

STUDY ON THE CHANGES OF SOIL PROPERTIES IN AREA AFFECTED BY TAUNGYA METHOD

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ABSTRACT

Although little or no soil changes occur in the natural forest environment, soil damage and nutrient depletion usually occur on cleared forest land. Slash-and-burn system is the most important factor in the changes taking place in the micro-environment which ultimately upsets the natural balance without control. Taungya system is an agroforestry system based on a slash and burn practice. In order to identify the consequences of taungya system on land, one needs to know the soil nutrient content at each stage of process time. Knowledge of these nutrient changes will provide an essential background to understand the nature of these changes and consequently evolve some means or methods to compensate for nutrient lost and provide some remedies. Therefore this study was conducted in an area which was then selected to form a mixed- forest plantation pertaining teak, pyinkado and sit in compartment 26 of Yezin Reserved Forest. Soil samples from the area were taken before and after burning in April of the first year and once again in April of subsequent year. In this study, it was found that there were slight negative changes in pH, organic matter, phosphorous and potassium whereas marked losses in nitrogen, calcium and magnesium were observed.

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1. INTRODUCTION

1.1. Soil Conditions Related to Taungya Method

Although the stability of forest stand has a potential for high productivity, it may produce low return under poor soil conditions. Soil under forest improves the fertility status and soil physical properties, because of the formation of the useful humus from the forest floor. A closed nutrient cycle exists mutually in the soil-forest system.

Misuse and mismanagement of the forest can lead to serious soil deficiencies in its conditions. Large areas of forest land remain degraded in the various forms. The problem of low soil fertility and degradation of land may be brought about by the losses of soil cover. Therefore the important role of the soil has been largely threatened by the reduction of vegetation.

When there is removal of forest, the forest ecosystem of nutrient cycle is altered, the physical structure of soil destroyed and retention of water weakened (Warmer, 1991). Over the past two centuries, much of the changes in the world's soil have occurred due to removal and alteration of the natural vegetation (Palo & Salmi, 1987).

With the increasing number of wood-based industries established by the national and international firms under the market oriented economy, the demand for wood as raw material is also increasing day by day. Therefore plantations have been established to have a remarkable potential for the future timber supply by forest department.

The plantation forestry also plays a vital role to enrich or restore degraded forestlands. Taungya system is well known by various names in many countries, which is used as a cheap and efficient method for the plantation establishment. The taungya system offers some helps in the solution of tropical land use problems and the development of a stronger rural and national economy although there are very few insurmountable biological problems in agro-silviculture (Constantines, 1976).

In this method slash-and- burn practice is a primary technique practised for disposal of debris prior to planting. If the burn is incomplete, the remaining debris was piled up and reburned again. The resulting layer of ash will just neutralize the acid soil and again this nutrient may be easily lost from the exposed soil.

A direct impact of reducing vegetation cover creates a pre-condition for the

increase of soil erosion rate during heavy rainfall. Serious erosion problems have occurred in some localities with the removal of soil cover. Since no soil erosion control measure is taken, soil deterioration and nutrient depletion occurs on cleared forestland. Consistent and accurate environmental data are prerequisites for effective action to protect natural resources and environmental stability.

1.2. Objective

The practice of slash and burn has long been assumed as one of the major causes for declining productivity in the uplands. Soil erosion and even landslides may increase with such cultivation resulting in low production with inferior quality.

When the equilibrium nutrient cycle is destroyed by using the slash and burn practice, the soil undergoes a series of changes through clearing, burning and cropping. The main objective of this study is to quantitatively assess the soil properties of the area where slash-and-burn practice has been made in previous year.

2. LITERATURE REVIEW

2.1. Forest Soil Properties in Consequence of Burning

Farmers prepare land clearing by use of fire to any other means as the former can be done with minimum labour, and time saving. Certain of the nutrients in the standing vegetation and litter are transformed into the soil as ashes. Burning was done in April, before or at the onset of rain. The ashes from the burning are retained on the soil. While the rain showers, it gets mixed with the soil to form surface layer of soil fertility. The magnitude of the changes depends on the amount and base of content of ash as well as organic matters content of the soil. In these soils plant nutrients are easily lost through erosion by heavy rain as the soil cover is removed.

2.1.1. Changes in physical properties

The physical properties of soil are more important for the forest trees. Within limits, excellence in physical properties of soil may tend to compensate for poorness in chemical composition (Lutz, 1946). The cover of humus layer protects the destruction of soil properties. Water retention properties and important macro fauna that provide nutrients and improve the physical structure of the soil are also maintained.

Changes of soil physical properties for an area usually significantly occur during the time while the area is exposed to rain, wind and direct sunlight. The removal or reduction of the soil cover allows the heat energy of sunlight to the mineral soil directly. It results in the deflocculating of soil aggregates as a character of the soil deterioration. And consequently erosion begins with the direct impact of rain during the rainy season. On cleared lands the upper layer of soils dried out rapidly at the onset of rainy season. The soil temperature increases at the end of the dry season.

Depending on the intensity and duration of the burn soil temperature varies during the burning. Burning process over air and soil temperature in cleared areas increases than before. When wood is piled up the temperature may reach 100°C at the 5 cm depths. In savanna barely, the surface temperature may be as high as 500°C for three to five minutes at a depth of 5 cm (Moultapa, F. 1974). According to the changes of temperature, the soil moisture regime also changes. The loss of moisture in the topsoil horizons occurs in the most of the evaporation (Shanchez, 1940). Consequently, a dense crust is found on soil surface. The formation of aggregates in fine textured soil is due to dehydration of soil colloid. It retards the penetration of root.

The clearing of forest followed by burning resulted in exposing the forest soil. Based on the soil properties, the physical properties can become detrimental from the effect of clearing and burning. The physical condition of the surface deteriorates rapidly under the impact of the early rains and sheet or rill erosion may occur (Nye & Greenland, 1960).

