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TAUNGYA IN RELATION TO SOIL PROPERTIES SOIL EROSION AND SOIL MANAGEMENT

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ABSTRACT

Though taungya is in vogue in Kerala Forestry since 1922, the effects of taungya practices on soil properties have not been studied so far. Further, the present cropping patterns of rice-rice, rice-tapioca, tapioca-tapioca and lately ginger are ad hoc choices and either economic analyses or experimental data are not available to support these choices. Therefore, this project agrisilvicultural practices in relation to soil properties, soil erosion and soil management was taken up in April 1977 with the objectives of evaluating changes in soil properties due to taungya practices, assessing indirectly the extent of soil erosion in taungya plantations and improving the management of soils during the first two years of forest plantations.

Six taungya plots of 0.4 to 2.0 ha were selected in clear felled areas of Vazhachal, Trichur and Nilambur Divisions. Soil samples were collected from profiles to characterize the plots and 12 stratified surface samples (0-20 cm) were taken from each plot at various stages. Sand, siltand clay separates, pH in soil-water suspension, organic carbon, and cation exchange capacity were selected as the soil properties to be studied.

After two years of taungya cropping, changes tend to occur with sand, silt and clay contents, pH, organic carbon, and cation exchange capacity. Distribution of more silt plus clay and less sand in the surface samples after two croppings suggest that surface sample texture is influenced by the texture of the subsurface horizons. This observation is supported by the profile data. It implies that the surface horizons are partly eroded and the subsurface horizons are gradually getting exposed.

Since two years of crop growth is unlikely to cause much effect on the sand, silt and clay contents, organic carbon, and cation exchange capacity, the changes seen are likely due to the disturbance caused to the soil in the form of preplanting tillage, intercultivation and harvesting operations. The data suggest that one crop of rice causes less changes in some of these soil properties than rice-rice, rice-tapioca and tapioca crops. Further, the raising of one crop of rice causes minimum disturbance to the surface horizons of the soils and after the harvest, the residues form a surface, much which will retard runoff and erosion.

Based on the experimental data and well-established principles of tropical soil management, it is suggested that only one crop of rice may be allowed in taungya plantations. However, if a second crop is required for taungya plantations, rice may be cultivated with minimum preparation of land. If the choice is for tapioca or any tuberous/rhizomatous crop requiring thorough land preparation, soil conservation measures should be adopted for keeping soil loss to the minimum.

INTRODUCTION

Agrisilviculture (taungya) is the combination of agriculture and silviculture in which forestland is used for growing agricultural crops during the initial years of forest plantation. Taungya fits in with the concept of multiple land use and here the land is used simultaneously for rising agricultural and forestry crops.

Though taungaya is in vogue in Kerala Forestry since 1922, the effects of taungya practices on soils have not been studies so far. A general observation is that these practices lead to considerable soil erosion in our forest plantations. Even though short-term benefits are obtained through lease income and saving in weeding costs, loss through soil erosion is irretrievable. Further, the present cropping patterns of rice-rice, rice-tapioca, tapioca-tapioca, and lately ginger are choices out of exogenous considerations and experimental data are not available to support these choices. These observations necessitate an organized study on taungya practices for evolving optimal soil management practices in forest plantations during their initial years.

The present project agrisilvicultural practices in relation to soil properties, soil erosion and soil management was taken up in April 1977 with the objectives of evaluating changes in soil properties due to taungya practices, assessing indirectly the extent of soil erosion in taungya plantations and improving the management of soils during the first two years of forest plantations.

BACKGROUND

Origin and Development of Taungya in India

Taungya is a Burmese word, which means temporary cultivation on hilly lands. The word is derived from taung, which means hill and ya meaning cultivation usually of a temporary character. Taungya is also the term originally used for a shifting field of shifting cultivation in Burma (Blanford 1925).

In 1856 when Diertrich Brandis was in Burma (then part of India), shifting cultivation was rampant and there were several court cases against the encroaching villagers. Brandis realized that shifting cultivation which was so detrimental to the management of timber resources could possibly be rendered useful to the development of forestry. Based on the well-known German system of waldfeldbau which involves cultivation of agricultural crops in forests, and on the success of teak taungya plantations in Taungoo and Tharrawaddy Divisions, Brandis encouraged the concept 'regeneration of teak with the assistance of taungya'. (Blanford 1925, King 1979).

Soon Forest Department distributed teak (Tectona grandis) and rice (Oryza sativa) seeds to farmers and two decades later, this system had proved so good that teak plantations could be established very much cheaper than otherwise. At the same time the taungya system was of educational value. The villagers no longer had to defend themselves in court for destroying the forests; instead they promoted afforestation of the cleared land by sowing teak seeds. After the clearing and before afforestation the taungya fields were usually used for the intermediate cultivation of rice, tobacco (Nicotiana tabacum) and sesame (Sesamum indicum) in the valleys and of sugarcane (Saccharum officinarum), cotton (Gossypium spp.) and maize (Zea mays) on the slopes. Thus a symbiotic agreement between the Forest Department and farmers developed.

The Forest Department later introduced taungya into British India too. In India, the first taungya plantation was initiated in 1910s. In the Siwaliks (Uttar Pradesh), twelve new settlements were created with the villagers' help. Each farmer was given 0.3 to 1 ha of forestland to clear and cultivate. During the first two years, the whole area was cultivated whereas during the next three years cultivation took place between the sal (Shorea robusta) seedlings. The farmers agreed to look after and weed the plantation in return for the use of the land for cultivation of food crops.

When we study the history of forest management in India and Burma, it is evident that the aim of taungya was to curb shifting cultivation, which was harmful to timber resources. Simultaneously, food was produced for the local people. The advantages of taungya were manifold, ranging from higher yields of agricultural as well as tree crops, protection from soil erosion if contour cultivation and terracing were practiced on slopy lands and more regular employment for the local population. Discipline among farmers, expert knowledge on the part of forester and good organization were decisive factors or its success.

Taungya is extensively practiced in several States. It is called Kumri in Tamil Nadu and Kumri or Poonam in Kerala. There is considerable variation in the practices followed in different regions. Some of the finest taungya plantations can be seen in Gorakhpur Forest Division of Uttar Pradesh.

Taungya in some of the Tropical countries

Taungya is widely practiced in tropical forestry with local variations in the system. The principle underlying the system of taungya is that in all cases temporary fertility of the forestland is used by the farmers for cultivation of agricultural crops.

Burma

Taungya system was started in 1856. However from 1906 onward, taungya plantations were almost given up in most Forest Divisions and attention was turned more to the improvement of the natural stock by improvement fellings. Due to the earlier taungyas, teak plantations had been scattered in such an indiscriminate way in small blocks that organized tending and thinning were almost impossible. Hence for sometime there was a great prejudice against any further planting operations. The resumption of taungyas in the 1920s was a great step forward in Burma toward systematic forestry (Blanford 1925).

