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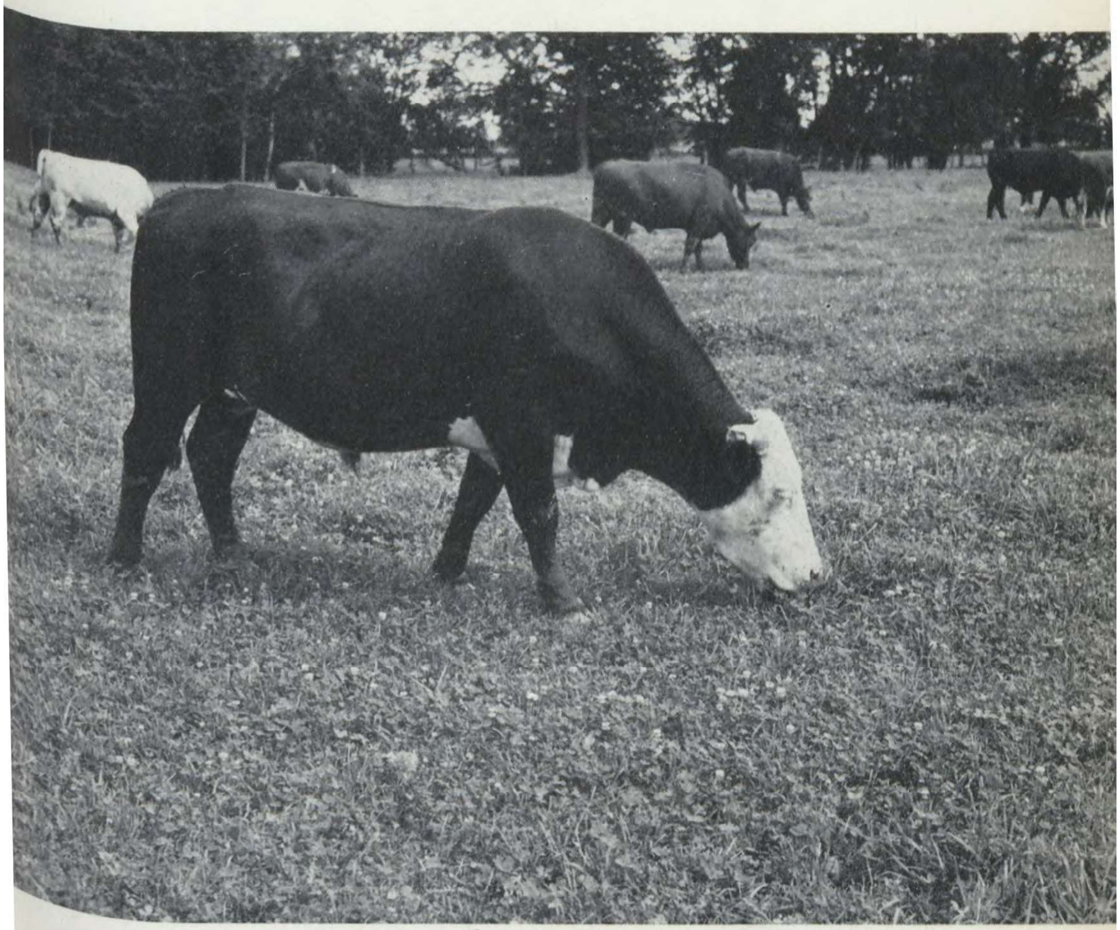
CANADA
DEPARTMENT OF AGRICULTURE
EXPERIMENTAL FARMS SERVICE

DIVISION OF FORAGE PLANTS

CENTRAL EXPERIMENTAL FARM, OTTAWA

T. M. STEVENSON, B.S.A., M.Sc., Ph.D., DOMINION AGROSTOLOGIST

PROGRESS REPORT
1937-1948



This attractive pasture is composed of Ladino clover, alfalfa, orchard grass, meadow fescue and timothy.

Published by authority of the Rt. Hon. JAMES G. GARDINER, Minister of Agriculture, Ottawa, Canada

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DIVISION OF FORAGE PLANTS
Progress Report, 1937-1948
Central Experimental Farm
Ottawa, Ontario

INTRODUCTION

This report covers the period 1937 to 1948 inclusive. The last previous progress report of the Division of Forage Plants, covering the years 1934-1936, was published in 1937. No progress reports were printed during the war years.

There have been a number of changes in the scientific staff during the past ten years. Dr. L. E. Kirk, Dominion Agrostologist from 1931 to 1937, inclusive, resigned and was succeeded by Dr. T. M. Stevenson, who was appointed during 1938. Other members who have been added to the scientific staff, since 1938, include:—Messrs. J. H. Boyce, H. A. McLennan, W. R. Childers, J. Witrofsky, and R. W. Robertson.

The activities of the Division of Forage Plants cover a wide range of crops and projects. They are related mainly to the development of improved varieties of all of the hay and pasture species of grasses and legumes, and to corn, sorghums, sunflowers, field roots, sugar beets and soybeans. These operations include genetical and cytological investigations designed to provide the plant breeder with fundamental knowledge; induced polyploidy, and other special lines of research.

While research work is chiefly in the field of plant breeding, many different field experiments are continually in progress. Among these are included the testing of species, varieties and strains; pasture and rangeland investigations; methods of seed production and multiplication; and various phases of turf grass research.

As will be observed, this progress report has been prepared in two sections:

Part I — Activities of the Division of Forage Plants, Central Experimental Farm, Ottawa, Ont.

Part II — A statement of the work conducted at the Dominion Forage Crops Laboratory, Saskatoon, Sask.

PLANT BREEDING

Corn (*Zea mays.* L.)

Since 1938, the year when hybrid corn was first grown in Canada, a new chapter has been written into the production of corn in this country. It is a story of much progress. Corn is grown for one purpose or another in every province of the Dominion, and until 1938 the entire acreage was planted with open-pollinated varieties. In 1938 a great change began. About 200 acres of the new "hybrid corn" were grown in southwestern Ontario, where approximately 250,000 acres are produced annually for husking purposes. By 1939, about 10 per cent of this acreage was hybrid. It increased to 25 per cent in 1940, and to 50 per cent in 1941. By 1948, 10 years after its introduction into Canada, over 95 per cent of the entire husking corn acreage was planted to hybrid corn. It is estimated now that about 70 per cent of the entire corn acreage of Ontario, averaging

550,000 acres annually, and including both corn for silage and husking, is planted with hybrid corn. The same story is largely true concerning the growing of corn in the other provinces. An increasing acreage is being planted with hybrid corn each year to replace the open-pollinated varieties.

The development of hybrid corn and its expanding use has been described as one of the greatest achievements in agriculture. Not only do adapted hybrids yield 20 to 30 per cent more grain or fodder than open-pollinated varieties of comparable maturity, but they also possess other superior qualities, such as better plant type, more uniform maturity and greater resistance to lodging and disease.

One of the great advances made possible by the development of hybrid corn has been the expansion of the area in which corn can be produced successfully for husking. While it is true that there have always been available certain early maturing varieties that could be grown to maturity in many areas of short season in Canada, the low yields produced and the difficulty of harvesting these varieties by modern methods has limited their use. The breeding of early maturing hybrids of high-yielding ability and improved plant type has made possible the expansion of grain corn production into many of the short-seasoned areas in recent years.

Corn improvement at Ottawa has followed along three main lines of endeavour:—

1. Breeding, or the production of inbred lines through selfing, and the testing of these lines in hybrid combination.
2. Testing of commercial hybrids for grain production.
3. Testing of commercial hybrids for silage production.

The corn breeding program was initiated at Ottawa in 1928, and its main objective was to develop early-maturing hybrids adapted for the production of grain in areas of short season. In the first few years selfing was begun with a number of the best early maturing, open-pollinated varieties, such as Howe's Alberta, Gehu, Twitchell's Pride, Quebec Yellow, (including Quebec No. 28), all yellow flints; and the following dents, early strains of Minnesota No. 13, Golden Moccasin, Falconer, Wisconsin No. 25, Pride, and Cornell No. 11 (all yellows); strains of Northwestern Dent (red), and Pioneer and Payne's (both white). From these varieties several hundreds of lines were isolated through selfing. Through top-cross tests, lines of poor inheritance were discarded and only those of good inheritance were retained. Inbreeding seeks to isolate those lines in which are concentrated such desirable characters as resistance to lodging and disease, good plant type, high pollen production and good seed-setting ability, together with good combining ability. Such inbreds, once they have been purified, can be mainained in a true breeding condition indefinitely. This is the outstanding feature of hybrid corn, that once the inbreds have been established and their inheritance fixed, it is possible to produce identically the same hybrid year after year by crossing the same inbreds in the same way.

It has been estimated that it requires from 20 to 25 years of patient work to produce a good hybrid, that is, from the time the first inbreeding is started on the parent varieties, until the double-cross hybrid is finally ready for commercial production. The first double-cross hybrids produced as the result of the breeding program begun at Ottawa in 1928 were made available for commercial production in 1948. Two hybrids were released at that time and were named Canbred 150 and Canbred 250. Both hybrids mature regularly at Ottawa and are capable of producing high yields of grain corn under suitable conditions. During 1947 and 1948 they were grown under field conditions in many areas of eastern Ontario, and performed very well both from the standpoint of yield and maturity. Canbred 150 has the following pedigree or inbred combination:—

$$(50 \times 32)(131 \times 140)$$

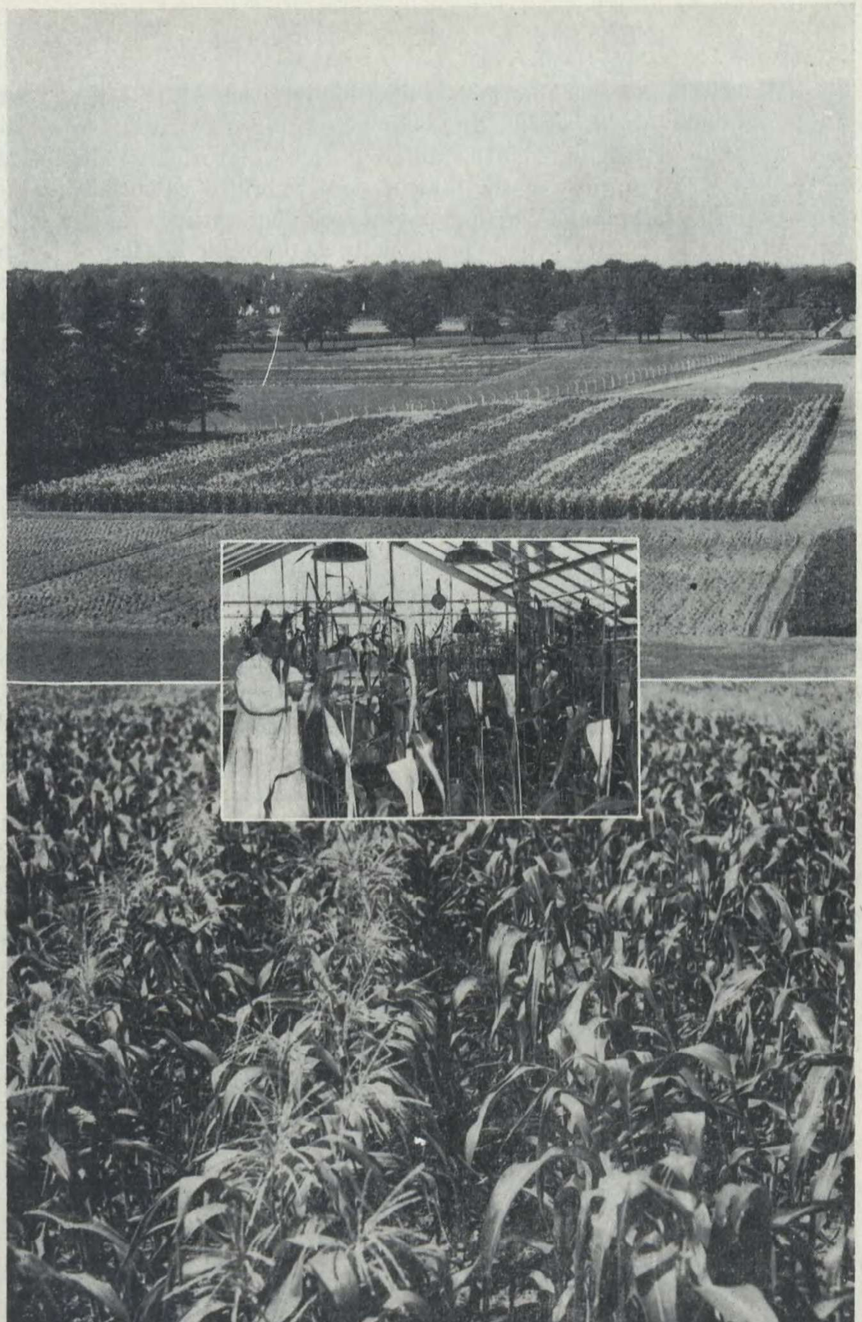


FIG. 1 (*Upper*)—Hybrid Corn Crossing Block, Central Experimental Farm, Ottawa, 1949. Photo shows male and female (detasselled) rows. This field is part of the Corn Breeding program of the Forage Plants Division, Experimental Farms Service. Usual planting method is 2 male rows (pollen parent) to 6 female rows (ear parent).

(*Centre Inset*)—Corn breeding under glass during the winter months (photographed February, 1946).

(*Lower*)—Close-up of above field showing male (pollen parent) and female (ear parent) rows.

Inbreds 32 and 50 are both of flint origin, having been derived from Twitchell's Pride, an eight-rowed, yellow flint variety. Inbreds 131 and 140 are both yellow dents, having originated from different early maturing strains of Minnesota No. 13. The purpose of the flint × dent hybrid is essentially twofold: to incorporate the earliness of the flint parent, together with the higher yield of the dent parent. The plant type is not usually as desirable as that of the pure dent hybrid, as the stalks are generally more slender and weaker, and there is also a tendency to produce suckers or tillers rather freely. Some growers also prefer the dent corn to the more flinty type of kernel produced by the flint × dent hybrid. This type of hybrid has a place, however, where earliness of maturity is of prime importance, and Canbred 150 was developed to satisfy this requirement.

Canbred 250 is a pure yellow dent and has the following pedigree:—

(103 × 99)(135 × 140)

Inbreds 103, 135 and 140 were derived from different early maturing strains of Minnesota No. 13, while 99 was developed from a nondescript variety (probably Falconer parentage) which was secured from Manitoba. Canbred 250 is about 7 days later in maturity than Canbred 150. It has the characteristic dent type of growth with few or no tillers. It is more resistant to lodging, more productive and husks a little easier than Canbred 150. Where it can be grown successfully it is recommended in preference to Canbred 150.

Performance trials in which Canbred 150 and Canbred 250 have been compared with Minnesota No. 13, are shown in Table 1.

TABLE 1—YIELD AND OTHER DATA OBTAINED FROM CANBRED 150 AND CANBRED 250 IN COMPARISON WITH MINNESOTA No. 13

Hybrid or Variety	Maturity*	Height		Yield per acre shelled corn (15% moisture)	Increase over Minnesota No. 13
	% moisture in ears at harvest	Plant	Ear		
		in.	in.	bu.	%
	Average 7 years (1939-1945)				
Canbred 150	34.1	84	26	75.1	22.7
Minnesota 13	36.6	77	27	61.2	
	Average 4 years (1943-1946)				
Canbred 150	37.6	90	29	63.6	14.7
Canbred 250	42.0	90	31	70.8	27.3
Minnesota 13	38.7	82	29	55.6	

* Based on ear shrinkage sample.

It is seen that while the two hybrids were comparable in maturity with Minnesota No. 13, they yielded 14.7 to 27.3 per cent more shelled corn per acre.

FIG. 2—Canbred 150 and 250—two early maturing, productive corn hybrids bred at Ottawa (photographed February, 1948).

Since Canbred 150 and Canbred 250 were released for commercial production, a great many other experimental hybrids have been undergoing test and several have shown considerable promise. Among the best of these is OX 201, a yellow dent, which has been included in performance trials during the past 3 years, (1946-1948), in comparison with Canbred 150 and Canbred 250, and two additional outstanding early maturing commercial hybrids, Canada 240 and Canada 255. Table 2 is a summary of these trials:—

TABLE 2—SUMMARY OF DATA OBTAINED FROM EXPERIMENTAL HYBRID OX 201 IN COMPARISON WITH OTHER OUTSTANDING HYBRIDS

Hybrid	*Average 3 years—(1946-1948)*			
	Maturity*	Height		Yield per acre shelled corn (15% moisture)
	% moisture in ears at harvest	Plant	Ear	
		in.	in.	bu.
OX 201	44.8	88	31	78.8
Canbred 150	41.3	83	27	58.1
Canbred 250	45.2	84	31	64.5
Canada 240	43.2	86	28	59.9
Canada 255	44.1	86	30	63.9

* Based on ear shrinkage sample.

From the standpoint of maturity, the new hybrid, OX 201, compares more favourably with Canbred 250 and Canada 255 rather than with the somewhat earlier maturing flint × dent hybrids, Canbred 150 and Canada 240. From the standpoint of yield it consistently outyielded the other hybrids in each of the three years tested. The yield data presented in the 3-year summary show that OX 201 produced 14.3 bushels, or 22.2 per cent more shelled corn per acre than Canbred 250, and 14.9 bushels or 23.3 per cent more shelled corn per acre than Canada 255. It is expected that sufficient stocks of Foundation seed will be produced to permit the release of OX 201, for commercial production by 1950.

More recent tests indicate that among newly developed experimental hybrids of both dent and flint × dent types produced at Ottawa, several are equally as promising as OX 201.

Mention has already been made of top-cross tests. These tests are used for the purpose of evaluating inbred lines. It is upon the results of these tests that inbreds are either discarded or retained for further study and investigation. In the type of top-cross used at Ottawa, the dent lines are crossed with Minnesota No. 13, while the flint lines are crossed with Quebec No. 28. Some of the top-crosses tested have performed so satisfactorily that consideration might well be given to the use of this type of hybrid for commercial production. While they may not possess all of the good characteristics of the double-cross hybrids, the simplicity of seed production is a distinct advantage. They might prove useful in new areas, before satisfactory commercial hybrids have become available. An indication of the productive capacity of certain top-crosses may be gained from Table 3, a summary covering a period of 4 years (1945-1948):—

TABLE 3—SUMMARY OF DATA OBTAINED FROM TOP-CROSS 179 AND 190 IN COMPARISON WITH OUTSTANDING COMMERCIAL HYBRIDS

Hybrid	Maturity*	Height		Yield per acre shelled corn (15% moisture)
	% moisture in ears at harvest	Plant	Ear	
		in.	in.	bu.
Top-cross 179	42.8	86	30	68.2
Top-cross 190	41.6	87	29	66.9
Canbred 150	40.6	84	26	62.0
Canbred 250	44.3	85	31	66.8
Canada 240	42.3	86	29	63.4
Canada 255	42.7	86	31	67.3

* Based on ear shrinkage sample.

The data show that Top-cross 179 (inbred 179 × Minnesota No. 13), and Top-cross 190 (inbred 190 × Minnesota No. 13) yielded equally as well and were as early in maturity as the commercial hybrids. There was some indication that the top-crosses were a little more susceptible to lodging, but the data were not consistent enough to include in the summary. Lack of uniformity, and susceptibility to lodging of the open-pollinated variety, which would be used as the female parent, have proved a disadvantage and an objection to the production of the top-cross hybrid.

In an endeavour to obtain a still earlier maturity than has so far been achieved, some attention has been directed to the production and testing of hybrids composed entirely of flint lines. There are several reasons why flint hybrids have not been regarded with too much favour. Their slender and weaker stalks, tendency to tiller freely, low carriage of ears and comparatively low yields, are undesirable characteristics which tend to make them unpopular. Commercial seed production is also somewhat more difficult. On the other hand, flint hybrids may be the only hybrids that can be matured regularly in certain areas where flint × dent and dent hybrids are too late. With several good flint lines available, single-and double-crosses were made in 1946 and 1947 respectively, and 7 experimental hybrids were tested in 1948. Included in the same test were hybrids Canbred 150 and Canada 240 (both flint × dent), an experimental flint hybrid from Wisconsin (W 1600), and the flint variety, Quebec No. 28. A summary of the data obtained in this test is shown in Table 4.

TABLE 4—SUMMARY OF DATA OBTAINED IN PERFORMANCE TRIALS OF EXPERIMENTAL FLINT × FLINT HYBRIDS IN COMPARISON WITH CANBRED 150 AND CANADA 240

Hybrid or Variety	Maturity*	Height		Shelling percentage	Yield per acre shelled corn (15% moisture)
	% moisture in ears at harvest	Plant	Upper Ear		
		in.	in.		bu.
Flint hybrid 1	34.8	73	15	82.7	54.9
Flint hybrid 2	34.8	76	16	82.7	59.1
Flint hybrid 3	33.1	71	14	83.7	57.5
Flint hybrid 4	38.0	75	16	81.3	59.8
Flint hybrid 5	35.0	77	16	83.9	55.2
Flint hybrid 6	33.6	72	15	82.5	53.4
Flint hybrid 7	34.6	73	14	82.3	54.9
W. 1600	32.5	63	13	84.0	51.9
Quebec No. 28	44.1	82	21	79.3	52.3
Canbred 150	41.4	84	27	82.5	75.6
Canada 240	42.3	88	30	84.0	80.7

* Based on ear shrinkage sample.
Planted May 19. Harvested Sept. 29.

The data show that the flint hybrids were characterized by early maturity, rather unsatisfactory plant type with respect to ear height, but relatively good yields. Improvement may be expected from further breeding work. The corn breeding program begun at Ottawa in 1928 has begun to bear fruit, and the future envisions new hybrids, new areas of production and new production levels.

Soybeans (*Glycine max.* L.)

In recent years the soybean has assumed a position of importance among the field crops of Canada, particularly in Ontario. Until 1941, the area devoted to the soybean crop seldom exceeded 10,000 to 12,000 acres annually, with production estimated at 150,000 to 200,000 bushels of beans. Only a small portion of the crop entered commercial channels. Since 1941, there has been a steady increase in the soybean acreage from 41,500 acres in 1942 to 94,000 acres in 1948. Production of beans in 1948 amounted to 1,683,000 bushels, valued at approximately $4,000,000. Most of the crop was marketed for industrial purposes. Soybeans produced in Canada provide an excellent source of vegetable oil and protein, and also constitute a valuable farm feed.

The work of the Department in developing varieties adapted to Canadian conditions has been largely responsible for the increased interest and production of soybeans in recent years. Such varieties as A. K. (Harrow), Harman, Harly, Mandarin (Ottawa), Capital, Kabott, and Pagoda, are all products of the breeding program in operation at Harrow and Ottawa. They occupy most of the present acreage devoted to the soybean crop, and have generally proven superior to imported varieties. In a field crop competition conducted in Ontario in 1948, by a large processing company, these varieties occupied 48 of the 64 positions awarded for the highest yields in four different maturity regions.

The soybean breeding program has been continuous at Ottawa since it was started in 1929. Its main objective has been to develop improved varieties adapted for production in areas of short season, somewhat similar to that prevailing throughout eastern Ontario and southern Quebec. In addition to satisfactory maturity, the breeding work has sought to incorporate in new varieties such desirable characteristics as high productivity, good plant type, resistance to lodging and disease, non-shattering of seed, yellow seed colour and high quality with respect to the protein and oil content of the seed. The methods adopted to achieve these results have been as follows:—

1. Introduction of varieties and strains from outside sources.
2. Selection within varieties and strains.
3. Hybridization between selected varieties followed by selection and testing of progenies.

New introductions have comprised seed samples received directly or indirectly from a great many sources, including the United States Department of Agriculture and various other United States institutions, Manchuria, Japan, England, Germany, Sweden and Russia. Hundreds of introductions have been planted in the breeding nursery for observation and study. Most of them have been discarded for various reasons, but some were retained and selections made from these have been carried into the yield tests. Hybridization has constituted an important phase of the breeding program and many crosses have been made between selected varieties including Manitoba Brown, Poland Yellow, Pagoda, Mandarin, O.A.C. No. 211, Manchu, and A. K. (Harrow). A number of selections from introductions have also been used in crossing work.

Since 1937, three new varieties, Kabott, Pagoda and Capital, developed at Ottawa have been licensed and made available for production. Kabott was selected from material introduced in 1933 from Ninguta, Manchuria, and was licensed as a variety in 1937. It is medium early, yields well and has a fairly wide distribution both in Canada and the northern United States. Pagoda originated from a cross between Manitoba Brown × Mandarin (Ottawa) and was licensed in 1939. It is one of the earliest maturing varieties available, ripening at Ottawa in about 100 to 105 days. It has good plant type, is strong in the straw, and yields well in relation to its maturity. Capital originated from a cross between Strain 171 × A. K. (Harrow) and was licensed in 1944. It is medium late, requiring about 120 to 125 days to ripen at Ottawa. It is a little weak in the straw, but possesses good plant type, yields exceptionally well and the seed is very high in oil. During the past 2 or 3 years, Capital has become one of the most popular soybean varieties and is now widely grown in areas in which it is adapted, both in Canada and the United States. It is well liked by the processing industry, because of its high oil content. In addition to these three most recent varieties, the Ottawa strain of Mandarin, released for production in 1934, still remains popular and is quite widely grown. A splendid tribute has been paid to Mandarin (Ottawa) and Capital by their selection as the check varieties in Zone 0 and Zone 1 tests conducted annually in the United States by the United States Regional Soybean Laboratory, U.S.D.A.

Among the many new strains that have been developed recently in the breeding program, several have reached the final testing stage. It is confidently expected that some of these will be found worthy of consideration as possible new varieties.

Chemical analysis of the seed of all strains from the breeding nursery has been an important part of the breeding program. The analyses have been limited to the determination of the protein and oil percentages and the iodine number of the oil. As most of the soybean crop is disposed of for processing for oil, it is essential that attention be given to this important constituent of the bean. The processing plants favour varieties that are high in oil content. Our analyses show that the protein and oil content of the seed tends to vary inversely—the higher the protein the lower the oil and vice versa. Determination of the iodine number of the oil is important as an indication of the value of any particular strain for a specific use. At present, soybean oil is used chiefly for edible purposes and it is desirable that it should show a low iodine value. On the other hand, if soybean oil should be used to a greater extent in paint manufacture, a high iodine value is desirable.

Some indication of the extent of the variations of the protein and oil content and iodine number, of the seed of strains harvested from the breeding nursery in the 4 years (1945-1948) are shown in Table 5.

TABLE 5—HIGH AND LOW VARIATIONS IN PROTEIN, OIL AND IODINE NUMBER OF OIL* OBSERVED IN STRAINS FROM THE BREEDING NURSERY (1945-1948)

	1945	1946	1947	1948
High protein	42.7	46.9	54.9	47.2
Low protein	32.8	37.1	41.1	33.3
High oil	22.0	17.7	18.5	21.4
Low oil	16.9	12.8	11.4	14.1
High iodine No.	138.0	142.0	140.0	140.0
Low iodine No.	128.0	126.0	121.0	117.0

* All analyses on dry matter basis.

The data show that irrespective of the effects of seasonal conditions, wide variations occur each year in the protein and oil content and iodine number of the seed of different soybean strains. While it may not be too difficult to develop strains that may satisfy the requirements of industry for these different seed properties, it is more difficult to combine such properties with all of the desirable agronomic characteristics that are so necessary in a good variety. Good progress has been made along these lines, however, and consideration is being given to the requirements of industrial processors and others in the planning of the work to breed varieties for specific uses.

Alfalfa (*Medicago* spp.)

There are three main species of alfalfa which are of value agronomically, *Medicago sativa*, *M. falcata* and *M. media*. *M. sativa*, or common, while highly productive in adapted areas, lacks sufficient hardiness for Canadian climatic conditions. *M. falcata*, yellow-flowered or sickle-podded alfalfa, while extremely hardy and drought resistant, is not very productive due to its early fall dormancy and poor seeding habits. Its value lies in its hybridizing potentialities. *M. media* or variegated, is supposed to be a natural hybrid between common and yellow-flowered alfalfa, and it is intermediate to them for most characters. It is recognized as the best species to meet Canadian climatic conditions. Such well known varieties as Ontario Variegated, Grimm, Ladak and Viking belong to this species.

Over 70 per cent of the total alfalfa acreage in Canada is located in Ontario where it is rated the most valuable legume component in hay mixtures. Under reasonably good management it is also a useful pasture species. Alfalfa will not do well on poorly-drained land or soils which are markedly acid. These shortcomings can be overcome by choosing the better drained fields and by reducing the soil acidity with applications of lime. Alfalfa is particularly susceptible to injury where ice sheets form during the winter. As yet no serious diseases threaten alfalfa culture in Eastern Canada. Although occasionally reported, wilt has never become of serious concern. Of insect enemies, the leafhopper is the most harmful, especially on aftermaths in particularly dry seasons.

Several objectives have been sought in alfalfa improvement work at Ottawa. These have been the production of improved varieties for seed, hay yield and pasture purposes.