Changes in the soil thermal and moisture regime can cause compacting the surface and sub soil and lead to the deterioration of soil structure, particularly when the soil is too dry, or too wet under the removal of forest cover. The absorptive capacity and prevention of water entry into the soil may alter as the condition of bulk density. The bulk density of surface soil may increase after clearing and total porosity decrease from 52 to 45 %. A similar decrease in water stable aggregates occurs over 3 years of clearing in Alfisol under bare period (Shanchez, 1940).

2.1.2. Changes in chemical properties

2.1.2.1.Organic matter

Organic matter in soil is derived from the residue of plants and animals. The high productivity of most virgin soil has always been associated with their content of organic matter. In addition to improving the physical condition of the soil, the presence of organic matter makes other chemical elements more readily available to the plant.

Burning of organic matter drastically speeds up the process of oxidation and releases the mineral nutrients. It reduces the organic acid, which are dissolved and rapidly leached into the mineral soil. During the burn, most of carbon, sulphur and nitrogen present in the vegetation (above the soil) are lost as vapours but not that in the soil humus. Soil organic matter little increases as there is only a small increase in soil organic carbon and total nitrogen after burning the vegetation (Evenson, 1994).

Low burning does not destroy soil organic matter, except reburning of pile situations. Slashed material less than 10 cm diameter with 1.9 kg m^{-2} of biomass was no significantly increased organic carbon in burned taungya area (Chacko et. al., 1989). As organic matters may increase in the incomplete burning material, soil organic matter slightly increases from burning. After about 4 months it tends toward to equilibrium level (Sanchez, 1940). When the erosion occurs in rainy season, topsoil organic matter sharply decreases.

According to Watters (1971), prior to burning the content of the organic matter was 10.6 %, and after burning it decreased to 9.8 %. It can be assumed that the process caused by intensity burn.

2.1.2.2.Soil reaction (pH)

Where high degree of base situation is lost from the soil layers, the soil acidity will become greater. Higher soil temperature, more precipitation, and changes in the soil flora and fauna result in the reduction of soil acidity.

Most forest soils are moderately to extremely acidic as a result of the release of organic acids during the decomposition of the litter layer and subsequent leaching of base from the surface mineral soil (Pritchett,1979). When leaching continues from the surface layers, soil acidity will become less leading to a high degree of base situation.

Burning of the forest litter alters the reaction of the soil in the alkalinity direction as the immediate effect. Depending on the total amount of biomass burned, soil properties, quality of ashes and the amount of rainfall, the degree of soil pH changes after burning. And it decreases gradually due to the leaching loss of bases (Pritchett, 1979; Sanchez, 1940). If the soil is in Alfisol the pH increased from 5.2 to 8.1 in the top 5-cm layer after burning and decreased to 7.0 after 2 years. pH changes occur above 40 cm soil depth by burning. The increase pH in the Latisol, 3.8 to 4.5, with burning quickly decreased to the original level within about 4 months. Where pH increased from 4.0 to 4.5 in the topsoil of Ultisol it remained stable during the first year. Even if the ashes contain the lower quantity of bases, these acid soils mineralized the increase in pH (Sanchez, 1940).

Under the slash and burning system pH changed from 7.7 to 8.0 (Watters, 1971). If the soil was analyzed from unburnt taungya area, pH content did not change in the condition of original pH 6.2 (Chacko et. al., 1989).

2.1.2.3.Nitrogen (N)

In the underlying mineral soil as well as the above ground material, the total nitrogen may significantly be fluctuated at times. Under forest soil total nitrogen is found largely in the humus layers of the forest floor. The total nitrogen is highly correlated with organic matter; soil organic matter has approximately 5% nitrogen. During decomposition or burning of organic matter, loss of nitrogen (ammonia gas) occurred. If it is under alkaline condition, these losses will be greater. If it is under acidic condition, the losses of nitrogen may be as nitrous oxides.

Nitrogen losses are the greatest in the 0-5 cm layer of topsoil with intense hot fires. The total amount of nitrogen from cutting and burning system can lose up to 676 kg/ ha which cannot economically be replaced by fertilization in India. However, in northern Thailand, the removal of forest by the use of that system lost about 100-150 kg/ha of nitrogen (Evenson,1994). They were dependent on the amount of burned biomass and intensively hot fires. Even if it is a prescribed burn for the purpose of fuel reduction, nitrogen may be lost to the extent of 20-80 kg/ha.

The ash deposits may stimulate the mineralization of nitrogen in residual organic matter, although total nitrogen will be reduced by the volatilization loss of nitrogen. The reduction of original acid soil as affected by ash layer enhanced the

microbial fixation of nitrogen. When absence of plants fails to absorb the nitrate ions (NO_3), these ions appear in the leaching losses. Nitrogen losses of soil also occur in erosion by high rainfall. The result of rapid mineralization and leaching after the clear-cutting process can cause topsoil nitrogen losses of 500-2,000 kg/ha within a year or two (Pritchett, 1979).

2.1.2.4. Phosphorus (P)

Phosphorus is critical in the growth of plants than other elements, with the possible exception of nitrogen. Under the forest, phosphorous is usually abundant in litter layer. The available phosphorous quickly changes to unavailable form in both acid and alkaline conditions. As phosphate ion is low in solubility properties, it does not leach from the soil to any appreciable extent. So the highest values were found in the layer of surface soil.

In most soil with decomposition of organic matter, the increase of the total organic carbon results in the increase of total phosphorus content, which is between 1 to 3 % in soil organic matter. In a few years it declines with the decrease of organic matter. Under the rapid decomposition and consequent high microbial population, a large amount of phosphate occurs in the microbial tissue. When the population is lower, some phosphorus may be obtained. Large quantity of organic phosphorus mineralizes from which plants absorb available phosphorus, at the same time some losses occurred as the adsorption of clay mineral precipitation.

