ODC 237.4:174.75

Research Paper 73
December 1983

FORESTS DEPARTMENT
OF WESTERN AUSTRALIA

THE EFFECT OF TWO METHODS OF ZINC APPLICATION ON THE GROWTH OF *Pinus radiata* D.DON ON SANDS OF THE SWAN COASTAL PLAIN.

by H. CHEVIS

SUMMARY

Applications of zinc are required for the satisfactory growth of *Pinus radiata* on the Swan Coastal Plain. This trial was initiated to test the hypothesis that zinc oxide applied with Superphosphate would provide sufficient zinc for *P. radiata* on the yellow and grey sands of the Karrakatta association, thus making foliar spraying unnecessary. Super CuZn 'A' (0.6% zinc) or Super CuZn 'B' (0.3% zinc) was applied with or without a 2½ per cent zinc sulphate foliar spray. Superphosphate (no zinc) was applied with a foliar spray.

On the yellow sands, what are normally considered adequate levels of zinc in the foliage for optimum growth were only achieved by the application of a zinc sulphate spray to the needles. Height growth rate of the pine, however, was not related to the levels of zinc in the foliage. Chlorosis occurred when zinc levels in the uppermost branches were less than 10 ppm.

On the grey sands there were adequate levels of foliar zinc for all treatments, and neither rate of height growth nor chlorosis were related to the levels of foliar zinc. Another factor must be limiting growth on this site.

INTRODUCTION

Pinus radiata D. Don is being grown by the Western Australian Forests Department on some areas of the Swan Coastal Plain west of Harvey. The area has a Mediterranean climate, receiving an average rainfall of 890 mm per year (McArthur and Bartle, 1980) (Fig. 1).

P. radiata is grown mainly on the soils of the Karrakatta association (McArthur and Bartle, 1980). This association is the eastern part of the Spearwood dune system and is divided into two phases. The soils of the yellow phase are leached yellow and brown sands overlying limestone at depth. The grey phase consists of grey sand overlying yellow within one metre. Along the easternmost fringe of the Karrakatta association there are wind blown deposits of grey sand. These grey sands are highly leached and contain particularly low concentrations of nitrogen, phosphorus and potassium (Stoate, 1950).

The low nutrient status of both the yellow and grey sands necessitates the application of some nutrients for the successful growth of *P. radiata*. Stoate (1950) found that lack of phosphorus and zinc limited the growth of *P. radiata* on several sites including the coastal plain west of Harvey. These deficiencies were corrected by applications of Superphosphate, and either foliar applications of zinc sulphate or solid applications of zinc oxide to the soil.

This trial was initiated to test the hypothesis that zinc oxide, applied with Superphosphate in commercial fertilizers, would provide sufficient zinc for the growth of *P. radiata* on both the yellow and grey sands of the Karrakatta association, thus making the application of expensive foliar zinc sprays unnecessary.

METHOD

The trial was carried out at two sites within the Harvey Coast Plantation. Both sites were within the Karrakatta association, one on grey sand and the other on yellow sand.

The native eucalypt forest was cleared and burnt in wind rows in 1970. The following year the sites were ploughed and the planting lines were furrowed. One-year-old *P. radiata* seedlings were transplanted into the field in early winter 1971, at a spacing of 2.7 metres by 2.1 metres.

Treatments were arranged in a 5 x 5 Latin square at each site. Measured plots were approximately 0.02 ha each.

The fertilizer treatments tested and their analyses are shown in Table 1. The Superphosphate was applied in a circle 10 cm from the plant in the spring. The zinc sulphate sprays were applied to the foliage in the spring of the following year. There was no evidence of chlorosis at this time.

Tree height was measured one and two years after transplanting. No further measurements were possible after the second year. Samples of foliage were taken from the current year's growth on the uppermost branches, two years after transplanting, for nutrient analysis. Chlorosis of the foliage of the pine was assessed at the same time.

RESULTS

Yellow Sands

Zinc oxide, applied in combination with Superphosphate (treatments 2 and 4, Table 1), produced an average foliar zinc concentration in the pine of less than 7 ppm. A correspondingly high percentage of trees with chlorosis were observed in these treatments (Table 2). Where foliar sprays of zinc sulphate were also applied (treatments 1, 3, 5, Table 1) foliar zinc concentrations rose above 14 ppm and no chlorosis was observed (Table 2).

Chlorosis only occurred in those plots where the level of foliar zinc in the pine was less than 10 ppm (Fig. 2).

