LONG-TERM GROWTH RESPONSE OF DOUGLAS FIR TO WEED CONTROL

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ABSTRACT

Survival and growth of young Douglas fir (**Pseudotsuga menziesii** (Mirb.) Franco) transplants in the warm, dry-summer climate of Oregon are heavily influenced by competition from grasses and other herbaceous weeds. The ephemeral increase in available soil moisture resulting from weed control reduced tree moisture stress in the summer. This not only resulted in immediately increased growth, but also had significant or highly significant positive effects on tree growth for several years following, hastening the onset of exponential growth and thus shortening crop rotation.

INTRODUCTION

A sequence of annual herbicide treatments can be applied to young forest trees to ensure their survival and rapid early growth where grasses and other herbaceous weeds compete for site resources. In a warm, low summer rainfall climate, the primary effect of weed control is to conserve soil moisture and reduce tree moisture stress. Preest (1975) showed that there was a strong positive correlation between available soil moisture and weed control and a strong negative correlation between tree moisture stress and available soil moisture. High moisture stress is known to affect photosynthesis and tree growth adversely (Zavitkovski and Ferrell, 1970; Cleary, 1970).

A stem analysis was made of trees growing in herbicide trial plots in an old field in the Oregon Coast Range, USA. The objects were to determine the effects and decide the merits of different sequences of annual herbicide treatments. A factorial experiment and multifactor analysis of variance was used for this purpose.

EXPERIMENTAL METHOD

The basic experimental units consisted of 16 rectangular main plots each 40.5 m^2. Selective chemical weed control was used on half of these during the spring and summer of 1968. The following year each plot was split north-south and the western half subjected to weed control. In 1970 the plots were again split, this time east-west, and the northern half of each was subjected to weed control. Thus by the end of the summer of 1970 each plot had been divided into four sub-plots or quadrants, designated NE, NW, SE, and SW, which among them had received eight different herbicide treatment sequences.

The chemical weed control treatments were regarded as factors designated A, B,

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and C respectively, each having two levels, 1 and 0, corresponding to the presence or absence of the factor.

In the winter of 1972/73 the trees on each quadrant were cut 7.5 cm above ground-level and stem analysis was used to determine the height (h) each year since planting and the stem diameter inside bark (d) each year since 1969. These measurements were used to calculate current average annual height increment (h_i-h_{i-1}) and current average annual diameter increment (d_i-d_{i-1}), relative stem volume ($v_i = d_i^2 h_i$) and current average annual relative volume increment (v_i-v_{i-1}). At cutting, the individual quadrants contained up to eight trees. The main plot, half plot, and quadrant means constituted the basic data for the statistical analyses .

RESULTS AND DISCUSSION

Though weed control in 1968 did not significantly increase height growth in 1968, it did cause significant ($p < 0.05$) or highly significant ($p < 0.01$) increases in each of the following 3 years. The failure to produce significant differences in height growth in 1968 may have been due to one or more of the following:

(1) Summer 1968 was abnormally wet;

(2) Douglas fir height growth takes place mainly in the early summer before soil moisture levels become critical;

(3) Height growth is largely dependent on reserves accumulated the year before. Thus the main impact of high moisture stress and reduced net photosynthesis is unlikely to be expressed until the year following;

(4) Newly-planted trees are unable to take maximum advantage of improved soil-moisture conditions, especially early in the summer when height growth occurs, because their root systems are poorly established.

In contrast, the effects on height growth after the 1969 and 1970 weed control treatments were significant or highly significant, both in the year of herbicide application and in succeeding years. The reasons for this more immediate response could be:

(1) The normal dry summers of 1969 and 1970;

(2) The better-established trees were able to take advantage of the improvement in soil moisture availability afforded by weed control.

(3) Established trees with adequate reserves are able to utilise any extra moisture available to produce late-season lammas (second "flush") growth.

Although the effect of A_1 on 1968 and 1969 diameter and volume growth was unknown, it was evident from the analyses that it had a strong positive influence on diameter and, especially, on volume growth during 1970, 1971, and 1972. Likewise, the effects of B and C on diameter and volume increment continued long after the moisture conservation effect due to weed control had passed.

