NOTE

ZINC DEFICIENCY IN PINUS RADIATA AT CAPE KARIKARI, NEW ZEALAND

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ABSTRACT

Pinus radiata D. Don trees exhibiting stunted growth and a terminal rosette of buds had foliar zinc concentrations less than 10 ppm. Corrective fertiliser application of 25 g zinc sulphate per tree (5.6 g Zn/tree) re-established tree vigour and improved foliar zinc concentrations to above 10 ppm.

Keywords: zinc; clay soil; nutrient deficiency; **Pinus radiata**.

INTRODUCTION

In February 1984 at Cape Karikari (latitude 34° 42′ S, longitude 173° 25′ E) in the Northland region of New Zealand, 18-month-old *Pinus radiata* seedlings exhibited symptoms thought to be due to a nutrient deficiency.

The soil type on which the seedlings were growing was described as Pukenamu Clay Loam 45a (N.Z. Soil Bureau 1954), a secondary podsolic soil derived from dacite and rhyolite. The site had been intensively prepared prior to planting (crushed, burnt, ripped, and bedded). After planting, the seedlings had received 80 g diammonium phosphate (DAP) per tree (15 g N, 16 g P).

The trees had stunted growth and a terminal rosette of buds. Needles below the terminal rosette were short with dead tips. Foliage collected from these trees had a zinc concentration of 1 ppm. Other trees in the same area not displaying these symptoms had foliar zinc concentrations of 11 ppm. Will (1985) reported these results briefly and suggested that below a level of 10 ppm *P. radiata* growth would be adversely affected. He pointed out that there was no practical experience of correction in New Zealand.

Most *P. radiata* stands in New Zealand have foliar zinc concentrations averaging 44 ppm and ranging from 19 to 65 ppm (Hunter *et al.* 1985). Therefore, all the trees in this area had zinc concentrations below the previously observed range.

The symptoms resembled those seen in zinc-deficient nursery seedlings at 6 ppm (Knight 1976). Zinc-deficient trees in Australia showed similar symptoms at a foliar concentration of 14 ppm (McGrath 1978). Similar symptoms of zinc deficiency have been described for other conifers in the Vancouver forest region where foliar zinc was less than 9 ppm (Carter *et al.* 1986).

Concentrations of all other elements tested were adequate.

It was decided to explore the possibility of correcting the deficiency symptoms by application of zinc fertiliser.

DIAGNOSTIC FIELD TRIAL

In April 1984, with the aim of achieving an early correction, a field trial was established in an adjacent plot of 10-month-old trees where similar zinc-deficiency symptoms were observed.

The trial design consisted of four replicates of two treatments applied to five-tree-row plots. One plot at random in each replicate received zinc sulphate at a rate of 25 g $ZnSO_4$/tree (equivalent to 5.6 g Zn/tree), spread evenly in a 1-m-diameter circle around the tree. The remaining plot was not treated with zinc sulphate.

In subsequent years foliage samples were collected from current season's growth (Will 1985), bulked by treatment, and analysed according to the methods described by Nicholson (1984) for nitrogen, phosphorus, and zinc.

Two yeaars after fertiliser application the trees were measured for height and root collar diameter. Tree heights and diameters were subjected to analysis of variance as a simple randomised complete block design.

RESULTS

Foliar Nutrient Response

When sampled in the late summer in the 2 years after fertiliser application, control rows had a zinc concentration that was still very low while treated rows had concentrations above the suggested critical level and within the national range (Table 1).

All trees were in a deficient state for phosphorus with less than 0.14% P dry weight (Will 1985). Nitrogen was adequate.

TABLE 1—Foliar analysis results in the 2 years after zinc application

Date sampled	Treatment	Nitrogen (%)	Phosporus (%)	Zinc (ppm)
Feb '85	−Zn	1.511	0.087	8
	+Zn	1.639	0.093	25
Feb '86	−Zn	1.464	0.075	9
	+Zn	1.584	0.072	24

Tree Growth Response

When the trial was inspected 14 months after fertiliser application tree vigour had increased in the treated plots. Leader growth had re-commenced and the rosetting had diminished.

After 2 years the zinc-treated trees averaged 2.57 m in height and 0.078 m in diameter, and were larger than the untreated trees at 2.12 m and 0.071 m. Diameter differences were significant at $p = 0.02$, tree height differences were significant at $p = 0.06$.

