TROPICAL ECOLOGY, Jan., 1962
Vol. III (1 & 2)

THE EFFECT OF PLANTING TEAK OF DIFFERENT SEED ORIGINS ON GANGETIC ALLUVIUM

By J. S. Singh
Central Botanical Laboratory, Allahabad

Introduction

At the suggestion of the IX All-India Silvicultural Conference, a symposium on teak (*Tectona grandia* Linn.) was held during December, 1957. This symposium felt that the information on teak ecology, especailly the relationship of the plant with the soil was very limited and recommended that this problem be studied in more detail. Dr. G. S. Puri, Director, Central Botanical Laboratory, Allahabad, who has been actively engaged on the teak and Sal (*Shorea robusta* Gaertn.f.) ecology, suggested me to investigate the growth behaviour in relation to soil conditions of teak of different seed origins in the plantations at Gorakhpur which were raised in 1931 on Gangetic alluvium.

In his book on Indian Forest Ecology, Puri (1960) observes that natural teak forests occur on basaltic hills and riverain alluvia at many places south of Vindhyas. Successful teak plantations have been raised on riverain alluvia in many parts of Bombay, Madras, Coorg, Mysore, Travancore and Uttar Pradesh. But raising of the plantations, especially in non-teak areas has many important problems like: selection of proper seed origin for the particular area, soil capability, parasites, suitable management practices, etc. The selection of suitable teak seed origin must be made by considering the growth behaviour of different origins on particular soil type and their overall effect on the mineral economy for a longer period of time. The later point becomes more important since it has been expressed by many research workers that in later years soil under pure teak plantations may deteriorate; degrading, thereby the quantity and quality of the crop. Soil deterioration under pure teak plantations has been attributed by different workers variously, viz., exposure of soil during prolonged leafless period (Anon, 1934), hardening of the existing lateritic soil or lateritic rock on exposure and insolation (Griffith and Gupta, 1947) and lowering down of the calcium status of the soil (Bhatia, 1954 and Puri, 1953). On examining the available literature on teak soil relationship (Puri, 1960; Seth and Yadav, 1957 and Seth, Khan and Gupta, 1957). Seth *et al* (1957) seem to be correct in concluding that sufficient (quantitative) data are not available to prove or disprove the hypothesis of soil deterioration due to mineral deficiency. The present study is therefore, directed to find out the possible effect of plantations of different teak seed origins on the mineral economy of the soil in U.P.

Material and Method

The study reported here was made on five teak seed origin plantations, *viz.,* North Burma, South Burma, Madhya Pradesh (dry), South Bombay (moist) and North Bombay (dry), raised in the All-India Teak Seed Origin Plot, at Ramgarh, Gorakhpur in 1931.

