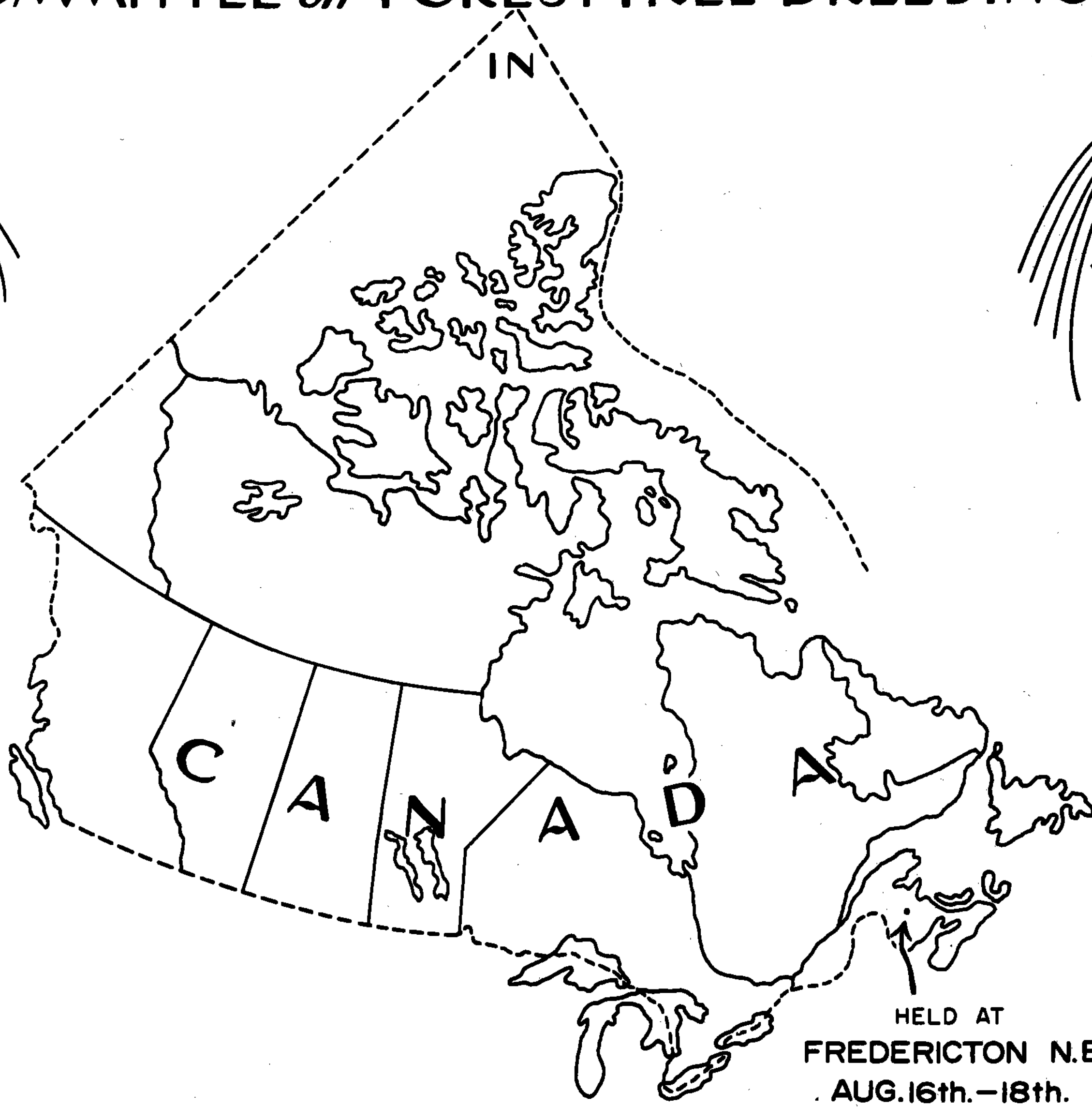
Proceedings of the Eighth Meeting
OF THE
COMMITTEE on FOREST TREE BREEDING
IN
CANADA



HELD AT
FREDERICTON N.B.
AUG. 16th.–18th.
1962

Part II
Progress Reports

PROCEEDINGS OF THE EIGHTH MEETING OF

THE COMMITTEE ON FOREST TREE BREEDING

IN CANADA

Held at the University of New Brunswick, Fredericton, N.B., August 16-18, 1962.

