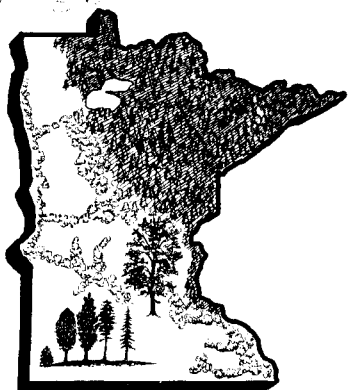
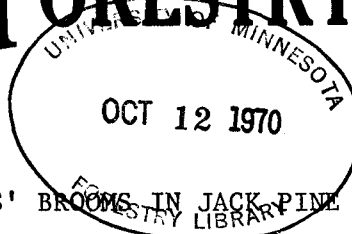




MINNESOTA FORESTRY NOTES

COPY 2



No. 158

January 15, 1965

DWARF SEEDLINGS FROM WITCHES' BROOMS IN JACK PINE I. 1/

Albert G. Johnson, Scott S. Pauley, and William H. Cromell 2/

A not uncommon, but sometimes spectacular, growth abnormality results in the bizarre "witches' brooms" found in many tree species and other plants. Broom-like growth may be induced by such agents as insects, mites, mistletoes, rusts, and viruses; others are apparently unassociated with parasitism. In the latter category are certain witches' brooms of jack pine (*Pinus banksiana* Lambert) observed by the senior author over a period of years. This report summarizes the results of studies of open-pollinated progenies grown from seed produced by such brooms.



Fig. Dwarf segregates of broom No. 1 in foreground and normal segregates of broom No. 4 in background at age of three years. North Central Experiment Station nursery, October, 1964. Rule is 36 inches in length.

goodness of fit to a 1 : 1 ratio indicated that the observed ratios did not deviate significantly from expected.

During the period in which these latter populations were grown, other fertile jack pine Establishment and maintenance support for this study was provided in part by the Charles K. Blandin Foundation, Grand Rapids, Minn.

2/ Respectively, Assoc. Scientist, Hort. Dept.; Prof., Sch. of Forestry; and Instructor, North Central Expt. Station, Univ. of Minn.

The first of the jack pine brooms to be observed critically was in the terminal portion of the crown of a tree about 25 feet in height located near Gordon, Douglas County, Wisconsin. The broom was a dense spherical mass about six feet in diameter. Inspection of the broom disclosed the presence of numerous small persistent closed cones. A few cones were collected and were found to contain some sound but extremely small seeds. The seed was planted in Massachusetts in 1950 and while the record of germination is incomplete, four seedlings still survive in a test plantation maintained by the Maria Moors Cabot Foundation for Botanical Research of Harvard University. Of the four surviving trees three are of apparently normal form and growth rate, but the remaining plant is a dwarfed individual closely resembling the parental broom in form and leaf character. When last seen in autumn, 1962, the plant was about 3.5 ft. in height while its normal siblings were 16-20 ft. tall. Dwarf segregates of the Gordon broom grown in a recent nursery test are shown in the Figure.

On the basis of this evidence of apparent seed-transmitted dwarfism, additional collections of seed from the same tree have been made and tested in recent years. The first of these progenies, grown in 1957, segregated normal and dwarf plants in the ratio of 42 : 48; another collection grown in 1961 produced 146 normal : 132 dwarfs (Table). Chi-square tests for

brooms had been located. In the fall of 1961 collections were made from five different jack pine brooms, all located in northern and central Wisconsin.

To determine if the small size of the broom-derived seed might result in germination and survival difficulties, germination and survival tests of broom-seed and normal seed from non-broomed portions of the crowns of the five trees were made in the greenhouse in spring, 1962. The thousand seed weight of the Gordon broom (No. 1 in Table) seed was 2.11 grams, whereas the weight of normal seed from the same tree was 4.39 grams. The seedlings were grown in flats until fall. Plants grown from normal seeds showed a survival of 73%. Plants from the small broom-seed, as might be expected, had a lower survival: 63%. All of the normal seed produced entirely normal seedlings but the broom-seed segregated normal - dwarf in various ratios, all of which did not deviate significantly from a 1 : 1 ratio (Table).

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, a 5-replicate randomized complete block nursery planting was made at the University of Minnesota's North Central Experiment Station nursery in May, 1962. A summary of these analyses will be published as Part II of this report. Segregation of the broom-derived seed in this planting was 810 normal : 871 dwarf. The Table indicates the ratio for each broom family and their chi-square values.

As indicated in the Table, there is considerable range in the chi-square values for the several tests. This may reflect results of differential survival of normal and dwarf segregates which, in small samples, might be expected to fluctuate rather widely. When all tests are combined, however, the chi-square value (.091) and associated probability of more than .70 is strong evidence that a normal-dwarf ratio of 1 : 1 characterizes the segregation ratio of such broom-derived seed.

In the absence of any evidence that the witches' brooms here described are due to a pathogen, the 1 : 1 segregation ratio observed in the open-pollinated progeny clearly suggests that the brooms are derived from a dominant somatic mutation or "bud sport." Since none of the brooms studied produced pollen the assumption may be made that the broom strobili were cross pollinated with normal pollen from normal portions of the crown of the same tree or neighboring trees. Such crosses of a heterozygote containing a dominant gene for dwarfness with a homozygous recessive "normal" would yield a 1 normal : 1 dwarf ratio in the offspring.

Of interest in this connection is the work of Von Tubeuf (1) who, in studies of similar brooms in Norway spruce (*Picea abies* L. (Karst)), found that 28.2 percent of 2814 seedlings grown from four brooms were dwarfs. He interpreted his results on the basis of a simple recessive mutation, i.e., a normal - dwarf ratio of 3 : 1. Liese (2) showed seed transmission of brooming in Scots pine (*Pinus sylvestris* L.) and concluded that mutation was responsible. But due to the small size of his sample he was unable to suggest mode of inheritance.

TABLE
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	3.457	.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.

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1. Von Tubeuf. 1933. Das Problem der Hexenbesen. Zeitsch. für Pflanzenkrankheiten 43: 194-242.
2. Liese, J. 1933. Vererbung der Hexenbesenbildung bei der Kiefer. Zeitsch. Forst. u. Jagdw. 65(10): 541-544.