Changes of the available phosphorous level, in the topsoil, are most dramatically affected by burning. This increase is short-lived, largely disappearing 4 years after the burning (Evenson, 1994). Extractable phosphorous in the top 5 cm layer increased four times and remained at this level for about six months. At the end of 1 year, only half of the extractable phosphorus may remain (Sanchez, 1940). There is a direct relationship between the increase in available phosphorous and the amount of burned biomass. Available phosphorus increased immensely with burning from 3 to 20 kg/ha (Watters, 1971). When no erosion occurs, the loss of total P is negligible.

2.1.2.5.Potassium (K)

Potassium is rapidly and efficiently cycled in the established forest stand. Forest trees use a considerably large amount of potassium in the soil and return it in the litter form.

Depending on the soil properties and the amount of ash composition, potassium sharply increases after burning and followed sharply by decrease. It leaches at a faster rate than other bases. In Ultisol, base depletion can occur in six month after burning. But no significant changes of these bases can be found after two years burning in Alfisol (Sanchez, 1940).

Even if it is in natural vegetation, potassium leaches in the range of 0 to 6 kg /ha/yr. Leaching losses of potassium is higher on bare land. These losses are important in course- textured, organic or humid tropic soils with high rainfall. The loss of potassium was 104 kg / ha / yr from the forest floor into the upper layer (Pritchett, 1979).

The amount of biomass burned directly increases the base situation. Extractable potassium may be almost doubled after burning, from 480 to 870 kg/ha (Watters, 1971). The bases content do not easily change without burning in taungya (Chacko et. al., 1989).

2.1.2.6.Calcium (Ca)

The losses of calcium from the surface soil are kept at a minimum by the healthy stands. The absence of stands on the ground results in the washing downward of the lime soil. It was observed that slash burning induces significant two to three fold increase in exchangeable bases. But these variations were short-lived and within six months the soil returned to original level (Chacko et. al., 1989). Exchange calcium content increases three fold with burning and followed by a gradual decrease under Ultisol and Alfisol (Sanchez, 1940).

The loss of base content occurs through runoff water. The downward movement of calcium from the surface soil (0-15 cm) has resulted in exchangeable calcium levels in subsoil layer (Santoso et al., 1995).

2.1.2.7. Magnesium (Mg)

The magnesium concentration of soil is typically 5 to 50 ppm in temperate region, although magnesium concentration is between 120 to 2400 ppm. The probable losses of magnesium and crop removal are very small compared with the total amounts in soils. The release of a very small fraction of the non-exchangeable magnesium will make the good soil properties. After burning magnesium increase tripled in Ultisol and followed decreased. But only slight changes occur in Alfisol (Sanchez, 1940).

2.2. Nutrient Transformation in Slash-and-Burn

A closed nutrient cycle exists mutually in the soil-forest system. The required nutrients are absorbed by the deep tree roots and returned to the soil surface in the annual leaf fall. Under undisturbed forest ecosystem the nutrient losses in drainage water are also minima. At any one time the total nutrients in soil – forest system are stored partly in the soil and partly in the vegetation.

Clearing and burning of vegetation disrupts the closed soil-forest nutrient cycle. Taungya burning destroys a large amount of humus in the soil cover. It may lose 617-1,112 t /ha of humus (Aung, 1995). After burning, nutrients are returned to the soil as ash, with small amount of loss in gases. Ash content of tree leaves has the largest amount of organic matter and mineral matter to the soil. The smallest amount is in the stem wood. But the bark of trees commonly contains more calcium content than other elements (Lutz & Chandler, 1946). The magnitude of nutrient additions to the soil by the process of clearing and burning are reflected by the species composition which depend on soil and climate. An average ash weight is added to the soil surface as follow in Table 2.1.

Table (2.1) Contributed ash weight in pine plantation **kg/ ha**

Ash Weight	Nitrogen	Potassium	Calcium	Potassium	Magnesium
2,900	23	70	314	54	22
5000-54000	-	46-545	37-1,128	-	-

Source:- Pritchett, 1979 & Watters, 1971

These increase nutrients can be utilized in a few years by plants and subsequently the decrease in nutrients followed. Erosion occurs under the unprotective cover in the rainy season. The loss of ash material and fertile topsoil by the effect of erosion results in the depletion of the nutrient capital of the site. After burning, there is a layer of nutrients on the fields that will be rapidly washed away by rain.

2.3. Soil Properties in Monoculture Plantation

Nutrients taken up by forest trees vary according to different species, age and composition of soil. If it is under the same habitat and drawing their nutrients from the soil solution, the various parts of species contain greatly different mineral and organic constituents. The amounts of nutrients accumulated under forest are also remarkable.

Nowadays, the increase in demand for timber and fuel wood is met by establishing forest plantations, which produce timber and fuel wood. The forest plantations are established with high value species like teak and multipurpose fast growing tree species.

Cultivation of plantation crops following clear felling did show the accumulation of soil nutrient. However, it would not approach to its original forest from the litter fall. Under a good secondary forest, the humus content of a soil at about 75 % of the former amount under the original forest (Nye & Green land, 1960). The addition nutrients to the soil from the trees standing on it are through litter fall are as follow in Table 2.2.

Table (2.2) Addition of nutrients from the forest litter **kg/ ha/yr**

Vegetation type	Litter	Nitrogen	Phosphorus	Potassium
Padauk plantation	3,470	43.72	3.47	18.52
Teak plantatio	3,890	24.52	3.24	15.96
Natural forest	8,000-9,000	134	7	53K,111Ca,32Mg

Source: Mongia & Bandyopadhy, 1994

When the natural forest is turned into the monoculture plantation, the change of water content in soil occurs. This is due to the decrease in retention time of water,

intake rate of soil and greater withdrawal of soil water from the active root zone. The water content up to 17 cm depth was minimum in teak plantation, while the maximum contents occur under virgin forest. Padauk plantation was intermediate. The bulk density of the surface soil has 1.05 mg m^{-3} in the virgin forest (evergreen). It has increased to 1.3 mgm^{-3} in padauk, 1.49 mgm^{-3} in teak plantation (Mongia & Bandyopadhyay, 1994).

