

devrait donner les meilleurs résultats si elle est faite entre le 10ème et le 13ème jour après le début de l'anthèse des chatons mâles.

L'émasculation ne blesse pas les fleurs femelles, et ne cause aucune réduction dans la fructification; elle a peut-être au contraire un effet légèrement favorable. L'emploi de sacs en papier Kraft cause cependant quelque réduction dans la fructification et il pourrait être préférable d'essayer sur les arbres les plus délicats un type de sac qui faciliterait la pénétration de la lumière et la circulation de l'air. Des sacs de coton à tissage serré pourraient peut-être convenir.

On décrit une technique simple pour la germination du pollen de châtaignier. On peut faire germer le pollen dans des gouttes d'eau distillée ou dans une solution de saccharose sur des lames de microscope, en employant des boîtes de Pétri comme chambre humide. On a obtenu une bonne germination à 28 et 27° C. Le fait que le pollen germe mieux à ces températures relativement élevées peut indiquer que la pollinisation faite pendant les jour-

nées chaudes, donnera de meilleurs résultats que pendant des journées froides. Cela doit cependant être vérifié par des expériences sur le terrain. L'acide borique à ½ et 1% retarde la germination et provoque une distorsion de tubes polliniques.

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Cone Characteristics and Natural Crossing in a Population of F₁ Pine Hybrids¹⁾

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During the past 15 years workers at the Northeastern Forest Experiment Station have produced a number of artificial species hybrids in series Laricoides of the hard pines. The earliest hybrids produced involved Scotch pine (*P. sylvestris* L.), Japanese red pine (*P. densiflora* SIEB. and Zucc.) and Japanese black pine (*P. thunbergii* PARL.). They are now old enough to fruit.

Natural crossing was studied in a plantation of these hybrids and their parent species; and cone characteristics were used as a means of identifying hybrid progeny. The vigor of these first hybrids and the ease of producing them by controlled pollination have already been reported (4, 5). (The trees originally identified as *P. nigra* ARNOLD in [4] are now considered to be *P. thunbergii*.)

An earlier study of this sort was reported by SAITO (3), who analyzed several natural hybrids between Japanese red pine and Japanese black pine grown in his nursery for 7 years. He does not state to which generation the hybrids belong, but concludes that trees tending toward one or the other parent in position of the resin ducts also tend toward the same parent in other characteristics.

All names and species limits used in this report are as used in REHDER (2).

Material and Methods

Arboretum Trees

The parents of the open-pollinated and F₁ hybrid progenies were located on the campus of Yale University,

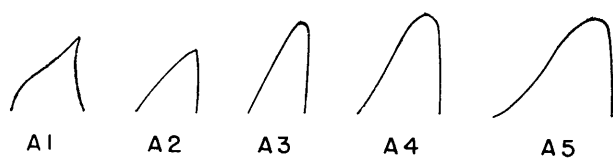
New Haven, Connecticut. Cones were also received from authentic specimens located in the Arnold Arboretum of Harvard University, Boston, Massachusetts; Eddy Arboretum of the Institute of Forest Genetics, Placerville, California; Morris Arboretum of the University of Pennsylvania, Philadelphia, Pennsylvania; and the Wind River Arboretum of the Pacific Northwest Forest Experiment Station, Wind River, Washington. These cone collections were used to establish the correct identity of the parents and progenies.

Standing Stone Plantation

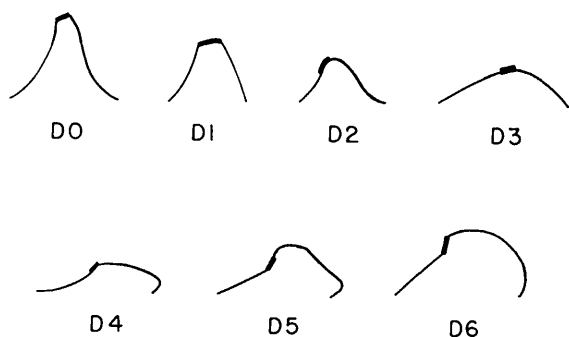
F₁ hybrid and open-pollinated progeny (all adjudged non-hybrid) of the New Haven trees were started from seed in 1940 and were outplanted in 1945 in a non-replicated permanent field planting on Standing Stone Experimental Forest in Huntingdon County, Pennsylvania. At the time of the first measurement (4) all cones from all hybrid trees and one cone from each non-hybrid tree were harvested. The extracted seeds were sown in the spring of 1949 in the Philadelphia nursery of the Northeastern Forest Experiment Station.