PART II

MEMBERS' PROGRESS REPORTS

Assembled and Distributed by the
Forest Research Branch, Department of Forestry, 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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Report to Committee on Forest Tree Breeding

1962

Michael G. Boyer

Canada Department of Forestry
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One request by tree breeders with respect to white pine blister rust work has been for methods of selecting seedlings and grafted material which would establish with certainty the resistance or susceptibility of the host. While probably the most effective method would involve the characterization of the rust resistant factors, the aspect we are at present investigating, techniques of inoculation could perhaps be improved. During initial studies on the physiology of the disease some techniques of inoculation were investigated to provide information on specific aspects of the disease. Four were attempted on white pine seedlings in the laboratory; a) pre-germinated teliospores prepared by removing telia from _Ribes_ leaves incubating on 2 per cent water agar at 16°C for 12 hours and applying them to parts of the seedling, b) aeciospore inoculation of leaves and stems with and without wounding and with or without _Ribes_ leaf extract, c) implantation of diseased leaf tissue in the hypocotyl region of the seedling and, d) inoculation with excised _Ribes_ leaves.

Infection was attempted by incubating seedlings at 15°C in the dark for five days in closed containers. Number of inoculations and successful transmission are indicated in Table I. A brief discussion of each method follows.

Table I

Effect of method of inoculation on infection of white pine seedlings

Number of Seedlings	Method	Place of Inoculation	Number	Number infected
50	aeciospores*	hypocotyl	50	0
6	"	cotyledons	20	0
10	"	primary leaves	23	0
66	excised telia	cotyledons	122	2
	"	primary leaves	120	5
	"	true leaves	100	4
	"	hypocotyl	21	0
34	infected white pine leaves	hypocotyl	34	3
24	Ribes leaves			24

*Methods of aeciospore inoculation are not listed completely because none was successful.

Inoculation with aeciospores

Scholz's report* that aeciospores caused canker-like infections when wound inoculated on white pine stems suggested a possible simple method of infecting seedlings. As a consequence seedlings were inoculated at various locations (Table I) either directly without wounding or by brushing viable aeciospores into a small longitudinal wound made with a sharp scalpel. An extract of Ribes leaves was included in some inoculations. To complement this study field inoculations were carried out on 50 first, second and third year shoots of approximately 15-year-old white pine. Under these circumstances no infection developed after five months although germination of aeciospores in the wounds were observed in all embedded material. Since in the case of seedlings infection could be induced on all parts by other methods it would appear that infection may be attained only under more restricted circumstances.

Inoculation with excised telia

The purpose of using excised telia was two-fold. By selections of vigorous productive telial columns it was hoped to be able to assure infection at any point and also to study the effect of distance of inoculum from the stem. Since viable telial columns were selected and transfer after 12 hours to 2 per cent water agar resulted in the active production of sporidia the failure to obtain a higher incidence of infection is puzzling. Penetration of sporidia on hypocotyls was observed frequently. Further work has been limited by space, and modification of the method has not been attempted as yet. However, it has been possible to show that all of the leaves are susceptible and while no infections on the hypocotyl were observed the fact that sporidial penetration was evident suggested that some resistance to sporidial infection is present.