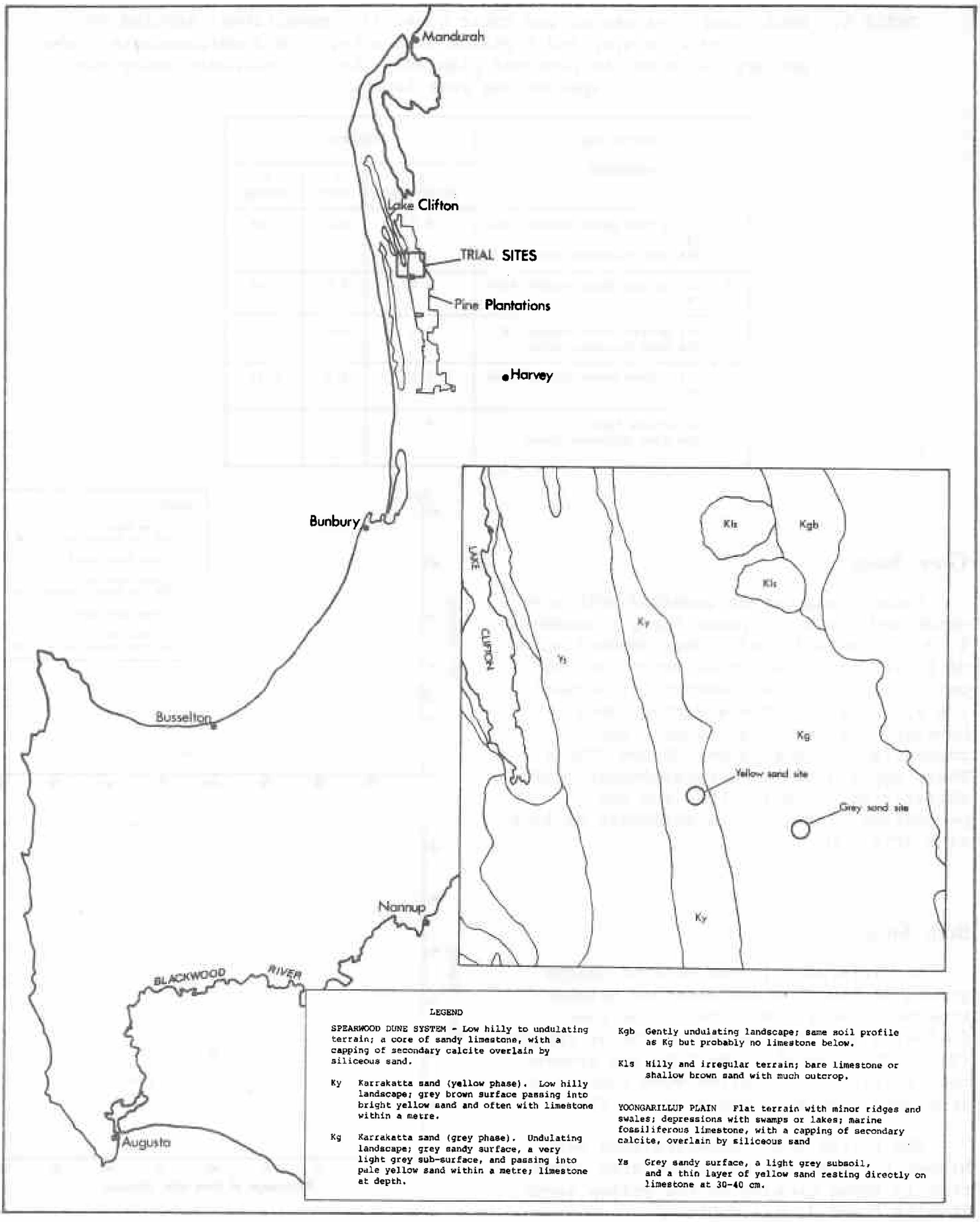

Figure 1 : Distribution of soils within part of the Harvey Coast Plantation. The trial sites are indicated. Taken from McArthur and Bartle, 1980.

TABLE 1: Fertilizer treatments, and their chemical compositions, applied to *P. radiata* on a grey and a yellow sand site. The Superphosphate (Super) was applied when the pine was planted. The zinc sulphate spray was applied one year later.

FERTILIZER TREATMENT	ANALYSIS		
	% PHOSPHORUS	% ZINC	% COPPER
1. 113 g/tree Super Copper Zinc 'A' 2½% Zinc Sulphate spray	8.2	0.6	0.66
2. 113 g/tree Super Copper Zinc 'A'	8.2	0.6	0.66
3. 113 g/tree Super Copper 'B' 2½% Zinc Sulphate spray	8.4	0.3	0.33
4. 113 g/tree Super Copper Zinc 'B'	8.4	0.3	0.33
5. 113 g/tree Super 2½% Zinc Sulphate Spray	9.1	-	-

Grey Sands

Those trees which received both zinc oxide and a zinc sulphate spray (treatments 1, 3, 5, Table 1) had higher concentrations of foliar zinc than those which received only the zinc oxide treatment (treatments 2 & 4, Table 1). These differences, however, were not significant, and all concentrations were above 20 ppm (Table 2). There appears to be no relationship between foliar zinc concentrations and the percentage of trees with chlorosis on this site (Fig. 2).

