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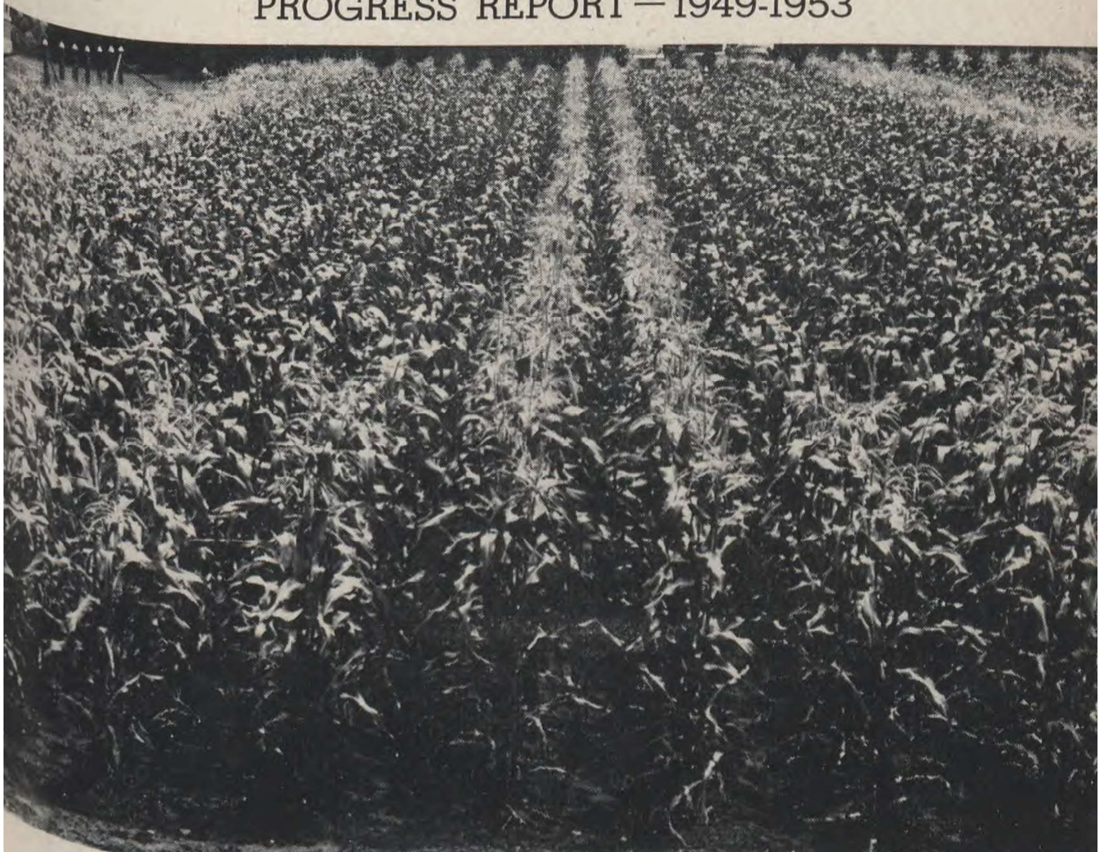
DEPARTMENT OF AGRICULTURE
EXPERIMENTAL FARMS SERVICE

FORAGE CROPS DIVISION
CENTRAL EXPERIMENTAL FARM
OTTAWA, ONT.

T. M. STEVENSON, B.S.A., M.Sc., Ph.D., Chief

PROGRESS REPORT—1949-1953



Final stage in the production of a Canbred strain of hybrid corn developed at Ottawa.

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INTRODUCTION

(This report covers the period 1949 to 1953 inclusive. The previous report of the Forage Crops Division, covering the years 1937-1948, was published in 1949.)

Personnel.—The personnel of the Division as of June, 1954, is listed on the inside cover page. There have been a few changes in the past five years. Dr. F.S. Warren, who joined the staff in June, 1949, as assistant in corn, soybeans and sugar beet breeding, was transferred to the Experimental Farm at Nappan, N.S., in July, 1953, to take charge of forage work. J. Witrofsky was assistant in pasture investigations from June, 1948 to Sept. 1950. L.S. Donovan, who joined the staff as assistant in pasture investigations in June, 1951, was transferred to the position of assistant, corn, soybean and sugar beet investigations in May, 1954. L.P. Folkins, formerly with the New Brunswick Department of Agriculture, replaced L.S. Donovan as assistant in pasture investigations in June, 1954.

Program.—A varied experimental program is conducted by the Forage Crops Division. The investigations are related to the improvement of all hay and pasture species of grasses and legumes and to corn, soybeans, sugar beets and field roots. Research is conducted in genetics, cytology, plant physiology and plant pathology to obtain fundamental information for the plant breeder. Additional experimentation includes the testing of species, varieties and strains in hay and pasture trials,—methods of seed production and multiplication and various phases of turf grass research.

As a result improved varieties of many forage species are now available to the farmer. This, in conjunction with an active program in hay and pasture investigations, has resulted in a pronounced improvement in hay and pasture management and utilization in Canada. The breeding of earlier and better-adapted varieties of soybeans and corn hybrids has produced a considerable increase in the acreage and yield of these crops.

This report merely summarizes this work. The reader is referred to the list of publications on page 58-59 where more complete information is desired. This report however does include more complete details on certain projects which may not be published elsewhere.

In the last Progress Report (1937-48), the investigations of the Forage Crops Division, Ottawa, and the Dominion Forage Crops Laboratory, Saskatoon, were published jointly. The present reports are published separately.

CORN INVESTIGATIONS

F. Dimmock

Breeding

The main objectives of the corn breeding program are to develop hybrids characterized by early maturity, high yield and good quality grain and adapted for production in areas with a short growing season as in eastern Ontario and western Quebec. Attention is also given to selection for resistance to such diseases as rusts and smuts and more recently to stalk rots. In certain seasons stalk rots are responsible for considerable stalk breakage late in the season, causing difficulty and loss in harvesting.

A number of good inbreds have been isolated in recent years as the result of selfing within selected varieties, including both flints and dents, and through the second cycle breeding of some of the better commercial hybrids, chosen on the basis of their performance in test trials. Most of these inbreds have been included in top-cross tests, using the variety Minnesota No. 13 as the tester. Those that have shown superior performance have been grouped and crossed in all combinations and the single crosses tested to study combining ability. The data from single-cross tests have been used to predict double-cross performance and the superior double crosses have been made and included in performance trials.

