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OF THE

COMMITTEE on FOREST TREE BREEDING

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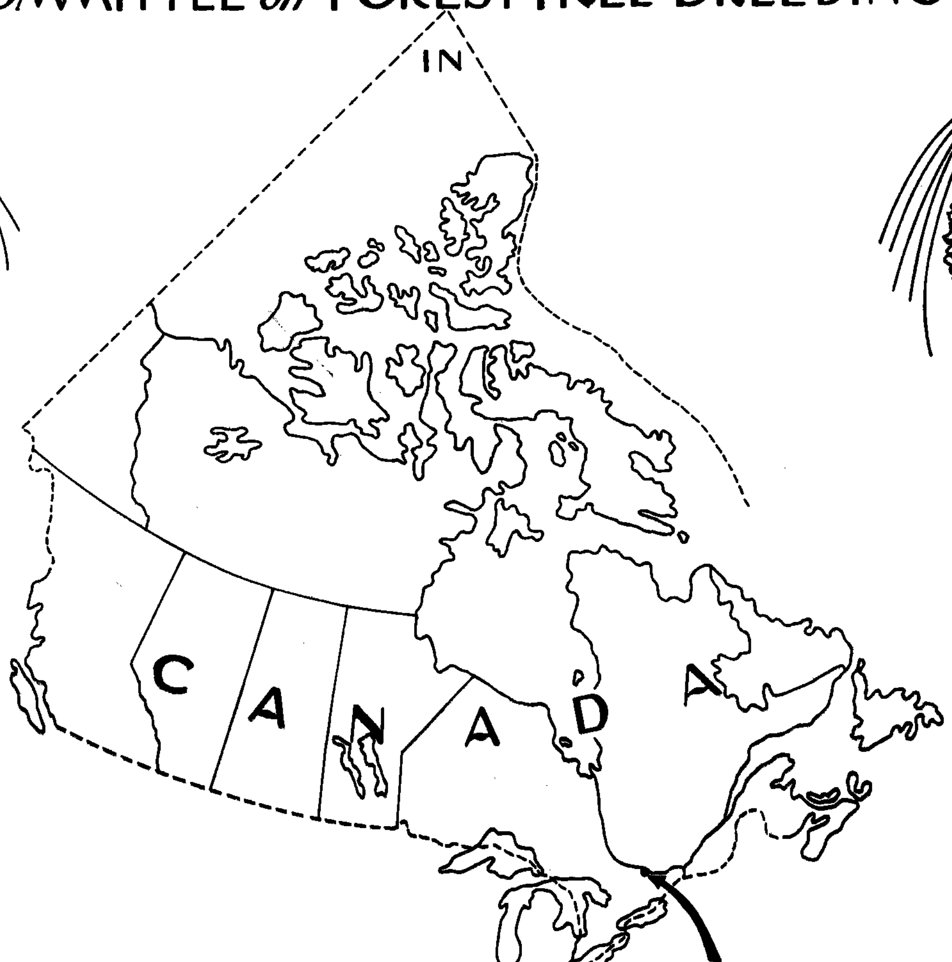

HELD AT
PETAWAWA FOREST EXPERIMENT STATION
SEPTEMBER 16th.– 18th.
1964

Part II

Reports and Papers

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PROCEEDINGS OF THE NINTH MEETING OF THE COMMITTEE ON FOREST TREE BREEDING IN CANADA

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Enquiries may be addressed to the authors or to the Secretary, C.F.T.B. in C., Petawawa Forest Experiment Station, Chalk River, Ontario, Canada.

The Tenth Meeting of the Committee will be held at the University of British Columbia, Vancouver, B.C., in August, 1966. Canadian and foreign visitors will be welcome. Upon request, further information will be distributed early in 1966.

If your name, title or address is incorrect or incomplete, please complete and return the correction slip below.

To: Secretary, Committee on Forest Tree Breeding in Canada,
Petawawa Forest Experiment Station,
Chalk River, Ontario.