Inoculation with the diseased pine leaf sections

Attempts to inoculate seedlings by transfer of thin sections of diseased leaf tissue into the pith region at the base of the cotyledonary node was prompted by the observation that the transfusion tissue of first year leaves promptly forms callus when wounded and placed in a high humidity. The possibility of grafting infected tissue to seedlings was considered. The technique involved the transfer of approximately one mm. leaf sections in which the fungus was located in the transfusions tissue into the base of the node by making a longitudinal incision and inserting the leaf section in such a way as to obtain contact between the pith cells of the hypocotyl and the transfusion tissue of the leaf. In two of the three successful transfers examined in detail the fungus had apparently moved directly into the proliferating cells of the pith and from thence into the ray cells of the xylem. Of the 34 inoculations (Table I)

* See Scholz, E. 1960. Zuchter 30(2), 61-72.

made at about 2 weeks after germination (the cotyledonary stage) none died and further growth impediment was slight or not observable. Failure to obtain a higher incidence of infection was investigated with free-hand material. In most cases the inability to obtain contact between the tissues either because of improper placement of leaf sections or because the leaf sections were not cut at right angles appeared to be the primary cause of failure.

Inoculation with excised leaves of Ribes

This method which has been used frequently in the past was employed to determine if the conditions used for inoculation, i.e., 5 days at 15°C in the dark, were satisfactory. Of the 24 seedlings inoculated 100 per cent exhibited dense multiple infections within one month.

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ONTARIO
DEPARTMENT OF LANDS AND FORESTS

Toronto, Ontario

REPORT TO COMMITTEE

ON

FOREST TREE BREEDING

August, 1962

Hon. J. W. Spooner
Minister

F. A. MacDougall
Deputy Minister

J. A. Brodie, Chief
Timber Branch

REPORT TO COMMITTEE ON FOREST TREE BREEDING

August 1962

A. J. Carmichael

Ontario Department of Lands and Forests

1 PROVENANCE TESTS

A. Red Pine

A red pine provenance test composed of 12 Ontario seed sources was outplanted in 1956. Measurements of total height, after 10 growing seasons from seed, were made in fall 1961 at Cochrane, Sault Ste. Marie and Lindsay Districts in northern, central and southern Ontario.

Mean Height in Feet for Red Pine Sources

Provenance		Planting Location - Site Region		
Site Region	Locality	3E	5E	6E
3W	Port Arthur	1.6	3.1	3.9
4S	Eagle River	1.5	2.9	3.8
4E	Timagami	1.7	3.2	3.9
5E	Barry's Bay	1.5	3.2	4.0
	Douglas	1.7	3.3	4.1
	Golden Lake	1.7	3.2	3.7
	Mattawa	1.5	3.1	3.7
	Pembroke	1.7	3.3	4.0
	Thessalon	1.6	3.3	3.6
	Average	1.61	3.20	3.86
6E	Angus	1.6	3.1	3.9
	Bruce	1.7	3.2	3.8
	Kemptville	1.7	3.4	4.2
	Average	1.67	3.25	3.97
General Average		1.62	3.18	3.90

An analysis of variance was completed following the design prepared by Dr. D. B. DeLury. This indicated, first, that the experiment had failed to show any significant difference between the heights of different provenances at each of the planting sites; and second, that there was a highly significant difference between the heights of all provenances when grown in different Site Regions. The height of all provenances was greater in the southern planting.

SUMMARY OF ANALYSIS

Source	df	ss	ms	F	F.05
Bet. Climatic Regions	2	129.5	64.7	176.4	4.3 **
Reps. (Within Regions)	9	3.3	0.37		
Bet. Provenances	11	1.6	0.14	<1	2.45
Regions x Provenances	22	0.93	0.04	<1	1.84
Reps. (Within Regions) x Provenances	99	17.1	0.17		
	143				

B. Jack Pine

A jack pine provenance test composed of 12 Ontario seed sources was outplanted in 1955. Measurements of total height after 10 growing seasons from seed, were made in fall 1961, at Swastika and Pembroke Districts in northern and central Ontario.

