

**Government of the Union of Myanmar
Ministry of Forestry
Forest Department**



**Some Physical and Chemical Properties of Surface Soils
(Phugyi Dam Watershed)**

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1992

ဖူးကြီးရေဝေရေလဲဒေသ သစ်တောမြေရူပနှင့်ဓါတု ဂုဏ်သတ္တိများလေ့လာခြင်း

ဒေါ်ခင်မေလွင် (B.Sc. [I.C] [Rgn.]) သုတေသနလက်ထောက် (၂)
ဦးချစ်လှိုင် (B.Sc. [For.] [Rgn.], M.Res. Sci. (UNE)) လက်ထောက်ညွှန်ကြားရေးမှူး
သစ်တောသုတေသနဌာန
နှင့်
ဦးစိန်သက် (B.Sc.[For.] [Rng.], M.Sc. (ANU), MIFA) လက်ထောက်ညွှန်ကြားရေးမှူး
ကင်းတားရေဝေရေလဲစီမံကိန်း

စာတမ်းအကျဉ်းချုပ်

ဖူးကြီးရေဝေရေလဲဒေသအတွင်း သစ်တောစိုက်ခင်းများ တည်ထောင်ခြင်းဖြင့် ရေမြေထိန်းသိမ်းရေး အထူးသဖြင့် ဖူးကြီးကန် ရေကောင်းရေသန့်ရရှိရေးနှင့် သစ်တောများပြန်လည် စိမ်းလန်းစိုပြေရေးအတွက် ဆောင်ရွက်လျက်ရှိပါသည်။ ဤစာတမ်းတွင် ဖူးကြီးရေဝေရေလဲဒေသရှိ သစ်တောဧရိယာ တောပျက် ခြုံပုတ်တောဧရိယာ မြက်ခင်းဧရိယာနှင့် ဥယျာဉ်ခြံမြေဧရိယာ အစရှိသော မြေအသုံးချမှု (၄)မျိုး(၄)စားမှ အပေါ်ယံမြေလွှာများ၏ အချို့သောရူပနှင့် ဓါတုဂုဏ်သတ္တိများကို လေ့လာခဲ့ခြင်းဖြစ်ပြီး တွေ့ရှိချက်များကို မြန်မာနိုင်ငံရှိ အချို့သောဒေသများမှ လေ့လာတွေ့ရှိပြီးဖြစ်သော သစ်တောမြေများ၏ ရူပနှင့်ဓါတုဂုဏ်သတ္တိ များနှင့် နှိုင်းယှဉ်တင်ပြ ဆွေးနွေးထားပါသည်။

Some Physical and Chemical Properties of Surface Soils (Phugyi Dam Watershed)

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Abstract

Soil and water conservation measures are currently being undertaken through reforestation Schemes in Phugyi Dam Watershed in order to restore the environmental function of the area, particularly in the aspect of water quality parameters. In this paper, physical and chemical properties of the Phugyi surface soils from 4 different land uses of forests, scrubs, wild grass lands, and fruit trees and orchard areas, are evaluated and also discussed in comparison with those of forest soils that had been previously investigated in some other parts of Myanmar.

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1. Introduction

Yangon is the capital and commercial centre of the Union of Myanmar and about 9% of the country's population resides in the city. From 1970 to 1990, the population of Yangon rose from 1.87 to some 3.6 million inhabitants. The city draws its major water supply from three rain-fed reservoirs, viz (a) Phugyi (b) Hlawga, and (c) Gyobyu; supplement by operation tubewells. While the Gyobyu catchment is environmentally sound, Hlawga, being closer to the city, is often subjected to water pollution even though the reservoir area is fully protected. Phugyi Dam Watershed, the most important water supply source, adjoins the heavily populated townships of Hmawbi and Taikgyi, with the result that the primary forests are seriously degraded, and urgent measures are needed to restore the protective forest cover, and water and soil conservation. Soil studies in the Phugyi Dam Watershed will provide some information for rehabilitation and management of the catchment.

Study Area

Phugyi Dam Watershed, which falls in parts of the reserves, Hlaing Yoma and South Hlaing Yoma, is located in Taikgyi township, about 40 miles in road distance from Yangon. It has a total area of some 7,930 ha, of which land area covers 78% and the rest is occupied by water impounded area (reservoir). General topography is rolling to moderately steep, and elevation at the dam site is round 75 m (a.s.l) and the highest elevation of 152 m (a.s.l) is found in the northern part. Average annual rainfall is about 2,700 mm with a wet season of 6 months from May through October.

Much of the original vegetation (mostly deciduous and semi-ever-green forests) has been degraded due to a number of inappropriate uses such as timber and fuelwood cuttings, exploitative farming and annual fire out-breaks. A list of tree species, occurring in the forests are given in Appendix 1.

It is an open-typed catchment and Section 144 has been recently notified and exercised in order to prohibit trespasses in the area.

As a result of population growth and agriculture encroachment, parts of the original vegetation has been converted to scrubs, wild grass lands (locally termed as Japanese grass), orchards, cultivated farms and "phonzo areas". At present, wild grass lands are being reforested by establishing forest plantations. In the past orchards were extensively established with citrus species and banana. However, due to degradation in soil structure and fertility with the age of cultivation, it was observed in recent years that there was a shift towards the introduction of new fruit trees such as Thiho-thayet. (*Anacardium occidentale* Linn.) in place of citrus species for better earnings.

