PINE DWARF SEGREGATES FROM WITCHES'-BROOMS [1]

by

A. G. Johnson, S. S. Pauley, and W. H. Cromell[2]

The tree nursery is a bridge in a sense between forestry and ornamental horticulture, inasmuch as it has been the source of much of the variation in cultivated trees. Every observant nurseryman is keenly aware of the often vexing variability in plants. Seed source variation in many tree species is abundantly documented, but there is also the individual seedling variation within populations that may occasionally be a significant factor in the production of uniform quality stock. One aim of the forest tree nurseryman is to produce plants approaching a uniform standard of size and quality at a given age. Such uniformity contributes to reduced costs in grading, fewer culled plants, and reduced transplanting costs both in the nursery and in mechanized outplantings.

To the curious and observant operator the occasional variants in the nursery are inviting novelties to be set aside for observation instead of being discarded. Enough of the variants have been detected and propagated in some species, for example, Norway spruce *(Picea abies* Karst), that the problem of classification and description becomes formidable. While many variants are of similar origin, they may vary considerably in phenotype due to the differences existing in total genetic background.

The expression of variation takes many forms. Plant form, foliage color, shape or texture may be affected. Variation in flowering and fruiting characteristics are commonly exploited for human benefit and pleasure. The inheritance of such anomalous characteristics can be simply explained in some cases, while in others it may be extremely complex.

Some preliminary observations on seedlings grown from jack pine *(Pinus banksiana* Lamb.) witches'-brooms indicated that the dwarf character of the parental broom was transmitted to some seedlings. On the basis of this observation and similar reports in the literature on other conifers (Liernur, 1927; von Tubeuf, 1933; Liese, 1933), an investigation of seedlings grown from witches'-brooms in jack pine, eastern white pine *(P. strobus* L.), red pine *(P. resinosa* Ait.) and sand pine *(P. clausa* Sarg.) was undertaken.

Johnson *et al.* (1965) gave evidence that a normal-dwarf ratio of 1:1 characterizes the segregation ratio of plants grown from open pollinated witches'-broom seed of jack pine (table 1).

Because there was no evidence that the five witches'-brooms tested were due to a pathogen, we concluded that the observed segregation was genetically determined. A 1:1 segregation ratio would be consistent with a simple Mendelian dominant gene for dwarfism, if fertilization is accomplished by normal pollen recessive for the dwarfism

Table 1.—*Chi-square tests of goodness of fit to a 1:1 ratio for normal dwarf segregates of open-pollinated jack pine brooms*

Broom no. Year tested Nursery (N) or Greenhouse (GH)	*Survival Percent*	*No. Normal 1-0 sdls.*	*No. Dwarf 1-0 sdls.*	*Chi-square*	*Probability (1 d.f.) Greater than:*
1-1957-N	–	42	48	.400	.50
1-1961-N	–	146	132	.705	.30
1-1962-GH[1]	55	120	98	2.220	.10
2-1962-GH	75	73	77	.107	.70
3-1962-GH	70	81	59	2.457	.05
4-1962-GH	68	68	67	.007	.90
5-1962-GH	57	55	59	.140	.70
1-1962-N[1]	51	240	269	1.652	.15
2-1962-N	54	128	143	.830	.30
3-1962-N	52	125	133	.248	.50
4-1962-N	68	181	158	1.560	.20
5-1962-N	61	136	168	3.368	.05
All tests:	–	1395	1411	.091	.70

[1]. Combined samples of seed from broom No. 1 collected in different years.

factor. This hypothesis was further supported by the absence of male strobili on the brooms studied, resulting in seed pollinated by pollen from surrounding normal trees, or possibly from normal parts of the broom-bearing tree.

In a comparable series of tests with progenies grown from seed produced in witches'-brooms of white pine (table 2) and sand pine (table 3), similar 1:1 ratios were observed.

Similar ratios of seed-transmitted brooming have been observed by Fordham (1966, 1967) in both jack pine and eastern white pine. Duffield and Wheat (1963) reported seed-transmitted dwarfism in Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco).

In all segregating populations, the distinction between normal and dwarfed trees was sufficiently clear to permit classification during the first season of growth. Only eight of the 1411 dwarf jack pine seedlings tallied were actually suppressed normal seedlings, an error of less than 0.6 percent.

Table 2.—*White pine*

Accession No.	*Normal*	*Dwarf*	*Chi-square*	*Probability (1 d.f.) Greater than:*
60161	332	339	.072	.700
63168	136	192	9.560	.001
63169	35	11	12.521	.001
All tests:	503	542	1.416	.200

level). Dwarf progeny height means were analyzed by Duncan's Multiple Range Test. The results are summarized in table 5.

Conspicuous needle-length differences characterized normal and dwarf segregates of the five broom-derived progenies studied. The average needle length of the normal progenies (7.36 cm) was almost twice that of the dwarfs (3.38 cm). Similar differences in needle length characterized the brooms and non-broomed portions of the crowns of parental trees. Analysis of variance of needle length means of the dwarf progenies indicated no statistically significant differences.

