EFFECT OF NURSERY FERTILIZATION ON *CASSIA SIAMEA* SEEDLING GROWTH AND ITS IMPACT ON EARLY FIELD PERFORMANCE

D. Kannan & K. Paliwal*

Department of Plant Sciences, School of Biological Sciences, Madurai Kamaraj University, Madurai - 625 021, India

Received May 1994

KANNAN, D. & PALIWAL, K. 1995. Effect of nursery fertilization on *Cassia siamea* seedling growth and its impact on early field performance. Nitrogen, phosphorus and potash fertilizers in eight treatment combinations, including an unfertilized control treatment were given to *Cassia siamea* seedlings in the nursery. Changes in the growth attributes of the seedlings due to fertilizer application and its impact on early field performance after transplantation were studied. Nitrogenous fertilizer application had positive effect on the growth attributes. Application of phosphorus or potash either separately or in conjunction did not show any significant effect on seedling growth and biomass production. However, these fertilizers in combination with N fertilizer evoked a positive response in seedling growth, biomass production and relative growth rate (RGR) during the initial growth. Fertilization of *Cassia siamea* using nitrogenous fertilizer in all combinations under nursery conditions had a major impact on subsequent growth in the field.

Key words: *Cassia siamea* - container seedlings - nursery cultural practice - fertilizer application - relative growth rate - outplanting performance

KANNAN, D. & PALIWAL, K. 1995. Kesan persenyawaan di tapak semaian ke atas pertumbuhan anak benih *Cassia siamea* dan kesannya kepada prestasi awal. Nitrogen, fosforus dan baja potasy yang dirawat di dalam lapan kombinasi, termasuk rawatan kawalan tak dibaja telah dilakukan ke atas anak benih *Cassia siamea* di tapak semaian. Perubahan di dalam sifat-sifat pertumbuhan anak benih akibat pembubuhan baja dan kesannya ke atas prestasi awal ladang selepas semaian alih telah dikaji. Pembubuhan baja bernitrogen memberikan kesan positif ke atas sifat pertumbuhan. Pembubuhan fosforus atau potasy sama ada secara berasingan atau berkaitan tidak menunjukkan kesan ketara ke atas pertumbuhan anak benih dan pengeluaran biojisim. Bagaimanapun, baja bersama dengan baja N memberikan tindakbalas positif di dalam pertumbuhan anak benih, pengeluaran biojisim dan kadar pertumbuhan relatif (RGR) semasa pertumbuhan awal. Persenyawaan *Cassia siamea* menggunakan baja bernitrogen di dalam semua kombinasi dalam tapak semaian mempunyai kesan yang besar ke atas pertumbuhan berturutan di ladang tersebut.

Introduction

Optimization of yield per unit land area is the main objective of intensive forest management (Fisher & Mexal 1984). Fertilization is an efficient silviculturalmeans which helps tree establishment (Gupta 1991) thereby contributing to increasing the plantation-crop production (Ericsson *et al.* 1992). The practice of fertilizer

**Author for correspondence*

application in the nursery can alter the seedling's growth to attain successful outplanting performance (Driessche 1980). Fertilizer application in the nursery can be a cost-effective method for improving the tree crop's productivity including yield responses throughout the life of the plantation (Wakeley 1969).

In the present study, an experiment was carried out to manipulate the vigour of *Cassia siamea* Lam. seedlings by fertilizer application under nursery conditions. Changes in morphological growth due to fertilizer application under nursery conditions was assessed in the nursery and in the field after transplanting.

Material and methods

Description of study area

The study was conducted at Madurai Kamaraj University Biomass Research Centre which is situated in southern India. The experimental site is located at 9° 55'N and 78° 10' E and lies at an altitude of 132.5 m above sea level. The area is sub-tropical, with semi-arid ecoclimate. The mean annual rainfall ranges between 500 and 600 mm and mean annual temperature between 20.3 °C (minimum) and 38.6 °C (maximum).

Nursery phase

Seed source

Cassia siamea seeds were obtained from the Forest Range Office, Vadipatti, 29 km northwest of Madurai. From the collection, equal size seeds were selected for the present study.

