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EFFECT OF NITROGEN AND PHOSPHORUS ON THE EARLY GROWTH OF THREE EXOTIC PLANTATION SPECIES IN PENINSULAR MALAYSIA

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WAN RASIDAH ABD. KADIR, AMINAH HAMZAH & SUNDRALINGAM, P. 1988. Effect of nitrogen and phosphorus on the early growth of three exotic plantation species in Peninsular Malaysia. Experiments on the effect of nitrogen (N) and phosphorus (P) fertilizers on the early growth of *Acacia mangium, Eucalyptus camaldulensis* and *Paraserianthes falcataria* were carried out on Durian series (Plinthoxic Tropudult) soil in Kemasul, Pahang, Peninsular Malaysia. P significantly influenced the height growth of the three species, but N in general had no significant effect.

Key words : *Acacia mangium - Eucalyptus camaldulensis - Paraserianthes falcataria* - fertilizers - growth response.

Introduction

The growing demand for wood, hampered by the low productivity of natural forests, has enhanced the role of plantation forestry which has higher yields. Intensive reforestation is being carried out in Peninsular Malaysia under a programme of the "Compensatory Forest Plantation" (Yong 1984). Fast growing exotic trees such as *A. mangium, E. camaldulensis* and *P. falcataria* are being planted.

Studies on the fertilizer requirements of plantation species in Malaysia are scarce. As Malaysian soils are generally low in nutrient content, especially phosphorus (P), and the addition of P to *Pinus caribea* var. *Hondurensis* in field trials showed a large increase in growth rate (Johari & Chin 1986). Thus, in general, P is regularly used in plantation forestry in Peninsular Malaysia.

Nitrogen (N), Phosphorus (P) and combinations of these two fertilizers showed positive height and diameter growth in seven *Eucalyptus* species in Australia (Cromer *et al.* 1981). This is in contrast to other reports (Crane 1978, McKimm & Flinn 1979) that eucalypts require less of P than most other plants and could grow on P poor soils. Chamshama and Hall (1978) recently showed that P fertilizer had no direct effect on height and diameter increment of *E. tereticornis*. The non-response effect by *E. tereticornis* is probably due to the sufficient supply of available P (8.8 *ppm*). However, N application increased height growth.

Effects of fertilizers on *A. mangium* and *P. falcataria* are not known in Malaysia. From nursery practices at Forest Research Institute Malaysia, it would appear

that these two species respond to fertilization only for the early growth (personal observations).

The present study was to find the most appropriate fertilizer combination to obtain the maximum initial growth response. N and P were chosen because lack of P will depress growth and N can be lost or gained by the system as a result of fire or fixation (Turner 1980). Also, the application of slow release compound fertilizer with high N content (18 - 8 - 6) significantly increased the height growth to *A. auriculiformis* in the Philippines (Maun 1977). N is also shown to improve wood production if the trees are adequately supplied with the other nutrients (Baule and Fricker 1970).

Materials and methods

A preliminary field fertilizer experiment was established in Kemasul Forest Reserve (102° 15'E & 3° 25'N), Pahang, Peninsular Malaysia in July 1983 with *A. mangium, E. camaldulensis* and *P. falcataria.* The soil is classified as Durian series (Plinthoxic Tropudult). The sites were manually prepared by clear felling, extracting the valuable logs and burning of the remaining trees. Potted seedlings at plantable height and of more or less uniform size and vigour were taken from the Kemasul nursery planted in holes and then left for field establishment for three months. No fertilizer was applied at this stage. Each treatment consisted of 49 trees, and the central 25 trees were measured. The layout was a completely randomized block design with five replications.

After field establishment, the initial height of the seedlings were measured (0 month), and the first fertilizer application was made by surface broadcasting. The schedule for fertilizers is shown in Table 1. Further fertilizer applications were made at six monthly intervals until 18 months. At six months age after first application, P fertilizer was not applied; we assumed that the residual from CIRP at the first application was sufficient for initial growth. Since no effect of N fertilizer was observed after one year, the amounts were doubled at the age of 18 months to observe any growth response.

