Taxus cuspidata nana pyramidalis

We are not sure of the correct name of this form. It bears the name given by a local nursery from whom we received the original plants. The dark green lustrous foliage suggests its relation to a media hybrid. Very dense growth and more columnare than pyramidal, it averages about 4 inches of growth a year. This plant is 25 years old from a cutting.

Thuja occidentalis Hetz
Hetz Midget

Found in the nurseries of the Fairview Evergreen Nursery Co., this is correctly a dwarf form of our common American Arbor Vitae. This plant is now 15 years old.

Tsuga canadensis pendula
Weeping Canadian Hemlock

There are several forms of this weeping type—two from the original selection and a number that have been raised from seed. They all show some difference in mature form. This plant is on an estate in Bristol, Rhode Island. The person who lends scale to our plant is our member, Alfred Martin. The age of this plant is a guess probably 75 to 80 years old.

MODERATOR HANCOCK: Thank you Roy for that straight, clear and well informed presentation of dwarf evergreens. For our last speaker we have a versatile and widely traveled individual, Mr. Albert G. Johnson who will talk on "Pine dwarf segregates from witches brooms."

PINE DWARF SEGREGATES FROM WITCHES'-BROOMS[1]

ALBERT G. JOHNSON, SCOTT S. PAULEY
AND WILLIAM H. CROMELL[2]

This report on the recovery of dwarf seedlings from seed collected from pine witches'-brooms goes back to 1946 and an initial observation of small but mature and apparently otherwise normal cones borne by a witches'-broom in a jack pine (*Pinus banksiana* Lamb.) tree in Douglas County, Wisconsin. The broom was large, about six feet in diameter and terminal in position.

Witches'-brooms, while not common in pines, are such conspicuous objects as to be frequently reported. They have been observed in nearly all our North American species. They are also known to occur in this country on the European Scot's pine (*Pinus sylvestris* L.) and Austrian pine (*P. nigra* Arn.) and are reported frequently in European literature.

A small quantity of seed obtained from a sample of cones of the above tree was planted in 1950. The surviving popula-

[1]Scientific Journal Series No 6769, Experiment Station, Department of Horticultural Science, University of Minnesota

[2]Research Fellow, Department of Horticultural Science, Professor and Instructor, School of Forestry, University of Minnesota, respectively

tion at the end of the growing season consisted of four seedlings. Three of the trees were normal appearing one year jack pines, but the fourth was much dwarfed resembling the parent broom in general morphology. This plant remains alive and has now reached a height of four feet, still retaining its broom-like form and dwarf habit. The three normal seedlings now exceed twenty feet in height and are normal jack pines except for the presence of grafts of the dwarfed seedling placed on low branches for observation of possible effects of grafting dwarfed material on normal trees. No effects were observed upon the host siblings as a result of this grafting operation. The scion material has simply maintained its characteristic dwarf form without effect upon the host tree.

To learn more about the mode of transmission of the dwarfed brooming character observed in this small test, larger collections of cones were secured from the original jack pine broom and from additional jack pine brooms, all collected in Wisconsin. Broom produced seed was also obtained from eastern white pine (*P. strobus* L.), red pine (*P. resinosa* Ait.) and from sand pine (*P. clausa* Sarg.).

In Minnesota Forestry Notes No. 158 (Johnson *et al*, 1965) evidence was given 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).

In the absence of any conclusive evidence that the five witches'-brooms tested were due to a pathogen, the tentative

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

conclusion was made that the observed segregation was genetically determined inasmuch as a 1:1 segregation ratio was consistent with a simple Mendelian dominant gene for dwarfism, if fertilization is accomplished by normal pollen recessive for the dwarfism factor. This hypothesis was further supported by the observed total absence of male strobili on the brooms studied resulting in seed pollinated by pollen produced by surrounding normal trees, or possibly rarely by pollen 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 3) and sand pine (Table 3) similar 1:1 ratios were observed.

Table 2. White Pine

Accession #	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
	503	542	1.416	.200

Table 3. Sand Pine

Acc #	# 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
			369	377	0.081	.70

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 brooming 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. In a few cases some suppressed normal seedlings were classified as dwarfs, but

these totalled only eight in the 1411 dwarf jack pine seedlings tallied, an error of less than 0.6 percent.

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 with 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 studies, 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 four 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 level). Dwarf progeny height means were analyzed by Duncan's Multiple Range Test. The results are summarized in Table 5.

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	30	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	

Conspicuous needle-length differences characterized normal and dwarf segregates of the five broom derived progenies studies. 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 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 brooming 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.

A pendulous jack pine discovered growing in Richfield, Minnesota in 1959 has been propagated by grafting on jack pine seedlings at the Minnesota Landscape Arboretum. Grafted high, the plant produced has a sprawling ascending habit lending itself possibly to small garden landscape use where an unusual effect is desired. Grafted low, the plant has remained prostrate forming a novel ground cover effect.

Seed collected from the above pendulous tree was planted in 1960. In an outplanting of 100 seedlings near Grand Rapids, Minnesota all progeny are prostrate or strongly reclining. In a second outplanting of 23 surviving trees in Washburn Co., Wisconsin one tree is nearly upright but of irregular form. The remaining trees are prostrate with only an occasional sprawling ascending branch. Obviously this bizarre tree can be sexually reproduced as long as selection is practiced to eliminate undesirable departures from the pros-

trate or pendulous form. Since jack pine is not easily grafted, seed reproduction of an abnormal ornamental variant has decided advantages.

LITERATURE CITED

Duffield, J W. and J. G. Wheat 1963. Dwarf seedlings from broomed Douglas -fir. Silvae Genetica 12 (4) ·129-133.

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

---------- 1967. Dwarf conifers from witches'-brooms. Arnoldia 27 (4-5) ·29-50.

Johnson, Albert G, Scott S Pauley and William H. Cromell. 1965. Dwarf seedlings from witches'-brooms in jack pine I. Minnesota Forestry notes No. 158. School of Forestry, Univ. of Minnesota, St. Paul. Sc. Jour. Ser. Paper No. 5618 of the Univ of Minn. Agr. Exp. Sta.

Liemur, A G. M. 1927. Hexenbesen: irhe Morphologie, Anatomie und Entstehung Nijh und van Ditmars. Uitgevers-Maatschappij, Rotterdam.

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

von Tubeuf, C. F. 1933. Das Problem der Hexenbesen Zeitach. fur Pflanzenkrankheiten 43.194-242.

MODERATOR HANCOCK: Thank you Mr. Johnson for a fine piece of research.