GROWTH OF DOUGLAS-FIR SEEDLING IN CALIFORNIA NURSERY VARY LITTLE UNDER FOUR FERTILIZER REGIMES

R. 0. STROTHMANN and 1. HENRY DOLL 1

Producing good quality nursery stock at the lowest possible cost is a continuing goal in plantation work. In the spring of 1965, the California Regional Office and the Six Rivers National Forest set up a fertilizer test at the Humboldt Nursery in north-coastal California. The species studied was Douglas-fir *(Pseudotsuga menziesii var. menziesii)* , normally shipped by the nursery to the field as 2-0 stock. The test aimed at developing a satisfactory once-per-crop, or once-per-year fertilization program by using slowly soluble fertilizers in granular form rather than the highly soluble fertilizers currently used. The stock then being produced had generally shown good survival and growth after field planting.

Site Conditions

The Humboldt Nursery has been in production only since 1962. Originally, the area was forested with a mixture of redwood, Sitka spruce, grand fir, western redcedar, and alder. The timber of commercial value was logged about 50 years ago, and the land was later used as stump pasture, with intermittent use as a log-decking area. When the land was acquired for nursery use, much of it had a heavy sod cover. One crop of Douglas-fir seedlings was raised before plots for the fertilizer test were established. The soil is a sandy loam.

In the summer of 1964, in the test plot area, 1,800 lbs. per acre of dolomite had been applied to remedy deficiencies indicated by earlier soil tests. Just before the fertilizer study was set up, a second soil test in March 1965 revealed that the soil was still low in most essential elements (phosphorus, potassium, calcium, magnesium, and the ammonium form of nitrogen) . Only nitrate nitrogen was present at medium-to-high levels. Soil pH ranged from about 5.2 to 5.8.

Study Layout and Treatments

The test formally included only three treatments: A, B, and C. But we compared them with the nursery's regular fertilizer program (treatment D) by applying it to an adjacent seedbed, sown at the same time as the others and with seed from the same seed lot. Treatments A, B, and C were replicated four times in a systematic pattern in three adjacent seedbeds. Individual plots were 4 feet wide and 100 feet long. Treatment D was applied to the full length of the 400-foot seedbed, just south of the others.

The four fertilizer treatments tested were as follows:

A. Application of 850 lbs. per acre of a granular, concentrated fertilizer mix (24-24-8) in which 60percent of the contained nitrogen is derived from nonleaching urea-formaldehyde, the balance in readily available ammonic form. On a per-acre basis, this treatment supplied 204 lbs. of nitrogen, 204 lbs. of available P_2O_5 and 68 lbs. of K_2O. (In elemental form, this application is equivalent to 204 lbs. of nitrogen, 90 lbs. of phosphorus, and 56 lbs. of potassium) The treatment represents a complete 2-year fertilizer program in a single application. The fertilizer is spread evenly over the seedbed surface before seeding and is then rototilled about 5 inches into the bed.

B. Application of the same 24-24-8 mixture used in A, but at the rate of 600 lbs. per acre. In the spring of the second year, 200 lbs. per acre of urea-formaldehyde granules were added as a topdressing on the seedbeds to provide extra nitrogen. This two-step treatment provided a total of 220 lbs. of nitrogen, 144 lbs. of $P_2O_5$and 48 lbs. of K_2O per acre (or, in elemental form, 220 lbs. of nitrogen, 64 lbs. of phosphorus, and 40 lbs. of potassium) .

C. No fertilizer (control treatment) .

D. Application of the nursery's regular fertilizers, using readily soluble forms of ammonium nitrate and diammonium phosphate. In 1965 the ammonium nitrate was applied in June, followel by application of diammonium phosphate in July.

1 Respectively, Research Forester, Pacific Southwest Forest and Range Experiment Station, stationed at Arcata, Calif., in cooperation with Humboldt State College, and Nursery Supt., Humboldt Nursery, Six Rivers National Forest, Nfc-Kinleyville, Calif.

In 1966 the sequence was reversed, the diammonium phosphate being applied in May, and, the ammonium nitrate in June. The program supplies about 154 lbs. of nitrogen and 53 lbs. of elemental phosphorus per acre during the 2-year period; no potassium is included.

In normal practice these highly soluble fertilizers are applied through the nursery's irrigation system, which uses rotary-type sprinklers. In this. study, however, they were applied in solution by tractor and tank, because keeping the spray off the other test beds would have been impossible if the irrigation sprinklers had been used.

All test beds were fumigated with methyl bromide and chloropicrin in late August 1964 and allowed to lie fallow over winter to permit toxic residues to escape. In April 1965, the plots to receive treatments A and B were fertilized. About 6 weeks later, late May 1965, all plots were seeded. Treatment B plots were given the final fertilization (the surface application of the urea-formaldehyde) in May 1966.

All plots received the nursery's normal weeding and watering, as well as the routine application of insecticides and fungicides. In addition, seedlings on all plots were root-pruned with a tractormounted subsurface blade in early fall of 1966. Fall root-pruning can be done at this nursery because there is no danger of frost-heaving. It permits the cut ends to heal over before lifting time, and the roots are then in good condition for winter planting.