Clear felling the natural forest and creation of pure teak plantation can lead to the washing away of the soluble minerals, leaving behind insoluble silica and sesquioxides in the surface soil. Erosion is very much enhanced in teak bearing high rainfall area and also on teak bearing sloping ground of natural forest (Keh, 1996). Under many teak plantations, podsolization and laterization are delicately balanced (Kadambi, 1993). It leads to having a low cation exchange capacity of the mineral fraction and a high content of relative iron and aluminium oxides.

Reduction and removal in organic matter content of soil renders the soil structurally fragile and highly vulnerable to splash erosion (Mouttapa, 1974). The only period during which the land is without a soil cover is important. As the insufficient of soil cover, the different soil erosion rates become under the various land uses in Table 2.3. Soil erosion is almost depending upon the inherent soil and land characteristics as well as management practices.

Table (2.3) Rate of Erosion in Tropical Forest and Tree Crop Systems

No	Land use system	Erosion (kg/ha/y)	
		Minimum	Maximum
1	Shifting cultivation, fallow period	50	7,400
2	Tree-crops with cover crops or mulch	100	5,600
3	Shifting cultivation, cropping period	400	70,050
4	Taungya, cultivation period	630	17,370
5	Forest plantation (litter removed)	5,920	104,800

Source :- Agroforestry for soil conservation (Young, 1985)

3. MATERIALS AND METHODS

This study is to provide some information of soil nutrient changes in one-year old taungya cultivation. The investigation was carried out in the training forest of the University of Forestry, Yezin. The area of training forest is 8,369 acre, which includes six compartments (26 to 31) of the Yezin Reserve Forest. It is covered mostly with deciduous forest, which is mainly disturbed by shifting cultivation. The forestland has been a degraded forest with extensive banana plantation and phonezo area (fallow land).

3.1. Topography, Soil and Climate

The topography is undulating; hilly with some steep slope area. This area is about 600 m above sea level. The soil is mostly yellow brown forest soil of tropical monsoon forests. The texture of soils is loamy sand (derived from sandstone). It is slightly acid in condition, contain medium content of organic matter, with very low phosphorus and low nitrogen, calcium and magnesium percentages. The study area's slope percentage is about 20% to 21%. Generally, monsoon rain sets in mid-may in these regions. The annual rainfall is between 1,250 mm and 1,700 mm. Average temperature ranges from 20°C and 30°C.

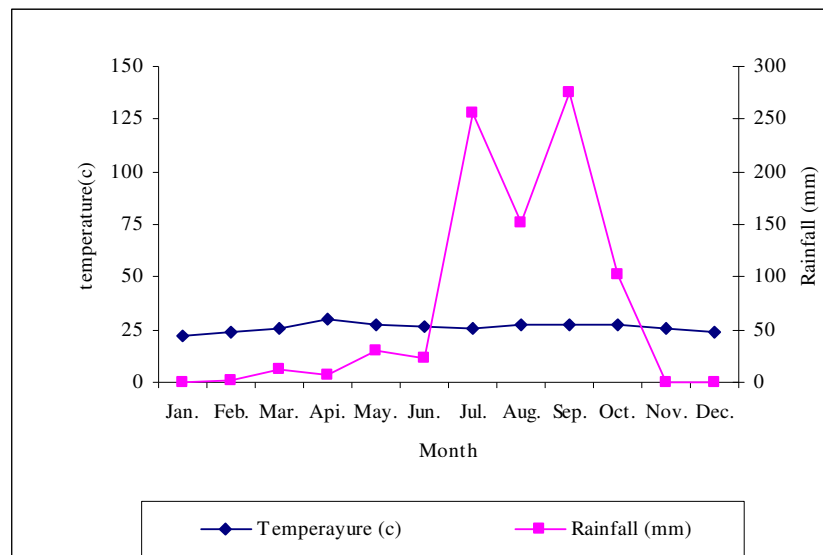


Fig. 1 Climatogram of Yezin
(Central Agriculture Research Institute, Yezin, 2000)

3.2. Field Methods and Laboratory Methods

Changes in soil properties of clearing and burning the forest cover were investigated by taking soil samples. Soil samples were collected at compartment No. 26 where 18 acre-wide plantation was formed in the year 2000. Simple random sampling design method was applied. Ten sample plots, each plot in the size of (20m x 14m), were selected at random along the middle portion of the slope. Each sample plot is equally divided into 4 sub-plots and 5 sampling of soil, at 0-15 cm layer, were taken at each sub-plots(see in Fig.2). Soil samples were taken at three stages “before burning”, “after burning” and “after one year” as shown in plate 1 to 3. LSD (Least significant difference) method was applied for mean comparison.

Soil samples were air-dried and grounded through a 2mm sieves, and analyzed for their physical and chemical properties.

3.2.1. Particle size distribution

Particle size distribution is carried out by mechanical analysis using the pipette method.

3.2.2. Organic matter

Organic matter was determined by weight loss on ignition method.

3.2.3. Soil reaction (pH)

Soil reaction (pH) reading was taken on soil / distilled water suspension (1:2.5) and measured by Jenway pH meter model 3020.

