RADIATA MANAGEMENT TECHNICAL NOTE

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Boron does not Reduce Malformation in Two High Country Douglas-fir Stands

Summary

Douglas-fir is a preferred timber species for South Island high country sites. Young stands often show a high incidence of leader tip dieback, leader break and stem distortion. These symptoms are indicative of boron deficiency, but may also be caused by frosting or wind damage. Boron fertiliser trials were installed in two young high country stands in the Rakaia Valley and Mackenzie Basin to determine if development of stem malformation could be prevented by applying boron. Tree growth and form were measured up to four years after fertiliser application. Stem malformation was high at both sites, but it was reduced by boron application only at the lower elevation Rakaia Valley site. At that site, only the highest boron application rate prevented malformation, but it also greatly reduced tree growth. At the Mackenzie Basin site, increased bud death in the third year after boron application followed the occurrence of late spring frosts, while high leader break appeared to be associated with high wind run. The results indicate that stem malformation was due to extreme weather rather than to boron deficiency. When compared with a previous study, these results suggest Douglas-fir is more sensitive to boron toxicity than *Pinus radiata*, and boron application rates to young Douglas-fir should not exceed 4 kg/ha. Foliar boron concentrations of Douglas-fir in unfertilised plots were 20 mg/kg and 12 mg/kg at the Rakaia Valley and Mackenzie Basin sites respectively. As there was no positive response to boron fertiliser, except at rates that reduced tree growth, it is suggested that the minimum foliar boron concentration for satisfactory growth for Douglas-fir be set at 12 mg/kg, the same as for *Pinus radiata*, instead of the currently recommended 15 mg/kg.

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Introduction

Douglas-fir is commonly planted in South Island higher elevation high country environments where annual precipitation exceeds about 800 mm. On favourable sites, Douglas-fir grows well compared to other species and is often considered the best species because of its tolerance to wind, snow and low winter temperatures. However, young Douglas-fir plantations in these environments often show a high incidence of leader tip dieback or breakage and stem and branch distortion (Fig 1). The symptoms are similar to those of boron deficiency. Boron deficiency occurs in pines on a range of soils in the South Island, particularly on free-draining coarse textured soils in low rainfall areas.

Because of the widespread occurrence of deformity in high country Douglas-fir, a study of the effect of boron on Douglas-fir growth and form was undertaken. Two trials were established in locations where nearby plantings exhibited typical stem deformity symptoms. Boron fertiliser was applied at a range of rates to allow determination of optimum rates should boron deficiency be confirmed. The results of the effect of boron on the early growth, form and foliar boron concentrations of Douglas-fir in the two trials are presented here.

Fig 1. Malformation in Douglas-fir at Lake Hill, Rakaia catchment

Methods

The trials were installed in two existing one- and two-year-old stands of Douglas-fir in the central South Island. One site was at Lake Hill near the southern end of Lake Coleridge in the Rakaia Valley, and the other at Balmoral Station to the east of Lake Pukaki in the Mackenzie Basin. Both trials were located on well drained silt loam Tekapo soils formed in loess on moraine surfaces. The Balmoral site (870 m) is at a

higher elevation than the Lake Hill site (570 m) and has a cooler and windier climate. Mean annual rainfall over the trial period was similar at the two sites (ca 880 mm).

Five rates of boron (0, 4, 8, 16, 32 kgB/ha) fertiliser (as ulexite), were applied to replicated 20 x 20-m plots at Lake Hill. At Balmoral the highest rate was omitted. Tree heights and ground level diameters were measured after the fertiliser treatments were applied in spring, and annually thereafter up to age five. Assessments of tree form were made in March (autumn) of the second, third and fourth years after fertiliser application. Sinuosity was assessed by measurement of stem displacement, and tree form and leader dieback were scored.

Observations during the trial indicated substantial between-year variation in leader bud death and leader breakage that may have been associated with wind or frosting during the spring period of active shoot extension. Daily minimum air temperature data were obtained for both sites from points interpolated on a 5-km grid based on daily weather station data. The occasions when air temperatures fell below 0^{o}C in the months of November and December were recorded, as new growth at this time of year can be damaged by freezing temperatures. For the Balmoral site only, daily wind run data were obtained from the nearby Tekapo airfield (760 m asl).

