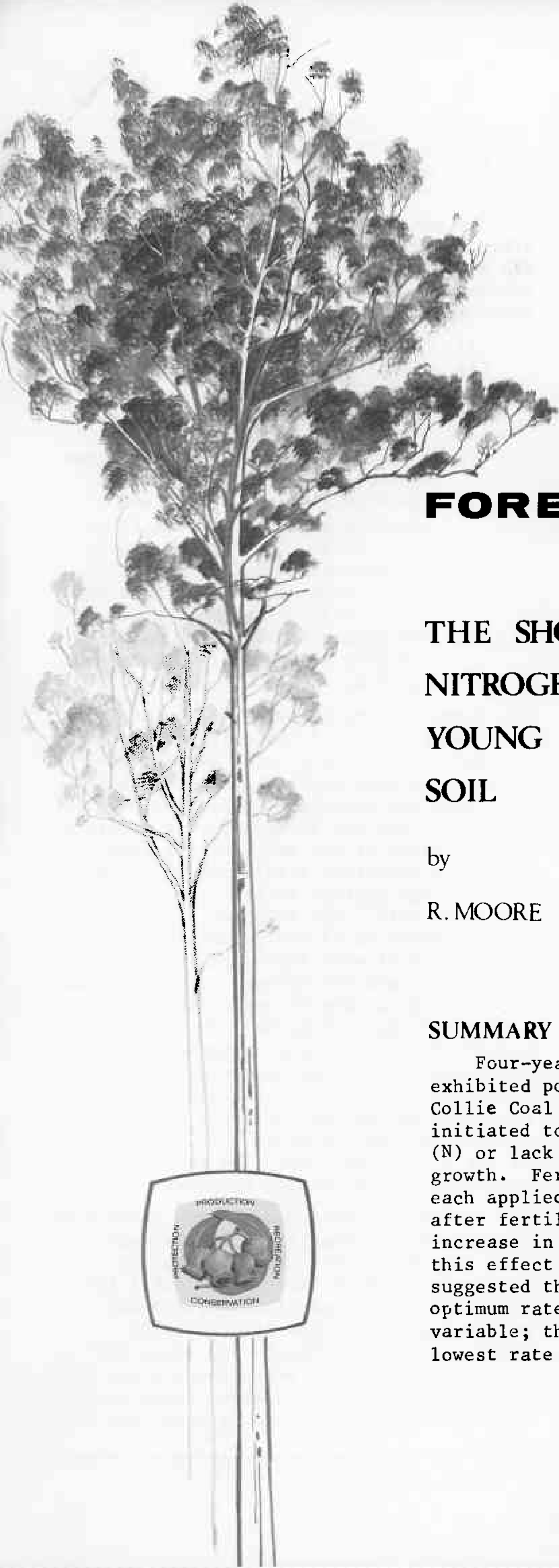

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FORESTS DEPARTMENT
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THE SHORT LIVED RESPONSE TO NITROGEN AND PHOSPHORUS BY YOUNG *Pinus radiata* ON SANDY SOIL

by

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SUMMARY

Four-year-old monterey pine (*Pinus radiata* D. Don) exhibited poor growth on infertile sandy soil in the Collie Coal Basin of Western Australia. A trial was initiated to test the hypothesis that lack of nitrogen (N) or lack of nitrogen and phosphorus (P) were limiting growth. Fertilizer treatments of N and compound NP were each applied at 0.25, 0.5 and 1.0 kg per tree. Two years after fertilization the trees showed a significant increase in diameter increment for all rates of NP, but this effect rapidly declined. The response curves suggested that approximately 700 $kg \cdot ha^{-1}$ NP is the optimum rate of application. Response to N alone was variable; the higher rates depressed growth while the lowest rate increased growth slightly.