Before the initial fertilization, ten soil samples under each species were randomly collected at two different depths: 0 to 15 *cm* and 15 to 30 *cm,* and later mixed to form composite samples, respectively. Potassium (K) was determined by leaching with ammonium acetate and detected using flame photometer, N by Kjeldahl digestion and P using Bray and Kurtz number 2 method.

Height and diameter at breast height were measured at six monthly intervals for the first two years and then annually. The height and diameter growth at each stage of measurement were calculated. The initial heights and diameters of the tree were correspondingly subtracted from those at each assessment age, and the data were analysed for variance. Effects of fertilizers at each assessment age were then assayed.

Table 1. Schedule of fertilizer application (per tree)

Fertilizer application time (months)	Treatment	AS (*g*)	TSP + CIRP (*g*)
0	N0P0	-	-
	N1P0	25	-
	N2P0	50	-
	N0P1	-	30 + 30
	N1P1	25	30 + 30
	N2P1	50	30 + 30
6	N0P0	-	-
	N1P0	25	-
	N2P0	50	-
	N0P1	-	-
	N1P1	25	-
	N2P1	50	-
12	N0P0	-	-
	N1P0	25	-
	N2P0	50	-
	N0P1	-	30 + 30
	N1P1	25	30 + 30
	N2P1	50	30 + 30
18	N0P0	-	-
	N1P0	50	-
	N2P0	100	-
	N0P1	-	30 + 30
	N1P1	50	30 + 30
	N2P1	100	30 + 30

AS - ammonium sulphate; TSP - triple super phosphate; CIRP - christmas island rock phosphate

Results and discussion

Data for the initial nutrient status of the soils showed that nutrient contents, except for N, were rather low in all planting sites (Table 2).

A. mangium

Effect of N fertilizer

Analysis of variance showed that application of N fertilizer had no significant effect on the diameter and height growth of *A. mangium* throughout the assessment period (Table 3). This may be that the requirement of N fertilizer by this tree is not very high as it belongs to the nitrogen-fixing family, with nodulating ability (Gavina & Garcia 1987).

Table 2. Soil nutrient content under respective species before fertilizer application

Species	Depth (*cm*)	Available P (*ppm*)	Exchangeable K (*meq*/100 *g* soil)	Total N (%)
A. mangium	0 - 15	4.00	0.25	0.10
	15 - 30	0.75	0.15	0.06
E. camaldulensis	0 - 15	2.80	0.25	0.15
	15 - 30	1.85	0.19	0.12
P. falcataria	0 - 15	5.10	0.25	0.12
	15 - 30	2.60	0.24	0.12

Effect of P fertilizer

Application of P fertilizer had a significant effect only on the height growth of *A. mangium* (Table 3). This was at 1% probability level during the first year of growth, it decreased to 5% in the second year, and was insignificant in the third year.

Table 3. Average height and diameter growth increment of *A. mangium* at each assessment age from initial planting

	Height growth (*m*)					Diameter growth (*cm*)		
Months Treatment	6	12	18	24	36	18	24	36
N0P0 (Control)	1.6	4.4	7.0	10.3	14.0	3.12	5.69	8.09
N0P1	2.1** (25)	5.0** (12)	7.3* (4)	10.8* (5)	14.2ns (1)	3.25ns	5.76ns	7.59ns
N1P0	1.6ns (-7)	4.4ns -	6.8ns -	10.3ns (.7)	14.2ns (2)	3.13ns	5.75ns	8.39ns
N1P1	2.0ns (22)	4.9ns (11)	7.5ns (7)	10.9ns (6)	14.3ns (2)	3.10ns	5.46ns	7.47ns
N2P0	1.8ns (11)	4.6ns (4)	7.0ns (2)	10.3ns (.5)	14.0ns -	3.06ns	6.16ns	8.67ns
N2P1	2.0ns (21)	4.9ns (11)	7.4ns (6)	10.9ns (6)	14.3ns (2)	3.93ns	5.89ns	8.32ns