Both Sites

No difference in the rate of height growth of the pine was observed between treatments on either site in the year following application of the foliar sprays (Table 2). Overall, the pine was growing much faster on the yellow sand than on the grey sand (Tables 2 and 3, $p < 0.05$).

The foliar zinc concentrations were higher in pine growing on the grey sands than in those growing on the yellow sands (Tables 2 and 3, $p < 0.05$).

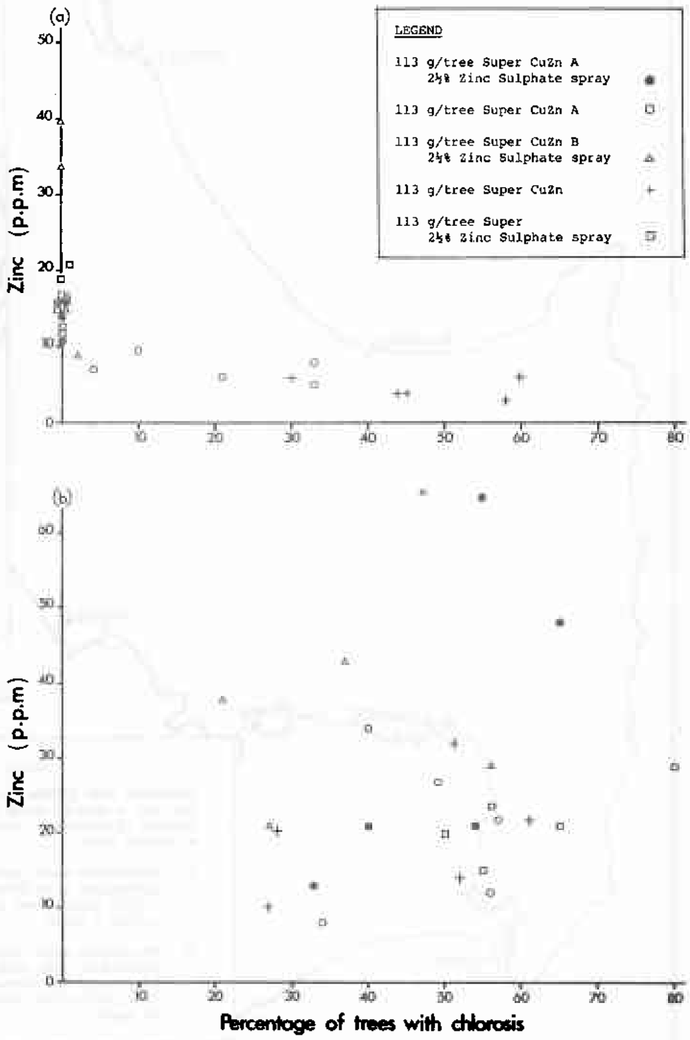

Figure 2 : Foliar zinc levels and percentage of trees with chlorosis of two year old *P. radiata* growing on (a) yellow sand and (b) grey sand. Figures are for individual plots.

TABLE 2: Height growth, levels of foliar zinc, and chlorosis of *P. radiata* in response to applications of phosphate with solid and foliar applications of zinc.

TREATMENT	YELLOW SAND			GREY SAND		
	Mean Height (cm)	Trees with chlorosis (%)	Mean Foliar Zinc (ppm)	Mean Height (cm)	Trees with chlorosis (%)	Mean Foliar Zinc (ppm)
1. 113 g/tree Super CuZn 'A' 2½% zinc sulphate spray	31.4	0^{c}	14^{ab}	15.3	49^{ab}	33
2. 113 g/tree Super CuZn 'A'	33.0	21^{b}	7^{bc}	18.4	47^{b}	21
3. 113 g/tree Super CuZn 'B' 2½% zinc sulphate spray	33.0	0^{c}	23^{a}	17.1	38^{b}	39
4. 113 g/tree Super CuZn 'B'	28.6	47^{a}	5^{c}	18.3	44^{ab}	20
5. 113 g/tree Super 22% 2½% zinc sulphate spray	27.5	0^{c}	16^{a}	15.1	61^{a}	22
SIGNIFICANCE	N.S.	$p < 0.05$	$p < 0.05$	N.S.	$p < 0.05$	N.S.

Height growth was measured between one and two years after transplanting. Common letters indicate non-significant differences at $P < 0.05$.

N.S. = No significance.

TABLE 3: Analysis of variance tables for height increment and foliar concentration in response to phosphate and zinc applications on a grey and a yellow sand site.