The cones were scored for 11 different characteristics, for each of which up to 5 or more recognizable grades were established. Insofar as possible the differences between grades of the same characteristic were kept uniform and were defined mathematically. It so happens that in most characteristics there was a gradation from *P. sylvestris* through *P. densiflora* to *P. thunbergii*; the grades were numbered so that grades, 1, 3, and 5 referred to cones of these three species respectively. The characteristics scored were:

¹⁾ This study was carried out in cooperation with the Morris Arboretum of the University of Pennsylvania, Philadelphia, Pennsylvania. Grateful acknowledgment is also given the other arboreta that sent in cone material.



SCALE TIP OUTLINE



BASAL SCALE PROFILE

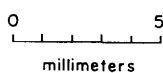


Figure 1. — Portions of cone scales typical of the grades recognized in thickness of scale tip and profile of basal scale

- A. Thickness of scale tip of a scale halfway up the cone (figure 1). The range was from a sharp-edged scale tip (A-1) to a thick rounded tip (A-5).
- B. Color of the apophyses, light greenish-gray to medium brown. Color, which is retained in the laboratory, was easily determined on unweathered ripe cones. The colors were defined in terms of their nearest equivalent in MAERZ and PAUL (1, p. 49, plate 13) as follows:

Grade	MAERZ and PAUL equivalent	Grade	MAERZ and PAUL equivalent
B-0	D-3	B-3	E-6, Arizona
B-1	D-5	B-4	E-7
B-2	E-5, Mastic	B-5	F-8, Toast

- C. Roughness of apophyses. C-1 was wrinkled as in Scotch pine. All other species and hybrids were smooth (C-5). This character is omitted from figure 2.
- D. Outline of apophysis of thickest basal scale. Grades were defined as follows (see also figure 1):

Grade	Scale thickness mm.	Scale thickest
D-0	3+	at umbo
D-1	2.1-3.0	at umbo
D-2	1.6-2.0	at umbo
D-3	1.0-1.5	at umbo
D-4	1.0-1.5	between umbo and scale tip
D-5	1.6-2.2	between umbo and scale tip
D-6	2.3-2.8	between umbo and scale tip

- E. Width of widest scale, in millimeters.
- F. Height/width ratio, apophysis of largest scale.

- G. Width (measured perpendicular to the axis of the cone) of largest umbo on cone, in millimeters.
- H. Angle formed by the base of fully opened scale.
- I. Cracking of the apophyses. Some fleshy apophyses cracked as if the epidermis were stretched too tightly. Three grades were recognized; I-1 not cracked; I-4 slightly cracked; I-5 more than 1/2 crack per scale on the largest scales.
- J. Cone length, in millimeters.
- K. Cone weight, in grams.

The mathematical equivalents of six of the characteristics are as follows:

Grade	E.	F.	G.	H.	J.	K.
	Scale width	Apophysis height width	Umbo width	Basal angle	Cone length	Cone weight
	mm.	ratio	mm.	degrees	mm.	gms.
1	5.5-6.5	1.2-1.3	1.8-2.1	rounded	25-27	1.5-2.1
2	6.6-7.5	1.0-1.1	2.2-2.5	100	28-31	2.2-3.0
3	7.6-8.5	.8-.9	2.6-3.0	110-120	32-35	3.1-4.2
4	8.6-10.5	.7	3.1-3.4	130-140	36-40	4.3-5.9
5	10.6-12.5	.6	3.5-4.0	150-170	41-45	6.0-8.5
6	—	—	4.1+	—	—	—

Philadelphia Nursery

The open-pollinated progeny of the Standing Stone trees were grown in the experimental nursery of the Morris Arboretum for 3 years, 1949-1951, and were outplanted in 1952. The trees were grouped in the nursery by female parent, but within female-parent groups they were completely randomized. For this reason growth differences ascribable to male parent are statistically more trustworthy than are differences ascribable to female parent (table 2).

