SPRUCE IMPROVEMENT RESEARCH AT THE TAKE STATES FOREST EXPERIMENT STATION---AN OUTLINE

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The spruces, our principal source of long-fibered wood pulp, are in short supply in the Lake States. For many years pulp mills there have had to depend upon Canadian imports for much of their spruce wood and pulp. The only way to provide any substantial increase in the amount of upland spruce is by planting. So far as possible the planting should be done with stock of the best inherent productivity, resistance to injury, and hardiness.

Comprehensive forest tree improvement research is the best basis for developing such planting material. For that reason the Lake States Forest Experiment Station has undertaken studies that deal with the racial variation, selection, phenology and physiology, controlled pollination, and propagation of spruces. Major emphasis has been placed upon white spruce at the outset, but other species are also included.

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Racial Variation Studies

It is highly important to know how much racial variation has developed within a species both as a basis for selection and breeding and as a guide to suitable seed sources in planting. Over the past 25 years the Lake States Station has, therefore, undertaken five studies which include some aspects of racial variation in the spruces, as follows:

1. In 1936 the Station planted stock of the following 8 spruces in northeastern Wisconsin, north-central Minnesota, northeastern Minnesota, central Upper Michigan, and northern Lower Michigan: White spruce (Picea glauca), 7 sources from the Lake States, Ontario, and the Black Hills; Norway spruce (P. abies), 6 sources, mostly from the U.S.S.R. and Yugoslavia; red spruce (P. rubens), 2 sources from Pennsylvania and North Carolina; and 1 source each of black spruce (r. mariana) from north-central Minnesota, Sakhalin spruce (P. glehni) from northern Japan, oriental spruce (F. orientalis) from the Caucasus region, Serbian spruce (P. omorika) from Yugoslavia and Siberian spruce (P. obovata) from Siberia. The severe drought of 1936 decimated all but the northeastern Wisconsin plantation. In that area 15 years after planting, the white spruces generally looked better than any other species, although some of the White Russian Norway spruce lots had done well. A white spruce source from Douglas, Ontario, was outstanding. There are some distinct differences among sources within both species. The oriental, red, Sakhalin, and Serbian spruces have demonstrated their unsuitability for the locality. The black and Siberian spruces have done moderately well.

2. In 1941 stock of 12 European sources of Norway spruce, received from the International Union of Forest Research Organizations, was fieldplanted in north-central Minnesota and in northern Lower Michigan. Seed sources ranged from Norway south to Switzerland and east to Yugoslavia, Poland, and Romania. Most of the lots suffered heavy mortality in Minnesota during the open winter of 1943-44. In Lower Michigan, 15 years' growth and survival have differed widely between seed sources. Among the poorest lots are one from Finland and another from Norway. The two best lots include one from Poland and another from Czechoslovakia.

3. In 1955 seed collections were initiated for a study of variation in white spruce over its entire botanical range. Because of poor seed crops in some localities additional collections had to be made in 1956 and a few more will be required in 1957. When completed the collections will represent 28 localities as follows: The Adirondacks, the White Mountains, Maine, New Brunswick, Newfoundland, 3 localities in Quebec, Li. localities in Ontario, Michigan, Wisconsin, Minnesota, 3 localities in Manitoba, 2 localities in Saskatchewan, the Black Hills, Montana, Alberta, northern British Columbia, Northwest Territory, and 3 localities in Alaska. Tests of the 1955 collections showed some marked differences in seed dormancy between sources.

4. To determine whether ecotypic variation has developed in white spruce within a narrow geographic zone, seeds were collected in 1956 in 10 localities in central Upper Michigan ranging from the Lake Superior shore to 40 miles inland. Approximately equal numbers of collections were made in each of 3 zones with frost-free periods of about 140, 110, and 80 days. Topography, annual precipitation, and summer temperatures are similar in the three zones although January temperature increases in severity going inland from the coast. During the first year detailed phenological observations will

be made on the parent trees, and seedlings of each collection will be studied for dry matter production under controlled light and temperature conditions. If promising leads develop, additional studies (including field plantings and volume growth data) will be made.

5. In the spring of 1957 nursery sowings were made of six sources of Norway spruce and two sources of Siberian spruce obtained from specific localities in the U.S.S.R. This will provide stock for further evaluation of these two species originating under continental climatic conditions somewhat comparable to those in the Lake States.

