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Variability of Rooting in a Small Second-Generation Population of the Hybrid Pinus Attenuradiata[1]

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Propagation of conifers by rooting of cuttings is an old art that has recently benefited by the findings of the plant physiologist. The forest tree breeder may now use rooting as a tool in his efforts to evaluate the heredity of his trees. In a study undertaken to use vegetative propagation of members of a variable hybrid population as a guide for selecting superior individuals, the authors found that wide differences occurred in rooting ability among members of the population, and that in general the differences corresponded in two successive years.

Selection among the members of a segregating F_2 hybrid population is a well-known and effective plant-breeding method. Variability of rooting capacity of different members of a segregating population is not so well known. Recently some information on this variability was obtained from a hybrid population of several hundred 3-year-old seedlings, derived from mutual wind pollination among a group of x *Pinus attenuradiata*[2] trees.

During the summer of 1946, 126 of these seedlings were selected for propagation as clones to determine whether the wide variations they exhibited had a genetic basis. They included several types: seedlings of the most vigorous growth and of conspicuously good form as well as a few dwarfs and some individuals showing chlorophyll deficiencies or other abnormalities. Rooting of cuttings was chosen as the most practical method of multiplying the types. One of the parent species and the F_1 hybrid were known to root readily (*4*), and the seedlings of this F_2 population combined the favorable characteristics of youth and considerable size.

On October 1, 1946, 10 to 30 cuttings were taken from each of the 126 seedlings. These cuttings averaged approximately 6 inches in length, but were quite heterogeneous in other respects, because of wide morphological variation among the seedlings, and because individual seedlings offered little opportunity to select numerous cuttings conforming closely to any predetermined standard. The cuttings were immersed for 15 hours in a 100-ppm. aqueous solution of indole-3 butyric acid, dipped in Fermate—a powered disinfectant, and planted at a spacing of 6 by 2 inches in pure sand of medium fineness; the sand was spread 6 inches deep over lead-covered heating cables in propagating benches in an otherwise unheated greenhouse. The beds were thermostatically maintained at 70° F., and moisture was automatically regulated by Grossenbacher's method (*2*). Since the purpose of the work was primarily to establish clones, and only incidentally to test their rooting ability, the group of cuttings were neither replicated nor randomized in planting.

After 90 days, the rooted cuttings were potted in soil and removed to a lath house. Percent of rooted cuttings varied from 0 to 100. This was not surprising, since similar results had been reported by Snow (7) for red maple. In fact, this variability had been anticipated as one of the interesting features of the work.

In November 1947 ten rooted cuttings from each original seedling were outplanted. Comparison of these clonal blocks will be the basis of more intensive selection of good types. Since some seedlings yielded few rooted cuttings, not all 10-plant blocks could be completed. To provide fillers, cuttings were taken on November 1, 1947, from 43 of the seedlings which had furnished cuttings in 1946.

Several factors that might be expected to affect rooting of the cuttings differed from one year to the next. In the first place, the seedlings were one year older. Secondly, they were larger, and thus offered a wider choice of cuttings. Thirdly, the seedlings had received ample irrigation in 1946, but very little in 1947. Fourthly, many of the cuttings taken in 1947 were made from shoots derived from short-shoot growing points, which became active early in 1947 following the severe heading back of the seedlings in

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[2]Stockwell and Righter (*8*) have described x *P. attenuradiata* (the cross *P. attenuata* Lemmon x *P. radiata* D. Don), contrasted it with its parent species, and described some of the features of a small F_2 population similar to the one which furnished material for the present study.

1946. Lastly, the cuttings were taken a month later in 1947 than in 1946.

Perhaps as a result of some or all of these factors, plus the fact that the rooting medium was not changed or cleaned between seasons, the aggregate rooting from all 43 seedlings was lower in 1948 (90 days after planting in propagation benches) than in the preceding year (Table 1).