3.2.4. Total nitrogen (Total N%)

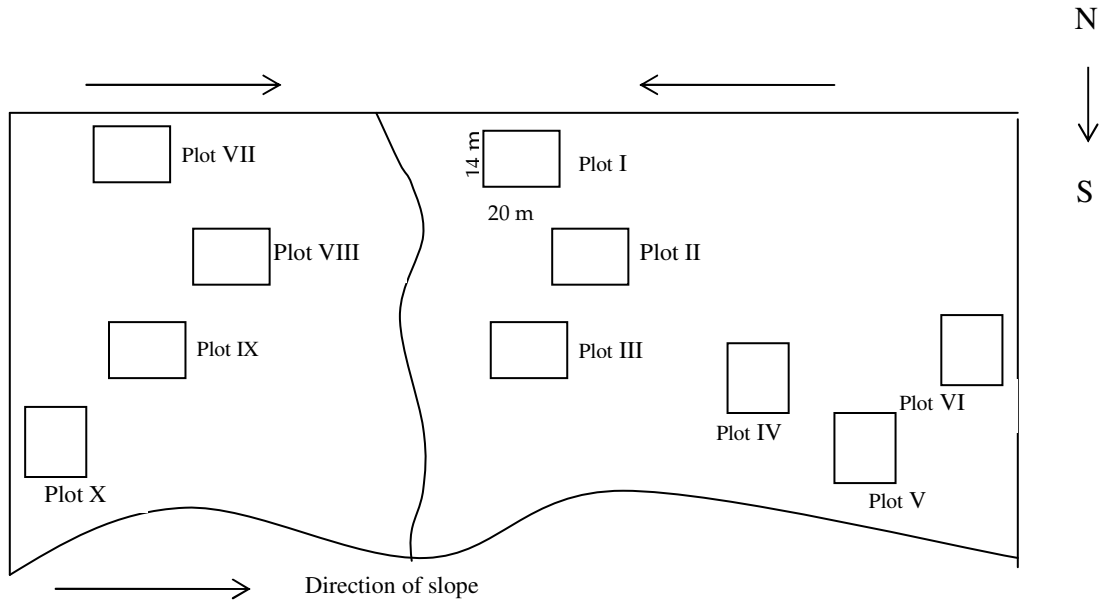
Total nitrogen levels were settled by Kjeldahl’s method by using Labconco Macro Kjeldahl digestion and distillation unit.

3.2.5. Available phosphorus

Available Phosphorus levels were resolved with double acid extracting solution and Molybdenum-blue complex method by using Spectrophotometer set at 660 nm wavelength.

3.2.6. Extractable potassium, calcium, magnesium

Extractable potassium, calcium and magnesium were assessed with double-acid extracting solution by using Perkin Elmer Atomic Absorption Spectrophotometer, model 2280.



Soil sampling in each plot

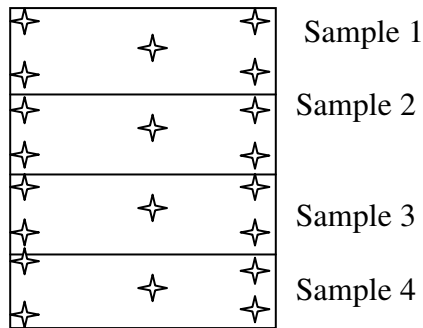


Fig. 2 Layout of sample plots

4. RESULTS AND DISCUSSIONS

4.1. Results

The soil texture in study area was loamy sand. Although burning of dry matter may actually produce nutrient availability in the form of ashes in the first year, the results show no significant changes between before burning and after burning. Minimal reduction in soil fertility has been observed in the first year.

Organic matter

Maximum soil organic matter before burning was 4.8% and 4.5% after burning, followed by 4.0 % after one year. The minimum values were 2.7 %, 1.7 % and 1.8 %. The highest average organic matter was 3.42 % before burning followed by after burning 3.17 % and 2.7 %. Organic matter contents were not significantly changed between treatments. However there was a slightly decreased after one year.

Table (4.1) Mean comparison for organic matter (%) (AVE. Over 10 rep)

Treatment	Means	Difference
Before burning (Control)	3.425	
After burning	3.175	(-)0.250 ns
After one year	2.743	(-)0.681 ns
mean	3.114	

ns = not significant Coefficient of variance (CV) = 29.4 %

Comparison S.E.D LSD (5%) LSD (1%)

2-T means 0.4077 0.8366 1.1298

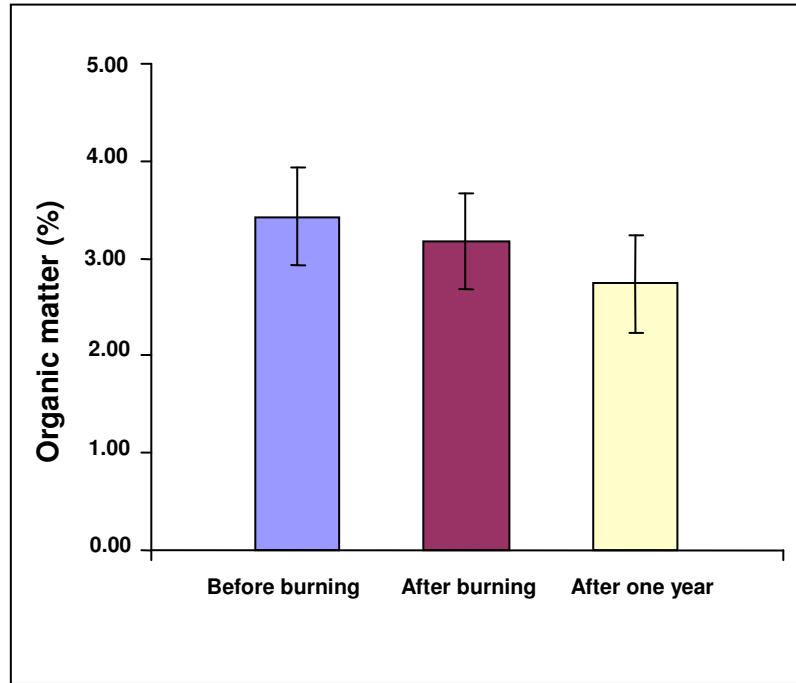


Fig. 3 Changes in organic matter at different stages

pH

Maximum soil pH was 6.6 before burning followed by 6.2 after burning and dropped 5.9 after one year. The minimum values were 4.7, 4.2 and 4.8. Before burning the highest average pH was 5.8 followed by 5.7 after burning and dropped 5.3 after one year. The soil reaction was not significant between before burning and after burning but it decreased after one year.