Seedling Removal

In mid-December 1966, we removed 20 randomly selected seedlings from each of the four replications of treatments A, B, and C, and from each of four subsections of treatment D (the regular fertilizer program). Thus, 80 sample seedlings were obtained from each of the four fertilizer treatments. The samples were taken from the inner six rows of each seedbed, the outer rows being excluded because fertilizer distribution might be more variable along the edges of the bed.

The roots of the sample seedlings were washed to remove all loose soil, and the following data were then recorded for each seedling: a. Height (root collar to tip of terminal bud), b. stem diameter (just above root collar), c. fresh weight of roots, d. fresh weight of tops, e. total fresh weight, and f. top/root ratio (fresh weight basis).

Results and Discussion

For each of the first five measurements listed, treatment D produced, by a small margin, the largest and heaviest seedlings (table 1). In the sixth category (top/root ratio) there was virtually no difference between the seedlings in treatments A, C,

TABLE 1.—*Measurements of Douglas-fir seedlings grown under four nursery fertilizer programs* [1]

Measurements	Treatments[2]							
	A		B		C		D	
	Av.	*Range*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Height _____ft.	1.06	0.61- 1.85	1.10	0.71- 1.73	1.03	0.60- 1.71	1.12	0.57- 1.86
Stem dia. _____mm.	4.9	3-8	5.0	3-9	4.7	3-8	5.1	3-8
Weight:								
Root _____gr.	4.2	1.1 -13.1	4.7	1.3 -18.5	4.1	1.5 -13.7	5.1	1.4 -14.0
Top _____gr.	9.7	2.0 -29.7	11.5	4.4 -40.8	9.6	3.0 -36.0	11.9	3.5 -32.9
Total _____gr.	13.9	3.6 -41.4	16.2	5.7 -59.3	13.7	5.0 -46.9	17.0	5.2 -41.0
Top/root _____ratio	2.39	0.84- 4.41	2.57	1.16- 4.32	2.35	1.19- 4.64	2.36	1.04- 5.54

[1] Each average and range is based on 80 seedlings.

[2] A = Fertilized before seeding with slow-release 24-24-8 @ 850 lbs./acre. Elemental dosages (lbs./acre): N=204, P=90, K=56.

B = Fertilized before seeding with slow-release 24-24-8 @ 600 lbs./acre. Second year, 200 lbs./acre of urea-formaldehyde (38-0-0) added. Total elemental dosages (lbs./acre): N=220, P=64, K=40.

C = No fertilizer.

D = Fertilized after seeding with readily soluble ammonium nitrate and diammonium phosphate applied once each year (nursery's regular program). Total elemental dosages (lbs./acre) for 2 years: N=154, P=53, K=0.

and D-all had a desirably low ratio. The slightly higher ratio for treatment B, though still quite acceptable, may have been caused by the second-year nitrogen booster applied.

Because of limitations in the experimental layout, an analysis of variance is not appropriate. The large within-treatment variation as compared with the between-treatment variation, however, suggests that treatments may have had no significant influence on seedling development. In any event, the differences, even if real, are probably of no great practical importance.

The relatively good growth of the unfertilized seedlings is possibly explained by the soil in this new nursery not yet being improverished by repeated cropping. Nutrients are undobutedly still available from the gradual decomposition of the large supply of prenursery organic matter. And some nutrients may have carried over from fertilization of the first crop of seedlings.

In this study, the several fertilizer treatments were evaluated solely on the basis of height, stem diameter, and fresh weight. If other characteristics had been measured or examined-for example, needle length or tissue nutrient content-the fertilizer treatments might have ranked differently. Because of lack of important differences in the major physical characteristics, however, such additional measurements did not seem warranted.

The apparent superiority of the nursery's regular fertilization program is not great in terms of the size and weight of the seedlings produced, but it has a cost advantage over the treatments using the granular-type, slow-release fertilizers. Such fertilizers must first be spread-either by hand or tractor -on the seedbed area, and then rototilled into the soil. This method is inevitably more costly than the nursery's current technique of applying highly soluble fertilizers through the irrigation system.

Wilde (2) has pointed out another important advantage of using fertilizers in liquid form, namely, that plants can absorb nutrients through their foliage as well as through their roots, thereby promoting more efficient use of nutrients. Sander (1) , working with lodgepole pine, found that 400 to 560 lbs. per acre of nitrogen in the form of urea-formaldehyde was needed to equal the effectiveness of 100 lbs. of soluble urea nitrogen applied as a liquid top-dressing in two 50-lb. doses during the second growing season.

Conclusions

The results of the present study suggest that the granular slow-release fertilizers, in quantities used, do not produce larger, heavier, or better balanced 2-0 Douglas-fir seedlings than those being produced by applying readily soluble fertilizers twice a year through the irrigation system.

Literature Cited

1. Sander, D. H.
   1966. Effect of urea and urea-formaldehyde on the growth of lodgepolc pine seedlings in a nursery. Tree Planters' Notes 79: 18-23.
2. Wilde, S. A.
   1960. Liquid fertilizer treatments of nursery soils their advantages and shortcomings. Tree Planters' Notes 42: 11; 12.