Mean Height in Feet for Jack Pine Sources

Provenance		Planting Location - Site Region		
Site Region	Locality	4E	5E	Average
3W	Geraldton	5.8	5.5	5.65
	Kab Lake	7.0	6.2	6.60
	Pickle Lake	6.2	5.8	6.00
3E	Connaught	6.6	6.2	6.40
	Timmins	7.1	7.1	7.10
	Franz	6.1	6.0	6.05
	Mobert	5.6	6.3	5.95
4S	Sioux Lookout	7.3	6.6	6.95
4W	Goldie	6.8	7.2	7.00
	Hardwick	6.9	6.8	6.85
5E	Markstay	7.4	7.2	7.30
	Algoma	6.4	6.4	6.40
General Average		6.40	6.60	

An analysis of variance was completed following the design prepared by Dr. D. B. DeLury. This indicated, first, that the experiment had failed to show any significant difference between the height of jack pine grown in different site regions; and second, that there was a highly significant difference in the height growth of different provenances, when the region in which they were grown was not considered.

Summary of Analysis

Source	Df	ss	ms	F	F.05
Bet. Climatic Regions	1	1.16	1.16	3.24	5.99
Reps. (Within Regions)	6	2.15	0.35		
Bet. Provenances	11	27.84	2.53	4.71	1.94**
Regions x Provenances	11	4.60	0.42	<1	1.94
Reps. (Within Regions)x Provenances	66	33.80	0.51		
	95				

11 SEED ORCHARDS

The emphasis on seed orchard establishment has been reduced currently in favour of the development of seed production areas. The present target is for 10,000 grafts to be carried out annually at five nursery locations (Sb 3000, Sw 3000, Pr 25000, Pw 1500).

Some changes have been made in grafting procedure to improve scion development. Grafts made at an earlier stage of stock plant development, seem to be beneficial for both spruce and red pine. Spruce are grafted when stock plant root activity is evident and before bud swelling occurs. Red pine are grafted when bud swelling is evident but before shoot elongation has progressed.

The release of developing spruce shoots from constriction within bud scales has been necessary and has resulted in greater survival with better shoot development.

Various methods for fall and early winter storage of understock have been employed to simplify maintenance procedures. Storage of stock growing in 5 inch clay pots has been carried out adequately in unheated sheds with limited natural light. Red pine and white pine have been carried over in excellent condition when no mulch was used on the pots. Some difficulties were experienced when pots and trees were covered with a conifer brush mulch. Further testing is indicated to obtain uniform results and these are being developed at each nursery.

The selection of orchard planting sites for spruce and pine has led to the examination of hardwood areas for the exclusion of foreign pollen. A few sites are available, however the difficulty in locating accessible areas that can be cleared at a reasonable cost, has indicated the possible value of using locations on large burned areas and controlling future planting around the orchard site.

111 SEED PRODUCTION AREAS

A. General

The selection of stands suitable for seed production area development has been hampered by the apparent lack of younger age classes. Therefore, older stands are being selected in which there are from 50 to 100 seed producing trees per acre at heights of from 40 feet to 80 feet. Cone collection from such trees will require the use of tree-climbing bicycles and thus increase seed collection costs. The use of truck or tractor-mounted ladders may be possible in some locations, however, stands of better quality are not always readily accessible and will require less cumbersome climbing equipment.

When tree-climbing bicycles are used extensively, it will be possible to train staff and develop collecting techniques that should enable more extensive collections from the better stands.

The development of plantations from selected seed sources offers one solution to the problem. Some white and black spruce sources are being grown for this purpose. A more extensive local development of select plantations, using seed from the best stands in the district, would provide ultimately for a cone collection source to supplement that from seed orchards and seed production areas in thinned natural stands.

B. White Spruce - Site Region 3W

A location at Pagwa in Geraldton District was scarified to induce seedlings beneath an excellent white spruce stand. Regeneration on the 20 acre block resulted in 20,000 seedlings per acre at the end of the first year. Subsequent counts have not been made, but there are still an adequate number of 2 year old plants.

