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Fertilizer Requirements of Newly Planted Teak (*Tectona grandis* L.f.) Seedlings

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ABSTRAK

Keputusan kajian ini menunjukkan bahawa pertambahan ketinggian dan perepang anak benih pokok jati yang baru ditanam dipengaruhi oleh baja N dan P dengan bererti. Berat daun, pucuk, akar dan berat keseluruhan anak benih menunjukkan respons statistik yang bererti kepada penggunaan baja semasa penuaian, satu tahun selepas penanaman. Nisbah akar: pucuk menurun hasil penggunaan baja. Kajian ini menunjukkan bahawa penggunaan 300 kg/ha "triple superphosphate" dan 200 kg/ha sulfat ammonia dikehendaki untuk menggalakkan tumbesaran ketinggian, perepang dan jumlah berat anak benih pokok jati yang baru ditanam di tanah siri Penambang.

ABSTRACT

The results of the present study indicated that height and diameter increments of newly planted teak seedlings were significantly affected by N and P fertilizers. Leaf weight, shoot weight, root weight and total dry matter production showed statistically significant responses to fertilizer application at harvest, one year after planting. Root-shoot ratio decreased as a result of fertilizer application. The present study also revealed that the application of 300 kg/ha triple superphosphate and 200 kg/ha ammonium sulphate are required to enhance the height and diameter growth and total plant weight of newly planted teak seedlings on Penambang soil series.

INTRODUCTION

Plantation forestry in Malaysia began in 1957 with the planting of teak in the northern states of Perlis and Kedah. Later in the 1960s and 1970s, tropical pines, especially *Pinus caribaea* var. *hondurensis* were introduced in Johore and Pahang as plantation species to curtail the import of pulp and paper products. In 1982, the Compensatory Forest Plantation Project (CFPP) was launched to meet the requirements for general utility timber. However, no comprehensive planting programme was undertaken for quality wood timber species such as teak. No detailed research studies were carried out to monitor the growth or to develop a fertilization regime for optimum growth of teak in Malaysia except for a preliminary study conducted by Sundralingam (1983).

A fertilizer trial was therefore conducted to determine the tree growth response to fertilization under field conditions.

MATERIALS AND METHODS

Experimental Site

The experimental site was located at the Forest Research Institute Malaysia (FRIM) sub-station, 17th milestone, Jalan Padang Besar, Perlis at an elevation of 33 m above sea level (*Fig. 1*). It falls within latitude 6° 40' North and longitude 100° 15' East. Generally, the site is flat with an average monthly precipitation of 136 mm. The soil type is Penambang Series with sandy loam texture.

The trial plot was set up in compartment No.17. Four-month old uniform sized seedlings were transplanted to the field in July. 1995. The spacing between plants was 4 x 4 m.

Fig. 1: Map of Peninsular Malaysia showing the experimental area

Experimental Design and Treatments

The experimental design was a randomized complete block (RCBD) with nine treatments and four replications. There were 25 plants per treatment giving a total of 100 plants in four replications. The height and diameter of the middle nine plants from each plot were measured monthly. The experiment was terminated after 12 months. Each plot was demarcated by inserting one meter long PVC pipe into each corner of the plot. There was one row of buffer trees to separate the plots and two rows to separate the blocks.

Three levels of nitrogen and phosphorus and one level of K (200 kg/ha) were applied in the form of ammonium sulphate, triple superphosphate, and muriate of potash. The fertilizers and dosages used are shown in Table 1. The different treatment combinations are given in Table 2. These treatments will be designated as: T1 (N0P0), T2, (N0P1), T3 (N0P2), T4 (N1P0), T5 (N1P1), T6 (N1P2), T7 (N2P0), T8 (N2P1) and T9 (N2P2) in the text.

The fertilizers were split into two doses. The first dose was applied one month after transplanting the seedlings to the field and the second dose, six months later. A radius of half to one metre circle for weeding was maintained around each seedling before fertilizer application and then every month before recording the data. The fertilizer was placed in a shallow circle made around the tree and then lightly covered with soil. Randomization of the treatment and lay-out of the experiment is as shown in *Fig. 2.*

Growth Measurements and Data Analysis

Height and basal stem diameter of the nine selected plants per plot per treatment were measured on a monthly basis for a period of 12 months. The relative height and stem diameter were then calculated from the initial and final measurements. Six plants from the heavily fertilized plots and six from the control plot were sampled destructively to determine the effect of fertilizer application on dry matter production of teak plants.