INTRODUCTION

Pine plantations in Western Australia are predicted to yield 60% of the State's timber requirements by the year 2010 (Forests Department of Western Australia, 1977). Monterey pine (*Pinus radiata* D. Don) is the preferred species because of its potential for rapid growth on fertile soils (Raupach, 1967). In Western Australia, only limited areas of highly fertile soils are available for pine planting and consequently large areas of infertile soils are being planted. Waring (1969) showed that nitrogen (N) and phosphorus (P) are key elements for growth, and measured five-fold increases in production of *P. radiata* in New South Wales with additions of these elements.

In 1973 a plot of four-year-old *P. radiata* growing on sandy soils in the Collie Coal Basin appeared unhealthy. As the pine was fertilized with P at the time of planting, it was presumed that growth of these pines was limited by a deficiency of N. An experiment was designed to test the hypothesis that growth of the pines was limited by either lack of N, or lack of N and P. A secondary objective was to determine the optimum application rate of fertilizer and the duration of the fertilizer effect.

METHOD

The experiment was established in a trial area 6 km south of Collie, on a lateritic podzol. The area was planted with *P. radiata* in July 1969. Prior to planting, the area was cleared of native jarrah (*Eucalyptus marginata*) forest, windrowed and disc-ploughed. One-year-old *P. radiata* seedlings were planted at a spacing of 2.7 m x 2.7 m (1370 stems per hectare). The area was divided in four sections and different fertilizers were applied at planting:

(1) superphosphate 22% (113 g per tree),
(2) superphosphate 22% + 0.33% Cu + 0.6% Zn (113 g per tree),
(3) superphosphate 22% + 0.33% Cu + 0.6% Zn (226 g per tree),
(4) superphosphate 22% + 0.33% Cu + 0.6% Zn (113 g per tree) + rock phosphate (340 g per tree).

There were subsequent treatments in August 1970:

(1) standard foliar spray of zinc sulphate (2.5% w/v*) at about 5 $kg{\cdot}ha^{-1}$ Zn,
(2) herbicide 2, 4, 5-T to control native scrub.

The present experiment was established after deficiency symptoms were noticed. The design of the experiment was a randomized block with seven fertilizer treatments. The treatments were:

(1) Control (no fertilizer),
(2) ammonium nitrate (34% N) as Agran 34:0 (0.25 kg per tree),
(3) ammonium nitrate (34% N) as Agran 34:0 (0.5 kg per tree),
(4) ammonium nitrate (34% N) as Agran 34:0 (1.0 kg per tree),
(5) ammonium nitrate (24% N) and ammonium phosphate (10.5% P) as Agran 24:24 (0.25 kg per tree),
(6) ammonium nitrate (24% N) and ammonium phosphate (10.5% P) as Agran 24:24 (0.5 kg per tree),
(7) ammonium nitrate (24% N) and ammonium phosphate (10.5% P) as Agran 24:24 (1.0 kg per tree).

The seven treatments were replicated four times within each of the original four sections, providing a total of 28 plots. Fertilizers were applied in late August 1973 when the pines were four years old. The fertilizer was broadcast over a circle with a radius of one metre around each tree. In addition, a solution of trace elements was applied to all trees in September 1973. The solution consisted of zinc sulphate (2.5% w/v), manganese sulphate (2.5% w/v) and copper sulphate (0.1% w/v), and was sprayed onto the trees as a mist at a rate of approximately 5.6 $kg{\cdot}ha^{-1}$ Zn, 5.6 $kg{\cdot}ha^{-1}$ Mn and 0.23 $kg{\cdot}ha^{-1}$ Cu respectively. Symptoms of Cu deficiency were noted in the plots with NP fertilizer in July 1975 and all plots were resprayed during the following October at a higher volume; 12 $kg{\cdot}ha^{-1}$ Zn, 12 $kg{\cdot}ha^{-1}$ Mn and 0.47 $kg{\cdot}ha^{-1}$ Cu. The respraying corrected the deficiency symptoms.