**significant at P = 0.01; * significant at P = 0.05; ns - not significant
Figure in parenthesis is % increment; Notations same for all Tables following

P improved the height growth of *A. mangium* by 24 and 11% at the assessment age six and 12 months, respectively. It then decreased to 5 and 1% at the age of 24 and 36 months, respectively. The response to P fertilizer during the initial growth after planting might have been due to the original low level of P in the soil (Table 2). P is required by the plant to stimulate its nodule formation and hence affects the rate of nitrogen fixation. This has been demonstrated in *Inga jinicuil* (a woody legume) in which application of moderate amounts of P fertilizer during its early growth showed greatest influence on nodule formation (Van Kessel & Roskoski 1983).

E. camaldulensis

Effect of N fertilizer

The response of *E. camaldulensis* to N fertilizer was similar to that of *A. mangium,* although *E. camaldulensis* is not a nitrogen fixing species. No significant effect was observed on height and diameter growth throughout the assessment period even when the level of N was double at 18 months age (Table 4). The lack of response could perhaps be due to the nitrogen content in the soil (0.12 to 0.15%) which is sufficient for the normal growth of *E. camaldulensis.* It seems that response to N application is only observed when the level of N in the soil is very low (Chamshama & Hall 1978). Cromer *et al.* (1981) found the response to N by several *Eucalyptus* species was determined by site factors: On most fertile sites the responses may be ephemeral and only useful starter application, whereas on less fertile sites the species responded either to N, P or combinations of the two. The lack of response could also be due to the volatization losses of N when surface broadcasted.

Ammonium sulphate alone is not highly prone to volatization, but application together with rock phosphate will induce the process. Rock phosphate increases soil pH by releasing a vast amount of CaO and the ensuing alkalinity will cause loss through volatization of ammonia. As a precaution, in this study P was applied on the following day after N to reduce this loss.

Effect of P fertilizer

Analysis of variance showed that application of P fertilizer significantly increased the height growth of *E. camaldulensis* throughout the assessment period except at the age of 18 months (Table 4). The height growth increments were 12 and 8% at 6 and 36 months after fertilization, respectively. However, no significant effect was observed on diameter growth at any period of assessment. Ward *et al.* (1985) assumed that the growth response of *E. saligna* to P, when N is also applied, is probably due to low P in the soil. This might also be the reason for the height growth of *E. camaldulensis* shown in this experiment; the P content in the soil (1.85 - 2.80 *ppm*) is inadequate for the normal growth of *E. camaldulensis.*

Table 4: Average height and diameter growth increment of *E. camaldulensis* at each assessment age from initial planting

	Height growth (*m*)					Diameter growth (*cm*)			
Months Treatment	6	12	18	24	36	12	18	24	36
N0P0 (Control)	2.9	4.0	5.2	6.6	7.9	0.84	1.7	2.8	3.7
N0P1	3.2** (12)	4.0* -	5.1ns -	6.6** (.2)	8.6** (8)	0.68ns	1.4ns	2.7ns	3.9ns
N1P0	2.6ns - -	3.7ns -	5.0ns -	6.1ns -	7.3ns	0.89ns	1.6ns	2.5ns	3.2ns
N1P1	3.2ns (11)	4.2ns (4)	5.4ns (3)	6.7ns (1)	8.4ns (7)	0.68ns	1.5ns	2.5ns	3.7ns
N2P0	3.0ns (4)	4.0ns -	5.0ns -	6.4ns -	7.9ns (.4)	0.90ns	1.7ns	2.7ns	3.6ns
N2P1	3.3ns (13)	4.5ns (11)	6.0ns (13)	7.5ns (12)	9.0ns (13)	0.91ns	1.8ns	3.1ns	3.9ns

Table 5: Average height and diameter growth increment of *P. falcataria* at each assessment age from initial planting