TABLE 1
Levels of nutrients applied

Commercial Fertilizer	Element	Level 1	Level 2 (g/plant)	Level 3 (g/plant)
Ammonium sulphate (21%N)	N	0 (0 kg/ha)	160 (100 kg/ha)	320 (200 kg/ha)
Triple superphosphate (48% P_2O_5)	P_2O_5	0 (0 kg/ha)	240 (150 kg/ha)	480 (300 kg/ha)
Muriate of Potash (60% K_2O)	K_2O		320 (200 kg/ha)	320 (200 kg/ha)

TABLE 2
Fertilizer treatments

1 N_0P_0	4 N_1P_0	7 N_2P_0
2 N_0P_1	5 N_1P_1	8 N_2P_1
3 N_0P_2	6 N_1P_2	9 N_2P_2

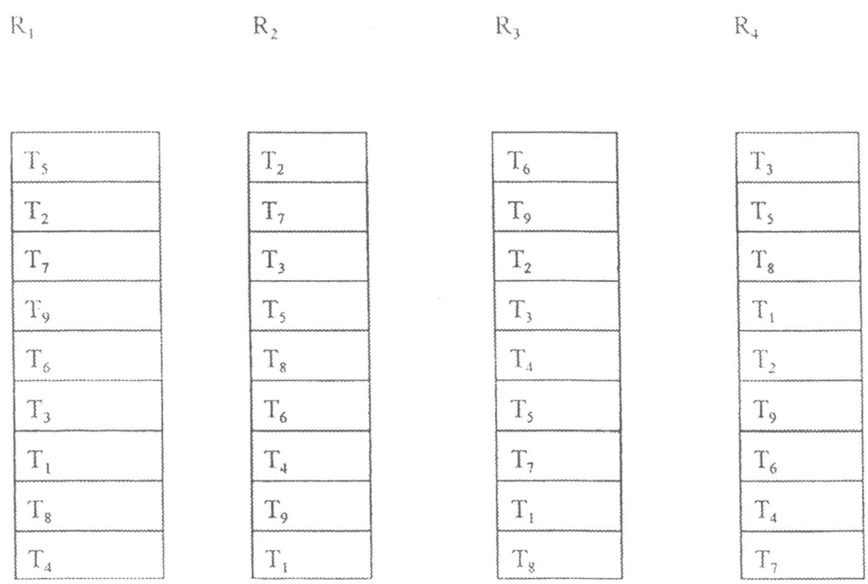

Fig. 2: Lay-out plan of the experiment

The Statistical Analysis System (SAS) was used to calculate the analyses of variance (ANOVA). One-way ANOVA was performed for a randomized block design with the individual fertilizer treatments as the main effects and interactions between the treatments as the secondary effects. Duncan's New Multiple Range Test was used to compare the mean values between treatments.

RESULTS

Height Increment

Application of N and P fertilizers significantly ($p<0.001$) increased the height of teak seedlings (Tables 3, 4). The increment was most significant at level 2 which had the maximum dosage of N at 200 kg/ha, where the increment was 32% higher than that of the control (Table 3). There was also a significant difference between all the three levels of fertilizers applied. The interactions (Table 3) between N and P for height increment were also significant (p<0.001) as shown in *Fig. 3*. The effects of N and P application only became apparent 5 months after the initiation of the treatment (*Figs. 4, 5*).

Diameter Increment

The main effect of N and P fertilizers (Tables 3, 4) and their interactions (*Fig. 6*) was highly significant (p<0.001) for diameter increment of teak seedlings. The most significant increment was observed at P2 where the difference between fertilized and unfertilized plants was about 66 per cent (Table 3). Increasing the quantity of N fertilizer from level 2 (100 kg/ha) to 3 (300 kg/ha) resulted in only a small increase (Table 3). The growth difference between nutrient levels became obvious at 5 months for N and P (*Figs. 7, 8*) indicating adequate reserves in the plants for the earlier growth.

