COMPARISON OF DIFFERENT PHOSPHORUS SOURCES ON THE EARLY GROWTH OF *ACACIA MANGIUM*

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Received February 1988

WAN RASIDAH WAN AB. KADIR, AHMAD SAHALI MARDI, RAZLEY MOHD. NORDIN & ZAHARAH AB. RAHMAN. 1989. Comparison of different phosphorus sources on the early growth of *Acacia mangium*. The efficiency of phosphorus fertiliser from different sources for *Acacia mangium* was assessed using isotope dilution method. Of the four sources of fertiliser used, namely Christmas Island Rock Phosphate, Moroccan Rock Phosphate, Jordanian Rock Phosphate and Triple Super-phosphate, the last showed the highest uptake by the plants. However, Jordanian Rock Phosphate treated plants showed the highest increase in dry matter weight. For eight weeks after fertiliser application, the order of efficiency in uptake was as follows : Triple Superphosphate > Jordanian Rock Phosphate > Moroccan Rock Phosphate > Christmas Island Rock Phosphate.

Key words: *Acacia mangium* - phosphate fertilisers - isotope technique - ^{32}P

Introduction

Acacia mangium (*Racosperma mangium*) from Queensland, Australia, one of the promising tropical hardwood species for reforestation, and has been planted widely in Malaysia. To date, thousands of hectares have been planted and several projects are underway to replace more of the degraded forests with *A. mangium* (Johari & Chin 1986).

In areas with relatively high annual rainfall, the tree grew so fast that the canopy closed within one year in the plantation. The species is considered one of the fast growing hardwoods capable of yielding general utility timber within 15 years.

A. mangium belongs to Mimosoideae subfamily and it can fix atmospheric nitrogen through nodulation. However, fertilisation is still needed in order to obtain optimum growth. Knight (1986) has shown that *Acacia melanoxylon* seedlings have a substantial requirement for phosphorus and sulphur. A previous study at Kemasul Forest Reserve revealed that *A. mangium* responded to phosphorus fertilisation at an early stage of growth on Durian (Plinthoxic tropudult) series soil (Wan Rasidah *et al.* 1988). In the experiment, a mixture of Triple Superphosphate and Christmas Island Rock Phosphate as a source of phosphorus (P) fertiliser was used. Based on this finding, the present study was carried out to investigate the most efficient source of P fertiliser and its availability to the plant. The following sources were used: Christmas Island Rock Phosphate (CIRP), Moroccan Rock Phosphate (MRP), Jordanian Rock Phosphate (JRP) and Triple Superphosphate (TSP). These fertilisers are commonly used in agriculture.

Materials and methods

Field trial

The study was carried out in a plantation at Setul Forest Reserve, Negri Sembilan. The site chosen for the study was a flat land, > 300 *m* above sea level. The annual rainfall distribution is between 2030 to 2290 *mm.*

Six-month-old seedlings with more or less uniform size and vigour were selected from Setul nursery and transplanted at 3 × 3.7 *m* spacing, at the end of April 1987 (during the rainy season). 30 *g* of heptachlor was applied around the seedling base to prevent termite attack. A total of 220 seedlings were transplanted within an area of 0.24 *ha.* Out of these trees, 44 were treated. The design was completely randomised with one seedling per plot, set between the guard rows. The following fertilisation was done 14 days after transplanting:

- T1 - 0.5 *mCi* ^{32}P per seedling
- T2 - 0.5 *mCi* ^{32}P + 200 *g* P as CIRP (15.18% P)
- T3 - 0.5 *mCi* ^{32}P + 200 *g* P as MRP (13.20% P)
- T4 - 0.5 *mCi* ^{32}P + 200 *g* P as JRP (14.08% P)
- T5 - 0.5 *mCi* ^{32}P + 200 *g* P as TSP (20.24% P)
- T6 - 200 *g* P as CIRP (15.18% P)
- T7 - no fertiliser

Treatments T1 to T5 consisted of four replicates whereas treatments T6 and T7 had 12 replicates.