Indonesia

Taungya is called Tumpangsari and it is prevalent in central Java for establishment of teak plantations. The farmers are allowed to cultivate blocks of land for two years, growing dryland rice and maize and simultaneously maintaining teak seedlings, Since 1974, as system of intensified taungya has been introduced to assist the farmers to obtain greater yields from their crops. Improved seeds, fertilizers and pesticides are supplied free to farmers in return for the maintenance of young teak crop. The State Forest Corporation considers taungya to be economically beneficial since the cost per hectare of establishing teak is considered to be as low as Rp 20,000 compared to Rp 40 000 using departmental labour (Rs 400 and 800 respectively).

In central Java, rice, maize, green beans (Phaseolus spp.), and tapioca (Mannihot esculenta) are cultivated along with teak and leucaena (Leucaena leucocephala) interplanted with rows of mahogani (Swietenia mahagoni) and rosewood (Dalbergia latifolia) surrounded by hedges of sappan (Caesalpinia sappan). Good selection of seed for the food crops, the correct use of fertilizers and weed control with herbicides contribute to what is claimed to be a massive increase in food production as well as the successful establishment of a tree crop. In north Sumatra, Pinus merkusii is planted with the special green belt of clove (Eugenia caryophyllata), nutmeg (Myristica fragrans) and cinnamon (Cinnamomum zeylanicum) on land subjected to shifting cultivation (Anonymous 1979).

Nigeria

Forest regeneration is commonly achieved through taungya system. A tract of commercially logged land is allotted to a farmer who cuts the residual trees and undergrowth, burns them and raises his food crops along with tree seedlings planted by the Forest Department. The farmer ordinarily crops the land for two years, then turns it over to the Forest Department and he is assigned a new area for cultivation (Onweluzo 1979).

Taungya in Kerala

Taungya is known by several names such as Poonam, Kumri and Tuckle. It was introduced in 1922 in an area of 84 ha of teak plantation in Konni Division (George 1961).Since that time, taungya has been gradually extended to other areas. In 1932, teak taungya plantations were initiated in Begur area of Wynad Division. The taungya system practised during 1930s was as follows (Laurie 1934):

The taungyadars were allotted their plots in May, usually about 0.4 ha to each family. They did a clean scraping of the area towards the end of may and ragi (Eleucine coracana) was sown at the beginning of the rains usually in the first or second week of June. The teak planted by the Forest Department was kept weeded by the taungyadars who also replaced casualties free of cost. Ragi was harvested either in November or December, by which time it was one metre high and very dense. With early stump planting, it was possible to get the teak seedlings upto over 45 cm before the ragi competed with them seriously. Regarding teak taungya, one difficulty was that in two years the teak saplings were so high that they interfered with the cultivation and taungyadars objected to being not given a new area for cultivation.

The taungya system practised now is similar to the one just described. Instead of allotting smaller areas to farmers, larger blocks are now leased for taungya by tender and generally contractors are the taungyadars and not farmers. Also a variety of crops are grown such as rice, tapioca, ginger (Zingiber officinale), sesame and pulses. The annual taungya area and lease amount for the period 1974 to 1978 are shown in Figures 1 and 2.

From Taungya to Agroforestry

As we have seen the taungya system is a development from shifting cultivation in that the agricultural crops are raised by destroying tree crops in shifting cultivation and in taungya, agricultural crops are grown in association with tree crops.

As the population increased considerably in the tropical regions, the use of forestland for agricultural purposes became a necessity and the commercialization of taungya led to a series of agrisilvicultural practices – all variations of taungya system – in most of the tropical countries. From these agrisilvicultural practices developed the concept of agroforestry involving integration of agriculture, animal husbandry and fisheries with forestry. In other words, agroforestry envisages the use of forestland for agriculture, animal husbandry and fisheries with forestry. In other words, agroforestry envisages the use of forest land for agriculture, animal husbandry and fisheries. However, the ways and means of achieving the desired ends by this integration will have to be developed. This evolutionary pattern of practices shows that taungya is possibly an intermediate step in the sequence shifting cultivation to agroforestry.

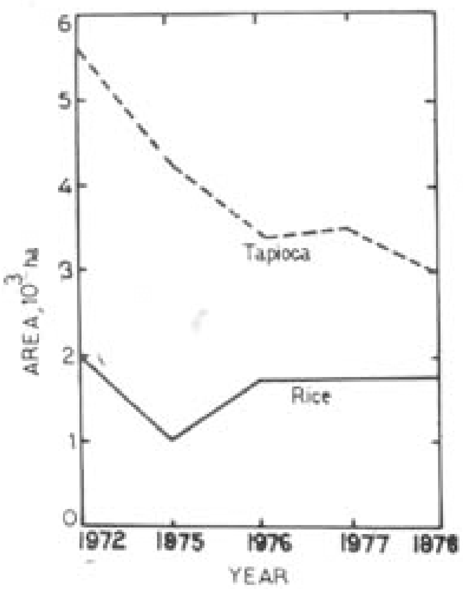

Figure 1. Taungya area for the years 1974 - 78

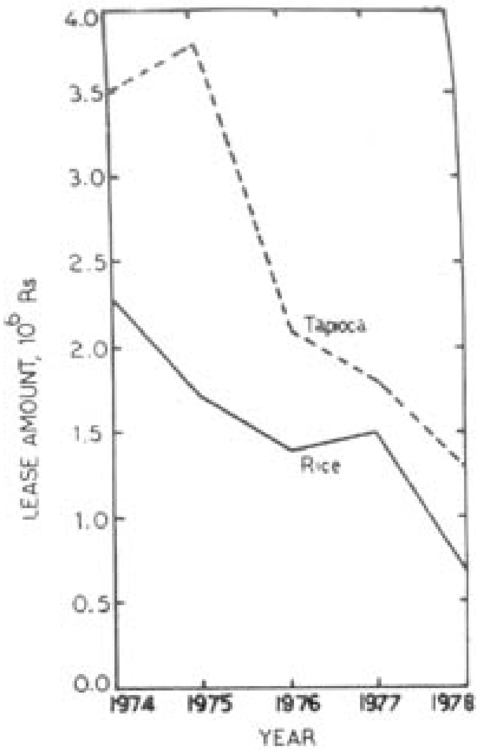

Figure 2. Taungya lease amount for the years 1974 - 78

In India, though taungya was intended to help the farmers (mostly tribals), directly or indirectly they were alienated from taungya operations. This is particularly true in Kerala. Presently, contractors are mostly the taungyadars and the products mainly tapioca, paddy and ginger are moved in to from the production area. Though in Kerala taungya has indirectly encouraged encroachment of forest lands, in countries like Thailand and Indonesia, the taungya plantations act as buffer zones against encroachment since farmers (mostly tribals) are very much involved in taungya operations.