Dry Matter Production

The highest levels of NP fertilizers significantly (p<0.001) increased total plant weight as evident from Table 2. The difference between fertilized and control plants was about 300 per cent.

The combined effect of NP fertilizers was also significant (p<0.001) on leaf weight. There was a marked difference of more than 200 per cent between fertilized and unfertilized plants (Table 2).

Shoot weight was enhanced significantly (p<0.001) as a result of fertilizer application (Table 2). The difference between fertilized and unfertilized plants was more than 100 per cent.

Root weight also followed a similar pattern of response to fertilizer additions as observed in

TABLE 3
Comparison between treatments and growth parameters of *T. grandis* seedlings 12 months after fertilizer application

		Height (cm)	Diameter (cm)	Trt	TPWT	LFWT	SHWT	RTWT	R/S
N	0	47c	1.22b	Control	156.2b	42.7b	75.1b	39.2b	0.44a
	1	59b	1.94a	Fert	618.1a	147.1a	365a	105.9a	0.34a
	2	62a	1.97a						
	LSD	1.2	0.03	LSD	294.9	48.2	158.1	25.6	29.4
P									
	0	47c	1.22c						
	1	58a	1.79b						
	2	62b	2.02a						
	LSD	1.2	0.03						

Note:
Similar letters are not significant
TPWT - Total plant weight, LFWT – Leaf weight, SHWT - Shoot weight, RTWT - Root weight, R/S - Root-shoot ratio, Fert. – Fertilized with N2P2, LSD - Least significant difference.

TABLE 4
Analysis of variance for height and diameter of teak seedlings in the field

Source Pr>F	DF	Sum of square	Mean square	F-value	P>F
Height					
N	2	60644	30322	125.01	0.001
P	2	40026	20013	82.51	0.001
N*P	4	54726	13681	56.40	0.001
Diameter					
N	2	177	87	458.98	0.001
P	2	103	51	265.78	0.001
N*P	4	47	11	60.73	0.001

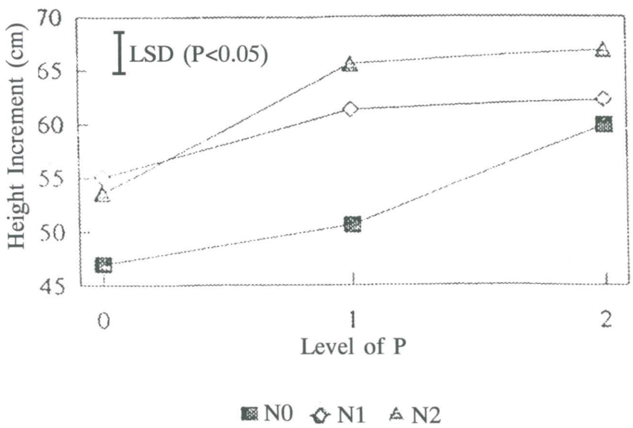

Fig. 3: Effect of combined NP fertilizer on height increment measured 12 months after treatment