Table (4.2) Mean comparison for pH (AVE. Over 10 rep)

Treatment	Means	Difference
Before burning (Control)	5.832	
After burning	5.651	(-) 0.181 ns
After one year	5.295	(-) 0.537 *
mean	5.592	

ns = not significant Coefficient of variance (CV) = 10.3 %

* = significant at 5% level

Comparison	S.E.D	LSD (5%)	LSD (1%)
2-T means	0.2564	0.5260	0.7103

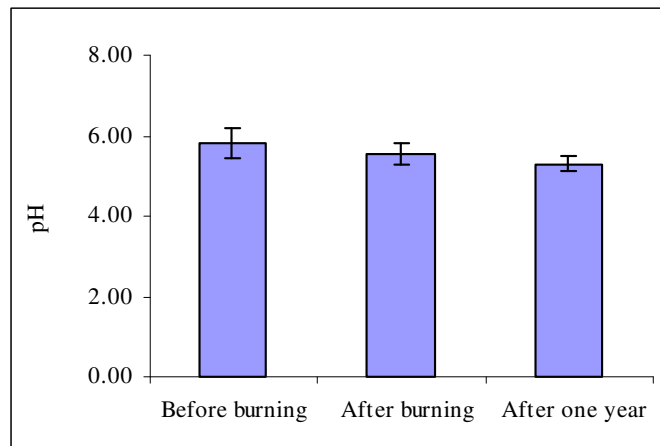


Fig. 4 Changes in pH at different stages

Available Phosphorous

Maximum phosphorous was 0.085 meq/ 100g before burning, 0.078 meq/ 100g after burning and dropped 0.062 meq/ 100g after one year. The minimum values were 0.021 meq /100g, 0.021 meq/ 100g and 0.014 meq/ 100g. After burning the highest average phosphorus was 0.049meq/ 100g followed by 0.045 meq/ 100g before burning and dropped 0.034 mqe/100g after one year. Phosphorous was not significant in this study.

Table (4.3) Mean comparison for phosphorus (meq/100 g) (AVE. Over 10 rep)

Treatment	Means	Difference
Before burning (Control)	0.045	
After burning	0.049	0.004 ns
After one year	0.034	(-) 0.011 ns
mean	0.043	

ns = not significant Coefficient of variance (CV) = 48.9 %
 Comparison S.E.D LSD (5%) LSD (1%)
 2-T means 0.0093 0.0192 0.0259

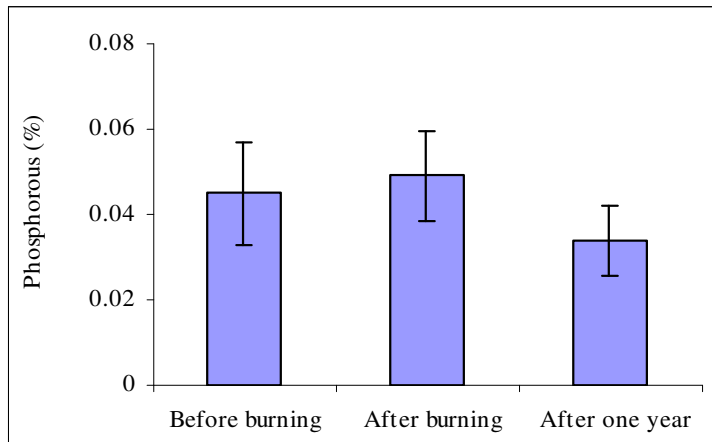


Fig. 5 Changes in phosphorous at different stages

Total Nitrogen

Maximum nitrogen was 0.102 % after burning followed by 0.089 % before burning and dropped 0.051 % after one year. The minimum values were 0.05 %, 0.05 % and 0.029 %. After burning the highest average nitrogen was 0.078 % followed by 0.072 % before burning and dropped 0.041 % after one year. Nitrogen content was not significant between before burning and after burning but it decreased after one year.

Table (4.5) Mean comparison for nitrogen (%) (AVE. Over 10 rep)

Treatment	Means	Difference
Before burning (Control)	0.072	
After burning	0.078	(-) 0.006 ns
After one year	0.041	(-) 0.031 **
mean	0.064	

ns = not significant Coefficient of variance (CV) = 17.4 %

** = significant at 1 % level

Comparison	S.E.D	LSD (5%)	LSD (1%)
2-T means	0.0050	0.0102	0.0137

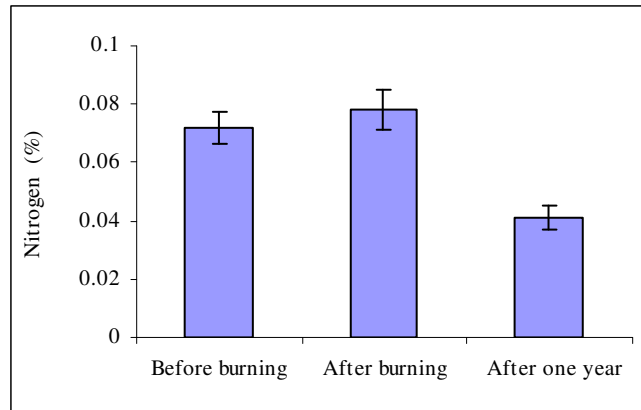


Fig. 6 Changes in nitrogen at different stages

Extractable Potassium

Maximum extractable potassium was 0.032 % before burning, 0.031 % after burning and 0.032 % after one year. The minimum values were 0.018 %, 0.022 % and 0.014 %. Before burning and after burning the highest average extractable potassium were 0.026 % and dropped 0.016 % after one year. Extractable potassium content was not significant between before burning and after burning but it decreased after one year.

