EFFECTS OF SOME PLANT GROWTH SUBSTANCES ON ROOT GROWTH OF DOUGLAS-FIR SEEDLINGS

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Climate and soil factors, condition of seedlings, degree of competition, or any of a host of other variables may cause unacceptably poor survival of trees in forest plantations. Thus the possibility of planting failure often deters forestation attempts. In fiscal 1965, about 1,320,000 acres (Anonymous 1966) were planted to forest trees in the United States. It is estimated that 80 percent of these acres will support acceptable stands. However, many Western States have very acute survival problems. For example, during a 5-year period, 12 million forest seedlings were planted in California (Stone 1955). Less than half survived. The survival of many plantings in Idaho is less than 10 percent after a single growing season (Loewenstein and Pitkin 1961).

Seedlings that succumb during the first year or two very often have been supported by root systems failing to develop appreciably after outplanting. If it were possible to induce early and vigorous root growth in planting stock, survival might be improved. The use of synthetic growth substances to regulate seedling development (Audus 1959, Koslowski 1962, and Osborn 1960) may be economically feasible. Such substances have already proved beneficial in various facets of forestry and allied fields (Snow 1959), and still further uses are likely to be found. These substances are now used routinely as selective herbicides for stimulating vegetative propagation, preventing fruit drop, fruit thinning, producing parthenocarpic fruit, flowering control, and in many other ways.

This investigation examined the influence of several auxin-like growth substances on Douglas-fir *(Pseudotsuga menziesii Franco).* The compounds were applied to seedlings grown in the greenhouse, effects on root development being the primary concern.

Experimental Precedures

Two year-old Douglas-fir seedlings obtained from the Clarke-McNary Nursery at the University of Idaho were used in a series of three greenhouse experiments. These dormant plants were carefully graded for uniformity of size and quality, and all long roots were initially pruned to 6 inches. The seedlings were removed from cold storage before treatment and randomly divided into groups of 20 for the first experiment and into groups of 16 for the other two.

Treatment solutions were made by dissolving a particular powdered growth substance in ethanol and diluting it with distilled water to the desired concentration. Growth substances were applied by root soaking. The roots of groups of seedlings were immersed in a particular solution for 2 hours in the first experiment, 10 hours in the second, and 12 hours in the third. These root-soak periods were representative of intervals used in previous work. Control seedlings were soaked in distilled water containing ethanol only. Root soaking was performed inside the greenhouse, and the seedlings were planted in sand immediately after treatment.

The first experiment continued for 83 days; the second, 102 days; and the third, 81 days. At the conclusion of each experiment seedlings were lifted, roots washed, and the following measurements taken:

Length of root system.-Root systems were measured to the nearest 1 / 10 inch, from root crown to the longest root tip; this indicated the depth of root penetration. The roots were not stretched out but measured in a configuration similar to the natural growing position.

Length of longest roots.-The average growth in inches of the three longest new roots on each seedling was recorded. This measurement might better indicate the differences in stimulation or

inhibition of root elongation rather than the measurement of the entire root system.

Density of new roots.-The apparent number of actively growing new roots was determined visually. Systems were judged either sparse, medium, or dense.

After concluding these examinations, the seedling tops were removed at the root crown. Roots were placed in paper towels to air-dry before the following two analyses were performed:

Air-dry weight.-The entire root system of each seedling was air-dried to equilibrium and weighed on an analytical balance to the nearest milligram.

Titration value.-The procedure used, detailed by Wilde and Voigt (1955), is believed to give the relative absorptive capacity of the root system. The method is summarized as follows: The air-dry roots are submerged in 3 N HCI for 15 seconds after which the excess acid is drained for 15 minutes. The root system then is soaked in 250 I. of distilled water for 10 minutes. Finally, a 10 ml. aliquot from the 250 ml. container is titrated with 0.3 *N* NaOH. The more base required in this titration, the higher the absorptive capacity is presumed to be.

Data from each of the three experiments (with the exception of density observations) were subjected to an analysis of variance. Where significance was indicated, the source was delimited by Duncan's Multiple Range Test (Li 1957).