The work in the selection of a high seed-producing strain resulted in the production and licensing of a variety named "Canauto". The basic material in the strain consisted of autogamous or self-tripping plants selected from Grimm, Sask. No. 666. This characteristic ensures reasonably good seed yields in seasons when a low wild bee population makes ordinary varieties unproductive. Regarding hay yield, Canauto appears to be fully the equal of Grimm, although slightly inferior to Ladak and Viking. A test of Canauto several generations after its origin, showed that the self-tripping ability is being fairly well retained in the strain. However, sufficient cross-fertilization takes place to prevent a reduction in vigour which usually accompanies excessive selfing. Because of the Grimm parentage in Canauto it has no wilt resistance so it is not adapted to areas where this disease is a problem.

Improved strains of alfalfa are being sought with regard to hay yield, using Ladak as the breeding material. Ladak is high yielding largely because of its ability to yield well from the first cutting. Selections are being sought which give a better aftermath. Because of the high variability in Ladak, this aim appears feasible of attainment. Ladak is also being used to test the possibility of applying the highly successful procedure with corn in the development of hybrids. Utilizing highly self-sterile plants, the maximum of cross-fertilization can be attained, and with it the fullest expression of vigour.

Alfalfa, being widely grown in Ontario for pasture purposes, breeding work is being carried out leading to the selection of distinctive pasture types. Tests with ordinary varieties under frequent clipping treatments have shown that they differ markedly in their persistence and yield. Viking was found to be more persistent than Grimm and Ladak, while a variety recently produced by the University of British Columbia, called "Rhizoma" was still more persistent than Viking. Work was carried on with *M. falcata* leading to a strain fairly productive for the species, and having good seed-producing habits. This strain, however, is characterized by early dormancy which makes it unproductive in late summer and fall. By hybridization with variegated alfalfa, strains were obtained combining the desirable characteristics of both. In addition, there is available for strain building purposes a collection of creeping-rooted types which have also proven wilt resistant in tests. Work is proceeding to utilize this wide range of material in the building of pasture strains.

Red Clover (*Trifolium pratense* L.)

Strains of cultivated red clover may be classified as single-cut or late and double-cut or early, according to the growth habit shown by the majority of the plants within the strain. The single-cut strains are best adapted to northern areas where the short growing season permits the harvesting of only one crop. Double-cut strains, on the other hand, are grown in the main crop area of older Ontario where the longer growing season permits the use of the aftermath for hay, pasture or seed production.

Red clover occupies a very important place as a hay and pasture species in Eastern Canada, taking precedence over alfalfa because of its wider adaptation. While red clover is hardy enough to withstand the average winter, exceptional conditions may cause severe winterkilling, resulting in a short harvest of domestic seed the next season. This has led to the periodic necessity of importation of seed from foreign sources. Over a period of years the Division of Forage Plants, Ottawa, has studied hundreds of imported red clover seed samples relative to

FIG. 3 (*Upper*)—Red clover breeding nursery—lines showing severe injury by *Sclerotinia trifoliorum* (June, 1947).

FIG. 4 (*Lower*)—Red clover breeding nursery—lines showing resistance to *Sclerotinia trifoliorum* (June, 1947).

their hardiness under Canadian conditions. The studies have amply demonstrated that our home-grown seed is the hardiest. The next best sources are United States (northern grown), Russia and Scandinavian countries. Seed from Britain, France, Italy, Australia and New Zealand usually winterkills over 40 per cent. These investigations were the basis for the legislation embodied in the Seeds Act which requires the staining of a certain percentage of all imported red clover seed according to the country of origin.

The object of red clover improvement at Ottawa has been the production of a hardy, high yielding double-cut variety. Using the regional strains grown by the farmers in the Ottawa Valley, and following mass selection methods, improvement work was started in 1913. Large nurseries of 10,000 to 15,000 plants have been periodically established and selections made of the best plants previous to the second cutting in the second year after establishment. This practice has eliminated the less hardy material. The single-cut types and the smooth stemmed plants have been eliminated by leaf-hopper attack. The selections have been threshed in bulk and the purple-seeded component of the sample picked out to establish the next nursery. The result of this work was the licensing of the "Ottawa" variety in 1936. Since 1935, mass selection has been supplemented by strain building methods in which selections have been brought into the greenhouse and crossed in pairs. These crosses are later evaluated in progeny tests and the best recrossed. Good material obtained in this way has been incorporated annually with the originally selected materials.

One of the more recent objectives in red clover breeding is to obtain a variety highly resistant to Sclerotinia root-rot. Co-operating with a pathologist from the Division of Botany and Plant Pathology, Science Service, the susceptible plants are eliminated in the seedling stage. The resistant plants are then subjected to the usual field nursery tests and strain building methods.

White Clover (*Trifolium repens* L.)

From an agricultural point of view, there are three main forms of white clover, namely Common or Dutch, Wild, Ladino or Mammoth. White clover grows abundantly under both wild and cultivated conditions in most areas in Eastern Canada, and thrives under a wide range of soil types and conditions, and constitutes one of the most valuable components in a pasture mixture. Canada does not produce a sufficiently large amount of domestic seed to supply her needs, but depends largely on imported seed of white Dutch clover from European countries and lesser quantities of wild white clover from Great Britain and New Zealand. Two methods of correcting this situation are evident—first, the breeding of named Canadian varieties which can be grown profitably for seed on cultivated land in combination with pasture use, and second, the development of a satisfactory technique for the profitable production of seed from old permanent pasture meadows.

Breeding work with white clover was undertaken in 1938 with the object of breeding strains of wild white clover from indigenous Canadian material which would be adapted for pasture purposes. A breeding block containing 4,250 spaced plants from seed collected at Nappan was established in 1938. The criteria used in selecting were vigorous growth habit, spreading ability and good seed-producing habits. A study made in 1938-39 regarding the hydrocyanic acid content of this material showed that there was no correlation between this character and such agronomic characters as winter survival and productivity. Consequently, this character has not been considered in selection. In 1939, 120 of the best plants were selected and established as clonal rows. Seed was harvested from the best of these rows in 1940 and the polycrosses were tested in the two succeeding years. The best of these polycrosses were combined into a single strain, of which the first seed increase was obtained in 1943. This strain was named "Pathfinder" and licensed in 1944. One of the difficulties encountered in getting this variety into use is that of seed production. However, a reasonably good supply of Foundation seed was obtained in 1948 and it is hoped to increase this rapidly in the future.

Ladino is another white clover type that has received considerable attention in recent years. While apparently not as widely adapted as wild white clover, it has outstanding merits for hay and pasture use in grass mixtures if the climatic conditions are suitable. The seed at present is relatively high priced, and there is an additional difficulty of providing the growers with a reliable seed supply. At the Ladino Work Planning Conference held at State College, Pa., in 1945, it was agreed that the use of certified seed was the best ultimate solution to the problem of insuring the farmers a source of true Ladino. It was agreed that there should be a free exchange of clones of selected plants among the various interested stations. On the basis of all tests, the best clones would be used as Foundation material from which to build up Foundation seed.

As an active co-operator in this project, the Division of Forage Plants, Ottawa, contributed clones of 30 selections in 1946, and received 100 clones from United States stations for testing. The evaluation of these clones was completed in 1947, and an isolation nursery for their multiplication was planned. This work may be regarded as of a tentative nature for insuring a supply of reliable seed in the immediate future. Considerable work remains to be done in Ladino improvement, aiming at such objectives as disease resistance, hardiness under varying conditions, and improved seed-producing habits.

Timothy (*Phleum pratense* L.)

Available figures indicate that there are approximately 9,000,000 to 10,000,000 acres of hay and clover grown in Eastern Canada each year, and an additional 6,000,000 acres in improved pasture. It is a fair assumption that at least half the seed used to seed out these areas is timothy. Indeed our annual domestic requirements of timothy seed for all Canada is almost equal to that of the total requirements of all the other grasses and clovers combined. While hay production varies widely, it may be assumed that Eastern Canada produces something in the neighbourhood of 15,000,000 tons of hay each year. It is impossible to estimate accurately the amount of timothy and the amount of other grasses and clovers that go to make up the total, but an estimate of 50 per cent timothy does not look too improbable, in view of the amount of seed used each year. If the arbitrary figure of 7,500,000 tons of timothy hay, either in mixture or alone, is accepted, the effect that even a small increase in the productiveness of timothy would have on the total production can be readily understood. A five per cent increase in productivity would mean 350,000 tons more hay, and ten per cent 750,000 tons. A similar effect would be exerted on improved pastures.

Improvement work with timothy has been actively pursued at Ottawa for a number of years, and has resulted in the development of two varieties, Boon and Climax. Boon has been widely grown but will now be displaced by Climax, which was licensed in 1947.

Climax is a relatively tall, upright type characterized by a leafy fine-stemmed growth. The variety has considerable resistance to leaf-spot and rust. It is a synthetic strain developed by combining a number of selected plants of desirable breeding behaviour.

The progress that has been made in the development of higher yielding strains in Canada is indicated by the summarized data in Table 6.

TABLE 6—YIELD OF HERBAGE IN TONS OF DRY MATTER PER ACRE

Variety	Hay 2-year Average (1946-1947)	Pasture 3-year Average (1946-1948)
Milton	2.10	2.31
Boon	1.94	2.24
Climax	2.13	2.44
Swallow	1.88	2.31
Drummond	2.02	2.16
Commercial	2.04	2.31
Medon	—	2.19

It will be observed that the differences between varieties are not great. However, as has been pointed out previously, small increases in productivity can have a large overall effect. The increased leafiness and disease resistance of most of the selected strains is not reflected in yield, but will markedly effect the quality of the forage produced.

Blue Grasses (*Poa* spp.)

Kentucky Blue Grass (*Poa pratensis* L.)

A limited breeding program has resulted in the development of Delta Kentucky blue grass and Chieftain Canada blue grass. Delta is an erect, fine-stemmed, early, extremely uniform type, highly resistant to mildew. It is a single plant selection out of native material, and it reproduces apomictally. The variety produces comparatively high yields of hay, pasture and seed, but since little Kentucky blue grass seed is produced in Canada from cultivated meadows, the seed of this variety is not available commercially.

Canada Blue Grass (*Poa pratensis* L.)

Since most, if not all, Canada blue grass seed produced in Canada comes from native stands or volunteer seedings, production of seed of recognized varieties is not being pursued at the present time. Therefore, seed of Chieftain, a very acceptable variety and a good seed producer, is not available in commercial quantities.

Orchard Grass (*Dactylis glomerata* L.)

This species has assumed a position of increasing importance in hay and pasture mixtures during the last few years. It is capable of supplying early spring grazing and is comparatively drought resistant. It is not completely winter hardy except in the most favoured sections. Its tendency to become coarse and unpalatable as it reaches maturity, mitigates against its use as hay and makes careful pasture management necessary.

An active breeding program has been in progress at Ottawa for some years. The variety "Hercules" has been developed. Under Ottawa conditions, it has proved to be more winter-hardy than commercial and imported named varieties. It is somewhat later than commercial and more leafy. Excellent seed yields have been obtained from it. However, it has not proved more productive than other varieties, and is as susceptible as others to the diseases that affect the species.

An intensive breeding program was begun in 1939 with the object of developing a variety that would be more suitable for pasture production. A collection of 105 strains from many diverse sources was assembled. From this collection, a single plant nursery of approximately 16,000 plants was established in 1939. From this nursery well over 500 plant selections have been made. These individual selections have been subjected to intensive study and a number of them now give promise of being capable of combining to produce a superior strain.

Meadow Fescue (*Festuca elatior* L.)

As another of the large-seeded grasses, this species is now making an important contribution in hay and pasture swards in Eastern Canada. Its ease of establishment, and its heavy bottom growth of leafy herbage makes it very acceptable for hay and pasture. Prior to 1944, the species was little used, and, as so often happens, its utilization increased rapidly at a time when prospects for adequate seed supplies did not appear bright. Fortunately, however, the Division was in a position to release to seed growers the variety "Ensign" in 1944, thus aiding in giving impetus to the production of seed of this species so that Canadian production rose from 4,500 lb. in 1943 to 500,000 lb. in 1948. The situation changed in six years from a position where negligible quantities had been produced and imported, to one where in 1947 and 1948 a substantial amount of seed was exported, and a very large quantity utilized in hay and pasture mixtures.

The Ensign variety grows to a height of 3 to 3½ feet. It is upright and uniform in habit of growth and produces a leafy bottom growth which forms dense tufts. It is productive in hay and pasture and an exceptionally good seed yielder. While it is impossible to estimate the effect of the timely release of this variety on the Canadian seed production of the species, it is safe to say that it is, at the present time, the most extensively grown recognized meadow fescue variety in Canada.

The variety has no resistance to crown rust. Since rust on meadow fescue undoubtedly affects yield, the breeding program with the species has, since the release of Ensign, been directed mainly toward the selection of types highly resistant to the disease. Up to the end of 1948, a total of 182 plant selections have been made which appear to have marked resistance.

Creeping Red Fescue (*Festuca rubra* L.)

A strain of creeping red fescue, mass selected out of Swedish material, was licensed under the name Duraturf. The variety is about two feet in height and comparatively uniform. It has a dense bottom growth with the restricted creeping habit characteristic of the species. The plants remain green late in the fall and seem to be able to remain in an active state even after severe frosts. The variety has the ability to form a dense sod of uniform appearance and the strong vigorous underground stems produce abundant new growth. It is a prolific seed producer and because of its uniformity in maturity is easily harvested.

The continuing breeding program has as its objective the development of a strain possessing some or all of the following desirable characteristics (1) aggressive spreading habit, (2) high seed-setting ability extending over several fruiting periods, (3) rapid recovery after clipping, (4) freedom from, or high resistance to, diseases such as *Helminthosporium dictyoides*, and (5) resistance to drought. There are now 198 individual plant selections under study.

Reed Canary Grass (*Phalaris arundinacea* L.)

This species has come into prominence as a highly productive species, extremely valuable for low lying areas and capable of making a substantial contribution on semi-upland soils. Its ability to stand long periods of partial innundation and to thrive indefinitely on poorly-drained soils makes it useful for many areas. A breeding program has been in progress at the Division since 1944. Emphasis has been placed on the development of a strain possessing the following desirable characteristics:—
(1) late maturity, (2) rapid recovery after mowing or grazing, (3) less pronounced sod binding tendencies, (4) increased frost resistance, and (5) improved seed yield.

A total of 257 individual plant selections have been made since the beginning of the breeding program. A number of these selections have been tested to the extent that they can now be recombined in polycross blocks for the creation of new strains.

Breeding Methods

Strain Testing

In evaluating new single plant selections or developed strains, it is necessary to obtain a measure of yielding ability. Since small differences in yield must be given significance if possible, it follows that the methods of testing must be such that the experimental error will be small.

With a view to establishing the relative efficiency of three types of plots, a carefully controlled test with timothy was established in 1945. The plot types used were: broadcast, spaced rows and individual plants. At the outset it was felt that if the individual plant type of plot could provide reliable information, the work of evaluating strains would be much simplified. Data was therefore assembled to determine the effectiveness of the different plot types. These data were thoroughly analyzed and results obtained are shown in Table 7.

TABLE 7—SUMMARY OF RESULTS OBTAINED IN EVALUATING THREE METHODS OF STRAIN TESTING, (1946-1947)

Item	Type of Plot		
	Broadcast	Spaced row	Individual plant row
Coefficient of variability	20.47%	12.12%	12.95%
Least significant difference-varieties (P = .05)	687 lb.	413 lb.	344 lb.
Least significant difference-years (P = .05)	405 lb	209 lb.	258 lb.

It will be observed that the coefficient of variability and the least significant difference for the broadcast type of plot is considerably higher than that of the other two types. It can therefore be assumed that the use of the spaced row and individual plant plot will give satisfactory results. One of the main reasons for this is that variation due to stand is minimized in these two types of plots. The ease with which the individual plant plot can be managed, and the small amount of land and seed required for testing, commends its use by the plant breeder in his testing work.

Appraising Parent Material

In searching for suitable parent material a great many individual plants must be observed and appraised. This work is laborious and time-consuming. With a view to eliminating, as far as possible, observations on useless material, metrical studies have been made to serve as a guide in plant selection. Correlations have been made between such factors as incidence of disease in fall of year, fall vigour, spring vigour, plant type, hay yield, aftermath, etc. Table 8 indicates the factors correlated, the correlation coefficients obtained and the necessary levels for significance.

It will be observed that varying degrees of correlation exist between the factors examined. It is evident that high fall and spring vigour indicates high yielding ability, while disease resistance as indicated by fall examination is positively correlated with high yields in the following year.

TABLE 8—CORRELATION DATA OBTAINED IN THE APPRAISAL OF PLANT BREEDING MATERIAL, (1939)

No.	Factors correlated	No. of pairs	Correlation coefficient	Necessary levels for significance	
				5%	1%
1.	Fall disease and plant type	423	−.177	.098	.128
2.	Fall disease and spring vigour	412	−.463	.098	.128
3.	Fall disease and fall vigour	452	−.003	.098	.128
4.	Fall disease and hay yield	423	−.251	.098	.128
5.	Fall disease and aftermath	419	−.049	.098	.128
6.	Fall disease and total yield	424	−.530	.098	.128
7.	Fall vigour and hay yield	414	+.359	.098	.128
8.	Fall vigour and plant type	444	−.003	.098	.128
9.	Fall vigour and spring vigour	421	+.452	.098	.128
10.	Fall disease and date of heading	281	−.020	.113	.148
11.	Fall vigour and date of heading	308	+.050	.113	.148
12.	Spring vigour and date of heading	237	+.080	.138	.181
13.	Spring vigour and plant type	424	+.260	.098	.128

Field Roots

Study of Induced Polyploids

A study was carried out from 1939 to 1941 to determine the value of induced tetraploids in the three field root crops, mangels, sugar beets and swedes. Tetraploid plants were obtained by means of colchicine treatments of germinating seed. The varieties treated were Caesina sugar beets, Tip-Top mangels and Laurentian swedes. After obtaining tetraploids, these were crossed with the normal diploids and triploids produced. Enough seed was obtained of each chromosome type to carry out randomized field tests for the three groups of material. Significant differences in yield were obtained. The diploids yielded significantly better than the tetraploids while the triploids were intermediate in yield. The various sugar beet chromosome types showed no significant differences in percentages of dry matter or sugar content. It was concluded that in the case of the varieties of field roots investigated the development of tetraploid strains would serve no practical purpose.

Resistance to Club-root of Swedes (*Brassica napus* L.)

Breeding work is limited chiefly to the development of club-root resistant varieties. This project is carried co-operatively with the Dominion Experimental Farm, Nappan, N.S. A disease nursery is maintained at Nappan and all varieties, strains and hybrids are tested there. Those which show resistance in this test are taken to Ottawa and used as parent material in the breeding program.

The variety Wilhelmsburger has shown fairly high resistance to club-root. Another variety known as Danish Giant has shown marked resistance and some of the white-fleshed turnips have shown almost complete immunity. None of these varieties of swedes or turnips meet the specifications established for desirable types of that crop. However, all are being used in the breeding program because of club-root resistant qualities which they possess.

From crosses of the above parent material some progenies have shown marked resistance to club-root, and there is now reason to believe that it is possible to obtain selections in which high resistance is combined with desirable plant type.

Fig. 5—Hybridization of swedes in greenhouse during winter (February, 1946).

Mangels (*Beta vulgaris*, var. *rapa* Dum.)

Breeding work with this crop has been carried on a much reduced scale because of the fact that acreage has decreased greatly during recent years. Some work has been done with a view to maintaining and improving the variety Tiptop which was developed a few years ago. This variety, while somewhat low in tons of harvested roots (green weight) is still one of the highest yielding varieties in terms of dry matter per acre. The limited breeding work now in progress is designed to improve the green yield of this variety without sacrificing the percentage of dry matter in the roots.

CYTOLOGY OF GRASS SPECIES

In addition to the routine cytological examination of breeding stocks of the principal grasses, an extensive study of the blue grass species, *Poa*, was completed and the results published. A similar study with the *Festuca* species is being carried out.

The somatic or body cell chromosome numbers of 20 species of Poa were determined. The species arranged themselves in a polyploid or multiple series of the basic number seven from diploid to dodecaploid, tetraploids and hexaploids being the most numerous. Polymorphism, or forms or types differing in their chromosome numbers, were found to be present in *P. pratensis L.*, *P. compressa L.*, *P. palustris L.*, and *P. nemoralis L.*

The chromosome variability and the mode of seed production were examined in *P. pratensis L.*, using selected, uniform strains, indigenous plants and plants grown from commercial seed. The chromosome number was found to range from 50 to 87 $\pm$ 1, 10 of the 19 plants examined having chromosome numbers which were aneuploid or not multiples of seven. Both sexual and asexual modes of seed production were found to occur. The Ottawa selection, Delta, having a chromosome number of 70 was found to produce seed asexually. This has resulted in a high degree of uniformity in the strain and has made seed multiplication relatively simple.

Twenty-three species of *Festuca* have been examined to date, covering 43 accessions. Seven proved to be diploid, 3 tetraploid, 28 hexaploid, 4 octoploid, and one aneuploid. Polymorphism was found in *F. alpina*, *F. amethyetina*, *F. ampla*, and *F. ovina*. Twelve new indigenous species remain to be examined. The existence of polyploidy within a single species is of significant importance in plant breeding. Studies by Scandinavian workers tend to show that the higher polyploids in a plant species are better adapted to northern latitudes. This question merits considerable study, considering the wide range of climatic conditions existing in Canada.

TRITICUM-AGROPYRON HYBRIDIZATION

The hybridization of wheat with perennial Agropyron grasses became the subject of research in 1935, in response to the need in Western Canada for new grasses that would aid in solving the problems of drought and soil erosion. The aim was not to produce perennial or hardy winter wheat but large-seeded forage grasses which could be readily established under drought conditions. The breeding work has been carried out at the Division of Forage Plants, Ottawa, Ont., and at the Dominion Forage Crops Laboratory, Saskatoon, Sask. Other experimental stations in Western Canada have conducted tests of advanced generation lines in recent years. Stations in other parts of the world have requested and received material and reported their results.

FIG. 6—Breeding nursery showing large-seeded, perennial grasses (Triticum-Agropyron hybrids), developed by crossing wheat and perennial grass (June, 1948).

Although crossing attempts were made at Ottawa with close to 30 species of Agropyron, only the two species *A. intermedium,* and *A. elongatum* crossed readily. These are tall-growing species indigenous to continental Europe, and to Asia. *A. elongatum* is of the bunch grass type, while *A. intermedium* creeps moderately by stolons. Cross-pollination in these species is usual, although not obligatory. Both species with their extensive root-systems and xerophytic leaf-characters possess considerable drought resistance. They are also immune or highly resistant to fungus diseases such as smut and rust. They have certain obvious faults such as harsh foliage and seed-shattering.

In the years 1935-43, over 110,000 florets of 42 varieties of wheat were pollinated with the two grasses, yielding over 11,000 seeds or a crossing success of about 10 per cent. When the F_1 plants were established in the field they proved to be perennial and inclined towards the grass parents for most morphological characters. There was a striking difference in the fertility of the two types of crosses in that the intermedium hybrids were completely sterile, while the elongatum hybrids exhibited a low degree of fertility. This difference in fertility was shown to depend on the degree of pairing of chromosomes at meiosis in the F_1 plants.

This difference in fertility has determined the breeding procedure in subsequent generations. With the elongatum hybrids, line-breeding methods have been followed, using as the main criteria in plant selection, perennialism, fertility and seed-weight. Other characters considered in the elimination of a large number of lines were tillering, height, forage quality, freedom from shattering, threshability and resistance to disease. The lines have now reached the seventh to ninth generation, with the most promising lines tracing to Kharkov and Vernal Emmer wheat parents. The seed weight of the average line is about 4 times that

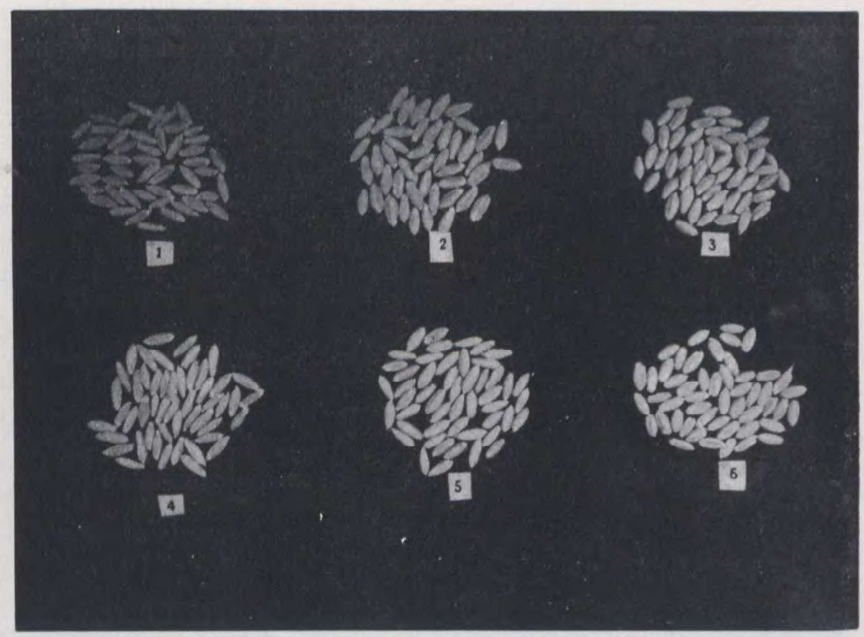


FIG. 6a—Seeds of Triticum-Agropyron hybrids. Nos. 1, 2, 4 and 5 are from perennial grass-wheat hybrids. Nos. 3 and 6 are Kharkov and Lutescens winter wheat respectively (January, 1946).

of the grass parent, and 2/3 that of the wheat parent. Selection for increasing fertility has also been successful and is closely correlated with the tendency towards chromosome stabilization. The perennial character has been firmly fixed in these late generation lines although there are differences in the degree of winter-hardiness associated with it. The value of tests at Western Canada stations for eliminating less hardy material is apparent.

In the intermedium hybrids two means of overcoming the sterility in the F_1 generation have been resorted to. The first method was to backcross to the wheat parent and carry on line selection. This proved fairly difficult because of the low crossing success and the almost complete loss of perennialism. Nevertheless, several perennial lines have been secured by this method, which are outstanding in seed size. The second method which is a striking advance in the work has been the creation of amphidiploids or plants with double the F_1 chromosome number. Colchicine, an alkaloid drug, obtained from the seeds of meadow saffron, when applied to the germinating seed causes a doubling of the chromosome number. The resulting plants grown from this treated seed are fertile and reasonably stable in their breeding behaviour. The amphidiploids are very productive of forage although the seed size does not equal that of the better line selections.

As yet, while there are a considerable number of promising lines, they must be thoroughly tested at Branch Farms and Stations before being multiplied and released for general use.

PLANT INTRODUCTIONS

The testing of new forage species and plant introductions has been an important function of this Division since its inception. The introduction and testing of these new species from foreign sources as well as native species collected in Canada is a valuable service of the Division, since it provides information to farmers, at relatively small cost, on the possible adaptation of new varieties under Canada's various climatic conditions. Much of the material tested has proven of little value and hence losses to agriculture are prevented by not furthering their distribution. On the other hand, some new species that have shown promise in the introduction nursery have been developed by the plant breeders into valuable strains for hay and pasture. When it is realized that most of our economic forage species were originally introduced to this country, the importance of a careful study of possible new additions to our forage crops is evident.

In addition to the testing nursery at Ottawa, other experimental stations with distinctive climatic and soil traits carry out comparable tests of material that is likely to be suitable for their representative farming areas. The Forage Crops Laboratory at Saskatoon tests such species as *Elymus*, *Agropyron*, and *Bromus* looking for new varieties outstanding in drought resistance and winter hardiness. The Agassiz Experimental Station tests the less hardy species such as *Lolium*. Maritime experimental stations carry out tests with legume species such as the lupines which are acid tolerant and have possibilities as cover crops in orchards.

During the past 18 years the extent of the number of introductions received and tested is apparent from the following summary:—

Standard grass species	—	1530
Standard legume species	—	1265
Miscellaneous grasses	—	3207
Miscellaneous legumes	—	2193
Miscellaneous species	—	1444
Total	—	**9639**

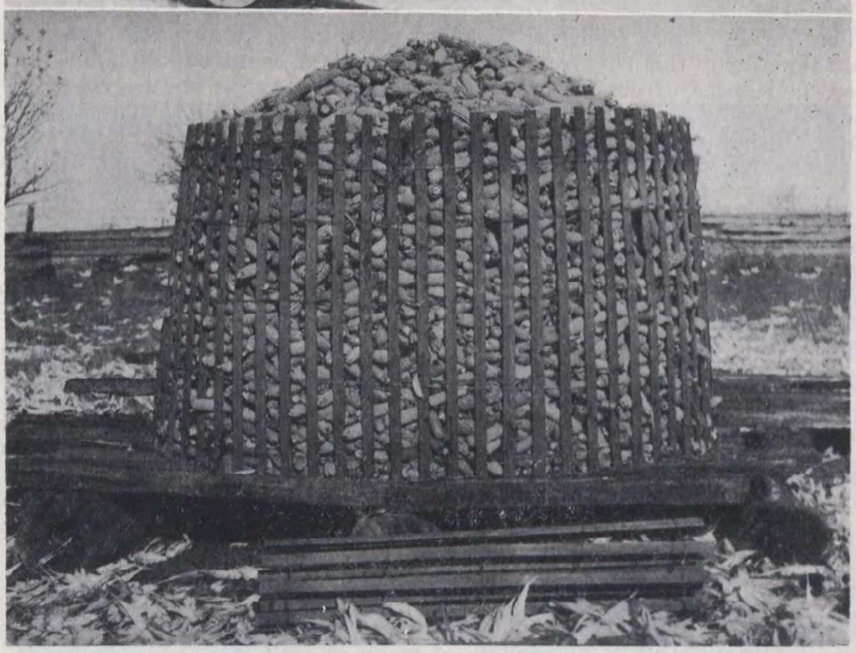


Fig. 7 (*Upper*)—Experimental corn crib at Ottawa—shelling corn in March, 1948.