There were few significant interactions. This suggested that the treatment responses were largely additive. However, the maximisation of the response to C_1 was conditional on the prior occurrence of both A_1 and B_1 though this interaction was statistically significant only in the 1970 diameter response.

Since the cumulative growth responses to a single first- or second-year treatment (A_1 or B_1) were similar and superior to the third-year treatment (C_1) response, the added survival value of A_1 would make it first choice where only a single treatment can be given. Likewise, the first treatment in a two-treatment schedule would logically be A_1, with B_1 as the choice for second treatment because of some value it may have in enhancing second-year tree survival.

The net effect of the various treatments was to foreshorten the lower portion or establishment-lag phase of the growth trajectories by varying amounts. The trees entered the steep phase of the exponential growth curve sooner, subsequent growth behaviour corresponding to that of trees planted earlier (Fig. 1). A rotation shortening of up to 2 years could be expected of the A_1 B_1C_1 schedule.

The continuing effect of treatment on tree growth must be due to some shift

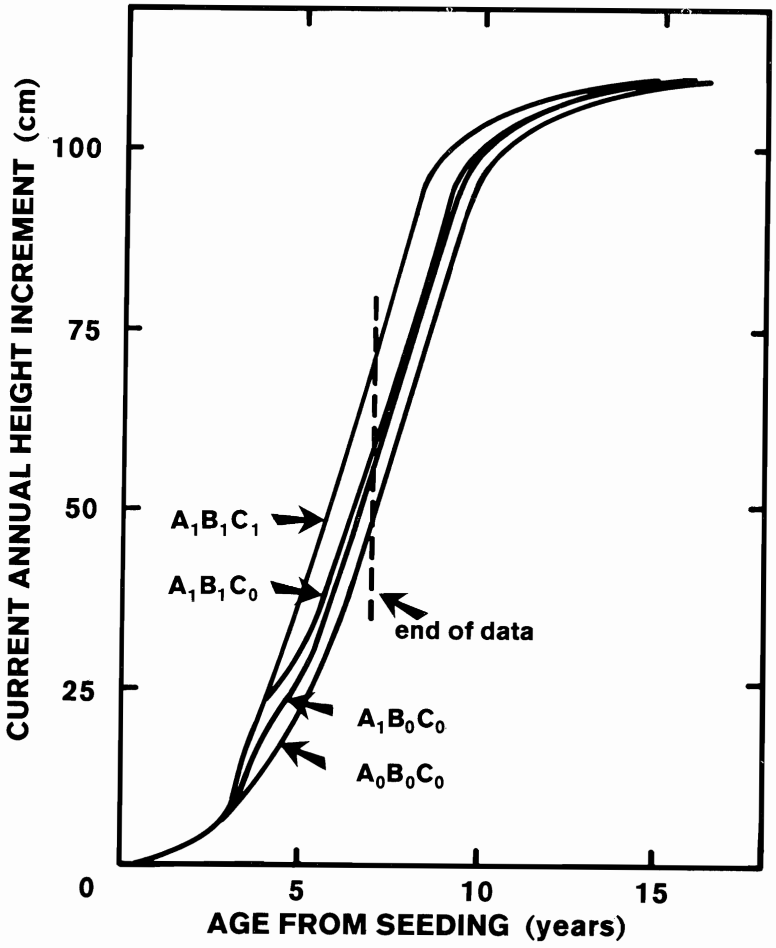

FIG. 1—Projected early height increment trajectories of trees benefiting from weed control in the first year, in the first and second year, in all three years, and no weed control at all.
Note added in proof: Steep sections of $A_1B_1C_0$ and $A_1B_0C^0$ traces should **not** touch; increment difference is maintained.

in the growth potential of the trees themselves, induced by the transitory amelioration of growing conditions afforded by weed control. It points to the fact that better-established trees with greater reserves are able to more effectively commandeer the soil moisture and nutrient capital of the site in future years so that the initial advantage conferred by weed control is compounded.

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