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PART 11

REPORTS AND PAPERS

Assembled and distributed by the
Department of Forestry of Canada, Ottawa

Part I, Minutes and Discussions, received restricted distribution to Committee members only. Part II received wider distribution to persons and organizations actively engaged or interested in forest tree breeding and improvement.

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VISITORS' PAPERS AND NOTES FROM ILLUSTRATED TALKS

LIST OF ACTIVE MEMBERS OF THE COMMITTEE ON FOREST TREE BREEDING IN CANADA, SEPTEMBER 1964

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MEMBERS' PROGRESS REPORTS

The incidence of apparent recovery from blister rust in white pine seedlings from resistant parents

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Documented recovery of trees from infection by wood rusts has been reported in the literature for both white pine infected with blister rust (Hirt, 1948; Riker, et. al. 1943; Struckmeyer and Riker, 1951), and slash and loblolly pine infected with fusiform rust (Snow, et. al. 1963). In the case of white pine recovery was due to the formation of wound periderm (Struckmeyer and Riker, 1951) which resulted in the expulsion of the fungus from the cortical tissue of the host, while in slash and loblolly pine, resistance appeared to be the result of increased development of the host which more or less enclosed the fungus (Snow, et. al. 1963). While these reports suggest that recovery from disease has a genetic basis, evidence in white pine clearly shows (Patton and Riker, 1960; Rhoads, 1920) that host vigour also markedly affects susceptibility or resistance. Whether host vigour is altered by environmental (predisposing) factors or by other agencies such as inbreeding (Heimburger, 1962). It is of importance to the tree breeder and the forest pathologist especially, to be able to separate genetically based resistance from induced resistance which may exert only transitory effects.

Some information in relation to this subject was observed in a study of 157 seedlings[1] representing eight crosses from naturally resistant parents.

[1] Seedlings were kindly provided by Dr. C. Heimburger, Ontario Dept. of Lands & Forests. The male parent was the same in all cases. Parent trees were located in Pointe Platon, P.Q. Each selection consisted of 20 seedlings except for two, one of which has 19 seedlings and another 18 seedlings.

After two series of inoculations, two seedlings were still uninfected, four died prior to recording susceptibility and 151 developed cankers. Living seedlings were maintained for a period of one year to determine if any recovery from disease existed.

Seedlings were assumed to have recovered when the cankers appeared shrunken and dried out and when growth was normal. Of the 151 seedlings, 8 gave initial evidence of recovery. Five of these seedlings came from one cross. Portions from the canker margins of all resistant seedlings were then fixed and embedded in wax and sectioned in order to determine, if possible, the reasons for recovery. Of the eight seedlings, five had produced an active wound periderm which eliminated the fungus and of these, four were produced by one cross (Population 737). The remaining seedlings could not be classified with certainty and have been retained for further study. The preliminary data, however, suggest that as indicated previously by Struckmeyer and Riker (1951) wound periderm formation may be an active stem resistance factor present in some selections but not in others.

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Quality wood study

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Three symposia on wood quality were held in 1959 to determine the future needs of the wood-using industries, particularly the pulp and paper industry. In brief, the results of these discussions indicated that for certain uses it was still necessary to provide ample supplies of quality woods.

Mainly as a result of these symposia the Ontario government undertook a quality wood research program, in which the Research Branch, Dept. of Lands and Forests; the Ontario Research Foundation; and the Faculty of Forestry, University of Toronto, were to be closely related. The general objectives of these studies is to define more specifically those wood characteristics which form the basis of superior quality in end-use products and endeavour to relate these characteristics to hereditary and environmental factors.

The Ontario Research Foundation obtain an annual grant from the provincial government to carry out a quality wood program directed by a Steering Committee comprising Dr. J.W.B. Sisam, Dean, Faculty of Forestry, Mr. R.N. Johnston, Chief, Research Branch, and Dr. S.G. Reid, Director, Organic Chemistry, Ontario Research Foundation. Their program is divided into two spheres of activity: anatomical studies under Dr. J.L. Ladell, and studies of wood chemistry under Dr. G.H.S. Thomas.