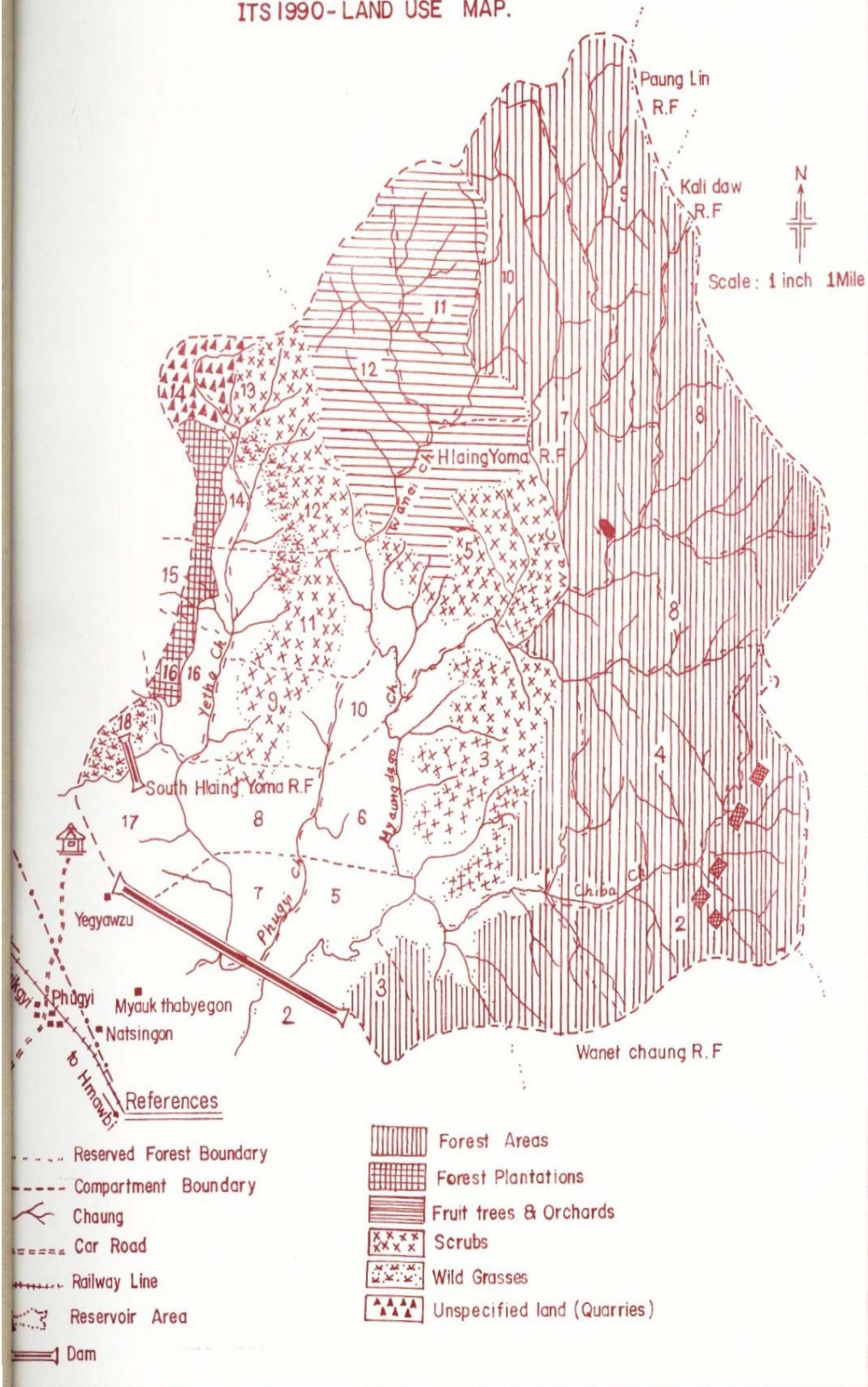
With reference to last-year field survey, undertaken by the Kinda Dam Watershed Pilot Project, the following land uses were identified in the catchment.

Land Use	Area (ha)	Percentage (%)
Forests	1350	17
Scrub	3050	39
Wild grass	500	6
Unspecified land (Quarries)	400	5
Forest plantation	100	1
Fruit tree orchards	700	9
Cultivated farms	80	1
Reservoir area	1750	22
Total	7930	100

Map showing the watershed area and land uses is shown in Figure 1.

Figure-1

PHUGYI DAM WATERSHED & ITS 1990-LAND USE MAP.



2 Materials and Methods

2.1 Soil Sampling

Surface soil samples were augered from randomly selected locations in 4 different types of land uses namely forests, scrubs, wild grass lands, and fruit trees and orchard areas.

Two locations were randomly marked on the standard trographic map in each of land use types; for forests, one in each of Compartments 4 and 7 of Hlaing Yoma Reserve; for scrubs, one in Compartment 9 of Hlaing Yoma Reserve and one in Compartment 3 of South Hlaing Yoma Reserve; for wild grass lands, one in each of Compartment 14 and 16 South Hlaing Yoma Reserve; and for orchards, one in each of Compartments 5 and 12 of Hlaing Yoma Reserve.