An internal measurement plot containing nine trees was established in the centre of each treatment plot. The diameter at breast height over bark (d.b.h.o.b.) for all trees in the measurement plots was measured annually from 1973 to 1975. After routine thinning to 750 stems per hectare in 1975, the measurement plots were reduced to five to seven trees each, which were measured annually from 1976 to 1978.

* weight per volume

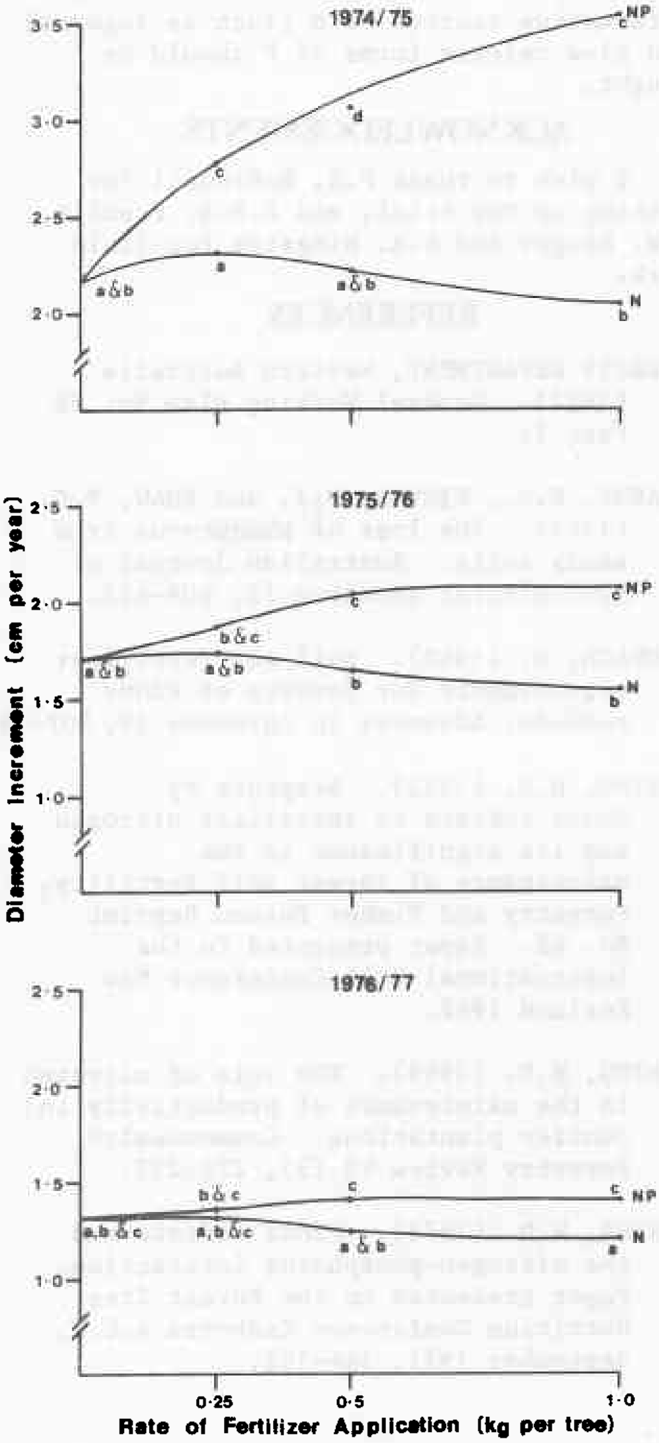

FIGURE 1: Diameter increments (cm per year) of *P. radiata* on infertile sands in the Collie Coal Basin in W.A., with different rates of application of NP and N fertilizers. Figure 1 shows increments for the second, third and fourth year respectively, after the fertilizers were applied to four-year-old pine. Data not having the same letter are significantly different at the p = 0.05 level.

The measurements of d.b.h.o.b. were used to calculate diameter increments per hectare. A preliminary analysis of variance of the data showed that there were no interactions between the initial and the refertilization treatments. Consequently, the data for all four sections of the trial were grouped together for further analysis.