In the centre of each plantation a

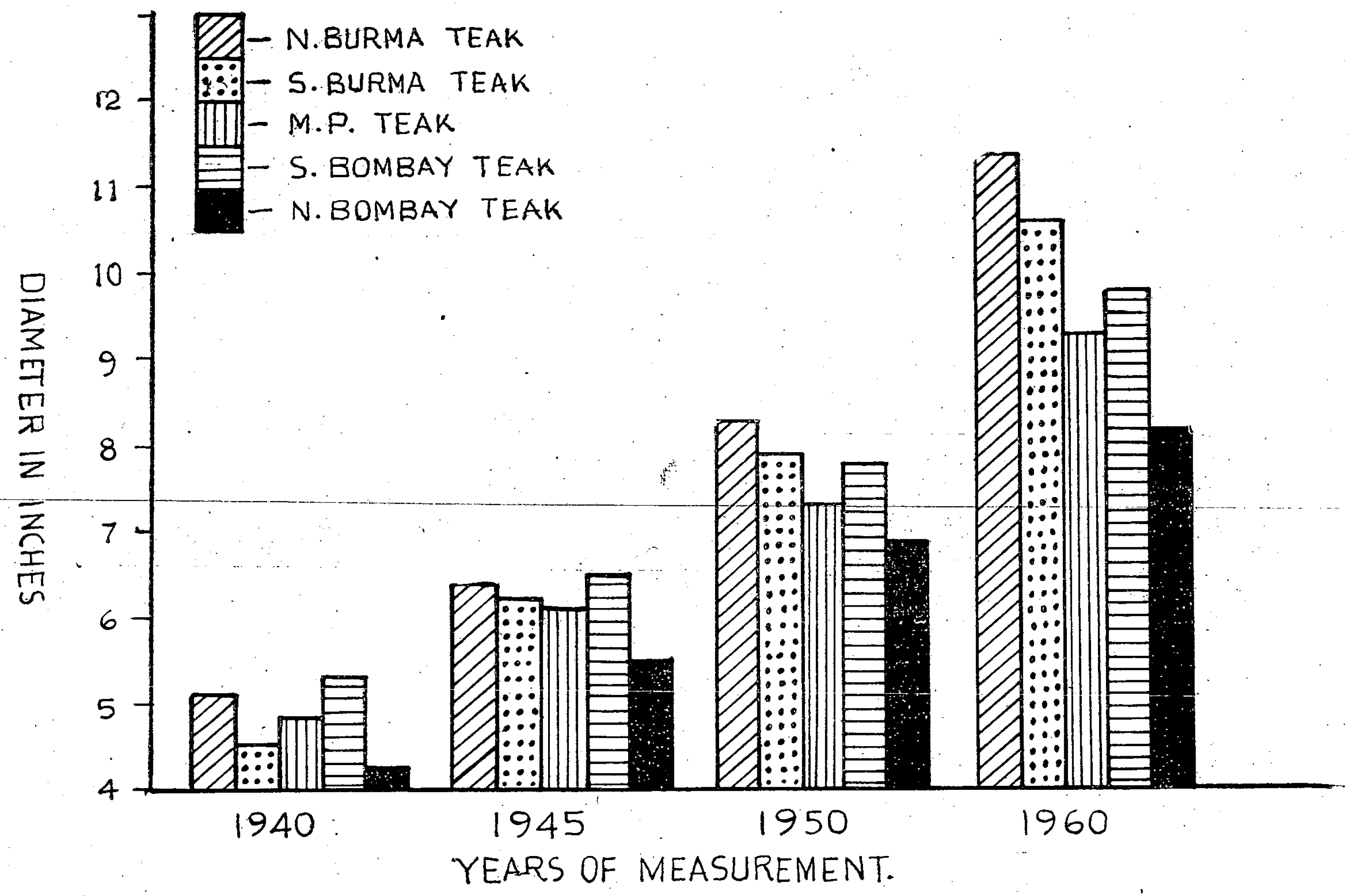

Fig. 1. A comparison of diameter of various teak seed origin trees in different years of study. The data for 1940, 45 and 50 are those of Mathauda (1951).

quadrat (30 m. × 60 m.) was marked and individual trees were charted on a graph paper with their girth measurements. Number and height of trees recently felled in each quadrat were also noted.

For soil analysis, composite soil samples were collected for 15 cms. horizon from surface upto 105 cm. depth by digging a soil profile in the centre of each quadrat. These samples were analysed in the laboratory, for exchangeable calcium, magnesium and potassium by the methods given by Piper (1944). pH was determined by Cambridge pH-meter in 1 : 5 soil water ratio using glass electrode. Samples of leaves, twig-wood, butt-wood of teak plants of each seed origin were also collected and analysed. The studies were made in March 1960.

Results

I. Growth Behaviour of Different Seed Origins

Mathauda (1951) has given a short history of the plantations and states that in the year 1931, six seed origins, *viz.*, North Burma, South Burma, Nilambur, North Bombay (dry), South Bombay (moist) and Madhya Pradesh (dry) were planted in a plot in order to find out the suitability of different seed origins on Gangetic alluvium. At the time of the formation of sample plots by Silviculture department in 1937, the Nilambur and South Bombay origins were considered to be the best, Madhya Pradesh and North Burma the second best and South Burma, the worst in growth. The position of the various origins with regard to top height, average diameter and stocking in 1940, 1945 and 1950 is given by Mathauda (1951), which shows that North Bombay origin is the worst and South Bombay and Madhya Pradesh also inferior to the remaining two seed origins. The present position with regard to girth and height classes, as observed in March, 1960 is given in Table 1.

TABLE 1

Growth behaviour of different teak seed origin plantations

Plantations	Total No. of trees felled recently in 30×60 m.	Girth classes					Total No. of trees in 30×60 m.	Height classes			Total number of sample trees.
		50 cm.—65 cm.	65 cm.—80 cm.	81 cm.—95 cm.	96 cm.—100 cm.	111 cm.—125 cm.		10—15 m.	16—20 m.	21—25 m.	
North Burma Teak seed origin.	27	..	4	22	18	10	54	2	5	3	10
South Burma Teak seed origin.	27	..	11	24	14	6	55	2	7	1	10
Madhya Pradesh Teak seed origin.	19	3	18	20	5	..	46	3	7	..	10
South Bombay Teak seed origin.	21	4	12	20	10	..	46	1	9	..	10
North Bombay Teak seed origin.	18	21	15	10	3	..	49	7	3	..	10