In the field, an equilateral triangle of 100 m sides out a each selected point and the final sampling sites were marked at the 3 corners of each triangle.

Surface soil sampling can be summarized as follows:-

Land Use Type	Forest Reserve	Compartment	No. of Sampling Sites
Forests	Hlaing Yoma	7	3
	South Hlaing Yoma	4	3
Scrubs	Hlaing Yoma	9	3
	South Hlaing Yoma	3	3
Wild grass	South Hlaing Yoma	14	3
	South Hlaing Yoma	16	3
Orchards	Hlaing Yoma	5	3
	Hlaing Yoma	12	3
Total number of sampling sites			24

Detailed sampling was undertaken in 2 strip planting trial plots of 1991-92 in Compartment 16 of South Hlaing Yoma Reserve. Area of each plot is about 10 ha (25 acres).

A diagonal line was drawn in the first plot (ie. Plot A) and augering was done at 5 sampling sites of equal distance demarcated on the line. Soil samples were augered from surface to a depth of 100 cm at each site with depth increments of 20 cm. Similarly, soil samples were collected in the second plot (ie Plot B).

2.2 Laboratory Techniques

All soil samples were air-dried and ground through a 2 mm sieve, and soil samples were analysed for physical and chemical properties.

2.3 Particle Size Distribution

Particle size distribution of soil samples were carried out by mechanical analysis using the hydrometer method.

2.4 Organic Matter

Organic matter was detected from the weight loss on ignition at 550 °C for two hours by means of Muffle furnace.

2.5 Soil Reaction P^H

P^H was determined by using Corning P^H meter model 12 equipped with glass electrodes on soil distilled water suspension (1:2.5).

2.6 Electrical Conductivity (E.C)

Electrical conductivity was determined by using YSI model 3 Conductivity Bridge meter and mentioned as umhos/cm.

2.7 Total Nitrogen (Total N%)

Total nitrogen levels were assessed by kjeldahl's methods by using Labconco Macro Kjeldahl, digestion and distillation unit.

2.8 Available Phosphorus (Ave. P%)

On fine earth, available phosphorus levels were assessed with Double acid extracting solution and Molybdenum – blue complex method by using Perkin Elmer 55E, Spectrophotometer at 660 nm wave length.

2.9 Available Potassium, Sodium, Calcium, Magnesium and Iron (Ava. K, Na, Ca, Mg and Fe %)

On fine earth, available potassium, sodium, calcium, magnesium levels were assessed with Double-acid extracting solution, by using Perkin Elmer, Atomic absorption Spectrophotometer, model 2280.

3. Results and Discussion

Physical and chemical properties of surface soil samples of differing land uses are presented in Appendix 2, and those of soil samples, collected from strip planting trial plots are presented in Appendix 3.

Sandy clay loam texture is common in Phugyi watershed. According to pervious studies conducted by Sein Thet and Tin Tin Ohn (1983) it is asserted that the Phugyi surface soils, regardless of differing land uses, are favourable for tree growth. Many of the apparent direct effects of soil acidity on tree growth may, in fact, result from its indirect effects on soil conditions such as microbial activity and nutrient availability. Most tree species can be grown in soils within the soil reaction range of P^H 4.5 and 6.5 (Pritchett, 1979). Moreover, tree seedlings generally develop best in soil having reaction values between p^H 4.5 and 6.0 (Harold *et al* 1966). Except for a few cases, most of the forest species grow well in fairly acidic soils. Regarding soil reaction, this study indicates that p^H values of the surface soils under any land uses type lies within the range, favourable for the plant growth.

Electrical Conductivity of surface soils from all sites, tends to decrease with depth (Appendix 3). Specific conductance approaching 1000 umho/ml is indicative of abnormally high concentrations of soluble salts (Sein That and Tin Tin Ohm, 1983).

Electric Conductivity of Phugyi surface soils are much lower than that of Yupataung soils of Thazi (Sein Thet and Tin Tin Ohn, 1984) and it is highly comparable to the surface soils from compt. 31 of Pozaundaung reserve of Yamethin, and Compt.93 of Saingye reserve and Compt.21 of Bondaung reserve of Taungoo (Sein Thet, 1983). Apparently, the Electrical Conductivity of the samples from all sites of differing land uses in this study area are much lower than the level, which is harmful to the growth of commercial tree species.

Organic matter contents of the surface soils from all sampling sites are found to be low, particularly if compared to those of East Pegu Yoma forest soils, investigated by Sein Thet and Tin Tin Ohn, 1982. Annual wild fires and soil erosion were possibly responsible for those low contents of the organic matter.

Various nutrient concentration levels for each land use in soils are shown in Table 1. This table presents the average of nutrient concentrations and this table is derived from Appendix 2. Wilde *et al* (1972) stated that species of low nutrient requirement may grow properly in soil of total nitrogen content as low as 0.07%. It was observed that mean nitrogen concentrations of samples from forests, scrubs are comparable to those of much of the soil from East Pegu Yoma (Tin Tin Ohn and Sein Thet, 1982), although mean nitrogen concentrations of samples from wild grass lands are considerably low. It shows that forest species would require additional nitrogen if forest plantations are to be established in the wild grass lands.