Carrier-free ^{32}P (0.5 *mCi*) was mixed with 5 *ml* 1000 ppm potassium dihydrogen phosphate to form a ^{32}P solution. For each treatment, the fertiliser was equally divided by four and applied at four different spots around the seedling at a distance of 25 *cm* from the seedling trunk and 10 *cm* depth. ^{32}P carrier-free was applied at another four different spots (Figure 1). Even though the current practice was to apply P in the planting hole, this could not be done so in this study since the application of ^{32}P carrier-free at the same spot as P fertiliser would cause a tagging effect which leads to a more erroneous result. The 25 *cm* distance was considered as the closest approximation because the application of ^{32}P will be monitored until two years, whereas all the P sources were applied only once at the beginning of the study. No other forms of nutrients were applied since currently only phosphorus fertilisation is applied in forest plantations.

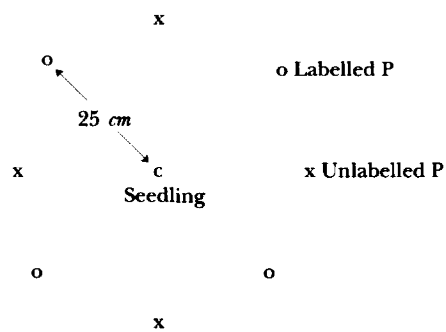

Figure 1. Fertiliser application of one treated seedling

Sampling

Samplings were carried out exactly eight weeks after fertiliser application (four half-life for ^{32}P). Every fourth leaf was sampled from each of the treated seedlings in treatments T1 to T5. These samples were individually kept in labelled paper bags. For treatments T6 and T7, two seedlings from each treatment were destructively sampled and different parts of a seedling were separated. Four six-month old-seedlings were also destructively sampled to analyse stock nutrients in the seedling.

All the samples collected were analysed for total P content by Scheele's method and ^{32}P activity (according to the requirement) using liquid scintillation counter. Prior to the analysis, the wet and oven dry weights of each sample were recorded.

Calculation

Calculations were made as follows (Anonymous 1986) :

$$\text{Pdfs*} = \frac{\text{s.a.* plant}}{\text{s.a. labelled fertiliser}}$$

Since the seedling receives only two sources of P, namely soil and fertiliser , therefore,

% Pdff* = 100 - % Pdfs

P fertiliser yield = % Pdff × P yield

$$\text{\% P fertiliser use (\% efficiency)} = \frac{\text{P fertiliser yield}}{\text{Rate of P applied}} \times 100.$$

(***s.a.** - specific activity; **Pdfs** - P derived from soil; **Pdff** - P derived from fertiliser)

Results and discussion

Dry matter weight

The dry matter weight of the leaves taken from seedlings treated with P fertiliser from different sources is shown in Table 1. JRP treated seedlings gave the highest yield in terms of leaf biomass followed by TSP, MRP and CIRP. However, they are not significantly different. JRP increased the dry matter weight of the leaves by 73.3%, TSP by 56.1%, MRP by 40.5 % and CIRP by 2.2%. These data show that different P sources probably have an influence on leaf biomass. Similar effects from different sources of P fertiliser have been recorded for the early growth of *Hevea brasiliensis* (Pushparajah 1964) and mycorrhiza activity in *Pueraria javanica*, a legume cover crop (Abu Talib 1986).

Table 1. Dry matter yield and P contents in the leaves of *Acacia mangium*

Treatment	Dry matter [a]		P yield [a]	
	Weight (*g*)	Increment %	(*g*)	Increment (%)
T1 - ^{32}P	18.0+0.80 ns	-	0.086 + 0.007 ns	-
T2 - ^{32}P + CIRP	18.4+3.10 ns	2.2	0.090 + 0.016 ns	4.6
T3 - ^{32}P + MRP	25.3+8.51 ns	40.5	0.154 + 0.041 ns	79.1
T4 - ^{32}P + JRP	31.2+8.55 ns	73.3	0.190 + 0.092 ns	120.9
T5 - ^{32}P + TSP	28.1+3.58 ns	56.1	0.329 + 0.047*	282.6

*significant at P = 0.05; ns - not significant; [a]Figures are means of four replications + SE; Stock P in the leaves is 0.016 *g*

For the whole seedling, the contribution of dry matter weight comes mostly from leaves (Table 2). The variability in values of individual treatments is small even before conversion into the percentage of total weight (Table 2). The leaves and stem comprise well over 80% of the total dry weight. The leaves supplied between 47.5 to 53.2%, the stem between 30.5 to 33.7%, the branches between 5.2 to 5.3% and the roots between 11.1 to 13.5% to the total dry weight of the seedlings. However, the variability between replications is rather high; example, for the roots, the standard errors are comparatively high. Site preparation might be the main contributor to this phenomenon, probably from the burning of logs in several parts of the study area.

