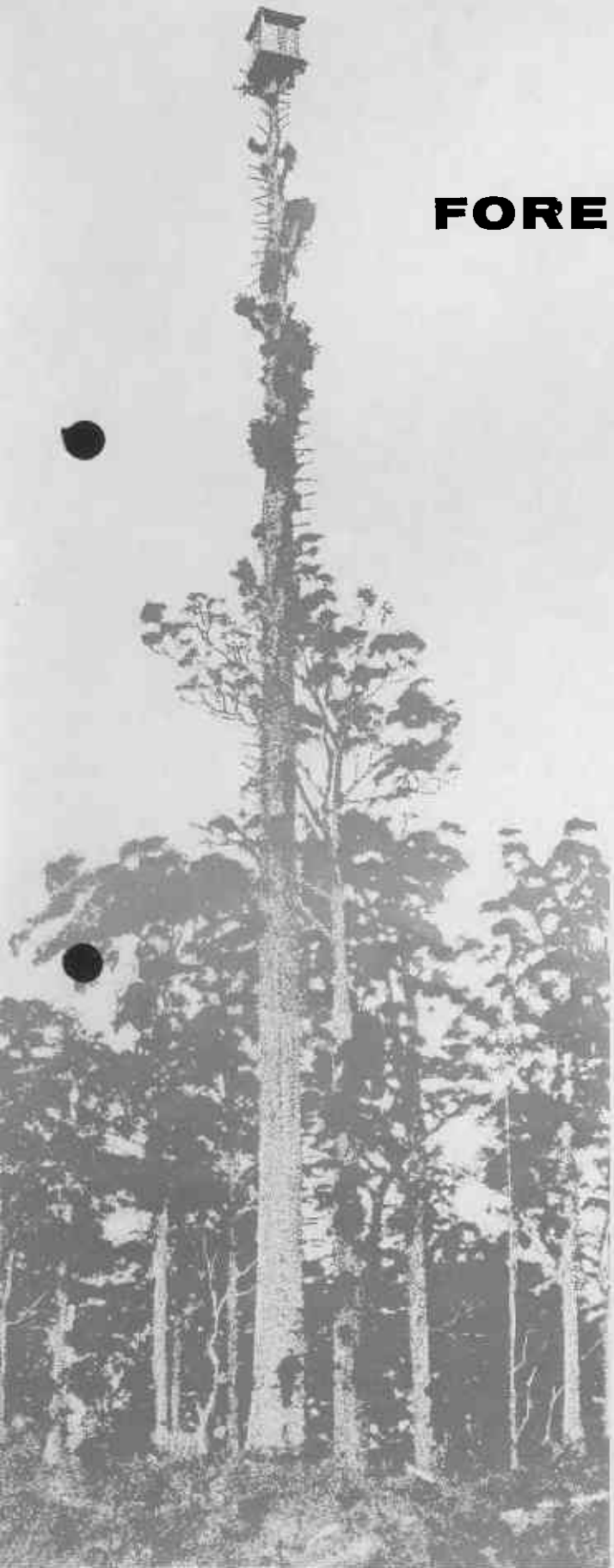
Research Paper No. 5
1971



FORESTS DEPARTMENT
OF WESTERN AUSTRALIA
54 BARRACK ST., PERTH

FERTILIZER RESPONSES IN PINUS RADIATA

by

E. R. HOPKINS

SUMMARY

Nutrition studies involving both field and pot trials show that poor growth in second rotation *Pinus radiata* at Berakin Plantation is associated with severe deficiencies in both nitrogen and phosphorus. Zinc and potassium were not deficient in the area and copper and a trace element mixture showed to advantage only with high levels of nitrogen fertilization.

Growth within the second rotation on the site can be greatly improved by the addition of 4 cwt of superphosphate and 2.5 cwt of urea per acre.

INTRODUCTION

A fire damaged the stand of *Pinus radiata* D. Don in Berakin Plantation, Compartment 4 in 1963. The stand at that time was 34 years old, site quality V and required salvage. Following cutting, the area was replanted with *P. radiata* in 1965.

