Response of Thinned, Immature Lodgepole Pine to Nitrogen Fertilization: 6-Year Growth Response

INTRODUCTION

Extensive forest nutrition research conducted during the past decade has clearly demonstrated that inadequate nutrition is a characteristic common to many interior forests. Nitrogen deficiencies are sufficiently widespread and serious that they have dominated nutrient management concerns. To address this problem, numerous fertilization trials have been established since 1981 to evaluate the effectiveness of nitrogen fertilization in stimulating growth of interior British Columbia forests (Brockley 1991).

One of these studies, begun in 1981, documented the growth response of thinned lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) to nitrogen fertilization. For the study, 11 research installations were established in pure, 18- to 25-year-old stands of fire-origin lodgepole pine located throughout the interior of British Columbia.

The following operational guidelines were recommended, based on the 6-year results of the study.

RECOMMENDATIONS

1. Results indicated that nitrogen-induced sulphur deficiencies may restrict growth response on some sites following nitrogen fertilization. It is recommended that sulphur be added with nitrogen in operational fertilization programs where pre-fertilization foliar sulphate-sulphur levels are below 80 ppm. Lodgepole pine growing on Luvisolic soils within the northern portion of the Interior Plateau may be especially vulnerable to fertilizer-induced sulphur deficiencies.

2. Inadequate boron nutrition, although less common, can also have an adverse effect on lodgepole pine health and vigour in the Interior. Even a single die-back episode leaves persistent stem defects which make the economic consequences of boron deficiency far greater than just volume losses. Stands with marginal boron status (i.e., < 12 ppm) may be susceptible to fertilizer-induced boron deficiency. The addition of a small amount of boron with nitrogen would be a wise "insurance policy" in these high risk stands.

3. Improved palatability and nutritive quality significantly increased the susceptibility of fertilized lodgepole pine to feeding attack by red squirrels, partially negating the beneficial effects of nitrogen additions. The best method for preventing or minimizing red squirrel feeding injuries to crop trees is to confine fertilizer operations to stands having a low hazard rating (see Sullivan 1990). Since the probability of girdling declines with increased stem diameter, fertilization of high risk stands should be delayed at least until crop trees are large enough to withstand damage wounds. Squirrel damage in operationally fertilized stands should be monitored over time. The use of sunflower seeds during the May–June damage period is a technique presently being investigated to protect the fertilizer investment.

4. Comparison of installations thinned at the time of fertilization (Type 1) to installations thinned at least 2 years before fertilization (Type 2) indicates that Type 1 installations are generally more responsive to fertilization. When thinning and fertilization are undertaken simultaneously, the added nutrients appear to combine more effectively with the improved light conditions and room for crown expansion, and this accelerates the recovery from thinning. Unfortunately, data also indicate that these stands are more susceptible than Type 2 stands to red squirrel feeding injuries and snowpress damage.

Given this information, it is recommended that fertilization be delayed for at least 1 year after thinning in stands where pre-thinning density exceeds 10,000 stems per hectare. This "adjustment period" reduces the risk of snowpress and allows the potential for red squirrel damage to be evaluated more fully before fertilization investment decisions are made.

METHODS

The trials were located on circumboreal sites within various subzones of the Sub-Boreal Spruce (SBS) and Montane Spruce (MS) Biogeoclimatic zones (Meidinger and Pojar 1991). Seral, fire-origin stands of lodgepole pine are especially widespread and abundant in these two zones.

Each installation consists of nine circular treatment plots 0.06–0.09 ha in size, depending on the post-thinning density prescribed for the site. Three different post-thinning densities were selected for the study (1100, 1600 and 2100 stems per hectare) to reflect the operational range of lodgepole pine juvenile spacing prescriptions in the Interior. All nine plots within an installation were thinned to the same density. One of three nitrogen application rates (0, 100 and 200 kg N/ha as urea 46-0-0) was randomly assigned to three of the plots.
Mensurational data were collected from subplots of 50 sample trees in the centre of the treated plots. Installations were of two types: 1) those thinned at the time of fertilization (Type 1); and 2) those operationally thinned 2–4 years before fertilization (Type 2). With one exception, the two installation types were established adjacent to each other at each study location so that any effects caused by timing of fertilization could be observed in relation to thinning.

DISCUSSION

Nitrogen fertilization was found to increase growth on both an individual-tree and land-area basis. For application rates of 100 and 200 kg N/ha, individual-tree volume gains averaged 25% (range 11–48%) and 32% (range 7–53%), respectively, over the 6-year response period. On a stand volume basis, the favourable effects of fertilization were partially negated in some installations by treatment-related damage and mortality caused by red squirrel feeding injuries, snow press, and induced nutrient deficiencies during the experimental period. In the absence of damage, nitrogen fertilization improved net volume growth by as much as 15 m³/ha over the 6-year period.

Only small differences appeared in mean growth response between application rates of 100 and 200 kg N/ha. In most installations, the differences were not statistically significant. This is consistent with nitrogen dosage effects reported for other lodgepole pine and jack pine research trials. In this study, the occurrence of red squirrel feeding injuries, snow press, and top die-back were positively related to nitrogen application rate, with greater damage occurring in stands fertilized at the higher rate. When damaged installations were omitted, differences in growth response between 100 and 200 kg N/ha become more apparent, particularly in the 3- to 6-year response period.

Results from this study indicate that the response of lodgepole pine to nitrogen fertilization is variable. This variability can be attributed partially to treatment-related damage as mentioned above, but other stand and site factors are undoubtedly also involved. Research data indicate that sulphur deficiencies, either induced or aggravated by nitrogen fertilization, may limit growth response on some sites. Inadequate sulphur nutrition has been implicated as a factor limiting the response of nitrogen-fertilized trees in other research studies in the interior of British Columbia (Brockley and Swift 1990; Yole et al. 1991). Further characterization of sites that are responsive or unresponsive to sulphur additions is needed to allow more accurate diagnosis of sulphur deficiencies.

Reliable predictors of fertilization response are needed so that forest managers can identify which stands have the greatest growth response potential, and isolate site and stand variables that are largely responsible for fertilization growth response—or lack of it. Additional response information from a wider range of sites and stand conditions is required so that interim recommendations can be modified and site-specific guidelines developed for operational fertilization in the interior of British Columbia.

LITERATURE CITED


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