Resume of Previous Taungya Studies

Though there have not been many detailed studies on the different aspects of taungya, many workers have recorded their observations based on the limited field studies. Based on the observations of taungya practices in the settlements of Paleungs, Burma, Watson (1908) expresses the fear of converting forest land into unproductive wasteland incapable of supporting any population in two decades. However, another observer (Anonymous 1919) from Burma notes that taungya system incorporating farming is more suitable for Burmese conditions. Adam (1923) stresses the importance of knowledge of agricultural crops used in taungya, with special reference to their effect on the tree crops. From observations of taungya in Thindawyo reserve in Burma, Hay (1924) records the suppression of tree seedlings by sugarcane. In the same vein, working in Cachar Division, Rowbotham (1924) points out the suppression of teak seedlings by rice in the first year. And, Hussain (1925) comments on the detrimental effect of shade of arhar (Cajanus cajan) on the sal seedlings.

In an Indonesian study Coster and Kardjowasono (1935) conclude that agricultural crop in any form retards teak growth and succession of more agricultural crops is harmful. Tapioca is found to be more harmful followed by dry paddy, groundnut and goat pepper. They also comment on root competition and shade effects. However, they suggest that ill effects of taungya are not so great as to abandon it. Another observer (Anonymous 1936) suggests that taungya practiced in areas covered by species other than bamboos or grasses have a profound effect on the lime requirement of the surface soils. This indirectly indicates that the leaching rate is increased under taungya. In this connection, Coster's (1939) report shows that teak is susceptible to root competition, especially that of grass.

Manning (1941) suggests that the quality of the agricultural crop in taungya must be improved. He also recommends that the improvement of the land can be achieved through terracing in hilly areas. Some of the general observations on taungya are those of Browne (1929), De (1932), Schnepper (1934), Aguirre (1963), and Champion and Seth (1968).

In Kerala, experiments conducted in Palghat Division (Anonymous 1947, 1949) indicate that many agricultural crops have no detrimental effect on teak growth. The workers suggest that hill rice, chillies, cotton, millets, tapioca, horsegram and ginger can be grown along with teak without any loss in height increment.

Commenting on the advantages of taungya in Java, Alphen de Veer (1954) notes that leasing of land to the planters serves a social purpose and in return the young trees take advantage of the good care which is given by the former in the form of regular weeding and soil working. Also from the Indonesian experience, Joeswopranjoto (1957) recommends that soil conservation measures should be adopted in teak plantations.

From Malaysian experience, Cheah (1971) recommends taungya as a measure against encroachment and for successful afforestation of unproductive area. Also Mansoor and Bor (1972) note that taungya system can play an important role in forest rehabilitation in Malaysia because it is an inexpensive means of afforestation. They comment that in addition to its desirable or positive economic aspects, because of the involvement of rural people, taungya also provides employment and improves the living standards of the rural population. Considering the positive roles of taungya practices, National Commission on Agriculture (1976) recommends that the Forest Departments should encourage taungya in afforestation sites to provide employment to rural population and simultaneously to increase productivity of agricultural crops.

MATERIALS AND METHODS

The experimental plots were laid out in forest plantations to conform to usual management practices. As management practices such as taungya leasing and cultivation of specified crops by the taungyadars were beyond our control, all the cropping sequences except tapioca-tapioca were available for soil-sampling before cropping, after first and after second croppings.

Soil Samples

Six taungya plots were selected in 1977 from clearfelling areas of Vazhachal, Trichur and Nilambur Divisions (Table 1). Soil samples were collected from profiles to characterize soil in each plot. For taking surface samples (0-20 cm), each plot was divided into four horizontal subplots and three random samples were collected from each subplot (Table 2). Such stratified surface samples were taken from all the plots before cropping (control); from Kollathirumed, Vazhachal, Pullamkandam, Elencheri and Kariem-Muriem after rice; from Elencheri and Kaiem-Muriem after rice-rice; from Kollathirumed after rice-tapioca; and from Kondazhi after tapioca cultivations. The soil samples were air-dried, passed through 2 – mm sieve and stored for analyses.

Rationale for the Analyses

One of the objectives of the study being evaluation of changes in soil properties due to taungya practices, properties of the soils have to be studied before cropping and after rice, rice-rice and tapioca croppings.

Particle-size distribution, an important physical property and soil reaction (pH), organic carbon and cation exchange capacity, three important chemical properties of the soils were selected for analyses. Considering the three year duration of the project as well as the general nature of the problem, study of these properties can throw enough light on the effect of taungya practices on soil properties.

Since soil erosion measurements would involve much instrumentation and a large number of plot-years, it was decided to asses the extent of erosion indirectly. Such an indirect assessment can be based on the premise that if surface horizon is being eroded or part of it is slowly removed, the properties of the horizon immediately below would tend to show up in the properties of the surface samples (0-20 cm) to be sampled after rice, rice-rice, rice-tapioca or tapioca croppings. Though the profile samples were essentially taken for characterization of each plot, the properties of the surface one or two horizons can be studied from the profile data.

Analyses

Particle-size separates (sand 2.00 – 0.02, silt 0.02 – 0.002, clay < 0.002 mm diameter), pH in soil water suspension, organic carbon and cation exchange capacity analyses were done according to methods described in Methods of Soil Analysis (American Society of Agronomy 1965) and Soil Chemical Analysis (Jackson 1958). A simplified textural diagram developed by us was used for determination of textural class of the soil after particle-size analysis (Fig.3).