Vegetative Propagation

Vegetative propagation is necessary to obtain a number of plants of identical genetic makeup. It is, therefore, an important adjunct to tree improvement work. Collecting vegetative propagation material along with the seed is especially desirable. To that end the Station has initiated both rooting and grafting studies with fall-collected material.

Cuttings taken from 30- to 40-year-old white spruce trees in the fall of 1955 have failed to root in the greenhouse under a variety of pretreatment and light conditions.

Considerably greater success has attended grafting studies, also made in the fall of 1955. Scions of white spruce, black spruce, and Norway spruce from trees more than 30 years old were side-grafted in the greenhouse on to potted stock of the same three species. Some grafts were waxed, some covered with sphagnum moss, and some enclosed in polyethylene bags. The stocks were pretreated at different daylength and temperature conditions, and the grafts were held under both short-day and long-day light conditions. Seven months after grafting, white spruce was best both as stock plant and scion wood, and the grafts protected by polyethylene bags took best. Highest results (66.6 percent take) of the various treatments and pretreatments occurred when stock given long-day pretreatment was exposed to long-day after grafting. A similar study was repeated in 1956. The root stock was in considerably better condition that year and the overall results were better, ranging from 60 to 100 percent. Results have yet to be analyzed, but indications are that any pretreatment which favors cambial activity of the root stock at the time of grafting will improve the results.

Phenology and Physiology

Much of the success of forest tree improvement research depends upon understanding the phenological and physiological responses of the species involved. The Station has initiated studies in both fields.

In 1956 the Station began a study of white spruce with the threefold objective of determining and describing: (1) the developmental stages in flower formation during the period of pollination; (2) the time interval between pollination and fertilization; (3) the first appearance of primordial male and female flowers and their development through one complete cycle. Observations were made and material collected at specified intervals from early spring to late fall. Microscopic examination of material gave some basis for early identification of male flowers, female flowers, and vegetative buds. Observations are being continued during 1957, and more complete analyses of material will be made.

During 1956 and 1957 three physiological studies involving white spruce were initiated. The first of these was undertaken to determine the minimum chilling requirements of white spruce seedlings and if long-day treatments can compensate for these chilling requirements. If successful, such treatments could make it possible for seedlings to go through two or more normal growth cycles in 1 year's time and thus hasten their development to certain desired stages.

Other work in tree physiology puts the emphasis on the auxin metabolism of the tree. Techniques are being developed for the extraction and assay of the natural auxins of pines and spruces. When perfected the technique will be employed in studies of the induction of flowering, rooting of cuttings, and formation of summerwood. Studies of these phenomena, involving the application of synthetic auxins and auxin inhibitors, are under way at this time.

Controlled Pollination

A basic practice in forest tree improvement research is controlled pollination. One of the studies undertaken by the Station in 1956 had to do with controlled pollination of white spruce. The study had five related objectives: (1) To determine the most effective bag type or combination; (2) to determine the developmental stage at which the female strobili show optimum receptivity; (3) to make a preliminary study of species and self-compatibility; (4) to study techniques for overcoming species incompatibility; and (5) to make a preliminary study of cone insect control methods.

First-year results indicated that (1) a combination of sausage casing and kraft bags was best, (2) the female flowers were receptive to pollination for a maximum of 5 days beginning at the time of the first pollen shedding, (3) several interspecies crosses yielded seed (although no seedlings have yet been grown to check for hybrids), (4) none of the hormones tested overcame species incompatibility[3], and (5) lindane gave partial control of cone insects. A modified repetition of the study was made in 1957, but was limited by poor flower production.

Selection

Beginning in the summer of 1957, apparently superior spruce trees noted by National Forest Rangers and others throughout the region are being checked by the Station genetics staff. Any promising trees will be propagated and used in later breeding studies.

Future Plans

Most of the Station's tree improvement work is now centered at the newly established Northern Institute of Forest Genetics at Rhinelander, Wisc. So far the emphasis has been on white spruce. Plans are to extend the research to other spruces, however, and as facilities permit, to several other important genera. The work in physiology will be strengthened, and it is planned that related work in pathology and entomology also will be added to round out the necessary attack on the problems to be solved.

[3] The authors apparently are using the term "incompatibility" in its broadest usage; not in its restrictive genetical application. Editor.