Fig. 8 (*Lower*)—Snow-fence corn crib. This is a popular type of crib for storing corn (photographed October, 1947).

COMPARATIVE STUDY OF VARIETIES

Corn (*Zea mays* L.)

Hybrids for Grain

Since 1938, a great many commercial hybrids from different sources have been tested for the production of grain. They have come from experiment stations and seed companies, principally in the United States. Because of the frequent release of new hybrids it has sometimes been difficult to adequately test and establish the merits of hybrids which they were to replace. Continuous improvement, however, is one of the outstanding features of hybrid corn, and a rapid succession of hybrids was to be expected in the early years of development. Until 1941, only a few hybrids were available for testing that could be matured at Ottawa. From 1942 to 1948, 106 early maturing hybrids from 18 different sources have been tested at Ottawa, and while the number of hybrids in each of the 7 years has varied from 18 to 32, outside of the checks used for comparison, not more than 6 of the hybrids have been tested for the same 3-year period, and these came from only two sources. It is impossible, therefore, to present a summary of data for any considerable number of hybrids for a period of years. New hybrids have appeared on the scene so rapidly and disappeared so quickly, in many cases, that it is often difficult to secure seed of the same hybrid

TABLE 9—SUMMARY OF DATA SECURED IN TESTS OF COMMERCIAL HYBRIDS FOR GRAIN PRODUCTION CONDUCTED AT OTTAWA AND SPENCERVILLE, ONTARIO, (1948)

Hybrid	Height		Maturity x	Shelling percentage	Yield per acre, shelled corn (15% moisture)
	Plant	Ear	% moisture in ears at harvest		
	in.	in.			bu.
Agsco 203	89	30	32.8	80.6	70.0
Agsco 279	91	31	41.4	82.6	82.7
Agsco 301	91	31	40.7	81.7	76.6
Agsco 800	94	36	39.8	79.8	82.8
Magill 813	84	29	34.2	80.2	70.1
Magill 828	93	33	39.9	80.6	76.3
Ottawa 201	92	35	39.5	83.7	85.3
Wisconsin 275A	97	37	43.1	84.0	85.7
Wisconsin 341	98	33	50.3	80.0	94.6
Wisconsin 412A	97	37	50.0	80.6	91.2
Wisconsin 416A	99	40	47.8	79.5	94.0
Funk's G 185	96	28	44.3	81.4	84.4
Funk's 7275	92	27	41.0	83.9	82.6
DeKalb 41	94	30	41.6	81.6	84.2
DeKalb 43	97	38	43.8	81.3	88.1
DeKalb 46	98	41	45.1	80.7	89.7
Kingscrost KE 1	96	38	42.3	83.8	86.5
Kingscrost KF 1	85	31	42.0	83.2	82.9
Kingscrost KE 3	89	28	40.5	84.6	79.5
Kingscrost—Wheatland blend	92	31	39.4	85.3	80.2
Newday (80 days)	86	27	36.1	82.3	71.8
Newday (80-85 days)	90	30	35.8	80.3	67.9
Newday (85 days)	91	32	41.8	81.6	75.7
*Canada 240	97	30	40.4	84.1	77.2
*Canada 275	97	34	45.8	84.2	86.7
*Canada 355	101	38	46.1	81.7	85.2
Necessary difference for significance (L.S.D.)					4.8

Date planted, May 18 (Ottawa) — Date harvested, Oct. 4 (Ottawa)
Date planted, May 26 (Spencerville) — Date harvested, Oct. 14 (Spencerville)
No lodging, no smut.
* Check for comparison.
x Based on ear shrinkage samples.

for more than 2 or 3 years in succession. Only the hybrids used as checks have been tested consistently from year to year. These have included Canada 240, Canada 255, Canada 275, Canada 275A, and Canada 355. Being among the first early maturing hybrids available, and having performed extremely well from the beginning, these hybrids have been used as checks for comparing and evaluating new hybrids since these tests were begun. In 1948, two tests of commercial hybrids were conducted, including the test at Ottawa and another on a farm about 60 miles south of Ottawa at Spencerville. A summary of the results obtained in these tests is given in Table 9. It represents the type of data secured from the hybrid tests during the 7 years (1942-1948).

From the data secured from tests of a reliable nature, hybrids are evaluated on the basis of yield of grain, maturity, resistance to lodging and disease, and ease of harvesting (including the easy removal of husks). Some attention is being given to the chemical composition of the grain, particularly the protein and oil fractions. Since the comparative tests were begun at Ottawa in 1942, the following commercial hybrids have been recommended for grain production:—
Canbred 150, Canada 240, Jacques 802, Canbred 250, Canada 255, Kingscrost KE 3, Kingscrost KE 1, Canada 275, Canada 279, Funk's G 42, and Canada 335. The hybrids are listed in order of earliness, Canbred 150 being the earliest and Canada 335 the latest maturing.

Hybrids for Silage

A total of 194 commercial hybrids have been tested for silage during the period from 1937 to 1948. The number tested during a single year varied from 10 to 48. The hybrids came from 26 different sources, chiefly experiment stations and seed companies in the United States. Of the 194 hybrids, the greatest number tested for the same 3-year period was 15 (1939-1941), and 10 (1940-1942). From 1942 until 1948 not more than 2 hybrids have been included in the tests for a period of 3 consecutive years, outside of those that have been included as checks for comparative purposes. New hybrids have been released frequently to replace earlier hybrids, so that, with few exceptions, it was difficult to obtain seed of the same hybrids for testing for a period of 3 years or longer. As a great many

TABLE 10—SUMMARY OF DATA SECURED IN TESTS OF COMMERCIAL HYBRIDS FOR SILAGE PRODUCTION, CONDUCTED AT OTTAWA AND SPENCERVILLE, ONTARIO, (1948)

Hybrid	Plant Height	Total Moisture when cut	Stage of Maturity	Yield per acre	
				Green	Dry
	in.	%		tons	tons
Funk's G 16A	115	74.5	E.D.	18.82	4.80
Funk's G 29	118	74.8	E.D.	17.21	4.34
Funk's 72906	110	73.4	D	18.06	4.81
Kingscrost KT	111	73.5	D	17.75	4.71
Kingscrost M2	107	72.2	L.D.	17.29	4.81
Pfister 56	102	73.6	D	16.57	4.38
*Canada 531	108	71.5	L.D.	16.01	4.57
*Canada 606	112	73.7	D	17.20	4.53
*Canada 645	109	72.9	D	17.41	4.72
*Canada 696	111	73.4	D	18.99	5.05
Necessary difference for significance (L.S.D.)				.60	.14

*Checks for comparison.
Date planted, May 18 (Ottawa) Date harvested, Sept. 27 (Ottawa)
Date planted, May 26 (Spencerville) Date harvested, Sept 15 (Spencerville)
E.D. — early dough D — dough L.D. — late dough

of the hybrids tested in the earlier years have passed out of commercial production and are no longer available, it would be of little value to present a summary of the data secured during the 3-year periods, 1939-1941, or 1940-1942. Instead, a summary of the data from the most recent tests, conducted at Ottawa and at Spencerville, Ont., in 1948, is presented in Table 10.

From data secured from tests of a reliable nature, and the comparison of this data with that of the checks, hybrids are evaluated largely on the basis of yield, maturity, plant type and resistance to lodging and disease. As the result of tests conducted during the 12 years (1937 to 1948), the following hybrids are recommended for silage production: DeKalb 65, Pioneer 355, Canada 531, DeKalb 240, Pfister 56, Canada 606, Canada 645, Pioneer 373, Funk's G 31, Pride D 66, and Canada 696. The hybrids are listed in order of earliness, DeKalb 65 being the earliest and Canada 696 the latest in maturity.

Chemical analyses have shown that there are no essential differences between the silage obtained from hybrids and that obtained from open-pollinated varieties of similar maturity. These analyses have included protein, fat, ash, crude fibre and nitrogen-free extract.

Statements have been made that dairy cattle fed silage made from hybrid corn have occasionally suffered certain disorders that are not apparent when they have been fed silage obtained from open-pollinated varieties. It has been suggested that hybrid corn silage has a lower sugar content than silage from open-pollinated varieties, and that this may have been the cause of the trouble.

In 1942 several hybrids were planted together with the varieties Golden Glow and Wisconsin No. 7 in order to determine by chemical analysis the sugar content of the silage harvested from each one. They were all harvested on September 15, the usual time for cutting corn for silage in this area, and they were very much of the same maturity except DeKalb 240, which was somewhat earlier, and Canada 696 which was somewhat later than the rest. The results obtained are given in Table 11.

TABLE 11—SUGAR CONTENT OF SILAGE OBTAINED FROM COMMERCIAL CORN HYBRIDS IN COMPARISON WITH THAT FROM OPEN-POLLINATED VARIETIES

Variety or Hybrid	Sugar %
DeKalb 240	7.40
Canada 606	7.75
Canada 645	8.40
Indiana 210	9.62
Canada 696	11.15
*Golden Glow	8.32
*Wisconsin No. 7	9.50

*Open-pollinated

The percentage sugar in the silage of the hybrids and varieties varied according to maturity, being lowest in the earliest and highest in the latest. There was little or no difference between the hybrids and varieties of similar maturity. Golden Glow was comparable in maturity to Canada 606 and Canada 645, while Wisconsin No. 7 was similar in this respect to Indiana 210 and Canada 696.

In 1943, a test was made in which an early and a late hybrid were compared with an early and a late variety, the corn being harvested at two different dates, September 1 and September 21. The first harvest was a little earlier than the usual time for cutting corn in this area, while the second harvest was possibly a little later, although much of the corn is regularly harvested after September 21. Results obtained with respect to percentage of sugar in the silage are presented in Table 12.

TABLE 12—SUGAR CONTENT OF SILAGE OBTAINED FROM COMMERCIAL CORN HYBRIDS AND OPEN-POLLINATED VARIETIES OF COMPARABLE MATURITY

Variety or Hybrid	Time of cutting	Stage of Maturity	Sugar %
Canada 531	Sept. 1	Late milk	12.45
Golden Glow (early)	" 1	" "	12.54
Canada 645	" 1	Early milk	19.04
Golden Glow (medium)	" 1	" "	15.47
Canada 531	" 21	Late dough	6.90
Golden Glow (early)	" 21	" "	7.15
Canada 645	" 21	Early dough	8.88
Golden Glow (medium)	" 21	" "	8.78

The data indicate that the differences between the sugar percentages of the two hybrids and the two varieties of comparable maturity were very small. It is obvious that the stage of maturity exerts a great influence upon the sugar content, which is much higher in immature corn, irrespective of whether it originated from the hybrids or the varieties. After the corn passes the early milk stage, there appears to be a steady decrease in the content of sugar as the crop advances towards maturity.

In 1945, a test was planted to compare the sugar content of silage made from two hybrids, Canada 606 and Canada 696, with that made from the varieties Golden Glow and Excelsior, the latter a varietal hybrid. The corn was cut at two different stages and results are given in Table 13.

TABLE 13—SUGAR CONTENT OF SILAGE OBTAINED FROM COMMERCIAL CORN HYBRIDS AND OPEN-POLLINATED VARIETIES HARVESTED IN EARLY STAGES OF MATURITY

Variety or Hybrid	Stage of Maturity	Sugar* %
Canada 606	Silking	19.2
Canada 696	"	19.6
Golden Glow	"	17.8
Excelsior	"	18.4
Canada 606	Early milk	23.1
Canada 696	" "	21.5
Golden Glow	" "	24.4
Excelsior	" "	22.6

* Analysis on dry matter basis.

The data presented from tests conducted in three different years do not show any appreciable differences between the sugar content of silage obtained from hybrids and varieties of similar maturity and harvested at the same stage of development.

It has already been stated that the better corn hybrids yield about 20 to 25 per cent more grain or silage than varieties of similar maturity. Likewise, it has been claimed that the first generation of a hybrid yields about 20 per cent higher than the second generation of the same hybrid. In 1941 and 1942, tests were conducted to compare the yields of silage produced from first and second generation seed of two hybrids and those obtained from the varieties Golden Glow and Wisconsin No. 7. Data obtained are presented in Table 14.

TABLE 14—COMPARISON BETWEEN THE YIELDS OF SILAGE OBTAINED FROM FIRST AND SECOND GENERATION CORN HYBRIDS AND OPEN-POLLINATED VARIETIES

Variety or Hybrid	Yield per acre		Relative yield 1st and 2nd generations (dry matter)
	Green	Dry	
1941	tons	tons	
Canada 606	13.98	3.81	127.0
Canada 606 (2nd generation)	11.07	3.00	100.0
Canada 645	12.10	3.82	120.5
Canada 645 (2nd generation)	10.95	3.17	100.0
Golden Glow (medium)	11.92	3.13	—
Wisconsin No. 7	11.92	3.28	—
1942			
Canada 606	14.34	3.40	117.6
Canada 606 (2nd generation)	13.01	2.89	100.0
Canada 645	14.87	3.51	117.4
Canada 645 (2nd generation)	12.75	2.99	100.0
Golden Glow (medium)	10.65	2.69	—
Wisconsin No. 7	12.23	3.07	—

The data show that the first generation of the two hybrids outyielded the second generation by approximately 20 per cent in the two years. Similarly, the first generation hybrids outyielded the average of the two varieties by approximately 20 per cent. The yields of the second generation hybrids were more nearly like those of the two varieties in both years, indicating that the gain in yield achieved by using first generation seed is lost by using second generation seed of the same hybrid. Only first generation seed should be used in growing hybrid corn for silage, in order to attain maximum yields.

Soybeans (*Glycine max.* L.)

Varieties for Seed

Seed production tests have included for the most part varieties and strains from outside sources, and superior strains developed in the breeding program at Ottawa. Standard varieties of known maturity and performance have been included in all tests for purposes of comparison, and to assist in the evaluation of new material. The average results obtained in the uniform tests for the 4-year period, 1938-1941, are shown in Table 15.

The data show that good productive varieties in the 124 to 127 day maturity class can be expected to produce the highest average yields at Ottawa and in areas with similar conditions. From a yield standpoint, the results indicate very definitely the importance of adaptation. Mandarin, Manchu and Selection 171 were able to mature normally and make use of the full season for maximum production. They are potentially high yielders. Certain of the other varieties requiring about the same period in which to mature, were definitely lower in yield potentiality. O.A.C. No. 211 proved to be too late and its yield suffered accordingly, while the yields of other varieties were low because of earliness. The earlier varieties, including Pagoda, Moscow, Kabott and Goldsoy indicate adaptation to areas of shorter season in accordance with their maturity periods.

The chemical analyses represent what may be expected from soybean varieties produced at Ottawa and under similar conditions of environment elsewhere. The oil content was not particularly high, although those above 19 per cent could be regarded as satisfactory for processing purposes. With one exception (Manchu), protein content was quite good, while the iodine values were well

TABLE 15—UNIFORM TESTS OF SOYBEAN VARIETIES AND STRAINS FOR SEED PRODUCTION. AVERAGES FOR 4 YEARS, 1938-1941

Variety or Strain	Height	Maturity period	Yield per acre (14% moisture)	Analysis of Seed*		
				Protein	Oil	Iodine No.
	in.	days	bu.	%	%	
Mandarin	34	126	31.7	38.7	20.3	131
Manchu	37	127	31.4	36.8	20.8	136
Selection 171	38	124	31.0	38.9	20.9	133
Goldsoy	31	120	29.4	38.8	20.8	135
Kabott	31	115	29.0	39.8	20.0	132
O.A.C. No. 211	35	138	29.0	39.9	19.3	134
Cayuga	40	123	28.1	38.7	19.7	134
Selection 49	39	123	28.0	42.1	19.4	130
Selection "I"	37	123	27.0	38.4	20.0	133
Moscow	30	114	26.4	40.9	18.7	133
Pagoda	31	106	24.8	40.6	19.7	129

* All analyses made by the Division of Chemistry, Science Service, Ottawa, Ont.

Sources of Seed—

Manchu	—T. B. Macaulay, Hudson Heights, Quebec
Moscow	—T. B. Macaulay, Hudson Heights, Quebec
Goldsoy	—Ontario Agricultural College, Guelph, Ontario
O.A.C. No. 211	—Ontario Agricultural College, Guelph, Ontario
Cayuga	—Cornell University, Ithaca, N.Y.
All other varieties and selections	—Central Experimental Farm, Ottawa, Ontario

within the range normally found in soybeans. While there was a definite tendency for high protein and low oil, and low protein and high oil to be associated, there was no definite trend of association between iodine value and either protein or oil.

In Table 16 are presented the average protein, oil and iodine number for all of the above nine varieties for each of the 4 years, 1938 to 1941.

TABLE 16—AVERAGE PERCENTAGE OF PROTEIN AND OIL, AND IODINE NUMBER OF 9 VARIETIES FOR 4 YEARS, 1938-1941

	1938	*1939*	*1940*	*1941*
Protein	32.8	39.3	43.2	42.2
Oil	21.7	19.9	19.5	18.8
Iodine No.	133.0	135.0	127.0	135.0

The data show that seasonal conditions have profound effects upon the chemical composition of the soybean. Dry seasons tend to increase the percentage of protein and lower the oil, while under conditions of high moisture the reverse seems to be true. As mentioned before, high oil appears to be associated with low protein and vice versa. In 1940, the iodine number was definitely low in comparison with the other years, while the average protein percentage was the highest. Iodine number and percentage protein do not show any definite association in the other three years.

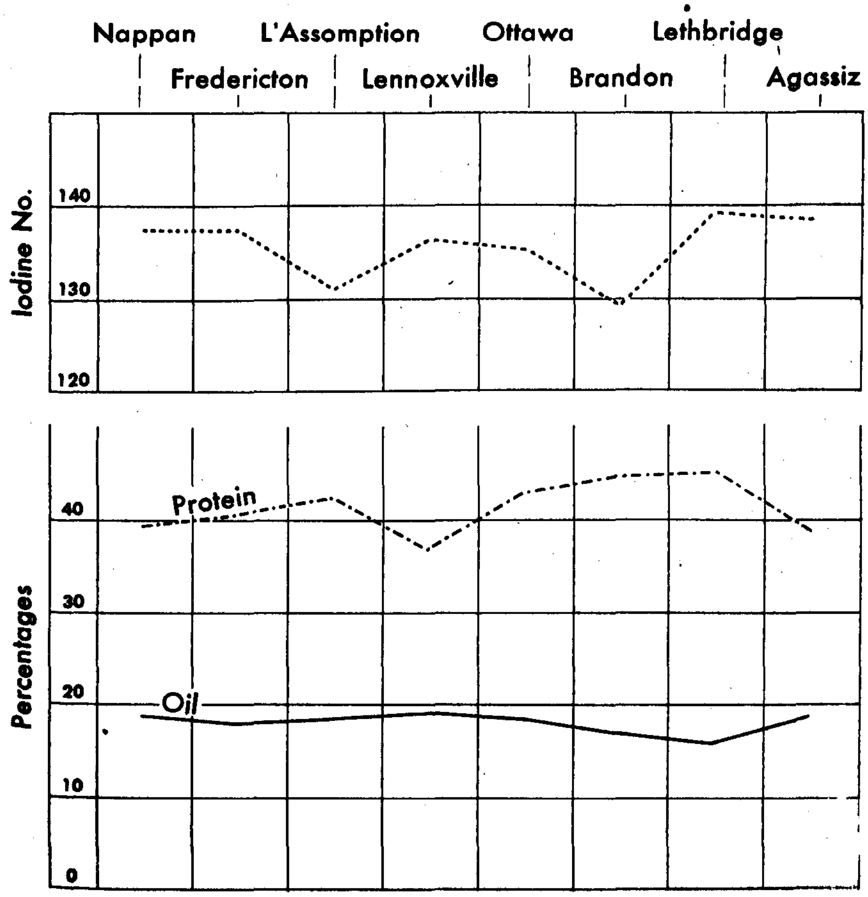
In addition to the testing of varieties and selections, a number of strains have been selected from the breeding nursery from time to time for testing for seed production each year. An endeavour has been made to arrange the strains in uniform groups on a maturity basis and extend the testing to several of the branch farms. The following branch farms have co-operated in carrying tests of the earlier strains:— Nappan, N.S.; Ste. Anne de la Pocatiere, Que.; Fredericton, N.B.; Lennoxville, and L'Assomption, Que.; Brandon and Morden, Man.; Indian Head and Swift Current, Sask.; Lethbridge, Alta.; and Agassiz, B.C. Summary reports of these tests will be made by the individual stations. These widely distributed tests have assisted greatly in evaluating the strains from the standpoint of adaptation, etc., and information has been obtained that could be secured in no other way. The number of strains tested in different years has varied considerably. In 1939, the same 32 strains were tested on 8 stations, including Ottawa. As most of these strains have since been discarded for various reasons, no purpose would be served by summarizing the field data, but as the chemical analysis of the seed was made of all varieties from all stations, a summary of the analytical data is given in Table 17. This summary is important because it shows the effect of environment upon the protein and oil content and the iodine number.

TABLE 17—EFFECT OF ENVIRONMENT UPON THE PROTEIN AND OIL CONTENT OF SOYBEAN SEED, AND THE IODINE NUMBER OF THE OIL, (1939)*

Average 32 strains	Nappan	Fredericton	L'Assomption	Lennoxville	Ottawa	Brandon	Lethbridge	Agassiz
Protein (%)...	39.5	40.7	42.1	37.1	42.7	44.5	45.0	38.9
Oil (%).......	18.9	18.0	18.6	19.1	18.5	17.0	15.8	18.5
Iodine No.....	137.0	137.0	131.0	136.0	135.0	129.0	139.0	138.0

* All analyses made by Chemistry Division, Science Service, Ottawa, Ontario.

The following figure presents a graphical illustration of the effect of environment upon the percentages of protein and oil, and the iodine number of the oil from soybean seed grown at the 8 different experimental stations.



The graph illustrates very clearly the association between high protein and low oil, and vice versa, and also indicates the tendency of the iodine number to behave rather independently of both of these.

The summary data and the graph also show the tendency for high protein and low oil seed to be produced at Brandon and Lethbridge, areas of relatively high evaporation and low moisture, and the opposite tendency at the remaining stations, areas of somewhat higher moisture or precipitation and lower evaporation.

During the 3 years (1946-1948) the scope of the seed production tests has been broadened at Ottawa to include Zone 0, Uniform, and Zone 0, Preliminary Tests which are conducted by the United States Regional Soybean Laboratory, United States Department of Agriculture. By doing this it has been possible to include promising strains developed at Ottawa and have them tested at many locations throughout the northern United States, in comparison with the best strains developed recently in that country. The advantages of securing data from so many widely distributed tests in a single year are obvious. The results already obtained have proved of great assistance in evaluating several promising new strains, which have reached the final testing stage.

Table 18 presents a summary of the agronomic and chemical data for varieties, all of which are grown in Canada at the present time, and which have been tested for the 3 years (1946-1948) at Ottawa and 9 different locations throughout the northern United States in the Uniform Test, Zone 0.

TABLE 18—THREE-YEAR SUMMARY, (1946-1948), OF AGRONOMIC AND CHEMICAL DATA FOR 6 VARIETIES TESTED AT OTTAWA, AND 9 DIFFERENT LOCATIONS IN THE UNITED STATES

Variety	Mean Yield per acre	Height	Maturity	Seed Analysis		
				Protein	Oil	Iodine No.
	bu.	(in.)	(days)	%	%	
No. of tests	25	22	16	26	26	26
Capital	25.9	30	123	40.1	20.6	133.6
Manchu	25.8	31	123	41.5	19.4	134.3
Mandarin (Ottawa)	24.8	27	125	42.2	19.6	131.2
Goldsoy	23.3	24	118	42.2	19.3	134.2
Flambeau	22.6	27	114	40.0	19.6	131.6
Kabott	21.5	24	113	42.4	19.4	132.1

The summary shows that Capital produced the highest yield and analyzed the highest in per cent of oil. It matured slightly earlier than Mandarin (Ottawa). Manchu, a strain selected by the late T. B. Macaulay, Hudson Heights, Que., yielded approximately the same as Capital, and had the same maturity, but was 1.2 per cent lower in oil content.

Strain 0-255, a new strain developed at Ottawa was included in the 1948 Uniform Tests, Zone 0. It ranked first in yield in 2 out of 8 tests and performed very satisfactorily in all other respects. It will be tested further in 1949. Additional Ottawa strains entered in the 1949 tests are 0-17, and 0-200.

As a result of the seed yield tests conducted at Ottawa during the past 12 years, the following varieties have been recommended: Pagoda, Kabott, Flambeau, Goldsoy, Capital and Mandarin (Ottawa). They are listed in order of maturity, Pagoda being the earliest and Mandarin (Ottawa) the latest. Pagoda is about 20 days earlier in ripening than Mandarin at Ottawa.

Varieties for Hay

In order to obtain information on the growing of soybeans for the production of hay, a number of varieties and selections were included in a yield test for the 3 years, 1937-1939. Seeding was done in close drills (7″) and each variety was cut for hay when the pods were about half filled out, and the leaves were still green. In Tables 19 and 20 agronomic and chemical data are given.

TABLE 19—THREE-YEAR SUMMARY OF DATA FOR SOYBEAN VARIETIES AND SELECTIONS TESTED FOR PRODUCTION OF HAY, (1937-1939)

Variety	Height	Date cut	Yield per acre	
			Green Wt.	Hay (15% moisture)
	in.		tons	tons
Mandarin (Ottawa)	36	Aug. 17	11.9	3.1
Variety "I"	39	" 16	11.9	3.1
Manchu	43	" 19	12.5	2.9
Selection 171	38	" 17	11.5	2.9
Selection 49	40	" 18	11.6	2.9
Cayuga	43	" 18	11.5	2.8
Kabott	37	" 10	10.7	2.8
Wisconsin Black	38	" 14	10.9	2.8
O.A.C. No. 211	43	" 24	12.6	2.8
Goldsoy	34	" 12	10.6	2.6

TABLE 20—CHEMICAL ANALYSIS OF SOYBEAN HAY (DRY MATTER BASIS)* 3-YEAR SUMMARY, (1937-1939)

Variety	Protein %	Fat %	Nitrogen-free Ext. %	Crude fibre %	Ash. %	Ca. %	P. %
Mandarin (Ottawa)	18.6	2.6	39.9	30.1	8.80	1.36	.30
Variety "I"	18.1	2.4	42.1	28.6	8.83	1.37	.30
Manchu	17.5	2.6	39.7	31.4	8.83	1.34	.29
Selection 171	18.3	2.6	40.4	30.5	8.19	1.52	.29
Selection 49	19.4	2.3	40.1	29.4	8.80	1.32	.30
Cayuga	16.7	2.6	40.7	31.9	8.29	1.23	.26
Kabott	19.2	2.7	40.9	28.2	9.07	1.44	.31
Wisconsin Black	19.7	3.2	38.1	30.1	8.85	1.31	.30
O.A.C. No. 211	18.9	2.5	38.8	30.6	9.19	1.28	.29
Goldsoy	19.8	3.1	39.9	28.4	8.80	1.31	.29

* All analyses made by the Division of Chemistry, Science Service, Experimental Farm, Ottawa, Ontario.

The data show that the soybean varieties produced good yields of highly nutritious hay. Most varieties reached the proper stage for cutting about three months after seeding, which at Ottawa was done on the average about May 20. The use of soybeans for the production of hay has not been recommended to any extent in this area, because of the difficulties involved in curing by ordinary methods.

Alfalfa (*Medicago* spp.)

Alfalfa variety tests for hay and pasture have included all of the commonly-grown varieties and strains of Canadian and American origin, as well as newly developed varieties. In addition, numerous strains and varieties have been received from time to time from European and Asiatic countries, and these have been included in preliminary tests in order to determine their adaptation to Canadian conditions. As far as possible, these tests are left down for a sufficient number of years, to permit the varieties and strains to be appraised, not only from the standpoint of yield of forage and seed, but also from the standpoint of hardiness and persistence.

The following brief notes are intended to bring out some of the more important qualities of the generally grown varieties.

Grimm—(*Medicago media*)—This is the most widely-grown variety in Canada and still leads the field in yield of seed and forage in most areas. However, due to the wide-spread occurrence of bacterial wilt in some parts of the country there is a demand for a wilt-resistant variety, which is suited to production under Canadian conditions.