As the result of this work four experimental hybrids have been released for production:

Canbred 210 released Feb. 5, 1951
Canbred 220 released Jan. 5, 1951
Canbred 230 released July 25, 1950
Canbred 260 released Sept. 9, 1953

These are now being produced commercially under the names Warwick 210, Northern 22, Pioneer 396 and Warwick 260 respectively and are being grown in eastern Ontario with good yields. Their introduction and use has greatly extended the area in which grain corn can be successfully and profitably grown.

Additional experimental hybrids are constantly undergoing test and it is fully expected that hybrids superior to those already released will soon be made available.

Since 1950 a study has been made of male sterility in corn. Seed of five cytoplasmic male-sterile, single-cross hybrids was obtained from Dr. D. F. Jones, New Haven, Conn. and this character has been transferred to two inbreds, 103 and 106, by a series of backcrosses. These two lines are now in the male-sterile condition and it is intended to transfer the male-sterile character to a number of other inbreds.

The use of male sterility in commercial seed production is probably the greatest advance in corn breeding since the introduction of hybrid corn itself. Its potential value to the seed producer is tremendous, as it will permit the growing of hybrid seed without the costly operation of detasselling. It is already in use by a number of commercial seed producers. There is every reason to believe from experiments conducted so far that male-sterile hybrids will yield slightly higher than their fertile counterparts.

All the hybrids released for commercial production up to the present have been combinations of either flint × dent or dent × dent lines. No hybrids consisting entirely of flint lines have been released although a number of experimental flint hybrids have been made and tested. While the performance of some of these in experimental trials has been fairly satisfactory, none has been quite good enough to warrant release for commercial use. During the past three or four years several flint varieties have been obtained from European sources and some promising new inbreds have been isolated from this material. It is hoped the use of these lines will result in hybrids that will combine early maturity and high yielding ability so they may prove useful in areas where the season is too short to grow hybrids now available.

Some preliminary studies on cold resistance have indicated that the germination of seed of inbreds may vary considerably in response to low temperature conditions, as it affects germination. These studies are still in progress.

Comparative Study of Varieties

Hybrids for grain.—A comparative test of commercial hybrids for grain production has been conducted each year. From 1949 to 1953, 75 early maturing hybrids from nine different commercial sources have been tested, the number varying from 12 to 18 in each of the five years. Of the 75 hybrids, 24 have been tested for one year, 14 for two years, five for three years and two for four years. With few exceptions, the same hybrids were seldom submitted for testing in consecutive years so it is not possible to present satisfactory summary data covering more than a single year. The data for the 1952 test are shown in Table 1.

The data presented in Table 1 are typical of those obtained in each of the five years. The same three check hybrids, Wisconsin 240, Wisconsin 275 and Wisconsin 355, have been used continuously to provide a basis for comparing data secured in the different years.

Based on the data obtained from tests of a reliable nature, hybrids are evaluated for yield of grain, maturity, resistance to lodging and disease and ease of harvesting (including the easy removal of husks). Some attention is given to chemical composition of the grain, particularly the protein, oil and N.F.E. fractions.

As the result of the tests conducted from 1949 to 1953 the following commercial hybrids have been recommended for grain production in this area: Funks G25, Warwick 210, Pioneer 396, Northern 22, Funks G8, DeKalb 43, Pfister 28, Warwick 260, Funks G11, Pfister 33 and Pioneer 388. The hybrids are listed in order of earliness, Funks G25 being the earliest and Pioneer 388 the latest maturing. The differences in maturity are not marked, however, particularly between the seven listed first.

Hybrids for silage.—Forty-eight commercial hybrids were tested for silage production from 1949 to 1953. These came from nine different sources and not more than 11 were tested in any year. Of the 48 hybrids, 22 were tested for one year, 10 for two years and two for three years. As the hybrids tested for more than one year were not always included in the same tests it is not possible to present a satisfactory summary of data covering a period of two or more years. The type of data obtained is shown in Table 2 which presents the results of the 1952 test.

TABLE 1.—COMPARATIVE TEST OF COMMERCIAL CORN HYBRIDS FOR GRAIN PRODUCTION. OTTAWA, 1952.

Date Planted May 28 — Date Harvested, Oct. 17

Hybrid	Plant height	Lodging (stalk breakage)	Maturity; moisture in grain at harvest	Shelling percentage	Shelled corn per acre (15% moisture)	Chemical analysis of grain* (dry-matter basis)				
						Prot.	Fat	Ash	Cr. Fibre	N.F.E.
	in.	0—10	%	%	bus.	%	%	%	%	%
DeKalb 41	88	·6	31·9	81·5	96·31	10·85	5·06	1·76	2·51	79·82
Pioneer 388	93	·2	41·8	83·8	102·65	9·71	4·59	1·70	2·71	81·29
Pfister 33	92	·4	34·6	80·9	115·02	10·31	4·67	1·70	2·70	80·62
Pfister 44	99	·2	44·3	81·2	128·36	10·04	5·25	1·69	2·54	80·48
Pfister 28	88	·6	28·3	83·2	115·29	10·29	5·04	1·65	2·41	80·61
Pfister 8653	90	·5	29·6	83·2	108·15	10·91	4·92	1·64	2·37	80·16
Funks G188	94	·5	34·8	83·3	102·00	11·05	5·19	1·83	2·64	79·29
Funks G25	93	·6	27·2	82·8	93·16	11·51	4·88	1·80	2·52	79·29
Funks 11004	93	·4	34·9	84·4	96·49	11·18	4·80	1·64	2·49	79·89
Pride PN1	84	·6	32·5	82·1	95·82	9·99	5·22	1·76	2·34	80·69
Pride PN1A	88	·5	38·0	82·2	91·06	10·15	5·23	1·76	2·30	80·56
Pride PN4	92	·5	35·8	80·2	102·24	9·77	5·04	1·78	2·30	81·11
Pride B3A	90	·7	31·7	83·7	100·20	9·33	4·86	1·70	2·50	81·61
Jacques 901J	95	·4	42·0	78·1	102·88	10·96	4·48	1·79	2·54	80·23
Wis. 240	83	1·7	23·9	83·3	84·31	11·94	5·23	1·65	2·20	78·98
Wis. 275	84	·5	32·3	83·6	99·99	10·42	4·88	1·62	2·29	80·79
Wis. 355	90	·5	35·8	82·4	101·38	10·47	4·97	1·66	2·42	80·48

* Chemical analysis by the Chemistry Division, Science Service, Ottawa.