Table 1. Location and area of taungya plots

Plot	Area (ha)	Forest Division	Forest crop
Kollathirumed	1.5	Vazhachal	Albizia
Vazhachal	1.5	Vazhachal	Eucalyptus
Pullamkandam	1.5	Trichur	Teak
Kondazhi	0 4	Trichur	Eucalyptus
Elencheri	2.0	Nilambur	Teak
Kariem-Muriem	1.5	Nilambur	Teak

Table 2. Taungya treatments and number of surface samples

Plot	Before cropping	After rice	After rice-rice	After rice-tapioca	After tapioca
Kollathirumed	12	12	nil	12	nil
Vazhachal	12	12	nil	nil	nil
Pullamkandam	12	12	nil	nil	nil
Kondazhi	12	nil	nil	nil	12
Elencheri	12	12	12	nil	nil
Kariem-Muriem	12	12	12	nil	nil

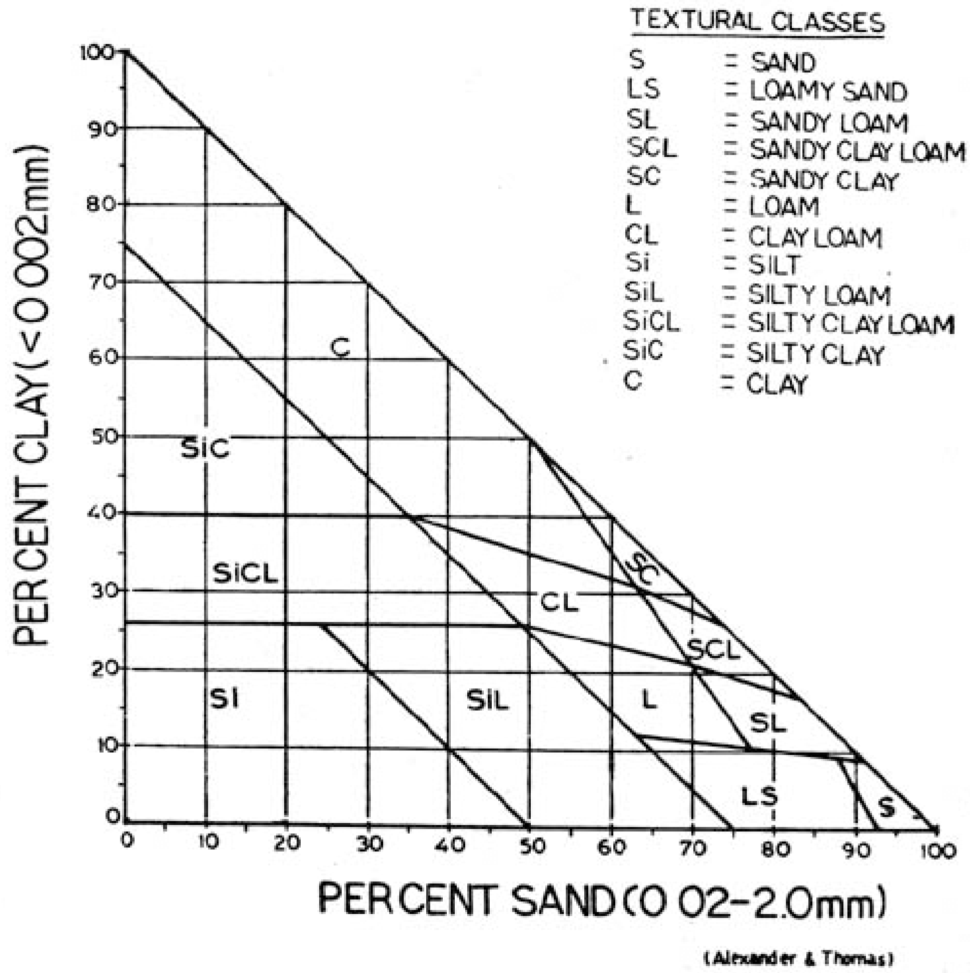

Figure 3. A simplified textural diagram

RESULTS

Descriptions of the profiles and their properties are given in Tables 3-8 and properties of surface samples in relation to taungya treatments are given in Table 9 and Figure 4.

Particle-size Separates

The relative proportion of sand, silt and clay separates determines soil texture. Most of the surface horizons are loam in texture. In the profiles, sand (coarser separate) decreases and silt plus clay (finer separates) increases with depth. In the surface samples, texture ranges from loamy sand to loam with most of them being loam.

Soil Reaction (pH)

Hydrogen ion activity or pH value is a measure of soil reaction. Most of the surface horizons are strongly acid. In Kollathirumed, Pullamkandam and Kariem-Muriem, pH decreases with depth and in the Vazhachal, Kondazhi and Elencheri profiles, it tends to increase with depth. The surface samples are medium to strongly acid.

Organic Carbon

Organic matter content of a soil can generally be calculated from organic carbon content by multiplying the latter by 1.72 since organic matter contains approximately 58% carbon. In all the profiles, organic carbon decreases with depth and beyond 100 cm depth, there is very little of it. This is expected as there will be more litter deposited in the surface horizons. The surface samples are fairly rich I the organic carbon.

Cation Exchange Capacity (CEC)

The sum of exchangeable bases (principally calcium, magesium, potassium and sodium) and exchangeable hydrogen plus aluminum is a measure of CEC of soil. CEC values tend to decrease with depth in Kollathirumed, Pullamkandam, Kondazhi and Elencheri and remains steady with depth in Vazhachal and Kariem-Muriem profiles. In the surface samples CEC values are fairly high.

Soil Properties in Relation to Taungya Cropping

Sand decreases and silt plus clay increases with rice in Kollathirumed, Vazhachal, Elencheri and Kariem-Muriem and with tapioca cropping in Kollathirumed and Kondazhi surface sample. In Pullamkandam, sand increases and silt plus clay decreases with rice cultivation. pH decreases with first rice in Kollathirumed , Vazhachal, Pullamkandam, Elencheri and Kariem-Muriem whereas it increases with second rice in Elencheri and Kariem-Muriem and with tapioca in Kollathirumed and Kondazhi. Organic carbon increases with rice cropping in Kollathirumed,; it comes back to the initial level with tapioca; it decreases with rice in Vazhachal and Pullamkandam; and it increases with rice in Elencheri and with tapioca in Kondazhi. Cation exchange capacity decreases with rice-tapioca in Kollathirumed, with rice in Vazhacahl and Pullamkandam and it increases with rice-rice in Elencheri and Kariem-Muriem. However, it remains unchanged with tapioca cropping in Kondazhi surface samples.

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Table 3. Kollathirumed profile and properties

Hilly, well drained, 1966 failed eucalyptus plantation.

0-10 cm	Dark reddish brown (5 YR 3/4), loam, granular structure, few to many roots.
10-35 cm	Dark reddish brown (5 YR 3/4), loam, granular structure, few roots.
35-80 cm	Yellowish red (5 YR 5/6), loam, massive structure, few roots.
80-120 cm	Reddish yellow (7.5 YR 7/6), loamy sand, massive structure, very few roots.

Depth (cm)	Sand	Silt (...........%...........)	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
0-10	71	16	13	5.3	2.87	22
10-35	67	16	17	4.3	1.90	18
35-80	64	18	18	5.0	1.20	14
80-120	78	12	10	5.5	0.49	9

Table 4. Vazhachal profile and properties

Hilly, well drained, evergreen forest.