Available phosphorus levels of the surface soils from all the sampling sites are found to fall between 0.00004% to 0.00112% (see Appendix 2). Wild *et al* (1972) claimed that for most of the plants, the minimum requirement of phosphorus for normal growth was about 0.002%. The phosphorus concentration levels in the surface soils of the catchment are therefore much lower than that requirement, like those of surface soils from Inbinwa and Pinyinma reserve of the Dry Zone (Sein Thet and Tin Tin Ohn, 1983).

Available potassium concentration in soils for normal plant growth was 0.00025% and above (Wilde *et al*, 1972) and the results reveal that available potassium concentrations in the soils of the watershed for all 4 land uses are well above this levels. Therefore, the catchment surface soils have quite sufficient concentrations of potassium (ranging from 0.00038% to 0.0093%) for plant growth.

Table 1. Physical and Chemical Properties of Surface Soils from 4 Different land Use Types.

Land Use	Texture (Sandy Clay Loam)			p ^H	E.C u mhos per cm	O.M %	Total-N %	Ava-P %	Ava-K %	Ava-Na %	Ava-Mg %	Ava-Ca %	Ava-Fe%
	% sand	% Silt	% Clay										
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Forest	51	15	31	5.4	3.4	1.09	0.0624	0.00005	0.0056	0.0065	0.068	0.101	0.248
Scrubs	59	15	25	5.4	3.4	2.57	0.0962	0.00011	0.0080	0.0078	0.089	0.115	0.328
Wild grass lands	70	8	20	5.5	4.3	2.25	0.0329	0.00035	0.0037	0.0064	0.062	0.099	0.077
Feuit trees and Orchards	54	16	29	5.2	4.6	1.80	0.1026	0.00017	0.0067	0.0063	0.063	0.090	0.105

Concentrations of other nutrients such as Calcium, Magnesium, Sodium and Iron tend to be high for normal growth of forest trees. The possible reason is that clay fraction of the surface soils in this study may hold both water and nutrients, in stead of leaching down words.

Although soil texture from the soils of the strip planting trial plots is found to be sandy clay loam through out the profile down to 100 cm, with the exception of the first 0-20 cm layer, which is sandy loam, chemical properties such as P^H value, Electrical Conductivity and concentrations of primary nutrients of the top layers of the samples are observed to be similar to those of surface soils from four different land use types.

4. Conclusion

Soil texture of the Phugyi Dam Watershed tends to be sandy clay loam, which is favourable for plant growth. Except for the deficiency of N in soils of wild grasslands and available phosphorus for the whole catahment, all other nutrients seem to be in the range which is positive for normal growth of forest trees. The comparable results between the surface soil at four different land use types and detailed study at trial plots showed that physical and chemical properties of surface soils for the whole Phugyi Dam Watershed are more or less in the same order of element concentrations. Choice of plantation species adaptable to the prevailing total rainfall and distribution as well as effective protection against annual fire out-breaks may be the key issues to revegetate the degraded catchment. It may also be a helpful tool in maintaining or even improving water resources development, particularly in the aspect of water quality parameters.

Generally, physical properties and primary nutrient concentration levels of the Phugyi forest soils under any type of vegetation are, with the exception of the phosphorus deficiency in all types of land use and nitrogen deficiency in wild grass lands, are in favourable conditions for tree growth.

Appendix 1.

Forest Tree Species found in the study area.

<u>Myanmar Name</u>	<u>Botanical Name</u>
Kyun	<i>Tectona grandis</i> linn.f.
Pyinkado	<i>Xylia dolabriformis</i> Benth.
Yemane	<i>Gmelina arborea</i> Roxb.
Pyinma	<i>lagerstroemia speciosa</i> Pers.
Binga	<i>Mitragyna rotundifolia</i> O. Ktze.
Mani awga	<i>Carallia brachiata</i> (Lour.)
Gyo	<i>Schleichera oleosa</i> (Lour.)
Myauk ngo	<i>Duabanga grandiflora</i> (Roxb.)
Myauk chaw	<i>Homolium tomentosum</i> Benth.
Bambwe	<i>Careya arborea</i> Roxb.
Nabe	<i>Lannea grandis</i> Engler.
Didu	<i>Salmalia insignis</i> Schott & Endl.
Letpan	<i>Salmalia malabrica</i> (DC.) Schott & Endl.
Bonmeza	<i>Albizia chinensis</i> (Osbeck.) Merr.
Aukchinsa	<i>Diospyros ehretioides</i> Wall.
Taung-peinne	<i>Artocarpus calophyla</i> Lamk.
Taung-petwum	<i>Pterospermum lanceaefolium</i> Roxb.
Sit	<i>Albizia proceara</i> Benth.
Kanyin	<i>Dipterocarpus alatus</i> Roxb.
Ma-u-letan-she	<i>Anthocephalus cadamba</i> Mig.
Zibyun	<i>Dillenia pulcherrima</i> kurz.
Gwe	<i>Spondias pinnata</i> Linn.
Tha-yet	<i>Mangifera indica</i> Linn.
The-bye	<i>Syzygium cumini</i> Linn. syzygium spe;
Zi-bhyu	<i>Emblica officinalis</i> Gaertn.
Hlat-htok	<i>Holorrhena antidysenterica</i> Wall.
Bebya	<i>Cratoxylon neriifolium</i> Kurz.
Ma-u-radon	<i>Nauclea orientalis</i> Linn.
Thande	<i>Stereospermum neuranthum</i> Kurz.
Kya-thaung-wa	<i>Bambusa polymorpha</i> Munio.