Within a year of planting it was observed that the pines were not getting away satisfactorily. On some ashbed locations, foliage colour and health appeared normal but height growth was slow. The majority of the pines were yellow in colour and growth was poor. In October 1967, two years after planting, plant height ranged from 50 inches to 20 inches with an average of 33 inches.

Although the original stand productivity was below average it was of sufficient magnitude to expect far better growth than that obtained on replanting. Results appear to indicate a decline in site productivity following the first rotation.

In 1967 a series of treatments were planned to investigate the situation. This report concerns results of a fertilizer study, commenced in 1967, to investigate nutritional aspects of the problem.

PROCEDURE

Both field and pot trials were involved.

The Field Trial

In October 1967, 84 plots of 16 trees (4 x 4) were selected in the problem area. Selection avoided ashbeds and concentrated on separating 16 tree planting units reasonably uniform within themselves in height growth and foliage colour and with adequate plant stocking. Each of the nine central trees (3 x 3) in each plot (4 x 4) was measured for height. The mean height of the five tallest trees per plot was calculated. It was necessary to use a five tree mean as mortalities had reduced the stocking of the central nine planting positions in some instances.

Plots were ranked to range from the tallest mean height to the shortest. Successive groups of 12 plots within the ranking were allocated to homogeneity blocks providing for a design of seven replications of each of 12 treatments. Treatments were randomly allocated to the plots and applied in October 1967.

The trial was designed as a factorial experiment to investigate the following main effects:

P0—no phosphate fertilizer added.

P1—the equivalent of 4 cwt superphosphate per acre, added.

P2—the equivalent of 8 cwt superphosphate per acre, added.

N0—no nitrogenous fertilizer added.

N1—the equivalent of 2.5 cwt urea, per acre, added.

N2—the equivalent of 5.0 cwt urea, per acre, added.

N3—the equivalent of 5.0 cwt of Nutrifert per acre added.

Nutrifert is a commercial fertilizer mix containing both organic and inorganic nitrogen and trace elements (5.2 per cent ammonia, 11.1 per cent phosphoric anhydride).

The fertilizers were broadcast by hand to the 16 tree plots. Height of the survivors in the central nine planting positions was measured in November, 1969 and 1970.

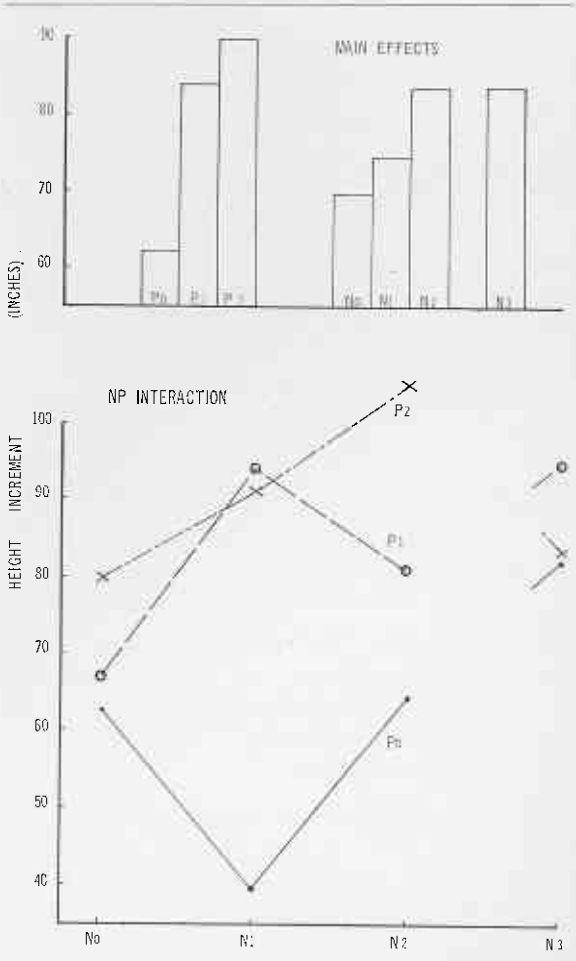


FIGURE 1: *Results for main effects and interaction in the field trial.*

The Pot Trials

Within the planting area, soil from the 0 to 9 inch depth in 25 locations was collected and mixed. The mixture was used to fill 100 pots (seven inch diameter and nine inch depth). These were sown with 20 seeds

of *P. radiata* in October 1967. The pots were watered and maintained in the Wanneroo glass house until August 1968. Germination was excellent but growth was very poor and the pines developed a pronounced yellow colour. In August each pot was thinned to leave the ten most uniform plants. Heights were measured, the mean per pot calculated, and the pots were ranked in order of decreasing mean height. The 50 tallest and 50 shortest pot heights were separated to form two uniformity blocks.