Diameter increments (cm per year) for each year from 1974 to 1977 are given in Figure 1. The diameter increments for 1974/75 (two years after fertilizers were applied) show a significant response ($p = 0.05$) to NP for all rates of application, and that increasing rates of NP produced an increasing response (Fig. 1). For N fertilizer, only the lowest rate increased growth, while the higher rates (0.5 and 1.0 kg per tree) depressed growth. There was a large drop in the response to NP fertilizers during 1975/76 (Fig. 1). The 1976/77 diameter increments (Fig. 1) show that this decline continued until there was no significant response three years after fertilization.

The response curve in Figure 2 shows basal area values in 1978 for the three application rates of NP fertilizers. The curve has levelled off at the highest rate of application (1.0 kg per tree).

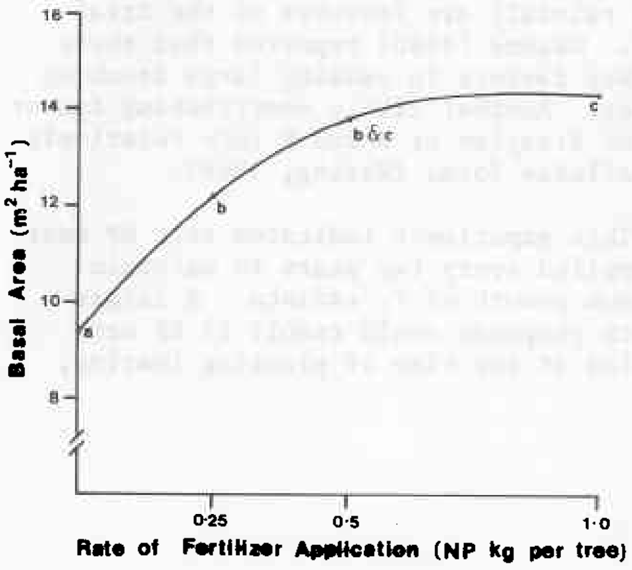

FIGURE 2: Basal areas ($m^2 \cdot ha^{-1}$) of *P. radiata* on infertile sands in the Collie Coal Basin in W.A. Five years later, different rates of NP fertilizer were applied. Data not having the same letter are signifcantly different at the same p = 0.05 level.

DISCUSSION

The experiment showed that the addition of a compound of N and P to four-year-old *P. radiata* increased growth. This response increased with increasing rates of NP, supporting the hypothesis tested. The response curve (Fig. 2) suggests that the optimum rate of application is about 0.5 kg per tree, approximately 700 $kg \cdot ha^{-1}$. The fact that N alone did not produce a significant increase ($p = 0.05$) in growth rate suggested that lack of P rather than lack of N was limiting growth. This corresponds with the findings of Waring (1962). As there was no treatment using P only, it is not possible to gauge the degree of response due to P and that due to the combined effect of N and P.

The experiment also found that response to the NP fertilizer was short lived. During the third year after refertilization, the growth rate of fertilized trees dropped considerably, and by the fourth year there was no significant difference between the growth rate of fertilized and unfertilized trees (Fig. 1). The transitory nature of the response is possibly caused by the forms of N and P in Agran 24:24 being highly soluble. Rapid leaching of these elements would also have contributed to making N and P unavailable to the pine, as highly permeable soils and high rainfall are features of the trial area. Ozanne (1960) reported that these are key factors in causing large leaching losses. Another likely contributing factor is the fixation of N and P into relatively unavailable forms (Waring, 1969).

This experiment indicated that NP must be applied every two years to maintain maximum growth of *P. radiata*. A larger growth response could result if NP were applied at the time of planting (Waring, 1971). However, refertilization with expensive NP fertilizers every two years is likely to be uneconomic. Therefore, alternative sources of N (such as legumes) and slow release forms of P should be sought.

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