Growing conditions

Cassia siamea seeds were treated with hot water and germinated in Petri dishes under laboratory conditions. Germinated seedlings were transplanted into polythene bags with a height of 20 cm and a breadth of 10 cm, containing a soil mix of clay soil, sand, red soil and farmyard manure (cowdung and rice straw) (2:1:2:2 by volume). Bulk density of the soil mix was 1.2 g cm^{-3}. The nursery soil contained 4.5 mg g^{-1} N and 0.80 mg g^{-1} P (N and P were analysed by Autoanalyser, Gradko, England) and the pH was 8.2.

Nitrogen, phosphorus and potassium fertilizers were applied in different combinations making a total of eight treatments. The experiment was laid out in RBD with three replications. For each treatment, 60 seedlings were accommodated in a nursery plot (replication) and thus the total number of seedlings used for this study was 1440, and were placed in 24 plots. The nutrient treatments were applied in the form of commercially available fertilizers - urea, superphosphate and muriate of potash. The fertilizers contained 46% w/w nitrogen, 16% w/w phosphorus and

59% w/w potassium. The elemental ratio (a value which indicates the exact amount of nutrients in a fertilizer to supply a tree seedling) used in this study for urea and potash fertilizer was 0.067 and for phosphate fertilizer 0.034.

The exact amount of fertilizer was calculated by using the formula,

$$\frac{100}{\%\text{ of element available in the fertilizer}} \times \text{elemental ratio}$$

and the fertilizer solutions as given Table 1 were prepared.

Table 1. Fertilizers used in the study

Fertilizer treatment	Quantity supplied (gram litre^{-1})		
	Urea	Super phosphate	Potash
Control (no fertilizer)	0.00	0.00	0.00
Urea (N fertilizer)	0.73	0.00	0.00
Super phosphate (P fertilizer)	0.00	1.06	0.00
Muraite of potash (K fertilizer)	0.00	0.00	0.57
N+P fertilizer	0.73	1.06	0.00
N+K fertilizer	0.73	0.00	0.57
P+K fertilizer	0.00	1.06	0.57
N+P+K fertilizer	0.73	1.06	0.57

Cassia siamea seedlings were fertilized only once in the nursery on 21 June 1991, 45 days after containerization. Seedlings separated for the different treatments were supplied with 200 ml (approximately 50% of the container medium was saturated) of the respective fertilizer solution. For the control, only water was used.

Measurements of morphological attributes

Height, diameter at root collar region and dry weight were measured for the seedlings under various fertilizer treatments in the nursery. The observations were made on the seedlings 45 and 135 days after fertilization. Four seedlings from each replication (total samples per treatment = 12) were randomly selected to compare the fertilizer effects of *Cassia siamea* seedlings on morphological growth attributes under nursery conditions. The relative growth rate (RGR) at different sampling periods was measured on the basis of biomass yield at 30 days interval; the first measurement was carried out between 15 and 45 days interval. After that

period, the RGR was measured between 45 and 75, 75 and 105, and 105 and 135 days. The RGR of seedlings between two successive sampling periods after fertilizer treatments was calculated with the formula,

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

where W_2 is the dry weight at time t_2 and W_1 is the dry weight at time t_1.

Post nursery phase after transplanting

After 180 days growth (135 days after fertilizer treatment) under nursery conditions, *Cassia siamea* seedlings were transplanted to the field at the Biomass Centre, on November 1991.

Before transplanting, the site was ploughed using a weighted disc-harrow, lightly disced again, and finally the land was levelled. Complete weeding was done before planting. The soil at the experimental site is a laterite loamy soil and has a bulk density of 1.47 g cm^{-3} ; pH 8.5 with total N 0.90 mg g^{-1}; and total P 0.14 mg g^{-1}. Randomized block design was used during planting. Eight treatments per block and 20 seedlings per treatment, totalling 480 seedlings, were planted at the experimental site. The seedlings from each treatment were planted with a spacing of 1.0 × 1.0 m in three replicated blocks.

Growth measurements in the field

After eight months growth in the outplanting site, seedlings were harvested for height, diameter at knee height (30 cm above the surface) and dry weight measurements. These growth parameters were determined on sub-samples of 2 trees per treatment from each of the block (total samples per treatment = 6).

Statistical analyses

Statistical Package for the Social Sciences (SPSS) was used to calculate the analyses of variance (ANOVA) and descriptive statistics (Hull & Nie 1981) for morphological growth data obtained 135 days after fertilization. ANOVA was performed for a completely randomized block design; individual fertilizer treatments were the main effects and interactions among the treatments were the secondary effects. For multiple comparisons, Students-Newman-Keuls test was used to compute the least significant differences (LSDs) at 95% level.