Ladak—(*Medicago media*)—This variety was introduced from Asia about 25 years ago. It excels in hardiness and equals Grimm in yield of forage where one or two cuts are taken for hay. It is somewhat slower to produce a second growth than is Grimm. Experience indicates that this variety contains about 10 per cent wilt-resistant plants.

Viking—(*Medicago media*)—This comparatively new variety was developed by the Dominion Forage Crops Laboratory, Saskatoon, Sask. It equals Ladak in hardiness and is somewhat more variegated in flower than Grimm. It is somewhat more persistent under pasture conditions than either Grimm or Ladak.

Rhizoma—(*Medicago media*)—This is a new variety developed by the University of British Columbia. It is characterized by the development of underground rhizomes, or creeping roots. Preliminary tests have shown it to be hardy and relatively productive. There are indications that it is relatively persistent under pasture conditions.

Canauto—(*Medicago media*)—This is another new variety, developed by the Division of Forage Plants, Central Experimental Farm, Ottawa. It is similar to Grimm in appearance, hardiness and yield of forage, and has been superior to Grimm in yield of seed.

Ferax—(*Medicago media*)—A variety recently developed by the University of Alberta. It is similar in hardiness and yield of forage to Grimm, and has given higher yields of seed than Grimm in some areas.

Ranger and Buffalo—(*Medicago sativa*)—These are two relatively new varieties developed in the United States, and are characterized by high wilt resistance. They have been somewhat lacking in winter hardiness under Canadian conditions.

Red Clover (*Trifolium pratense* L.)

Variety tests with red clover have included both single-cut or late-flowering types, and double-cut or early flowering types. In general, it can be said that the double-cut types have excelled in yield of forage in areas having a relatively long-growing season, whereas the single-cut types are favoured in the more northern areas. Most varieties of the single-cut type tend to show greater persistence, or to be more perennial in character than the double-cut types. However, there are some exceptions to this rule. The following varieties were included in hay and pasture tests.

Ottawa—This is a double-cut variety, developed by the Division of Forage Plants, Central Experimental Farm, Ottawa, and is widely grown throughout eastern Ontario. It is one of the most persistent of the double-cut types tested to date. It is high yielding, winter-hardy and possesses marked resistance to root-rot diseases.

Dollard—This is a double-cut variety developed by the Agronomy Department of Macdonald College. It is hardy and high yielding, but slightly later in maturity than Ottawa.

Longhurst—This double-cut variety was produced in Idaho, U.S.A. Tests have shown it to be hardy, but somewhat lower in production of forage than either "Ottawa" or Dollard.

Among the single-cut types tested are Altaswede, Manhardy, Mammoth, Temiskamingue and Graham. These types have all proven to be hardy under Canadian conditions, while Altaswede and Manhardy have been slightly superior in yield.

White Clover (*Trifolium repens* L.)

Among the varieties of white clovers tested are common white Dutch, New Zealand wild white, Kentish wild white, Pathfinder, Morso, Stryno and Ladino. New Zealand wild white, Pathfinder and Morso have been more productive than common white Dutch. They have proven to be entirely winter-hardy under Canadian conditions. Stryno and Kentish wild white have been shown to be somewhat lacking in winter-hardiness.

FIG. 9—Variety test—white clover, 1936.

Ladino, a giant white clover, has outyielded all other white clovers tested at Ottawa. However, it is somewhat less persistent than the better ordinary white clovers under pasture conditions.

Field Roots

The following varieties of mangels and swedes were included in variety tests during the past several years:—

Swedes

Acadia—This is a high yielding variety which is widely grown for stock feeding purposes. It is characterized by a large top with the leaves held well up on a relatively coarse neck. Quarter cracks frequently occur which gives the root a rough appearance. The root is of the globe type with purple top and yellow flesh. While the root is relatively rough in appearance this variety is rated very high in cooking quality, although it is grown chiefly for stock feeding purposes.

Ditmars—A variety characterized by high yield, smooth, globe-shape greenish or bronze-topped roots. The flesh is yellow and of good flavour. This variety is popular with stockmen.

Wilhelmsburger—This variety leads all others in resistance to the club-root disease. It is characterized by large, green-topped, globe-shaped roots. The flesh is of a lighter yellow colour than most other varieties. It is widely grown in areas where the club-root disease is prevalent.

Laurentian—A medium sized variety characterized by smooth, purple-top, globe-shaped roots, short necks and relatively small leaf growth. The flesh is yellow and of a fine even grain. It is widely grown as a table vegetable.

Other varieties—Most of these are globe in type and may be divided into three classes on the basis of colour of the above-ground parts of the root. Purple top varieties include—: Bangholm, American Purple Top, Elephant, Canadian Gem, Hall's Westbury, Superlative, Jumbo, Masterpiece, Perfecta, Imperial, Purple King, etc. Bronze-top varieties would include:— Kangaroo, Lord Derby, Hazard's Improved, Invicta, etc. There are a few green varieties among which may be found Improved Yellow Swedish, Wintergreen, Green Top, etc.

The varieties Ditmars and Acadia have continued to be outstanding in yield. The variety Laurentian, while somewhat lower in yield than some of the others, is a very smooth globe-type and is highly favoured where roots are grown for table purposes. The variety Wilhelmsburger leads all others in resistance to club-root disease.

TABLE 21—GREEN AND DRY MATTER YIELDS IN TONS PER ACRE OF SIX VARIETIES OF SWEDES GROWN AT OTTAWA, ONTARIO. SIX -YEAR AVERAGE (1937, 1938, 1940, 1941, 1942 AND 1945)

Variety	Green Yield	Dry Matter Yield
Acadia	25.44	2.82
Ditmars	26.42	2.84
Hall's Westbury	24.99	2.75
Wilhelmsburger	23.03	2.35
Bangholm	22.67	2.53
Laurentian	22.07	2.30

Mangels

Prince—This variety may be described as half-long, skin colour above ground greenish white to greyish green. The underground parts of the roots are white. The flesh is white. This variety produces high yields per acre, but is relatively low in dry-matter content. It is well adapted to growing on deep, fertile soils.

Tip-Top—The roots are intermediate in type with some variants approaching the half-long and ovoid types. The underground portions of the roots are reddish-orange in colour, while the above ground parts are orange-yellow. The flesh is mostly white in colour. This variety is not a high yielder in terms of tons of roots per acre, but the roots are unusually high in dry-matter content. Its keeping qualities are good. This variety has shown marked resistance to damage from the cercospora leaf-spot disease.

Yellow Intermediate—(*Moore's*)—The skin colour above ground is olive-green grading to smoky-grey. Below ground parts are wax yellow. Flesh is white in colour. This variety is intermediate in dry-matter content and keeps well in storage.

Frontenac—This is an intermediate type which is relatively uniform, smooth and free from coarse shoulders and pronginess. The below ground parts of the root are a deep-orange colour. Above ground parts vary from smoky-yellow to orange-yellow. The flesh is white. The dry-matter content of this variety is intermediate to high, and its keeping qualities are good. This variety has considerable resistance to the cercospora leaf-spot disease.

Giant White Sugar—This is of the half-long type varying in colour from light-green to smoky-grey above ground to white below ground. The flesh is also white. This variety stands high in yield of tons per acre. It is intermediate in dry-matter content.

TABLE 22—GREEN AND DRY MATTER YIELDS IN TONS PER ACRE OF MANGELS GROWN AT OTTAWA, ONTARIO FIVE-YEAR AVERAGE, (1943-1947)

Variety	Green Yield	Dry Matter Yield
Prince	38.65	3.28
Giant White Sugar	31.39	3.29
Frontenac	31.18	3.26
Yellow Intermediate	28.55	2.84
Tip-Top	25.86	3.30

Although the Prince variety gave the highest green yields of all varieties, it was not significantly higher than most of the commonly-grown varieties in tons of dry matter per acre.

SEED PRODUCTION

Foundation Stock Seed Production and Distribution

Foundation stock seed is recognized by the Canadian Seed Growers Association as the propagating stock in possession of the plant breeder, or institution, who originates a variety. It must be produced by methods and conform to the standards, prescribed by regulations of the Association. It is, in fact, the basic stock from which registered, certified and commercial seed of developed varieties derive. It is the responsibility of the institution which has developed a variety to maintain adequate foundation stocks so that registered seed growers, or other producers, may be able to renew their seed stocks as required.

At the present time, the Division is required to maintain foundation stock seed of 22 strains including the single crosses of two hybrid corn varieties. Depending on demand, the production of seed has varied from year to year. However, in the 12-year period ending in 1948 some 62, 423 pounds of foundation seed were produced.

Distribution has been confined mainly to growers who are interested in the production of registered seed in accordance with the standards of the Canadian Seed Growers Association. However, the foundation stock seed program exerts a considerable overall effect on the quality of forage crops produced.

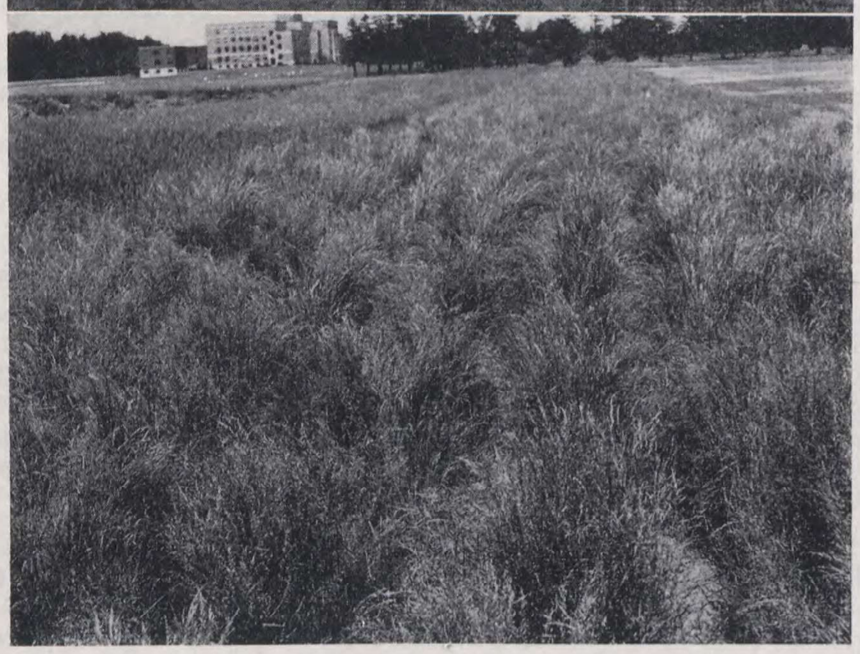


FIG. 10 (*Upper*)—Seed Multiplication Block of Climax Timothy (July, 1948).

FIG. 11 (*Lower*)—Seed Multiplication Field of "Ensign" Meadow Fescue (June, 1946).

A Comparison of Broadcast or Close Drill Seeding versus Spaced Row Seeding

Data has been obtained which shows that seed yields for the common grasses are generally higher from spaced row planting than from broadcast or close drill seeding. The price of seed will generally determine whether spaced row seeding is practical however. For example, timothy in rows may give a 50 per cent higher yield than in a solid stand, but with seed generally at a low price the increased yield may not pay for the extra labour involved.

Of the common legumes, only alfalfa gives substantially higher yields in spaced rows than in solid seeding. Were alfalfa a dependable seed crop in this area, it is probable that spaced row seeding would be worthwhile.

The Influence of Stage or Maturity at Harvest on Yield and Quality of Swede and Sugar Beet Seed

During the war years when the production of root seed was of necessity stimulated in Canada, many problems of production arose. One of such problems which proved vexatious on many occasions was the determination of the stage at which field root seed should be harvested in order to give the best return of good quality seed. An investigation of the problem was carried out in 1941 on crops of Acadia swede and sugar beets. Much detailed data was obtained. Seed was harvested at various stages of maturity and such data as seed yield, weight per 1,000 seeds, percentage of germination and weight of seedling growth was recorded and analysed. Harvesting at "Stage one", when about 40 per cent of pods had taken on a yellow tinge and few pods were ripe, it was found that seed yields, weight per 1000 seeds and percentage of germination were lower and the percentage of shrunken seed higher than for the later stages. Harvesting at "Stage two", when pod tips were yellowish in colour, seed is changing colour and ranging from green to purple and still soft, seemed in every way comparable with that of the later stages. The conclusion was reached that this stage was the most satisfactory for harvest since there would be little if any loss from shattering.

With sugar beets it was found that the most acceptable time for harvest was between 12 and 18 days after the first indication of ripening. Earlier harvest gave lighter seeds, lower germination and a high percentage of shrunken seed, while late harvest resulted in considerable reduction of yield by shattering.

Effect of Time of Cutting on Seed Production of Red Clover, Alsike, White Clover and Alfalfa

Data have been accumulated to provide information on the proper time at which the legumes should be cut in order to assure maximum seed production from the subsequent growth. Since seasonal differences and other factors have a marked effect on growth and seed yield, it is not possible to draw definite conclusions. However, it would seem that the first growth of red clover, white clover and alfalfa should be removed shortly after the first blooms appear in order to have optimum conditions for seed production from the succeeding crop.

It has been well established that alsike should not be clipped at all prior to taking a seed crop. Even with early clipping, subsequent seed yields have been very low. These findings may be used as a guide to growers who would like to obtain some grazing from their alsike fields prior to seed harvest.

Influence of Rate of Seeding and the Influence of the Nurse Crop on Alsike Seed Production

An experiment designed to establish the proper rate of seeding alsike to obtain useful stands for seed production revealed that a seeding rate of 4 pounds per acre was as satisfactory, under most circumstances, as any higher rate up to 16 pounds per acre. Furthermore, it was found that as good stands and as good yields were obtained when the nurse crop of grain was seeded at the optimum rate for grain production as when the rate was cut in half.

The Relation of Pollinating Insects to Seed Setting in Clover and Alfalfa

The studies dealt mainly with the relationship between the pollinating bees and the flower structure. Cross pollination in red clover is mainly effected by species of bumble bees and honey bees. The honey bee is not an active worker on red clover particularly when other nectar sources are available. Working on the theory that the corolla tubes in red clover are too long for the nectar supply to be readily accessible to the honey bee, European plant breeders have developed strains of red clover with short corolla tubes. The relative seed production of two such varieties, Zofka and Kellner, were studied under controlled conditions in comparison with the Ottawa variety. Over a hundred plants of each variety were grown in a screenhouse and subjected to the cross-pollinating agency of a colony of Italian honey bees. The resulting seed yield for each plant was determined. For the Ottawa variety, the average for all plants under test was 39.5 seeds per head which was more than double that of either of the other strains. The effect of breeding for short corolla tubes in these strains appeared to be a loss in vigour and a reduction in the number of florets per head. Under field conditions these two strains winter-killed 40 per cent as compared with 5 per cent for Ottawa. Being smooth-stemmed they were also badly injured by leafhoppers. It was evident that if there was any value in plants possessing short corolla tubes it would be necessary to develop strains. From the actual seed yield data, this did not appear justified.

A problem being investigated currently is the relationship between nectar amounts and concentration, and seed yield. It was thought possible that these might be factors which affect the attractiveness of individual plants to honey bees. This problem is being carried out in co-operation with the Bee Division.

A study was made in 1947 on a number of plants of the Ottawa variety, refractometer readings being obtained on four different dates on all plants. The difference in nectar concentration on any given day between the highest and lowest plant was fairly large but with a few exceptions the individual plant behaviour from day to day was not consistent. This indicates that all plants do not respond in the same way to varying environmental factors which affect nectar concentration. The data suggested that the amount of nectar secreted is more important than the concentration, from the standpoint of seed setting. Plants that secreted nectar abundantly were found to have a large number of seeds per head while those with scanty nectar production set considerably less. Differences in seed yield based on seeds per head, were significantly different in the group of plants studied both for the first and second seasonal seed harvest. The average number of seeds per head on the first cutting was 32.1 and for the second cutting 67.8 The results on the whole suggested that selection would be effective in developing a high nectar strain of red clover. Such a strain would increase the beekeeper's profits and also make red clover seed yields more reliable.

A study was made in 1948 of the frequency of bee visitors to the various plots of red clover, alfalfa, alsike and white clover. The observations were made daily for the period June 18 to July 8 when all crops were at maximum bloom. Three classifications of bees were counted, honey bees, bumble bees and small wild bees. The bumble bees consisted mainly of queens as the workers had not yet been reared. The wild bees were of several species the most frequent one being *Halictus* spp.

The preference of the three classes of bees for different plant species was quite striking. Practically all the foraging bumble bee queens worked on the red clover. The honey bees almost ignored the red clover preferring primarily alsike and white clover with almost equal preference for alfalfa. The wild bees divided their attention fairly equally among the various plant species but with some preference for red clover. The number of bees observed from day to day was fairly constant and also the relative frequency of the various types of bees on the various plant species. The percentages of bees on the various crops for the whole period is summarized in Table 23.

TABLE 23—THE PERCENTAGES OF VARIOUS TYPES OF BEES OBSERVED ON LEGUME CROPS IN 1948

	Red Clover	Alfalfa	Alsike and White Clover	Total
Honey bees	1.1	26.3	32.6	60.0
Bumble bees	3.3	0.1	0.1	3.5
Wild bees	16.2	11.7	8.6	36.5
Total	20.6	38.1	41.3	100.0

This study shows not only the preferences of the various bees for certain legume species but it also shows the importance of competing plant species for the service of the bees in securing seed-setting. In the studies made in 1947 it was noted that the seed set on the second harvest of red clover was more than double that of the first. This was due not only to a larger bumble bee population in late summer as compared with late June, but also to the fact that the honey bees are more frequent visitors due to a lack of other nectar and pollen sources.

The Effects of Immaturity and Artificial Drying Upon the Quality of Seed Corn

In the production of corn for seed use, the maturity of the ears at harvest has an important relation to the quality of the product. This is equally true whether the corn is dried naturally or artificially. At the present time, a large proportion of the seed crop produced in Canada is conditioned for storage by the use of heated air under forced draft. Immediately after harvest, the corn is dried on the ear in specially constructed driers at temperatures which cause little or no damage to the viability of seed that has reached normal maturity, at which time it contains approximately 35 per cent moisture. In almost every year, however, for various reasons some portion of the crop fails to reach maturity and is harvested in an immature condition. It was to obtain information regarding the effects of immaturity and artificial drying upon the quality of seed corn that this investigation was conducted during the period from 1941 to 1945.

There are two very important factors to be considered in the artificial drying of seed corn. One is the temperature to be employed and the other the stage of maturity of the ears that are to be dried, for in the drying process it is essential that, in addition to conditioning the seed for safe storage, no harm be done to either its viability or its germinating strength. As the result of investigation and actual experience, it has been found that temperatures ranging from 105°F, to 110°F. are highly satisfactory for the drying of seed which has matured normally.

In this investigation, studies were made of the effects of immaturity and artificial drying on seed of the yellow dent variety, Minnesota No. 13, in which the kernel moisture content of the different ear samples ranged from approximately 20 to 58 per cent at harvest. At the lower moisture level, the corn had dried considerably since maturity, while at the higher level it was decidedly immature, being in the condition commonly referred to as the milk stage. Artificial drying was accomplished by blowing heated air through the ears in a Freas electric oven, the temperature of which was controlled within a range of 3° F. The time of drying varied from two to thirty-two days and the temperatures used ranged from 108°F. to 150°F. In order to ascertain the effects of artificial drying, observations were made simultaneously on the behaviour of comparable air-dried material.

The stage of maturity of the corn at harvest had very definite effects upon its appearance as seed. Decided immaturity resulted in the production of small, dull, wrinkled, unattractive seed, irrespective of the method of drying. Maturity also profoundly affected the kernel weight, its volume and specific gravity, all of which increased directly with advancing maturity.

Mechanical analyses of the seed showed that immaturity brought decreases in the actual weights of the constituent parts, including tip cap, pericarp, germ and endosperm, while in relation to the total weight of the kernel the percentages of tip cap and pericarp increased, the germ decreased, and the endosperm remained approximately the same. Chemical analyses on the other hand showed that the percentages of protein, ash, crude fibre, nitrogen-free extract, and starch remained essentially the same irrespective of maturity, while that of the fat tended to decrease with immaturity.

In relation to kernel weight, the highest percentage imbibition of water was by the most immature seed, but the actual weight of water imbibed was highest in the most mature seed. While sprouting of the radicles was highest at the beginning in the immature seed, the plumules sprouted most rapidly and with more apparent vigour and vitality in the mature seed. As was to be expected, therefore, seedling emergence occurred quicker in the mature corn when planted in soil. Lateral roots developed more slowly in the immature, high-moisture samples, and also were fewer per kernel than in the mature samples. Activity of the enzyme, diastase, was very low in the dry seeds, but was highest in the air-dried immature samples. This was also true of the soaked seed which remained ungerminated at the end of three days, but in the germinated seeds diastase activity of the mature samples had reached the same level by the third day as that of the immature samples, and continued to be equally as high thereafter.

Artificial drying at 108 ± 1.5°F. accentuated most of the effects which resulted from immaturity in the air-dried corn. In comparison with natural drying, its only noticeable effect upon the appearance of the kernels was to cause a somewhat greater degree of blistering or lifting of the pericarp and a rather bleached appearance in the highly immature seed. While it had no effect upon the kernel weight, volume or specific gravity, and caused no appreciable changes in the composition of the kernels, it resulted in an increased imbibition of water and speeded up the sprouting of radicles in the immature samples to a greater degree than in the comparable air-dried corn. Reduced diastatic action in all of the artificially-dried seed was probably the result of a partial destruction of the enzyme or a general lowering of its activity. A significant relationship was indicated between the reduction and retardation of seedling emergence and the lowered diastatic activity of the artificially-dried, immature seed. As the food reserves in both the air-dried and artificially-dried kernels were essentially the same, the wide differences between them in seedling emergence must be attributed to some other cause, the most important of which was probably diastatic activity. Although many of the artificially-dried, immature seeds germinated, they failed to emerge, presumably because the activity of the diastase was reduced to the extent that it was unable to make the food reserves available to the young seedlings fast enough to supply the necessary strength and vigour to enable them to push through to the surface of the soil before they succumbed.

Imbibition of water was highest in amount in the mature seed but highest in percentage in the artificially-dried, immature corn. It has been suggested that the greater attraction of a given unit of immature kernel for water might be due to greater porosity of the pericarp or the higher proportion of soft starch accompanied by a larger percentage of intergranular space. As the result of this investigation, two additional hypotheses are advanced to explain the rapid absorption of water by the artificially-dried, immature seed. First, less cutinization of the epidermis and second, a relatively high kernel sugar content, both brought about by the sudden arrest of the metabolic and maturation processes because of the rapid drying of the seed, which resulted in the reduction of the kernel moisture to 14 per cent or slightly lower in 48 hours. In comparison, the immature, air-dried samples required several weeks to reach the 14 per cent moisture level, during which the rate of respiration would continue to be relatively high and the living processes within the seed proceed at an active although slowly diminishing rate as the moisture content became reduced. Assuming the suggested hypotheses to be correct, then the extent to which they would affect the rate of water absorption should depend largely upon the relative maturity of the seed at the time of drying. In other words, the more immature the corn the less the cutinization of the epidermis and the higher the kernel sugar content. The first of these would increase the porosity of the pericarp, while the second would exert its effect through osmotic pressure within the cells. The results obtained lend support to these hypotheses.

By means of copper-constantan thermocouples inserted within the kernels during drying, it was found that heat penetrated the mature, low-moisture ears most readily, and the temperature in them rose higher and more quickly than in the immature, high moisture ears. The results obtained indicated that the greater evaporation rate of moisture from the immature ears was effective in maintaining a lower and more uniform temperature of the kernels during the early stages of drying, but as drying continued and the moisture differences between the mature and the immature ears were lessened, the temperature readings showed less variation and became more nearly alike.

Drying at temperatures ranging 130°F. to 150°F. for six-hour periods up to a total of 24 hours proved injurious to the germination and retarded the seedling emergence of well matured corn, which tested 22.5 and 26.0 per cent moisture at harvest. The corn was dried both shelled and on the ear, and it was found that the shelled corn suffered greater injury than the ear corn at all temperatures and at all periods of drying. Drying at 120°F. on the ear for 24 hours caused little or no injury to the seed which contained 22.5 per cent moisture. Emergence was retarded somewhat and the seedling vigour reduced slightly, but the percentage germination and total emergence were as high as in the comparable air-dried seed.

Mature corn containing 25.9 and 34.1 per cent moisture and immature corn containing 44.6 per cent moisture at harvest, and artificially dried at 108 ± 1.5°F. for 32 days was reduced to approximately 2.0 per cent moisture in all samples. The mature seed suffered no injury to the germination as the result of extreme dessication, but seedling emergence was increasingly retarded as the time of drying extended beyond four days. The percentage germination of the immature seed was reduced as the drying period increased, and seedling emergence was greatly retarded even after two days of drying, in comparison with the mature seed.

Inbred lines and single-cross and double-cross hybrids, harvested at four stages of maturity, showed a differential response to artificial drying at 108 ± 1.5°F. Evidence was obtained that each of them included individuals which were affected to a greater or lesser extent than the average. The results obtained with the inbred lines suggested the possibility of combining inbreds which prove to be largely unaffected by the drying process to produce hybrids that could be artificially dried without suffering serious damage to the germination and vitality of the seed even when harvested in seasons unfavourable to the maturity of the crop.

In comparative yield tests conducted for two years and which included eight air-dried and artificially-dried single and double-cross hybrids, together with the variety Minnesota No. 13, it was found that while the maturity of the seed at harvest had practically no effect upon the percentage emergence and stands obtained from the air-dried samples, it did have a very profound effect upon the productive capacity, as with few exceptions the yields produced by the immature samples were considerably below those produced by the mature samples. Comparison of the air-dried with the artificially-dried corn showed that while artificial drying had either little or no effect upon the stands or the yields obtained from the mature samples, its effect upon the immature samples was to greatly reduce the resulting stands and consequently the yields produced by nearly all of them.

In conclusion, it may be stated as the result of the comparative tests that seed corn harvested in a mature condition produced excellent stands and high yields, irrespective of the method of drying. The only apparent effect produced by artificial drying at 108 ± 1.5°F. was a slight retardation in the emergence of the seedlings. Seed corn harvested in an immature condition and air-dried, while slow in seedling emergence, produced excellent stands but was low in productive capacity. Artificial drying of immature seed at 108 ± 1.5°F. resulted in the production of poor stands brought about by low germination and poor seedling vigour, with consequent low yields.

These studies indicated that the retardation of seedling emergence in the air-dried, immature corn was probably due to low storage of reserve food material in the seed and its exhaustion before the seedlings became well established as diastatic activity was high in this seed. Low yield was the result of inferior plant performance caused by under-nourishment in the early seedling stage, rather than pooor stand. On the other hand, in the artificially-dried, immature seed, low yield was the result not only of low reserves and its effect upon plant preformance, but chiefly of poor stands caused by poor germination and the inability of the seedlings to emerge from the soil. The studies on diastase suggest that both the failure to germinate and the poor emergence were probably the result of injurious effects which artificial drying had upon this enzyme. It seems likely that in some seeds the enzyme was totally or almost totally destroyed. These seeds failed to germinate for lack of soluble food to nourish the embryo. In other seeds, the enzyme was either partially destroyed or its general activity lowered to the extent that the amount of food made available to the developing embryo was insufficient to furnish the necessary vigour and vitality to enable the young seedlings to push through to the surface of the soil. Those seedlings which did manage to do so were mostly weak, spindly, slow to develop and relatively unproductive.

The use of heated air under forced draft to cure and condition seed corn demands an understanding of the proper relationship between the process of drying and the maturity of the crop. It is obvious from these investigations that every effort should be made to harvest the crop in a well matured condition and seed production should be planned with this in mind.

Influence of Maturity and Time of Threshing Upon the Quality of Soybean Seed

The quality of soybean seed for commercial use is based largely upon its two chief constituents, protein and oil. It has been stated that in some years when the maturity of the crop has been poor because of late seeding, unfavourable seasonal conditions, early fall frosts or other causes, the quality of the seed has been affected in a manner that makes it less valuable for commercial purposes. It has been suggested that under such conditions the percentage of oil is deccreased and the quality of the oil is poorer in comparison with that produced under more favourable conditions. Soybeans have sometimes been harvested in the spring, when conditions in the fall made harvesting at that time impossible.

To study the effect of maturity and time of harvest on the quality of soybean seed, a special test was conducted in 1943 and 1944, using the Mandarin variety. In the two years, the plots were handled as follows:—

1943 1. Planted May 22, and harvested Sept. 1, 8, 15 and 22.
     2. Planted May 22, 29 and June 5 and 12 and harvested September 28.

1944 1. Planted May 19, and harvested Sept. 1, 8, 15 and 19.
     2. Planted May 26, June 2, 9, 16 and 23 and harvested September 19.

Eight separate lots of Mandarin were planted and harvested in 1943, while nine were planted and harvested in 1944. Each lot comprised 8 rows, 20 feet long. In both years following harvest, each lot was divided into two sheaves, one of which was threshed at once, while the other was allowed to remain standing outside throughout the winter until the spring, when it was threshed. The threshed samples of seed were all analysed for protein, oil and iodine number.

