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Effects of Fertilization on Shoot Growth of Defoliated and Undefoliated Red Oak Seedlings

by Johnson Parker

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Abstract

Fertilization of red oak (*Quercus rubra* L.) seedlings increased their terminal shoot growth. Dry, liquid, and liquid + dry fertilizer was applied to groups of undefoliated, once-defoliated, and twice-defoliated seedlings. Terminal shoot growth was measured after the first and second growing season and compared to that of a similar group of unfertilized seedlings. On the average, defoliated seedlings treated with dry or liquid + dry fertilizer grew more than unfertilized, undefoliated seedlings. The foliage color of twice-defoliated seedlings was not influenced by fertilization, but a difference in leaf color between unfertilized and some of the fertilized seedlings was observed. The liquid + dry fertilizer stimulated growth more than the other fertilization treatments.

THE PROBLEM

USUALLY NOTHING is done to enhance vigor and growth of forest trees that have been severely defoliated by insects. However, dry or liquid fertilizer could be applied to the soil in the hope that it would stimulate vigor in coming years. The effects of fertilizer on the recovery of defoliated trees are unknown, but a previous study (Parker and Patton 1975) indicated that fertilization of defoliated seedlings had no effect on recovery other than to produce darker green leaves and decrease carbohydrate levels. In that study, growth was not specifically measured, and only a liquid fertilizer was used.

The present study was designed to test the effects on terminal shoot growth of red oak (*Quercus rubra* L.) seedlings of 10/10/10 fertilizer, a nutrient solution, and the two together in factorial combination with various defoliation treatments.

METHODS AND MATERIALS

Ninety-six seedlings of red oak that were grown for 2 years from seed in 24-cm diameter, 24-cm high pots were divided into 12 groups of eight seedlings, with one seedling per pot. The planting medium was prepared by mixing equal amounts of sand and loam soil of low fertility obtained from a forest site. The sand-loam mixture had a pH of 5, and N, P, and K concentrations that were moderately deficient according to a standard soil test. The experiment was conducted in a greenhouse that was maintained at a temperature of about 28 C. Seedlings were moved outside during winter.

Of the 96 seedlings, 32 were undefoliated; 32 received one defoliation treatment on 30 April 1976; and 32 received defoliation treatments on 30 April and 28 May 1976.

Eight seedlings in each group received no fertilizer, and eight in each group received each of the three fertilizer treatments.

The 10/10/10 fertilizer contained 1,500 mg N, 650 mg P, and 1,250 mg K per 15 g. This quantity was based on the amount successfully used for trees in the field (Neely et al. 1970). The nutrient solution (Hoagland 1920) contained 420 mg N, 62 mg P, and 465 mg K per liter, plus additional amounts of essential elements.

The dry fertilization treatments were made in one application on 30 April 1976 by adding 15 g of the 10/10/10 to four 10-cm deep holes in each pot. The nutrient solution was applied on 30 April and again on 28 May 1976 at the rate of 1 liter per pot. Before the nutrient solution was added, the pots were allowed to dry out for 2 days to assure maximum uptake of the solution. Only a minor portion of liquid passed through the pots.

In the fall of 1976, the terminal growth of the seedlings' leaders and laterals was measured. This growth included three flushes in the twice-defoliated seedlings, two in the once-defoliated, and one or two in the undefoliated. Lengths of all new shoots were measured again in late May 1977 following the spring flush for that year.

