Poplar Breeding in Canada

By L. ZUFA

Abstract

Poplar breeding in Canada is described according to the regions in which it has been carried out. In Quebec, tests of introduced poplars are mentioned. In Ontario, aspen and cottonwood breeding is described. In the Prairie Provinces, the breeding of poplars for shelterbelts is delineated. In British Columbia, the selection of black cottonwood and the tests of introduced poplars are reviewed. The importance of poplars to meet increased timber requirements is pointed out and the need is indicated for better planning of national and regional breeding programs.

Résumé

Populiculture au Canada

L'auteur décrit la culture des peupliers au Canada, d'après les régions où les travaux se poursuivent.

D'abord, il traite des essais d'introduction de peupliers au Québec. Puis, il décrit la multiplication des trembles et des peupliers en Ontario; la culture des peupliers comme rideaux protecteurs dans les Prairies. Enfin, il analyse les travaux de sélection sur le peuplier noir en Colombie-Britannique et les essais d'introduction de nouveaux peupliers.

L'auteur souligne l'importance économique que la populiculture prendra demain en vue des approvisionnements en bois. Il insiste sur la nécessité de planifier, mieux que jamais, les programmes d'amélioration des arbres tant à l'échelle nationale que régionale.

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Poplars occupy a unique and anomalous position in the Canadian forest economy. They constitute nearly 54% of Canada's net merchantable hardwood timber, yet only an insignificant part of the theoretical yield is harvested and utilized.

Poplars have the potential to meet increased timber requirements. This was realized much earlier in Europe than in the U.S.A., and only recently in Canada. Features particularly favouring poplars include their great ecological amplitude, ease of propagation, fast growth and the multivarious uses of their wood (Maini, 1968).

Eight species of the genus *Populus* L. have been reported as native to Canada (Anon. 1961). *P. tremuloides* Michx. (trembling aspen) is an ubiquitous species which extends across Canada. *P. grandidentata* Michx. (large tooth aspen) is restricted to deep, fresh sandy slopes in Eastern Canada. *P. deltoides* Marsh (eastern cottonwood) is found scattered throughout South and Southeastern Canada. *P. deltoides* Marsh var. *occidentalis* Rydb. (plains cottonwood) is limited to Southern Alberta and Saskatchewan. *P. balsamifera* L. (balsam poplar) is sparsely scattered along the tree line throughout Canada and is confined to moist depressions. *P. trichocarpa* Torr and Gray (black cottonwood) grows on the West Coast and in the Rocky Mountains. *P. acuminata* Rydb. (lanceleaf cottonwood) and *P. angustifolia* James (narrowleaf cottonwood) are restricted to the stream banks in Southern Alberta.

A considerable amount of within species variation and introgressive hybridization has been re-

ported in poplars (Maini, 1968; Brayshaw, 1965). These, together with their fast growth, early flowering and ease of vegetative propagation, are important prerequisites of successful breeding.

Poplar breeding in Canada was initiated regionally with poplars which had local economic importance or other desired characteristics. The descriptions which follow will be according to these regions.

Poplar Breeding in Quebec

Hybrid poplar varieties have been obtained from Dr. E. Schreiner and tested for disease resistance and winter hardiness (Hubbes, 1968), the objective being to select the best clones for mass-propagation and planting on a large scale. Observations were made on 68 varieties in 13 trial plots established in Quebec between 1963 and 1965, in plantations of the same varieties established in 1951 at the Harrington Tree Farm of the International Paper Company and at Macdonald College. Up to the present, 16 clones have been chosen for further observation. They are of the following parentage: *P. deltoides* x *caudina*, *P. angulata* x *deltoides*, *P. candicans* x *berolinensis*, *P. angulata* x *trichocarpa*, *P. nigra* x *eugenii*, *P. deltoides* x *plantierensis* and *P. maximo-wiczii* x *trichocarpa*.

Since 1962 Dr. L. Parrot has established three test plantations with 50 poplar clones obtained from Italy, the United States and Ontario (Smith, 1968).

Selection and breeding work with native poplars have not been reported in Quebec.