TABLE 2.—COMPARATIVE TEST OF COMMERCIAL CORN HYBRIDS FOR SILAGE PRODUCTION, OTTAWA, 1952.

Date Planted May 27

Hybrid	Plant height	Date cut	Total moisture when cut	Yield per acre		Chemical analysis of silage* (dry matter basis)				
				Green	Dry	Prot.	Fat	Ash	Cr. Fibre	N.F.E.
	in.		%	tons	tons	%	%	%	%	%
Pfister 44	92	Sept. 4	76·3	19·61	4·64	8·99	3·06	4·54	18·82	64·59
Pfister 71	91	" 16	71·7	18·16	5·13	8·61	2·76	3·99	18·13	66·51
Pfister 233	99	" 16	74·8	22·39	5·63	7·69	2·01	4·47	22·99	62·84
Pride K300	96	" 4	78·4	21·11	4·55	8·47	1·82	4·66	22·13	62·92
Pride D49	94	" 4	76·2	19·71	4·69	8·03	1·96	4·61	23·14	62·26
Pride Grass silage	86	" 4	74·5	15·27	3·90	8·68	2·18	4·54	21·71	62·89
Funks G30A	102	" 16	73·9	21·85	5·71	8·59	3·07	3·77	17·06	67·51
Funks G77A	104	" 16	73·3	26·06	6·98	7·26	1·42	4·69	26·48	60·15
Harvic 482	106	" 16	76·5	25·50	6·01	7·33	1·58	4·80	25·53	60·76
Warwick 800	103	" 16	74·5	23·89	6·08	7·60	1·94	4·29	23·55	62·62
Wis. 531	93	" 4	76·0	18·61	4·47	8·18	2·08	4·83	23·31	61·60
Wis. 606	99	" 16	73·4	18·39	4·88	6·59	1·71	5·11	26·52	60·07
Wis. 641AA	96	" 16	73·0	21·05	5·69	8·01	2·16	3·76	20·23	65·84
Wis. 645	97	" 16	71·5	17·59	5·02	7·21	2·03	4·18	22·57	64·01
Wis. 696	104	" 16	73·2	21·23	5·69	7·29	2·47	3·84	20·87	65·53

* Chemical analysis by the Chemistry Division, Science Service, Ottawa.
Note—No lodging.
No smut.

The same hybrids, Wisconsin 531, Wisconsin 606, Wisconsin 645 and Wisconsin 696, have been used as checks throughout to furnish a basis for the comparison of data obtained in different years.

From the data secured from tests of a reliable nature and comparison with 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 from 1949 to 1954, hybrids Funks G30A, Funks G77A, and Warwick 800 are recommended for silage production in this area. These are additional to hybrids already recommended on the basis of tests conducted in previous years.

Effect of Date of Planting on the Yield and Chemical Composition of Grain Corn

A test was conducted for three years (1950-52) to determine the influence of time of planting on the yield and chemical composition of grain corn, using the hybrid, Warwick 210. Planting was done on five different dates, beginning on the average with May 24, the normal seeding time, and then at weekly intervals, May 31, June 7, June 14 and June 21.

Agronomic data are presented in Table 3, chemical data in Table 4.

TABLE 3.—EFFECT OF DATE OF PLANTING ON YIELD AND OTHER AGRONOMIC CHARACTERS OF CORN. (3-YEAR AVERAGES).

Date planted	Plant height	Tasselling date	Stalk breakage	Maturity	Shelling	Yield per acre 15% moisture
	in.		%	*	%	bus.
1. May 24.....	83	23/7	10	28·7	84·6	77·6
2. May 31.....	82	28/7	4	30·6	83·4	73·1
3. June 7......	85	1/8	5	35·7	83·9	73·8
4. June 14.....	86	4/8	1	39·9	81·7	64·6
5. June 21.....	88	7/8	1	48·3	77·8	43·6

* % moisture in grain at harvest.

TABLE 4.—EFFECT OF DATE OF PLANTING ON THE CHEMICAL COMPOSITION OF GRAIN CORN*. (3-YEAR AVERAGES).

Date planted	Chemical composition* (dry matter basis)				
	Protein	Fat	Ash	Crude Fibre	N.F.E.
	%	%	%	%	%
1. May 24.......	11·67	4·04	1·49	2·19	80·6
2. May 31.......	11·68	4·26	1·61	2·25	80·2
3. June 7........	11·43	4·08	1·63	2·25	80·6
4. June 14.......	11·75	3·45	1·70	2·47	80·6
5. June 21.......	12·37	3·37	2·06	2·83	79·4

* Chemical analysis by the Chemistry Division, Science Service, Ottawa.

The data show clearly the advantage of timely planting of corn. The first three plantings produced high yields of well-matured grain. Stalk breakage was higher than in the last two plantings, but not high enough to be serious.

Tasselling dates narrowed considerably in relation to planting dates, but this is common.

Chemical analysis of the grain showed that protein, ash and crude fibre tended to increase with delayed planting but the fat content decreased. The percentage N.F.E. was not greatly influenced by the planting date.

Effect of Rate of Planting on the Yield and Chemical Composition of Grain Corn

In the growing of ear corn, the rate of planting is one of the important factors affecting both yield and quality of the grain. A three-year test (1950-52) at Ottawa has compared corn planted with the plants in the rows spaced 6,9,12,15 and 18 inches apart, in rows three feet apart. At these five planting rates the number of plants per acre amount to 29,040, 19,360, 14,520, 11,616, and 9680 respectively. The hybrid, Warwick 210, was used for these tests.

The average date of planting the tests was May 22, while harvesting was done early in October. Pertinent data are presented in Table 5.

TABLE 5.—YIELD, KERNEL WEIGHT AND CHEMICAL COMPOSITION OF GRAIN CORN PLANTED AT DIFFERENT RATES. (3-YEAR AVERAGES).

