Effects of Continuous Bagging of White Pine Cones

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STATION PAPER NO. 99 • NORTHEASTERN FOREST EXPERIMENT STATION • 1957
FOREST SERVICE • U.S. DEPARTMENT OF AGRICULTURE • UPPER DARBY, PA.
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PREFACE

HYBRIDIZATION between and within species will probably play an important role in the development of new strains of white pines for the Northeast. However, high mortality among control-pollinated cones has proved to be a limiting factor in the development of these new strains. This report describes the results of one method used to increase cone set.

Grateful acknowledgment is made to Harry C. Kettlewood, who assisted in the 1955 and 1956 pollinations and seed counts; and to R.T. Bingham, R.C. Brown, P.A. Godwin, R.D. Lane, and E.J. Schreiner, for their helpful critical review of the manuscript. The study would have been impossible without the assistance of the many arboreta and private owners on whose trees the observations were made.

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CONE mortality has been a serious hindrance to the Northeastern Forest Experiment Station's interspecific hybridization work with the white pines. The magnitude and approximate time of this mortality in some Pennsylvania stands of eastern white pine (*Pinus strobus* L.) are shown in the following tabulation:

Pollination date (Year)	Flowers wind-pollinated (Number)	Sound conelets present 12 months after pollination (Number)	Sound cones matured 15 months after pollination (Number)
1950	1164	72	29
1951	789	4	4
1952	2542	371	121
1953	1480	180	25

[1] At the time of this study the authors were stationed at the Morris Arboretum of the University of Pennsylvania, Philadelphia, Pa., where many of the observations recorded here were made. Dr. Wright, formerly Geneticist, Northeastern Forest Experiment Station, is now Associate Professor of Forestry, Michigan State University, E. Lansing, Michigan. Mr. Gabriel, Geneticist, Northeastern Forest Experiment Station, is now associated with the Station's hardwood research project conducted in cooperation with the University of Vermont, Burlington, Vermont.

The white-pine cone beetle (*Conophthorus coniperda* (Schw.)) appears to have been mainly responsible for this cone mortality. There is not sufficient data on the biology of this insect to state its time of oviposition. However, adult cone beetles--several to a conelet--were found in infested conelets present in April and May of the second growing season on nearly every parent tree used in this study. Also, a lepidopteran coneworm (*Dioryctria* sp.), which attacks the second-year cones, was responsible for minor cone losses. So were squirrels.

Other species of white pine have suffered less cone mortality in the Philadelphia area than eastern white pine. However, there have been occasional complete cone-crop failures on some trees of all species except Japanese white pine (*P. parviflora* Sieb. and Zucc.).

BAGGING TECHNIQUES

Since 1951 we have experimented with the continuous enclosure of pollinated white pine branches in synthetic sausage casings ("Visking" brand) as a method of increasing cone and seed set. This procedure was tested intensively because of favorable preliminary results obtained by accident.[2] The parent trees used were scattered over a distance of 100 miles, and some were on steep rocky slopes.[3]

Sausage casings cut into bags 12 inches long, with a diameter of 2-3/4 inches when inflated, were used in the experiments. Before application these were stapled at one end. They were tied securely in place, with cotton to seal the bag-branch joint, on the newly developing shoots 1 to 2 weeks before pollination time.

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[2]Wright, J.W. 1953. Tree breeding technique: some beneficial effects of continuous bagging. Northeast. Forest Expt. Sta. Forest Res. Note 5. 4 pp.

[3]The eastern white pine trees used as parents were located in native privately owned 30- to 50-year-old stands near Pocono Pines, Pa., and near Brodheadsville, Pa. In the other pine species studied the 20- to 60-year-old specimens used as parents were located in the Morris Arboretum; Haverford College Arboretum, Haverford, Pa.; Westtown School Arboretum, Westtown, Pa.; Andorra Nursery, Conshohocken, Pa.; and in private yards near Philadelphia.

At the time of bagging, in late May or early June, the female flower buds were 3/16 to 1/4 inch long, and the flowers were still enclosed in the bud scales. At pollination time, pollen was blown into the bag from a medicine dropper through a small hole. The hole was sealed immediately with cotton or cellophane tape. The bags were left in place until they were broken by the developing conelets or until cone maturation.

RESULTS

The continuous bagging method was most successful for eastern white pine (table 1). Nearly all trees matured a higher percentage of cones and more seeds per cone on the continuously bagged branches than on the wind-pollinated branches. However, there were exceptions to this general trend: for example, one tree matured 153 wind-pollinated cones and only 3 (from 79 flowers) continuously bagged cones in 1955.

The increased cone set following continuous bagging of eastern white pine is believed due to the protection afforded the developing conelets against insect attack. On the other hand, the increased seed set following continuous bagging was probably due to a temperature effect of the bag on the developing ovules. All seed counts were made on cones that were not infested with insects, and unbagged and bagged female flowers were probably pollinated equally well because all the female parents were situated in native stands, close to heavily pollinating trees.