Poplar Breeding in Ontario

The objectives of poplar breeding in Ontario have been to develop fast growing, high quality poplars for plywood, match stock and pulp production.

Poplar breeding was initiated by Dr. C. Heimbürger in 1935 at the Petawawa Forest Experiment Station and since 1946 continued at the Southern Research Station, Maple (Heimbürger, 1936, 1940). The work has been summarized by Heimbürger (1956, 1958, 1968). His aims were the production of aspen-like hybrids suitable for growing in Southern Ontario, having good growth rate and growth form, suitable wood and ease of vegetative propagation.

Raising aspen seedlings on an industrial scale represented a problem, therefore the main objective was the production of new hybrids with good rooting ability from stem cuttings. *P. alba* L. (white poplar) was the only source of material with good rooting ability available for transfer into aspen-like poplars. Great emphasis was put on breeding white poplar with various aspen species.

Most *P. alba* planted in Eastern Canada appeared to be of Normandy origin and showed reasonable rooting ability. The rooting ability of its hybrids differed according to their aspen parentage. Hybrids with *P. sieboldii* Miq. rooted the best. They were followed by *P. alba* x *grandidentata*, *P. alba* x *tremula* and *P. alba* x *davidiana*, while the *P. alba* x *tremuloides* hybrids usually had the lowest percentage of rooting.

Fig. 1. — Dr. C. Heimbürger examines the seed catkins of an artificially crossed *P. canescens* poplar.

Fig. 2. — Hybrid Poplar Tubed Seedlings in Greenhouse.

By crossing *P. canescens* (Ait.) Sm (a hybrid introgression of *P. alba* x *tremula*) with *P. alba* x *grandidentata* hybrids of Eastern Canada it was possible to combine the rooting ability of white poplars of different origin and to obtain hybrid vigour from a combination of different aspen species of the original hybrids. The seedlings obtained by means of such double crosses were extremely heterogeneous. They were propagated and screened with respect to their nursery performance prior to field testing (Heimbürger, 1968).

During the last survey of the experimental plantations, excellent trees were found, particularly among *P. alba* x *grandidentata*, *P. alba* x *davidiana*, *P. alba* x *sieboldii*, *P. canescens* x (*alba* x *grandidentata*), *P. canescens* x *grandidentata*, *P. alba* x *tremuloides* and *P. alba* x *tremula* hybrids (Zufa, 1968).

The good performance of many of the *P. alba* x *grandidentata* hybrids has already been described (Heimbürger, 1936). A surprisingly good and uniform performance was observed in the majority of *P. alba* x *sieboldii* and *P. alba* x *davidiana* hybrids. In an experimental plantation located in Wainfleet, Southern Ontario, on a clay soil, the above mentioned crosses were superior to other aspen hybrids and they competed successfully with the fast growing Italian cottonwood hybrids (*euramerican* poplars). Examples of six year growth are as follows (8 x 8 ft. spacing):

	Mean Values	
	dbh (in.)	ht (ft.)
<i>P. x euramericana</i> cv I-214.....	4	26
<i>P. x euramericana</i> cv I-45/51.....	4	23
<i>P. alba</i> x <i>davidiana</i>	4	26
<i>P. alba</i> x <i>sieboldii</i>	4	25
<i>P. tremuloides</i> , Maple x <i>tremula</i> , Italy	3	20
<i>P. canescens</i> , Czechoslovakia.....	3	18
<i>P. tremula</i> , USSR.....	1	16

Similar to the successful *P. canescens* x (*alba* x *grandidentata*) crosses, new multiple crosses of unrelated parents are being attempted to produce heterogeneous populations with outstanding individuals. Examples of such successful crosses are: *P. (alba* x *davidiana*) x (*alba* x *grandidentata*), *P. (alba* x *sieboldii*) x (*alba* x *grandidentata*), *P. canescens* x (*alba* x *davidiana*). This work has now reached the stage where the development of clonal varieties with easy vegetative propagability and superior growth can be attempted.