	SS	Df	MS	F	Sign
Height Increment (cm)					
Treatment	119.5	4	29.9	0.7	N.S.
Site	2402.6	1	2402.6	60.6	p 0.001
Treatment x Site	61.0	4	15.3	0.4	N.S.
Residual	1586.0	40	39.6		
Total	4169.2	49	85.1		
Foliar Zinc Concentration (ppm)					
Treatment	2430.9	4	607.3	5.1	p 0.01
Site	2422.1	1	2422.1	20.4	p 0.001
Treatment x Site	269.7	4	67.4	0.6	N.S.
Residual	4749.2	40	118.7		
Total	9871.9	49	201.5		

SS = Sum of squares
Df = Degrees of freedom
MS = Mean squares
F = F. ratio
Sign = Significance

DISCUSSION

The requirements of zinc by *P. radiata* were adequately supplied by zinc oxide applied with Superphosphate on the grey sands, but not on the yellow sands, judging from the concentration of zinc in the uppermost whorl of branches. A critical level of 10-12 ppm is generally accepted for *P. radiata* (McGrath and Robson, in press; Hill and Lambert, 1981). On the yellow sands, very low concentrations of zinc were found in the foliage where only zinc oxide was applied. Features of the yellow sands of the Karrakatta association, such as high iron concentration (Havel, 1968) may be limiting the availability of zinc to the pine (Loneragan *et al.*, 1979). A spray of zinc sulphate applied to the foliage just adequately supplied the pines' needs on this site.

The chlorosis of the foliage of pine growing on the yellow sand appeared to be related to deficiencies of zinc. The chlorosis, so common in *P. radiata* on the grey sand, was not related to the foliar zinc content. It appears to be due to the lack of some nutrient other than zinc.

There was no relationship between the foliar concentration of zinc and the height growth of the pine on either the yellow or the grey sand. McGrath and Robson (in press) observed a reduction in the height growth of *P. radiata* when the concentration of zinc in the uppermost branches fell below 10 ppm. The pine growing on yellow sand which did not receive a foliar spray, did have deficient levels of foliar zinc, and a reduction in growth would be expected. The visual symptoms of chlorosis, however, only became evident in the year in which the height measurements were made (Fremlin, personal communication*). It is possible that insufficient time had passed for the deficiencies in zinc to cause a reduction in the growth of the pine. The zinc concentrations in the pine growing on the grey sand were all greater than the deficiency level so no differences in growth between treatments would be expected.

The pine was growing much slower on the grey sand than on the yellow sand. This, and the symptoms of chlorosis which were not related to foliar concentrations of zinc, suggest that other factors are limiting the growth of the pine. It may be that there are deficiencies of the major elements such as phosphorus, nitrogen and potassium. If these were corrected then it is possible that a minor element, such as zinc, may also become deficient on the grey sands.

CONCLUSIONS

On the yellow sands foliar sprays of zinc sulphate are needed to adequately supply the pines requirements for this nutrient. On the grey sands applications of solid zinc oxide were sufficient in this experiment. However, other nutrients are limiting growth on this site and correction of these deficiencies may also necessitate the addition of more zinc in some form.

ACKNOWLEDGEMENTS

I wish to thank F. H. McKinnell for setting up the trial, and R.R.A. Fremlin, J.W. Kruger and R.A. Hingston for carrying out the field work.

REFERENCES

HAVEL, J.J. (1968). The potential of the Northern Swan Coastal Plain for *Pinus pinaster* Ait. plantations. Bulletin 76, Forests Department of Western Australia.

HILL, J. and LAMBERT, M.J. (1981). Physiology and management of micronutrients in forest trees in Australasia. Australian Forest Nutrition Workshop: Productivity in Perpetuity, Canberra 1981. C.S.I.R.O. Division of Forest Research, Canberra.

LONERAGAN, J.F., GROVE, T.S., ROBSON, A.D., SNOWBALL, K. (1979). Phosphorus toxicity as a factor in zinc phosphorus interactions in plants. Soil Science Society of America, Journal 43, 966-972.

* R. Fremlin.
Technical Officer, Forests Department of Western Australia, Busselton W.A.

McARTHUR, W.M., and BARTLE, G. (1980). Soils and land use planning in the Mandurah-Bunbury coastal zone, Western Australia. Land Resources Management SEries No. 6, C.S.I.R.O., Australia.

McGRATH, J.F., and ROBSON, A.D., (in press). The distribution of zinc and the diagnosis of zinc deficiency in seedlings of *Pinus radiata* D. Don. Australian Forest Research.

STOATE, T.N. (1950). Nutrition of the pine. Bulletin 30, Forestry and Timber Bureau, Canberra.