Planting rate	Yield per acre (15% moisture	1000 kernel weight	Chemical analysis*(dry matter basis)				
			Protein	Fat	Ash	Crude fibre	N.F.E.
	bus.	g.	%	%	%	%	%
6″ spacing......	102·1	248	10·3	4·02	1·51	2·21	82·0
9″ spacing......	100·8	290	11·0	4·18	1·55	2·26	81·0
12″ spacing......	86·1	295	11·4	4·19	1·54	2·20	80·7
15″ spacing......	78·2	296	11·8	4·44	1·63	2·30	79·8
18″ spacing......	67·1	314	11·9	4·46	1·65	2·34	79·6

* Chemical analysis by the Chemistry Division, Science Service.

The six- and nine-inch planting rates yielded significantly higher than the wider spacings. The grain from the six-inch planting was decidedly smaller than grain from all other spacings, lowest in protein, fat, ash and crude fibre content, and highest in percentage of N.F.E. As the spacing between the plants in the rows increased, the yields showed a corresponding decrease but the grain increased in size and contained increasing percentages of all the chemical constituents except N.F.E. In general, therefore, closer spacing increased the yield but lowered the quality of the grain.

The rate of planting usually recommended for practical purposes in this area is nine- to twelve-inch spacing between the individual plants in the rows, giving a total population of about 16,000 to 18,000 plants per acre. At this rate, the data indicate the yield will be maintained at a high level while the size and quality of the grain will be satisfactory. Obviously any decision concerning the optimum plant population must take into consideration the fertility of the soil on which the crop is to be grown. The results of this experiment, however, clearly indicate that increasing the spacing of the plants more than 12 inches greatly reduces the yield of grain and cannot be recommended.

A Comparison of Moisture Determination Methods for Grain Corn

Rapid and accurate moisture determination is essential in experimental work with corn for effectively comparing grain yields from performance trials.

Three methods for determining moisture in corn are commonly used in Canada: first the Brown-Duvel oil distillation method in which the moisture in a weighed quantity of grain is vaporized by heating in oil, the vapor condensed and measured in a graduate cylinder; second, the Electrical Tester* method in which the moisture is indicated by the change in capacitance of a condenser when grain becomes the dielectric; and third, the Ear Shrinkage method in which the moisture is calculated from the weight of the ear after a period of drying. The comparative reliability of these methods has been under investigation for four years (1949 to 1952), using 122 samples of grain ranging in moisture content from 21.6 to 44.2 per cent.

The Brown-Duvel is one of the official methods of testing the moisture content of corn. In accuracy it compares closely to the vacuum oven. However, it is not readily adaptable to experimental work with large numbers of samples during the relatively short harvesting period.

The Electrical Tester provides a rapid estimate of the moisture present in the grain. In these investigations, approximately 70 per cent of the Electrical Tester readings differed by less than one per cent of moisture from the corresponding Brown-Duvel results. This method was considered sufficiently accurate for comparing corn yields on general experimental work.

Ear Shrinkage moisture determinations averaged more than 10 per cent higher than the corresponding Brown-Duvel readings, probably due to the influence of the moisture in the cob which cannot be dissociated from the moisture of the grain. The Ear Shrinkage method was somewhat less reliable than the Electrical Tester. While Ear Shrinkage determinations may be made at any time, this factor would not offset reduced accurary.

It was concluded that for experimental work with corn the Electrical Moisture Tester was sufficiently reliable and much more rapid than the Brown-Duvel. The Ear Shrinkage method is convenient, but less accurate than either of the others.

Comparison of Agronomic Characters in Reciprocal Crosses of Flint and Dent Single Crosses

In the production of double-cross hybrids between flint and dent single crosses the question is frequently asked, which way should the cross be made? Theoretically there should be no difference in performance, whether the double cross is produced from using either the flint or dent single cross as the female or seed parent.

Eight double-cross hybrids were produced by crossing flint single crosses and dent single crosses both ways, using both the flint and dent single crosses as male and female parents. Tests were conducted in 1951 and 1952 and the data for the two years are summarized in Table 5.

As the data show, the mode of combination of the two types of single crosses produced no important differences in the performance of the double crosses. Similar results could be expected by making the double cross either way. There is an advantage, however, in using the dent single cross as the female parent from the seed production standpoint. By doing this, approximately 50 per cent more seed was obtained than by using the flint as the female parent, and the seed was much better from the standpoint of grading.

* The Steinlite Electrical Moisture Tester, Serial No. 7748, Type S, was used in these investigations.

TABLE 5.—COMPARISON OF FLINT SINGLE CROSS AND DENT SINGLE CROSS AS PARENTS OF THE DOUBLE-CROSS HYBRID (SUMMARY 2 YEARS, 1951–52)

Hybrid	Plant height	Tasselling date	Stalk breakage	Ears per hill	Maturity	Shelling	Yield per acre (15% moisture)
	in.		%		*	%	bus.
Flint × *Dent*							
(42 x 62) (179 x 221)	77	July 22	40·0	3·7	24·7	83·2	79·4
(226 x 39) (179 x 190)	86	" 25	11·0	3·7	25·4	84·4	83·4
(32 x 226) (190 x 221)	79	" 22	19·0	3·4	25·5	86·1	76·1
(226 x 42) (179 x 221)	80	" 23	19·0	3·5	25·4	85·6	77·9
Dent × *Flint*							
(179 x 221) (42 x 62)	79	July 23	36·0	3·7	23·1	82·2	78·2
(179 x 190) (226 x 39)	83	" 24	9·0	3·8	26·9	84·4	84·5
(190 x 221) (32 x 226)	83	" 22	11·0	3·6	27·5	86·2	79·0
(179 x 221) (226 x 42)	79	" 22	21·0	3·8	22·8	84·4	80·7

* % moisture in grain at harvest.

SOYBEAN INVESTIGATIONS

F. Dimmock

Breeding

The soybean has become an important field crop in Canada, although production is limited almost entirely to Ontario. The soybean crop area increased from 103,800 acres in 1949 to 216,000 acres in 1953, while production increased from 2,605,000 to 4,400,000 bushels during the same period. The 1953 crop, valued at about $12,000,000, amounted to somewhat less than 50 per cent of the total consumption of soybeans and soybean products in Canada. Crushings totalled 8,600,000 bushels, from which 91,000,000 pounds of oil and 207,000 tons of meal were produced.