At the end of the third year the following vegetative characteristics seemed to have the most diagnostic value and were scored or measured for each seedling in the nursery:

Bud color, Amount of needle twist, Needle fineness, Needle length, Needle color, Tree height. — Five grades of needle length and needle color were recognized; three grades corresponding to species, hybrid, and species for the other characteristics. The scoring was less objective than was the scoring of cone characteristics.

The range of variation of the species and F₁ hybrids had already been established from the plantation trees and from other young control-pollinated material present in the nursery. However, the appearance of the F₂ and backcross generations could only be inferred on the arbitrary assumptions that the F₂ and F₁ were similar and that the backcross was intermediate between a species and the F₁.

Progeny of a species were adjudged backcross or F₁ hybrids if they had 1 and 2 characteristics respectively of the other species. Progeny of the F₁ were adjudged backcross hybrids if they exhibited 1 or 2 characteristics of the species (none exhibited more) and F₂ hybrids if they exhibited only F₁ characteristics. There were probably few errors in the identification of the F₁'s and species but more errors in the identification of the F₂'s and backcrosses.

Results

Cone Characteristics of the F₁ Hybrids and Parent Species

The early fruiting characteristic of *P. densiflora* was dominant in F₁ hybrids involving that species (4) (table 1).

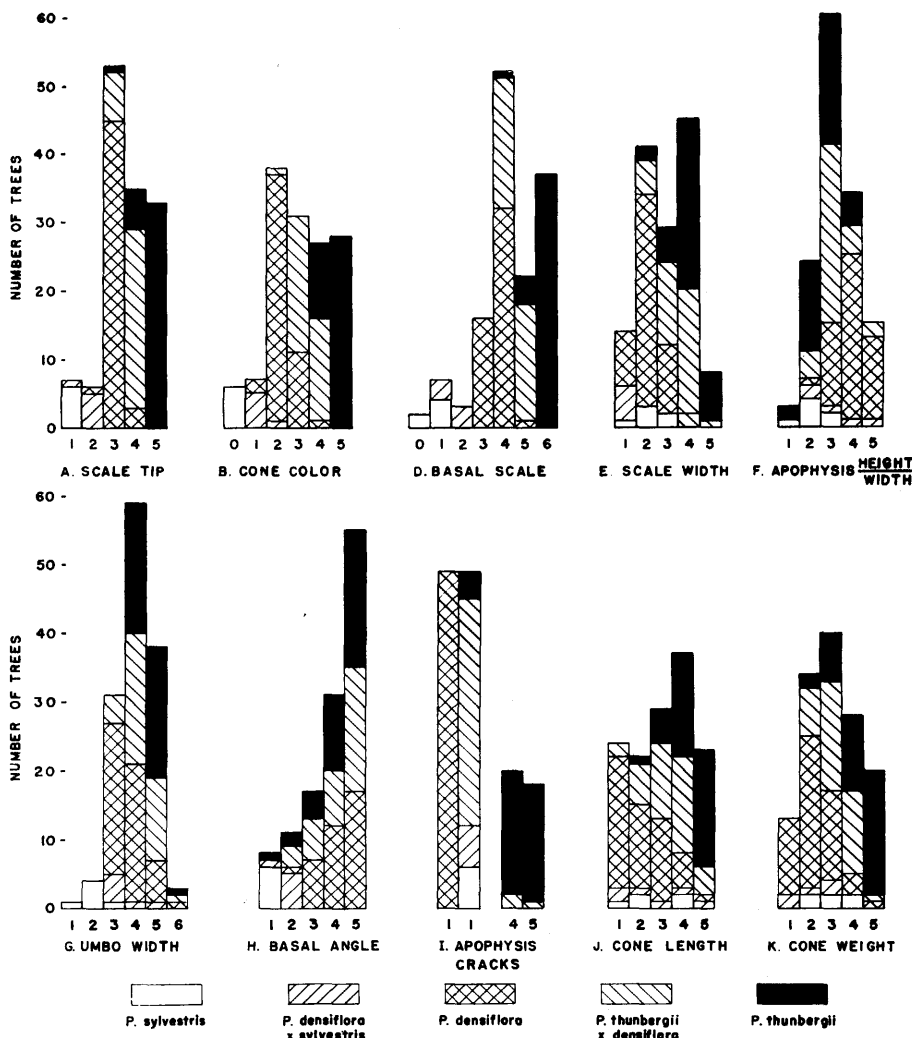


Figure 2. — Frequency distribution of cone characteristics of parent species and F_1 hybrids in the Standing Stone plantation

Table 1. — Fruitfulness of species and hybrids in the Standing Stone plantation, 1948

Parentage	Total trees	Trees having			
		0 cones	1-5 cones	6-10 cones	11+ cones
	No.	Per-cent	Per-cent	Per-cent	Per-cent
<i>sylvestris</i>	6	100	0	0	0
<i>densiflora</i> × <i>sylvestris</i>	11	45	27	9	18
<i>densiflora</i>	523	45	30	12	14
<i>thunbergii</i> × <i>densiflora</i>	51	31	35	12	22
<i>thunbergii</i>	256	86	12	1	1

However, the hybrids were intermediate between the parent species in most other cone characteristics.

