ZINC DEFICIENCY IN NURSERY-GROWN *PINUS RADIATA* SEEDLINGS

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ABSTRACT

A disorder which affected the 1973/74 **Pinus radiata** seedling crop locally in several areas of Sweetwater Forest Service Nursery, was found to be associated with abnormally low foliar zinc concentrations (< 6 ppm).

The visual symptoms generally corresponded closely to those described in the literature for pine seedlings raised in zinc-free solution culture.

Affected seedlings responded positively to foliar application of dilute zinc sulphate solution within 7-8 weeks of treatment, while control plants showed no improvement.

As several of the beds affected by the disorder were clearly divided along their length into 'good' and 'poor' halves, it is possible that the deficiency was induced by locally excessive fertilizer deposition during bed preparation.

INTRODUCTION

Sweetwater Nursery, located in the North Auckland peninsula, was established in 1967 on 29.5 ha of strongly acid, deep sandy peat soil (McKinnon and Nicholson, 1974).

An earlier, distinctive disorder which affected the crop in some parts of the nursery was found to result from copper deficiency (Knight, 1975). After this disorder had been successfully corrected by application of cuprous oxide, it became obvious that a few remaining small patches of stunted seedlings located in several nursery blocks would not respond to this treatment, and were subject to a different disorder.

Visual Symptoms

As the symptoms displayed ranged widely in degree of severity, it is convenient, for descriptive purposes, to distinguish three main grades:

mild Some bronzing of foliage evident—rather more noticeable on the primary foliage of the apical tuft. Height growth somewhat depressed.

moderate Bronzing of foliage more pronounced. Yellowing does occur in some plants but is relatively uncommon. Viewed *en masse,* however, the seedlings are yellowish in colour. Limited and rather irregular necrosis occurs on the tips of both primary and secondary needles. Instead of the more usual loose, open apical tuft of soft green primary foliage characteristic of healthy plants, the apical region commonly consists of a rosette of closely-packed, stunted, pale yellowish-green primary needles. In many plants these needles remain tightly grouped in retarded bud formations. Growth is moderately to severely stunted.

severe Complete necrosis of the apical region is common (see Figure 1). This can extend downwards, frequently resulting in death of the seedling. Necrosis of foliage is more pronounced, but is still irregular. Lateral shoots arising from the lower stem may be similarly, but less, necrotic. Yellowing of foliage is often pronounced. Seedlings remain stunted.

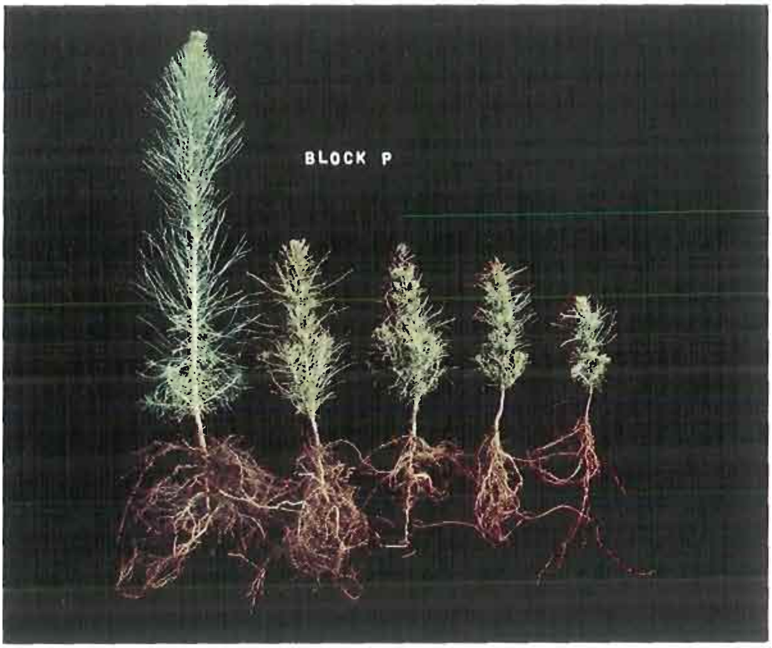

FIG. 1—View of 10-month-old seedlings from bed containing both healthy (left) and severely affected seedlings (H. Hemming)

Distinct partitioning of several affected nursery beds into relatively good and poor halves, especially in 1/0 crop areas, strongly suggested that the condition was induced by some mechanised treatment—possibly uneven fertilizer deposition such as could result from overlapping of fertilizer swathes during basal dressing application. Nursery records of fertilizer applications show that the blocks in which the problem areas were located had received a relatively heavy basal application of agricultural lime (2.2-4.4 tonne/ha) and diammonium phosphate (18-20-0) (250 kg/ha) during bed preparation. Additionally maintenance sidedressings of a granulated NPK fertilizer (elemental rating 15-7-12) during cropping had amounted to 440 kg/ha for the 1/0 crop, and 310 kg/ha for the $1\frac{1}{2}$/0 crop.

Visual Diagnosis

The range of symptoms displayed by the affected seedlings were generally quite different from those reported previously for seedlings affected by copper deficiency in this nursery. The symptoms did however correspond closely to those described by Smith and Bayliss (1942), and Smith (1943) for zinc-deficient radiata pine seedlings in solution culture. Early field experiments conducted in Australia by Kessell and Stoate (1936, 1938) had already shown that certain distinctive disorders of planted pines referred to as "rosetting" and "dieback", could be corrected by spraying affected trees with dilute aqueous solutions of zinc chloride or sulphate. A full account of the effects of zinc deficiency on planted *Pinus radiata* and *P. pinaster* in certain areas of Western and South Australia, together with details of treatment which has been found successful, was subsequently given by Stoate (1950).