The function of the Quality Wood Unit is to ensure that the program carried out by the Ontario Research Foundation is directed to the aims of the Steering Committee, and to relate these findings to field applications, thus providing an improved wood supply for industry. In addition, trials will be run to assess the natural variations found in specific wood properties such as wood density and spiral grain.

During 1961 and 1962 a program was organized at the Ontario Research Foundation and Dr. Thomas prepared a series of reviews relating to the evaluation of wood species for their pulping characteristics. At this time, trials were conducted to develop techniques for pulping small wood samples and testing their paper strength. Aspen (populus tremuloides) wood samples were used in this preliminary work. Black spruce (Picea mariana) was accepted as the significant species for study in 1963.

WOOD FIBRES

Dr. Ladell is studying relationships between external foliar characteristics and wood fibre morphology. He first assessed the relation between needle spacing on shoots and needle mass per unit length of shoot for black spruce. He found that with increasing needle density, weight per needle tended to decrease, but needle weight per centimetre increased. There was a significant positive correlation between needle weight per centimetre and height or diameter. The study was based on 30 trees in each of four age-classes from 16 to 150 years, in the Cochrane District of northern Ontario.

General verification of this relationship was determined by the Research Branch for a 100 tree samples from a 16 year old black spruce plantation at Moonbeam in Kapuskasing District, belonging to the Spruce Falls Power and Paper Co. A foliage sample was used including 1961-63 internodes from a mid-height branch. In this sample there was a highly significant correlation ($F=8.27^{**}$) between tree diameter at breast-height and needle mass per centimetre of shoot length. There was not a significant correlation ($F=0.97$) between tree height and needle mass.

The objective of the present phase of the investigation at the Ontario Research Foundation is to develop a relationship between needle mass and fibre morphology.

WOOD CHEMISTRY

Dr. Thomas has established a procedure for simultaneously pulping 16 samples of black spruce chips by the sodium bisulphite process, using a wood sample of 5 grams to 20 grams. With this chemical it is possible to duplicate the preparation of pulping liquor, and with the aid of an oil bath having temperature changes controlled by a Temperature Programmer Transmitter to obtain an exact cooking schedule. Other equipment is available to make small sheets of paper and to run standard paper tests such as tensile, burst and tear strength.

One of the defects in paper is caused by compression wood. The chemical section pulped compression wood and non-compression wood samples taken from the same disc. The tests are not yet complete but it is evident that compression wood does not pulp as thoroughly or as quickly as non-compression wood. The chemical differences of these pulps and the quality of the paper they make have yet to be determined. When this has been done, tests can be run to determine the effects on paper strength of various proportions of compression wood. Then in subsequent sampling for particular fibre characteristics, the effect of a proportion of compression wood can be better evaluated.

Interspecific crosses in the genus Abies

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The program of crossing foreign species of Abies with local A. balsamea is still under way. The principal aim of this investigation is still the production of interspecific hybrids that may bring together qualities of growth, resistance, etc., of interest to tree breeders.

Pollen from the following foreign species have been used successfully in crosses with A. balsamea: alba, Ernesti, fraseri, homolepis, koreana, lasiocarpa var. arizonica, nobilis, nordmanniana, and sachalinensis. These hybrid seedlings are growing in a "natural" environment well suited to the growth of the local species. Possible damage of the severe winter of 1963-64 has not been assessed as yet. A study of these hybrids with respect to morphology, cytology, etc., is being conducted.

1962-63 Biennial progress report
Shelterbelt tree breeding

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Favourable weather conditions prevailed for the 1962 - 1963 nursery programs. The frost free period of 1962 was 117 days (May 9 to September 18), and that of 1963 was 150 days (May 23 to October 19), while the precipitation in the frost free periods was 9.8 and 17.6 inches, respectively. The amount of bloom on Caragana in 1962 was apparently severely reduced by the drought of 1961, whereas the opposite was noted on Colorado Spruce, for which there as an abundance of both male and female flowers on all selections. Following the abundant crop of cones in 1962, very few spruce selections had any bloom in 1963. Shortage of male bloom was especially noted for spruce, consequently all controlled-pollinations in 1963 were performed with stored 1962 pollen.