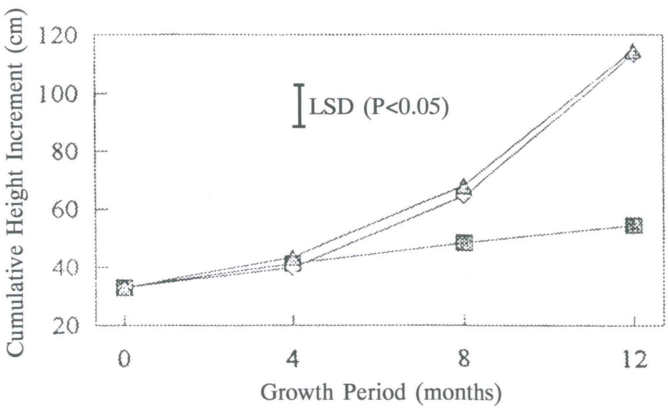

Fig. 4: Height growth at different levels of N

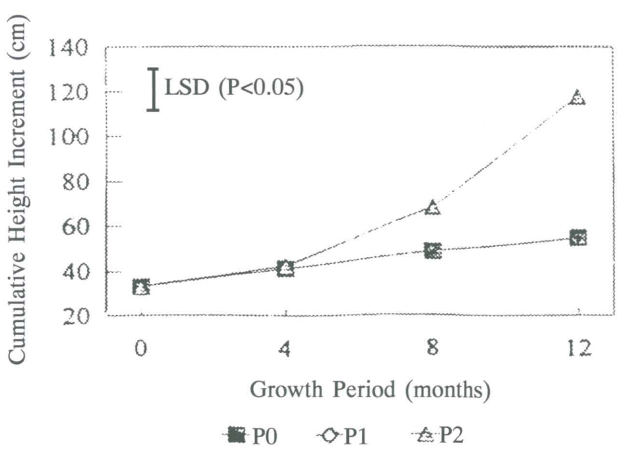

Fig. 5: Height growth at different levels of P

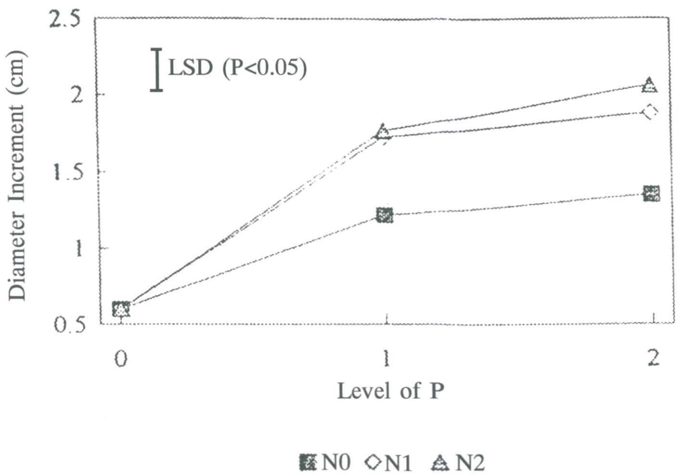

Fig. 6: Effect of combined NP fertilizer on diameter increment measured 12 months after treatment

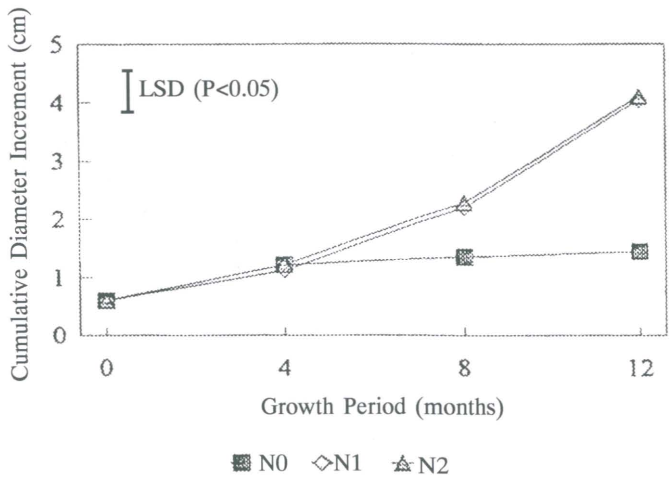

Fig. 7: Diameter increment at different levels of N fertilizer

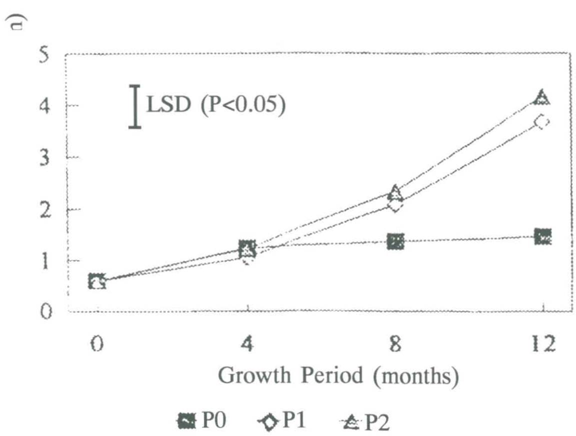

Fig. 8: Diameter increment at different levels of N fertilizer

leaf and shoot weights. Table 2 shows the significant response of root weight to fertilizer application. The difference between fertilized and unfertilized plants was 170 per cent (Table 2).