Appendix 2.

Some Physical and Chemical Properties of surface Soils.

Sr. No.	Properties	Sampling Sites		
		1	2	3
I. FOREST LAND USE				
A. Compt. 7 of Hlaing Yoma Reserve				
Physical Properties				
1.	Texture	sandy	sandy	Sandy
		clay	clay	Clay
		loam	loam	Loam
	Sand %	55	51	59
	Silt %	14	18	16
	Clay %	28	28	22
Chemical Properties				
2.	Soil Reaction (P ^H)	5.8	5.0	5.6
3.	Electrical Conductivity (u mhos/ml)	3.8	5.0	4.0
4.	Organic Matter Content (%)	1.52	1.54	1.50
5.	Total Nitrogen N(%)	0.0760	0.0817	0.1045
6.	Available Phosphorus P(%)	0.00006	0.00006	0.00004
7.	Available Potassium K(%)	0.0067	0.0049	0.0077
8.	Available Sodium Na(%)	0.0066	0.0064	0.0066
9.	Available Magnesium Mg(%)	0.067	0.068	0.068
10.	Available Calcium Ca(%)	0.100	0.098	0.098
11.	Available Iron Fe(%)	0.241	0.187	152

Sr. No.	Properties	Sampling Sites		
		1	2	3
I. FOREST LAND USE				
B. Compt. 4 of South Hlaing Yoma Reserve				
Physical Properties				
1.	Texture	sandy	sandy	Sandy
		clay	clay	Clay
		loam	loam	Loam
	Sand %	28	52	61
	Silt %	18	18	4
	Clay %	49	29	25
Chemical Properties				
2.	Soil Reaction (P ^H)	5.3	5.4	5.3
3.	Electrical Conductivity (u mhos/ml)	2.5	2.5	2.5
4.	Organic Matter Content (%)	0.88	0.62	0.46
5.	Total Nitrogen N(%)	0.0798	0.0703	0.0703
6.	Available Phosphorus P(%)	0.00006	0.00004	0.00004
7.	Available Potassium K(%)	0.0047	0.0047	0.0050
8.	Available Sodium Na(%)	0.0069	0.0064	0.0065
9.	Available Magnesium Mg(%)	0.075	0.069	0.064
10.	Available Calcium Ca(%)	0.105	0.104	0.101
11.	Available Iron Fe(%)	0.336	0.316	0.259

Sr. No.	Properties	Sampling Sites		
		1	2	3
III.				
A. Compt. 14 of South Hlaing Yoma Reserve				
Physical Properties				
1.	Texture	sandy	Sandy	Sandy
		clay	Clay	Clay
		loam	Loam	Loam
	Sand %	65	74	77
	Silt %	8	8	8
	Clay %	24	14	12
Chemical Properties				
2.	Soil Reaction (P ^H)	5.3	5.4	5.5
3.	Electrical Conductivity (u mhos/ml)	3.8	5.0	-
4.	Organic Matter Content (%)	2.03	2.59	2.03
5.	Total Nitrogen N(%)	0.0399	0.0589	0.0190
6.	Available Phosphorus P(%)	0.00032	0.00047	0.00044
7.	Available Potassium K(%)	0.0037	0.0038	0.0038
8.	Available Sodium Na(%)	0.0064	0.0066	0.0067
9.	Available Magnesium Mg(%)	0.062	0.062	0.062
10.	Available Calcium Ca(%)	0.092	0.092	0.105
11.	Available Iron Fe(%)	0.030	0.019	0.171

Sr. No.	Properties	Sampling Sites		
		1	2	3
III.				
B. Compt. 16 of South Hlaing Yoma Reserve				
Physical Properties				
1.	Texture	sandy	Sandy	Sandy
		clay	Clay	Clay
		loam	Loam	Loam
	Sand %	73	59	72
	Silt %	6	8	8
	Clay %	18	30	18
Chemical Properties				
2.	Soil Reaction (P ^H)	5.8	5.1	5.5
3.	Electrical Conductivity (u mhos/ml)	5.0	3.8	3.8
4.	Organic Matter Content (%)	1.73	2.80	2.27
5.	Total Nitrogen N(%)	0.0190	0.0209	0.0399
6.	Available Phosphorus P(%)	0.00028	0.00028	0.00032
7.	Available Potassium K(%)	0.0052	0.0026	0.0026
8.	Available Sodium Na(%)	0.0063	0.0064	0.0064
9.	Available Magnesium Mg(%)	0.064	0.064	0.062
10.	Available Calcium Ca(%)	0.104	0.103	0.102
11.	Available Iron Fe(%)	0.105	0.077	0.064