On April 1, 1963 the former Forest Nursery Stations of Research Branch at Indian Head and Sutherland were transferred to the Prairie Farm Rehabilitation Administration of Canada Department of Agriculture and re-designated "Tree Nurseries". The investigational program has consequently been changed to support increased tree production.

Staff changes included the transfer of Dr. R. Grover, Plant Physiologist, to the Experimental Farm at Regina, Saskatchewan. Mr. P.J. Salisbury, Pathologist, resigned and Mr. A.C. Patterson was appointed Nursery Manager. Mr. C.H. Lindquist has of necessity taken charge of the Tree Improvement Program.

CARAGANA BREEDING

The Siberian pea-tree (Caragana arborescens Lam.), the common caragana, has proved the most reliable species of woody plants for field shelterbelt plantings in the Canadian prairies since 1908.

Evaluation of combining ability for vigour has been the major phase of a breeding program since 1949 to produce more vigorous hybrids of Caragana arborescens Lam. for field shelterbelt plantings. Regrettably, self-incompatible selections to 1953 proved cross-incompatible so that new accessions were sought for genetic diversity. In 1961 and 1962 all vigorous selections of accessions from U.S.S.R., U.S.A., and Europe were evaluated as to their self-compatibility.

The number of ovules per ovary were recorded for 109 selections from seven seed sources. The results, listed in Table 1, indicate that seed source has some influence on the number of ovules per ovary. The accession material originating in the more northern climates apparently has more ovules, indicated by a mean of 19.1 ovules for accessions from Finland and only 11.7 for U.S.A. material.

TABLE 1. Frequency Distribution of Number of Ovules per Ovary for Six Seed Accessions and One Local Hybrid of C. arborescens.

Frequency class (ovules)	Accessions						
	Finland (D138)	USSR (D190)	USSR (D191)	Norway (D142)	Sask. (A101)	U.S.A. (D180)	Hybrid (B24 x V2)
No.							
0 - 1	-	1	-	1	-	-	3
3	-	-	-	-	-	-	-
6	-	-	1	-	-	3	-
9	-	1	5	-	2	7	2
12	-	11	3	1	5	10	14
15	2	43	16	7	9	8	40
18	16	82	36	7	4	2	21
21	15	57	33	3	-	-	2
24	1	32	13	1	-	-	-
27	-	5	1	-	-	-	-
Mean	19.1	18.5	18.5	16.6	14.3	11.7	15.0

In 1963, 22 selections having low self-compatibility were selfed and cross-pollinated with three original self-incompatibles (B2-4, A-1 and V-16) and one self-compatible (V-2) selections. Pollen from each of the 22 selections was applied to one self-incompatible (V16) seedtree. These self-, cross-, and open-pollinations are summarized in Table 2.

It was evident that all the new self-incompatible selections were also

TABLE 2. Self-, Open- and Cross-Compatibility * of Selected Accessions of Caragana.

Seedtree Accessions ♀	Pollens ♂ and Percentage set *						Set(♀)*
	Selfed (%)	B2-4 (%)	A-1 (%)	V-16 (%)	V-2 (%)	OP (%)	V16 (%)
D191-71	0	0	0	0	7	5	0
D143-2	0	0	0	0	2	0	0
D142-6	0	0	0	0	5	2	0
D16-10	0	0	0	0	46	24	0
D180-20	0	0	0	0	15	0	7
D-16-3	0	0	0	0	21	4	7
D180-19	0	0	0	0	0	0	21
D180-12	0	0	0	0	0	0	27
D190-1	0	0	0	0	0	0	29
D180-24	0	0	0	0	14	2	35
D14-112	0	0	0	0	0	-	37
D10-13	0	0	0	0	8	0	39
D180-23	0	0	0	0	0	0	41
D14-12	0	0	0	0	5	17	50
D14-26	4	0	0	0	40	83	21
D191-31	4	0	0	0	0	4	30
D190-6	5	-	10	7	32	0	21
D191-14	6	0	2	0	19	0	31
B14-71	7	12	0	2	0	0	14
D191-49	11	0	0	0	31	12	28
D14-13	11	7	4	6	0	6	56
D11-8	13	0	0	0	0	0	10