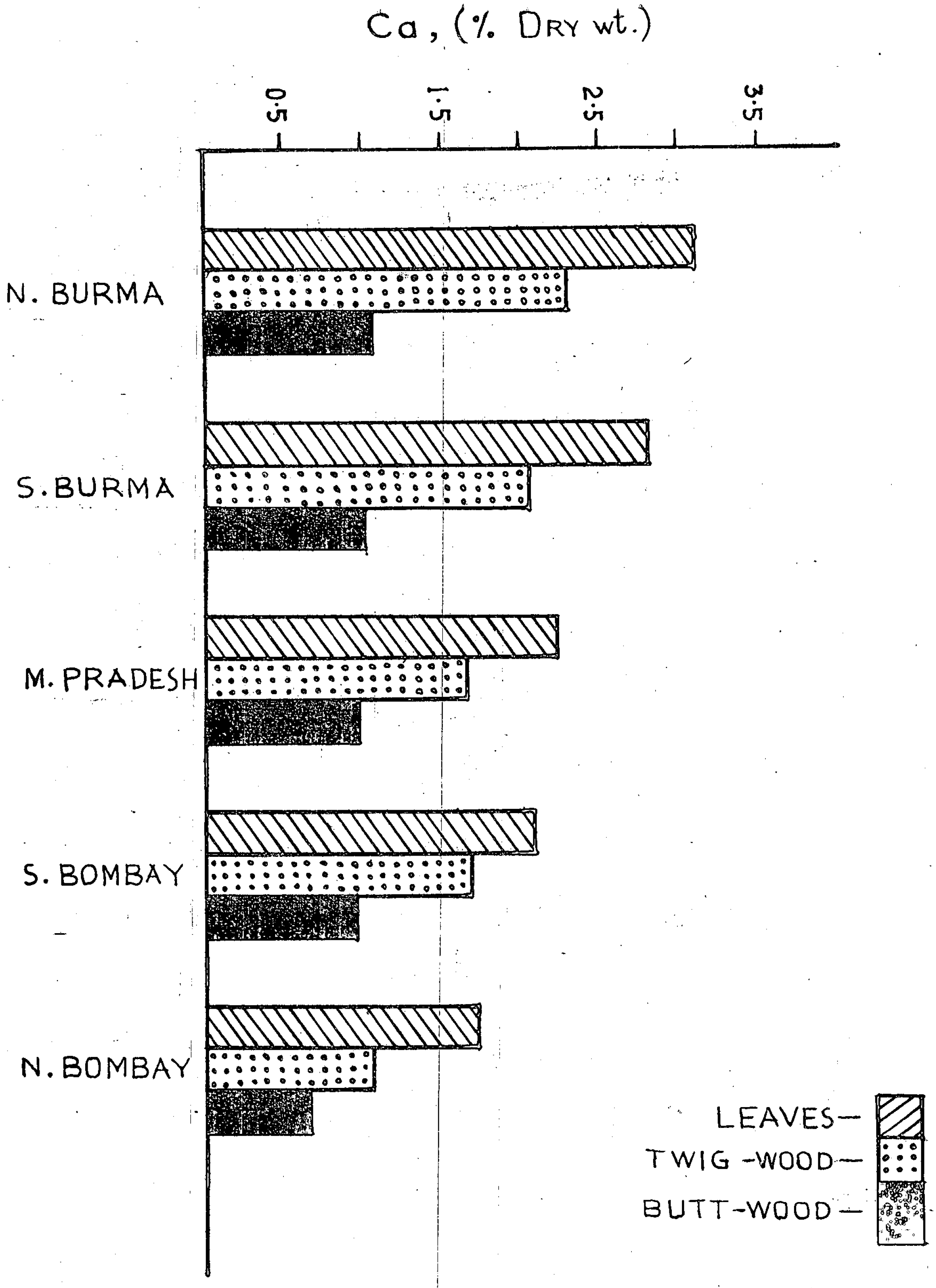

Fig. 2. Calcium status of leaves, twig-wood and butt-wood of different teak seed origin trees.

A comparison of the present growth with respect to the diameter of tree with those of early data given by Mathauda (1951) is presented in fig. 1. Since the values given by Mathauda are in inches, the same scale has been used in preparing the figure. It shows that in early stages of growth (i.e., in 1940), South Bombay seed origin is best and North Bombay is worst. In 1945, data show that although South Bombay is still the best in growth, North Burma is catching up. The growth of North Bombay and other seed origins has also comparatively improved. By 1950, North Burma has shown the best growth, second best being that of South Burma, while South Bombay seed origin becomes third. In 1960 considerable differences in the growth of all the five seed origins are seen, North Burma seed origin showing best growth, following by South Burma, South Bombay, Madhya Pradesh and lastly by North Bombay.

From Table 1 it is evident that maximum number of trees from an area of 30 m. × 60 m. of North Burma seed origin falls into the three girth classes between 81 cm. to 125 cm.; that of South Burma between 81 cm. to 110 cm.; Madhya Pradesh and South Bombay between 66 cm. to 95 cm.; and North Bombay between 50 cm. to 80 cm. The position with regard to height shows that 80% of the trees of North Burma origin fall in 16 m. to 25 m. range, 70% each of South Burma and Madhya Pradesh and 90% of South Bombay in 16 m. to 20 m., and lastly 70% of North Bombay seed origin trees fall in 10 m. to 15 m. height range.

From these data, it becomes clear that North Burma seed origin teak now shows best growth behaviour followed by South Burma, South Bombay, Madhya Pradesh and lastly by North Bombay origin. It may also be noted that North and South Burma Teak origin plantations yield quantitatively more timber, as is apparent from the number of recently felled trees, than the North Bombay and others (Table 1) seed origin teak.

II. Mineral Status of Plants

As a function of soil mineral status, leaves, twigs and butt-wood were separately analysed for each teak seed origin type. The results are given in Table 2. From a study of this table, it is seen that foliar calcium is heighest in North Burma teak seed origin followed by other origins in the order given in the table. The order almost synchronizes with the growth behaviour of the plants. Similarly the stored calcium in twigs and butt-wood is highest in North Burma teak, following the same decreasing sequence (Fig. 2). Ash, magnesium and phosphorus contents have been found to behave like calcium content, whereas potassium status does not show any regular trend.

III. Mineral Status of Soils

pH of the soil under different seed origin plantations is alkaline. The pH has been found to decrease with depth in case of N. Burma, S. Burma and South Bombay whereas under N. Bombay and Madhya Pradesh it shows tendency to increase with the depth (Table 3). However, the values of pH fluctuate in the intermediate horizons in all the cases.

Soil calcium in the top layers is more in North and South Burma and lowest in North Bombay, while the condition is reverse in the subsoils. A somewhat similar pattern is followed for magnesium and potassium contents. However, the decrease in these elements with the depth is more in the soils under North and South