Root-shoot ratio was found to decrease with fertilizer application (Table 2). The difference between fertilized and unfertilized plants, however, was not significant (P<0.05).

DISCUSSION

Application of different levels of N and P in the presence of 200 kg/ha of muriate of potash significantly enhanced height and diameter growth of teak seedlings on the Penambang soil series. The height increment was maximum at (P3) 300 kg triple superphosphate per hectare (33% higher than control). Diameter increment was more impressive than increment in height. There was a marked diameter increase of 66% at P3 as compared to control. The N and P interaction was synergistic, thus resulting in increase in height as well as diameter of the plants (Table 3). The improved growth as a result of a single application of N and P or in combination is well documented (Ogbonnaya 1994; Gupta *et al.* 1994 and Gupta 1991).

Plants supplied with adequate nitrogen attain vigorous growth, large leaves, and long stems (Plaster 1985). Phosphorus is intimately associated with all life processes and is a vital constituent of every living cell. It is also important because its high concentration is found in plant parts that are growing rapidly (Sopher and Baird 1982).

The results of the present study confirm that of earlier studies by other researchers on teak. Sundralingam (1983) found that phosphorus fertilizer improved the height and diameter of teak seedlings. Significant effects of N and P additions on growth of *Eucalyptus globulus* have also been reported in a recent study by Bennett *et al.* (1997). In another study, Bennett *et al.* (1996) observed a significant growth response to application of combined N and P fertilizers to eucalyptus species in Australia. Similar responses to fertilizer additions have been reported by Wan Rashidah *et al.* (1988) in Malaysia and Kannan and Paliwal (1995) in India on various tree species. On the contrary, Morrison and Foster (1995) reported significant growth response of *Pinus banksiana* to only N and not to P or Mg fertilizers. Paudyal (1995) attributed N to be a more influential element on growth performance of *Acacia mangium* on Serdang Series. This might be due to the high demand of N by these species.

Results of the present study indicated that teak requires nitrogen and phosphorus fertilizers for improved growth on Penambang soils. It is evident from the results that newly planted teak requires more P than N or K for the possible production of new roots during the establishment phase. Although there was significant response to N, P proved to be a more influential nutrient for teak growth. Based on the results of the field trial, it seems plausible to suggest that phosphorus at the rate of 300 kg/ha and nitrogen at the rate of 200 kg/ha are sufficient for better growth of teak on Penambang soils.

Fertilization also had a marked influence on the patterns of dry matter allocation in *T. grandis* seedlings as shown in the results where leaf, shoot and root weights of the tree increased at least 150 times (Table 2). Cromer and Jarvis (1990) attributed such positive response in dry matter production of *E. grandis* to the additions of nitrogen and phosphorus (Krischbaum *et al.* 1992) at high rates. Low root-shoot ratio in the present study is not surprising as shoots and not the roots are the harvest index in forest species. Similar results have been reported by Kamis and Ismail (1987) and Ogbonnaya (1994) on *Gmelina arborea.* It has been frequently reported that a high nitrogen supply reduces root-shoot ratios of plants (Ingested and Laund 1979; Ericsson 1981; Cromer *et al.* 1993). Studies on 15-20 year old *P. sylvestris* showed a substantial decrease in root biomass and an increase in the above-ground biomass following application of N fertilizer (Linder and Rook 1984). In contrast, the present study showed that roots as well as the above-ground biomass increased as a result of fertilizer additions.

The increase in growth of teak as a result of nutrient application in this study is largely due to greater leaf biomass and their photosynthetic capacity. A similar effect of nutrient supply was noted in *E. grandis* by Cromer *et al.* (1993) when there was a substantially enhanced production of foliage in young trees and a high proportion of radiant energy was intercepted resulting in enhanced photosynthesis. Earlier studies on eucalyptus species reporting an increase in biomass production as a result of fertilizer applications conform to our findings (Birk and Turner

1992; Cromer and Jarvis 1990; Kirschbaum and Tompkins 1990; Krischbaum *et al.* 1992; Sands *et al.* 1992).

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