Table (4.6) Mean comparison for Potassium (%) (AVE. Over 10 rep)

Treatment	Means	Difference
Before burning (Control)	0.026	
After burning	0.026	0.0002 ns
After one year	0.021	(-) 0.005 *
mean	0.025	

ns = not significant Coefficient of variance (CV) = 19.6 %

* =significant at 5 % level

Comparison	S.E.D	LSD (5%)	LSD (1%)
2-T means	0.0021	0.0044	0.0060

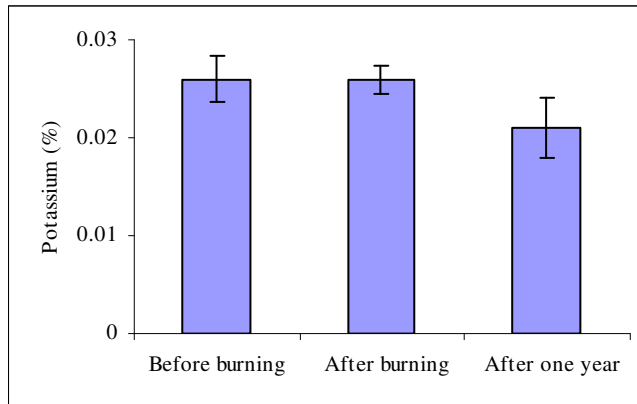


Fig. 7 Changes in potassium at different stages

Extractable Calcium

Maximum extractable calcium was 0.142 % before burning, 0.136 % after burning and dropped 0.024 % after one year. The minimum values were 0.063 %, 0.062 % and 0.013 %. Before burning the highest average extractable calcium was 0.094 % followed by 0.089 % after burning and dropped 0.016 % after one year. Extractable calcium content was not significant between before burning and after burning but it decreased after one year.

Table (4.7) Mean comparison for calcium (%) (AVE. Over 10 rep)

Treatment	Means	Difference
Before burning (Control)	0.094	
After burning	0.089	(-) 0.006 ns
After one year	0.016	(-) 0.078 **
mean	0.066	

ns = not significant Coefficient of variance (CV) = 31.3 %

** = Significant at 1 % level

Comparison S.E.D LSD (5%) LSD (1%)

2-T means 0.0093 0.0191 0.0258

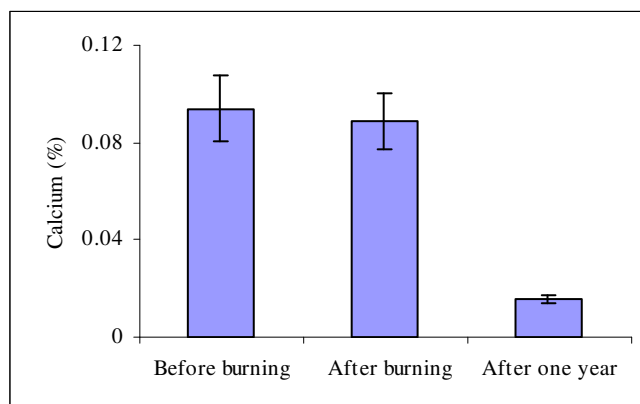


Fig. 8 Changes in calcium at different stages

Extractable magnesium

Maximum extractable magnesium was 0.036 % before burning, .037 % after burning and dropped 0.022 % after one year. The minimum values were 0.017 %, 0.014 % and 0.012 %. Before burning the highest average extractable magnesium was 0.026 % followed by 0.022 % after burning and dropped 0.015 % after one year. Extractable magnesium content was not significant between before burning and after burning but it decreased after one year.

Table (4.8) Mean comparison for Magnesium (%) (AVE. Over 10 rep)

Treatment	Means	Difference
Before burning (Control)	0.027	
After burning	0.023	(-) 0.004 ns
After one year	0.015	(-) 0.011 **
mean	0.021	

ns = not significant Coefficient of variance (CV) = 27.9 %

**= significant at 1% level

Comparison	S.E.D	LSD (5%)	LSD (1%)
2-T means	0.0027	0.0055	0.0074

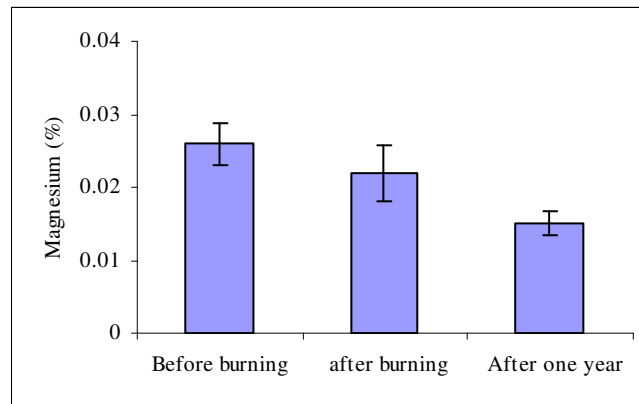


Fig. 9 Changes in magnesium at different stages

4.2 Discussions

A good burn improves the yields of the crops and reduces the time spent in weeding. Much of the nutrients are likely to be removed from the surface layer by the first rain, through leaching and runoff as the exposed soil.

Organic Matter

The content of organic matter in the soil does not significantly changed in this study. It may be due to lack of fierce burning. The losses of organic matter may be above the 110 °C (Lab. Manual, FRI). There is only a slight decrease in soil

organic matter in after one year. It may be due to biological decomposition of the organic matter and the loss of surface layer through the soil erosion.

pH

Depending on the total amount of biomass burned, pH value was always increased after burning. In this study, pH was not significantly changed between, before and after burning. It may be due to the lack of ash effects especially potash. It was found that one year after taungya , the pH of soil slightly decreased. It may be the loss of base in the top portion. And the biological decomposition normally may form organic acid which contributes to the soil acidity.

