WHY FALL FERTILIZE

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ABSTRACT

A 3x3 factorial experiment comprising 3 levels of N (0, 60, and 120 pounds NH_4NO_3) and 3 levels of P (0, 90, and 180 pounds of Triple Superphosphate) fertilizer applied in October was undertaken to determine if fall nursery fertilization would increase physiological quality of 2-0 Douglas-fir. Vigor and growth potential were assessed in terms of percent bud break, frost hardiness, bud height and root growth rate. Increasing amounts of N caused increases in all four variables. P addition increased root growth rate but decreased or had no effect on the other three variables. Fall application of 60-120 pounds per acre of NH NO can be used in nurseries to increase vigor of Douglas-fir seedlings.

INTRODUCTION

Foresters and nurserymen are both certain they can identify a "superior" seedling. What do they look for? Criteria differ but all include some of the following: height, root collar diameter, root size and shape, needle length and color, and bud size. A good quality seedling must score high in many of these areas. However, even when morphological characteristics are good, a given lot of seedlings may survive much better than another with similar appearance. This demonstrates a difference in physiological vigor that may not be visually apparent but is important to field survival.

The concept of inducing physiological vigor is not new to nursery production. For years we have been limiting water and nutrients during late summer to promote bud formation and onset of dormancy. Results show that such treatments definitely increase survival. It is logical that after dormancy is insured in the fall, the re-introduction of higher levels of water and fertilizer would enhance such energy requiring processes as frost hardening, bud formation and root growth.

Workers who have attempted to show the advantages of fall fertilization have had mixed results. Anderson and Gessel (1966) found that 50 pounds/acre of N applied as 250 pounds $(NH_4)_2SO_4$ increased both survival and growth of 2-0 Douglas-fir seedlings. On the other hand, Gilmore et al. (1959) found no difference in survival of loblolly and slash pine which received up to 400 pounds of N/acre applied in the nursery in late October. Application of N to Sitka spruce transplants in early September advanced budbreak and increased growth after outplanting, but had no effect on growth in the nursery (Benzian et al. 1974). A possible explanation of the variability of these results may be traced to the dependence these studies had on field conditions to discriminate between vigor levels in their seedlings.

The following experiment was undertaken to examine the effect of all nursery fertilization with N and P on four laboratory easures of vigor and growth potential.

Methods and Materials

Two-year-old Douglas-fir seedlings from Seed Zone 252 were fertilized on October 29, 1981 with either 0, 60, or 120 pounds of N1i$_4$NO and 0, 90, and 180 pounds of Triple superphosphate arranged factorially in a randomized block design with 3 blocks. Fertilizer was spread by hand over 20 ft. sections of nursery bed.

Previous to such treatments, all seedlings had received 50 pounds of N during the first growing season and 140 pounds of N during the second growing season with the last 30 pounds applied on July 15. Water was withheld after August 1 in the second growing season unless pre-dawn PMS readings exceeded -10 bars.