C. Red Pine, Lynn Tract, Simcoe County

Trees of 12 ft. to 20 ft. in height were thinned to a 12 ft. x 12 ft. and an 18 ft. x 18 ft. spacing in 1957. Five years later the crowns of trees at the 12 ft. spacing again required release, whereas the 18 ft. spacing will be adequate for at least another 5 years and possibly 10 years. The 18 ft. spacing has been accepted generally for thinning in stands up to a 40 ft. height.

The seasonal changes in foliar nutrient levels are being examined on this area by Professor K. Armson. His work will determine the best sampling procedure to assess the nutrient capital of young red pine. When coupled with a measure of the tree's photosynthetic potential it should be possible to differentiate those trees that produce cone crops above their normal level and thus evaluate the true effects of fertilizer treatments.

The physiological factors involved in flower induction and the effects of fertilizer applications on these still need to be examined.

D. Wood Quality

The development of a black spruce seed production area from seed obtained at Parnell Township in Kapuskasing District, necessitated the felling of 32 trees for cone collection. Each of the felled trees was sectioned and blocks 1 foot in length were taken to represent each 100 inch level above the ground. Blocks were measured to develop stem analyses for each tree and then shipped to the Forest Products Laboratory in Ottawa for cellular examination.

REPORT ON TREE BREEDING - 1962

L. P. Chiasson
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After the loss of promising hybrid material in 1960, efforts were continued to produce interspecific Abies hybrids.

In the spring of 1960, the following exotic pollens were used on Abies balsamea female cones: A. cephalonica, A. concolor, A. homolepis, A. homolepis var. umbellata, A. koreana, A. lasiocarpa, and A. nordmanniana.

The hybrid seeds were collected in early September, 1960 and stored in a dry room over winter. They were stratified for a month at approximately 5°C, and then sown in specially prepared outdoor beds. These beds were covered with a double layer of cheesecloth, and were sprinkled once a day through the summer months.

Table I shows the results in terms of cones collected for each cross.

TABLE I

Putative Male Parent	No. of cones collected	Seeds germinated-1961
A. cephalonica	10	
A. concolor	17	
A. homolepis	303	X
A. homolepis var. umbellata	84	X
A. koreana	167	
A. lasiocarpa	70	X
A. nordmanniana	68	

The germination was extremely low not only for these potentially hybrid seeds but also for balsamea seeds that had been collected, planted and stored under identical conditions.

In the spring of 1962 the balsamea-lasiocarpa crosses seemed to be the only ones that had overwintered successfully, but more careful examination of the beds is required before a final assessment can be made.

In the spring of 1961, the only exotic pollen available was from A. nordmanniana. A crop of 49 cones presumably containing hybrid seeds were collected, and after stratification, have been planted this spring.

In the spring of 1962, the following exotic pollens have been used on balsamea ovulate cones: alba, cephalonica, cilicica, concolor, ernesti, Fraseri, homolepis, lasiocarpa var. arizonica, nephrolepis, nordmanniana, sachilanensis, sibirica, Veitchii. Only 92 ovulate cones were isolated this spring, as there was a scarcity of these and many of those that were visible were not available for isolation with the equipment at our disposal.

Investigation of the comparative cytology of *Abies* species is continuing in anticipation of obtaining confirmed interspecific crosses.

1960-61 Biennial Progress Report

Shelterbelt Tree Breeding

W.H. Cram,
Superintendent

Forest Nursery Station,
Canada Department of Agriculture,
Indian Head, Saskatchewan.

GENERAL

Drought conditions, which have prevailed since 1957, were unfavourable to the Nursery and Breeding research programs in 1960 and 1961. 1961 was the driest year on record for this station with an annual precipitation of only 7.5 inches. The frost free period of 1960 was 117 days (May 17 to September 10) and of 1961 was 112 days (May 13 to September 2) and the precipitations in these periods were 4.9" and 1.6" respectively. Heavy losses, due to drought and extreme temperatures, were noted for germination capacity, seedling stand and even mature stands of trees in permanent plantings.