There is some evidence of similarity in shape and density

Table 3.—*Sand pine*

Acc. No.	*No. Seeds planted*	*Survival percent*	*Normal sdls.*	*Dwarf sdls.*	*Chi-square*	*Probability (1 d.f.) Greater than:*
63440	200	86.5	91	82	.468	.50
63441	200	82.5	68	92	5.096	.02
63443	200	85.5	81	90	.473	.50
63444	200	76.5	84	69	1.470	.20
63445	180	49.4	45	44	.010	.90
All tests:			369	377	0.081	.70

Aside from the gross differences characterizing dwarf and normal seedlings, there were distinct differences between the progeny of different brooms. These differences, reflected chiefly in the height and crown density of the seedlings, appeared quite uniform within progenies.

With the objective of providing adequate data for an analysis of height growth and other differences among the normal and dwarf segregates of the five broom progenies studied, a five-replicate randomized complete block nursery planting was made at the University of Minnesota's North Central Experiment Station nursery on May 4, 1962. The seed was sown in 4-foot rows at the rate of 50 seeds per row. Each plot consisted of two rows, i.e., 100 seeds; spacing between rows was 12 inches. Survival and segregation counts were made at the end of the first growing season. During the second growing season some normal plants were removed from all plots to provide release for overtopped dwarf plants. Survival in the thinned plots at the end of the first growing season ranged from 51 to 68 percent. Mean heights of dwarf and normal trees were determined for each plot in April, 1964 (table 4).

The magnitude and uniformity of differences in height between dwarf and normal progenies in all replicates is apparent in table 4. Analysis of variance of the five dwarf progenies indicated a highly significant (.01 level) difference in height means. Analysis of the normal progeny height means do not indicate a statistical difference (.05

Table 4.—*Mean height of dwarf (D) and normal (N) 2-0 seedling progenies April, 1964*

Progeny No. dwarf (D) normal (N)	*Replicate 1*	*2*	*3*	*4*	*5*	*Mean*
	Mean height in cm					
1-D	17	17	18	19	19	18.0
1-N	38	44	36	49	46	42.6
2-D	28	29	33	28	34	30.4
2-N	42	48	39	38	42	41.8
3-D	25	23	23	25	30	25.2
3-N	58	36	40	30	40	40.8
4-D	25	30	31	27	29	28.4
4-N	50	62	44	42	42	48.0
5-D	17	18	18	18	18	17.8
5-N	38	52	40	47	47	44.8

Table 5.—*Multiple range test. Mean heights of dwarf seedlings*

(Values not included in the same bracket are significantly different at the indicated probability level.)

Dwarf Segregates

Progeny No.	*Mean height in cm.*	
2	30.4	
4	28.4	
3	25.2	P = .01
1	18.0	
5	17.8	

between the parental brooms and the dwarf progenies derived from them. With increasing age of the dwarf plants some meaningful correlations may be detectable. If dwarf seedlings are to be grown for ornamental purposes the choice of parental seed should be based on suitable progeny tests.

Statistical data relating to the transmission of browning in red pine have not been completed and hence are not included at this time. Preliminary results from a single broom, however, indicate no significant departure from the observations made above on jack, eastern white or sand pine.

LITERATURE CITED

Duffield, J. W. and J. G. Wheat. 1963. Dwarf seedlings from broomed Douglas-fir. Silvae Genet. 14(4):129-133.

Fordham, Alfred. 1966. Dwarf white pines from witches'-brooms. Amer. Nurseryman. 123(1):14-15, 85-87.

Fordham, Alfred. 1967. Dwarf conifers from witches'-brooms. Arnoldia 27(4):29-50.

Johnson, Albert G., Scott S. Pauley and William H. Cromell. 1965. Dwarf seedlings from witches'-brooms in jack pine. Minn. Forest. Notes 158. School of Forestry, Univ. of Minn. Also, Sci. J. Ser. Pap. 5618, Univ. Minn. Agr. Exp. Sta.

Liernur, A. G. M. 1927. Hexenbesen: irhe Morphologie, Anatomic und Enstehung. Nijh und van Ditmars. Uitgevers-Maatschappij, Rotterdam.

Liese, J. 1933. Verebung der Hexenbesenbildung bei der Kiefer. Zeitsch. Forst. u. Jagdw. 65(10):541-544. (Jour. Forestry 32:617-619. 1934).

von Tubeuf, C. F. 1933. Das Problem der Hexenbesen. Zeitsch. far Pflanzenkrankheiten 43:194-242.

---

1. Scientific Journal series No. 6769, Experiment Station, Department of Horticultural Science, University of Minnesota, St. Paul.

2. Research Fellow, Dept. of Horticultural Science, Professor, School of Forestry, and Assistant Professor, School of Forestry, respectively, University of Minnesota.