RESULTS

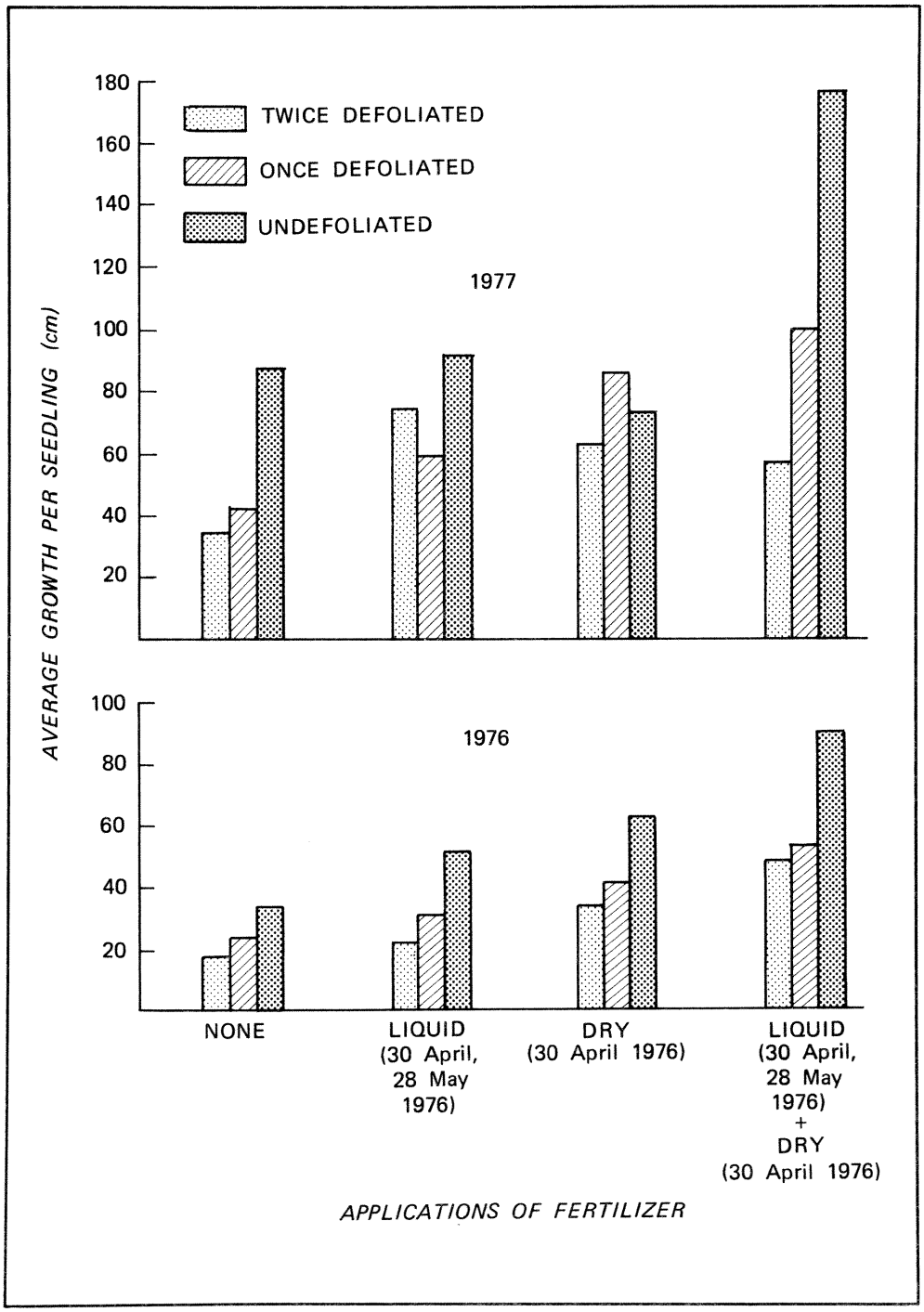
In the first growing season—1976—there were definite differences in growth among treatments (Fig. 1, bottom). An analysis of variance showed that differences were significant among fertilizer treatments and defoliations, but not among their interactions at the 5 percent probability level. In each treatment category and the control, growth was greatest in the undefoliated seedlings and least in those twice defoliated. With fertilizer added, growth increased in once- and twice-defoliated seedlings more than in the control seedlings. The addition of nutrient solution to defoliated seedlings improved growth; growth increased even more by the use of dry fertilizer alone, and was further improved by the application of liquid + dry fertilizer.

Of special interest is that once- or twice-defoliated seedlings grew faster than control seedlings when they were treated with dry or liquid + dry fertilizer. Although statistical comparisons of any two treatment combinations (represented by bars in Fig. 1, bottom) showed no significance at the 5 percent level, the addition of liquid + dry fertilizer increased growth about half again as much in twice-defoliated seedlings as in control seedlings.

During the winter of 1976-1977, mice girdled and killed many seedlings. The growth patterns of the surviving seedlings are shown in Figure 1, top. Growth by late May 1977 followed much the same pattern as in the previous season, although it was much more irregular. On the average, the once-defoliated, although not the twice-defoliated seedlings that were treated with liquid + dry fertilizer grew more than the control seedlings (Fig. 1, top).

We observed foliage color in late June 1976, when there seemed to be real differences among treatment of twice-defoliated seedlings. New

Figure 1.—Average seedling shoot growth for 1976 (bottom) and 1977 (top) by defoliation and fertilization treatments. Bars in the 1976 groups represent an average of eight seedlings; in 1977, the number of seedlings varies. Analysis of variance showed significant differences (5 percent level) among defoliations and among fertilizer treatments, but not among interactions. Statistical comparisons of any two individual treatment combinations (bars in figure) showed no significance at the 5 percent level.



leaves were lighter green than those of undefoliated or once-defoliated seedlings regardless of fertilizer treatment. New leaves of fertilized, undefoliated and once-defoliated seedlings tended to be darker green than those of unfertilized seedlings.

DISCUSSION

This experiment indicates that fertilizers can improve growth and vigor of defoliated seedlings over those of unfertilized, undefoliated seedlings. The greater effectiveness of the dry fertilizer was probably because it contained more of N, P, and K than the nutrient solution. The increased growth following each of the fertilizer treatments was probably the result of N and perhaps P in combination with N, judging by the results of tests by Phares (1971) and Auchmoody (1972).

Whether these results can be extrapolated to forests that contain large trees with extensive root systems and to soils with varying nutrient and moisture levels is questionable. Under those conditions, growth response to fertilization might be entirely different from the results observed here. Nevertheless, from my studies (unpublished) of forest soils in southern New England, it has been my impression that most of the soils were very low in N, P, and K, and that forest trees should respond well to fertilizers.

In this experiment, the effects of fertilization evidently persisted into the second year, although the results were more erratic. This irregularity is perhaps because fertilizers were being used up and the ill effects of defoliation were being overcome by storage of new photosynthates. It also reflects the reduction in the number of seedlings.

Mortality of shoots during the first and second seasons was very low. Two defoliations increased shoot mortality, but fertilizer treatments had no consistent effect on its increase or decrease. Shoot mortality was so irregular among treatments that few clear conclusions could be drawn. Therefore, results have not been presented.

The next logical step in this research would be to test some commercial fertilizers in forests and compare the growth of defoliated and undefoliated trees. Shigo (1973) however, warns that fertilizers—at least when used in excess—may increase forest trees' susceptibility to insect infestations and fungus disease. In general, however, fertilizers should enhance tree vigor and help prevent increase in susceptibility.

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