Results

Fertilization did not cause much variation in seedling height or root collar diameter at 45 days after fertilization (Figures 1 and 2). Following this period, seedlings applied with nitrogenous fertilizer alone and in combination either with phosphorus or potassium or both fertilizers showed significant ($p \leq 0.05$) increment in height and root collar diameter. At day 135, variations in the growth of seedlings subjected to different fertilizer treatments became apparent (Figures 1 and 2).

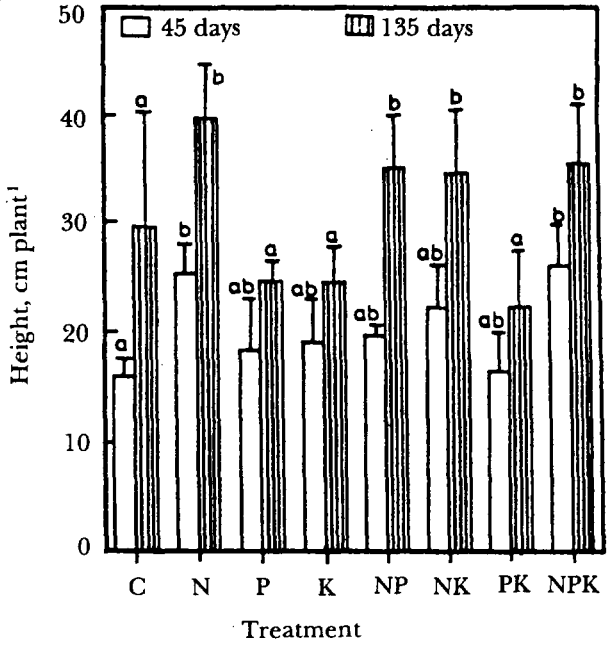

Figure 1. Height of *Cassia simaea* seedlings at 45 days and 135 days growth after fertilizer application in the nursery. Vertical lines indicate the SE of means (n=12). Bars sharing common letter(s) do not differ significantly at $p \leq 0.05$.

Seedlings applied with phosphorus and potash fertilizers produced nearly equal amounts of biomass at 45 days after fertilization as the seedlings which received no fertilizer (Figure 3). On the other hand, seedlings receiving nitrogenous fertilization alone or with phosphorus or potash, or both fertilizers produced greater biomass than unfertilized seedlings (Figure 3).

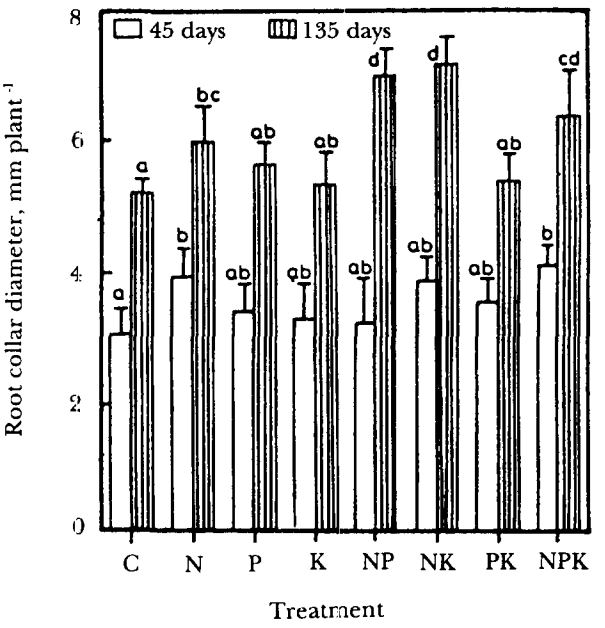

Figure 2. Root collar diameter of *Cassia simaea* seedlings at 45 days and 135 days growth after fertilizer application in the nursery. Vertical lines indicate the SE of means (n =12). Bars sharing the common letter(s) do not differ significantly at $p \leq 0.05$.