The most useful diagnostic characteristics for the separation of parents and hybrids were: scale-tip thickness, cone color, and basal-scale profile (figure 2). A single cone scored for all three characteristics could be identified with certainty although none of these three characteristics in itself was sufficient for positive identification. Umbo width, scale width, and cone size were also of considerable diagnostic value. Basal angle of the opened cone and wrinkling of the cone scales were useful only in the identification of Scotch pine; cracking of the apophyses was useful only in the identification of Japanese black pine.

Amount of Natural Crossing in the Standing Stone Plantation

The scoring of the three-year-old seedlings indicates that approximately 40 percent of the progeny of the Standing Stone plantation were pure species or F_2 hybrids, 57 percent were backcrosses, and 3 percent were F_1 hybrids (table 2). These figures reflect not only crossability relationships but also pollen availability. *P. densiflora* seemed to be the most effective pollinator in this young planting.

The percentage of natural crossing is great enough to indicate that backcrosses or F_2 hybrids could probably be mass-produced economically in simply designed natural crossing gardens composed entirely of seedling trees. However, for the mass-production of F_1 hybrids, it would presumably be necessary to establish the natural crossing gardens with clones selected for male sterility or self-incompatibility.

In any such mass-production scheme that does not involve controlled pollinations, a certain amount of contamination can be expected. With the particular hybrids considered in this paper, this contamination would not be serious, as all the hybrids could be identified with reasonable certainty in the nursery.

Table 2. — Supposed parentages of progeny of the Standing Stone trees and their heights after three years in the Philadelphia nursery

Female parent	Putative male parent			
	<i>densiflora</i> × <i>sylvestris</i>	<i>densiflora</i>	<i>thunbergii</i> × <i>densiflora</i>	<i>thunbergii</i>
	No. trees	No. trees	No. trees	No. trees
<i>densiflora</i> × <i>sylvestris</i>	10	14	0	0
<i>densiflora</i>	5	23	1	0
<i>thunbergii</i> × <i>densiflora</i>	0	52	28	22
<i>thunbergii</i>	0	7	25	26
Tree height ± standard deviation				
	cm.	cm.	cm.	cm.
<i>densiflora</i> × <i>sylvestris</i>	53.2 ± 5.1	48.2 ± 1.6		
<i>densiflora</i>	55.8 ± 3.0	49.4 ± 2.5	22	
<i>thunbergii</i> × <i>densiflora</i>		53.1 ± 2.2	58.7 ± 2.5	58.3 ± 2.2
<i>thunbergii</i>		63.3 ± 6.7	67.5 ± 3.3	53.5 ± 3.1

The F_1 's, F_2 's, and backcrosses exhibited greater vigor than did the pure species. The F_1 hybrid *P. thunbergii* × *densiflora* and the backcross to *P. thunbergii* were the most vigorous (table 2).