0-12 cm	Reddish brown (5 YR 4/3), loamy sand, granular structure, abundant roots.
12-57 cm	Yellowish red (5 YR 4/6), loam, granular structure, many roots.
57-107 cm	Yellowish red (5 YR 5/6), loam, massive structure, few roots
107-162 cm	Reddish yellow (5 YR 6/6), loam, massive structure, very few roots.
162-182 cm	Reddish yellow (5 YR 7/6), loam, massive structure, no roots.

Depth (cm)	Sand	Silt (...........%...........)	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
0-12	83	10	7	5.4	1.60	11
12-57	75	11	14	5.5	0.77	11
57-107	70	11	19	5.8	0.35	14
107-162	74	11	15	5.6	0.24	11
162-182	75	11	14	5.6	0.21	11

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Table 5. Pullamkandam profile and properties

Hilly, well drained, evergreen forest.

0 – 15 cm Reddish brown (5 YR 4/3), loam, granular structure many roots.

15 – 40 cm Yellowish red (5 YR 4/6), clay loam, granular to blocky structure, few to many roots.

40 – 120 cm Reddish yellow (5 YR 6/6), loam, massive structure, few roots.

120 - 150 cm Yellowish red (5 YR 5/8), loam, massive structure, very few roots.

Depth (cm)	Sand	Silt	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
	(…………%………)					
0 - 15	72	14	14	6.2	1.96	20
15 - 40	60	11	29	6.0	0.58	13
40 - 120	70	12	18	5.5	0.25	10
120 - 150	62	16	22	5.4	0.27	13

Table 6. Kondazhi profile and properties

Level to gently rolling, moderately well drained, moist deciduous forest.

0 – 12 cm Dark reddish brown (5 YR 3/3), loam, granular structure, many roots.

12 - 52 cm Dark reddish brown (5 YR 3/4), clay loam, granular to blocky structure, many roots.

52 – 90 cm Yellowish red (5 YR 4/6), loam, massive structure, few roots.

90 – 140 cm Yellowish red (5 YR 4/6), sandy loam, massive structure, few roots.

Depth (cm)	Sand	Silt	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
	(…………%………)					
0 - 12	76	12	12	5.3	1.45	17
12 - 52	65	10	25	5 3	0.69	16
52 - 90	71	11	18	5.4	0.18	15
90 - 140	78	8	14	5.6	0.16	12

Table 7. Elencheri profile and properties

Level, moderately well drained, 1920 teak plantation (second rotation).
0 - 15 cm Reddish brown (5 YR 4/4), loam, granular structure, many roots.
15 - 50 cm Reddish brown (5 YR 4/4), loam, granular structure, many roots.
50 - 120 cm Yellowish red (5 YR 5/6), silt loam, massive structure, few roots.

Depth (cm)	Sand (............%............)	Silt	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
0 - 15	74	14	12	5.5	1.72	15
15 - 50	67	13	20	5.5	0.98	13
50 - 120	69	27	4	5.7	0.18	10

Table 8. Kariem-Muriem profile and properties

Gently rolling, well drained, moist deciduous forest.

0 - 10 cm Dark reddish brown (5 YR 3/3), sandy loam, granular structure, few to many roots.

10 - 60 cm Yellowish red (5 YR 4/6), clay loam, massive structure, few roots.

60 - 120 cm Reddish yellow (5 YR 6/6), clay loam, massive structure, very few roots, soft plinthite in the lower part of the horizon

Depth (cm)	Sand (............%............)	Silt	Clay	pH in water	Organic carbon (%)	Cation exchange capacity (me/100g)
0 - 10	80	9	11	5.8	2.43	14
10 - 60	63	10	27	5.7	0.78	14
60 - 120	61	9	30	5.3	0.28	14

Table 9. Properties of surface samples (0-20 cm) in relation to taungya treatments*

Treatment	Sand (...		Silt .... %		Clay ......)		pH in water		Organic carbon (%)		Cation exchange capacity (me/100g)	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
Kollathirumed												
Before cropping	75	3	13	2	12	2	5.3	0.3	2.04	0.30	20	3
After rice	73	1	14	1	13	2	4.2	0.3	2.28	0.20	19	2
After rice-tapioca	70	2	14	1	16	2	5.7	0.2	2.01	0.32	17	1
Vazhachal												
Before cropping	83	1	11	1	6	1	5.5	0.1	1.99	0.24	16	3
After rice	81	1	11	2	8	2	5.1	0.2	1.77	0.22	15	2
Pullamkandam												
Before cropping	71	3	16	1	13	2	6.2	0.3	1.63	0.30	21	2
After rice	73	3	15	1	12	2	5.1	0.2	1.44	0.23	19	2
Kondazhi												
Before cropping	80	4	10	2	10	3	5.4	0.1	1.35	0.16	15	3
After tapioca	75	4	10	2	15	2	5.6	0.3	1.53	0.20	15	2
Elencheri												
Before cropping	71	9	17	6	12	3	5.6	0.2	1.64	0.33	17	4
After rice	70	5	17	4	13	1	5.1	0.3	1.80	0.35	19	3
After rice-rice	67	7	16	5	17	3	5.7	0.3	1.77	0.34	18	3
Kariem-Muriem												
Before cropping	76	6	11	3	13	4	5.7	0.2	2.01	0.43	18	4
After rice	77	5	10	3	13	3	4.8	0.1	2.17	0.35	19	3
After rice-rice	73	7	11	3	16	4	5.8	0.1	2.21	0.45	19	3

* Each value is the average of 12 different sample values.