Results and Discussion

The influence of added growth substances on length of root systems was generally negative. For example, exposure of roots to a solution of 100 p.p.m. of NAA (Naphthalene acetic acid) in the first experiment produced plants with average root system lengths of 7.65 inches, compared with 9.80 inches for untreated specimens. This reduction was statistically significant. Another statistically significant reduction occurred in the third experiment, in which both 2,4-D (2,4-dichlorophenoxyacetic acid) and P-CPA (p-chlorophenoxyacetic acid) at 100 p.p.m. concentration were inhibitory. In this experiment, some significant stimulation of root growth was observed. Whereas average root length of control seedlings was 9.00 inches, the roots of plants treated with a 25 p.p.m. solution of O-CPA (o-chlorophenoxyacetic acid) averaged 10.62 inches, an 18 percent increase.

In experiments I and 3, the average length of the three longest new roots of each seedling was calculated. This could not be measured in experiment 2 because the long growing period (102 days) made it difficult to locate the point of origin of many new roots. Results were much the same when average lengths of root systems were compared. Root soaks with NAA at 100 p.p.m., 2,4-D at 100 p.p.m., and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) at 100 p.p.m. reduced significantly root elongation. O-CPA at 25 p.p.m. apparently stimulated growth of new roots, but not significantly. Although the total length of the root system was not affected by IAA (Indole-3-acetic acid) at 10 or 50 p.p.m., the average length of the three longest new roots was significantly reduced by these treatments.

While significance was not shown, the data indicate that in each of the experiments *seedlings from several treatments had root systems that outweighed those of control plants.* For example, in the second experiment, roots of controls averaged 790 mg., but plants that had been treated with solutions containing 25 p.p.m. of IBA (3-indolebutyric acid) had root systems that averaged 1,005 mg. when air-dried. Seedling-root-weights also averaged considerably more than when controls were treated with NAA at 10 p.p.m., NAM (a-naphthalene acetamide) at 1 p.p.m., O-CPA at 25 p.p.m., and P-CPA at 25 p.p.m. On the other hand, certain growth substances restricted weight gains, as illustrated by the treatment of P-CPA at 100 p.p.m. where seedling-root-weight averaged 355 mg. compared with 597 mg. for untreated stock.

No statistically significant differences were found in absorptive capacity, as expressed by the titration value. However, the figures do suggest that the absorptive capacity was being influenced by treatment. For example, use of 100 p.p.m. 2, 4-D reduced the titration value to almost half that of the control. In contrast, for seedling roots soaked in a 0.0001 solution of Kinetin, the titration value was 50 percent higher than that found for untreated specimens.

In the first experiment, seedlings treated with NAA at 100 p.p.m. produced not only short root sys-

tems, but also the systems were much less dense than the control. No other treatment in this or the second experiment caused an apparent effect on the density of root systems. In the third experiment, root system density was greatly reduced by 2,4-D, 2,4,5-T, and P-CPA at 100 p.p.m.

Many mycorrhizallike short roots were formed under the influence of NAA at 100 p.p.m. However, such appendages seem to be useless to seedlings, as the fungal associate found in the natural mycorrhizal relationship is absent. ,

Initiation of new lateral roots was promoted by several treatments. The most notable stimulation occurred in the treatments using NAA. Some increase in lateral root initiation was also seen in seedlings treated with solutions of IAA at 100 p.p.m., 2,4-D at 25 and 100 p.p.m., and 2,4,5-T at 100 p.p.m. These laterals appeared on the stem near the root crown and also on existing roots. Numerous new laterals were initiated but did not elongate.

Although total root length was measured, it was not possible to ascertain the rate of root elongation during the experimental period. This may be of considerable importance. For example, a particular growth substance might not influence the total length of the root system produced by the end of a given period. The influence might be reflected in more immediate root elongation than would occur in controls. Use of such a substance in field plantings might permit the roots to quickly evade drought developing in surface soil, thus enhancing survival. This factor is now being examined.

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