DISCUSSION

The foliar nutrient response is similar to the rise in foliar zinc levels after the application of a 2.5% by weight zinc solution to *P. radiata* in Western Australia (McGrath 1978). Growth responses in the Cape Karikari trial may well have been more marked if additional phosphorus had been applied to overcome the phosphorus deficiency that occurred. Ruiter (1969) has, however, pointed out that zinc deficiency can be induced by application of an NP fertiliser (such as DAP) at time of planting, but the early phosphorus deficiency in our trial suggests that zinc deficiency was not fertiliser-induced at this site.

Further occurrences of zinc deficiency in New Zealand plantations have recently been identified (Hunter & Skinner 1986). Although occurrences have been infrequent to date they should not necessarily be seen as insignificant or site specific. There is a generally high level of multi-leadering in *P. radiata* plantations in North Auckland which could be due to temporary slight zinc deficiency. Managers of forests on North Auckland podsol soils need to be aware of the symptoms, particularly in drought periods, to enable early detection and rectification.

It should be noted that the severe deficiency exhibited in this plantation was detected at the end of a period when rainfall was below the 30-year rainfall normal (1479 mm/year) (Table 2). We believe that the onset and severity of this zinc deficiency may be related to moisture stress. Carter *et al.* (1986) also concluded that the periodic appearance of acute deficiencies was influenced by inadequate soil moisture. If this is so, then the onset and severity of zinc deficiency symptoms may be similar to boron deficiency symptoms which are closely associated with moisture stress (Will 1985). The higher rainfall after the establishment of the trial may have been partly responsible for the higher zinc concentrations in the untreated trees compared with the concentrations encountered in the initial diagnostic area.

TABLE 2—Rainfall recorded at Kaitaia airport

Dec-Jan-Feb mean (mm)						
	1979–80	1980–81	1981–82	1982–83	1983–84	1984–85
	76	50	54	35	112	341
Annual as percentage of 30-year normal						
	1980	1981	1982	1983	1984	1985
	106	103	6	74	82	105

Source: N.Z. Met. Serv. (1979, 1980, 1981, 1982, 1983, 1984, 1985)

CONCLUSION

A foliar zinc concentration of 10 ppm was confirmed as the critical level below which visual deficiency symptoms can occur and growth reduction may be expected. In young trees the deficiency can be corrected by applying 25 g $ZnSO_4$/tree.

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REFERENCES

CARTER, R. E.; SCAGEL, A. M.; KLINKA, K. 1986: Nutritional aspects of distorted growth in immature forest stands of southwestern coastal British Columbia. **Canadian Journal of Forest Research 16(1):** 36–41.

HUNTER, I. R.; NICHOLSON, G.; THORN, A. J. 1985: Chemical analysis of pine litter: An alternative to foliage analysis? **New Zealand Journal of Forestry Science 15:** 101–10.

HUNTER, I. R.; SKINNER, M. F. 1986: Establishing radiata pine on the North Auckland podsols. **New Zealand Forestry 31(3):** 17–23.

KNIGHT, P. J. 1976: Zinc deficiency in nursery-grown **Pinus radiata** seedlings. **New Zealand Journal of Forestry Science 5:** 260–4.

McGRATH, J. F. 1978: Phosphate and zinc nutrition of young **Pinus radiata** D. Don in the Donnybrook Sunkland. **Forests Department of Western Australia Research Paper 34:** 1–8.

NICHOLSON, G. 1984: Methods of soil, plant, and water analysis. **New Zealand Forest Service, FRI Bulletin No. 70.**

N.Z. MET. SERV. 1979: Meteorological observations for 1979. **New Zealand Meteorological Service Miscellaneous Publication 109.**

——— 1980: Meteorological observations for 1980. **New Zealand Meteorological Service Miscellaneous Publication 109.**

——— 1981: Meteorological observations for 1981. **New Zealand Meteorological Service Miscellaneous Publication 109.**

——— 1982: Meteorological observations for 1982. **New Zealand Meteorological Service Miscellaneous Publication 109.**

——— 1983: Meteorological observations for 1983. **New Zealand Meteorological Service Miscellaneous Publication 109.**

——— 1984: Meteorological observations for 1984. **New Zealand Meteorological Service Miscellaneous Publication 109.**

——— 1985: Meteorological observations for 1985. **New Zealand Meteorological Service Miscellaneous Publication 109.**

N.Z. SOIL BUREAU 1954: General survey of the soils of the North Island, New Zealand. **Soil Bureau Bulletin No. 5.**

RUITER, J. H. 1969: Suspected copper deficiency in radiata pine. **Plant & Soil 31(1):** 197–200.

WILL, G. M. 1985: Nutrient deficiencies and fertiliser use in New Zealand exotic forests. **New Zealand Forest Service, FRI Bulletin No. 97.**