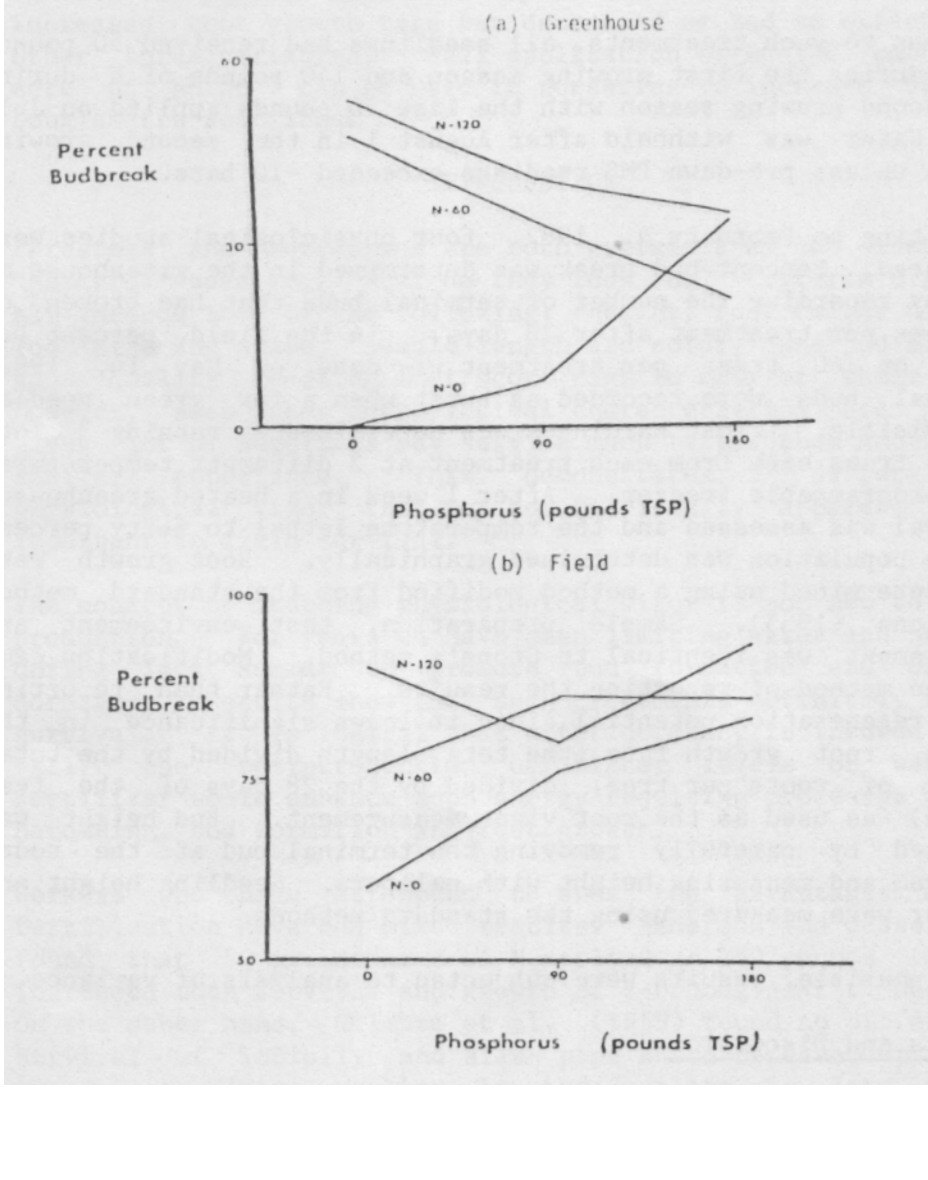
At lifting on February 4, 1982, four physiological studies were initiated. Percent bud break was determined in the greenhouse at 20°C by recording the number of terminal buds that had broken on 15 trees per treatment after 28 days. In the field, percent bud break on 60 trees per treatment was done on May 14, 1982. Terminal buds were recorded as burst when a few green needles were visible. Frost hardiness was determined by running 3 lots of 15 trees each from each treatment at 3 different temperatures in a programmable freezer. After 1 week in a heated greenhouse, survival was assessed and the temperature lethal to fifty percent of the population was determined graphically. Root growth rate was determined using a method modified from the standard method of Stone (1955). Sample preparation, test environment and measurement was identical to Stone's method. Modification came in the method of reporting the results. Rather than reporting root regeneration potential since it loses significance in the spring, root growth rate (the total length divided by the total number of roots per tree, divided by the 28 days of the test period) was used as the root vigor measurement. Bud height was measured by carefully removing the terminal bud at the nodal diaphram and measuring height with calipers. Seedling height and caliper were measured using the standard methods.

Where possible, results were subjected to analysis of variance.

Results and Discussion

Measurements of vigor and growth potential did differ significantly between the various treatments although no significant difference in height or caliper was found. Bud break in the field and in the greenhouse (Figure 1) varied in a similar way with N treatment. Although the number of measurements in the greenhouse was too few to allow statistical analysis, the effect of N and P in the field were significant at the p = .05 and p = .1 levels respectively. No significant interaction (N*P) was found. Seedlings not given nitrogen were significantly slower to break bud than those that received N.