Sr. No.	Properties	Sampling Sites		
		1	2	3
IV. ORCHARDS				
A. Compt. 5of Hlaing Yoma Reserve				
Physical Properties				
1.	Texture	sandy	Sandy	Sandy
		clay	Clay	Clay
		loam	Loam	Loam
	Sand %	69	58	56
	Silt %	8	14	22
	Clay %	19	27	26
Chemical Properties				
2.	Soil Reaction (P ^H)	5.5	5.2	5.3
3.	Electrical Conductivity (u mhos/ml)	12.5	2.5	2.5
4.	Organic Matter Content (%)	0.11	0.39	0.73
5.	Total Nitrogen N(%)	0.0342	0.0171	0.0570
6.	Available Phosphorus P(%)	0.00006	0.00006	0.00006
7.	Available Potassium K(%)	0.0090	-	0.0056
8.	Available Sodium Na(%)	0.0064	0.0064	0.0065
9.	Available Magnesium Mg(%)	0.066	0.064	0.066
10.	Available Calcium Ca(%)	0.102	0.100	0.058
11.	Available Iron Fe(%)	0.236	0.123	0.064

Sr. No.	Properties	Sampling Sites		
		1	2	3
IV. ORCHARDS				
B. Compt. 12 of Hlaing Yoma Reserve				
Physical Properties				
1.	Texture	sandy	Sandy	Sandy
		clay	Clay	Clay
		loam	Loam	Loam
	Sand %	44	39	59
	Silt %	16	18	14
	Clay %	36	38	26
Chemical Properties				
2.	Soil Reaction (P ^H)	5.3	5.0	4.9
3.	Electrical Conductivity (u mhos/ml)	3.8	3.8	2.5
4.	Organic Matter Content (%)	3.53	3.75	2.31
5.	Total Nitrogen N(%)	0.4560	0.0171	0.0342
6.	Available Phosphorus P(%)	0.00028	0.00028	0.00028
7.	Available Potassium K(%)	0.0041	0.0041	0.0041
8.	Available Sodium Na(%)	0.0060	0.0064	0.0062
9.	Available Magnesium Mg(%)	0.062	0.062	0.062
10.	Available Calcium Ca(%)	0.094	0.093	0.092
11.	Available Iron Fe(%)	0.091	0.069	0.051

Some Physical and Chemical Properties of Soil samples of strip planting trial plots
(From 2 trial plots of 1991-92, compt.16 of Hlaing Yoma Reserve, Phugyi Dam
Catchment.

Sr. No	Properties	Depth from surface (cm)				
		0-20	20-40	40-60	60-80	80-100
I. Plots A						
a. Sampling Site A1.						
Physical Properties						
1.	Texture	sandy	sandy	sandy	sandy	sandy
			clay	clay	clay	clay
		loam	loam	loam	loam	loam
	Sand %	88	76	67	69	67
	Silt %	2	4	4	4	6
	Clay %	8	16	26	22	26
Chemical Properties						
2.	Soil Reaction (P ^H)	5.5	5.4	5.6	5.3	5.4
3.	Electrical Conductivity (u mhos/ml)	6.8	5.0	5.0	3.8	2.5
4.	Organic Matter Content (%)	0.59	0.92	0.81	0.54	1.05
5.	Total Nitrogen N(%)	0.065	0.084	0.057	0.046	0.067
6.	Available Phosphorus P(%)	0.00050	0.00035	0.00038	0.00034	0.00035
7.	Available Potassium K(%)	0.0150	0.0146	0.0147	0.0144	0.0147
8.	Available Sodium Na(%)	0.0076	0.0075	0.0073	0.0072	0.0075
9.	Available Magnesium Mg (%)	0.130	0.132	0.137	0.135	0.133
10.	Available Calcium Ca(%)	0.049	0.052	0.051	0.051	0.050
11.	Available Iron Fe(%)	0.0193	0.0229	0.0253	0.0174	0.0088
b. Sampling Site A2.						
Physical Properties						
1.	Texture	sandy	sandy	sandy	sandy	sandy
		clay	clay	clay	clay	clay
		loam	loam	loam	loam	loam
	Sand %	77	70	65	68	66
	Silt %	6	6	6	6	6
	Clay %	16	20	26	24	23
Chemical Properties						
2.	Soil Reaction (P ^H)	5.4	5.3	5.4	5.6	5.6
3.	Electrical Conductivity (u mhos/ml)	3.8	3.8	3.8	3.8	2.5
4.	Organic Matter Content (%)	0.58	0.67	1.17	0.41	0.77
5.	Total Nitrogen N(%)	0.086	0.065	0.049	0.015	0.049
6.	Available Phosphorus P(%)	0.00050	0.00038	0.00040	0.00034	0.00038
7.	Available Potassium K(%)	0.0148	0.0152	0.0148	0.0148	0.0148
8.	Available Sodium Na(%)	0.0073	0.0072	0.0074	0.0074	0.0073
9.	Available Magnesium Mg(%)	0.131	0.133	0.130	0.127	0.125
10.	Available Calcium Ca(%)	0.053	0.046	0.046	0.046	0.047
11.	Available Iron Fe(%)	0.0095	0.0027	0.0212	0.0236	0.0206