The soybean breeding program has as its main objective the development of improved varieties adapted for production in areas of short season. In addition to satisfactory maturity, the breeding work has sought to incorporate in new varieties such desirable characteristics as high yielding ability, good plant type, resistance to lodging and disease, non-shattering of seed, yellow seed color and high quality of seed, particularly with respect to oil content. The following methods have been used:

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

While the first two methods are important in the breeding program, the third has become the principal source of new varieties. Following hybridization, both the bulk and pedigree methods have been used in subsequent work. In recent years these varieties and strains have been used in the hybridization program: Acme, Comet, Herb 22, 050-11, W6S292, Capital, Mandarin, Hardome and Harosoy. Each year several hundred hybrid progenies are grown in the nursery and their performance is related to that of the Mandarin variety, grown every tenth row as the check.

In 1953, two new varieties, Acme and Comet, were licensed and released for production. Acme is a selection from the variety Pagoda, produced at Ottawa and licensed in 1939. It matures at Ottawa in about 105 days, possesses good plant type and excellent strength of straw, produces yellow seed of high quality and yields well in relation to its early maturity. Comet is a selected progeny from a cross between Pagoda and Mandarin made in 1941. It matures about 10 to 12 days later than Acme but three to five days earlier than Capital and Mandarin.

Comet is a good yielder of high quality yellow seed and possesses excellent plant type and strength of straw. It carries its pods well up above the ground, superior to most varieties in this respect. It is expected that Acme and Comet will prove popular with growers in eastern Ontario and will assist greatly in expanding the acreage devoted to soybeans in this area. It seems likely that Acme may be used in an attempt to establish soybean growing in southern Manitoba.

Among the many new strains developed recently in the breeding program, several have reached the preliminary testing stage. Results so far indicate that some may become worthy of consideration as possible new varieties if they continue to maintain their fine performance in future tests.

Because of the importance of the quality of soybean seed, especially with respect to oil content, seed samples from all strains included in the breeding nursery are submitted for chemical analysis each year. These analyses have been limited to the determination of protein and oil percentages and the iodine number of the oil.

Comparative Study of Varieties

Several new varieties and many of the most promising strains developed in the breeding program at Ottawa and elsewhere have been tested in comparison with the well-known standard varieties: Kabott, Capital and Mandarin. The data obtained from these tests are summarized in Table 6.

TABLE 6.—SUMMARY OF AGRONOMIC AND CHEMICAL DATA OBTAINED FROM COMPARATIVE TESTS OF VARIETIES AND STRAINS FOR 3 YEARS

Variety or strain	Height	Days to maturity	Lodging	Yield per acre, 14% moisture	Seed analysis		
					Protein	Oil	Iodine No.
	in.		0–5	bus.	%	%	
a) Early maturing (tests 1950-52-53)							
Mandarin x Pagoda 1·2·1	23	115	1·0	28·6	43·1	19·6	135
Pagoda 30	24	115	0·5	28·8	41·4	19·3	130
Pagoda 46	22	115	0·5	28·9	42·0	18·8	131
Nutter 3·14·6	22	114	0·5	28·8	42·4	18·9	132
Acme	23	115	0·5	30·9	41·4	19·2	130
Flambeau	28	120	2·5	35·2	43·3	18·1	132
Kabott	25	119	2·0	31·7	44·8	17·6	133
b) Medium maturing (tests 1951-52-53)							
W6S292	32	134	2·0	38·9	40·4	19·5	138
W8S1460	30	130	0·5	34·0	41·2	19·4	136
Renville	33	137	0·5	35·6	39·6	20·3	138
Comet	33	129	0·5	33·9	40·9	19·2	135
Flambeau	30	129	2·5	33·6	41·8	18·6	135
Mandarin	29	133	0·5	35·7	41·5	18·9	132
Capital	34	133	2·0	37·2	39·0	19·0	138

The data in both tests indicate a close association between yield and maturity. While all varieties and strains are capable of producing good yields, where the later-maturing varieties can be grown they may be expected to yield more than the earlier varieties.

Among the earliest maturing varieties Acme proved superior to all others from the standpoint of yield and the oil content of its seed is highly satisfactory. Flambeau is later in maturity and yielded high but the percentage of oil in the seed tends to be low. It is rather susceptible to lodging.

Among the medium-maturing varieties, W6S292, Renville and Capital yielded the highest and produced high-quality seed. Comet and Flambeau were earliest in maturity and yielded well, but the seed of Flambeau was again low in oil content. W6S292 and W8S1460 were developed at the Wisconsin Agricultural Experiment Station, and are to be named and released as new varieties.

On the basis of these tests varieties recommended for the Ottawa district and areas with similar climatic conditions are Acme, Comet, Flambeau, Capital and Mandarin.

Effect of Date of Planting on the Yield and Quality of Soybean Seed

The varieties Capital and Mandarin were used in this study. Capital is slightly earlier maturing than Mandarin, yields somewhat higher and the seed is higher in oil content. Both are regarded as full-season varieties at Ottawa.

The experiment with Capital was begun in 1950, with Mandarin in 1951. Five plantings were made of each variety each year, with four replications of each planting. Plots consisted of three rows, 30 inches apart and 20 feet long, with only the centre row harvested for yield and other data. Beginning with the first planting at the normal time of seeding, subsequent plantings were made at weekly intervals, the fifth planting being seeded four weeks later than the first. All seeding was done by hand. Two seeds were dropped every three inches in the rows and the stand was thinned to a single plant every three inches shortly after emergence.

Plots were harvested and threshed in a single day, about mid-October each year, after frost prevented further growth. At that time the first, second and third plantings appeared to be well matured, while the fourth and fifth plantings showed evidences of immaturity. Seed yields were calculated to 14 per cent moisture basis. A composite sample of seed, obtained from the four replicates of each of the five plantings, was used for chemical analysis, which included the percentages of protein and oil and the iodine number of the oil. All chemical analyses were determined on a moisture-free basis. The data for both varieties are summarized in Table 7.