Staff changes included the appointment of Dr. R. Grover in October 1960 as Plant Physiologist, to conduct Herbicidal and seed technology investigations related to tree production, and Mr. P.J. Salisbury, Pathologist in April 1960 to conduct investigations in disease problems related to tree production.

CARAGANA BREEDING

Evaluation of combining ability for self-incompatible selections continued to be the major phase of the Breeding program for *Caragana arborescens* Lam. Preliminary research led to the selection of vigorous self-incompatible plants from Indian Head material. These selections were cross-incompatible and therefore unsuited for planting in isolated natural-crossing blocks to mass produce intra-specific crosses. This demonstrated the need for new accession material to provide additional self-incompatible plants of genetic diversity and cross-compatible with existing material. Cross-compatibility of nine self-incompatible selections from accession material with pollen of five similar selections from Indian Head material was determined in 1961, with the results listed in Table 1.

Table 1. Cross-Compatibility[1] of 9 Self-incompatible Accession Selections with 5 Self-Incompatible Local Selections of Caragana

Accession Selection	Source	Indian Head Selections (♂) A1	V16	V17	B24	V2
(♀)	(country)	(%)	(%)	(%)	(%)	(%)
D10-13	Sweden	0	0	0	0	0
D11-8	U.S.A.	0	0	0	0	0
D14-71	Czech.	0	0	0	0	0
D16-3	France	0	0	0	0	0
D16-10	France	0	0	0	0	6
D14-26	Czech.	0	0	0	0	19
D14-13	Czech.	0	2 ?	0	0	50
D14-112	Czech.	0	0	0	17	48
D14-12	Czech.	0	0	11	15	17

[1]Compatibility as % of cross pollinated flowers setting pods
?Extreme deviate may be contamination due to protruding flowers

The nine selections listed in Table 1 were made in 1959 and 1960, by selfing 140 vigorous plants produced from eight seed accessions. Regretably the 1961 breeding program was seriously disrupted and the results distorted by the prevailing drought and high temperatures. Nevertheless, cross-compatibilities listed in Table 1 suggest four of the accession selections carry the same incompatibility factors as five local selections, and are of the genotype S_1 S_2. However, five of the accessions appear to carry one or more different incompatible factors, which permit cross-compatibility with pollen from three local selections. These accessions offer promise as parental material for the establishment of natural-crossing blocks. In the next few years, it will be necessary to repeat and confirm these 1961 compatibility tests, propagate the selections by cuttings and evaluate the vigor potential of hybrid progenies for all possible combinations.

Relative vigor of hybrid caragana progenies, when evaluated in terms of plant height, was found to change until the seedlings reached sexual maturity after 6 years of growth. Height data, as recorded for eleven polycross progenies after 3, 4, 5 and 6 years of growth from seed, have been summarized in Table 2. Relative vigor, as portrayed by the juvenile seedlings after 3 and 4 years of growth, was maintained beyond sexual maturity for only one of the eleven progenies, namely for V-13. On the other hand that of all other progenies changed in the 5th and 6th years of growth. This change was slight or gradual for some progenies but extreme for others. For example the vigor rankings for the polycrosses V-2 and 21-28 changed from fourth and first place to second and third place, respectively, in the 5th and 6th year, whereas that of 21-31 changed from eleventh to first place. As a result ratings for the vigor potential of hybrid caragana progenies should be postponed until the seedlings attain sexual maturity after 6 years' of growth.

Table 2. Comparative Mean Heights and Rankings of Heights[1] for Eleven Polycross Progenies as 3, 4, 5, and 6 year-old seedlings.