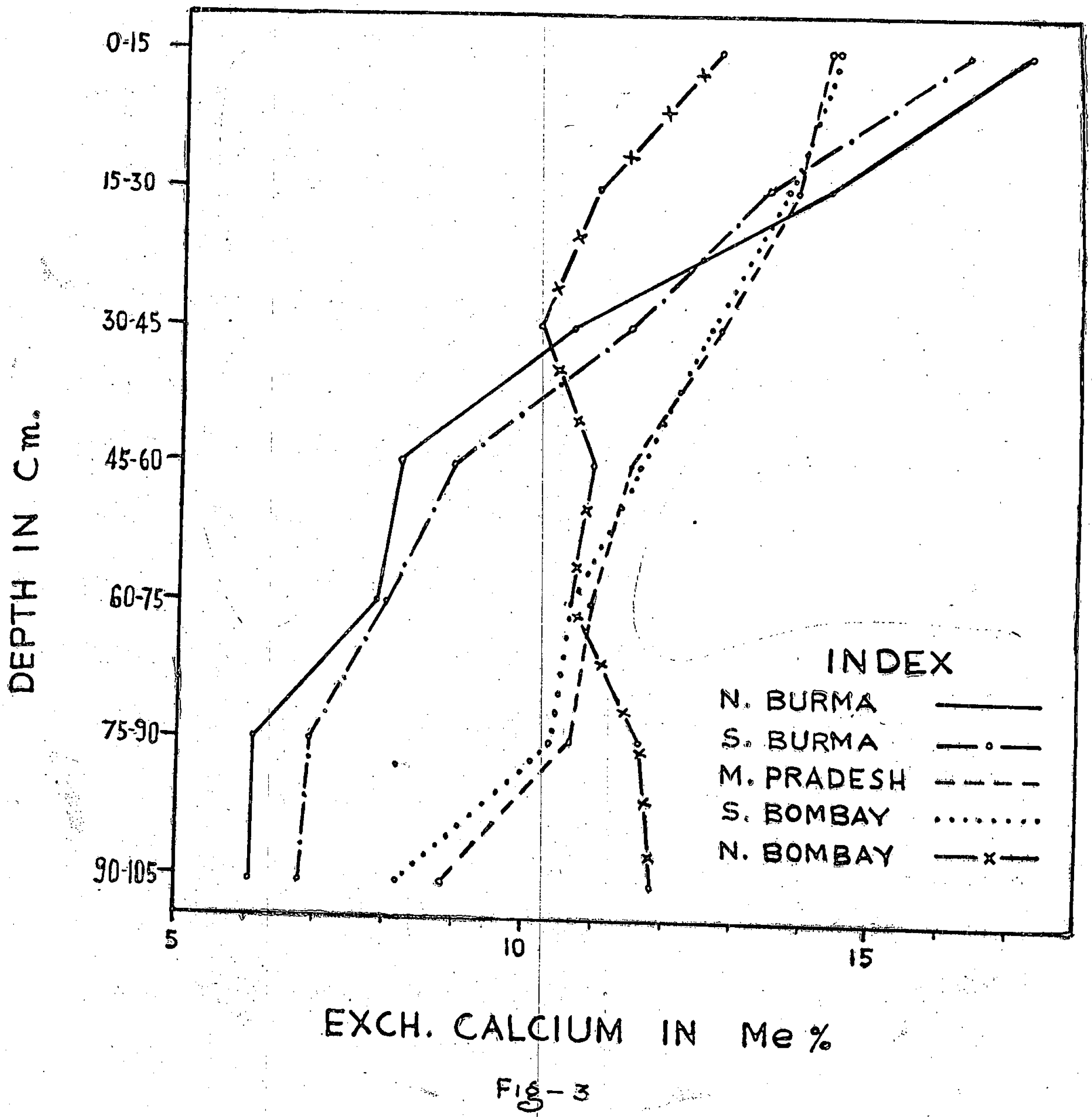

Fig. 3. Variation in exch. calcium with depth in soil profiles under different teak seed origin plantations.

TABLE 2

Mineral status of leaves, Twig-wood and Butt-wood in different teak seed origins (in %, Dry wt.)

	Ash	Ca	Mg	K	P
North Burma					
Leaves	16·11	3·12	0·820	0·896	1·220
Twig-wood	6·40	2·32	0·362	0·620	0·960
Butt-wood	3·40	1·06	0·061	0·036	0·076
South Burma					
Leaves	15·27	2·82	0·820	0·896	1·001
Twig-wood	6·00	2·03	0·364	0·660	0·820
Butt-wood	3·00	1·00	0·040	0·042	0·060
Madhya Pradesh					
Leaves	13·22	2·23	0·661	0·892	0·972
Twig-wood	4·20	1·62	0·260	0·660	0·860
Butt-wood	2·52	0·96	0·032	0·056	0·054
South Bombay					
Leaves	13·12	2·06	0·660	0·893	0·960
Twig-wood	4·15	1·64	0·280	0·720	0·700
Butt-wood	2·49	0·942	0·038	0·032	0·043
North Bombay					
Leaves	12·53	1·68	0·624	0·895	0·964
Twig-wood	3·42	1·02	0·190	0·940	0·500
Butt-wood	2·40	0·64	0·024	0·046	0·046