TABLE 7.—AVERAGE YIELD AND CHEMICAL COMPOSITION OF SEED OF CAPITAL AND MANDARIN FROM FIVE PLANTINGS

Average planting date	Yield per acre, 14% moisture	1000 seeds weight	Chemical composition*		
			Protein	Oil	Iodine No.
	bus.	gm.	%	%	
		Capital (3 years, 1950-52)			
May 19	41·5	140	38·9	19·8	137
May 26	37·8	135	38·9	19·3	138
June 2	34·5	138	40·6	18·4	138
June 9	28·8	130	40·9	17·2	140
June 16	21·6	129	41·6	17·2	140
		Mandarin (2 years, 1951-52)			
May 19	38·4	207	40·6	19·4	133
May 26	34·5	202	42·2	18·4	134
June 2	32·3	202	42·8	18·6	134
June 9	27·1	196	42·3	18·2	136
June 16	16·2	184	42·3	18·0	138

*Chemical analysis by the Chemistry Division, Science Service, Ottawa.

The data presented in Table 7 show that delayed planting had a definite influence on the yield and composition of soybean seed. For each delay there was a corresponding reduction in the yield and the percentage oil content of the beans. Delaying the planting time from May 19 to June 16, a difference of four weeks, reduced the yield of both varieties approximately 50 per cent and reduced the content of oil 2.6 per cent in the case of Capital and 1.4 per cent in the case of Mandarin. In 1950 and 1951 the effects of delayed planting were much more marked than in 1952 when temperatures were somewhat warmer than average. The effects of delayed planting, therefore, may be expected to be more severe in years when seasonal conditions tend to be cooler than average.

Such a season was experienced in 1951. In that year the fifth planting of Capital yielded 49 per cent of normal, while the oil content of the seed dropped from 21.1 to 17.1 per cent, a difference of four per cent.

The environmental effects resulting from late planting were responsible for reducing Capital from a normally high-yielding, high-oil-content variety to a low-yielding low-oil-content variety. The yield of Mandarin was even more seriously affected by the late planting in the same season. It was reduced to 28 per cent of normal, while the oil content dropped from 18.7 to 16.6 per cent. Reductions of such magnitude could be of serious consequence to both the grower and the processor.

The success of the plant breeder in developing high-yielding, high-oil-content varieties may be completely nullified by environmental effects brought about by delayed planting. Complete physiological maturity seems to be essential for the highest expression of the two important characteristics: high yield and high oil content.

Delayed planting tended to increase the protein and the iodine number of the oil. Usually the protein and oil content of soybeans show an inverse relationship, so any decrease in oil content resulting from delayed planting would be expected to be accompanied by an increase in the percentage of protein.

Reduction in yield was not accompanied by a corresponding reduction in the 1000-seeds weight. This is illustrated by the data and was true of both varieties. Seed of almost equal size was harvested from all plantings. Thus yield losses due to late planting resulted from a reduction in podding and consequently the number of seeds produced rather than from a reduction in seed size.

While this experiment was limited in its scope, the results were sufficiently consistent to conclude that the planting of soybeans at or near the normal date of seeding will give the best results from the standpoint of yield and composition of the seed, particularly with respect to oil content.

Effect of Rate of Planting on the Yield and Composition of Soybean Seed

A rate-of-planting test has been conducted for two years. A single variety, Mandarin, was selected for this test because of its excellent strength of straw. Preliminary tests indicated that certain other varieties were unsuitable for a test of this nature because at the closer spacings lodging was heavy and the plots difficult to harvest.

Planting was done at the following row widths: 7, 14, 21, 28 and 35 inches. In each row width, plants were thinned to one, two or three inches apart. Thus there were three rates of thinning at each row width and each of these was replicated four times. Each plot comprised three rows of which only the centre row was harvested for yield and other data.

Seasonal conditions were entirely different during the two years of the test. The season of 1952 was extremely favorable with an abundance of moisture at all times and almost ideal temperatures. In contrast, 1953 was a season of prolonged hot, dry weather during July and August. These differences produced quite different results. Under the ideal conditions of 1952, the closer spacings yielded the highest, while the unfavorable conditions of 1953 resulted in the wider spacings producing the highest yields. In 1952, lodging was severe in all the 7-, 14- and 21-inch row plots, irrespective of the thinning rates. In 1953 no lodging occurred at any of the planting rates but growth was much shorter than in the previous year.

Neither the season nor the rates of planting showed any marked effects upon the protein or oil content of the seed but the iodine number of the oil was considerably lower for all planting rates in 1953 than in 1952, the average being 122 as compared with 134.

This test will be continued. No definite conclusions can be drawn from the data obtained so far.

GRASS BREEDING INVESTIGATIONS

R. M. MacVicar and W. R. Childers

An active breeding program is being conducted by the Division. During the past few years interest has been centered on reed canary grass, red fescue, meadow fescue, tall fescue, perennial rye grass, timothy, brome and orchard grass with primary emphasis on the development of strains of superior agronomic value. Considerable time has also been devoted to the development of techniques and the assessment of material for disease resistance.

Plant Selection

Reed Canary Grass (*Phalaris arundinacea* L.)—The value of this species for wet locations is well known. Only recently has there been a growing appreciation of its virtues for certain upland conditions. It is a growthy, persistant and relatively drought-resistant grass that can be utilized for both hay and pasture.

Emphasis has been placed on the selection of a leafy, late-maturing strain with a restricted creeping habit. At the present time three high-yielding, synthetic strains originating from the breeding program are under final test. There is reason to believe that one of these strains will prove to have sufficient merit to justify its release as a new variety.

Meadow Fescue (*Festuca elatior* L.)—This grass is now of considerable economic importance in Canada and a sizable amount of seed is produced and utilized in hay and pasture mixtures. Available varieties such as Mefon, Ensign and S215 seem to be fairly adequate from a production standpoint having in mind its role in the hay and pasture sward. However these varieties, and indeed the whole species, is highly susceptible to crown rust (*Puccinia coronata* (Pers.) Cda. It is felt that the incidence of this disease in midsummer has an effect on the palatability of the grass. Because of this, even though it has widespread utilization in other countries, meadow fescue is frequently discriminated against in Canada.

The search for plants with some measure of resistance has been diligently pursued. Many thousands of plants have been screened and tested during the past few years. On the whole, results have been disappointing. It appears that the species has little or no resistance to crown rust.

At the present time seven plants which offer promise of carrying some resistance have been isolated. If, after prolonged testing, these selections maintain their indicated measure of resistance a start will have been made on the development of a new strain.

Tall Fescue (*Festuca elatior* var. *arundinacea* Schreb. Wimm.).—This species has not been widely utilized in Canada and its value not fully assessed. A limited selection program has been undertaken with the objective of developing a leafy, persistant strain offering a promise of greater palatability. At the present time one synthetic strain has been brought to the initial testing stage.