Some of the lots at harvest were quite immature. These were allowed to stand until the pods were dry before threshing.

The chemical data obtained for both years are presented in Table 24.

TABLE 24—THE EFFECT OF MATURITY UPON THE QUALITY OF SOYBEAN SEED

	1943							
	Fall Threshed				Spring Threshed			
	Protein*	Oil*	Iodine No.	1000 Seed Wt.	Protein*	Oil*	Iodine No.	1000 Seed Wt.
Planted May 22	%	%		gm.	%	%		gm.
Harvested Sept. 1....	34.08	20.55	133.2	161	35.64	20.46	135.0	173
" " 8....	35.02	20.20	134.2	190	34.09	21.82	134.6	181
" " 15....	35.60	19.59	132.8	206	36.99	20.46	133.3	211
" " 22....	35.71	20.59	135.5	211	37.30	20.29	133.7	224
Harvested Sept. 28								
Planted May 22.......	39.21	19.23	133.6	236	39,42	19.58	131.6	228
" " 29.......	41.09	18.25	134.9	226	40.29	19.21	135.5	221
" June 5.......	42.27	18.14	136.2	237	39.82	18.03	134.1	232
" " 12.......	35.09	18.89	135.6	199	36.97	18.91	137.5	208
	1944							
	Fall Threshed				Spring Threshed			
	Protein*	Oil*	Iodine No.	1000 Seed Wt.	Protein*	Oil*	Iodine No.	1000 Seed Wt.
Planted May 19	%	%		gm.	%	%		gm.
Harvested Sept. 1....	41.17	19.71	127.6	183	43.14	21.97	126.2	178
" " 8....	39.47	19.73	130.4	189	41.65	20.81	124.4	192
" " 15....	39.64	20.53	130.3	207	42.14	20.35	126.9	197
" " 19....	40.21	19.62	127.2	197	42.25	20.63	126.9	201
Harvested Sept. 19								
Planted May 25......	39.43	19.86	130.2	199	42.40	20.92	125.8	186
" June 2......	39.79	20.04	132.3	194	41.23	20.40	128.6	180
" " 9......	39.64	20.26	130.8	191	42.08	19.68	124.0	183
" " 16......	38.19	19.26	131.2	185	40.02	19.54	131.9	174
" " 23......	40.17	19.13	131.5	167	41.02	19.48	132.1	157

* All analyses on dry matter basis

While the results for the two years are not entirely consistant, there seems to be no evidence from these results that immature seed was definitely lower in quality than well matured seed or that the seed threshed in the spring was of poorer quality than that threshed in the fall, although there was a definite indication in the 1944 data that the iodine number of the oil was lower in spring-threshed seed than that threshed in the fall. Obviously the immature seed was smaller and lighter in weight than the mature seed and would, therefore, be expected to yield less protein and oil per given unit area.

HAY AND PASTURE INVESTIGATIONS

The pasture research work on which this report is based is concerned principally with the evaluation of species, varieties and mixtures of both grasses and legumes in improved, short-term pastures in the farm rotation. In conducting these tests three separate management practices are followed: (1) Hay crop harvested for first 2 years followed by one or more years of pasture: (2) Hay crop harvested during the first year followed by two or more years of pasture: (3) Pasture continuously for three or more years beginning with the year following seeding.

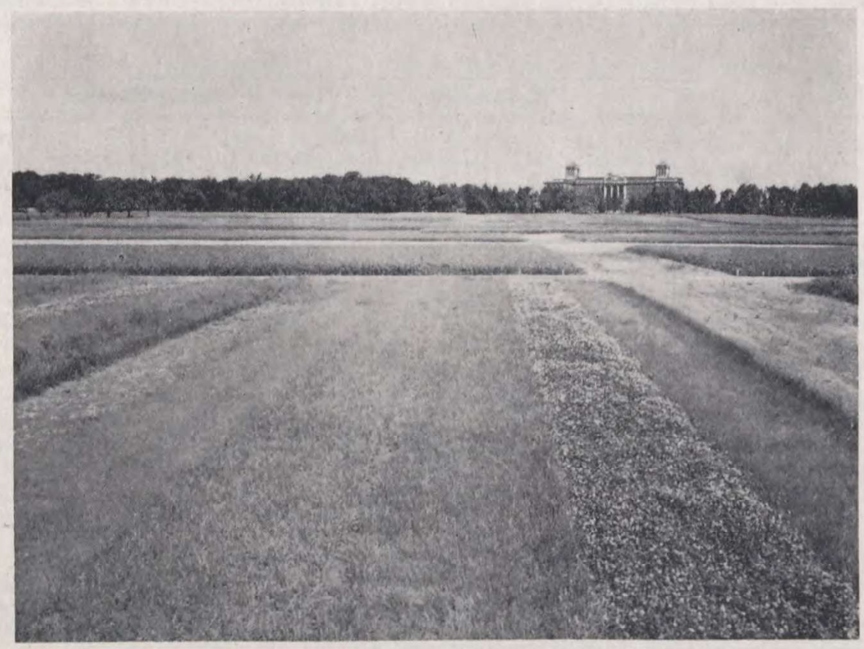


FIG. 12—Pasture Plots, Division of Forage Plants, Ottawa, Ontario, (June, 1935).

In this type of pasture tests, large numbers of species, mixtures and varieties are compared in small plots. These plots are clipped closely several times per year in a manner which experience has shown to provide conditions similar to those obtained by actual grazing. The species, varieties and mixtures which are definitely shown to be superior on the basis of the data secured from these tests are later included in actual grazing trials with livestock under field conditions where they are compared with standard pasture mixtures in common use throughout the district.

All pasture seedings are made with a nurse crop of cereal grains.

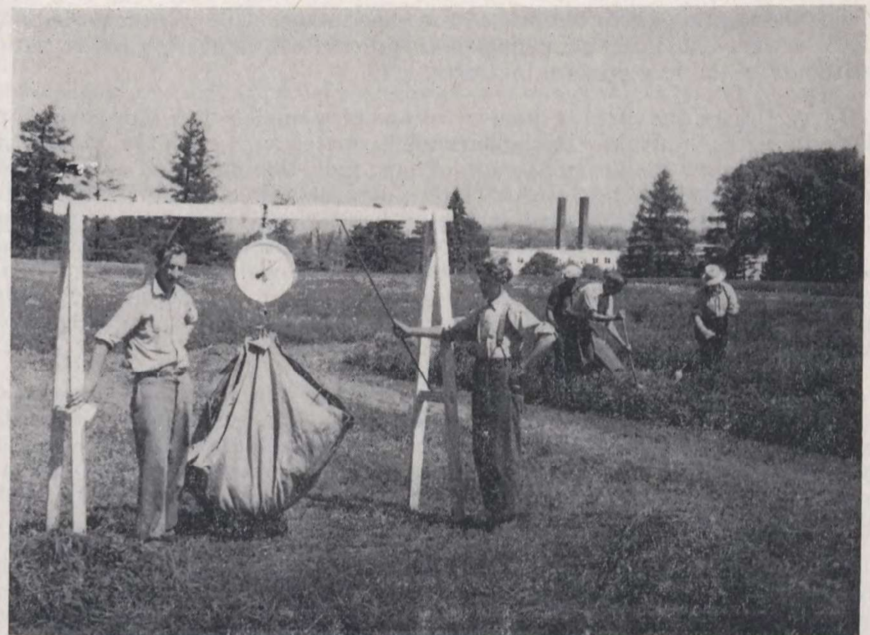


FIG. 13 (*Upper*)—Harvesting and Weighing Pasture Plots (June, 1948).

FIG. 14 (*Lower*)—Harvesting Pasture Plots with a Power Mower. Cutting-bar in Front and Specially Designed Pan to Catch the Grass (June, 1948).

The ability of different varieties and species to compete well in mixture and to persist under pasture conditions is most important. This is determined by careful yearly analyses of the stands beginning with the year of establishment and continuing throughout the life of the experiment. The data recorded show clearly the effect of different management practices upon the stands of various constituents of the hay-pasture mixtures.

Harvesting of the plots is done by means of a small power mower equipped with a cutting-bar in front. In the harvesting operation, a strip the width of the cutting-bar is taken for the full length of each plot, the harvested herbage being collected in a specially designed pan which is attached directly behind the cutting-bar. Green weights are recorded at time of harvest, and representative samples are drawn from each plot on which to make dry matter determinations, and which may also be used for chemical analyses. The yield data recorded in this report are on the basis of pounds of dry matter per acre. Equivalent hay weight may be calculated by adding approximately 15 per cent to the weight of dry matter given in any particular case.

In designing these experiments and carrying out the various operations necessary, including seeding, harvesting, sampling, etc. every known precaution is taken against unnecessary error. Modern plot experimental designs, which are widely accepted and which include adequate randomization and replication of treatments are in use. All data are examined critically on the basis of recognized methods of statistical analyses.

The yield of herbage on tests which are grazed by livestock are obtained through the use of wire cages which protect the herbage beneath them from being grazed by the livestock. The herbage beneath the cages is harvested at intervals to provide a measure of the amount of herbage available to the animals outside the cages. After harvesting, each cage is moved to an adjacent area which was grazed previously by the livestock. This type of pasture experiment usually involves in addition to yield of herbage an actual record of livestock gains or of milk production as the case may be.

All species, varieties and strains of grasses and legumes which appear to possess some value for hay and pasture purposes are included in these tests. This includes many of the plant breeders' new productions which must be evaluated before a decision can be made to release them for general use or to eliminate them as the case might be. In the following pages detailed information is given concerning the performance of many species and of improved varieties of both grasses and legumes.

The Value of Alfalfa in Hay-Pasture Mixtures

Alfalfa, principally *Medicago media* Pers. has met with wide acceptance as a hay and pasture legume in areas suited to its production. Its use as a pasture crop particularly has increased greatly during recent years.

The results of experiments conducted at the Division of Forage Plants, Central Experimental Farm, Ottawa, indicate clearly that alfalfa is one of the most productive legumes available when used in short-term pastures. Not only has it excelled in total yield per acre but also in distribution of yield throughout the grazing season. During the dry midsummer period when pastures in eastern Ontario become relatively unproductive, alfalfa frequently supplies almost the only herbage available to the livestock.

In Table 25 are listed a number of mixtures in which alfalfa is included, in comparison with mixtures containing legumes other than alfalfa. It will be noted that without exception mixtures containing alfalfa have given a higher yield than mixtures in which no alfalfa was included.

TABLE 25—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF MIXTURES CONTAINING ALFALFA VERSUS SIMILAR MIXTURES WITHOUT ALFALFA, (1945-1948)

Mixture No.	Species	Seeding rate per acre	Treatments: Hay 1 year followed by pasture	Treatments: Pasture only
		lb.		
1.	Timothy	10	4820	3964
	Red Clover	8		
2.	Timothy	10	5293	4900
	Alfalfa	8		
3.	Timothy	10	5094	3716
	Alsike	2		
	Red Clover	6		
4.	Timothy	10	4950	4287
	Alsike	2		
	Alfalfa	6		
5.	Timothy	6	3795	3779
	Red Clover	8		
	Alsike	2		
6.	Timothy	6		
	Red Clover	4	6385	4170
	Alsike	2		
	Alfalfa	4		
7.	Timothy	8		
	Kentucky blue grass	3	4795	5102
	Red Top	1		
	N.Z.W. W. Clover	1		
	Alsike	1		
	Red Clover	5		
8.	Timothy	8		
	Kentucky blue grass	3	6804	6488
	Red Top	1		
	N.Z.W.W. Clover	1		
	Red Clover	3		
	Alfalfa	4		
	Alsike	1		

Alfalfa Varieties

Tests designed to evaluate several different varieties of alfalfa for hay, hay-pasture or pasture purposes have been conducted over a period of years. In some tests the varieties were sown in a mixture with timothy since it was desirable to evaluate varieties not only from the standpoint of comparative yield in pure stands but also with respect to their ability to compete with grasses when sown in mixtures for different purposes. It is of interest to note from the data given in Table 26 that there were only small differences between the yields of

TABLE 26—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF ALFALFA VARIETIES. FOUR-YEAR AVERAGE, (1945-1948)

Variety of Alfalfa and Rate of Seeding*	Hay 2 years Pasture 2 years	Hay 1 year Pasture 3 years
Ladak (12) and Timothy (8)	7905	6712
Grimm (12) and Timothy (8)	7679	6868
Falcata 1291 (12) and Timothy (8)	4405	3739
Canauto (12) and Timothy (8)	7385	6572
Viking (12) and Timothy (8)	7684	6698

* lb. per acre.

the better known varieties when used in short term, hay-pasture mixtures. Ladak was the most productive variety when cut for hay for two years before being clipped to simulate pasture for two years. The old standard variety Grimm was the most productive when cut for hay, for one year, followed by pasture for 3 years. It might be pointed out that the variety designated as "Falcata" possesses superior drought resistance and hardiness and would possibly show up to better advantage in long term, hay-pasture mixtures.

Another group of alfalfa varieties grown in mixture with timothy was tested for hay and for pasture purposes as shown in Table 27. The Ladak variety again produced the highest yield when cut for hay. Grimm was the most productive variety when clipped to simulate pasture.

TABLE 27—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF ALFALFA VARIETIES CUT FOR HAY OR CLIPPED TO SIMULATE PASTURE, (1941-1945)

Variety of alfalfa and rate of seeding*	Hay only 5-year Average	Pasture only 5-year Average
Ladak (8) and Timothy (10)	7200	5579
Viking (8) and Timothy (10)	7155	5730
Rhizoma (8) and Timothy (10)	6757	5993
Canauto (8) and Timothy (10)	6306	—
Grimm (8) and Timothy (10)	6138	6093
Falcata 1291 (8) and Timothy (10)	4853	4068
Semipalatinsk (8) and Timothy (10)	—	4764

* lb. per acre.

The Grimm variety gave the highest average yield because of the very high yields which it produced in the first two years. In the last three years of the test, this variety was overtaken by "Rhizoma" and also by "Viking". Ladak declined considerably in the last three years proving to be a poor pasture type over the five-year period.

The results of two yield tests of alfalfa varieties grown alone for hay purposes are shown in Table 28. In both tests, Ladak and Viking yielded highest. Canauto was grown in one test only and outyielded Grimm by a good margin. The varieties Ranger and Buffalo which possess resistance to bacterial wilt were intermediate in yield under conditions where this disease is not prevalent. Both of these varieties lack winter hardiness.

TABLE 28—YIELDS OF ALFALFA VARIETIES FOR HAY IN POUNDS OF DRY MATTER PER ACRE

Varieties	3-Year Average 1941-43	3-Year Average 1944-46
Ladak	6174	6253
Viking	5969	6117
Rhizoma	5910	5281
Ranger	5402	5639
Grimm	5410	5497
Ferax	4817	5064
Buffalo	—	5335
Canauto	—	5929

White Clover (*Trifolium repens* L.)

White clover (*Trifolium repens* L.) is essentially a pasture plant. No other legume is so universally used in pasture mixtures and few others are so admirably adapted for grazing purposes. Common white clover grows abundantly under natural conditions throughout eastern Canada. Tests have shown that while white clover does not begin growth as early in the spring as most grasses, it produces an abundance of palatable and nutritious herbage throughout a considerable part of the season when moisture is adequate. It is worthy of note

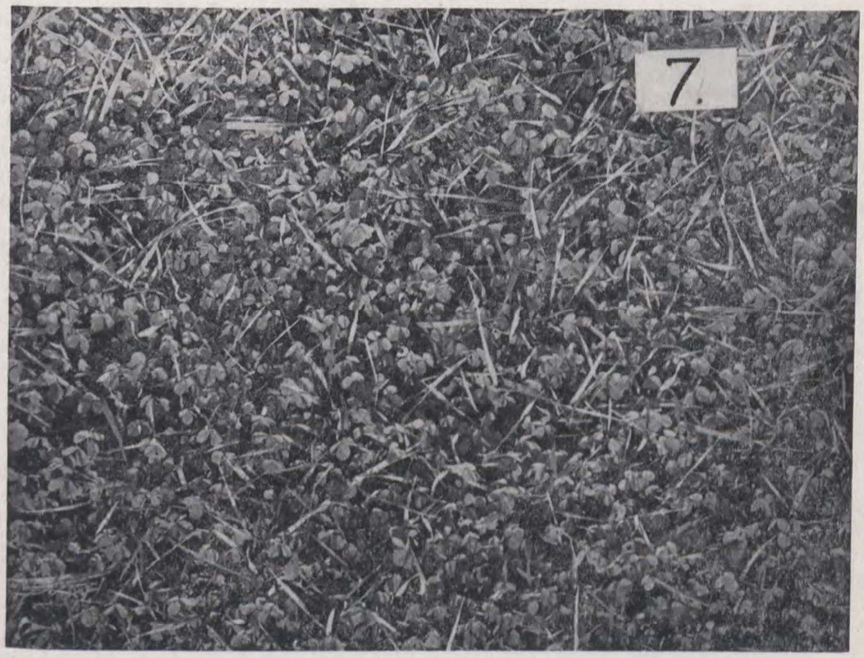


FIG. 15—A Good White Clover and Timothy Pasture (September, 1936).

also, that grasses growing in mixture with white clover yield more than when grown alone and are also usually higher in protein content. A number of different varieties of white clover have been included in pasture tests over a period of years. These include both the common white Dutch, wild strains of various sources, and Ladino.

Ladino White Clover

This clover, known also as Mammoth White and Lodi, is a relatively new introduction to Canadian agriculture. It differs from the common white clovers only in the fact that all plant parts are larger. It is adapted to most parts of eastern Canada where the double-cut type of red clover is grown successfully. It thrives under conditions similar to those suited to alsike and has become very popular as a pasture plant in eastern Canada.

In Table 29, data are presented to show the comparative value of Ladino white clover in mixtures with grasses for hay and pasture purposes.

TABLE 29—YIELDS OF HERBAGE, IN POUNDS OF DRY MATTER PER ACRE, OF HAY-PASTURE MIXTURES CONTAINING LADINO CLOVER COMPARED WITH SIMILAR MIXTURES CONTAINING ALSIKE. (1937-1940 AND 1946-1948)

Mixture No.	Species	Seeding rate per acre	Treatment	
			1 year hay followed by pasture	Pasture only
		lb.		
1.	Timothy Alsike	10 2	4216	4479
2.	Timothy Ladino	10 2	6063	5222
3.	Timothy Red Clover Alsike	6 8 2	4750	4498
4.	Timothy Red Clover Ladino	6 8 2	5278	4831
5.	Timothy Alfalfa Red Clover Alsike	8 4 4 1	9059	8197
6.	Timothy Alfalfa Red Clover Ladino	8 4 4 1	8647	7464
7.	Timothy Brome Meadow Fescue Orchard grass Reed Canary grass Alfalfa Red Clover Alsike N.Z. W.W. Clover	4 4 4 4 2 2½ 2½ 1 1	7082	5765
8.	Timothy Brome Meadow Fescue Orchard grass Reed Canary grass Alfalfa Red Clover Ladino	4 4 4 4 2 2½ 2½ 2	7057	6334

It will be noted from data presented in Table 29, that the replacement of alsike by Ladino in hay-pasture mixtures has resulted in a significant increase in yield except in those mixtures in which alfalfa provides a considerable part of the herbage. Ladino is evidently unable to compete successfully in hay-pasture mixtures containing a relatively high amount of alfalfa.

The results of mixtures designed expressly for pasture and which were left down for five years are shown in Table 30. It will be noted that during the first crop year the yields were much higher where red clover or alfalfa was present. The Ladino mixture, however, soon overtook the other mixtures and at the end of five years was the most productive.

TABLE 30—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF DIFFERENT LEGUMES IN LONG TERM PASTURE MIXTURES

Mixture and rate of seeding in lb. per acre	Seasonal Production					
	1936	1937	1938	1939	1940	5 yr. Average
Tim. 6, Kty. Bl. 3, Red Top 2, W.W.Cl. 2. Red Clover 8	6985	3561	6650	4958	4382	5307
Tim. 6, Kty. Bl. 3, Red Top 2, W.W.Cl. 2, Ladino 4	4930	5042	7879	5073	4800	5545
Tim. 6, Kty. 3, Red Top 2, W.W.Cl. 2, Alfalfa 8	6714	4073	6636	4708	4395	5305

Other Varieties of White Clover

The varieties of white clover included in these tests were as follows:— Common white Dutch, Morso, Kentish Wild, New Zealand Wild, New Liskeard, Quebec grown, Duron, Pathfinder and S-100. All of the above varieties were seeded in a basic mixture consisting of timothy, Kentucky blue grass and Canada blue grass, and were harvested in a manner designed to simulate grazing. From five to six clippings were taken from all plots during each season.

Based upon the results obtained in these tests, New Zealand wild white clover was the most productive variety. Some of the indigenous Canadian strains followed closely, while common white Dutch and Kentish wild white clover were the least productive.

Other Legumes

Birdsfoot Trefoil, (*Lotus corniculatus* L.)

This is a relatively new hay and pasture legume in Canada. Preliminary tests indicate that this legume is not as productive as the more commonly grown hay-pasture legumes, including alfalfa, red clover and Ladino white clover when used in mixtures for hay. Experimental results indicate that it may have some value in pasture mixtures due largely to its superior drought resistance.

In Table 31, two varieties of Birdsfoot trefoil are compared with New Zealand wild white clover from the standpoint of yield of pasture herbage.

TABLE 31—BIRDSFOOT TREFOIL COMPARED WITH WHITE CLOVER IN MIXTURES FOR PASTURE. DRY MATTER YIELDS IN POUNDS PER ACRE, (1940-1948)

Kind and Variety of Legume—Sown in Mixture with Timothy and Blue Grasses	Average yield 8 crop years
Broad-leaved Birdsfoot Trefoil (New York Strain)	3869
Narrow-leaved Birdsfoot Trefoil (New York Strain)	2873
New Zealand Wild White Clover	3310

These data show that there was a marked difference in yield between the two strains included in the test. The broad-leaved type has been consistently more productive and more persistent than the narrow-leaved type in pasture tests conducted at Ottawa, Ont. It will also be noted from the data presented in Table 31, that the broad-leaved strain of Birdsfoot trefoil has been more productive than the highest yielding variety of white clover, as shown in a previous section.

Birdsfoot trefoil is relatively slow to become established and makes a rather poor showing the first year following seeding. However, during subsequent years it contributes considerably to the yield of pasture herbage particularly during the dry midsummer period.

Red Clover (*Trifolium pratense* L.)

This legume forms the basis of most hay mixtures in eastern Canada. There are two main types of red clover—"double-cut and "single-cut". The double-cut varieties are somewhat better suited for hay in eastern Ontario as may be seen in Table 32.

TABLE 32—YIELDS IN POUNDS OF DRY MATTER PER ACRE OF SINGLE AND DOUBLE-CUT VARIETIES OF RED CLOVER, WHEN CUT FOR HAY, (1940)

Variety and Type	Seasonal Yield
Graham (single-cut type)	4819
Mammoth " "	4247
Altaswede " "	4104
Manhardy " "	3978
Temiskamingue (single-cut type)	3961
Ottawa (double-cut type)	6284
Dollard " "	6166
Longhurst " "	4857

The variety "Graham" was the most productive of the single-cut types. The "Ottawa" variety has been fairly consistently the most productive of the double-cut varieties.

Orchard Grass For Hay-Pasture or Pasture

Orchard Grass (*Dactylis glomerata* **L.**)

This grass, also known as "cocksfoot", is receiving more and more attention in eastern Canada. It is well noted for its early vigorous growth in the spring and its rapid recovery after cutting or grazing.

The comparative yielding ability of different varieties of orchard grass under pasture conditions is shown in Table 33. In all cases seedings were at the rate of 16 pounds of orchard grass and 2 pounds of wild white clover.

TABLE 33—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF DIFFERENT VARIETIES OF ORCHARD GRASS. THREE-YEAR AVERAGE, (1946-1948)

Variety	Hay one year Pasture 2 years	Pasture 3 years
Commercial	4491	4476
Hercules	4266	4330
Avon	4210	4409
Oron	4128	4168
Mass selection	3987	4079

It will be seen that varieties differed in yielding ability under different treatments. The commercial variety was the most productive in these tests. It is also of interest to note that all varieties of orchard grass were slightly more productive when treated as pasture from the beginning rather than harvested for hay the first year following seeding.

While no winter killing of orchard grass was recorded during the period of these tests it should be pointed out that this species winter-killed severely on several occasions during the past 15 years at Ottawa.

Meadow Fescue For Hay-Pasture or Pasture

Meadow Fescue (*Festuca elatior* L.)

Although not widely known in eastern Canada, it is adapted to most well-drained soils in good state of fertility. It has shown itself to be winter-hardy at Ottawa in all tests to date and grows well in association with most other grasses and legumes. A number of varieties have been grown in mixture with New Zealand wild white clover. The results of these tests are summarized in Table 34.

TABLE 34—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF MEADOW FESCUE VARIETIES, (1946-1948)

Variety	Hay 1 year pasture 2 years	Pasture 3 years
Sturdy	4646	4780
Ensign	4598	4455
Mefon	4520	4134
Commercial	4336	4427

The variety "Sturdy" surpassed all other varieties in yield per acre. This variety was slightly more productive when clipped for three years to simulate pasture conditions than when cut for hay one year and followed by pasture. Other varieties tested for a shorter period of years included a number of selections, introductions and strains such as S-53 from Aberystwyth, but none of these were equal in yield to the "Sturdy" variety.

Creeping Red Fescue (*Festuca rubra* L.)

This is essentially a "bottom" grass used in pasture mixtures. It is winter-hardy and is not readily injured by moderate periods of drought. Although it produces little during severe drought periods, it recovers readily and resumes growth as soon as moisture becomes available. This grass is the least palatable of all the more commonly grown pasture grasses when grown in pure stands, but is nutritious and eaten fairly well by larger animals, when grown in mixtures with other grasses and legumes.

The varieties of creeping red fescue grown at Ottawa were:— Olds, Viking, Duraturf, Reptans, Refon, 1-38 and S-59. The yields of herbage based on 3 or 4 clippings per year showed that the Viking and Olds varieties were just about equal in production and outyielded other varieties.

Slender Wheat Grass, (*Agropyron trachycaulum* (Link) Malte,)

This is also known as western rye grass. Although it is usually regarded as a prairie grass, it also does well in certain areas in eastern Canada. In tests conducted by the Division of Forage Plants at Ottawa, this grass has yielded just about equal to brome grass and timothy, when sown in short term hay-pasture mixtures with a legume. Varieties tested included:— Fyra, Mecca, Commercial, Grazier, Strains 28, 77 and 97. No significant difference in yield was observed in tests with the above varieties.

Tests With Blue Grass for Pasture

Both Canada blue grass (*Poa compressa* L.) and Kentucky blue grass (*Poa pratensis* L.) occur naturally in certain sections in Ontario pastures. The latter species is dominant in natural or untilled pastures on non-acid soils in many areas. These grasses have been grown alone in test plots. Over a 12-year period, the average production, when clipped four or five times per season was as follows:— Canada blue grass 1921 pounds and Kentucky blue grass, 1672 pounds of dry matter per acre. When grown in combination with wild white clover, the average in six crop years was:— Canada blue grass, 3203 pounds, and Kentucky blue grass, 2707 pounds of dry matter per acre.

The question of the performance of different varieties of these grasses is not yet fully investigated and tests are still in progress. Varieties of Canada blue grass grown are: Commercial, Canon and Chieftain, while the varieties of Kentucky blue grass tested are:— Commercial, Kenon and Delta. Present information indicates no significant differences between the yields of the above varieties of blue grass when used for pasture.

Timothy For Pasture

Timothy (*Phleum pratense* L.)

This is still regarded as the most widely adapted of all grasses used for hay and pasture purposes in eastern Canada. Under average growing conditions, timothy produces as much or more herbage than most other grass species used for similar purposes. It grows well in association with most legumes and forms the basis of most hay-pasture mixtures recommended in this area.

A number of varieties of timothy grown in association with wild white clover were tested for pasture purposes. The results given in Table 35 show wide variations in yields of different varieties. In general, the tall-growing hay types of timothy were the most productive. The low-growing types were quite leafy and formed a good "bottom", but were in general comparatively low in yields. The variety "Climax" has led all others in yield of herbage per acre. Other varieties grown for one or two years in addition to those in Table 35 were:— S-50, Svalof and Huron. These were not highly productive during the years tested.

TABLE 35—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF DIFFERENT VARIETIES OF TIMOTHY GROWN WITH WILD WHITE CLOVER AND TREATED AS PASTURE, (1946-1948)

Variety or Strain	Three-year Average
Climax	4883
Commercial	4628
Milton	4619
Cornell 1777	4542
Dural	4522
Boon	4488
Ottawa 1956-14	4484
Cornell 4059	4459
Marietta	4448
Medon	4377
Drummond	4324
Swallow	4295
S-48	4118
Paton	3804

Brome Grass In Hay-Pasture Mixtures

Brome Grass (*Bromus inermis* Leyss.)