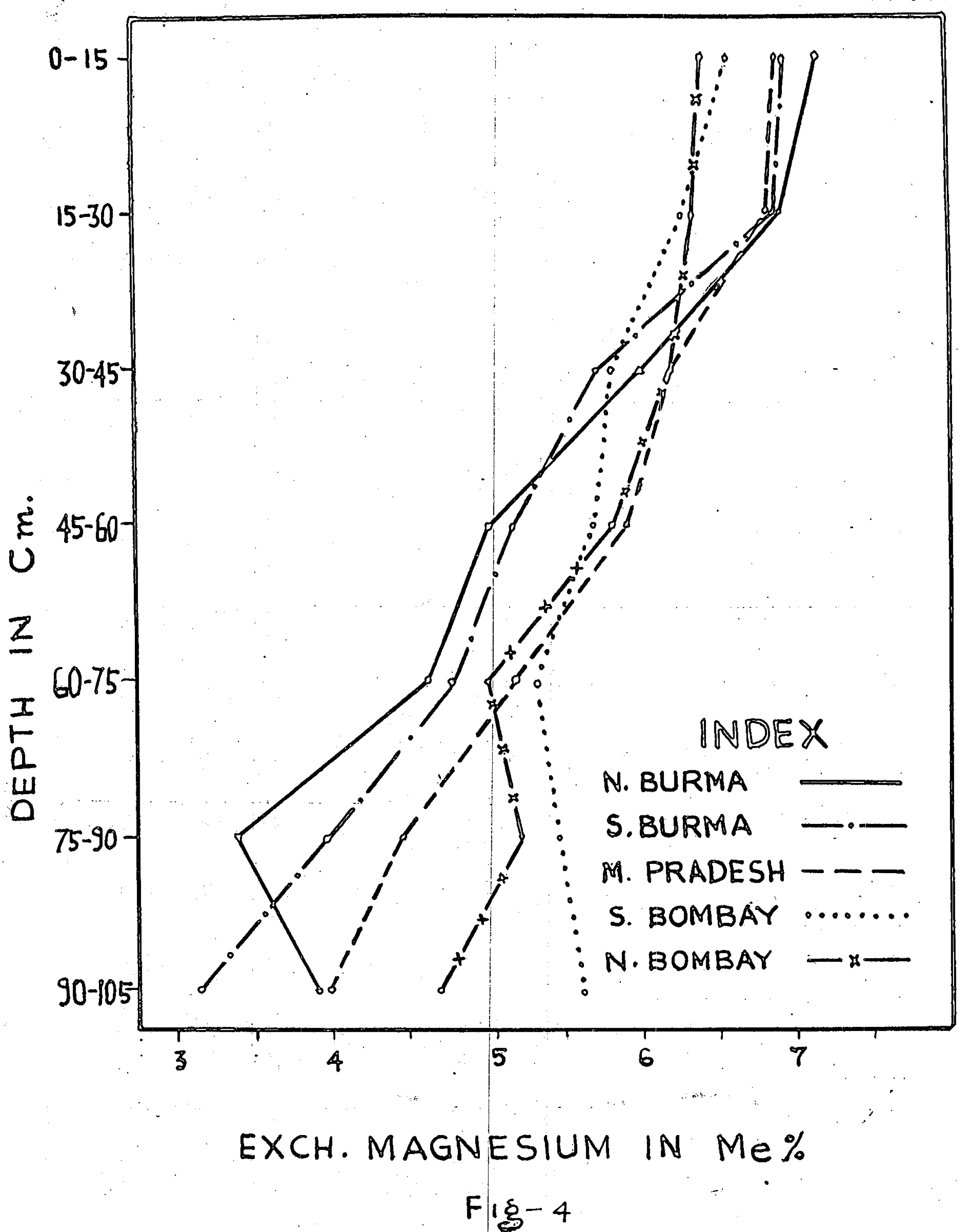

Fig. 4. Variations in exch. magnesium depth in soil profiles under different teak seed origin plantations.

TABLE 3

pH of the soils under different teak seed origin plantations

Depth	N. Burma	S. Burma	M. P.	S. Bombay	N. Bombay
0—6″	7.7	7·6	7·1	7·5	7·6
6– 12″	7·8	7·1	6·8	7·4	7·6
12—18″	7·4	7·5	7·3	7·3	7·6
18—24″	7·3	7·2	7·0	7·7	7·7
24—30″	7·7	7·4	7·3	7·6	7·7
30—36″	7·7	7·5	7·1	7·2	7·6
36—42″	7·2	7·1	7·3	7·2	7·8

Burma and less in South and North Bombay; that under Madhya Pradesh figuring in the middle. The data are graphically given in figs. 3, 4 and 5.

Discussion

Jenny (1941) has emphasized the role of plant as a pedogenic factor. Apart from the function of micro-organisms, vegetation has been treated by him as both dependent and independent variables. The return of mineral nutrient from the plants has been found by the author in two ways, viz., through leaf-fall and death and decay of root system. Under similiar conditions of climate and original soil factor the further metamorphosis of the soil will largely depend upon the plant factor, (Pandeya, 1959–61). In view of this, it is obvious that the soil characters under different teak seed origin plantations may be different entities.

The growth behaviour of teak of different origins under study shows two remarkable features.

1. The growth is best in North Burma teak seed origin at present followed by that of South Burma, South Bombay, Madhya Pradesh and lastly by North Bombay origins. The growth behaviour of the plantations appear to be positively correlated with the nutrient status (Table 2, fig. 2), especially calcium, magnesium and phosphorous of the leaves, twigs and butt-wood, i.e., trees of best grown seed origin (North Burma) shows higher minerals status than that of the other four seed origins, North Bombay being the poorest.

2. The mineral status of the soils under teak of different seed origins have been found to differ remarkably with each other. As mentioned earlier, the surface soils under better grown teak plantations are richer in minerals than the poor grown types. In this respect relationship between foliar calcium with surface and sub-soil calcium is interesting. As seen in figs. 6 & 7, the foliar calcium of different seed origin trees is positively correlated with