Polycross progeny	Height in centimeters				Rankings for Height			
	3Yr.	4Yr.	5Yr.	6Yr.	3Yr.	4Yr.	5Yr.	6Yr.
21-31	54	80	145	194	11	11	2	1
V-2	73	109	143	187	1	1	4	2
21-28	72	109	148	184	2	2	1	3
21-16	64	98	140	181	7	8	6	4
V-15	68	97	136	178	6	9	8	5
A-1	69	102	142	177	3	3	5	6
A-3	59	99	134	176	9	7	9	7
21-27	68	100	144	173	5	6	3	8
V-16	68	101	140	171	4	5	7	9
V-13	59	92	130	166	10	10	10	10
21-32	64	102	114	156	8	4	11	11

[1]Mean height of some 40 seedlings for each year and progeny

Pollen viability and storage investigations were continued for caragana in 1961. One study involved the influence of sucrose content of water-agar culture media on pollen germination. Pollen from two selections of caragana (V16 and V17) was incubated in petri dishes on 2% water-agar media with 1, 5 and 10% sucrose content. Germination was recorded after 5, 20, 52 and 76 hours of incubation with the results given in Table 3. Germination of pollen increased with each increment

Table 3. Pollen Viability[1] for Two Caragana Selections at Three Sucrose Levels

Incubation Period[2]	A-2			V-17			Means
	1%	5%	10%	1%	5%	10%	
(Hrs.)	(%)	(%)	(%)	(%)	(%)	(%)	
5	45	42	56	32	40	70	47.4
20	26	40	69	45	56	77	52.1
52	26	53	63	24	63	88	52.6
76	43	41	65	33	53	88	53.6

[1]Viability as % germination in one field across petri dish
[2]Then sample removed and stained with Aceto-carmine for recording germination

in the sucrose content of the agar media for both selections and for all periods of incubation. The data showed that germination after 20 hours of incubation on 2% water-agar substrate with 10% sucrose provides a reliable measure of pollen viability for caragana.

Viability of pollen from bud and bloom stages of caragana after two types of storage at two temperatures was investigated. Buds in full color and freshly-opened flowers were harvested from one selection (V17) on June 1st. These were placed in manila paper and polyethylene bags, then stored at 0° and 40°F. Pollen samples were taken from these buds and open flowers after 7, 13, 28 and 42 days of storage, and the germination recorded after incubation for 24 hours at 70°F on 5% sucrose-agar medium. The following conclusions on viability of caragana pollen were drawn from the results of this study: -

(1) Storage temperature at 40°F was superior to that of 0°F;

(2) Storage in paper bags was better than storage in poly bags;

(3) Pollen viability decreases rapidly from 66% to 8% after 13 days of storage;

(4) Buds in full color if stored in paper bags at 40°F seem to provide the best pollen for extending the period for cross-pollinations in a caragana breeding program.

Four types of media were investigated for the rooting of softwood caragana cuttings in 1960. In all cases the rooting media were placed in wooden flats and cultured on heating cables under intermittent mist. Shoots were collected from one clone at 5 bi-weekly intervals from June 8 to August 3 and made into 4" terminal and basal cuttings. Ten cuttings of each sample of 20 cuttings were dipped in 'Rootone' hormone just prior to planting. Records for rooting were taken 21 days after planting and are summarized in Table 4. Rooting was greatest (38%) in a pure medium of local screened sand, and next highest in Flint-shot Ottawa-silica sand. Peatmoss additives had no beneficial influence, whereas applications of Rootone hormone materially increased rooting.

Table 4. Rooting[1] for Terminal and Basal Cuttings of Caragana in Four Media with (+) and without (-) Hormone Treatment

Rooting media	Terminal +	Terminal -	Basal +	Basal -	Media Means
Local screened sand	26	4	72	52	38.5
Ottawa sand Flint shot	2	6	74	52	33.5
Local sand & moss	28	4	44	40	29.0
Ottawa sand & moss	10	16	46	28	24.5
Means	16	7	59	43	

[1]Mean value for 10 cuttings & 5 dates as % of number planted.