This grass is not widely used in eastern Canada, chiefly because it is difficult to sow along with other small-seeded species. Brome grass seed is very large and cannot be sown through the usual grass seed box. Successful establishment depends largely upon shallow seeding into a firm seed-bed. Once established this grass compares very favourably with timothy for hay or for pasture purposes as shown in Table 36.

TABLE 36—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF DIFFERENT MIXTURES FOR HAY-PASTURE AND PASTURE PURSPOSES. THREE-YEAR AVERAGE, (1940-1942)

Species and Rate of Seeding	Treatment		
	Hay 2 years pasture 1 year	Hay 1 year pasture 2 years	Pasture 3 years
Tim. 8, alfalfa 4, red clover (early) 4, alsike 2, Kentucky Bl. 1½, Canada blue 1½, red top 2, New Zealand Wild White Cl. 1	5658	4177	3242
Brome 16, alfalfa 4, red clover (early) 4, alsike 2, Kentucky Bl. 1½, Canada Bl. 1½, red top 2, New Zealand Wild White Cl. 1	6207	4348	3230
Slender wheat grass 12, alfalfa 4, red clover (early) 4, alsike 2, Kentucky Bl. 1½, Canada Bl. 1½, red top 2, New Zealand Wild White Cl. 1	5977	4127	2997
Tim. 8, alfalfa 4, red clover (early) 4, alsike 2	5815	4299	3599
Brome 16, alfalfa 4, red clover (early) 4, alsike 2	5598	3893	3186
Slender wheat grass 12, alfalfa 4, red clover (early) 4, alsike 2	6021	4079	3230
Timothy 10, alfalfa 8	6137	4669	3834
Brome 16, alfalfa 8	6505	4697	3296
Slender wheat grass 12, alfalfa 8	6739	4537	3580
Average yield of dry matter	6753	4314	3355

The performance of the three grasses in this test was very similar under all treatments, although timothy had a slight advantage over Brome grass when no hay crops were taken or where hay was cut for one year and then followed by two years of pasture.

The performance of brome grass compared with other commonly grown grasses may be found in another section of this report.

Two varieties most widely used are common and parkland. On the basis of yield alone, there was very little difference between these two varieties as shown in Table 37. Parkland is somewhat slower in becoming established, but does not get sod-bound as quickly as the more rhizomatous types. It is preferred to the common variety if the seeding is intended for long term hay-pasture or pasture purposes.

TABLE 37—DRY MATTER YIELDS IN POUNDS PER ACRE OF COMMON AND PARKLAND BROME GRASS. THREE-YEAR AVERAGES, (1936-1938)

Variety and Mixture	Treatment	
	Hay 1 year pasture 2 years	Pasture 3 years
Common Brome only	2899	2416
Parkland Brome only	2836	2363
Common Brome Wild White Cl.	3998	3405
Parkland Brome Wild White Cl.	3898	3434
Common Brome Alfalfa	4823	3403
Parkland Brome Alfalfa	4906	3466

The data in Table 38 give 3-year average yields, (1940-42), of several other grasses grown alone and in mixtures treated in different ways.

TABLE 38—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF SEVERAL DIFFERENT GRASSES GROWN ALONE AND IN MIXTURES TREATED IN DIFFERENT WAYS. THREE-YEAR AVERAGES, (1940-1942)

Species and Mixtures	Treatment		
	Hay 2 years pasture 1 year	Hay 1 year pasture 2 years	Pasture 3 years
Timothy alone	2398	2644	1878
Brome alone	2112	2343	1846
Slender Wheat alone	1962	2211	1869
Kentucky Blue alone	1864	1875	1544
Canada Blue alone	2293	2237	1867
Timothy and Wild White Cl.	3152	2947	2172
Brome and Wild White Cl.	2746	2508	2070
Slender Wheat and Wild White Cl.	2846	2467	2124
Kentucky Bl. and Wild White Cl.	2593	2085	1947
Canada Bl. and Wild White Cl.	2609	2459	2423
Timothy and Alfalfa	6802	4890	3815
Brome and Alfalfa	6718	4628	3483
Slender Wheat and Alfalfa	6816	4582	3720

Annual Crops For Hay

In Table 39 data are presented to show the comparative yield of various annuals grown alone or in mixture for hay.

TABLE 39—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF ANNUALS FOR HAY, (1944-1947)

Kind and Rates of Seeding	Four-year Average
Millet—Empire (20 lb.)	4826
Oats (2 bu.) Millet—Empire (15 lb.)	4704
Sweet Sudan grass (25 lb.)	4344
Sudan grass (25 lb.)	4318
Oats (2 bu.) + Sudan grass (15 lb.)	4316
Oats (2 bu.) + Sweet Sudan (15 lb.)	4234
Oats (2 bu.) + Italian rye grass (20 lb.)	4018
Oats (3 bu.)	3945
Oats (2 bu.) + Fall Rye (1 bu.)	3578

These data show that highest yields of annual hay crops may be expected from millet and sudan grass or mixtures of these with oats in areas where these annuals are adapted. It is worthy of note that while oats are more widely used as annual hay crops than any other of our commonly grown annuals, they gave the lowest yields of hay per acre, with the exception of the mixture of oats and fall rye.

Oat varieties for hay—Yields of hay obtained from a number of different varieties of oats are shown in Table 40.

It will be noted that some of the newer varieties, particularly Roxton, have excelled in yield of hay per acre.

TABLE 40—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF DIFFERENT VARIETIES OF OATS CUT FOR HAY

Variety or Strain	1944	1945	1946	1947
Joanette	2375	—	—	—
Mabel	2210	—	—	—
Gopher	2185	—	—	—
Banner	2178	—	—	—
Alaska	2160	—	—	—
Goldrain	1798	—	—	—
Vanguard	2141	—	—	—
Erban	2129	4379	4067	3591
Victory	2132	3798	4292	2922
Roxton	—	4596	4776	3702
Beaver	—	4241	4067	3214
2797—601	—	4272	—	—
R.L. 1225	—	—	4332	2760
Beacon	—	—	4987	2150
Ranger	—	—	3104	1917
3003 D	—	—	—	3474
Garry	—	—	—	2615

Annuals Alone or in Mixture for Pasture

In Table 41, the results of various annuals, grown alone and in mixtures for pasture, show as was the case of annual hays that oats when grown alone do not provide the highest yields by any means.

TABLE 41—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF ANNUALS CLIPPED TO SIMULATE PASTURE, (1944-1947)

Kind of Crop and Rate of Seeding	Four-year Average
Sudan grass (25 lb.)	2313
Oats (2 bu.) + Sudan (15 lb.)	2210
Sweet Sudan (25 lb.)	2083
Oats (3 bu.)	2010
Millet—Empire (20 lb.)	1992
Oats (2 bu.) + Sweet Sudan (15 lb.)	1988
Oats (2 bu.) + Millet—Empire (15 lb.)	1975
Oats (2 bu.) + Italian Rye grass (20 lb.)	1778
Oats (2 bu.) + Fall Rye (1 bu.)	1686

The highest yields of annual pasture were obtained from Sudan grass followed by a mixture of oats and Sudan grass. It will be noted, however, that when used for pasture crop oats were slightly higher yielding than millet.

Oat varieties for pasture:—Yields of a number of different varieties of oats are shown in Table 42. It will be noted that Roxton, Beaver, Erban and Beacon headed the list in yield of pasture per acre.

Fall Rye for pasture:—In Table 43, are presented yield data on a number of varieties of fall rye. While fall rye may provide some grazing during the year of seeding, if sown before September 1, these variety tests were sown after September 15 with a view to securing data on pasture yields the following year.

In addition to the above, the varieties, Prussian, Balbo and White Russian were grown for a shorter period of years.

On the basis of these tests, it may be concluded that the varieties Horton and Midsummer are superior in ability to provide early spring pasturage. Dakold variety is relatively late in beginning spring growth, but is reasonably productive later in the season.

TABLE 42—YIELDS IN POUNDS OF DRY MATTER PER ACRE OF OAT VARIETIES GROWN FOR PASTURE, (1944-1947)

Variety	Four-year Average
Roxton	1879
Beaver	1869
Erban	1848
Beacon	1836
Ranger	1778
Victory	1773
R. L. 1225	1742
Gopher	1708
Goldrain	1647
Vanguard	1647
Joanette	1644
Mabel	1631
Alaska	1596
Banner	1444

TABLE 43—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF FALL RYE USED FOR SPRING PASTURE, (1939-1944)

Variety	Six-year Average
Horton	2466
Midsummer	2416
Dakold	2198
Rosen	2085
Vasa 957	2062
Imperial	1961

TURF RESEARCH

The amount of turf research conducted by the Division of Forage Plants was reduced to a minimum during the war years in order to permit full co-operation with the Departments of National Defence and Transport in establishing and maintaining turf on aerodromes, building areas and ammunition depots at air training schools and other military establishments throughout eastern Canada. This involved the direct supervision of all turf establishment and maintenance operations on 50 aerodromes, 59 building areas and one explosive depot.

While this work was considered a valuable contribution to the war effort, it also was beneficial to the Division, since a considerable amount of experience in large scale turfing operations was gained and it was possible to verify the results of research which had previously been conducted on turf problems by the Division. This experience was further augmented by work done during 1945 and in succeeding years at the National Research Atomic Division Project at Chalk River, Ont., and at the townsite at Deep River, Ont., at which places the Division outlined and supervised to some extent the entire program for turfing and stabilizing the soil under very adverse soil conditions.

Kentucky blue grass (*Poa pratensis* L.) continues to be the most generally suitable grass for lawns, parks, fairways, aerodromes and similar turfed areas throughout eastern Canada and is used as the basis of most seed mixtures for such areas. It is usually sown in mixtures with such species as colonial bent (*Agrostis tenuis* Sibth.) and red top (*Agrostis alba* L.). The value of the latter species as a component of seeds mixtures was well shown in turfing operations during the war years. While red top is usually considered to be a moist land grass, it provided a valuable contribution to the sward under a wide variety of conditions including some very dry sandy soils.

Creeping red fescue (*Festuca rubra* L.) and Chewing's fescue (*Festuca rubra* var. *commutata* Gaud) are adapted to dry, sandy soils and do well in shady places and should be included in seed mixtures for such situations.

Rough-stalked meadow grass (*Poa trivialis* L.) is adapted to moist, shady conditions.

Canada blue grass (*Poa compressa* L.) is not considered to be a good quality lawn grass, because it produces an open sward and has a rather poor bluish green colour, but neverthless it has a place in certain locations, particularly on sandy and shaley soils of low fertility. Some aerodromes, particularly in Prince Edward and Hastings counties in Ontario, although seeded to mixtures of several species, including Canada blue grass, have developed solid stands of that species to the exclusion of all other grasses.

Timothy (*Phleum pratense* L.), a hay species not ordinarily recommended for turf, was used with success as a small part of the seeds mixture (not over 10 per cent) on many aerodromes. Its chief virtue is that it germinates quickly and thus permits rapid stabilization of the soil.

Perennial rye grass (*Lolium perenne* L.) was used as a nurse grass in many mixtures with good results, but it is recommended that its use be limited to milder climates, such as in southwestern Ontario.

Meadow fescue (*Festuca elatior L.*), another hay species, may also prove to have certain uses in turf. A close relative, tall fescue (*Festuca elatior* var. *arundinacea* Schreb. Wimm.) has received a great deal of publicity in the United States as a grass for aerodromes, roadsides, sports fields and similar areas. In 1948, some meadow fescue was included in a seeds mixture with Kentucky blue grass, creeping red fescue and red top to seed a 10-acre field being developed as a playground area at Lansdowne Park, Ottawa. A good stand of all species was secured despite very dry weather and adverse soil conditions. This area was used as a parking lot for a week during August and at frequent intervals throughout the fall. It was interesting to note that meadow fescue was the only species to survive this rough treatment. Test plots of different varieties of Meadow fescue and tall fescue as well as other turf grasses were laid out in the fall of 1948.

Colonial bent (*Agrostis tenuis* Sibth), creeping bent (*Agrostis palustris* Huds.) and velvet bent (*Agrostis canina* L.) are the only species adapted to the production of fine turf on putting and bowling greens. They may also be used on high quality lawns, but such lawns require more care and are considerably more costly and difficult to establish and maintain than those seeded with mixtures based on Kentucky blue grass. Part of the turf research program being carried on by the Division at the present time involves the testing of the many new strains of creeping and velvet bent, which have been developed during recent years.

The value of using high rates of fertilization prior to seeding was shown in all large-scale turfing operations during the war. Rates of application of such complete fertilizers as 4-12-6 up to 1000 pounds per acre were used and every increase in rate of application produced better results in turf establishment and quality.

The Control of Snowmould in Turf

Snowmould is a very serious fungus disease of turf throughout a great part of Canada. It usually occurs in the early spring when the melting snow provides the cool, moist conditions which favour the development of the causal organism, *Typhula* spp. It appears as a white cottony growth which later becomes dirty white or grayish in colour. The infected turf becomes light brown in colour and dead in appearance. Sometimes growth of the infected grass is merely delayed, but often the turf is completely killed.

Snowmould may be controlled by making applications of certain mercurial fungicides late in the fall just before the first lasting snow. A fungicide commonly recommended is a mixture of 2/3 calomel and 1/3 bichloride of mercury which is applied at rates of 3 to 4 ounces per 1000 square feet.

During the war when supplies of mercury became limited and it was thought that it might not be available for use in turf fungicides, a research program was started to find a suitable substitute, or failing this, to find how mercury could be used most economically. This program was carried on over a period of five years. None of the non-mercurial compounds tested viz. sulphur, borax, copper sulphate, malachite green, bordeaux mixture, silver nitrate, hydrated lime, tetramethyl thiuramdisulphide and a specially processed calcium, copper, zinc, cadmium chromate proved satisfactory for snowmould control. Some of them gave no control, others gave slight control at high rates of application; one, silver nitrate, controlled the disease but injured the turf severely.

Of the mercurials tested, bichloride of mercury and two organic forms gave the best control. Oxide of mercury gave very poor control and calomel was intermediate between the oxide and bichloride. Ceresan controlled the snowmould but damaged the turf very severely. In tests of mixtures containing different proportions of bichloride of mercury and calomel the mixtures having the higher proportions of bichloride gave the best results. In experiments on methods of application it was found that the fungicides produced the same results whether applied dry, mixed with sand or in water as a spray or sprinkle providing uniform distribution was made. Other tests showed that spring treatments were not effective in controlling the disease or reducing the amount of injury caused by it. It is essential that, if protection from snowmould is desired, suitable mercury fungicides be applied late in the fall.

Experiments are now under way to test the efficacy of many new fungicides' mercurial and otherwise, that have been developed in recent years.

The Control of Turf Weeds

Prior to the war, a considerable amount of work was done in an effort to find some chemical means of eliminating turf weeds without injury to the grass. Among the materials tested were iron sulphate, sodium chlorate, arsenicals, copper nitrate, oils, cyanamid, di-nitro compounds and others. While many of these gave good control of certain weeds at times, they could never be depended upon to give uniformly good results. Some of them were poisonous, others were explosive under certain conditions and all injured the desirable turf plants to some extent, sometimes making the treated areas unsightly for a month or more.

The development of 2, 4-Dichlorophenoxyacetic acid as a selective herbicide has provided a very valuable weapon for the warfare against certain broad-leaved weeds and this chemical is particularly useful in turfed areas. 2, 4-D is truly selective in action, will kill the common broad-leaved turf weeds without injuring most grasses, is cheap, non-poisonous and non-explosive.

Some 30 different 2, 4-D preparations representing several formulations have been tested by the Division since 1945. No differences have been found between these preparatations with respect to rapidity and thoroughness of kill when applied at rates supplying 3/4 to 1 pound of 2, 4-D per acre.

Turf weeds that can be effectively killed with 2, 4-D include dandelions, plantains, buckhorn, cinquefoils, ground ivy, heal-all and others of minor importance. The chickweeds are more difficult to kill but can usually be eliminated with two or three treatments. Knotweed can be easily killed when young, but appears to become resistant with maturity. White clover receives a setback when treated with 2, 4-D but usually recovers. When making 2, 4-D treatments, it is recommended that the manufacturer's directions and warnings be followed closely.

Although 2, 4-D provides valuable assistance in eliminating broad-leaved weeds, it cannot be considered a "cure-all" for the turf weed problem. It is useless to kill weeds in turf unless steps are taken to replace them with desirable species. This can usually be done by accompanying the weed killing treatments with a suitable fertilizer program and by following other desirable cultural practices. If large bare areas occur as a result of weed elimination reseeding is necessary.

Now that broad-leaved weeds can be controlled with 2, 4-D, the major turf weed problem is the control of crabgrass. Research is being carried on in an effort to find suitable methods of eliminating this weed. Some of the materials being tested have shown promise, but more research is necessary before definite recommendations can be made.

DOMINION FORAGE CROPS LABORATORY

Saskatoon, Sask.

INTRODUCTION

The Dominion Forage Crops Laboratory was established in 1932 by a co-operative arrangement with the University of Saskatchewan at Saskatoon. Office, laboratory, storage, greenhouse, and field space is provided on a rental basis by the University while the Laboratory is staffed and financed by the Experimental Farms Service of the Dominion Department of Agriculture. The University classes on forage crops have been taught by the staff of the Laboratory. This arrangement has proven mutually very satisfactory.

The primary function of the laboratory is to develop varieties and strains of grasses, legumes, and miscellaneous crops that are adapted to conditions existing in the Prairie Provinces. Many of the crops worked with are naturally cross-pollinated and the breeding techniques and systems for such plants are not as well established as they are in the case of the self-pollinated cereal crops. Consequently it has been necessary to investigate and evolve applicable methods of breeding and a number of studies are directed towards that goal. Another phase of research related to breeding involves enlarging the knowledge about particular characteristics of concern in the breeding programs. The acquisition of such knowledge is often necessary in order to maintain the breeding program on a sound basis. To illustrate this fact an example from alfalfa may be cited. In breeding for improved seed yield in this crop it is essential to understand fully the seed-setting process and factors which influence it. Thus, as a guide to the development of a high seed-setting variety, it became necessary to investigate the seed-setting process. Similarly, in respect to other breeding objectives, not infrequently it has been essential to gain fundamental information of the character being worked with.

In respect to both forage and seed, the capacity to yield highly is obviously an important characteristic of any variety or strain irrespective of any other virtues it may possess. It is consequently necessary to be continually evaluating the products of breeding programs in yield trials and many such tests are conducted each year. Varieties developed by plant breeders in other provinces and countries and new species brought in from other regions are received each year and evaluated in yield trials.

In addition to the breeding and related investigations a certain number of projects are conducted to determine the most satisfactory way of growing and handling the various crops. Such matters as depth of seeding, spacing of rows, rates of seeding, and fertilizer treatments are studied in projects of this nature.

In breeding projects involving resistance to diseases, the staff of the Dominion Laboratory of Plant Pathology at Saskatoon and at Edmonton actively co-operate. Similarly, in problems involving insects, the staff of the Dominion Entomology Laboratory at Saskatoon participates co-operatively. In investigations requiring chemical analysis, the Chemistry Division, Science Service, Ottawa, the Oils Seeds Laboratory, National Research Council, Saskatoon, and the Chemistry Department, University of Saskatchewan, Saskatoon, have all contributed.

It is the purpose of this report to summarize for the period 1937 to 1948 the progress which has been made in the above described major categories of investigation. Much of the detailed results have been omitted for the sake of brevity but in many cases the details may be found in papers published in scientific journals.

OBJECTIVES AND PROGRESS IN PLANT BREEDING

Alfalfa

The main objectives in the alfalfa breeding program at the Laboratory are: (1) high seed yield, (2) resistance to winter crown-rot disease, (3) resistance to bacterial wilt disease, (4) resistance to black stem disease, and (5) persistance under grazing. Resistance to cold and high forage yield are of primary importance and are considered in conjunction with each of the above objectives. Ultimately, it is hoped to produce a variety that is resistant to all of the above diseases, resistant to cold and high in seed and forage yield.

Breeding for black-stem resistance has been started recently and while some advance has been made the project will not be dealt with in this report.

Breeding for High Seed Yield

The generally poor and erratic seed-setting behaviour of alfalfa has been an almost universal experience. In many areas of Western Canada, yields have been so low that seed production has been completely discouraged. Even in districts where seed production has become a major enterprise, yields have commonly ranged around 50 to 75 pounds per acre and 150 to 200 pound crops have occurred only rarely. Although such factors as soil and climatic conditions, beneficial insects, and injurious insects interact to influence yields in poor yielding fields it has been observed frequently that a certain proportion of the plants were heavily loaded with pods. This observation led to the assumption that varieties of superior yielding ability could be developed. It was with this possibility and purpose in mind that a breeding program was undertaken.

Tripping of the flowers is a fundamental process in seed-setting of alfalfa. In tripping, the male and female parts of the flower are rather violently released from the petals enclosing them and come to rest upon the large standard petal. Investigations have shown that only a very small percentage of flowers ever set pods without tripping and furthermore that bees are the primary factor in causing tripping. However, it is possible to select plants which trip automatically to a high degree. Such plants are often described as self-tripping. Since the wild bee population generally is considered to be inadequate to trip the flower effectively, the selection of self-tripping plants seemed to offer hope of escaping dependence upon bees to perform the essential process.

Consequently, in the earlier breeding program, emphasis was placed upon the selection of self-tripping plants. A fairly large population of such plants was obtained from fields around Saskatoon. Selection was based on high self-fertility as well as self-tripping. In yield trials it was found that several of these plants or their hand-made intercrossed progenies yielded as much as four to six times the seed yield of the Grimm. While the seed yield performance of these plants was remarkable, further work with them established that they were of little or no value for developing a superior seed-yielding variety. Their high self-fertility and self-tripping behaviour resulted in self-pollination rather than cross-pollination.

Selfing or inbreeding in alfalfa has been shown by several studies to result in a marked drop in forage, particularly in seed yield. When seed was collected from the highly self-tripping plants growing under field conditions and progenies grown from this seed, it was found that the seed yield of the progenies was less than that of Grimm. The only plausible explanation to account for this result was that the seed produced by the highly self-tripping plants resulted from self-pollination. There was no known breeding system which would circumvent the habit of self-pollination in the self-tripping plants. Therefore, it was necessary to abandon any further work with them.

As another approach to the development of a high seed-setting variety, selection was started in 1942 for plants which were non-self-tripping, highly cross-fertile, and low or moderately low in self-fertility. These criteria for selection were used since it has been shown that plants possessing such characteristics will cross-pollinate to a high degree under natural pollination conditions. Thus, the possibility of selfing occurring naturally was eliminated largely by selection on this basis.

To-date, a few hundred non-self-tripping, highly cross-fertile plants have been selected and progenies of many of them have been tested. The seed yield and also the forage yield of the progenies of several of these plants have been very promising. To illustrate their performance, the yield of crosses between three selected plants in comparison with commonly grown check varieties have been summarized in Table 44.

TABLE 44—SEED AND HAY YIELD OF CROSSES BETWEEN SELECTED PLANTS COMPARED WITH CHECK VARIETIES AT SNOWDEN, SASK. (SEED YIELDS OBTAINED IN 1944 AND HAY YIELDS IN 1945)

Parents of crosses or check variety	Yield of seed in pounds per acre	Yield of hay in tons per acre
S-42-*85* × S-42-*119*	360	5.76
S-42-*85* × S-42-*124*	388	4.81
S-42-*119* × S-42-*124*	359	4.92
Check—Grimm	129	4.29
Check—Ladak	168	5.60
Least significant difference	82	1.06

It is clearly shown in Table 44 that the crosses between the selected plants gave seed yields that were two to three times as much per acre as those of the check varieties. In addition, the crossed progenies were somewhat superior to Grimm and almost the equal of Ladak in hay yield. Although the above crosses were hand-made, the characteristics of the parent plants are such that when the plants are paired off or grouped they will intercross to a high degree under natural field conditions. It is therefore possible to duplicate the crosses naturally.

A number of naturally produced crosses between selected plants were made in 1947. The seed was used to establish seed and hay yield tests at many of the Dominion Experimental Stations and Farms in Western Canada in 1948, the results of which will be available in 1949. If the yield performance proves to be as outstanding as indicated in Table 44 steps will be taken to increase seed of the best cross combination for distribution to farmer growers.

A new variety possessing the seed yielding capacity of any one of the three crosses listed in Table 44 would increase very materially the yields for seed growers. The larger total production would in time result in a lowering of the price of this presently high priced seed. With a lowering of price, alfalfa would be more generally grown with attendent benefits in greater feed supplies and soil improvement.

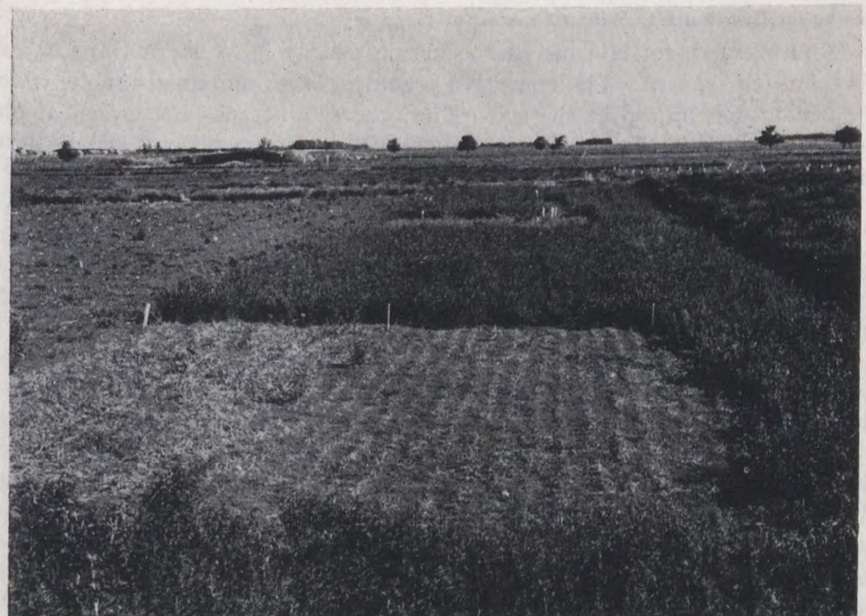


FIG. 16 (*Upper*)—Alfalfa killed by winter crown-rot on an area on which the disease organism was spread in the fall of 1947. Note that there was practically complete killing (May, 1948.)

FIG. 17 (*Lower*)—An alfalfa field in northern Saskatchewan, showing a spot killed by winter crown-rot. Such spots tend to enlarge and merge into one another (June, 1943).

Breeding for Resistance to Winter Crown-Rot

Winter crown-rot is a disease occurring mainly in Western Canada, as far as is definitely known. The causative organism is an unnamed fungus which is very widely distributed in the soil. The organism attacks the crown of plants just as the snow is disappearing in the spring and consequently the killing is commonly confused with cold killing.

Surveys conducted by the Dominion Plant Pathology Laboratory at Edmonton as well as observations made by the Saskatoon Laboratory staff indicate that the disease is a principal cause of killing in at least the central and northern parts of Alberta and Saskatchewan. In a majority of fields that are two or three years old, it is possible to find patches killed by the disease. Occasionally, when winter or spring conditions are favorable for the disease, killing may attain epidemic proportions. Such was the case in northern Saskatchewan in the spring of 1942 when literally thousands of acres of alfalfa were wiped out by the disease. While complete killing is the most obvious damage caused, it is by no means the only damage. In a high proportion of plants it is frequently found that parts varying from a small sector to almost the complete crown have been killed and yet the remaining portion of the plant has survived. The partial crown damage undoubtedly reduces the yield and contributes to the shortening of the life of plants. All in all, the disease can be said to be highly destructive.

Although certain management practices, such as limiting the number of cuts taken per year, are known to lessen the severity of attack, there is no known treatment which provides control. The development of a variety or varieties resistant to the disease offers the only means of greatly reducing or eliminating the losses now incurred. From a project, launched in 1940, it is hoped to produce a resistant variety. The breeding project is a co-operative attack by the Dominion Laboratory of Plant Pathology at Edmonton and the Dominion Forage Crops Laboratory.

To date, a few hundred plants have been selected which possess some degree of resistance to the disease. A considerable proportion of these plants have survived from 2 to 4 winters under severe epidemic conditions. Crosses between some of the resistant plants were included in a test sown on disease-infested soil in 1947. The progeny of certain of these crosses showed a survival of 25 per cent in the spring of 1948 whereas check varieties were almost completely killed. While a level of resistance which only enables 25 per cent survival may seem to be insignificant, it should be noted that a somewhat parallel situation exists in the case of bacterial wilt disease of alfalfa. Varieties having only 25 to 35 per cent of wilt resistant plants under severe epidemic conditions have been found to extend the life of stands two or more years under natural field infection.

While in this project the progress to date is considered to have attained a level of resistance of practical significance, it is planned to continue the breeding program in the hope of increasing the degree of resistance. The results provide justifiable confidence that a resistant variety will be developed which will materially reduce the losses presently experienced.

FIG. 18—Difference between alfalfa varieties in winter survival in the winter of 1945-46. The strain in the centre of the figure was completely killed by cold, while varieties in adjacent rows survived well (June, 1946).