Sr. No.	Properties	Depth from surface (cm)				
		0-20	20-40	40-60	60-80	80-100
I. Plots A						
c. Sampling Site A3.						
Physical Properties						
1.	Texture	sandy	sandy	sandy	sandy	Sandy
			clay	clay	clay	Clay
		loam	loam	loam	loam	loam
	Sand %	65	70	66	63	62
	Silt %	6	8	10	10	12
	Clay %	21	21	23	25	23
Chemical Properties						
2.	Soil Reaction (P ^H)	5.6	5.8	5.5	6.4	5.3
3.	Electrical Conductivity (u mhos/ml)	4.0	5.0	3.8	3.8	2.5
4.	Organic Matter Content (%)	0.96	0.92	0.57	0.60	0.34
5.	Total Nitrogen N(%)	0.084	0.051	0.040	Nil	nil
6.	Available Phosphorus P(%)	0.00040	0.00038	0.00040	0.00038	0.00038
7.	Available Potassium K(%)	0.0154	0.0147	0.0148	0.0149	0.0149
8.	Available Sodium Na(%)	0.0070	0.0068	0.0064	0.0060	0.0061
9.	Available Magnesium Mg(%)	0.048	0.048	0.050	0.060	0.073
10.	Available Calcium Ca(%)	0.123	0.136	0.133	0.130	0.137
11.	Available Iron Fe(%)	0.0178	0.0066	0.0148	0.0147	0.0145
d. Sampling Site A4.						
Physical Properties						
1.	Texture	sandy	sandy	sandy	sandy	sandy
		clay	clay	clay	clay	clay
		loam	loam	loam	loam	loam
	Sand %	81	80	65	71	83
	Silt %	10	8	12	6	4
	Clay %	7	11	19	15	9
Chemical Properties						
2.	Soil Reaction (P ^H)	5.5	6.1	5.5	5.5	5.5
3.	Electrical Conductivity (u mhos/ml)	4.5	5.0	3.8	2.5	2.0
4.	Organic Matter Content (%)	0.76	0.70	0.60	0.34	0.48
5.	Total Nitrogen N(%)	nil	nil	nil	0.038	0.019
6.	Available Phosphorus P(%)	0.00030	0.00100	0.00034	0.00030	0.00039
7.	Available Potassium K(%)	0.0148	0.0146	0.0146	0.0147	0.0146
8.	Available Sodium Na(%)	0.0061	0.0072	0.0072	0.0080	0.0071
9.	Available Magnesium Mg(%)	0.066	0.064	0.066	0.070	0.064
10.	Available Calcium Ca(%)	0.141	0.139	0.133	0.129	0.136
11.	Available Iron Fe(%)	0.0189	0.0194	0.0169	0.0187	0.0114

Sr. No.	Properties	Depth from surface (cm)				
		0-20	20-40	40-60	60-80	80-100
I. Plots A						
e. Sampling Site A5.						
Physical Properties						
1.	Texture	sandy	sandy	sandy	sandy	sandy
			clay	clay	clay	clay
		loam	loam	loam	loam	loam
	Sand %	75	69	63	61	68
	Silt %	6	8	6	8	8
	Clay %	15	19	23	23	21
Chemical Properties						
2.	Soil Reaction (P ^H)	5.1	5.6	5.4	5.5	5.3
3.	Electrical Conductivity (u mhos/ml)	5.0	3.8	2.5	2.5	2.5
4.	Organic Matter Content (%)	1.90	1.14	1.86	1.36	1.84
5.	Total Nitrogen N(%)	0.1064	0.076	0.057	0.0608	0.038
6.	Available Phosphorus P(%)	0.00048	0.00040	0.00027	0.00030	0.00030
7.	Available Potassium K(%)	0.0147	0.0150	0.0145	0.0146	0.0145
8.	Available Sodium Na(%)	0.0080	0.0072	0.0077	0.0074	0.0072
9.	Available Magnesium Mg(%)	0.067	0.064	0.066	0.068	0.070
10.	Available Calcium Ca(%)	0.132	0.129	0.134	0.133	0.131
11.	Available Iron Fe(%)	0.0064	0.0186	0.0184	0.0191	0.0216

Sr. No	Properties	Depth from surface (cm)				
		0-20	20-40	40-60	60-80	80-100
II. Plots B						
a. Sampling Site B1.						
Physical Properties						
1.	Texture	sandy	sandy	sandy	sandy	sandy
			clay	clay	clay	clay
		loam	loam	loam	loam	loam
	Sand %	61	57	51	54	50
	Silt %	6	12	6	6	6
	Clay %	19	31	35	35	37
Chemical Properties						
2.	Soil Reaction (P ^H)	5.8	5.6	5.3	5.5	5.2
3.	Electrical Conductivity (u mhos/ml)	3.5	3.8	2.5	3.8	2.5
4.	Organic Matter Content (%)	1.60	1.61	0.96	1.13	0.96
5.	Total Nitrogen N(%)	0.1102	0.0646	0.0627	0.0532	0.0399
6.	Available Phosphorus P(%)	0.00034	0.00030	0.00004	0.00004	0.00004
7.	Available Potassium K(%)	0.0144	0.0180	0.0160	0.0159	0.0140
8.	Available Sodium Na(%)	0.0077	0.0069	0.0072	0.0060	0.0058
9.	Available Magnesium Mg(%)	0.072	0.071	0.0203	0.198	0.200
10.	Available Calcium Ca(%)	0.138	0.135	0.201	0.206	0.188
11.	Available Iron Fe(%)	0.0235	0.0244	0.249	0.200	0.167
b. Sampling Site B2.						
Physical Properties						
1.	Texture	sandy	sandy	sandy	sandy	sandy
		clay	clay	clay	clay	clay
		loam	loam	loam	loam	loam
	Sand %	76	68	67	67	61
	Silt %	4	6	6	6	8
	Clay %	19	25	27	25	27
Chemical Properties						
2.	Soil Reaction (P ^H)	5.9	4.8	5.3	5.3	5.3
3.	Electrical Conductivity (u mhos/ml)	5.0	5.0	2.5	3.8	2.5
4.	Organic Matter Content (%)	0.85	0.76	0.57	0.57	0.59
5.	Total Nitrogen N(%)	0.0589	0.0285	0.0228	0.038	0.019
6.	Available Phosphorus P(%)	0.00004	0.00006	0.00006	0.00006	0.00006
7.	Available Potassium K(%)	0.0140	0.0131	0.0129	0.0134	0.0134
8.	Available Sodium Na(%)	0.0056	0.0051	0.0054	0.0057	0.0050
9.	Available Magnesium Mg(%)	0.218	0.207	0.200	0.190	0.184
10.	Available Calcium Ca(%)	0.199	0.198	0.198	0.200	0.199
11.	Available Iron Fe(%)	0.148	0.370	0.319	0.256	0.194