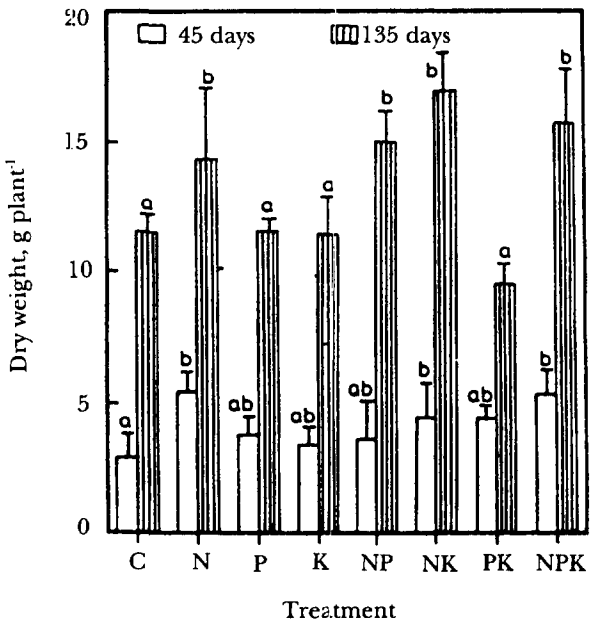

Figure 3. Total dry weight of *Cassia simaea* seedlings at 45 days and 135 days growth after fertilizer application in the nursery. Vertical lines indicate the SE of means (n = 12). Bars sharing common letter(s) do not differ significantly at $p \leq 0.05$.

Table 2. Effect of fertilizer application in the nursery on relative growth rate of *Cassia siamea* seedlings between different days of the experimental period. Values are means ± SE (n=12). Values in a column sharing common letter(s) do not vary significantly at $p \leq 0.05$.

Treatment	Relative growth rate (mg day^{-1})			
	Harvest intervals (30 days)			
	15 - 45	45 - 75	75 - 105	105 - 135
Control	15.03 ± 2.10a	11.11 ± 2.16a	1.97 ± 0.93a	4.90 ± 0.93ab
N	20.45 ± 3.84a	8.93 ± 0.57a	5.50 ± 1.56a	0.33 ± 0.26a
P	15.50 ± 2.20a	6.67 ± 1.64a	3.63 ± 1.16a	4.87 ± 1.17b
K	15.23 ± 2.12a	9.60 ± 2.68a	3.70 ± 2.13a	3.57 ± 1.00ab
NP	20.53 ± 1.31a	10.47 ± 1.38a	6.97 ± 0.97a	1.00 ± 0.78ab
NK	17.50 ± 1.40a	8.77 ± 1.24a	5.60 ± 0.71a	3.77 ± 0.99ab
PK	14.82 ± 2.80a	6.47 ± 0.55a	3.43 ± 0.98a	1.17 ± 0.63ab
NPK	20.17 ± 2.07a	7.93 ± 1.52a	4.83 ± 1.09a	2.63 ± 0.95ab

Table 3. Effect of nursery fertilization on the growth performance of *Cassia siamea* seedlings at eight months growth in the field after transplanting. Values are means ± SE (n = 6). Values in a column sharing common letter(s) do not vary significantly at $p \leq 0.05$.

Treatment	Height (cm)	Diameter at knee height (cm)	Dry weight (g plant^{-1})
Control	121.33 ± 1.73a	21.80 ± 1.45ab	509.02 ± 41.27a
N	156.00 ± 14.03b	27.30 ± 0.67b	813.40 ± 43.03b
P	115.00 ± 6.18ab	23.50 ± 1.02ab	518.53 ± 61.94a
K	101.00 ± 4.00a	20.17 ± 2.24a	462.49 ± 58.58a
NP	127.66 ± 4.81ab	22.87 ± 1.05ab	669.60 ± 11.13b
NK	119.00 ± 10.08ab	23.30 ± 0.93ab	583.69 ± 40.73ab
PK	92.00 ± 4.33a	16.83 ± 1.88b	379.07 ± 45.35a
NPK	127.60 ± 10.30ab	22.33 ± 2.03ab	683.06 ± 25.89b

Between 15 and 45 days of the experimental period, NP fertilizer treated seedlings had 36% greater relative growth rate (RGR) and PK treated seedlings had 16% less RGR value than the RGR value of the seedlings that received no fertilizer (control), although no statistical differences were found among the various treatments (Table 2). At the final measurement (from day 105 to 135), a considerable reduction was noted in the seedlings applied with N fertilizer.