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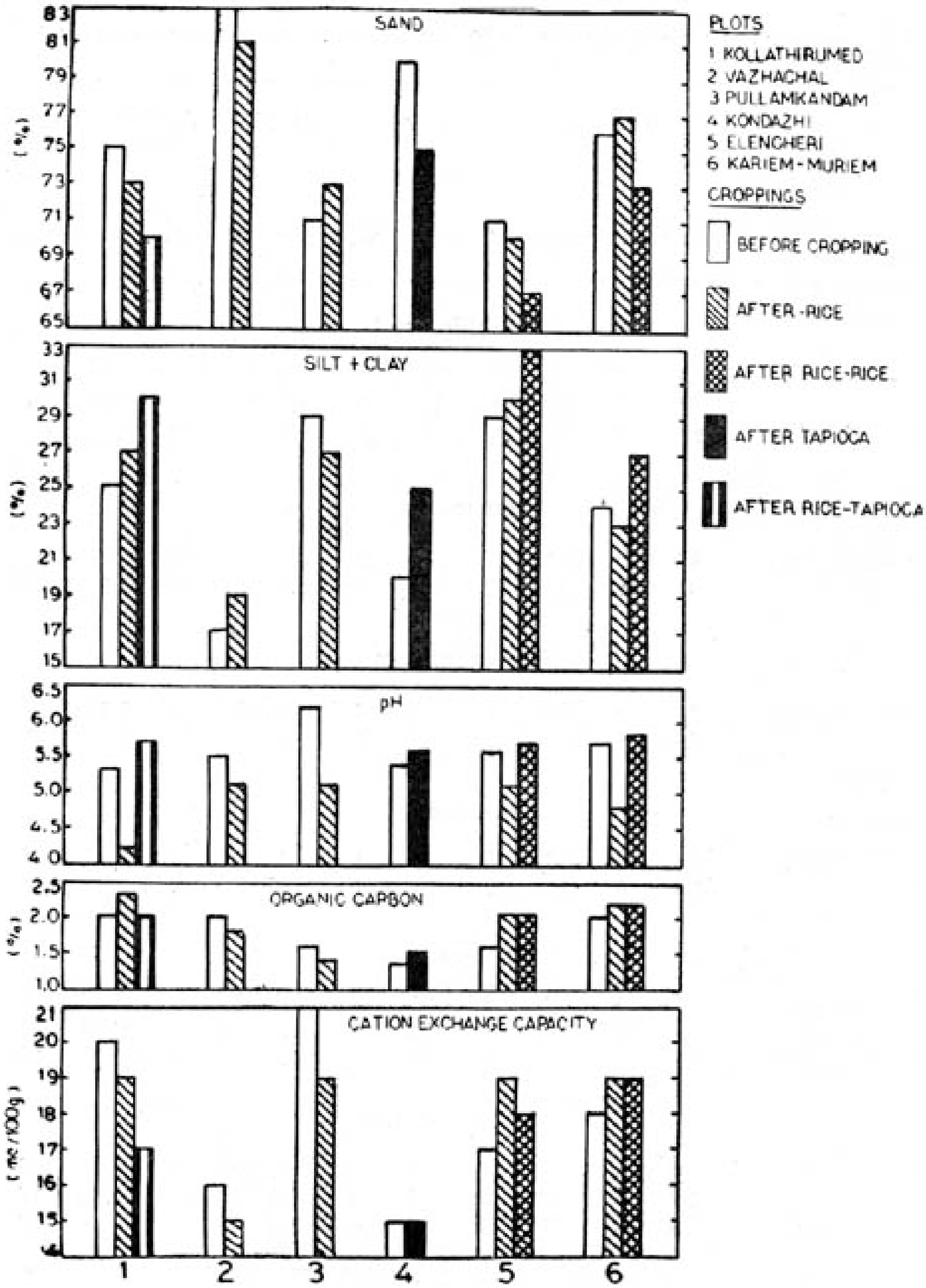

Figure 4. Effect of taungya cropping on the properties of surface samples (0-20 cm)

DISCUSSION

Changes in Soil Properties

After two years of taungya cropping, changes tend to occur with sand, silt and clay contents, pH, organic carbon and cation exchange capacity. Distribution of more silt plus clay and less sand in the surface samples after two years of cropping suggests that surface sample texture is influenced by the texture of the subsurface horizons. This is evident when we study the properties of the top two horizons of the profiles (Tables 3-8). The san content decreases and silt plus clay content increases with depth in the profiles. For example, Kollathirumed 10-35 cm horizon has 67% san and 33% silt plus clay compared to 71% san and 29% silt plus clay in the 0-10 cm horizon. The same trend is evident in Vazhachal, Pullamkandam, Kondazhi, Elencheri and Kariem-Muriem profiles. In all the profiles organic carbon decreases with depth and cation exchange capacity tend to decrease with depth in all the profiles except Vazhachal and Kariem-Muriem.

Since two years of crop growth is unlikely to cause much effect on the sand, silt and clay contents, organic carbon and cation exchange capacity, the changes seen are likely due to the disturbance caused to the soil in the form of preplanting tillage, intercultivation and harvesting operations. The data suggest that one crop of rice causes less changes in some of these soil properties than rice-rice, rice-tapioca and tapioca crops.

These findings are in concordance with the nature of disturbance caused to the soil in establishing second crop of rice or first or second crop of tapioca. The maximum disturbance to the soil is from the mound formation for tapioca planting. Even though initial disturbance will be there in raising the first rice crop, during harvesting of rice there is hardly any damage to the soil. In fact the crop residues form a good surface much which retard surface runoff and erosion. In the case of tapioca as well as second rice crop, ground preparation is necessary for crop establishment.

Soil Erosion

Many of the advantages of taungya are vitiated by its greatest disadvantage of accelerated erosion and hence soil loss. The soil loss is so visible in many areas that its quantification is not at all necessary for taking steps to combat this acute problem associated with taungya. Though we have not conducted field studies to estimate the runoff and soil loss through erosion, there is enough evidence to show that soil erosion is an acute problem in taungya plantations (Fig. 5-10). There is also indirect evidence from the data of soil properties as discussed already. In many of the sites, the properties of the surface samples are influenced by those of subsurface horizons. It implies that the surface horizons are partly being eroded and the subsurface horizons are gradually getting exposed.