*Compatibility expressed as % of pollinated flowers-setting pods.

cross-incompatible when pollinated with the original self-incompatible selections. However, when V16 was used as the seedtree, pollinations by all except four of the 22 accession selections produced a good seed crop. These new 18 self-incompatible selections will be used as seedtrees and pollinated by vigorous self-fertile selections for future progeny tests of the vigour potential for the various combinations.

High general combining ability (C.A.) for vigour has been manifested (Table 3) by the superior mean height of hybrid progenies for one self-incompatible Ⓢ and one self-compatible Ⓧ selection, B2-4 and B2-7, respectively. Maximum specific C.A. for vigour was demonstrated by the hybrid combinations B2-4 x B2-7 and B2-4 x V2. The three selections constituting these superior hybrids must now be propagated vegetatively and paired-planted in isolated crossing plots for the mass production of hybrid seed on the self-incompatible clone.

TABLE 3. Comparative C.A.* of 34 Hybrid Caragana Progenies from Combinations of Self-incompatible Ⓢ and Self-compatible Ⓧ Selections after 4-, 6- and 8- Years of Growth.

Pollen of Ⓧ Selections	Ⓢ Seedtrees Selections					Mean Heights		
	B2-4	21-16	A-1	V16	15-2	4 Yrs.	6 Yrs.	8 Yrs.
	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
B2-7	250	-	233	210	-	114	190	231
V-2	252	227	214	207	220	109	184	224
B2-4B	244	223	216	209	-	112	189	223
B4-2	247	223	234	221	189	88	172	223
B5-1A	224	-	227	214	200	105	181	216
13-5	226	-	205	-	-	100	176	216
10-3	220	211	226	199	-	100	178	214
B5-5	-	-	225	200	-	95	172	212
B4-5	217	224	184	193	207	100	167	205
Means	235	222	218	207	204	103	179	218

*Combining ability measured in terms of linear plant height in centimetres.

Combining ability for vigour when expressed as height, for three self-incompatible Ⓢ selections (A-1, V-16, 15-2) with 13 vigorous Ⓧ selections is summarized in Table 4. The plants were from greenhouse sowings and field planted in 1957. It is evident from the mean height data, that the relative heights change from year to year. In 1958, progeny of the selection 7-9 was ranked eighth, whereas in 1963 it ranked first. Only progeny of selection 10-4 consistently demonstrated the lowest vigour. The most vigorous progeny were

TABLE 4. Comparative Heights* of Eight-Year-Old Progenies of <u>Caragana arborescens</u> from Combinations of Three Seedtrees with Thirteen Selections.

Selections (Ⓧ) ♂	Seedtree (Ⓢ) ♀ and Height (cm)				Annual Growth
	A-1	V-16	15-2	Mean	
7-9	222	216	223	220	43
13-8	201	218	234	218	33
B2-7	220	206	-	213	32
B4-2	211	212	210	211	32
16-1	206	215	-	210	32
10-3	-	-	209	209	33
B3-3	213	201	211	208	33
21-29	209	203	-	206	32
13-1	205	200	-	203	30
8-4	190	208	207	201	30
B3-5	190	204	198	197	30
7-7	198	197	193	196	31
10-4	191	195	185	191	31
Mean	205	206	208	206	32

*Vigour expressed as height of plants in centimetres.

produced by the selection 7-9, which exhibited an annual growth rate of 43.0 cm., compared with a general mean of 32.4 cm. for all progenies tested. Thus the selection 7-9 has high general combining ability for plant vigour. Highest specific combining ability for vigour was demonstrated by progenies of 15-2 x 13-8 and 15-2 x 7-9. Clonal material of the three parental selection (15-2, 13-8 and 7-9) should be vegetatively propagated from cuttings and set out in isolated crossing blocks for natural production of hybrid seed on the self-incompatible clone.