Hybrid varieties of these types probably could not be used in the Boreal Forest Region because of their southern parentage. To develop trembling aspen varieties for northern conditions, the study of its variation and a selection of the best types are indispensable. Maini (1960, 1967) observed clonal variation in phenology, growth, form and disease resistance and in the reproductive response of aspens. Intraspecific variation was observed within a given locality and between widely separated populations. Vaartaja (1960) demonstrated that photoperiodic ecotypes of trembling aspen have evolved in the populations of latitudinally distant sites.

Fig. 3. — *P. alba* x *grandidentata* trees in Whitchurch, Ontario. Age 13-yrs., d.b.h.-8", ht.-60'.

Fig. 4. — Trembling aspen stand, Kinogami Lake, Engelhart Management Unit. age-40 yrs., d.b.h.-14", h.-80'.

The main work with trembling aspens at Maple at present consists of the production of *P. tremuloides* x *tremula* hybrids. The heterotic vigour of these hybrids is a well known subject (Johnsson, 1956). Their production is being continued in Scandinavian countries on a large scale and data is available to show the superiority of the hybrids as compared with native aspen (Johnsson, 1956, Syrach Larsen, 1953).

Hybrid seed is being produced by crossing trembling aspen trees showing good performance in the Boreal Forest Region with *P. tremula* of chosen origins. Efforts have been made to use this seed for the production of hybrid seedlings in conveniently located nurseries. This would allow for the establishment of the first experimental plantations of *P. tremuloides* x *tremula* hybrids in the next several years.

An attempt is underway at Maple to develop hybrid poplar clones with good rooting ability for the Great Lakes and Boreal Forest Region by breeding aspens or their hybrids native to these regions with cottonwoods and balsam poplars or their hybrids.

Aspens do not breed easily with cottonwood and balsam poplars. Large differences in compatibility have been observed due to the variation in combining ability of the single parent trees. The progeny

of such crosses is usually heterogenous, containing few superior seedlings and a larger number of dwarfed, sterile and labile hybrids. Clonal varieties could be developed from a few superior seedlings. The sterile and labile hybrids may be changed into better established, fertile organisms by polyploidy induction (Zufa, 1968). Backcrosses of such polyploids with diploid poplars could give rise to entirely new types of triploid hybrid poplars having superior growth and good rooting ability.

Aspens cannot be grown economically on light sandy-loams or in silver maple swamps, but cottonwood can grow rapidly on such sites and it may create a timber culture of high value. Large areas of both types are available in Southern Ontario and provide a potential for cottonwood timber production.

Cottonwood selection has recently been started at Maple (Larsson, 1966, Zufa, 1968). Outstanding eastern cottonwood trees (*P. deltoides* Marsh) were found on light sandy-loams of lake banks and river bottoms as well as in swampy areas. The growth of native cottonwoods in swamps is vigorous. The form of these trees is excellent and the heartwood is clear and white. Examples of the growth of selected cottonwood trees are as follows: Beverley Swamp, age 20 yrs., d.b.h. 12", height 65'; same location, age unknown, d.b.h. 48", height 95' — it is still a very vigorous tree; Wainfleet, age 35 yrs., d.b.h. 20", height 105'. These trees were growing in 1/2-3 ft. of black muck of nearly neutral reaction, which was overlying fine sand. In many cases limestone bedrock was found at a depth of 5-10 ft.

Jackii poplars (*P. jackii* Sar., represent *P. balsamifera* x *deltoides* hybrid introgression) were observed growing in similar swampy conditions, but mainly in the belt which represents the northern limits of the natural cottonwood range. Several trees of excellent growth and form were selected. Examples of the growth of these trees are as follows: Gore Bay, Manitoulin Island, age 8 yrs., d.b.h. 8", height 50'; Walkerton, age 25-30 yrs., d.b.h. 24.6", height 91'; Flesherton, age 50 yrs., d.b.h. 26", height 90'.

The selected jackii poplars and swamp-type cottonwoods may play an important role in the development of new clonal varieties while at the same time they represent an excellent source of breeding material. Crosses are being attempted with combinations of *P. deltoides* x *balsamifera*, *P. deltoides* x *nigra* and *P. jackii* x *nigra*.

