	0.004[a]	0.001	0.25[a]	0.01	2.0[a]	0.0	73[a]	1	10[a]	1	16[a]	1
	3	5.8[a]	0.4	0.018[a]	0.002	0.0036[a]	0.0023	0.003[a]	0.001	0.27[a]	0.00	3.0[a]	0.6	65[a]	9	15[a]	5	17[a]	4
	3	6.3[a]	0.1	0.022[a]	0.006	0.0088[a]	0.0005	0.003[a]	0.001	0.28[a]	0.10	2.7[a]	0.7	60[a]	12	15[a]	4	23[a]	9
	3	6.0[a]	0.2	0.023[a]	0.003	0.0042[a]	0.0024	0.002[a]	0.000	0.10[a]	0.00	2.0[a]	0.0	79[a]	2	8[a]	0	11[a]	2
	3	6.3[a]	0.2	0.022[a]	0.004	0.0025[a]	0.0003	0.004[a]	0.000	0.16[a]	0.04	3.0[a]	1.0	70[a]	6	11[a]	3	21[a]	4

Different alphabet shows different significant levels at ($p < 0.05$)