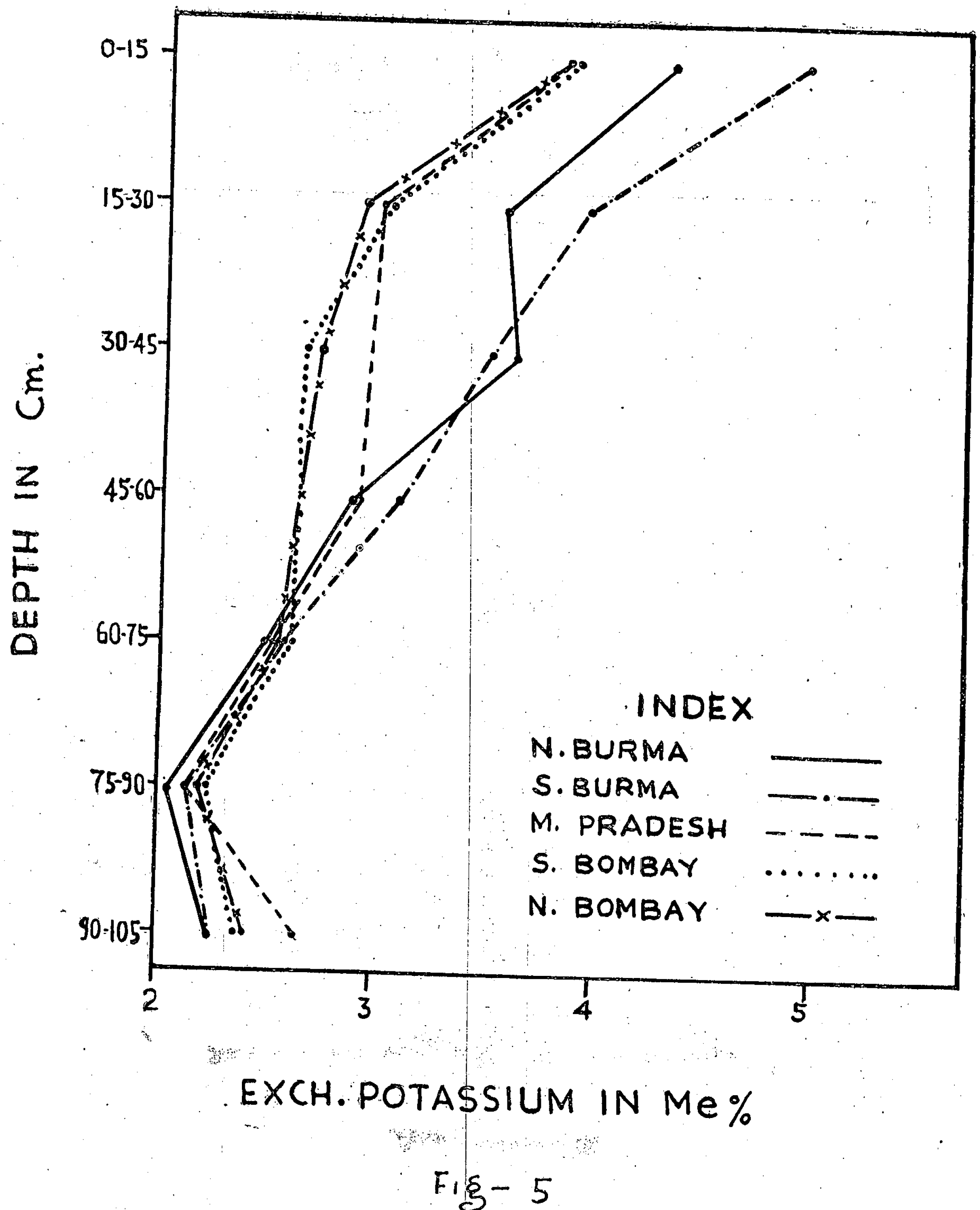

Fig. 5. Variation of exch. potassium with depth in soil profiles under different teak seed origin plantations.

surface soil calcium. But this relationship becomes reverse in case of sub-soil calcium, i.e., higher foliar calcium of North Burma teak is correlative of lower calcium status of the sub-soil and vice versa.

The explanation for the lowering down of the calcium status of the sub-soil in case of North Burma and South Burma origin plantations is probably met with by taking into consideration the girth and height of the trees and the calcium status of leaves, twigs and butt-wood (Table 2 and fig. 2). It is apparent, that to cope up with the higher demand for calcium of North and South Burma teak origins, much of calcium is absorbed from the sub-soil in these cases. Though calcium is returned in higher quantity to the soil in the above-mentioned cases, a good proportion is lost in the harvested boles. It may be noted here that the number of felled trees is much more in case of North Burma and South Burma teak plantations than in others (Table 1).

Litter Status and its Role in Mineral Economy of the Soil

Being the main source of mineral return to soil, leaf-fall assumes great importance in balancing the circulation of organic matter and minerals through the ecosystem. With a view to see the quantitative effect of litter on the forest floor, one metre quadrats were studied at random by the method followed by Puri (1954) and analysed for calcium, magnesium, phosphorus and potassium. The data is given in table 4.

It seems to follow that of all the plantations the highest amount of litter becomes available on the forest floor under the plantations of North Burma teak seed origin, which has the highest growth rate also. There is a progressive decrease in the amount of leaf litter under the plantations of teak seed origins which have lower growth behaviour. In view of the fact that the North Burma teak litter, has a higher amount of minerals, the enrich-

Table 4

Litter Status and minerals brought on the forest floor in different teak seed origin plantations

(Kilograms per hectares).