Effect of size of seed on ultimate tree vigour or height was investigated with a 1956 field planting of caragana seedlings from two sizes of seed. Height data are presented in Table 5, for seedlings from seed of two diameters and five inbred progenies as one- to eight-year-old plants. The effect of seed size on progeny vigour differed between seedtrees. Inbred seedlings of V-10 were generally larger for the 3.0 mm. seed, while those of the other four progenies had the most vigorous seedlings from the larger 3.5 mm. seed. The maximum increase in height for seedlings from the 3.5 mm. seed occurred at the fifth year. However, over a period of eight years the average annual growth

TABLE 5. Height* of the One-, Three-, Five- and Eight-Year-Old Seedlings of Five inbred Caragana Progenies from Seed of Two Sizes.

Age of Seedlings	Seed** Size	Inbred Progenies & Heights*					Mean
		V-3	V-10	21-27	B4-4A	B4-4	
(yrs.)	(mm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)
One	3.5	20	20	32	17	20	24
	3.0	16	23	26	10	14	18
Three	3.5	53	61	63	63	80	64
	3.0	43	59	64	49	65	56
Five	3.5	137	125	126	140	166	139
	3.0	94	125	120	136	144	124
Eight	3.5	202	194	222	231	261	222
	3.0	180	210	208	211	269	216
Annual Av.	3.5	26	25	27	31	34	28
	3.0	23	27	26	29	36	28

*Vigour or height of seedlings expressed in centimetres.
**Diameter size of seed expressed in millimetres.

was the same for seedlings from both sizes of seed. It appears that seedlings from large seed become established earlier than seedlings from smaller seed, but seedling vigour due to seed size tends to disappear after eight years of growth.

Natural self- and cross-pollinations for *C. arborescens* have been estimated from self- and open-pollination progenies by use of genetic markers. Two types of such genetic markers have been reported (Proc. Gen. Soc. Can. 3:47-94. 1958) for caragana, namely one simple recessive "p" for the pendula character governing the production of the 'pendula' habit of growth, and another "a" for the albino character governing production of 'yellow-white' chlorophyll-deficient lethal seedlings. In 1962 self- and open-pollinated seed were harvested from one selection, which was heterozygous (Aa) for a chlorophyll deficient factor. Data from greenhouse germination of this seed have been summarized in Table 6.

TABLE 6. Segregation for the Albino character in Self- and Open-pollinated Seedlings of Y26Y.

Seed		Seedlings		X^2	Genotypes of seedlings	
Tree	Pollen	green	yellow	value	green	yellow
Y26Y	self	148	49	.001*	AA,Aa	aa
Y26Y	O.P.	280	48	14.090	AA,Aa	aa

*good fit to 3:1 ratio

From the results listed in Table 6 it is evident that approximately 131 (328-197) of the open-pollination seed or 40% were produced by natural cross pollination and some 60% (190) was the result of natural self-pollination. Further information is required from several trees over a period of years to establish a range of natural cross-pollination for the species. However, for the present it may be assumed that natural cross-pollination of caragana approaches 40%.

SPRUCE BREEDING

Colorado spruce (*Picea pungens* Engelm.) has proven the most promising spruce species to date for home shelterbelt and park plantings on the calcareous soil of the prairie region. It has demonstrated a resistance to the pine needle scale and spider mite, infestations of which no doubt contribute to losses of white and Norway spruce during drought years. Resistance of Colorado spruce to these insects appears to be related to the intensity of "blue" needle coloration, genetics of which is being investigated.