Summary

Artificial *Pinus densiflora* × *sylvestris* and *P. thunbergii* × *densiflora* hybrids were started from seed in 1940

and outplanted in central Pennsylvania in 1945. When studied in 1948 these hybrids were fruiting heavily. Study of 11 cone characteristics showed that the hybrids were essentially intermediate between their parents. However, the early fruiting of *P. densiflora* was dominant in hybrids involving that species. Scale-tip thickness, cone color, and basal scale profile are the best diagnostic characteristics for the identification of hybrids by their cones.

Open-pollinated cones were collected from this Pennsylvania plantation of hybrids and parent species in 1948. The resulting seedlings were scored for vegetative characteristics in 1951. According to the results of this analysis, more than half the progeny were backcrosses. At the age of 3 years the backcross and F_1 progeny showed considerable vigor.

Zusammenfassung

Titel der Arbeit: *Zapfenmerkmale und Nachkommen von frei abgeblühten F_1 Kiefernhybriden.*

Hybriden zwischen *Pinus densiflora* und *silvestris* sowie zwischen *thunbergii* und *densiflora* wurden 1940 künstlich hergestellt und 1945 in Central-Pennsylvania ausgepflanzt. 1948 zeigten diese Hybriden reichlichen Zapfenanhang. Die Untersuchung von 11 Zapfeneigenschaften ergab im wesentlichen intermediäres Verhalten zu den entsprechenden Kennzeichen der Eltern. Dagegen dominierte die frühe Fruchtbarkeit von *P. densiflora* in den Hybriden mit dieser Art. Stärke der Schuppenspitzen, Zapfenfarbe und basales Schuppenprofil sind die besten diagnostischen Zapfenmerkmale zur Identifikation der Hybriden. Eines dieser Merkmale genügte hierzu jedoch nicht.

Aus freiem Abblühen entstandene Zapfen der Hybriden und der reinen Elternarten wurden im Jahre 1948 auf der Pflanzung in Pennsylvania geerntet. Aus der vegetativen Entwicklung der entstandenen Sämlinge bis zum Jahre 1951 konnte geschlossen werden, daß mehr als die Hälfte dieser Nachkommen Rückkreuzungen waren. Im Alter von 3 Jahren zeigten diese Rückkreuzungen und die F_1 Nachkommenschaften beträchtlich größere Wuchskraft als

die reinen Arten. Am wüchsigsten waren die F_1 Hybriden *thunbergii* \times *densiflora* und die Rückkreuzung mit *thunbergii*.

Résumé

Titre de l'article: *Facteurs caractéristiques des cônes de pin et descendance d'une population F_1 de pins hybrides après fécondation libre.*

Des croisements artificiels entre *Pinus densiflora* et *P. silvestris* ainsi qu'entre *P. thunbergii* et *P. densiflora* furent faits en 1940 et les hybrides obtenus plantés en Pennsylvanie centrale en 1945. En 1948, ces hybrides ont commencé à fructifier. L'étude de 11 caractères des cônes montra que les caractères étaient intermédiaires entre ceux présentés par les parents. Cependant, la mise à fruit précoce de *P. densiflora* est dominante dans les hybrides avec cette espèce. L'importance de l'umbo, la couleur des cônes et le profil de la base de l'échaille sont les meilleurs caractères permettant l'identification des hybrides. Un seul caractère ne suffit pas pour une détermination certaine.

Des cônes produits par fécondation libre furent récoltés dans la plantation de Pennsylvanie en 1948, sur les hybrides et sur les parents. Le développement végétatif des semis jusqu'à l'année 1951 montre que plus de la moitié des descendants sont des croisements en retour. A l'âge de 3 ans ces croisements en retour et les descendants des F_1 avaient une plus grande vigueur que les espèces parentes. Les hybrides F_1 , *P. thunbergii* \times *P. densiflora* et le croisement en retour avec *P. thunbergii* ont la croissance la plus rapide.

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