Plantations	Litter	Calcium	Magnesium	Phosphorus	Potassium
North Burma Teak seed origin. ..	17,380	550·94	139·04	212·03	156·42
South Burma ..	11,200	316·96	89·60	112·00	100·80
Madhya Pradesh ..	6,650	148·96	43·89	66·50	59·85
South Bombay ..	6,710	142·25	44·28	67·10	60·39
North Bombay ..	6,060	104·83	37·57	58·17	54·54

Fig-6

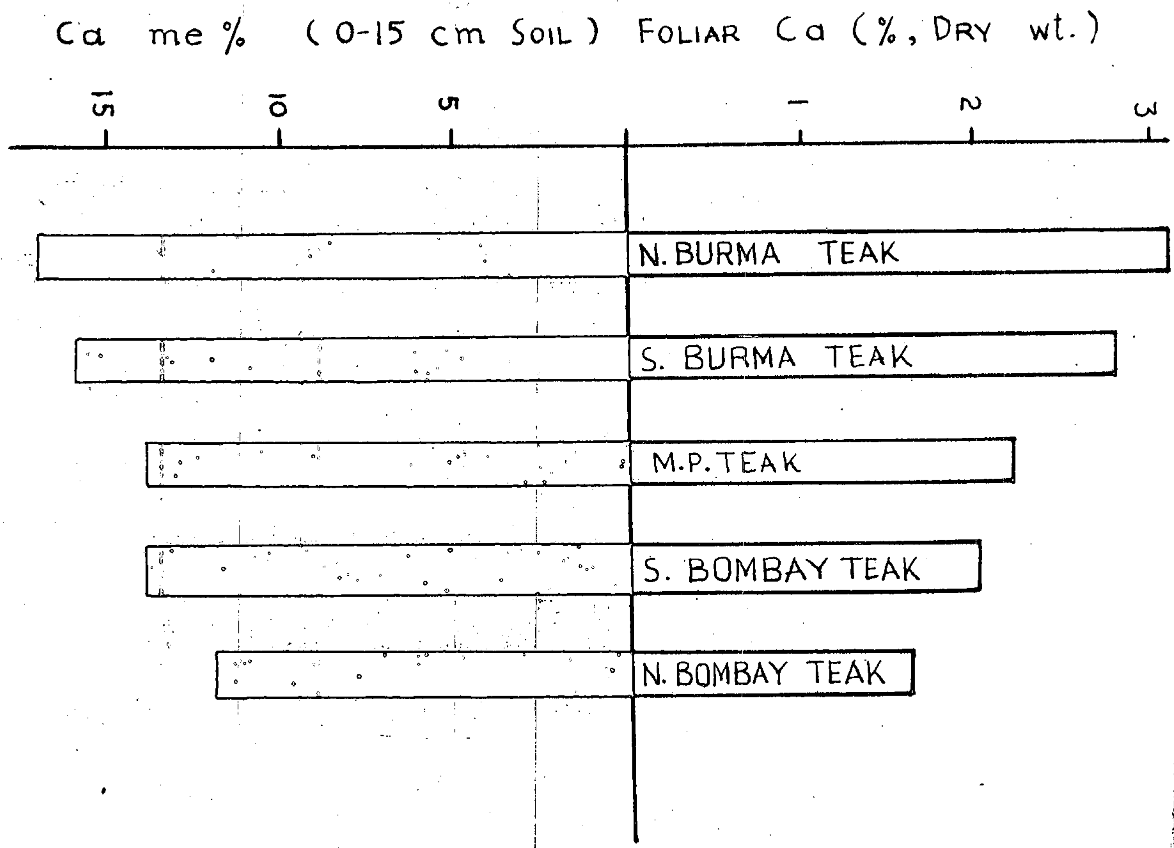

Fig. 6. Relation of foliar calcium with surface soil exch. calcium under different teak seed origin plantations.