	Height growth (*m*)					Diameter growth (*cm*)			
Months Treatment	6	12	18	24	36	12	18	24	36
N0P0 (Control)	1.6	3.8	5.4	6.4	8.7	3.3ns	5.7ns	7.0ns	8.2ns
N0P1	2.1** (22)	4.3* (13)	7.3** (26)	9.9** (35)	10.8** (20)	3.3ns	6.3ns	8.4ns	9.7ns
N1P0	1.6ns (17)	4.5ns (26)	7.3* (33)	9.6* (17)	10.4ns	4.4ns	6.9ns	9.0*	10.1*
N1P1	2.2ns (25)	5.7ns (34)	9.3ns (42)	12.2ns (47)	13.5ns (36)	5.0ns	8.6ns	11.3ns	13.2ns
N2P0	1.5ns (10)	4.2ns (23)	7.0* (31)	9.4* (16)	10.3ns	4.1ns	7.0ns	9.4*	10.7*
N2P1	2.4ns (34)	5.0ns (24)	8.2ns (35)	11.0ns (42)	12.2ns (29)	3.6ns	7.1ns	8.8ns	10.2ns

The non-significant effect on height growth at the assessment age of 18 months is difficult to explain. At 12 months age, in some of the plots, the plants were attacked by the fire blight, caused by the fungus, *Cylindrocladium quinqueseptatum.* The badly affected plants died but the rest recovered after treatment with the fungicide, Calixin. This infection could have been the cause. After the attack, a response was, however, observed at the 24 and 36 months age. The response to P was still observed at 36 months age eventhough the fertilizer application was stopped after 18 months. Attiwill (1981) showed that in mature *E. obliqua*, 46% of the demand for P was met by biochemical cycling. This efficient use of P by the eucalypt could mean that any extra P supplied in fertilizer would also be efficiently recycled and so the prolonged response. To examine this prolonged response to P fertilizer in *E. camaldulensis*, growth measurements may have to be carried out for a longer time.

P. falcataria

Effect of N fertilizer

P. falcataria responded to N in both height and diameter growth at the later stage, significant at 5% level (Table 5. However, the need for N by this species is unclear. Maun (1977) too showed a similar effect in *A. auriculiformis*; application of compound fertilizer (18-8-6) to this woody legume caused no growth increase for the first year, increased the growth by 20% for the second year and 40% for the third year. *P. falcataria* is a legume and can fix its own nitrogen. Increasing the amount of N fertilizer could inhibit nitrogen fixing activity, letting the plant to depend on applied N fertilizer. This has been well documented for herbaceous legumes (Mengel *et al.* 1974, Manhart & Wong 1980, Ssali & Keya 1980) and a woody legume (Van Kessel & Roskoski 1981).

Effect of P fertilizer

Application of P fertilizer significantly increased the height growth of *P. falcataria.* However, its diameter growth was non-significant (Table 5). Hence, additional P fertilizer is needed by *P. falcataria* for early growth which might not have been met by the original P content of the soil which is low (2.6 to 5.1 *ppm*). Application of P1 improved the height growth of *P. falcataria* by 19% at the assessment age of 36 months. Interaction between N and P was insignificant although combination of NP seemed to give the best results among the treatment combinations (Table 5).

Conclusions

From this preliminary experiment, P is recommended for application when planting *A. mangium, E. camaldulensis* and *P. falcataria* on Durian series (Plinthoxic

Tropudult) soil in Malaysia. In this experiment, the amount of P applied was 60*g* (30*g* TSP + 30*g* CIRP). It was surface broadcasted under the tree canopy for the initial growth of the trees. The optimum level of P was not determined here.

N fertilizer application is not recommended in these plantations. Sufficient N in for the crop's requirement seems to be present in the soil.

Further experiments should be carried out to find the best method, frequency, optimum level and source of fertilizer to be applied.

References

ATTIWILL, P. M. 1981. Nutrient cycling in an *Eucalyptus obliqua* (L'Herit) forest. IV. Nutrient uptake and nutrient return. *Australian Journal of Botany* 28 : 199 - 222.