The continuous-bagging method was moderately successful on limber pine (*P. flexilis* James) flowers pollinated by Himalayan white pine (*P. griffithii* McClel.). Twenty-two of 24 tree x tree combinations devoted to this cross during the years 1951 to 1956 yielded seed. In contrast, only 18 of 33 wind-pollinated single-tree cone collections made during this same period yielded filled seed. In limber pine, this method gave better cone sets than wind-pollination on most trees in the Haverford College collection and poorer cone sets than wind-pollination on a group of four roadside trees near Blue Bell, Pa. The former have been fruiting since 1948 and have heavy infestations of cone in-

Table 1.--*Comparison of cone and seed set on continuously bagged and wind-pollinated branches of 5-needle white pines, 1952-55*[1]

Female parent	Treatment	Male parent	Cones matured	Full seeds per cone
			Percent	*Number*
strobus	Bagged	*strobus*	9.3	15.1
strobus	Wind-pollinated	(2)	5.5	8.6
flexilis	Bagged	*flexilis*	28.0	0.9
flexilis	Bagged	*griffithii*	31.2	4.6
flexilis	Wind-pollinated	(3)	47.0	6.4
ayacahuite[4]	Bagged	*strobus*	41.0	25.1
ayacahuite	Bagged	*griffithii*	21.1	14.7
ayacahuite	Wind-pollinated	(2)	53.5	18.9
peuce	Bagged	*strobus*	38.8	5.3
peuce	Wind-pollinated	(2)	51:3	4.7
griffithii	Bagged	*griffithii*	21.9	4.5
griffithii	Bagged	*strobus*	15.4	1.0
griffithii	Bagged	*flexilis*	18.1	0.03
griffithii	Wind-pollinated	(5)	41.2	4.6
monticola	Bagged	*strobus*	4.5	13.0
monticola	Wind-pollinated	*strobus*	95.0	18.8
monticola	Wind-pollinated	(2)	4.5	14.6

[1]The results are based on approximately 13,100, 2,300, 1,900, 500, 4,700, and 600 female flowers in *Pinus strobus, P. flexilis, P. ayacahuite, P. peuce, P. griffithii,* and *P. monticola* respectively. The numbers of wind-pollinated flowers were estimated. All other numbers are based on actual counts.

[2]Probably x *strobus*.

[3]Probably x *flexilis*.

[4]Tentative identification.

[5]Probably x *griffithii*.

sects; the latter started to flower in 1955 and have almost no cone insects.

In Mexican white (*P. ayacahuite* Ehrenb.) and Macedonian white (*P. peuce* Griseb.) pines, continuous bagging increased the cone sets in 1953 and 1954. However, in 1955 nearly all wind-pollinated cones matured on these trees, and the wind-pollinated cone set was much greater than the cone set after continuous bagging. Continuous bagging caused a slight increase in seed set in these species. This increase may have been due to a physiological effect of the bags or to more effective pollination. Most of the wind-pollination was from a few nearby eastern white pine trees that did not pollinate heavily.

In Himalayan white pine and western white pine (*P. monticola* Douglas ex D. Don in Lambert) the cone and seed sets were much higher on unbagged than on continuously bagged branches. The deleterious effects of continuous bagging on cone set in western white pine were independently confirmed in northern Idaho: the enclosed branches all died, apparently as a result of heat injury.[4]

In addition to influencing cone and seed set, continuous bagging with sausage casings resulted in: (1) stunting and malformation of vegetative growth; (2) complete inhibition of flower-bud formation; and (3) occasional branch death (most of the dead branches showed signs of insect damage).

The sausage casings affect the enclosed branches in two major ways: by increasing the temperature and by excluding (and sometimes including) insects. Presumably the exclusion of cone insects accounted for most of the increases in cone set; and the increased temperature accounted for most of the increases or decreases in seed set, the stunting of vegetative growth, and the inhibition of flower growth. Evidently these different processes have different temperature coefficients and any one set of growth conditions is not always best for all processes in a tree.

SUMMARY

Experiments were conducted on the effects of continuous enclosure of flowering branches in sausage casings from pollination time until cone maturation in six species of white pines. The bagging affected the enclosed branches in two principle ways; it excluded cone insects and raised the temperature surrounding the conelets. On trees that were heavily infested with cone insects the continuous bagging gave higher cone sets than were obtained on unbagged branches. This was true in the majority of eastern white pine (*P. strobus* L.), in all the trees in one group of limber pine (*P. flexilis* James), and in Mexican white pine (*P. ayacahuite*

[4] R.T. Bingham and A.E. Squillace, personal communication.

Ehrenb.) and Macedonian white pine (*P. peuce* Griseb.) in certain years. The method was rarely successful in Himalayan white pine (*P. griffithii* McClel.) and western white pine (*P. monticola* Dougl. ex D. Don in Lamb.). However, only in eastern white pine was the average cone set for all trees higher on the continuously bagged branches than on unbagged branches.

The use of this method resulted in a large increase in the set of viable seeds per sound cone in nearly all trees of eastern white pine and in many trees of limber pine; it resulted in a slight increase in Mexican white and Macedonian white pines; it resulted in a slight decrease in the other two species.

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