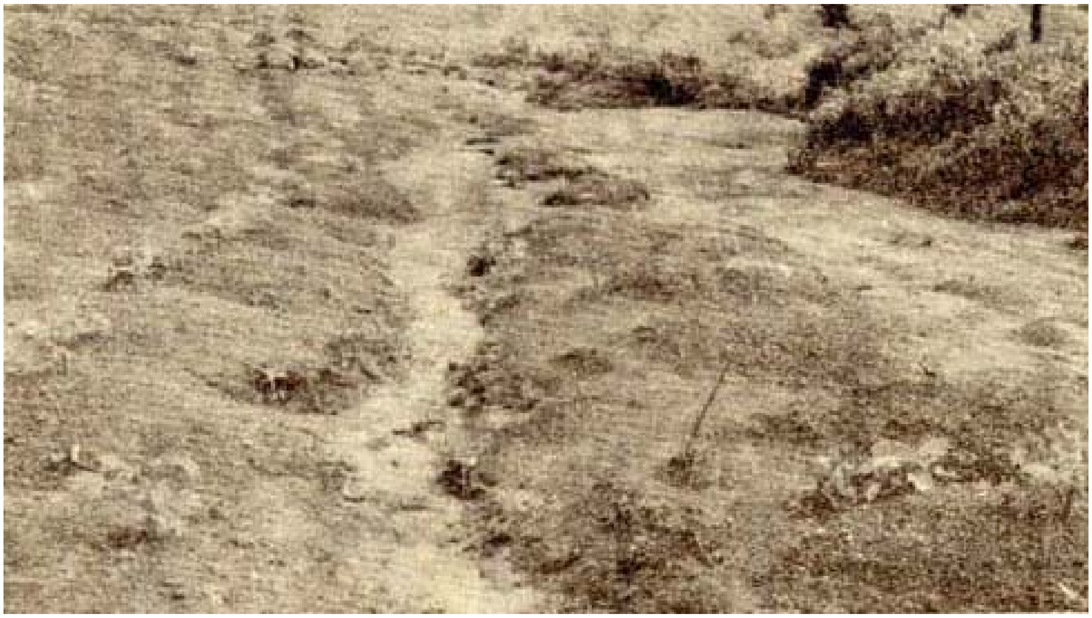

Figure 5. Erosion of tapioca mounds in tapioca taungya at Wadakkancheri Range

Figure 6. Erosion of tapioca mounds in tapioca taungya at Wadakkancheri Range

Figure 7. Beginning of gully erosion in ginger taungya at Neriamangalam Range

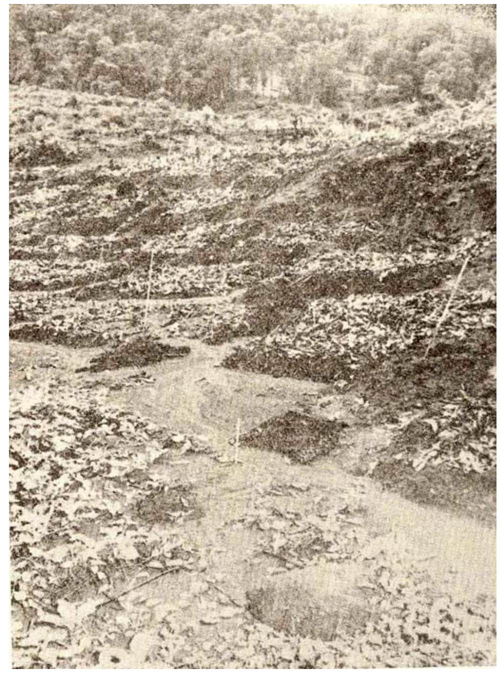

Figure 8. Erosion of ginger beds in ginger taungya at Mullaringad Range

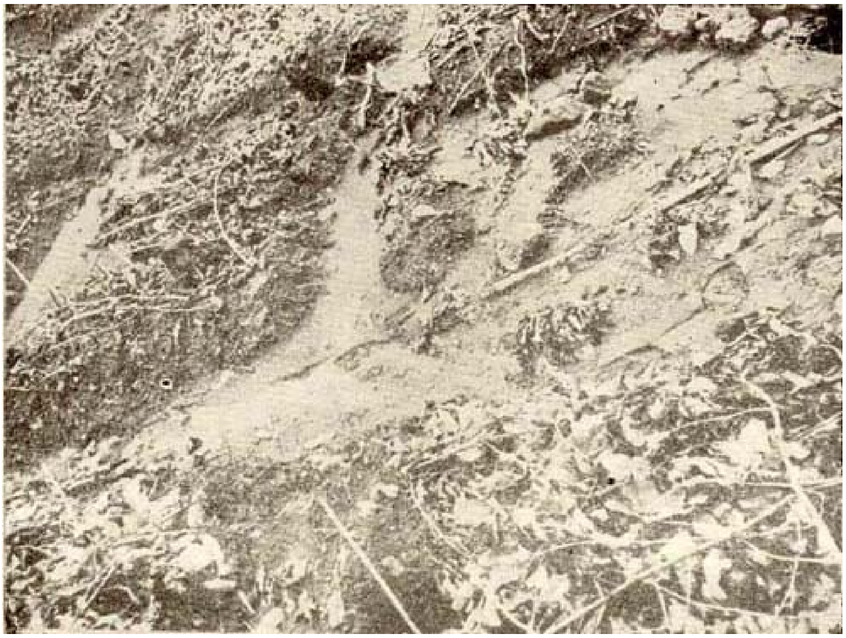

Figure 9. Ginger beds being washed down the slopes in ginger taungya at Neriamangalam Range

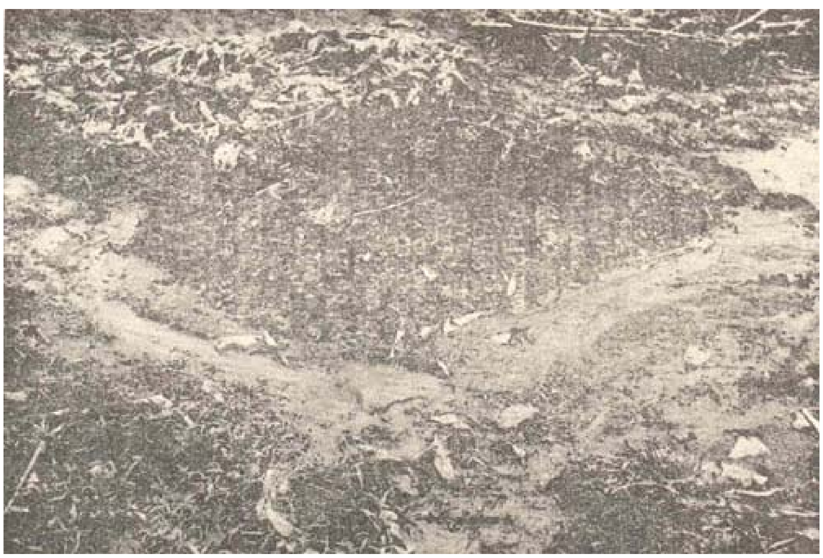

Figure 9. Two-way slopes showing erosion along two sides of ginger bed at Mullaringad Range

Soil erosion is a function of the erosivity of the rain and the erodibility of soil. Erosivity is the potential ability of the rain to cause erosion whereas erodibility is the vulnerability of the soil to erosion. The latter depends on the inherent characteristics of the soil and how it is managed. In taungya plantations without soil conservation measures, both erosivity and erodibility are enhanced. Under rice-rice, rice-tapioca and tapioca cultivations, due to the additional soil disturbance in establishing these crops, both these factors are accelerated and therefore soil erosion occurs considerably more here than in the case of just rice cultivation.

Soil Management

The experimental data point out the need for a different approach in the management of soils in taungya plantations. If the forest land is not properly managed in taungya, productive land will be converted into unproductive marginal land. This is mainly because the taungyadar has only a transient interest in the area he cultivates or gets it cultivated. Two years of cultivation without proper soil management practices can convert an area into an unproductive one. Also permanent damages occur in our taungya plantations. For instance, combined use of land for agriculture and silviculture is often detrimental to forest plantations, especially on slopy areas. Also the exposure and loss of topsoil can lead to increased laterization which results in the formation of a hard surface layer or a hard crust on the surface of the soil.