Red Fescue (*Festuca rubra* L.).—Emphasis in the red fescue breeding program has been directed to the development of a desirable turf strain. Previous work with emphasis on forage characteristics resulted in the development of three synthetic strains having the merits of increased vegetative growth and rapid

FIGURE 1. **Reed canary grass** breeding nursery. This grass attains a height of more than six feet under favorable conditions and many selections possess desirable agronomic characteristics.

spring growth. Under turf conditions these strains did not prove to be superior to other varieties. Because of this they have been set aside since the species is much more important in Canada as a turf than as a forage species.

At the present time all red fescue plant selections made are cloned and put under actual turf conditions. As a result of this program 12 plants have been isolated which seem to have superior turf-forming ability as well as resistance to the leaf spot disease (*Helminthosporium dictyoides* Drechs.) If these desirable attributes should persist under further testing a good start will have been made in developing a desirable turf strain.

Perennial Rye Grass (*Lolium perenne* L.).—The major effort with this species has been to develop a measure of winter hardiness. The procedure has been the planting of successive large nurseries originating from seed harvested from nurseries that had been subjected to rigorous winter conditions. This program has to date brought about a fair measure of improvement in hardiness as indicated in Table 8.

It is hoped that after two or three more generations of selection the material will possess sufficient hardiness so that selection for other desirable agronomic characters can begin.

Timothy (*Phleum pratense* L.).—The Climax variety, licenced in 1947, has had widespread acceptance in Canada. Because of this, considerable emphasis has been placed on incorporating into the variety greater resistance to brown stripe (*Scolecotrichum graminis* Fckl.) The timothy species is generally susceptible to brown stripe and Climax is not an exception. Brown stripe does not attack until timothy is well on toward maturity.

TABLE 8.—PERCENTAGE WINTER SURVIVAL OF TWELVE PERENNIAL RYE GRASS STRAINS AT OTTAWA, LENNOXVILLE AND FREDERICTON

Variety	Winter survival in per cent		
	Ottawa	Lennoxville	Fredericton
Ottawa selection (2nd generation)	33	99	50
Ottawa selection (3rd generation)	53	100	60
Ottawa selection (4th generation)	51	100	60
Pacific	20	99	25
Peron	12	95	35
S23	0	26	1
S101	0	17	1
Hawkes Bay	0	12	0
Vic Gin	0	10	2
S24	2	7	1
New Zealand	0	6	2
Wimmera	0	0	2

Some plants carrying marked resistance to the disease have been selected. However the incidence of resistant plants is low so many thousands will have to be screened to obtain enough desirable resistant material.

Brome Grass (*Bromus inermis* L.).—Brome grass is a deeply rooted, leafy and palatable species of wide adaptation. Selection work at Ottawa is directed toward the development of a productive, leafy variety, preferably with a restricted creeping habit, that will combine well with legumes such as alfalfa.

As the result of a program of selection three groups have been brought to the stage of testing in an isolated polycross block.

Group 1 is made up of a number of leafy, dense, upright plants with restricted rhizomes. Group 2 contains plants which are extremely leafy and recover rapidly after cutting. Unfortunately plants in this group are poor seed producers so further seed type selection will be necessary. Plants in Group 3 are more of less typical of the species: tall growing, vigorous high-yielding plants with good seed producing qualities.

Progeny tests of this material will be made with a view to testing the yielding ability of the individual clones. If this test is satisfactory the best clones may be combined to form a synthetic strain.

Orchard Grass (*Dactylis glomerata* L.).—This species is now an important component of hay and pasture mixtures in Eastern Canada and British Columbia. It has the ability to make rapid spring growth and recover quickly following mowing or grazing. Under proper management the coarseness and unpalatability that results from its early maturity can be largely overcome. Its primary weakness under local conditions is lack of complete winter hardiness.

In the breeding program at Ottawa there are three main objectives: the development of strains possessing (1) winter hardiness (2) leafiness and good seed producing capacity and (3) disease resistance.

The possibilities of making progress in the selection of a winter-hardy variety have been demonstrated by tests involving the Ottawa variety Hercules, selected for its hardiness, and varieties from European and Pacific sources. In one test during the winter of 1949-50, Hercules showed a winter survival of 91 per cent while the average of nine foreign-bred strains was approximately 50 per cent.

Foliar diseases such as *Rhynchosporium Secalis* (Oud.) and *Scolecotrichum graminis* Fckl. attack orchard grass in midsummer seriously affecting yield and palatability. Progress has been made in the selection of leafy, late-flowering types possessing some resistance to these diseases. A number of promising clones have been selected and polycross blocks established which offer promise in the development of a new synthetic variety.

Techniques in Grass Breeding

Selection for Protein Content.—Consideration is being given to selecting varieties of grasses with higher protein content. It is apparent that even a small increase of this nature would be of considerable economic importance.

The problem has been to determine the variability that exists between plants and strains as to protein content and to work out a satisfactory technique of measurement.

In 1951, 10 strains of meadow fescue were thoroughly sampled at the heading stage for crude protein content. The results were:

Strain	Mean of 10 observations N×6·25
Ensign	16·17
Bottnia	16·15
Commercial (Suttons)	15·96
S-53	15·71
Late Swedish	14·98
U.S.D.A.	14·52
Sturdy	14·36
Danish	13·97
Hungarian	13·41
Japanese	13·23
Mean	14·84
L.S.D. at 5%	1·12

Some of these strains gave significantly higher protein values than others and the individual plant protein values varied widely suggesting a good possibility for the selection of high protein lines.

The determination of the stage at which sampling of plants can be done to have a satisfactory comparative basis for selection for protein content poses a difficult problem. To obtain information that will aid in its solution, sampling has been done at various stages of plant maturity. Indications are that the stage of maturity most likely to give reliable comparative results are those that are clearly defined such as the blooming and mature seed stages. Further investigations are proceeding.

Techniques of Breeding for Disease Resistance.—The development of strains carrying resistance to disease is a primary objective in the grass breeding program. Unfortunately the creation of satisfactory artificial epiphytotics to facilitate this work is difficult. However some progress has been made with two common diseases.