Results

Boron application did not significantly (P>0.05) improve tree growth, and higher rates (8 kg/ha or more) significantly (P<0.05) reduced stem diameter, height and volume.

At both sites, trees exhibited a high degree of malformation and symptoms which appeared to match boron deficiency, including sinuous stems, leader bud death and leader stem break. With one exception the symptoms were more pronounced at Balmoral than at Lake Hill, consistent with lower foliar boron concentrations in the unfertilised treatment at Balmoral (12 mg/kg compared to 20 mg/kg at Lake Hill). However, stem malformation was not reduced by boron application at Balmoral and reduced at Lake Hill only at an application rate sufficient to severely stunt tree growth, showing that stem malformation was not caused by boron deficiency at either site. The key contributors to malformation, as defined in this study (stem forking or multi-leadering), include leader bud death and stem break, neither of which was reduced by boron application at Balmoral. At Lake Hill, leader break was reduced by boron, but again only at the highest rate, which was sufficient to greatly reduce tree growth. Neither of the malformation conditions appeared to be attributable to boron deficiency.

The occurrence of sinuous stems, leader bud death, leader break and consequent high degree of malformation evident in the trials is more likely to be due to wind and frost damage than to boron deficiency. New Zealand montane environments are characterised by high wind speeds, snow and frosts that can occur in any month of the year. The incidence of these phenomena increases with elevation. Malformation symptoms were more common at Balmoral, consistent with its higher elevation than Lake Hill. Greater leader break in all boron treatments at Balmoral occurred in year three (when 39% of all stems had broken leaders) than year four (12%). This was consistent with the greater number of days of extreme wind run (more than 500 km/day) recorded at Balmoral over the November–February period in year three (40 days) than year four (24 days). Similarly, high leader bud death in year three at Balmoral (19% of all leader buds dead compared 4% or less in years two and four) coincided with the occurrence of three events in mid to late November of year three when air temperatures were -2 ^{o}C or lower. Freezing temperatures at this time of year when plants are flushing can kill buds and soft foliage.

In the present study, where growth and malformation were measured over a three-year period, no tree form response to boron was obtained except where boron rates were sufficient to stunt tree growth. The boron concentration of 12 ppm in mature current year foliage sampled in autumn, as found in unfertilised plots at Balmoral, appeared adequate for optimum growth and form of Douglas-fir. This concentration is also considered satisfactory for radiata pine in New Zealand. The minimum foliar boron concentration for satisfactory growth for Douglas-fir should be set at 12 mg/kg, instead of the current value of 15 mg/kg.

While boron is an essential nutrient, it can be toxic to plants if its supply is excessive as was the case at the higher application rates in the present trials. Douglas-fir growth was reduced at both Lake Hill and Balmoral at an application rate of 8 kg B/ha. In a study of boron response in radiata pine, Olykan *et al.* (2008) [1] used the same fertiliser (ulexite) and application rates as the present study, and found growth reductions at both of their study sites. Although the growth reductions tended to be at

higher boron application rates (16 and 32 kg B/ha), for some measures in some treatments reductions were also observed at a rate of 8 kg/ha. High boron fertiliser rates reduced stem volume growth by more than 50% in Douglas-fir in the present study, but either had no significant effect or reduced volume growth by 14-18% in radiata pine (Olykan *et al*. [1]), suggesting that Douglas-fir is more sensitive to boron toxicity. While Olykan *et al.* (2008) [1] concluded that application of 8 kg B/ha as ulexite was safe for *P. radiata*, the present study indicates that this rate is likely to reduce growth of young Douglas-fir, and that a rate of 4 kg/ha is more appropriate.

Reference

1. Olykan, S. T., Xue, J., Clinton, P. W., Skinner, M. F., Graham, D. J., & Leckie, A. C. (2008). Effect of boron fertiliser, weed control and genotype on foliar nutrients and tree growth of juvenile Pinus radiata at two contrasting sites in New Zealand. *Forest Ecology and Management, 255*, 1196-1209.