Fig-7

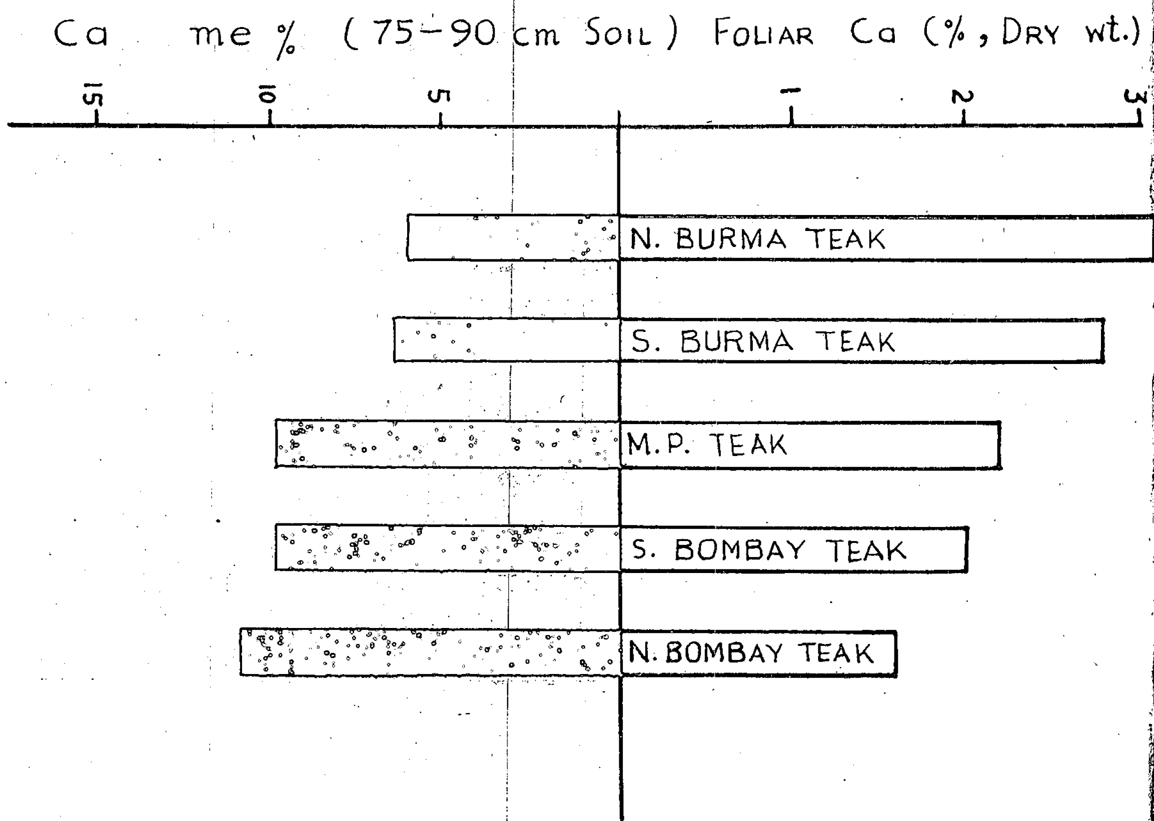

Fig. 7. Relation of foliar calcium with sub-soil exch. calcium under different teak seed origin plantations.

ment of soil by the proper decomposition of this material becomes obvious. The rate of decomposition was studied by measuring the rate of carbon dioxide evolution from soil (by absorbing the CO_2 in baryta water and titrating it back with standard hydrochloric acid). The following results were obtained:

Plantations	CO_2 *output* (*mg. per square metre per hour. Average of* 6 *readings*).
North Burma teak seed origin	78·60
South Burma teak seed origin	68·20
Madhya Pradesh teak seed origin	41·78
South Bombay teak seed origin	42·34
North Bombay teak seed origin	42·66

This shows that the litter of high mineral content, especially calcium, decomposes faster in comparison with that having less minerals.

The removal of leaf litter by any means in the plantations of different seed origins will influence the mineral return to the soil differently, as is clear from Table 3.

A consideration of all these facts shows that the better growing teak seed origin plant is replanishing the soil mineral economy in two ways:—

(*a*) by enhancing the cycle of mineral circulation, i.e., by absorbing more minerals from sub-soil and depositing on the surface soil, thus making the loss of nutrients, especially calcium, magnesium and phosphorus, more susceptible in case if litter is removed or the surface soil gets washed away in erosion, and,

(*b*) by removing minerals especially calcium and magnesium from the soil in the harvested tree boles of larger size and of higher mineral status (Table 1, 2).

In the end it may be said that on the Gangetic alluvium, North and South Burma Teak seed origins are quite suitable and may be tried, if the soils are studied first and only those rich in minerals are selected. It may not be out of place to suggest here, that forest trees also need fertilizers and applications of compounds rich in calcium and phosphorus, especially in teak plantations during different developmental stages may bring about better growth.

Summary

At the suggestion of the IX All-India Silvicultural Conference, a symposium on teak (*Tectona grandis* Linn.) was held during December, 1957. This symposium felt that the information on teak ecology especially the relationship of the plant with the soil was very limited and recommended that this problem be studied in more detail. The present studies were aimed to investigate the growth behaviour in relation to soil conditions of teak of different seed origins in the plantation at Gorakhpur which were raised in 1931 on Gangetic alluvium.

The growth is best in north Burma teak seed origin trees followed by that of South Burma, South Bombay, Madhya Pradesh and lastly by North Bombay origins. The growth behaviour of the plantations appears to be positively correlated with the nutrient status of the leaves, twigs and butt-wood. The mineral status of the soils under teak of different seed origins have been found to differ remarkably. A consideration of all these facts shows that the better growing teak seed origin plant is replanishing the soil mineral economy in two ways:—

(*a*) by enhancing the cycle of mineral circulation, i.e., by absorbing more minerals from the sub-soil and depositing on

the surface soil, thus making the loss of nutrients, especially calcium, magnesium and phosphorus, more susceptible in case if litter is removed or the surface soil gets washed away in erosion, and,

(*b*) by removing minerals especially calcium and magnesium from the soil in the harvested tree boles of larger size and of higher mineral status.

ACKNOWLEDGEMENT

The author wishes to express his thanks to the Chief Botanist, Botanical Survey of India for the facilities provided and Dr. G. S. Puri, Director, Central Botanical Laboratory for guidance during the course of the present study. The author is also grateful to Dr. S. C. Pandeya and Dr. S. S. Ramam for helpful suggestions.

REFERENCES

ANON, 1934. *Annual report on silviculture, working plans and research in the Central Provinces,* paras 34-36.

BHATIA, K. K. 1954. *Factors in the distribution of Teak (Tectona grandis Linn.) and a study of teak forests in Madhya Pradesh.* Ph.D. thesis to Saugar Univ.

GRIFFITH, A. L. and R. S. GUPTA, 1947. Soil in relation to teak with special reference to laterization. *Indian For. Bull.* No. 141.

JENNY, H. 1941. *Factors of soil formation.* McGraw Hill. London.

MATHAUDA, G. S. 1951. The All India teak seed origin sample plots. *Proc. 8th Silva. Conf.,* Dehradun; 229–237.

PANDEYA, S. C. 1959. The concept of maturation in Indian soils, *Proc. Nat. Acad. Sci., India.* 24 : 262–271.

———. 1960. Climatic and edaphic factors in determining the distributional pattern of vegetation, *Memoir Indian Bot. Soc.,* 3 : 35–42.

PIPER, C. S. 1944. *Soil and Plant analysis.* The University of Adelaide, Adelaide.

PURI, G. S. 1953. The probable effect on the mineral economy of soils of the planting of teak in gaps or in clear felled patches in some sal forests of U. P. (Unpublished).

———. 1954. Leaf fall in Dehradun Forests. *Bull. Bot. Soc. Univ. Saugar,* 6 : 28–34.