The drought of 1961 apparently stimulated the development of sexual buds of _Picea pungens_ resulting in an abundance of bloom for all selections in 1962. Some 55 seedtree selections were evaluated by self-, cross- and open-pollinations. Self-compatibility ranged from 0 to 59 sound-seed per cone for a mean of 7.2. Cross-compatibility for three pollens ranged from 0 to 101 for a mean of 16.6. Open-pollination ranged from 3 to 156 for a mean of 63.9. Nine selections were self-incompatible, and of these, three were cross-incompatible. The other six self-incompatible selections will be grafted for planting in isolated hybrid seed production plots. Severe insect damage occurred in many isolation bags despite spraying the branches with insecticides prior to isolation. This indicates the need for further research on the control of cone and seed insects of spruce.

The influence of five levels of sucrose, boron and pH on viability of spruce pollen was investigated in 1962 using a basic medium of 1.5% water-agar with the results listed in Table 7. Germination for pollen of Colorado spruce increased from 39 to 71% as sucrose content of the media increased from 0 to 10%, but reduced at higher sucrose levels. On the other hand, germination for pollen of white spruce increased from 4 to 57% as the sucrose level was increased from 0 to 15%, then decreased to 16% at the 20% sucrose level.

Germination of Colorado spruce pollen was not affected by boron at 1 and 5 ppm. Higher boron concentrations actually reduced germination. Germination of white spruce pollen on the other hand, was increased by boron at 1, 5 and 10 ppm with reductions at higher concentrations. Germination for pollen of both spruce species improved by increasing the pH of the media from 2 to 3, but was gradually

TABLE 7. Germination and Growth of Colorado and White Spruce Pollen under Five Levels of Sucrose, Boron and pH.

Species	Level*	Germination**			Growth†		
		sucrose (%)	boron (%)	pH (%)	sucrose (u)	boron (u)	pH (u)
Colorado Spruce	1	38.8	50.6	0.8	47.4	103.3	5.5
	2	67.1	53.0	61.6	153.0	116.7	96.6
	3	71.0	50.0	60.1	159.9	96.8	143.7
	4	40.9	37.8	56.9	91.2	81.4	136.3
	5	0.8	27.2	39.2	6.5	59.7	77.9
	Mean	32.7	43.7	43.7	91.6	91.6	91.6
White Spruce	1	4.5	30.9	39.4	12.7	41.8	57.2
	2	34.2	45.9	44.6	50.7	86.7	75.5
	3	56.8	40.7	40.5	87.8	64.6	67.6
	4	57.3	34.6	35.3	99.9	56.7	63.2
	5	15.7	16.4	8.6	40.4	41.6	28.0
	Mean	33.7	33.7	33.7	58.3	58.3	58.3

*Levels-Sucrose - 0,5,10,15,20, per cent by weight
-Boron - 0,1,5,10,50 ppm
-pH - 2,3,4,6,8 for Colorado and 3,4,5,6,8 for white spruce.
**Germination as average % for 2 replications of 100 pollen grains.
†Growth of pollen tube in microns.

reduced by higher pH levels. Germination of white spruce pollen was only 8% at a pH of 8.0, whereas that for Colorado spruce was 39% indicating greater tolerance of Colorado spruce to highly alkaline conditions.

The pH of the female flowers of Colorado and white spruce mascerated in distilled water was 3.5 and 4.6 respectively. The pH of the pollens in solution was found to change and become constant at about 6.5, irrespective of the initial pH of the original solution (Table 8). It is apparent that although

TABLE 8. Changes of pH for Solutions with Pollen of Colorado and White Spruce.

Pollen types	original* pH	pH recorded after			
		10 min.	2 hrs.	6 hrs.	24 hrs.
Colorado Spruce	8.0	7.00	6.00	6.05	6.50
	5.0	5.51	5.45	5.80	6.30
	3.0	3.40	4.75	5.60	6.20
White Spruce	8.0	6.70	6.02	6.25	6.70
	5.0	5.70	5.72	6.00	6.60
	3.0	3.40	4.90	5.70	6.20

*pH adjusted with Hydrochloric acid or Sodium hydroxide.

the pH of the germination media for pollen will change, the initial pH is important to effect good germination as illustrated in Table 7. Buffer solutions were tried to overcome this phenomenon, however the pollen failed to germinate on any of the buffers tested.