Field growth

Seedlings applied under nursery conditions with K and PK fertilizers showed a significant difference in height than seedlings applied with the N fertilizer at eight months after transplanting. N fertilizer applied seedlings also showed increased stem diameter in the field condition. Seedlings treated with N, NP and NPK fertilizers in the nursery showed greater biomass production at eight months of

field growth. N fertilizer treatment in the nursery had a greater impact on seedling volume increment in the field, when compared with the seedlings subjected to other treatments.

Discussion

Improved growth response by N fertilization in the present study agrees with previous results (Troeng & Ackzell 1988, Högberg 1989, Holopainen & Heinonen-Tanski 1993) on crop growth in relation to N supply. Without nitrogen addition, *Cassia siamea* failed to utilize P and K fertilizers. There are some reports (Waring 1972, Donald *et al.* 1984, Loxton & Donald 1987) to show the increment of tree crop growth by NP interaction. Moreover, the effect of nitrogen application on nursery seedling's root collar diameter reported by Driessche (1984) supports the results of the present study.

The effect of N fertilizer on biomass yield was greater as reflected in the combined effect of gains in diameter and height. Driessche (1988) also found a similar trend. Phosphorus or potash fertilizer either separately or in combination failed to evoke any response in seedling dry matter production. This is inconformity with the earlier reports of Duryea and McClain (1984). The present study further confirms the view of Cobbina *et al.* (1989) that nitrogen addition also increased the productivity of leguminous species (*Cassia siamea* in this study). Seedling RGR was slightly increased between 15 and 45 days after N, NP, NK and NPK fertilizer treatments than in other treatments (Table 2). The results of Steinbeck (1971), Elowson and Rytter (1988), and Tschaplinski and Norby (1991) also support the finding in the present study that exogenous nitrogen application would increase tree crop RGR.

Between day 105 and day 135 after N fertilization, a sharp decline in RGR was observed. A declining trend was also noted in seedlings under other treatments. However, the magnitude of reduction was not that much as in N fertilization (Table 2). During the same growth period, seedlings fertilized with N alone still ranked first in biomass production at the transplant stage (Figure 3). From these results, it seems that attainment of initial RGR (between 15 and 45 days in this study) determined the seedlings growth and thereby the biomass production at later stages. Hence, seedling RGR can be much improved by fertilizer application and thereby it is possible to produce vigorous seedlings. Moreover, planting those seedlings with improved vigour provided competitive advantage and accelerated the seedling growth in the field condition. The results are in line with the reports of Hinesley and Maki (1980), and Simpson (1988).

Conclusion

The above results clearly indicate that nitrogenous fertilizer application is an efficient means of improving early growth of container-grown *Cassia siamea* seedlings. Its effectiveness, however, needs to be tested further under more diverse field conditions at a longer response period.

Acknowledgements

This work was supported by a financial grant from the Ministry of Non-Conventional Energy Sources, Government of India to the second author. We are thankful to P. Suguna for typing this manuscript, and the anonymous referee for his critical and helpful comments on this manuscript.

References

COBBINA, J., KANG, B.T. & ATTA-KRAH, A.N. 1989. Effect of soil fertility on early growth of *Leucaena* and *Gliricidia* in alley farms. *Agroforestry Systems* 8 : 157 - 164.

DONALD, D.G.M., LANGE, P.W., SCHULTZ, C.J. & MORRIS, A.R. 1984. The application of fertilizers to pines in southern Africa. Pp. 621 - 635 in Grey, D.C., Schönau, A.P.G. & Schutz, C.J. (Eds.) *Proceedings of the IUFRO Symposium, Site and Productivity of Fast Growing Plantations.* South Africa, 1984.

DRIESSCHE, R. VAN DEN. 1980. Health, vigour and quality of conifer seedlings in relation to nursery soil fertility. Pp. 100 - 120 in Abrahmson, L.P. & Bickelhaupt, D.H. (Eds.) *Proceedings, North American Forest Tree Nursery Soils Workshop.* Bickelhaupt, D.H. State University, New York.

DRIESSCHE, R. VAN DEN. 1984. Relationship between spacing and nitrogen fertilization of seedlings in the nursery, seedling mineral nutrition and outplanting performance. *Canadian Journal of Forest Research* 14 : 431 - 436.

DRIESSCHE, R. VAN DEN. 1988. Nursery growth of conifer seedlings using fertilizers of different solubiliites and application time, and their forest growth. *Canadian Journal of Forest Research* 18 : 172 - 180.