Table 2. Dry matter yield and P content in parts of the seedling of *Acacia mangium*

Treatment	Parts of seedling	Dry matter [b] weight (g)	Dry matter weight (%)	P yield [b]
T6 - CIRP	Leaves	30.10 ± 3.00	53.2	0.166 ± 0.013
	Stem	17.25 ± 0.45	30.5	0.055 ± 0.071
	Branches	2.95 ± 0.95	5.2	0.015 ± 0.033
	Roots	6.30 ± 1.10	11.1	0.023 ± 0.001
	Total	56.60		0.259
T7 - control	Leaves	23.65 ± 3.75	47.5	0.137 ± 0.012
	Stem	16.80 ± 0.10	33.7	0.054 ± 0.004
	Branches	2.65 ± 0.25	5.3	0.009 ± 0.001
	Roots	6.70 ± 2.60	13.5	0.023 ± 0.010
	Total	49.80		0.223

[b]Figures are means of two replications ± SE

Phosphorus detection level

Phosphorus content in each treated seedling varies according to the respective fertiliser source. Significant increment at 5% level was obtained with TSP treated seedlings. TSP increased the P content in the leaves by 282.6%, JRP by 120.9%, MRP by 79.1% and CIRP by 4.6% (Table 1). The high increment found in TSP treated trees is due to the high concentration of total P detected, whereas for JRP treated trees, high increment obtained is due to the high dry matter content. These data give the impression that no linear correlation exists between dry matter yield and total P concentration, for this species.

As for the whole seedling, the levels of phosphorus for the treated and untreated are 0.259 and 0.223 *g* respectively (Table 2). The highest content was detected in the leaves regardless of the fertiliser application, which contributed more than 60% of the total P content of the tree. At this stage, in all parts of the plant, no difference could be observed between the P fertilised and unfertilised seedlings. This is probably because of the characteristic of CIRP which releases only a small amount of available P at a time. For both T6 and T7, the order of P levels was leaves > stem > roots > branches.

Phosphorus distribution and use

The specific activity of ^{32}P showed it to be slightly higher in T2 and T3 than T1 when the amount of P present in the leaves was taken into consideration. Since the method used was indirect and the soil was labelled with ^{32}P instead of fertiliser, the higher activity detected in the leaves was an indication of high uptake from soil. The specific activity of each source is given in Table 3. It is clear that all the P taken up by CIRP and MRP treated seedlings came from the soil, whereas the uptake of P from JRP and TSP treated seedlings was derived from soil and fertiliser.

Table 3. P fertiliser uptake and efficiency

Source	s.a.*	% Pdff[a]	% Efficiency
P	355.4	-	-
CIRP	463.2	0	-
MRP	395.5	0	-
JRP	260.5	26.70	0.023
TSP	44.9	87.37	0.137

[a]%P derived from fertiliser; *s.a. = specific activity

The effect of the different sources of P fertilizer to *A. mangium* seedlings is clearly defined from % Pdff and efficiency (Table 3). Out of 0.329 *g* of P increment detected in the leaves of the seedlings treated with TSP (Table 1), 87.4% was derived from fertiliser. Use of JRP by the seedling was comparatively acute and the figure could be neglected. Thus for the first period of eight weeks after fertiliser application, only P from TSP had been used by the plants due to the highly soluble fertiliser. The solubility characteristic of TSP and CIRP has been well established (Lau 1981).

The percentage efficiency shows that the P source in TSP was the most efficient among the four sources used under the conditions of this experiment. The order of efficiency is TSP > JRP > MRP > CIRP. These results agree with the data obtained by Lee (1986) who showed CIRP to be the least efficient P source. In Lee's experiment, TSP and Togo Rock Phosphate were used for comparison, and the test crop was maize. The conclusion for the present study is made without taking into consideration the costings.

Conclusion

The eight weeks duration of this study is rather short to make any conclusion on residual effect of rock phosphate on *A. mangium.* However, this study is being continued to find the efficiency after longer time intervals and also to assess the residual effect of various rock phosphates.

Acknowledgements

We thank the staff in the soil laboratories of Forest Research Institute Malaysia and Nuclear Energy Unit, Malaysia, for the technical assistance. Fauzidah Ahmad assisted in the statistical analysis.

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