Ninety-six pots were used for two nutrition studies carried out simultaneously.

The major trial, referred to as the Macro Trial, was a factorial study embracing three levels of phosphorous (P), three levels of nitrogen (N), two levels of zinc (Z) and two levels of potassium (K), i.e.

P0	N0	K0	Z0
P1	N1	K1	Z1
P2	N2		

Treatments were randomly allocated to 36 plots in each of the two blocks.

Initially, nutrient solutions were added to the pots at weekly intervals. This application was reduced to fortnightly intervals over the final months. Treatment was discontinued in March 1969, heights were measured and the shoots were harvested, oven dried and weighed. Concentrations of N, P and K were determined for the dry needle residues.

The subsidiary trial, termed the Micro Trial, used as its base the N1 P1 K1 and N2 P2 K1 levels of the Macro Trial. It included two levels of zinc, two levels of copper (Cu) and two levels of a trace element mix (T), i.e.

N1	P1	K1	Z0	Cu0	T0
N2	P2	K1	Z1	Cu1	T1

This trial was randomized amongst 12 pots in each block using the treatments common in the Macro Trial to permit comparison of 16 treatments with 2 replications of each.

Measurement and harvesting were similar to that for the Macro Trial.

RESULTS

The Field Trial

Analyses of height measurements carried out in 1969 and 1970 proved to be significant and separated a pronounced NP interaction. The order of the main effects and interaction was similar for both sets of results and only the 1970 results will be considered in detail.

The addition of P fertilizer alone at rates of 4 and 8 cwt per acre produced small height increments of 7 and 27 per cent respectively (Table 1). Addition of urea alone depressed growth at the 2.5 cwt level and produced no useful effect at the 5.0 cwt level (Figure 1). It is not unusual for a direct application of nitrogenous fertilizers to depress growth of young *P. radiata*. Normally however, one would expect the depression to be at least as great with the heavier dressing of urea. The result recorded was identical in the 1969 measurement.

TABLE 1
PERCENTAGE RESPONSE OF HEIGHT INCREMENT TO FERTILIZER TREATMENTS IN 1969 AND 1970

Phosphorus Level	Nitrogen Level			
	N0	N1	N2	N3
	1969			
P0	100	61	108	114
P1	108	140	117	125
P2	128	132	152	130
	1970			
P0	100	63	103	132
P1	107	150	129	151
P2	127	145	168	133

Data provided for the N3 source cannot be considered as an extension of the N1 and N2 levels since the Nutrifert fertilizer (N3) is in fact a mixture of organic and inorganic nitrogenous nutrients together with some phosphorus. The N3 data will be interpreted separately.

With the P1 level of phosphorus a positive response was obtained with the urea additions, the N2 response being less than the N1. Combined with the P2 addition, the N1 value was similar to that of P1 N1 while the N2 value provided the highest increment recorded.

Data in Figure 1 suggest that both N and P are lacking for growth. For the N1 application, P1 is adequate to fully utilize the nitrogen applied while for the N2 application, the P2 level of phosphorus is necessary. Effective fertilizer use required the use of N and P in combination and in a correct ratio.

The slow acting NP source N3 provided an appreciable and reliable response at all levels of P. Results are, however, not superior to the more economical N1 P1 addition and cost would rule out the use of Nutrifert for plantation fertilizing in practice.

Quantitive expression of response by treatments in Table 1 show that the beneficial effects of applications are increasing with time since the first measurement. A true appreciation of the relative benefits of treatment is not expected until the response has been recorded for at least another three years. Height

increment is also a rather unsatisfactory indication of response and in future years the trees will be sufficiently large to express response to both height and diameter growth as volume.