BAULE, H. & FRICKER, C. 1970. The fertilizer Treatment of Forest Trees. *BLV Verlagsgesellschaft mbH, Germany:* 40 - 45.

CHAMSHAMA, S. A. O.& HALL, J. B. 1978. Effect of site preparation and fertilizer application at planting on *Eucalyptus tereticornis* at Mongoro, Tanzania. *Forest Ecology and Management* 18 : 103 - 112.

CRANE, W. J. B. 1978. Phosphorus stability in Eucalyptus forest. *Australian Forestry* 41 : 118 - 126.

CROMER, R. N., CAMERON, D., CAMERON, J. N., FLINN, D. W., NEILSEN, W. A., REUPACH, M., SNOWDON, P. & WARING, H. D. 1981. Response of *Eucalyptus* species to fertilizer applied soon after planting at several sites. *Australian Forestry* 44 : 3 - 13.

GAVINA, L. D. & GARCIA, M. U. 1987. Growth and nodulation of four species of *Acacia (auriculiformis, mangium, aulacocarpa* and *mearnsii)* in grassland soil. *Nitrogen Fixing Tree Research Reports* 5 : 14 - 15.

JOHARI BAHARUDDIN & CHIN, T. Y. 1986. Review of plantation experiences in Peninsular Malaysia. In the *Ninth Malaysian Forestry Conference,* 13 - 20 October 1986 in Kuching, Forestry Department, Sarawak, Malaysia.

MANHART, J. R. & WONG, P. P. 1980. Nitrate effect on nitrogen fixation (acetylene reduction) : Activity of legume root nodules induced by *Rhizobia* with varied nitrate reductase activities. *Plant Physiology* 65 : 502 - 505.

MAUN, M. M. 1977. Survival and growth of four reforestation species applied with slow release tablet fertilizer. *SYLVATROP Philippine Forest Research Journal* 2 (3) : 219 - 222.

MCKIMM, R. J. & FLINN, D. W. 1979. Eucalypt species, site preparation and fertilizer requirement for afforestation for the Toorongo Plateau in central Victoria. *Australian Forestry* 42 : 117 - 124.

MENGEL, K., HAGHPARAST, M. & KOCH, K. 1974. The effect of potassium on the fixation of molecular nitrogen by root nodules of *Vicia faba. Plant Physiology* 54 : 535 - 538.

SSALI, H. & KEYA, S.O. 1980. Nitrogen level and cultivar effects on nodulation, dinitrogen fixation and yield grain legumes. II. Common bean cultivars. *East African Agriculture and Forestry Journal* 45 (4) : 277 - 283.

TURNER, J. (1980). Nitrogen and Phosphorus distribution in naturally regenerated *Eucalyptus* spp. and planted douglas-fir. *Australian Forest Research* 10 (3): 289-294.

VAN KESSEL, C. & ROSKOSKI, J. P. 1981. Nodulation and nitrogen fixation by *Inga jinicuil,* a woody legume in coffee plantations. II. Effect of soil nutrient on nodulation and nitrogen fixation. *Plant and Soil* 59 : 207 - 215.

VAN KESSEL, C. & ROSKOSKI, J. P. 1983. Nodulation and nitrogen fixation by *Inga jinicuil,* a woody legume in coffee plantations. III. Effect of fertilizers and soil shading on nodulation and nitrogen fixation (acetylene reduction) of *Inga jinicuil* seedlings. *Plant and Soil* 72 : 95 - 105.

WARD, S. C., PICKERSGILL, G. E., MICHAELSEN, D. V. & BELL, D. T. 1985. Responses to factorial combinations of nitrogen, phosphorus and potassium fertilizers by saplings of *Eucalyptus*

saligna Sm. and prediction of the responses by DRIS indices. *Australian Forest Research* 15 (1) : 27-32.

YONG, C. T. 1984. Compensatory plantations in Peninsular Malaysia. Pp. 35 - 44 in Liew, T. C. (ed.). *Proceedings of Seminar on Forest Plantation Development in Malaysia*, 9 - 14 July 1984, Forest Department, Sabah, Malaysia.