Since a number of zero values occurred in the rooting data for each year, a simple regression analysis could not be made. Therefore, the seedlings were grouped in five classes determined by their rooting in 1947 (0-20 percent, 21-40 percent, etc.). The means of each class for each year were computed and plotted (Fig. 1). This simple analysis, as refined as the nature of the data warrants, suggests that the differences between seedlings observed in two successive years show sufficient correspondence to support the hypothesis that they are heritable. On the other hand, the numerous wide discrepancies between 1947 and 1948 values evident in Table 1 preclude evaluation of relative rooting ability of single seedlings. To accomplish this, larger samples and more precise technique will be required. Edgerton (*1*), working with the red maple material first studied by Snow (*7*), found that relative rooting ability was fairly comparable in two successive years.

In 1947 and again in 1948 cuttings bearing male catkins rooted readily. This finding appears to contradict Jacobs' (*3*) report that cuttings of *Pinus radiata* bearing male catkin primordia would not root. On the other hand, the great inter-seedling variation in rooting response found in the present study suggests that hereditary differences between Jacobs' and our material way explain this discrepancy. Cuttings from all parts of the seedlings rooted with apparently equal success, with one conspicuous exception. The leafless terminal shoot found on many of the seedlings (shoots of *P. radiata* and its relatives often start elongation in early autumn at Placerville) invariably failed to root, and in-

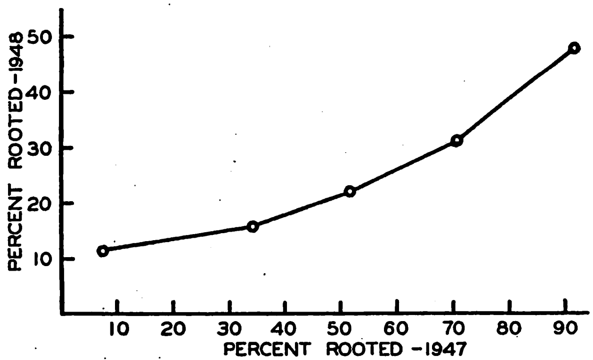

FIG. 1.—Relation of 1948 to 1947 rooting of cuttings taken from 43 seedlings of an F_2 population of x *P. attenuradiata.* Data grouped by 1947 outcome classes.

TABLE 1.—PERCENT ROOTED, AFTER 90 DAYS, OF CUTTINGS TAKEN FROM 43 SEEDLINGS OF A F_2 POPULATION OF X *P.* ATTENURADIATA IN TWO SUCCESSIVE YEARS

Clone No.	1947	1948	Clone No.	1947	1948
2	20	0	59	67	50
7	60	10	61	50	50
9	90	100	65	85	50
12	75	50	85	0	10
21	0	10	69	75	70
25	80	0	70	46	20
26	74	50	71	82	40
33	69	10	72	100	40
36	31	0	74	67	0
37	100	90	77	38	30
40	81	0	80	73	40
41	28	10	83	47	0
42	100	30	97	37	30
44	19	10	103	55	30
47	0	0	107	87	47
48	0	30	109	7	30
53	38	50	111	64	20
54	25	0	113	33	20
55	100	30	114	40	10
56	38	0	116	13	0
			123	40	10
57	63	20			
58	27	10	Average	51.7	25.7

deed died rather promptly. Rooting was often successful, however, if two or three fascicles of needles had started to emerge when such cuttings were made. Terminal cuttings bearing the uppermost whorl of branches rooted promptly and profusely. It appears likely that the effects of position from which cuttings are taken, so frequently discussed in the literature—for example, Snow (*6*), Sherry (*5*), Edgerton (*1*)—become more conspicuous in older plants. Here, too, genetic variability is possibly important.

This study furnishes additional evidence that individual seedlings vary in rooting ability. It shows also that caution should be exercised in predicting rooting of cuttings taken from single seedlings on the basis of a single year's performance. Nevertheless, it appears likely that within certain species and hybrid populations of pines, individuals may be selected which can be readily propagated by cuttings once certain technical problems are worked out. Further, when the rooting behavior of certain "standard" clones becomes thoroughly known, these clones may be used more effectively than the genetically heterogeneous materials heretofore employed, for working out many of the details of rooting technology.

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