The Pot Trials

Results for dry weight production in both the Macro and Micro Trials proved to be highly significant on analysis. Means for main effects are contained in Figure 2. It is necessary to note however, that in the Macro Trial the NP interaction was highly significant (Figure 3) and in the Micro Trial interaction between NPK and copper and NPK and trace element mix were significant (Figure 4).

In the Macro Trial, zero phosphorus and the P1 and P2 provided no response in the absence of nitrogen (N0. A response was obtained by the addition of N1 alone and this interacted with the P1 and P2 applications to provide a similar, higher response. The effect of N2 without P was similar to that N1 but the interaction with P1 and P2 was increased. The P2 level proved to be of no advantage over the P1 level.

Analysis of results of foliar uptake of N, P and K provided highly significant values for each nutrient within the NP interaction (Figure 3). Data indicating uptake trends suggest that limited N availability has restricted further growth in the P2 N1 and P2 N2 treatments. In practice, N2 and P2 solutions added were double the concentrations of the N1 and P1 solutions.

The addition of potassium and zinc produced no significant response in dry weight in the Macro Trial. On analysing weight of nutrients taken up by treatment a significant P x Z interaction revealed that zinc assisted N uptake at the P2 level. The presence of zinc also increased uptake of potassium, in the absence of added K, at the N2 level.

In the Micro Trial, the presence of copper and the trace element mix significantly increased dry weight production at the N2P2K1 level (Figure 4). Zinc again had no influence on dry weight production. No interactions were significant in the analysis of nutrient uptake by treatments.

DISCUSSION

Both the field and pot trials show that pine growth on the problem site can be greatly improved by the addition of fertilizers. Bearing in mind the cost of fertilizers and the nature of the NP interaction recorded, fertilizer additions of the order of 4 cwt of superphosphate and 2.5 cwt of urea per acre appear to be the desirable treatment.

It is possible that future measurements of the field trial will bring the P2N2 treatments into greater relative advantage. Realization of the difficulties of N application suggest however, that the same fertilizer cost in applying the P1N1 treatment twice, at a five year interval, should provide sounder benefit than one single heavy application.

An NP interaction, rather than separate responses from N and P fertilizers, has been shown before for laterite soils in Western Australia (Turton and Keay 1970). The soil in question is laterite in nature with the appearance of a red loam. General experience with *P. radiata* growth in Western Australia shows that nitrogenous fertilizers, if required, must be applied in conjunction with phosphorus and generally several years after the plant has been established.

Some evidence of minor element effects from the N3 (Nutrifert) addition in the field and the applied treatments in the pots suggest that the use of commercial super-copper-zinc fertilizer may have more satisfactory long term effects on growth than would straight superphosphate. These soils apparently have adequate potassium and this element need not be considered for amelioration measures, for the present at least.

Experience would indicate that on second rotation soils it is worth considering the application of 2 ozs. of super-copper-zinc per tree at time of planting. At age two or three the super and urea could then be added by broadcasting. This would avoid nitrogen damage to the seedling pines and should guarantee early establishment and growth. On most sites considered for planting *P. radiata,* this treatment should prove economical.

Results for the field trial emphasize problems associated with field testing; even when adequate stratification and replication of plots are employed. These problems can largely be overcome provided the trial is assessed over a period sufficiently long to allow expression of treatment effects in the measurement parameter. Treatments were applied to a very retarded stand and major effects of improvement, as expressed in height growth, would need to follow rebuilding the crown. Height growth is not a very sensitive measure of treatment effects and is of little value by itself, in gauging the economies of response. It will be advantageous when some expression of stem diameter is obtained in the next measurement.

Field results are adequately verified by the pot trials and the overall study leaves little doubt as to the value and nature of required fertilizer treatment. This information could not be obtained from the pot studies alone. Considering the small amount of work involved in the pot trial, the procedure is recommended as a complement to the necessary field experimentation required to diagnose and prescribe for nutritional problems. Essentially, it is suggested, field trials should be kept simple, concern no more than three elements and be well replicated. Further elements