The production of jackii poplars for a northern extension of cottonwood is being attempted by crossing *P. deltoides* with *P. balsamifera* of the Boreal Forest Regions.

By using *P. nigra* L. (black poplar) in crosses, the development of hybrids exhibiting heterotic growth, a well known characteristic of *P. deltoides* x *nigra* (*P. x euramericana* (Dode) Guinier) hybrids, is expected as well as induced disease resistance, as cottonwood is susceptible to virus diseases and *Marssonina brunea*, *Aplanobacterium populi* (Steenackers, 1969).

Fig. 5. — Mr. H. C. Larson observes a *P. deltoides* plus tree in Beverley Swamp, Ontario, age-unknown, d.b.h.-48", ht.-95' — still a very vigorous tree.

To fill the gap which will exist from the present until the clones can be proven for commercial planting, selected euramerican poplars were imported from European countries and their testing for Ontario's conditions began. These poplars provide a most productive pulp, chip and veneer log resource in managed even-aged stands on marginal farm land in Europe, Argentina, Australia and Japan. Growth rates of 400 cubic feet or more per acre per year are common, surpassing the M.A.I. of many of our wild forest stands by a factor of ten. The aim is to demonstrate the growing potential of these poplars and to select clones which are adaptable to our conditions.

Poplar Breeding in the Prairie Provinces

Poplars were formerly planted around prairie farm homesteads to provide early shelter but few persisted beyond 16 years because of the adverse effects of drought, site, disease and insects. More recently poplars have been planted as the outside row in home shelterbelts, with the inner rows of more permanent species (Cram, 1968).

The late Dr. F. L. Skinner, famous plant breeder of the prairies was the first to produce new poplar varieties by means of hybridization and selection (Heimbürger, 1968). Four poplar exotics, *P. tristis* (Himalayan balsam poplar), *P. songarica* (an unregistered variety similar to *P. berolinensis*, but free from *Septoria musiva* Peck cankers), *P. simonii* (China balsam poplar) and *P. laurifolia* Ledeb (laurel poplar) were introduced by Skinner (1956) from Kew Gardens, England in the late twenties. The first poplar hybrids raised were from crosses between *P. deltoides* and a local balsam poplar. An outstanding female seedling was selected and used in crosses with the above listed exotics. Progeny testing of selections from these hybrids is in progress (Roller, 1968).

In 1938, crosses were made by Heimbürger (1940), of which three are important to the prairie provinces (Heimbürger, 1968): (i) *P. canescens* x *tremuloides* var. *aurea*. The western trembling aspen is winter hardy and wind and drought resistant, and therefore a potentially valuable parent in the production of aspen-type poplars for the prairies (ii) *P. acuminata* x *eugenii*. Lanceleaf cottonwood is native to Southern Alberta where it is drought resistant (iii) *P. berolinensis* x "Northwest" a cross in which both parental forms are hybrids involving balsam poplar and eastern and plains cottonwood. This cross appears very promising for the purpose of breeding valuable poplar materials for shelterbelts in the prairies.

Poplar breeding work in the Prairie Provinces has resulted in local hybrids between cottonwood, balsam poplar, and black poplar (*P. nigra* L.). They have been planted and propagated at Brooks, Alberta, Indian Head, Saskatchewan and at Morden and Dropmore in Manitoba. However, these plantings were not very successful because the poplars were not suited to the climate and also were susceptible to disease (Roller, 1966). The first comprehensive work on tests of cultivars and natural

hybrids considered adequate for farm and shelterbelt plantations was published by Cram (1960). He recommended the planting of the following clones in areas which are comparable to the Indian Head District:

Clone	Parentage	Origin
FNS no. 44-52 38 P 38	<i>P. deltoides</i> x ? <i>P. tacamahaca</i> x <i>simonii</i>	J. Walker FNS E. C. Smith
<i>tristis</i> no. 1	<i>P. balsamifera</i> x <i>tristis</i>	F. L. Skinner
<i>gelrica</i> BNW no. 4	<i>P. canadensis</i> x <i>nigra</i> <i>P. berolinensis</i> x northwest	G. Houtzagers C. Heimbürger
northwest	<i>P. deltoides</i> x balsam?	Prairie Nurseries
Saskatchewan	<i>P. deltoides</i> x ?	F.N.S. Indian Head