The data tend to show that one crop of rice causes minimum changes whereas rice-rice, rice-tapioca and tapioca cultivations cause maximum changes in some of the soil properties. The advantage of one rice crop is that it causes minimum disturbance to the surface horizons of the soils. After the harvest, the residues form a surface much which will retard runoff and erosion.

Soil management practices to combat soil erosion are generally based on two broad principles; firstly, practices which increase infiltration rates of soils for reducing runoff and secondly, practices which help safe disposal of runoff water if rainfall exceeds the infiltration capacity of the soils. Usually a combination of both practices are essential for adequate erosion control. Practices which help to maintain high soil infiltration rates are based on farming operations which will maintain a mulch or vegetative cover on the soil. The safe disposal of runoff water requires physical manipulation of land including landshaping, laying out of contour bunds, terraces, waterways, and ridges. Considering the constraint of financial resources in laying out engineering control methods, the least we can follow is the use of crop residues from the previous crop for conservation of soil.

As suggested before, the residues left after the harvest of first rice crop form a surface mulch which prevents direct raindrop impact on the soil. Because there is minimum tillage, it decreases runoff and reduces soil loss. Further, such a mulch reduces weed growth and conserves moisture in the soil profile.

CONCLUSION AND RECOMMENDATION

Agrisilvicultural practices (taungya) tend to cause changes in sand, silt and clay contents. pH, organic carbon, and cation exchange capacity of the soils. Raising of one crop of rice causes minimum where as rice-rice, rice-tapioca or tapioca cultivations cause maximum changes in some of the soil properties. Indirect evidence points to more soil erosion with rice-rice, rice-tapioca and tapioca than rice alone cultivations. Based on the experimental data and well-established principles of tropical soil management, it is suggested that only one crop of rice may be allowed in taungya plantations. The cultivation of one crop of rice results in minimum soil disturbance which is helpful in reducing soil loss. Furthermore, residues left after rice harvest form a surface mulch which will retard runoff and soil erosion in taungya plantations.

However, if a second crop is required for taungya plantations, rice may be cultivated with minimum preparation of land. If the choice is for tapioca or any tuberous/rhizomatous crop requiring thorough land preparation, soil conservation measures should be adopted for keeping soil loss to the minimum. Otherwise valuable topsoil will be lost for the short-term benefit of lease income from taungya.

LITERATURE CITED

ADAM, J.B.M.1923. Field crops in taungya plantations. Ind. For. 49: 597-600.

AGUIRRE, A. 1963. Silvicultural and economic study of the taungya system in the conditions of Turrialba, Costa Rica. Turrialba 13: 168-171.

ALPHEN, de VEER E.J. et al 1954. Teak cultivation in Java. Proc. 4th World For. Cong. Dehra Dun, 3: 323-338.

AMERICAN SOCIETY OF AGRONOMY. 1965. Methods of Soil Analysis. Parts 1&2. BLACK, C.A et al (ed), ASA, Madison, Wisconsin, USA.

ANONYMOUS. 1919. A plea for teak taungyas. Ind. For. 45: 6-10.

ANONYMOUS. 1936. Editorial note. Ind.For.62: 372.

ANONYMOUS. 1947. The effect of different of Kumri crops on teak. For. Res. India & Burma, Part ii, p. 53.

ANONYMOUS. 1949. Effect of different of Kumri crops on teak raised with them. For. Res. India & Burma, Part ii, p.37.

ANONYMOUS. 1979. Eighth World Forestry Congress: Study Tour to East Kalimantan, Bali, East and Central Java. Common. For. Rev.58: 43-46.

BLANFORD, H.R. 1925. Regeneration with assistance of taungya in Burma. Ind. For. Rec. 2, Old Series (Silv). Also Ind. For Records, Vol xi, part iii, 37p. (1924)

BLANFORD, H.R. 1931. Experiments in connection with sowing and planting teak in taungya plantations. Burma For. Bull.24 (Silv. Series 14), 15p.

BROWNE, R.S. 1929. Report on a tour of inspection of some of the teak plantations in the State of Travancore. Ind. For. 55: 627-638.

CHAMPION, H.G. AND SETH, S.K. 1968. General Silviculture for India. Govt. of India Publications Branch, New Delhi.

CHEAH, L.C. 1971. A note on taungya in Negeri Sembilan with particular reference to the incidence of insect damage by oviposition of insects in plantations in Kenaboi Forest Reserve. Malay. For.34: 133-47.

COSTER, C.1939. Grass-teak taungya plantations. Ind. For. 65: 169-170.

COSTER, C AND KARDJOWASONO, M.S. 1935. The influence of agricultural crops in taungya plantations on the growth of teak. Tectona. 28: 464-487.

DE, R.N. 1932. Taungya in Garo Hills Division, Assam. Ind. For. 58: 93-99.

GEORGE, M.P. 1961. Teak plantations of Kerala. Ind. For. 87: 646-655.

HAY, E.F.A. 1925. Sugarcane in taungyas. Ind. For. 50: 644.

HUSAIN, M.S. 1925. The development of sal seedlings in Gorakhpur taungya. Ind. For. 51: 69-72.

JACKSON, M.L. 1958. Soil Chemical Analysis. Prentic- Hall Inc. Englewood Cliffs, NJ, USA.

JOESWOPRANJOTO, S. 1957. Soil conservation in teak plantations in Indonesia. 2nd Sess. FAO Teak Sub Comm. Bandung. No.FAO/TSC-57/29,5p.

KING, K.F.S. 1979. Agroforestry and the utilisation of fragile ecosystems. For. Ecol Manage 2: 161-168.

LAURIE, M.V. 1934. Summary of current methods of raising teak plantations in Madras 4th Silv. Conf. P.290-297.

MANNING, D.E.B. 1941. Some aspects of the problem of taungya in Burma. Ind. For. 67: 502.

MANSOR, M.R & BOR, O.K. 1972. Taungya in Negeri Sembilan. Malay. For. 35: 309-316.

NATIONAL COMMISSION ON AGRICULTURE. 1976. Abridged Report of Dept. of Agriculture, Ministry of Agriculture & Irrigation, New Delhi.

ONWELUZO, S.K. 1979. Forestry in Nigeria. J. of For. 77: 431-433 and 453.

ROWBOTHAM, C.J. 1924. The taungya system in Cachar Division. Ind. For. 50: 356-358.

SCHNEPPER, W.C.R. 1934. Application of artificial fertilizer to Forest cultivation. Tectona 27: 417-440.

WATSON, H.W.A. 1908. Taungya cutting. Ind. For 34: 264-269.