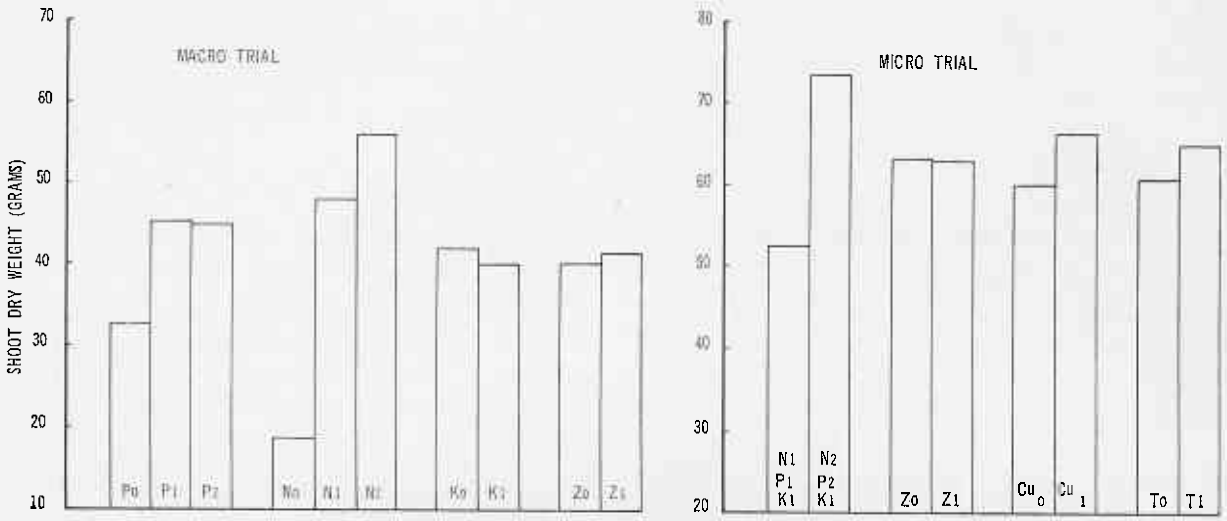


FIGURE 2: *Main effect for Pot trials.*

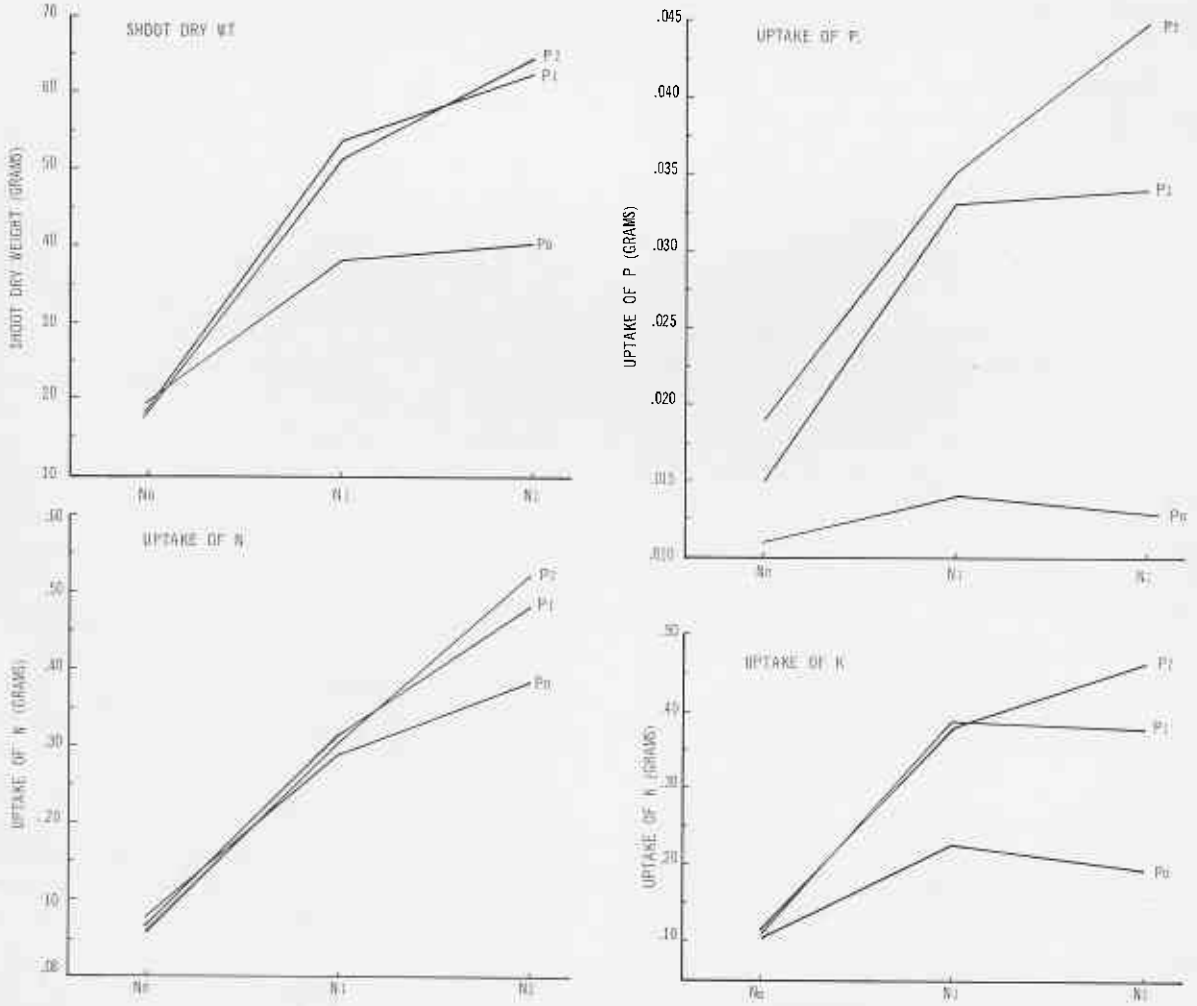


FIGURE 3: *Interactions obtained for shoot dry weight, nitrogen uptake, phosphorous uptake and potassium uptake in the Macro pot trial.*

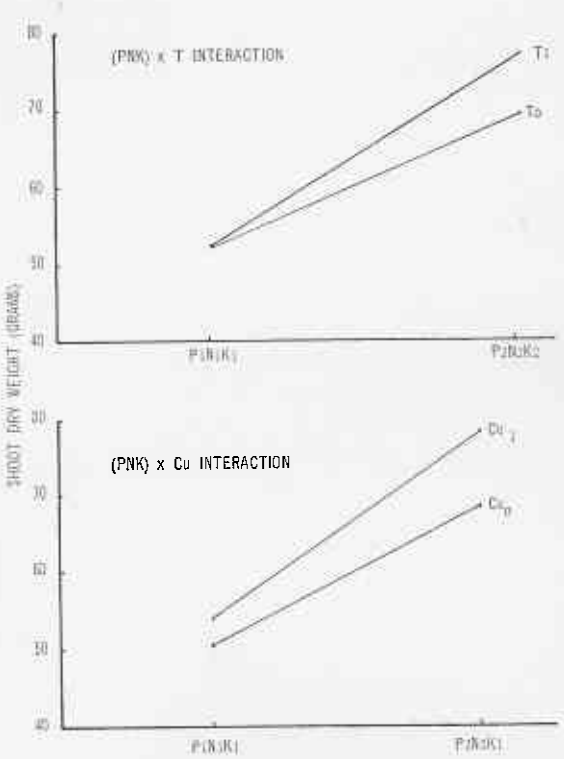


FIGURE 4: *Interactions obtained with the addition of a trace element mix and copper in the Micro pot trial.*

and levels of application can be explored in the pot trial.

Cost involved in the analysis of N, P and K in the foliage is considerable. From this study it is suggested that the limited amount of further information obtained through these analyses does not warrant the expense. Results were adequately expressed and interpreted from height and dry weight measurements.

It was not possible to obtain a soil sample for inclusion in the pot trial which would represent the situation prior to the first rotation. Deficiences recorded in the problem area cannot necessarily be related to the influence of the first rotation.

CONCLUSIONS

Early pine growth on sites similar to the Berakin problem area can be materially improved by the addition of nitrogenous and phosphatic fertilizers.

LITERATURE CITED

Turton, A. G. and Keay, J. 1970. Changes in dry weight and nutrient distribution in maritime pine after fertilization. Aust. For. 34(2): 84-96.