In Manitoba, Roller (1966) has undertaken the testing of poplar cultivars. The following three have proven to be the best:

Clone	Parentage	Origin
<i>P. cardeniensis</i>	unknown	Exp. Farm, Modern, Man.
<i>P. petrowskyana</i>	? <i>P. laurifolia</i> x <i>deltoides</i>	Main, U.S.A.
<i>P. brooks</i> no 1.	<i>P. deltoides</i> x <i>petrowskyana</i>	E. Griffin, Brooks, Alt.

Regional test plantings of poplar in the Prairie Provinces have been conducted on a co-operative basis since 1964, the objective being to evaluate the potential for shelterbelts and pulp of all available poplar clones in Alberta, Saskatchewan and Manitoba (Cram, 1968a, 1968b).

Prior to 1940 poplar material distributed by Tree Nurseries in the Prairie Provinces was limited to four clones, but was gradually increased to thirteen by 1958 as new clones became available. Since 1965, distribution has been restricted to five clones which performed best in local and regional tests. These clones, now being mass produced and distributed in prairie planting are *P. "Northwest"*, *P. "Saskatchewan"*, *P. FNS 44-52*, *P. gelrica* and *P. tristis* (Cram, 1968a).

Poplar Breeding in British Columbia

The work has been concentrated on *P. trichocarpa* Torr. and Gray (black cottonwood), the species of most economic importance to British Columbia, and on the introduction of cottonwood hybrids. The objective is the development of fast growing, high quality varieties for veneer and pulp production.

In their efforts to secure a sustained source of high quality poplar veneer, the Western Plywood Company and the Westminster Paper Co. began a joint venture which eventually led to the formation of West Tree Farms Ltd., in 1956. In 1966, the 2,000 acres of poplar plantations created by West Tree Farms represented more than 75% of the Canadian total (Smith and Blom, 1966).

In 1957, West Tree Farms selected 16 black cottonwoods primarily on the basis of superior growth, good form and relative freedom from epicormic branching. Four of these clones demonstrated resistance to *Melampsora* rust. Black cottonwood

clones were also selected by Columbia Cellulose near Terrace (Smith and Blom, 1966). It is apparent that the considerable genetic variation in black cottonwood would allow a rapid improvement by selection and vegetative propagation, as well as through breeding.

Breeding the black cottonwood with *P. deltoides* or *P. nigra* L. shows a beneficial effect in rust resistance in the progeny. Muhle Larsen's *P. trichocarpa* x *deltoides* hybrids, imported in 1964 represent such descendants.

Several euramerican hybrid poplars (*P. x euramericana* (Dode) Guinier) have been imported and tested by West Tree Farms. At the University of B.C. Research Forest, comparative plantations have been established, comprising a large number of poplar varieties. In addition, other companies, such as the Kootenay Forest Products Ltd., Columbia Cellulose, Tahsis Co., etc. have introduced and tested various poplars, mainly of the cottonwood type (Smith and Blom, 1966).

Black cottonwood has proven to be a fast growing, high yielding species. The short rotations and fast rates of growth in volume and value may offer substantial potential returns, but a sustained research program is required to reduce the risks involved.

Discussion and Conclusions

The poplar breeding work has not been organized on a national level. It has been carried out on a regional basis. In British Columbia and the Prairie Provinces it was oriented towards immediate problems. In the former province only fragmentary solutions were gained. A more fundamental study of the genetics of black cottonwood, followed by selection and breeding work could ensure better results in the future. In the Prairie Provinces a number of hybrid varieties were tested and proven for commercial use. Even there a basic study of the native poplars is needed to ensure further improvement. Brayshaw's (1965) study of native poplars