Sr. No.	Properties	Depth from surface (cm)				
		0-20	20-40	40-60	60-80	80-100
II. Plots B						
c. Sampling Site B3.						
Physical Properties						
1.	Texture	sandy	sandy	sandy	sandy	sandy
			clay	clay	clay	clay
		loam	loam	loam	loam	loam
	Sand %	69	67	68	63	59
	Silt %	6	6	6	6	6
	Clay %	23	27	25	27	31
Chemical Properties						
2.	Soil Reaction (P ^H)	5.7	5.4	5.3	6.4	5.4
3.	Electrical Conductivity (u mhos/ml)	2.5	2.5	2.5	2.5	3.8
4.	Organic Matter Content (%)	1.31	0.15	1.02	0.72	0.26
5.	Total Nitrogen N(%)	0.019	0.0228	0.0057	nil	nil
6.	Available Phosphorus P(%)	0.00014	0.00006	0.00005	nil	nil
7.	Available Potassium K(%)	0.0136	0.0133	0.0132	0.0140	0.0131
8.	Available Sodium Na(%)	0.0050	0.0047	0.0049	0.0048	0.0044
9.	Available Magnesium Mg(%)	0.200	0.200	0.198	0.199	0.200
10.	Available Calcium Ca(%)	0.179	0.215	0.207	0.207	0.194
11.	Available Iron Fe(%)	0.188	0.150	0.172	0.158	0.150
d. Sampling Site B4.						
Physical Properties						
1.	Texture	sandy	sandy	sandy	sandy	sandy
			clay	clay	clay	clay
		loam	loam	loam	loam	loam
	Sand %	72	69	75	78	77
	Silt %	6	4	6	6	6
	Clay %	19	25	17	13	15
Chemical Properties						
2.	Soil Reaction (P ^H)	5.2	5.2	5.4	5.5	5.5
3.	Electrical Conductivity (u mhos/ml)	2.5	3.8	2.5	2.5	2.5
4.	Organic Matter Content (%)	1.16	1.00	1.58	1.88	1.31
5.	Total Nitrogen N(%)	0.0779	0.0684	0.057	0.0247	0.0969
6.	Available Phosphorus P(%)	nil	0.00004	0.00010	0.00004	0.00010
7.	Available Potassium K(%)	0.0136	0.0135	0.0135	0.0134	0.0134
8.	Available Sodium Na(%)	0.0047	0.0046	0.0085	0.0073	0.0070
9.	Available Magnesium Mg(%)	0.200	0.200	0.200	0.200	0.199
10.	Available Calcium Ca(%)	0.188	0.183	0.182	0.167	0.208
11.	Available Iron Fe(%)	0.142	0.156	0.130	0.152	0.148

e. Sampling Site B5.

Physical Properties						
1.	Texture	sandy	sandy	sandy	sandy	Sandy
			clay	clay	clay	Clay
		loam	loam	loam	loam	Loam
	Sand %	70	62	62	61	60
	Silt %	6	6	6	6	6
	Clay %	20	29	29	31	29
Chemical Properties						
2.	Soil Reaction (P ^H)	5.7	5.1	5.3	5.5	5.5
3.	Electrical Conductivity (u mhos/ml)	5.0	5.0	2.5	2.5	2.5
4.	Organic Matter Content (%)	1.14	0.92	1.27	1.14	2.01
5.	Total Nitrogen N(%)	0.0703	0.0152	0.0627	0.0456	0.0342
6.	Available Phosphorus P(%)	0.00014	0.00010	0.00014	0.00006	0.00004
7.	Available Potassium K(%)	0.0126	0.0127	0.0132	0.0130	0.0132
8.	Available Sodium Na(%)	0.0070	0.0070	0.0149	0.0157	0.0151
9.	Available Magnesium Mg(%)	0.199	0.199	0.199	0.200	0.196
10.	Available Calcium Ca(%)	0.199	0.189	0.185	0.179	0.172
11.	Available Iron Fe(%)	0.168	0.146	0.130	0.136	0.148

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