Cross- and self-compatibility determinations were continued in 1963 for 'blue' selections of Colorado spruce (Picea pungens Engelm) with the objective of mass production of 'blue' seedlings. Scarcity of male and female bloom for Colorado spruce prevailed in 1963, evidently due to unusual climatic conditions or the abundant seed-crop of 1962. This situation seriously limited the breeding program for 1963 and necessitated the use of stored 1962 pollen from one 'blue' and one 'green' selection. Viability of the stored 1962 pollen from these two 'testers' varied as to the type of storage. Pollen stored at 0°F in sealed jars manifested germination of 85.5% on water-agar in 1963, whereas that stored in open jars gave 71.6% germination. On the other hand, pollen stored at 41°F in sealed containers germinated 46.1% and in open jars 0%. Controlled pollinations as conducted for 16 'blue' selections of Colorado spruce have been summarized in Table 9. Extremely low seed sets were general for Colorado spruce in 1963

TABLE 9. Open-, Self-, and Cross-Compatibility* of Sixteen Colorado Spruce Selections.

Selections ♀	Pollens ♂ and Seed Set*			
	Open (NO)	Self (NO)	XNC4-16† (NO)	XRC-1† (NO)
NC2-135	2.2	22.0	-	24.9
NC4-110	0.0	-	184.0	24.0
NC4-5	-	-	-	21.2
NC2-142	18.2	-	18.4	16.9
NC7-3	1.3	-	25.0	15.0
NC7-2	0.0	0.0	-	6.8
NC2-141	10.0	7.7	44.9	6.5
NC5-112	0.0	-	-	3.9
NC4-122	0 0	0.0	-	0.0
NC4-60	0.0	0.0	-	0.0
NC4-96	0.0	0.0	0.0	-
NC4-121	-	0.0	-	0.0
NC7-1	0.0	-	-	0.0
NC4-125	0.0	-	-	0.0
NC4-126	0.0	-	-	0.0
NC5-15	0.0	0.0	-	0.0

*Compatibility expressed as number of seeds per cone harvested. - Not pollinated due to scarcity of stored† or fresh pollen.

even for natural open-pollinations, and also following artificial self- and cross-pollinations. Nevertheless, the results in Table 8 demonstrate that hybrid seed was obtained from both crosses on four trees for subsequent genetical analysis. Only one of the new selections appears to be both self-incompatible and cross-compatible; as required for mass production of the hybrid seed.

Seed from 67 self-, cross-and open-pollinations of the 1962 breeding, was sown in a seedbed in 1963. Severe damping-off losses (78.9%) occurred in some rows despite two fungicidal drenches of Captan. Survival in August of this sowing was only 35% (2937 seedlings).

Hybrid seedlings from 24 Colorado spruce selections were transplanted in 1963 from the seedbed to the transplant plots. This material will be field planted in 1965 to evaluate vigour and 'blue' color characters for the various hybrid combinations and for future seed production.

ELM BREEDING

The Siberian elm (Ulmus pumila L.) has demonstrated a resistance to drought and rapid growth as plantings in the drier regions of the prairies. Regretably it is very susceptible to damage from 2,4-D, and as a seedling manifests an indeterminate type of growth in the nursery row.

Inbreeding studies were initiated in 1961, when 22 selections of the Siberian elm were self-pollinated. Seven of the 22 selections appeared self-incompatible, whereas the remainder produced from 0.5 to 43.1% sound seed per isolated branch. The respective set of sound seed per branch on open-pollination varied from 0 to 99%. These results suggest that some degree of self-incompatibility may exist within the species. Germination capacity of the open-pollination seed was 70.9%, and that of the inbred seed was 62.2%. Fifteen of the resulting inbred progenies were field planted in 1963 to evaluate the genotypes of the original selections. Segregation within these inbred progenies may permit selection of earlier defoliating lines which would be valuable to facilitate harvesting of nursery seedlings.