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of Southern Alberta and their hybrids is a worthy example of interest in this regard. A more comprehensive work on poplar breeding has been done in Ontario, particularly on breeding aspen type poplars for Southern Ontario's conditions. The work was recently extended to aspen in the Boreal Forest Region and to cottonwood and balsam poplar. In Quebec and several other provinces, tests of introduced hybrids were initiated. Although such varieties have been developed for particular environments in other countries, some of them could prove to be successful under Canadian conditions as well. Nevertheless, this could be a temporary solution, only. The number of such varieties is very limited. To satisfy the requirements of an expanding and specialized wood using industry we will need a larger series of improved new varieties. Studies of populations of native poplars and continuous selection and breeding of the best types is the only way to produce them. Up to the present, only fragmentary work has been done on these problems. However, the results of these studies give a sound basis for further programming.

Poplar breeding work should be planned on a Canada-wide basis as well. A study of genetic variation within the species which grow across several provinces and of the introgressive hybridization existing between the species would be of basic significance.

The needs for a more rapid timber production in plantations are increasing all over the world. As poplars are well suited to this rapid production, their importance is continually increasing.

Tree breeding takes time. It has to be done today to satisfy the needs of to-morrow. A well planned poplar breeding programme will be a good and rewarding investment; the accumulated experience on poplar genetics and breeding here and elsewhere in the world, the ease of vegetative propagation in poplars, their fast growth, early flowering, wide ecological adaptability and clear reactions to an improved environment are all guarantees of success.

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Genetics and Breeding of Black Spruce and Red Spruce

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"Red and black spruce have hybridized on the very extensive New Brunswick lowland plain. Trees that were less than 50 percent red spruce were not seriously defoliated even in a year of heavy budworm defoliation."

Abstract

This review emphasizes findings that are of value for early application in tree breeding and silviculture. Black spruce and red spruce are closely related genetically and hybridize where their ranges overlap, particularly in the Maritime Provinces. Black spruce provenance experiments indicate a possibility of increasing yield by moving southern provenances from continental areas north into mild maritime climates. Red spruce provenance experiments and field studies suggest that populations containing hybrids are vigorous and more resistant to the spruce budworm than pure populations. As reforestation programs develop, priorities in the application of genetics to silviculture are: (1) designation of seed zones; (2) development of seed production areas; and (3) selection of plus trees and establishment of seed orchards.

Résumé

Génétique et Amélioration de l'Épinette noire (*Picea mariana* (Mill.) BSP.) et de l'Épinette rouge (*Picea rubens* Sarg.)

Cette étude met en relief des résultats importants qu'il faut connaître avant d'entreprendre des travaux de croisement et de sylviculture. L'Épinette noire et l'Épinette rouge étant de constitution génétique très rapprochée, se croisent à l'intérieur de leur aire de distribution commune, surtout dans les Maritimes.

Les études de provenance sur l'Épinette noire

démontrent qu'il est possible d'en accroître le rendement, par l'implantation des lots de graines provenant des régions continentales méridionales, vers le Nord, dans un climat maritime plus doux.

Des travaux similaires sur l'Épinette rouge et des études sur le terrain suggèrent que les populations comportant des hybrides sont vigoureuses et plus résistantes à la Tordeuse des bourgeons de l'épinette que les populations pures.

A mesure que les programmes de reboisement se développent, l'application de la génétique à la sylviculture commande les priorités suivantes: a) un choix de zones de collection de semences, b) la création de réserves pour la production de graines, c) la sélection d'arbres "plus" et l'établissement de vergers à graines.

Black spruce, *Picea mariana* (Mill.) BSP., and red spruce, *Picea rubens* Sarg., are important species of Canadian forests. Black spruce is commercially the most important species in the Boreal Forest Region (Rowe 1959). The large volumes available and high wood quality make it the most important pulp species and determine to a considerable extent the competitive position of the Canadian pulp and paper industry (Flatt 1955, Reid and Ladell 1965). In the Acadian Forest Region, red spruce is the most valuable species because of the quantity available (New Brunswick Dept. of Lands and Mines 1958, Hawboldt and Bulmer 1958) and its suitability for both pulp and lumber.

The increasing use of black spruce in reforestation has given impetus to breeding programs with