SPRUCE BREEDING PROGRAM

Self- and open-compatibility was determined for 31 selections of Colorado spruce (*Picea pungens*) in 1960. Self-compatibility of these trees ranged from 0 to 46 seeds-per-cone and averaged 12; while open-compatibility ranged from 0 to 118 and averaged 51 seeds-per-cone. This wide range for self-compatibility in the species suggests the potential use of self-incompatible lines for the breeding program.

Open-, cross-, and self-compatibilities were also investigated for nine selections of Colorado spruce, which had differed as to self-compatibility in 1959. Two previous selections, RC1 and RC2, which were outstanding for 'blue' needle color, were utilized as pollen parents to test relative cross-compatibilities and subsequent inheritance of needle color. Colorado spruce produced few flowers in 1960 so that it was impossible to conduct all the desired pollinations. The results for 1959 and 1960 appear in Table 5.

Table 5. Open-, Cross-, and Self-compatibility[1] for Nine Selections of Colorado Spruce in 1959 and in 1960

Seedtree	Open-pollination[2] 1959	Open-pollination[2] 1960	Cross- 1960 RC-1	Cross- 1960 RC-2	Self-pollination 1959	Self-pollination 1960
	(%)	(%)	(%)	(%)	(%)	(%)
NC4-5	87.4	50.0	0	0	1.4	0
NC5-23	65.3	41.5	8.0	14.6	3.5	0
NC5-25	128.0	67.0	14.5	34.0	0.6	0
NC4-51	29.4	15.5	37.0	-	1.5	0
NC5-28	144.8	-	42.7	4.6	32.4	0
NC4-18	33.3	29.5	0	25.0	0.0	*
NC4-60	61.4	53.8	13.2	15.5	0.0	2.5
NC5-16	100.6	75.6	10.8	43.8	4.5	6.8
NC5-58	44.0	28.3	33.8	45.0	1.2	-
Weighted Means	68.5	51.6	15.4	26.1	5.4	1.5

[1]Compatibility expressed in terms of the sound seeds-per-cone
[2]Seed set reduced by losses due to pre-harvest shedding of seed
*No male flowers in 1960, - - no data available.

Seed set was generally less in 1960 than in 1959. For example the average set from open-pollination in 1960 was 45 seeds-per-cone, only 66% of that for the same trees in 1959. Nevertheless, the efficiency of the techniques for artificial cross-pollinations approached 40% of that for natural open-pollinations, despite possible cross-incompatibility interactions. Differential seed sets for pollen of RC1 and RC2 with the seedtrees NC5-28 and NC4-18 suggest that degrees of cross-compatibilities exist within the species. Failure of both pollens to effect seed-set with the seedtree NC4-5 indicates the possibility that cross-incompatibilities exist within the species. However, inconsistency of the seedsets following self-pollination of six trees in 1959 and 1960 demonstrates a need for further research to ensure comparable results from year to year.

Self-compatibility was determined for 41 selections of Colorado spruce in 1961 and in addition self- and cross-compatibility were checked for 10 selections showing low self-compatibility in 1960. Regretably, drought, heat and seed insect problems seriously disrupted the 1961 spruce breeding program and generally reduced seed set. These results suggested precautions must be taken in the future to reduce insects and temperatures within isolation bags.

Survival, height and needle coloration data were recorded in 1961 for 13-year-old plants in open-pollination progenies of 24 Colorado spruce selections. Similar data were recorded for these plants in 1953, and height data were compiled in 1956. The results have been listed in Table 6. An average survival of 91% demonstrates the ability of Colorado spruce, which had become adequately established under favorable conditions from 1954 to 1956, to withstand subsequent adverse conditions while in the juvenile stage. Blue coloration of the needles of 13-year-old plants bore no relationship to that of the same plants when 5 years old. All plants of three progenies exhibited some degree of blue needle color, and only three progenies had high average color ratings exceeding the mean. Height of plants after 13 years of growth was closely related to that after 8 years of growth as indicated by a correlation coefficient of 0.88.