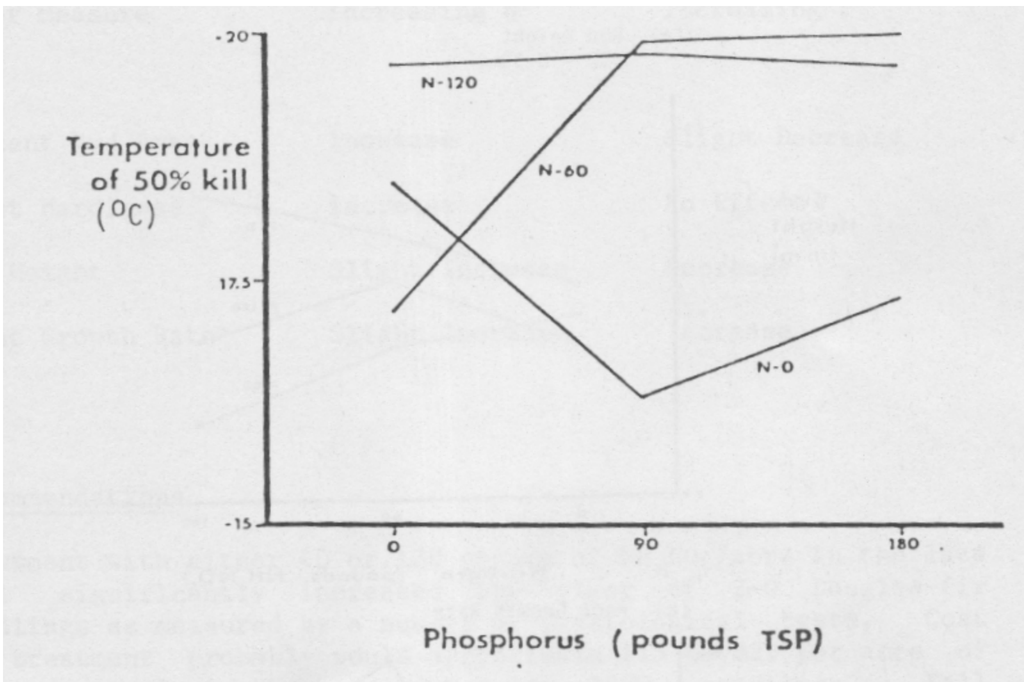
Figure 1. Percent budbreak after 28 days in the greenhouse (a) and on May 14 in the field (b). Phosphorus is given in pounds of triple superphosphate. Each line represents changes in budbreak of treatments having the same application of NH_4 N0 3 (N = 0, N = 60, N = 120) as it varied with changing TSP levels. All points area mean of 15 trees in the greenhouse and 60 trees in the field.



The earlier bud break effected by fall fertilization with nitrogen may aid seeling growth and survival. In the Northwest, where summer droughts often curtail growth in the latter part of the growing season, early growth and bud set permit seedlings to withstand drought (Heiner and Lavender 1972).

In the present experiment, addition of N increased frost hardiness, while P had little effect (Figure 2). In a year of high stress or on a poor site, N addition in the nursery should increase survival.

Figure 2. Frost hardiness. Each line represents changes in frost hardiness of the treatments having the same application of NH4 NO_3 (N = 0, N = 60, N = 120) as it varied with changing TSP levels.