Breeding for Resistance to Bacterial Wilt

Bacterial wilt of alfalfa was first recognized in North America in 1925 and has become regarded as one of the most destructive and widespread diseases. Every irrigated area in Western Canada so far examined has been found to be contaminated with the disease. In addition, many districts in the more moist parts of the three prairie provinces have been shown to be infected. On disease-infected soil, non-resistant varieties consistently have killed out almost completely in four to five years, whereas prior to the disease establishment the same varieties persisted 8 to 10 years or longer. It has been further established that prior to actual death, the stunting caused by the disease reduces the yield considerably. The annual loss occasioned by stand and yield reduction has amounted to literally thousands of dollars in recent years. As the disease spreads, as it undoubtedly will, losses will increase.

Sanitary and other measures of control have proven to be of no avail. Resistant varieties have been found to be the only effective means of combatting the disease. Ranger and Buffalo, the wilt-resistant varieties produced in the United States have persisted two or more years longer than non-resistant varieties such as Grimm or Ontario Variegated. For Western Canadian conditions, however, Ranger and particularly Buffalo have been shown to lack sufficient cold resistance. This latter fact has dictated the necessity for a breeding program on the Canadian prairies.

Breeding for wilt resistance is arranged as a co-operative project between the Dominion Experimental Station at Lethbridge, Alta., and the Dominion Laboratories of Plant Pathology at Edmonton and Lethbridge. Although just started in 1946, a few resistant plants have been found among the Saskatoon material. From material submitted each year for testing under epidemic conditions at Lethbridge, further resistant plants are expected. There is, consequently, every reason for confidence that a new variety which is cold and wilt-resistant will be produced in the not too distant future.

An adapted resistant variety will increase the life of stands and increase the yield of hay and pasture. Losses now estimated to cost thousands of dollars annually will be reduced very considerably.

Development of Creeping Rooted Pasture Types

The commonly grown varieties such as Grimm and Ladak generally persist only a very few years when pastured. This situation exists whether the alfalfa is grown alone or in mixture with grass. In contrast, the yellow-flowered species of alfalfa is considerably more persistent under grazing. The greater persistence of the yellow-flowered species is attributed to the fact that the crown of the plants is deeper in the soil and thus less likely to be damaged by tramping and furthermore there is a certain proportion of creeping rooted plants. Experience has indicated that the creeping rooted plants are very persistent. Commercial utilization of the yellow-flowered alfalfa is practically impossible because of the very poor seed yield. Crossing varieties such as Grimm or Ladak with yellow-flowered types offers the possibility of combining the persistence of the latter type with the seed yielding and other desirable characteristics of the variegated alfalfa varieties. With this possibility and purpose, a crossing program is under investigation at Saskatoon.

FIG. 19—Comparison of spread of creeping-rooted and ordinary type of alfalfa plants. The strongly creeping rooted plant in the lower foreground, and sister plants in the same row are the first generation of a cross between a creeping rooted yellow-flowered plant and a plant of the Ladak variety. Some plants in other rows display the creeping tendency in various degrees (May, 1948).

Encouraging results have been obtained from crosses made between certain selected plants. Among a fairly large number of progenies established in a nursery in 1945, a few progenies have displayed marked tendencies to spread or creep by underground roots. Data on a few of the better progenies have been summarized in Table 45 to illustrate the strong creeping tendencies compared with standard varieties.

TABLE 45—AVERAGE SPREAD IN INCHES OF TWO-YEAR-OLD PROGENIES OF CERTAIN YELLOW-FLOWERED PLANTS CROSSED WITH GRIMM OR LADAK PLANTS, (MEASURED MAY, 1947)

Strain Number of Yellow-Flowered Parent Plant	Average Spread of crossed progenies in inches	Average Spread of Grimm and Ladak Parents
S-43-$\overline{23}$	20.6	5.6
S-43-$\overline{27}$	14.1	5.9
S-43-$\overline{35}$	18.8	5.6
S-43-$\overline{26}$	8.3	5.8
S-43-$\overline{22}$	5.9	5.6

The average spread of progenies of the first three yellow-flowered plants listed in Table 45 was very much greater than that of Grimm or Ladak plants. Data were included on progenies of two additional plants in order to show that certain yellow-flowered plants throw crossed progenies which closely resemble the standard varieties in spreading habit.

It is considered that crosses having the creeping tendencies of the first three crosses listed in Table 45 will have superior persistence under grazing. A test to prove or disprove this supposition is already established. The breeding program is proceeding to explore the methods by which the desirable characteristics of these first generation hybrids can be passed on in a new variety to farmer growers.

It has been demonstrated frequently over a wide range of conditions that a grass-alfalfa mixture outyields grass alone. This has been found to be particularly true as stands age. The superiority of the mixture frequently has been very pronounced. For example, in a test sown in 1937 at Saskatoon from 1942 to 1948 inclusive, the brome-alfalfa mixture has averaged 3661 pounds of hay per acre contrasted to 1440 pounds per acre for brome grass grown alone. Results of this nature have strongly indicated that if an alfalfa variety were developed which would persist under grazing the carrying capacities of pastures would be increased considerably.

Sweet Clover

Sweet Clover is one of the most important forage crops in the Prairie Provinces. In terms of acreage, it ranks high and it is also one of the highest yielding of the forage crops grown. In addition, it fulfills an important role in soil improvement in many areas. Yet it is cursed by many and frequently classed as a weed. Its characteristic of volunteering in grain crops and elsewhere is a major reason for the condemnation heaped upon it. A further cause for complaint against the crop is the fact that animals will sometimes hemorrhage when wounded or injured if they have been feeding on improperly cured sweet clover hay. The breeding projects at the Laboratory are directed towards eliminating the characteristics of the crop which give rise to these objectionable features.

Breeding a Permeable Seeded Variety

Sweet Clover normally produces a large proportion of "hard" seeds, so called because the seed coat is of such a nature that it cannot absorb moisture. To overcome this condition the seed must be processed so as to chip crack or puncture the seed coat without damaging the remainder of the seed. This process is known as scarification. Without scarification, 98 or 99 per cent of the seed is unable to germinate immediately.

It is as a direct consequence of the impermeable nature of the seed coat that sweet clover occurs persistently as a volunteer in grain and other fields. If unscarified or improperly scarified seed is sown or if plants mature seed and it is shattered to the ground the seed will retain its capacity to germinate for several years and only a small proportion of the seed will germinate in any one year. From one seeding of poorly scarified or unscarified seed, sweet clover plants may appear over a period of at least 15 and probably more years.

A variety of sweet clover having soft (permeable) seed coats would eliminate this serious volunteering problem without the necessity of mechanical scarification of the seed. Seed of such a variety would germinate uniformly and immediately that proper conditions of moisture, temperature and air existed. This fact is illustrated in Fig. 20.

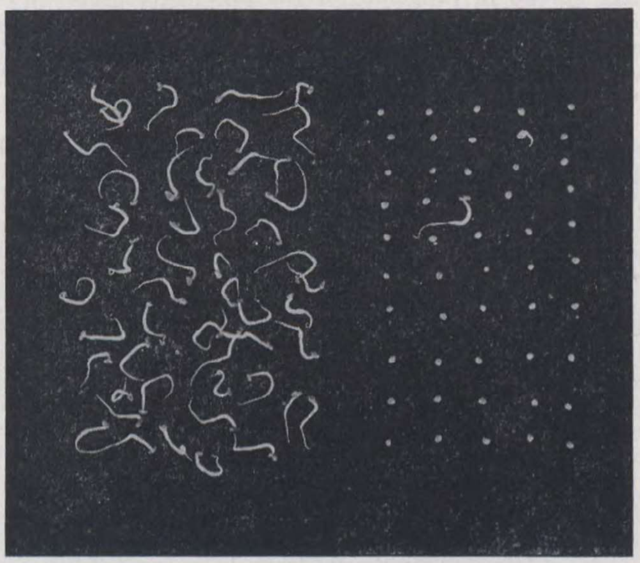


FIG.20—Left, 100 percent germination in 3 days of 50 unscarified seeds of a permeable seeded strain of sweet clover compared with 4 percent germination of 50 unscarified seeds of Arctic variety on the right. Unless scarified, the remaining seeds of the Arctic variety would not germinate (1947).

In an attempt to eliminate the above objectionable characteristic, a breeding program was started in 1931. Selection was practised for plants which produced seed that would germinate without being scarified. Results obtained from the nursery harvested and tested in 1947 have indicated that the goal has been attained. A few strains have been developed which have seed that is almost 100 per cent permeable as is shown in Table 46.

Certain strains are now quite uniform for high seed coat permeability. It is consequently planned to increase some of these strains in 1949 and to include them in variety tests at a number of points in 1950. Providing the hay yield of these strains is satisfactory, field scale increases for farmer distribution will be commenced in 1952.

TABLE 46—PERMEABILITY OF SEED OF SELECTED STRAINS COMPARED WITH ARCTIC CHECK. SEED HARVESTED 1947

Strain No.	Average Permeability of seed in per cent
S-42-16-4-1	99.83
S-42-16-4-2	99.83
S-42-16-4-3	99.89
S-42-31-1-1	100.00
S-42-30-2-1	99.60
S-42-30-2-2	100.00
Arctic Check	0.88

With a permeable seeded variety, the problem of sweet clover volunteering should be largely overcome or simplified. Seed which is sown or which shatters from plants will germinate immediately where moisture and other conditions are favourable. With a variety of this nature available, many farmers who refuse or are reluctant to grow present varieties will undoubtedly use the permeable seeded variety.

Breeding for Low Coumarin Content

Reference has been made to the fact that under certain circumstances sweet clover hay when fed to stock may produce a condition leading to hemorrahaging after an operation or injury. In recent years, research has established that this condition is caused indirectly by a compound called coumarin which is contained in all parts of plants of commonly grown sweet clover varieties. Investigations have revealed that when sweet clover hay becomes spoiled in the curing process, the coumarin is converted to a compound called dicoumarol. This latter compound has the capacity of reducing the clotting power of the blood of animals consuming feed containing it. These facts provide an explanation for the frequently reported occurence of animals bleeding profusely following operations, etc., when fed sweet clover hay.

The desirability of developing a low coumarin variety is further emphasized by the fact that coumarin is the compound causing the bitter stinging flavour of sweet clover. This latter characteristic is responsible for the clover being less palatable to stock than would otherwise be the case.

The so-called 'Melilot taint' of wheat is due to the absorption of sweet clover jucies by the grain in the threshing process. Coumarin contained in the juices is responsible for the odour and flavour of the grain. Because of this taint, a number of carloads of wheat from the prairies are graded down each year and a discount of several cents per bushel suffered.

There are thus at least three distinct undesirable effects attributable to the coumarin content of sweet clover. Use of a coumarin-free variety would eliminate these problems. Although a coumarin-free species (*Melilotus dentata*) exists, it is so unsuitable in other respects that it cannot be utilized as a cultivated crop. Consequently, it is necessary to develop a suitable variety that is low in or preferably free of coumarin.

By use of a rapid chemical test for the presence of coumarin, a variety was developed by selection from the Arctic variety. This variety was named Pioneer and the initial increase of it was started in 1939. Employing another test for coumarin, it was found that although low in one form or type of coumarin, Pioneer contained quite large amounts of another form of the compound. The primary improvement effected through development of Pioneer was that of increased palatability and this was not considered sufficiently important to justify further increase and distribution of the variety.

Renewed stimulus in this project has arisen from obtaining a cross between the coumarin-free species and ordinary sweet clover. This cross, ordinarily impossible to obtain, was made by Dr. W. K. Smith of the University of Wisconsin at Madison, Wisconsin, by a novel procedure. A few seeds from the progeny of the cross were kindly supplied to the Laboratory. Plants derived from this seed were rather undesirable in plant type but were extremely low in coumarin content. They have been used in crosses to transfer their low coumarin content desirable to plant types.

From the breeding material now available, it is hoped that a variety will be developed which is very low in or free of coumarin. The advantages of such a variety are apparent from the above discussion of the conditions for which coumarin in sweet clover is responsible.

Brome Grass

The breeding program with brome grass was commenced at the University of Saskatchewan in 1923 and the material was taken over by the Laboratory on its inception in 1932. The main achievement of this program was the production of the Parkland variety which was released in 1935. Although lower than common brome in forage and seed yield, Parkland represented real progress in the development of a less strongly creeping variety.

FIG. 21—Difference between strains of brome grass in extent of creeping. The strain in the central row is of the restricted spreading type while the row to the right is strongly spreading. On the left, is a strain which is variable for this characteristic (1937).

Following the release of Parkland, efforts were continued to develop strains even more restricted than Parkland in creeping habit. One strain was found to be superior in this respect but its high susceptibility to leaf-spot diseases rendered it unsuitable for use. In more recent years selection has included both strongly and weakly creeping types with special emphasis placed upon density of growth, leafiness, resistance to leaf-spot diseases, and superior yielding ability.

FIG. 22 (*Upper*)—View of crested wheat grass single plant nursery showing the inter-plant variation in degree of damage caused by western wheat aphis. Very short stunted plants are heavily attacked, while tall plants are free or practically free of damage (June, 1946).

FIG. 23 (*Lower*)—Single plants of crested wheat grass attacked by western wheat aphis. Note very stunted growth, and the deformity of the heads (June, 1946).

Fairly large numbers of plants have been selected each year on the basis of characteristics listed above. Each selected plant has been tested for self-fertility, seed setting under ordinary pollination conditions, and for ability to transmit high yield to crossed progenies. A very wide range of expression of each of these characters has been found. Certain plants have been shown to be almost completely self-fertile while others were almost completely self-sterile. Likewise some plants displayed almost complete sterility under open or ordinary pollination conditions and others were highly fertile. Open or cross-pollinated progenies of selected plants have yielded from about 70 to 125 per cent of the hay yield of Commercial brome. Obviously, it has been necessary to select for further breeding those plants producing high yielding progenies and which were also highly fertile under open-pollination. Crossed progenies of plants which were even moderately self-fertile have been found to contain a fair proportion of plants which were comparatively weak and apparently selfs. Thus, in order to insure a high degree of crossing between plants, it has been found necessary to select rather rigidily for self-sterility.

Evaluation of breeding stock for the above mentioned criteria requires considerable time and also working with large populations in order to find plants possessing the desired combination of characters. On the basis of work done to date, some superior plants are available and work in progress will isolate others. These plants will form the basis of a new superior yielding variety.

Crested Wheat Grass

From the position in 1915 of being an almost unknown immigrant to Western Canada, crested wheat grass has attained a place of prominence among our cultivated grasses. As valuable and popular as it has become, this grass has certain recognized shortcomings.

The relatively short growth habit, particularly of the Fairway variety, is criticized by farmer growers wishing to harvest it as hay. Compared with brome grass crested wheat is definitely less leafy. In respect to both height and leafiness, rather marked differences are found between individual plants. Thus an opportunity exists for breeding more desirable types.

Since 1945, the western wheat aphis (*Brachycolus tritici* Gill.) has consistently attacked the crested wheat grass nurseries at Saskatoon. This insect has the habit of establishing itself within the leaf sheath of plants and of causing a marked stunting of tillers and malformation and sterility of heads as shown in Figure 23. While not yet a pest of economic significance under field conditions, the extensive damage caused in the nurseries has indicated that it is a potential threat and breeding has been directed towards the development of resistant strains.

In the earlier breeding program with this grass, the procedure of inbreeding and selecting in inbred lines was followed. More recently this method has been more or less abandoned because the extremely high self-sterility existing in the species limits the number of plants which can be used and the size of populations. Since 1944, selection has been based mainly upon open-pollinated plants possessing the desired height, leafiness and resistance to western wheat aphid. Plants selected have been evaluated for their ability to pass high yield on to their crossed progenies. Crossed progenies have been found to range from as low as 50 per cent to as high as 140 per cent of check varieties.

From the breeding program to date, plants superior in height, leafiness, resistance to western wheat aphis and yielding potential are available. Additional plants will be secured from tests currently in progress. The foundation material for new varieties is thus building up.

An inbred strain (S-31-$\bar{6}$-1) has appeared promising in a test located at Melfort, Sask. The stand of this strain persisted whereas stands of the Fairway and Standard varieties were badly killed out about four years after seeding. The reason for the superior survival of the S-31-$\bar{6}$-1 strain has not been definitely established but is thought to be due to a higher degree of resistance to root-rot. The strain has merited more extensive and critical testing and such tests will be established in 1949.

Selection for resistance to western wheat aphis has been largely confined to the Standard type as this type has been found to be more susceptible than the Fairway variety. Evidence that selection for resistance has been effective and that resistance was inherited was obtained from a test in 1948. In this test, progenies of crosses between certain resistant parents were almost free from attack while crossed progenies of certain susceptible parents were severely infested.

Sunflowers

Sunflowers have been grown in Western Canada for many years on a limited scale. Tall growing, late maturing varieties have been used for silage production. A semi-dwarf type growing 3.5 to 6 feet tall, has been grown on a more or less garden-sized scale for its seed which is used as a confectionery mainly by Mennonite farmers. With the market for wheat depressed and glutted in the middle 1930's, it was considered desirable to explore the possibility of breeding a type of sunflower suited to producing seed for oil extraction and thus providing an alternative crop to wheat. A breeding project was consequently started in 1936, by selecting a few hundred heads of the so-called Mennonite variety in fields around Rosthern and Swift Current, in Saskatchewan. This project which was born with the object of relieving a depression situation actually came to fruition in helping to relieve the vegetable oil shortage during World War II.

The selections made from the Mennonite variety were extremely variable with respect to plant height, stem branching, stem strength, seed size, oil content and several other factors. Through the breeding program, an effort was made to secure strains which were uniform for early maturity, short non-branching stems, high seed yield, and high oil content in the seed. Resistance to rust, frost and sunflower moth were also sought after. In addition to selecting in the Mennonite variety, introductions were obtained from the Division of Forage Plants, at Ottawa and from Russia and the Argentine.

The Sunrise variety was released in 1942. Its ancestry traces back to a strain introduced from Russia in 1937. Its desirable attributes were high oil content and resistance to rust and the sunflower moth but these were offset by low yield and late maturity. In spite of its shortcomings, it replaced the Mennonite variety in southern Manitoba to a considerable extent.

Inbreeding was practised to secure uniformity for the desired characteristics. It was soon apparent that inbreeding was resulting in a marked loss in vigour. In order to restore vigour it was decided to try to make single crosses between the inbred lines, such single crosses being similar to single cross hybrid corn. From this work it was established that inbred lines would cross naturally to a high degree when planted in alternate rows providing the two lines came into flower simultaneously. It was further found that certain crosses were superior in yield and uniformity.

The performance of one single cross (S-37-$\overline{388}$ × Sunrise) was particularly outstanding and the cross was assigned the name Advance and released for distribution in 1945. Evidence of the superior merits of this hybrid variety was shown in its ready acceptance by farmer growers. From the few demonstration strips sown in 1945, use of Advance increased to the point where in 1948 it was estimated that it occupied about 98 per cent of the 30,000 acres grown in southern Manitoba.

FIG. 24 (*Upper*)—Row of Mennonite variety. Note lack of uniformity (1944).

FIG. 25 (*Lower*)—Row of Advance hybrid. Note uniformity of height, flowering date, stem strength (1944).

The introduction of Advance has been a significant factor in stimulating the production of the crop and in increasing the yield and therefore the return to farmer growers. Since the oil content of Advance seed is four to five per cent higher than that of Mennonite seed, the companies crushing the seed for oil extraction have benefited materially also.

In utilizing the Advance hybrid, it is necessary to make the cross each year. This is a relatively simple procedure, however, involving seeding the two parents in alternative pairs of rows with space isolation to prevent crossing with other varieties, etc.

The greater uniformity of the Advance hybrid contrasted to the Mennonite variety is shown in Figures 24 and 25. The advantages of uniform height, maturity, seed size, etc., are obvious.

The use of sunflowers as a grain crop in many areas of Western Canada is limited to the fact that present varieties are roughly 15 to 20 days later in maturity than wheat. The Early Saratov variety introduced from Russia matures in about the same time as wheat but it is very short growing and low in yield. A number of crosses having Early Saratov as one parent were found to be considerably earlier than Mennonite or Advance and fairly high yielding. However, the great difference in date of flowering between this early variety and other strains now available makes the use of Early Saratov as one parent of a single cross hybrid very difficult if not impossible.

In an effort to capitalize on the earliness of Early Saratov, a crossing program is in progress involving this variety with the parents of the Advance hybrid variety. From this work, it is hoped to develop strains having the desirable characteristics of the S-37-388 and Sunrise but considerably earlier maturity. If this objective is accomplished it should result in the acreage expanding westward and northward from its present centre in southern Manitoba.

Triticum-Agropyron Hybridization

Throughout the drier parts of Western Canada, difficulty is frequently encountered in securing stands of grasses. The fact that all of the cultivated grasses have small seeds and should not be sown to a depth of over one inch is the primary factor responsible for this problem. Not infrequently these small seeds are sown so deeply that they are unable to emerge. On the other hand, seedings made at the optimum depth of one-half to one inch often fail due to wind erosion or to the soil drying out rapidly to beyond the depth of seeding. A grass with seed approaching the size of wheat would permit seeding to a depth of two to three inches and thus largely eliminate this problem.

The success of Russian investigators in crossing certain wheat grasses with wheat suggested the possibility of developing a large seeded perennial grass. A crossing program was consequently started in 1935.

Crosses were successfully made between wheat and tall wheat grass (*Agropyron elongatum*) and intermediate wheat grass (*A. intermedium* or *A. glaucum*). Hybrids involving the tall wheat grass were partially fertile and progenies have now advanced to the sixth generation from the cross. Hybrids of intermediate wheat grass parentage were almost completely sterile and no further progress was made with them at Saskatoon.

Investigations to date with crosses between wheat and tall wheat grass have been discouraging due primarily to the poor winter hardiness and to the small seed size possessed by derivatives of this cross. Winter hardiness showed a definite trend to decrease with each advance in generation and this trend was greatly aggravated by backcrossing once to wheat. Seed produced by hybrid plants has been very similar in size to that of the grass parent and thus the primary object of the cross has not been attained. Backcrossing to wheat greatly increased seed size of the progeny but the backcrossed progenies were so lacking in winter hardiness that they were of no value as a perennial crop.

Although this project at Saskatoon has been unproductive of valuable material, the work at Ottawa, as summarized in an earlier section of this report, has yielded fertile large-seeded strains which are hardy under Ottawa conditions. Certain of these lines have winter-killed badly at Saskatoon but it may be possible to select winter-hardy strains from them. With this possibility in mind, a fairly large nursery at Ottawa lines will be established in 1949 at Saskatoon.

Studies on Methods of Breeding

Methods of Crossing in Crested Wheat Grass and Brome Grass

Crossing is frequently necessary in order to combine desirable characteristics possessed by two or more plants or lines. Furthermore, in breeding cross-pollinated crops it is important to determine the capacity of selected plants to pass high yielding ability on to their crossed progenies. Plants possessing such ability are said to be good or high combiners. The critical evaluation of combining ability involves controlled crossing and the testing of the crossed progenies. Crossing techniques must be such as to produce considerable seed with a minimum expenditure of time and effort.

In both crested wheat grass and brome grass, crossing was attempted on a fairly extensive scale using the technique of emasculating and pollinating individual florets such as is practised in breeding cereal crops. Extremely poor seed setting was obtained. This fact combined with the very heavy expenditure of time and energy required made the technique entirely impractical. An alternative procedure was evolved in which pollination was done on a bulk or mass basis and dependence was placed upon natural self-sterility rather than emasculation to prevent or limit selfing.

FIG. 26—Various methods of crossing crested wheat grass. Note the large test tube standing at the base of the first plant in the outside row. Head bearing stems of the male parent stand in water in this test tube, and the heads are enclosed in one of the parchment paper bags along with heads of the other parent. The bags in the horizontal position between the two rows each enclose heads of two parents. Other parchment paper bags enclose only heads of the female parent, and these are pollinated by means of a pollen gun (June, 1948).

Most plants of crested wheat grass are highly self-sterile while in brome grass a wide range is found for self-sterility. Consequently, when crossing brome grass without emasculating, it is essential to predetermine the self-fertility level and use only highly self-sterile plants.

Extensive studies have shown that the time of artificial pollination must correspond with the natural flowering cycle. Repeating pollinations on two or three different days has given considerably higher seed setting than single pollinations. Four methods of pollinating have been investigated. The simplest and one of the most effective procedures has been to cut off head-bearing stems of the male parent, insert the stems in water in a large test tube, and enclose the heads in the parchment paper bag along with heads of the female parent. Another efficient method has been to collect pollen from the male parent in large paper bags and with a pollen gun discharge the pollen into the parchment paper bag containing flowering heads of the female parent. Exchange of bags containing pollen between the two parents has given poorer seed setting and has been more time consuming than these other procedures.

By employing the technique briefly described above, it has been possible to secure seed setting approximately half as good as that obtained under natural pollination with a minimum expenditure of time and energy. Usually sufficient seed has been secured to plant preliminary tests.

Studies on Methods of Selfing Grasses

Self-pollination or inbreeding is practised to increase the uniformity of some desired character. Since crested wheat grass and brome grass are naturally cross-pollinated, it is essential in selfing to prevent pollen from other plants from reaching the plant or portion of the plant which is to be selfed. It is important that the pollen excluder should completely inhibit pollen penetration and exert a minimum depressional effect on seed setting. In artificial or hand crossing, exclusion of undesired pollen is essential just as it is in selfing.

Cotton cages, parchment, kraft, glassine and cellophane paper bags have been used in a study to determine their effectiveness as pollen excluders and their influence on seed setting. It was found that seed setting in cotton cages was considerably higher than in paper bags. However, studies showed that there was considerable penetration of pollen through the cotton and therefore they were unsatisfactory. All types of paper bags used were effective in excluding pollen providing they did not crack or tear. Glassine paper bags cracked or tore easily and holes wore through kraft bags rather quickly so from this standpoint bags made from these papers were less satisfactory then parchment or cellophane.

Consistently better seed setting has been obtained under parchment bags than with the other three types. A study conducted in 1948 involved placing bags of various types on heads after natural pollination had been completed. The seed setting obtained thus measured the effect of the bags on post-pollination seed development. It was interesting to find that all bags depressed seed production but parchment was decidely the least detrimental. The depressional effect of kraft and cellophane was even evident in specially constructed bags having one half parchment and the other half either one of these other papers.

On the basis of the above results, parchment paper bags are now used exclusively in the selfing and crossing programs with grasses at the Laboratory.

Methods of Intercrossing Selected Alfalfa Plants

In alfalfa it is frequently desirable to intercross plants selected for various purposes in order to secure seed for testing the crossed progenies. Crossing by hand is impractical on the scale required. Pairing of plants in space isolated plots and allowing them to intercross naturally is an alternative procedure, but the plants are exposed to the ravages of insects, rodents and in some cases to large animals. In addition, it is difficult to be sure that the isolation is adequate. Another alternative is to force honey bees to cross-pollinate the plants within screen cages.

This latter method was tried in 1947 and 1948 and found to result in heavy seed production. The average yield of seed from 34 caged groups of plants was 597 pounds per acre in 1947 and 316 pounds in 1948. The good seed yields have indicated that a high degree of cross-pollination was obtained but definite data are not available as yet on this important consideration.

SEED-SETTING STUDIES

Factors Influencing Seed Setting in Alfalfa

Seed production of alfalfa expanded very rapidly in northern Saskatchewan in the decade from 1930 to 1940. The tremendous increase in acreage was stimulated by the high seed yield obtained. But by the close of the above decade and for most years since then, yields have been relatively poor ranging in general as an average from 50 to 75 pounds per acre. With the objective of gaining an understanding of factors controlling and influencing seed setting and of assisting growers to increase yields, a series of studies were commenced in 1939.

The necessity of tripping had been debated for a considerable period of time and consequently this was one of the first factors investigated. Detailed observations were made on over 4400 flowers during a four-year period and only 0.7 per cent of these flowers were found to set pods without tripping. These data show conclusively that tripping is an essential process for pod setting.

Investigation on the factors causing tripping revealed that wild bees were the principal agency. When bees were prevented from reaching portions of plants the amount of tripping and the amount of seed setting was small compared with that occuring on portions of the same plants exposed to bees. Furthermore, observations over a four-year period in seed producing fields in northern Saskatchewan showed that high positive correlations existed between the populations of wild bees and the percentage of flowers tripped. Honey bees were found to be of little or no consequence as tripping agents. A certain amount of automatic or self-tripping occurred but it was insignificant compared with that caused by bees.

Studies were conducted on the extent of natural crossing and its significance in relation to seed setting. It was found that generally around 85 to 95 per cent of the seed set was the result of cross-pollination. Comparison of seed setting followed crossing and selfing demonstrated that crossing produced three to four times as much seed as selfing.

Under field conditions, tripping insects are the primary if not the only means by which cross-pollination is obtained. This factor further emphasizes the important function which wild bees play in seed setting in this crop.

Studies of the life history and feeding habits of wild bees showed that they nested mainly in wild undisturbed land. It was apparent that at certain periods of the flowering season of alfalfa the wild bees were attracted away from that crop to such plants as perennial sow thistle and fireweed.