In this investigation, analysis confirmed abnormally low zinc concentrations in the foliage of affected seedlings, and nursery trials demonstrated that the disorder could be corrected by zinc sulphate. These results show zinc deficiency in radiata pine occurring in a previously unreported situation.

METHODS

(a) *Preliminary Assessment of Nutrient Status*

In March 1974, composite samples of the entire shoots of 5-month-old seedlings (1/0 crop) and 13-month-old seedlings ($1\frac{1}{2}$/0 crop) respectively, were collected from adjacent affected and healthy nursery areas and analysed for a wide range of essential nutrient elements.

(b) *Nursery Trials with Zinc Sulphate*

As a sequel to the earlier visual diagnosis and analytical findings, trials were established in the nursery in May-June 1974 to test the response of affected seedlings to zinc sulphate. Trial plots were laid out in the three nursery blocks—blocks 0 and P with 7-month-old seedlings of the 1/0 crop, and block T with 15-month-old seedlings of the $1\frac{1}{2}$/0 crop.

Each trial area consisted of a series of replicated treatment and control plots. Treatment plots in the block 0 and T trials received a foliar application of 1% w/v aqueous solution of fertilizer-grade zinc sulphate on 15 May 1974. Sufficient of the solution was applied by watering can to thoroughly wet the seedling foliage. The treatment plots in the block P trial were watered with a 0.6% w/v solution of the same zinc salt on 21 June 1974.

On 5 August, 1974 composite samples of soils and seedlings respectively were collected from selected trial bed areas for chemical analysis. The samples were taken from adjacent 'good' and 'poor' areas for comparison purposes.

(c) *Chemical Analyses*

The methods used for analysing the plant and peat samples for total nutrient elements were as outlined previously (Knight, 1975). Exchangeable cations and pH were determined in peat samples by the method described by Blakemore *et al. (1972)*. "Available" phosphate was determined by the Bray No. 2 method (Bray and Kurtz, 1945) as modified by Hanley (1965).

Acid-extractable Zinc: Finely ground (*c.* 70-mesh), oven-dried peat was shaken with 0.1N HCl (20 ml) on a wrist-action shaker for 5 minutes. The suspension was filtered through a double acid-washed filter paper and the filtrate retained for zinc analysis by atomic absorption spectrophotometry.

RESULTS AND DISCUSSION

Analyses of composite samples of entire seedling tops taken from adjacent affected and healthy nursery areas are given in Table 1. These show that the affected seedlings had higher N and P levels, but lower zinc levels than normal seedlings.

TABLE 1—Elemental analyses of composite entire shoot samples of seedlings sampled in March 1974

Sample description	N	P	K	Mg	Ca	B	Cu	Mn	Zn
			%				ppm		
Block O; 5-month-old 1/0 crop:									
Healthy seedlings	2.06	0.21	1.09	0.16	0.23	38	14	178	20
Stunted seedlings	3.49	0.46	0.69	0.25	0.36	47	35	153	2
Block T: 13-month-old 1½/0 crop:									
Healthy seedlings	1.58	0.11	0.66	0.16	0.25	32	4	189	9
Stunted seedlings	1.75	0.13	0.55	0.24	0.34	33	12	280	2

In the nursery trials, the first obvious response to zinc sulphate treatment was noted 8 weeks after application, in the earlier-established series. Whereas the condition of the affected control seedlings remained virtually unaltered, the treated seedlings had begun to show a distinct improvement with fresh green growth appearing throughout the treated plots. A similar improvement in the zinc-treated seedlings in the block P trial was evident within at least 7 weeks of application. The improvement in both was maintained up until the time the trial was terminated in early September.

Seedling samples taken from trial areas in August 1974, i.e., about a month after response to zinc had become evident, were analysed for the same nutrient elements as earlier in the season. As before, levels of all nutrients examined, other than zinc in the affected control seedlings, were consistent with adequate supply. The stems and roots of healthy plants from the 'good' half of affected beds contained appreciably lower N and P concentrations than those of stunted plants, consistent with the deficiency being induced by nutrient imbalance. However the soil tests, possibly because they were collected late in the season, failed to show differences in soil chemical properties which would account for either the difference in plant size or foliar zinc concentration.

In Table 2 the zinc concentrations in the 1/0 seedling components are shown in relation to seedling appearance, height and dry weight. The foliar values for untreated, stunted seedlings are abnormally low and fall within the deficient range (1-5 ppm) given by Leaf (1973). The corresponding value for nearby untreated seedlings of normal appearance is at the lower end of the range (15-125 ppm) which Stone (1968) suggests is normal for many non-accumulating tree species.

TABLE 2—Zinc concentrations in components of seedlings of 1/0 crop collected from trial areas in August 1974

Seedling category	No. in composite sample	Mean Ht cm	Mean Wt g	Zinc concentration (ppm) needles	stems	basal whorl branches	roots
A	15	16.3	4.3	4	18	*	15
B	8	21.0	6.8	5	15	7	16
C	10	17.8	6.0	50	39	41	50
D	12	44.6	14.2	15	18	12	16

* Branches were absent
A Symptoms of disorder severe
B Symptoms of disorder moderately severe
C Formerly as A, recovering after foliar application of 1% w/v zinc sulphate solution in mid-May
D Untreated seedlings of normal appearance

The stunted and the normal control plants had very similar zinc concentrations in their respective stems and roots. As the zinc concentration in the stems of affected plants was 3-4 times greater than in the foliage, it seems that foliar analysis affords a rather more sensitive indication of seedling zinc status than entire shoot analysis.

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