Available Phosphorous

Many of the soils in Myanmar are deficient in phosphorous (FRI, 2001). Phosphorous concentration levels were not significantly different in this study. The slight decrease was in available phosphorous after one year. The loss was 0.2377 kg/ ha. It may be due to the fixation and weed consumption.

Total Nitrogen

In this study there was only slight difference in nitrogen content between, before and after burning. However, there was a slight increased perhaps due to the mineralization of nitrogen. As nitrogen was readily soluble in water, they can therefore be lost in the drainage water. In after one year of taungya cutting, it (nitrogen) was found to be decreasing. It was lost 690.4 kg/ ha. It may be easily lost by the affects of leaching, feeding by plants and fixation of microorganisms and volatilization losses.

Extractable Potassium

Since the ash residue was lack in this study, there was no significantly a change of potassium content between, before and after burning. Comparing with after one year, this bases content was found to decrease up to 114.3 kg/ha. This disappearance or decrease may be through the leaching loss since the soil type derivates from the sand stone. Presently the increasing weed may also use up extractable potassium.

Extractable Calcium

The result of this study indicates that calcium content did not differ between, before and after burning. The decrease of calcium content in third time of data collection may be due to leaching, runoff water and intake by increasing weeds.

Extractable Magnesium

Changes of magnesium amount occurred in the third time of treatment. It may be due to surface wash and leaching losses.

5. RECOMMENDATIONS AND CONCLUSIONS

5.1. Recommendations

Mountainous and hill forest lands derived sheet and gully erosion as a result of taungya. Controlled cutting and burning that kill most of the trees but does not destroy all of the organic matter should be utilised as a soil cover. As the soil properties have very slow power of recovery, the direct effect of heat on the soil should be minimised. Burning is far less damaging if confined to early part of the dry season. And the burning material should be in small size to control burning. High intensity burn destroys the soil organic matter and soil structure.

In case of one year after burning, a considerable loss of nutrient was found in the topsoil layer probably because of the rapid leach and runoff processes. A dense ground cover cropping will be required in the first year of taungya area.

Plantation establishment with the inadequate of soil cover will loose soil fertility through erosion, especially when there was heavy rainfall. The major reason for soil erosion was improper cultivation methods and mismanage of tree and herbaceous vegetation, which leaves the soil stripped of protection and hence susceptible to erosion. Since each species and ultimately each community had got its own requirement and capacity for utilise the soil materials and also for returning to the soil, mixed vegetation reflected best performance on soil properties among the plantation. Plantation should therefore be established, in mixed with suitable soil cover crops and soil improving species.

Taungya method leads to certain disaster in high rainfall and semi-arid areas if soils are more susceptible to erosion by water and wind. Productive lands can

convert into less productive bush lands without maintains of soil productivity and improving of the soil fertility. Trees should be planted among the few remaining living trees, stumps and fallen trees. In order to avoid excessive erosion and a decline in soil productivity, steep slopes should not be used for taungya. Hedgerow of nitrogen fixing tree species should be formed as a sort conservation measure in hilly area.

5.2 Conclusions

Much of the surface of the soil lies barely to the tempestuous rains and therefore the amount of nutrients available begins to drop in after one year. It is hardly found in sheet erosion in this study area. The combustion material was not burnt completely in this area as the cutting/burning was too late, the slash was not dried enough for a good burning. The unburned materials like mulch prevent the higher losses of soil nutrient through the runoff water.

Generally the exchangeable nutrients, in the topsoil, under this area will be restored closely to their original level if it has sufficiently long period of rest fallow without human disturbances.

A long fallow period was necessary with the proper soil conservation management in the hilly region where intense rainfall was in existence since this method could lead to nutrient depletion and deterioration of physical structure.

Taungya system has been proved to be successful in the conversion of degraded and unproductive forest into commercial plantation. However large areas of land once yielding a sufficient nutrient supply have become unproductive owing to regardless of management practices, as the declining soil fertility , increasing weed competition, increasing pest problem or accelerated erosion. Since this study was carried out for only one-year duration, further improvement in the assessment of soil properties would be required to achieve a proper management of taungya system in plantation establishment.

Statistical analysis of soil nutrient

Analysis of variance for Organic Matter

SV	DF	SS	MS	F
Stages	2	2.7843	1.3921	1.67 ns
Errors	27	22.4446	0.8312	
Total	29	25.2289		

ns = not significant

Analysis of variance for pH

SV	DF	SS	MS	F
Stages	2	1.4955	0.7477	2.28 ns
Errors	27	8.8719	0.3285	
Total	29	10.3674		

ns = not significant

Analysis of variance for Phosphorus

SV	DF	SS	MS	F
Stages	2	0.00113	0.00056	1.30 ns
Errors	27	0.01178	0.00043	
Total	29	0.01292		

ns = not significant

Analysis of variance for Nitrogen

SV	DF	SS	MS	F
Stages	2	0.00787	0.00383	32.01 **
Errors	27	0.00332	0.000123	
Total	29	0.01119		

**= significant at 1% level

Analysis of variance for Potassium

SV	DF	SS	MS	F
Stages	2	0.000182	0.000091	3.94 *
Errors	27	0.000623	0.000023	
Total	29	0.000805		

*= significant at 5 % level

Analysis of variance for Calcium

SV	DF	SS	MS	F
Stages	2	0.03791	0.01859	43.83 **
Errors	27	0.01167	0.000433	
Total	29	0.04959		

**= significant at 1% level

Analysis of variance for Magnesium

SV	DF	SS	MS	F
Stages	2	0.000657	0.000329	9.23 **
Errors	27	0.000961	0.000004	
Total	29	0.001619		

**= significant at 1% level

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