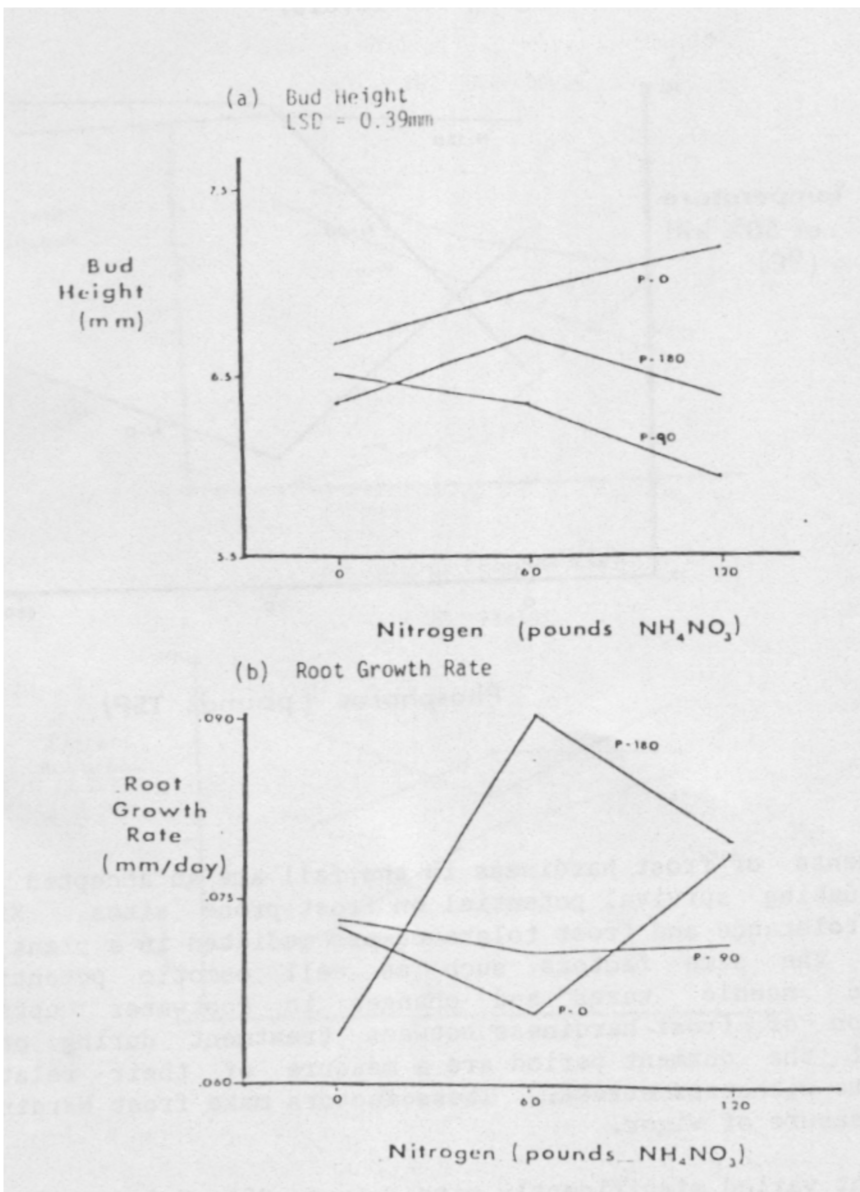


Measurements of frost hardiness in the fall are an accepted way of evaluating survival potential on frost prone sites. Since drought tolerance and frost tolerance are mediated in a plant by many of the same factors such as cell osmotic potential, increased needle waxes and changes in rootwater uptake, comparison of frost hardiness between treatment during other times of the dormant period are a measure of their relative ability to withstand stress. These factors make frost hardiness a good measure of vigor.

Bud height varied significantly with P (p = .05), N (p = .10) and N*P (p = .10). In general, P decreased bud height while N in the absence of P increased it. Strong interactions occurred when both N and P were added (Figure 3).

Although not statistically significant, high P in the presence of N seemed to produce the best root growth rate (Figure 3).

Figure 3. Average bud height of 25 trees from each treatment. (b) Growth rate of 8 trees from each treatment during 28 days in a test environment. Each line represents changes in the measured variable in treatments having the same TSP level (P = 0, P = 90 or P = 180) as it varied with changing N levels.



Both root growth and shoot growth are important to survival in the field. Root growth in the spring can best be measured by root growth rate during the 28 day test period (Thompson and Timmis 1978). Bud height is related to the number of needle primordia present in the bud and as such is a good measure of shoot growth potential.

In summary, the inescapable *conclusion* is that N fertilization in the fall increases seedling vigor.

able 1. Summary Table of Figures 1-3.
Effect of *increasing* N *or increasing P on various vigor* measures.

Vigor Measure	Increasing N	Increasing P
Percent Bud Break	Increase	Slight Decrease
Frost Hardiness	Increase	No Effect
Bud Height	Slight Increase	Decrease
Frost Growth Rate	Slight Increase	Increase

Recommendations

Treatment with either 60 or 120 pounds of NH_4NO_3/acre in the late fall significantly increased the vigor of 2-0 Douglas-fir seedlings as measured by a number of physiological tests. Cost of treatment probably would approximate $15 to $25 per acre of nursery or less than 2 cents per 1000 seedlings. Fall fertilization with N seems justifiable when potential advantages of enhanced survival are considered.

Although the results of the N addition are conclusive, many further questions must be addressed before the optimum timing, N source and rate can be determined. For present, application in mid-October of 60-120 pounds N}14N03 has been shown effective. Early application, say mid-September, may be more beneficial but before more research is done, the risk of second flushing is too great to permit such a recommendation.

Phosphorus addition in the fall seems of doubtful utility. Van den Driessche (1980) and Armson and Sadreika (1974) have reported that addition of P has variable effects depending on the P availability in the soil. The soil used in this study has a relatively high P value in soil analysis but does not have sufficient P available to the plant. Additional P may, therefore, have more effect in this soil than in a soil where sufficient P is available. The form of P fertilizer was probably not the best. A more soluble form such as $(NH_4)_2PO_4$ will be used in further studies.

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