DURYEA, M.L. & MCCLAIN, K.M. 1984. Altering seedling physiology to improve reforestation success. Pp. 77-114 in Dureya, M.L. & Brown, G.N. (Eds.) *Proceedings of the Physiology Working Group Technical Session, "Seedling Physiology and Reforestation Success".* Society of American Foresters National Convention, Portland, Oregon, USA. October 16-20,1983. Martinus Nijhoff/Dr. W. Junk Publishers, Dordrecht/ Boston/London.

ELOWSON, S. & RYTTER, L. 1988. Dynamics of leaf minerals, leaf area, and biomass from hardwoods intensively grown on a peat bog. *Trees* 2 : 84 - 91.

ERICSSON, T., RYTTER, L. & HINCKLEY, T. 1992. Nutritional dynamics and requirements of short rotation forests. Pp. 35-65 in Mitchell, P., Sennerby-Forsse, L. & Hinckley, T. (Eds.) *Ecophysiology of Short Rotation Forest Crops.* Elsevier Applied Science, London.

FISHER, J.T. & MEXAL, J.G. 1984. Nutrition management: a physiological basis for yield improvement. Pp. 271-300 in Dureya, M.L. & Brown, G.N. (Eds.) *Proceedings of the Physiology Working Group Technical Session, "Seedling Physiology and Reforestation Success".* Society of American Foresters National Convention, Portland, Oregon, USA. October 16-20, 1983. Martinus Nijhoff/Dr. W. Junk Publishers, Dordrecht/Boston/London.

GUPTA, G.N. 1991. Effects of mulching and fertilizer application on initial development of some tree species. *Forest Ecology and Management* 44 : 211 - 221.

HINESLEY, L.E. & MAKI, T.E. 1980. Fall fertilization helps long leaf pine nursery stock. *South African Journal for Applied Forestry* 3 : 132-135.

HÖGBERG, P. 1989. Growth and nitrogen inflow rates in mycorrhial and non-mycorrhizal seedlings of *Pinus sylvestris. Forest Ecology and Management* 28 : 7 - 17.

HOLOPAINEN, T. & HEINONEN-TANSKI, H. 1993. Effects of different nitrogen sources on the growth of Scots pine seedlings and the ultrastructure and development of their mycorrhizae. *Canadian Journal of Forest Research* 23 : 362 - 372.

HULL, C.H. & NIE, N.H. 1981. *SPSS Update: New Procedures and Facilities for Releases 7-9.* McGraw-Hill, Inc., Hightstown, New Jersey.

LOXTON, R.F. & DONALD, D.G.M. 1987. The effect of nitroacta (urea formaldehyde) on the growth and development of *Eucalyptus grandis* and *Pinus elliottii. South Africa Forestry Journal* 142 : 68 -70.

SIMPSON, D.G. 1988. Fixing the edsel - can bareroot stock quality be improved? Pp. 24-30 in Landis, T.D. (Coordinator) *Proceedings, Combined Meeting of Western Forest Nursery Associations.* Rocky Mountain Forest Range Experimental Station, USDA Forest Service General Technical Report RM-167. British Columbia Ministry of Forest, Vernon, Canada.

STEINBECK, K. 1971. Growth responses of clonal lines of American sycamore grown under different intensities of nutrition. *Canadian Journal of Botany* 49: 353 - 358.

TROENG, E. & ACKZELL, L. 1988. Growth regulation of Scots pine seedlings with different fertilizer compositions and regimes. *New Forests* 2 : 119 - 130.

TSCHAPLINSKI, T.J. & NORBY, R.J. 1991. Physiological indicators of nitrogen response in a short rotation sycamore plantation. I. CO_2 assimilation, photosynthetic pigments and soluble carbohydrates. *Physiologia Plantarum* 82 : 117 - 126.

WAKELEY, P. C. 1969. Results of Southern pine planting experiments established in the middle twenties. *Journal of Forestry* 67 : 237 - 241.

WARING, H.D. 1972. *Pinus radiata* and the nitrogen-phosphorus interactions. Pp. 141 - 161 in Boardman, R. (Ed.) *Chemical Aspects of Nutrition : Specific Elements and Interactions. Proceedings, Australian Forest Tree Nutrition Conference 1971.* Forestry and Timber Bureau, Canberra.