The facts as outlined above provided a partial explanation at least for the seed yielding behaviour of the crop. It also enabled recommendations to be made for improving seed yields. The trend to lower yields was apparently due, in part at least, to the rapidly expanded acreage without a similar increase in bee population. In fact, the bee population was undoubtedly lowered by the destruction of nesting sites through bringing the land under cultivation. There was in general, therefore, a scarcity of tripping bees. The adjustment required to meet this situation was to limit the size of individual fields and to locate the fields where they were surrounded by or situated close to wild undisturbed land which would serve as nesting sites for the bees. Elimination or reduction of the competing flowering plants was recommended as means of forcing the bees to forage on alfalfa.

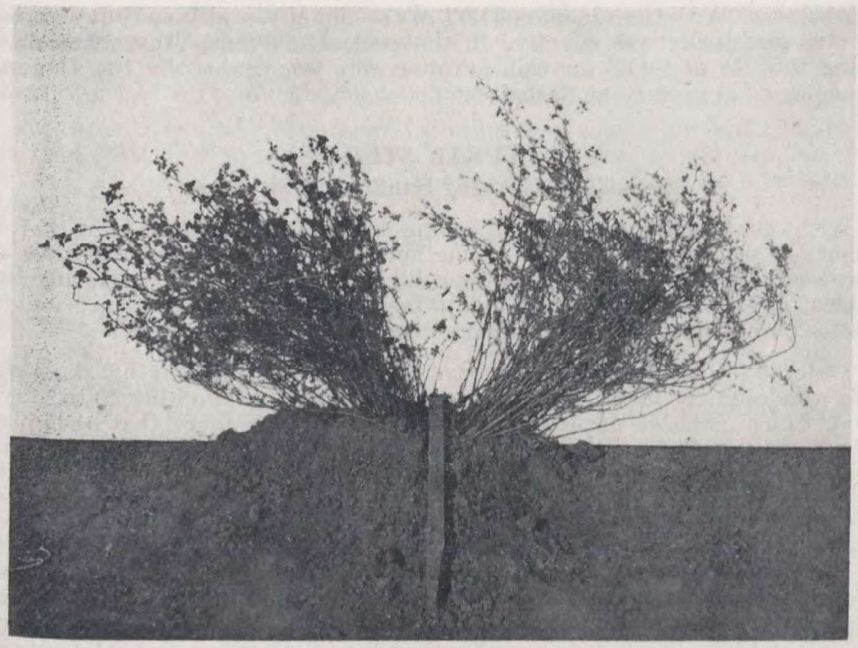


FIG. 27—A single plant of alfalfa showing the effect on seed setting of excluding bees. The right hand half of the plant was enclosed in a screen cage and very few pods were set. The left hand half was exposed to bee visitation and heavy pod setting was obtained (August, 1941).

Observation of the nesting habits of certain species of leaf-cutter bees showed that they utilized holes made by wood boring insects in trees, stumps and logs. This fact led to a study of the possibility of inducing them to nest in holes drilled mechanically in logs, etc. It was found that a high percentage of holes drilled with a brace and bit were used for nesting purposes. Although the possibility of increasing the leaf-cutter bee population by providing artificially-made nesting sites was not fully investigated, the results suggested that it might have practical application.

In working in seed fields in northern Saskatchewan it became evident that lygus bugs were a serious injurious insect. Studies consequently were made of the populations of the insect, the extent of damage caused by them, and possible means of control. Over a four-year period, 92 fields were examined and a high proportion of them were found to be heavily infested. Damage to buds and flowers was very evident in fields having heavy infestations and there was no doubt that seed yields were adversely affected by this damage. Seed collected from 19 fields was closely examined and the content of brown shrivelled seed attributable to insect damage was found to range from 9 to 51 per cent and to average 22 per cent. The bulk of this damaged seed was so light that it would be lost in threshing or cleaning.

Prior to and during the period this investigation was in progress, research in United States had shown that control of lygus by use of insecticides available at that time was impractical. Observations in the seed-growing area of northern Saskatchewan indicated that early spring burning of the stubble and trash on the fields afforded at least some control of the insect. Later studies suggested that the favourable effects of burning was due in part at least to the control of plant diseases. With the advent of DDT at the end of World War II, it was found that this insecticide was effective in the control of lygus. Investigations involving the use of DDT for this purpose were undertaken by the Dominion Entomology Laboratory at Saskatoon.

CULTURAL STUDIES

Methods of Growing Sunflowers for Grain

With the commencement of a breeding program with sunflowers in 1937, the necessity of securing information on methods of growing the crop for grain was recognized. Tests were undertaken to determine the optimum planting time, the most satisfactory spacing of plants in the rows, when the crop should be harvested, and the effect of fertilizer applications on yield.

Dates of seeding tests conducted over a few years established that the highest yields were obtained at Saskatoon from seedings made in the May 10 to May 20 period. Contrary to the general opinion of farmers, it was found that when plants were spaced about six inches apart in rows spaced 36 inches apart the yields were considerably higher than when the plants were spaced about 36 inches apart in the rows. Furthermore, the close intra-row spacing resulted in smaller head size and a higher oil content in the seed that did the wider spacing. In combining, the smaller head size was definitely desirable. Harvesting plots at ten-day intervals from September 1 to October 20 established that there was no measurable loss of seed nor change in oil content due to delayed harvesting. In order to escape heating and spoilage of the seed, it was found that delaying of harvesting was essential. In most cases seed harvested prior to the end of September or early October was too high in moisture content for safe storage.

The information obtained from these tests formed the basis for recommendations to farmer growers when commercial production of the crop commenced in Western Canada in 1942. Practical experience on field scale production has established their soundness.

Studies on Dates of Seeding Grasses and Legumes

Difficulties are frequently experienced in securing stands of forage crops in the dry prairie areas. This difficulty is largely due to the fact that all of the cultivated grasses and legumes must be sown at a depth of less than approximately one inch and the soil frequently dries out rather rapidly to beyond that depth. Drying of the surface layer is obviously the least rapid during cool seasons of the year and seedings made during the cool periods should consequently provide more ideal conditions for establishing stands.

Dates of seeding tests with crested wheat grass, brome grass, western rye grass, sweet clover and alfalfa have shown that the best stands were obtained from early spring, early fall or late fall seedings. Sweet clover, however, has been shown to be unadapted to fall seeding as the seedlings winter-kill badly.

The winter survival of fall sown grasses and legumes was studied in detail. From this research it was found that seed which had germinated but not emerged at freeze-up winter-killed rather severely. From that stage of development up to plants which were 2 or 3 inches high at freeze-up, there was a progressive increase in survival, the large plants being almost completely hardy. Sweet clover was an exception to this general behaviour, since nearly all plants died over winter irrespective of stage of late fall development. It was also shown that grass and alfalfa seedlings established in stubble or a dead weed covering survived the winter considerably better than seedlings growing on summerfallow. The difference in survival under these two conditions was particularly large when plants were small, there being relatively little difference when plants were 2 or 3 inches tall at freeze-up. These results substantiated those obtained from dates of seeding tests in showing that fall seedings should be done in early September or late enough that the seed would not germinate until the next spring. It also showed the importance of fall seeding being done into stubble or a trash covering.

The results from these tests as well as other tests conducted on Experimental Farms and Stations in Western Canada have formed the basis for recommendations to farmers in respect to seeding. These recommendations have been widely adopted.

Fertilizer Tests on Alfalfa For Seed

Fertilizer tests in the alfalfa seed growing area of northeastern Saskatchewan were conducted by the Soils Department, University of Saskatchewan, prior to World War II. When this department was unable to continue the tests during the war, the Laboratory carried them on from 1943 to 1946, after which the Soils Department again assumed responsibility for this work.

In the work conducted by the Laboratory, a considerable number of different fertilizers were tested on soils ranging in texture from clay to sand. It was found that on sandy soils treatments with fertilizers containing sulphur resulted in seed yields which were from two to eight or nine times as great as secured on untreated plots. The seed yield response to fertilizers not containing sulphur was negligible as was also the response with all fertilizers on heavy loam or clay soils.

Rates of application experiments showed that per acre amounts of sulphur equivalent to that contained in 50 pounds of ammonium phosphate 16-20-0 gave highly satisfactory results. Fall as compared with spring applications were tested at two locations. The results showed that late fall application was at least equal if not preferable to spring application.

Each year the results of the fertilizer tests were made known to interested farmer growers through various channels. This information resulted in a large increase in the use of fertilizers particularly on sandy soils but also on the lighter loams and even on the heavier soils. The yields on many individual farms and the total production was undoubtedly considerably increased through utilization of this knowledge.

VARIETY TESTS

Comparison of Southern and Northern Brome Grass Strains and Varieties

Awnless brome grass was brought to this continent from Europe and Asia. In recent years it has been recognized that two types were represented, one having originated in Northern Europe or Asia and the other of southerly origin. On this continent the so-called Northern type has been utilized over much of the brome growing area. The southern type became established in certain parts of the Central and Southern Great Plains area but was not distributed extensively until recently when yield trials demonstrated its superiority in certain States. Annually, Western Canada has produced several million pounds of seed of the Northern type of brome, a large part of which has been exported to the United States. It appeared that the publicity given to the superiority of the Southern varieties or strains in fairly extensive areas in U.S.A. threatened the seed market for brome grass from Western Canada. Variety tests to investigate seed and forage production of Southern strains in Western Canada were consequently undertaken.

Three different tests comparing Southern and Northern strains have been conducted in Saskatoon. In all tests the differences between strains in hay yield were not significant but as an average in two of the three tests the Southern strains significantly outyielded the Northern strains. Thus in general, the hay yield of the Southern strains was similar to that of the Northern strains there being, however, some evidence that the Southern were slightly higher yielding.

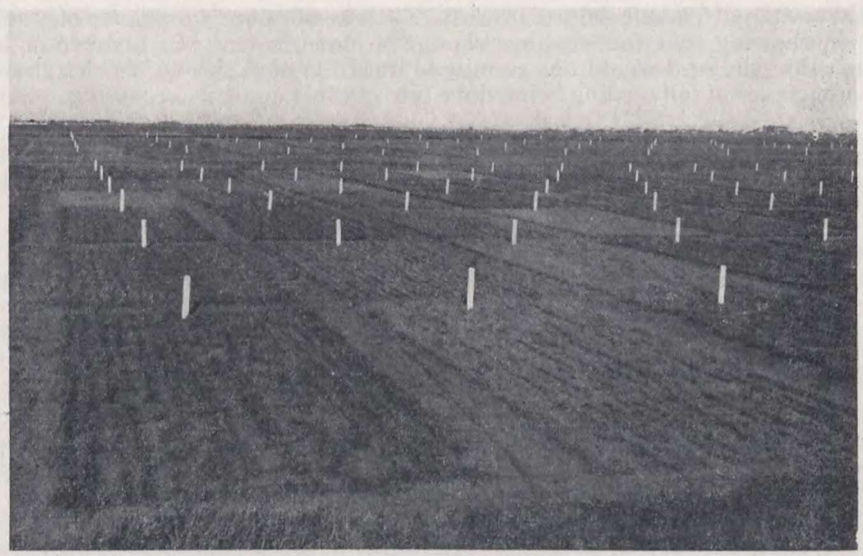


FIG. 28—View of a test of various grass species. Each plot occupies an area 8 × 20 feet. In this particular experiment each species occurs in six different plots scattered at random over the test area. This may be seen by observing the distribution of the greyish coloured plots in which Russian wild rye grass is growing.

The results of seed yield tests present a considerably different picture. Seed yields of the Southern strains were markedly and significantly lower than those of Northern strains with the exception of the Parkland variety. The differences were such that until the price offered for seed of the Southern strains becomes approximately twice that offered for Northern strains farmers in Western Canada can not be expected to grow the Southern strains for seed.

New Grass Species

In recent years a few grass species, in addition to those at present grown, have appeared promising for use as cultivated crops in Western Canada. Among these are tall wheat grass (*Agropyron elongatum*), intermediate wheat grass (*A. intermedium* and *A. glaucum*) Russian wild rye grass (*Elymus junceus*), Canadian wild rye grass (*E. canadensis*), and Virginia wild rye grass (*E. virginicus*) (*var*) *submuticus*). These species have been included in hay yield trials and in preliminary pasture tests.

The results of hay tests show that tall wheat grass and intermediate wheat grass are higher yielding than Fairway crested wheat and commercial brome grass. The yield superiority of the above two grasses was in the order of 30 to 40 per cent in two tests and 8 to 10 per cent in the third test. While the hay of these new species is somewhat coarser than that of the standard grasses, a preliminary feeding test using mature cows indicated that the hay was reasonably palatable. Consequently, these grasses are regarded as potentially valuable and more extensive testing of them is in progress.

Canadian wild rye grass has not been found to outyield the standard grasses and its hay was the least palatable of all the species fed to cattle. The Virginia wild rye grass has been consistently low yielding and has recovered very slowly after cutting or grazing.

In two tests the results show that Russian wild rye grass is slightly lower in hay yield than crested wheat grass or brome grass. Nevertheless, because of its extreme drought resistance and its characteristic habit of producing a mass of basal leaves and very few stems, it is regarded as a potentially valuable pasture grass for Western Canada. Very poor seed yield is the primary characteristic limiting its utilization.

Fairway and Standard Crested Wheat Grass

The Fairway variety was widely distributed for seed production when crested wheat grass was first released to farmer growers in Western Canada about 1930. Consequently, a very high proportion of the crested wheat grass which is grown in Canada is of the Fairway type. Data are now available which indicate that the Standard type is superior in certain respects to Fairway. Yield data are presented in Table 47 comparing Fairway with two strains of the Standard type in 10 tests conducted from 1937 to 1948.

Fairway has been consistently lower in yield than either strain of Standard. In certain tests the differences have been small but as an average it has amounted to about 10 per cent in favour of Standard. Other factors in favour of the Standard type have been its taller growth and reduce tendency to go dormant. While Standard appears to be less leafy than Fairway, actual leaf percentage determinations have failed to show any marked difference.

TABLE 47—COMPARISON OF HAY YIELD OF STANDARD AND FAIRWAY CRESTED WHEAT GRASS IN TESTS FROM 1937 TO 1948

Block location of Test	Duration of Test	Yield of hay in 9ounds per acre		
		Standard S-131	Standard U.S.D.A. 19537	A. cristatum Fairway
608	1937-43	—	2468	2449
307	1938-43	—	2623	2066
1307	1939-43	—	2661	2534
307	1941-45	—	1905	1861
307	1942-46	—	2603	2396
1407	1939-47	2038	—	1698
907	1944-47	3420	2774	2726
508	1946-48	2752	—	2324
708	1947-48	4793	—	4271
507	1948	5112	5390	4647
Average of 5 tests		3623	—	3133
Average of 7 tests		—	2918	2663

In view of the superiority in yield and height of growth in particular, it is felt that the Standard type should be more widely grown in Western Canada. From the standpoint of seed export to United States, the Standard type is definitely preferred. With the object of securing a suitable Standard type, several strains are under test at Saskatoon and it is expected that one will be named and released for distribution in the near future.

Alfalfa Varieties

In recent years a number of varieties have been developed in North America. Many of these have been included in variety trials using Grimm as the Standard. The general conclusions reached from these tests are summarized below.

Ladak has consistently outyielded Grimm in hay production and has been at least equal to it in seed yield. Ladak has also been slightly superior to Grimm in winter hardiness.

Of the new bacterial wilt resistant varieties, Ranger has been slightly lower in hay yield than Grimm. It has been somewhat lacking in winter hardiness, killing considerably more than Grimm in severe winters. Buffalo, a variety of Common alfalfa, has been decidedly lacking in hardiness.

Rhizoma, selected for creeping rooted habit, has not displayed that characteristic in tests at Saskatoon. Canauto and Ferax, both selected for high seed yield, have shown some superiority in this regard. Both varieties have been somewhat less hardy than Grimm, but approximately equal in hay yield to this standard. Viking, selected for superior winter-hardiness, has displayed this characteristic but in this respect probably has not been outstanding compared with Ladak. In hay yield, Viking has been found to be intermediate between Grimm and Ladak.

PROGRAM OF EXPERIMENTAL WORK

The program of experimental and research work, for which the Division of Forage Plants is responsible is, of necessity, diversified, both with respect to the crops and the problems involved, and the wide range of soil and climatic conditions encountered and the different types of farming practised in various sections of this country.

All of the work, whether it be carried on at divisional headquarters, Central Experimental Farm, Ottawa, Ont., at the Dominion Forage Crops Laboratory, Saskatoon, Sask., or on the forty-one branch stations and sub-stations, which are located at strategic points across Canada, is organized under carefully planned projects. A list of active forage crop projects which are being carried at each branch unit is shown in the following pages.

The various lines of investigation on all branch units are closely co-ordinated. Variety tests, for instance, are arranged, as far as possible, so that the same varieties are studied, on all branch units located in a specified agricultural region. When the tests are completed the results from all these stations are summarized, and these form the basis for recommended practices in the area concerned.

Plant breeding work is centered largely at the Division of Forage Plants, Central Experimental Farm, Ottawa, Ont., for Eastern Canada, and at the Dominion Forage Crops Laboratory, Saskatoon, Sask., for the Prairie Provinces. However, since 1939, major plant breeding projects have been allotted to branch experimental farms and stations on the basis of regional needs. This plan is based upon the belief that research on a major problem can best be carried on in the area where the problem exists. All such plant breeding projects are under the close supervision of the two major plant breeding units. All major projects involving breeding for disease resistance are planned and conducted jointly with pathology units of the Botany Division of Science Service.

In addition to experimental and research work relating to the improvement of forage crops, the Division of Forage Plants at Ottawa is responsible for pasture research relating to the evaluation of species and varieties and mixtures for various soil and climatic conditions, and for various kinds of livestock. Factors such as hardiness, drought resistance, total annual yield, seasonal productivity and methods of establishment are under investigation.

The evaluating of new species and strains of forage crops obtained from abroad is a major consideration. In co-operation with the Division of Botany, Science Service, several thousand new introductions are obtained from Botanic Gardens throughout the world annually. These are tested in selected agricultural zones. In addition, a steady flow of material is obtained annually on an exchange basis with agricultural experimental stations in foreign lands.

Other lines of investigation relate to methods in pure seed production, verification of seed stocks in co-operation with the Canadian Seed Grower's Association, and methods in processing forage seeds, the value of various species and varieties for special uses, including soil conservation, and the chemical control of weeds in forage seed production and in turf grass.

LIST OF FORAGE CROP PROJECTS AT THE DIVISION OF FORAGE PLANTS, CENTRAL EXPERIMENTAL FARM, OTTAWA, AND AT BRANCH UNITS ACROSS CANADA.

	Ottawa	Charlottetown	Kentville	Nappan	Fredericton	Ste Anne	Lennoxville	Normandin	L'Assomption	Harrow	Kapuskasing	Morden	Brandon	Indian Head	Saskatoon Lab.	Melfort	Scott	Swift Current	Lethbridge	Lacombe	Manyberries	Prince George	Kamloops	Summerland	Agassiz	Saanichton	Smithers	Beaverlodge	Fort Vermilion	Sub-Stations
Ag. 255—Plant Introduction and testing of new species	x	x	x	x	x	x	x	x			x	x	x	x	x		x	x	x	x	x	x		x	x	x	x	x	x	
PLANT BREEDING																														
Ag. 7—Corn	x									x		x	x						x											
Ag. 17—Root Breeding, Mangels and Sugar Beets	x					x													x					x	x					
Ag. 37—Carrots	x																													
Ag. 52—Swedes	x					x																			x					
Ag. 55—Swedes, Resistance to club-root and brownheart (Coop.)	x	x	x	x	x																									
Ag. 77—Sunflowers	x									x		x			x															
Ag. 87—Orchard grass	x																													
Ag. 88—Western Rye grass															x		x													
Ag. 89—Brome grass													x		x															
Ag. 95—Crested Wheat Grass															x			x												
Ag. 86—Timothy	x			x																										
Ag. 90—Methods and technique in forage plant breeding	x														x															
Ag. 92—Triticum x Agropyron hybridization	x												x	x	x		x	x		x										

	Ottawa	Charlottetown	Kentville	Nappan	Fredericton	Ste Anne	Lennoxville	Normandin	L'Assomption	Harrow	Kapuskasing	Morden	Brandon	Indian Head	Saskatoon Lab.	Melfort	Scott	Swift Current	Lethbridge	Lacombe	Manyberries	Prince George	Kamloops	Summerland	Agassiz	Saanichton	Smithers	Beaverlodge	Fort Vermilion	Sub-Stations
Ag. 93—Meadow fescue and tall fescue breeding	x																													
Ag. 96—Perennial rye grass	x																								x					
Ag. 3—Cytology of forage species	x																													
Ag. 4—Induced polyploidy of forage crops	x																													
Ag. 97—Grass breeding-miscellaneous grasses	x														x				x						x					
Ag. 98—Miscellaneous forage species, other than grasses & legumes															x				x											
Ag. 111—Alfalfa	x			x		x							x		x			x	x						x			x		
Ag. 112—Sweet clover	x												x		x															
Ag. 114—Red clover	x			x											x	x				x										
Ag. 115—White clover	x					x									x	x														
Ag. 116—Alsike clover	x														x	x						x								
Ag. 117—Soybeans	x									x																				
Ag. 118—Selection & hybridization in native grasses																		x												
Ag. 119—Selection & hybridization in native legumes																		x												

	Ottawa	Charlottetown	Kentville	Nappan	Fredericton	Ste Anne	Lennoxville	Normandin	L'Assomption	Harrow	Kapuskasing	Morden	Brandon	Indian Head	Saskatoon Lab.	Melfort	Scott	Swift Current	Lethbridge	Lacombe	Manyberries	Prince George	Kamloops	Summerland	Agassiz	Saanichton	Smithers	Beaverlodge	Fort Vermilion	Sub-Stations
SEED PRODUCTION STUDIES																														
Ag. 58—Field roots, swedes		x	x	x	x																									
Ag. 101—Grasses, legumes, corn, soy-beans, field roots & miscell. crops	x					x	x	x					x		x			x	x	x		x			x	x	x	x	x	
Ag. 130—Alfalfa																												x		
Ag. 155—Red clover					x																									
Ag. 164—Sweet clover															x															
Ag. 202—Timothy					x																									
Ag. 213—Brome Grass															x															
Ag. 224—Western rye grass															x															
HAY AND PASTURE STUDIES																														
Ag. 241—Pasture value of cereal crops under different systems of grazing														x																
Ag. 246—Annual grasses and legumes alone and in mixtures for hay	x				x		x	x			x		x	x	x		x	x	x	x								x	x	x
Ag. 240—Annual grasses and legumes alone and in mixtures for pasture	x					x														x	x					x				
Ag. 264—Perennial and biennial grasses and legumes for hay	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x

	Ottawa	Charlottetown	Kentville	Nappan	Fredericton	Ste Anne	Lennoxville	Normandin	L'Assomption	Harrow	Kapuskasing	Morden	Brandon	Indian Head	Saskatoon Lab.	Melfort	Scott	Swift Current	Lethbridge	Lacombe	Manyberries	Prince George	Kamloops	Summerland	Agassiz	Saanichton	Smithers	Beaverlodge	Fort Vermilion	Sub-Stations
Ag. 264B—Grasses with sweet clover in short leys																												x		
Ag. 267—Perennial and biennial grasses and legumes for pasture	x	x	x	x	x	x	x				x		x	x	x	x	x	x	x	x		x		x	x	x	x	x		
Ag. 270—Effect of stage of maturity, frequency of cutting, artificial fertilizer, & rare elements on the chemical composition of pure species for pasture	x																													
COMPARATIVE STUDY OF VARIETIES																														
Ag. 1—Corn for silage	x	x	x	x	x	x	x	x	x		x	x	x	x			x	x	x					x	x	x		x	x	
Ag. 2—Corn for grain	x				x	x	x		x	x		x	x	x			x	x	x			x								
Ag. 16—Field roots	x	x	x			x	x	x			x			x					x					x				x	x	
Ag. 64—Fleshy annuals	x														x													x		
Ag. 66—Sugar Beets								•	x	x						x			x											
Ag. 76—Sunflowers	x							x							x							x							x	
Ag. 126—Alfalfa	x	x	x	x	x	x	x	x			x		x	x	x	x	x	x	x	x								x	x	
Ag. 126B—Test of Alfalfa varieties in grass mixture	x														x															
Ag. 146—Red clover	x	x	x	x		x	x	x			x		x							x										

	Ottawa	Charlottetown	Kentville	Nappan	Fredericton	Ste Anne	Lennoxville	Normandin	L'Assomption	Harrow	Kapuskasing	Morden	Brandon	Indian Head	Saskatoon Lab.	Melfort	Scott	Swift Current	Lethbridge	Lacombe	Manyberries	Prince George	Kamloops	Summerland	Agassiz	Saanichton	Smithers	Beaverlodge	Fort Vermilion	Sub-Stations
Ag. 161—Sweet clover	x	x	x	x				x			x		x	x	x		x	x	x	x								x	x	
Ag. 181—Soybeans	x		x	x	x				x	x		x	x		x				x						x					
Ag. 191—Sorghums												x	x					x												
Ag. 201—Timothy	x	x	x	x		x	x	x			x									x										
Ag. 221—Western rye grass													x		x		x		x	x										
Ag. 231—White Dutch clover	x	x	x	x							x									x					x			x		
Ag. 251—Millet	x																	x												
Ag. 252—Crested Wheat Grass																x		x												
Ag. 253—Brome grass												x	x	x	x	x	x	x	x	x										
Ag. 254—Comparative test of miscellaneous grasses, legumes and other crop species	x																													
SPECIAL PROJECTS																														
Ag. 71—Field roots: Methods of winter storage				x																										
Ag. 182—Soybeans: Influence of methods of planting on yield										x																				
Ag. 215—Turf Grass Experiments	x	x										x			x										x	x		x		

	Ottawa	Charlottetown	Kentville	Nappan	Fredericton	Ste Anne	Lennoxville	Normandin	L'Assomption	Harrow	Kapuskasing	Morden	Brandon	Indian Head	Saskatoon Lab.	Melfort	Scott	Swift Current	Lethbridge	Lacombe	Manyberries	Prince George	Kamloops	Summerland	Agassiz	Saanichton	Smithers	Beaverlodge	Fort Vermilion	Sub-Stations
Ag. 276—Herbarium: Collection and preservation of plant specimens.......	x														x			x			x							x		
Ag. 102—Nutritional & physiological studies with reference to the growth and seed production of forage plants...	x														x															
Ag. 88A—Inheritance of rachilla character in western rye grass........															x															
Ag. 112A—Flower structure in relation to self-pollination in sweet clover															x															
Ag. 112B—Interspecies crossing in Melilotus.........................															x															
Ag. 112C—Inheritance of pigmentation in sweet clover seed...........															x															
Ag. 112D—Seed-coat permeability in sweet clover....................															x															
Ag. 112E—Inheritance of pod color in sweet clover....................															x															
Ag. 137—Factors affecting seed-setting in alfalfa.....................	x													x	x															
Ag. 268—Dates of seeding perennial grasses and legumes.................															x			x		x										
Ag. 269—Dates of cutting alfalfa.....																				x										

	Ottawa	Charlottetown	Kentville	Nappan	Fredericton	Ste Anne	Lennoxville	Normandin	L'Assomption	Harrow	Kapuskasing	Morden	Brandon	Indian Head	Saskatoon Lab.	Melfort	Scott	Swift Current	Lethbridge	Lacombe	Manyberries	Prince George	Kamloops	Summerland	Agassiz	Saanichton	Smithers	Beaverlodge	Fort Vermilion	Sub-Stations
Ag. 216—Development of superior strains of turf grasses for semi-arid conditions															x															
Ag. 296—Forage Plants for alkali soils															x															
Ag. 307—A study of plants in relation to soil erosion control															x			x												
Ag. 308—Spaced rows vs. close drilled rows of forage crops for hay, pasture and seed production																		x												
Ag. 400—A comparison of various species, varieties and strains of forage crops													x (Mel.)																	
RANGE INVESTIGATIONS																														
Ag. 500—A taxonomic study of the native flora of the ranching areas of Saskatchewan, Alberta and British Columbia																		x			x									
Ag. 501—A study of the growth developments of the principal native species																		x			x		x							
Ag. 502—An ecological investigation dealing with plant succession, classification of vegetative areas, and the influence of soil types on the distribution of species																		x			x		x							

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Ag. 503—The effects of various systems of grazing on the vegetative cover of range pastures																		x			x									
Ag. 504—The revegetation of range lands, including depleted range pastures, abandoned fields, saline soils, and eroded areas such as badlands, burn-outs, etc.																		x			x		x							
Ag. 505—The improvement of pastures by means of surface cultivation, the application of fertilizers and the eradication of weeds and poisonous plants																		x			x									
Ag. 506—The productiveness and carrying capacity of range pastures																		x			x									
Ag. 507—A study of the management of mixed cultivated and native grasslands on community pastures																		x												
Ag. 508—A grazing and land-use survey of P.F.R.A. community pastures, ranches, and other grazing regions in range areas of Western Canada																		x												
Ag. 509(A-975)—The nutritive value of range grasses																					x									

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