The leaf spot disease of the fescues (*Helminthosporium dictyoides* Drechs.) was isolated and cultured in the laboratory. Sporulation was brought about by exposing the culture to ultraviolet rays. A satisfactory suspension was obtained by mixing the culture with sterile water in a blender. When this suspension was sprayed on plant material in a moisture chamber characteristic brown lesions occurred. In subsequent trials this method proved reliable and is being used for the screening of selected plant material.

In timothy, brown stripe, incited by *Scolecotrichum graminis* Fckl. occurs in the field each year in epiphytotic proportions. Somewhat similar conditions were obtained in the greenhouse by interspersing 70 heavily infected timothy plants among a group of nine-week-old seedlings. One month after the placement of these infected plants considerable blight occurred and three weeks later a majority of the seedlings showed symptoms of brown stripe. In all, only seven plants out of a total of 1788 showed a degree of resistance. This technique has been adopted to aid in the selection of lines resistant to the brown stripe disease.

TRITICUM-AGROPYRON HYBRIDIZATION

H. A. McLennan

The Triticum-Agropyron breeding program which has as its objective the production of a large-seeded, drought-resistant, perennial forage grass has been continuing on a somewhat reduced scale. Work is confined mainly to selection within advanced generations of lines still segregating for important characters. The main problem in selection has been to maintain hardy, perennial material so less attention has been given to such characters as fertility, seed size, and forage quality.

Hybrid lines grown at Ottawa have been of three distinct types: (1) lines which were the result of straight selection from partially fertile F_1 hybrids of wheat × *A. elongatum* and in which the major problem at first was to increase fertility and seed size; (2) lines produced by back-crossing sterile F_1 hybrids of either *A. elongatum* or *A. intermedium* with the wheat parent; (3) amphidiploid lines or lines resulting from the doubling of the chromosomes of sterile F_1 hybrids of wheat × *A. intermedium*. Lines of the first two types were eliminated completely between the fifth and ninth generation due to lack of hardiness or loss of the perennial character. Many were highly fertile biennials with large seed-size, reasonably stable for most characters. The only lines which still show some promise after eight to nine generations are the amphidiploids.

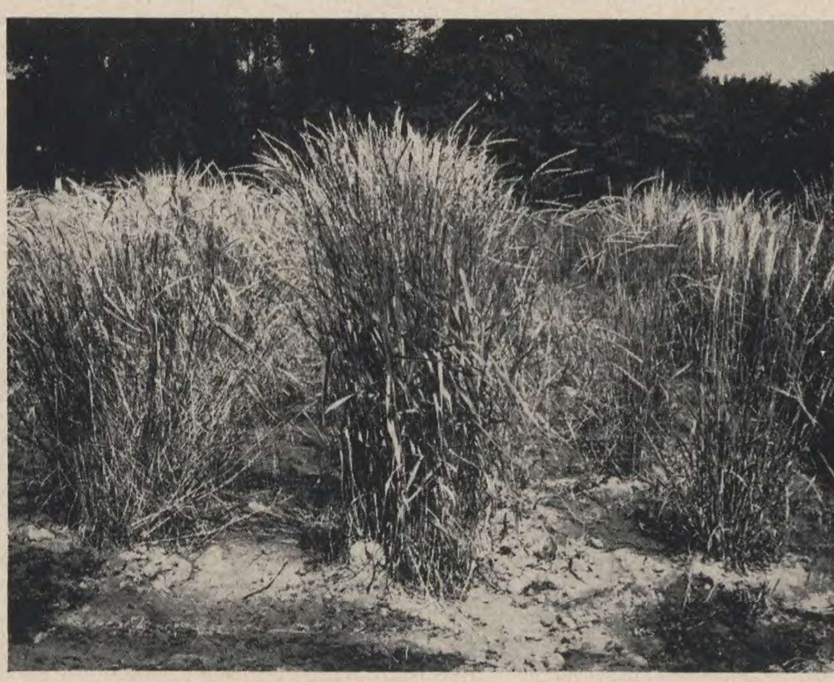

FIGURE 2. **Triticum-Agropyron** lines in breeding nursery. The amphidiploid material is subjected to line selection. This picture illustrates the difference in three sister lines. The line in the centre is leafy, upright and desirable. The one to the right was badly winter-killed while the one at left lacks strength of straw.

Amphidiploid lines from which selections are being made trace to three F_1 plants, S91 (*T. dicoccum* × *A. intermedium*), S107 (*T. turgidum* × *A. intermedium*) and S147 (*T. vulgare* × *A. intermedium*). All are segregating a much higher percentage of annual types than in early generations. From cytological examination it is known that lines from S91 and S107 have lost approximately 10 chromosomes from an original 70 and that S147 has lost approximately 24 from an original 84. It is apparent that the perennial character is lost with the loss of certain chromosomes. Success in this breeding program requires the location of cytologically stable lines which still possess the perennial character and up to the present none of the perennial lines has shown much stability.

LEGUME BREEDING INVESTIGATIONS

H. A. McLennan

Alfalfa Breeding.—Since alfalfa is one of the most important species for hay and pasture in Ontario, it is important that every effort be made to develop new improved varieties to meet the problems and needs of this area. Breeding efforts at present are being directed along two main lines: (1) development of an improved hay type and (2) production of a creeping-rooted, persistent pasture type.

In the development of an improved hay type the objectives are for higher forage and seed yields, resistance to bacterial wilt and other important diseases and winter-hardiness at least equal to that of Grimm. Since resistance to bacterial wilt disease is one of the major requirements of a new variety and since no facilities for wilt elimination work are available at Ottawa, use is being made of wilt-resistant clonal selections from the Saskatoon Laboratory. By this means considerable time and duplication is saved.

More than 200 such clones have been received and are under observation in clonal rows to determine their merits and suitability for this region. The best will be tested further in progeny tests to determine those most suitable for combining into a variety. Wilt-resistant clones have also been used in many crosses with high seed-setting selections, leaf-spot-resistant plants and leaf-hopper-resistant material in efforts to combine these desirable characters. Much further work will be required before it will be possible to develop a new strain.

In the breeding work to develop a creeping-rooted pasture type, considerable effort was made to locate creeping-rooted plants from *Medicago falcata* and other sources as parent material. After growing progeny rows of creeping-rooted material from the Swift Current station it was decided to use selections from these as a source of the creeping-root habit. Numerous crosses have been made between creeping-rooted selections and plants with other desirable characters including bacterial wilt resistance, high seed-setting and good forage qualities. Breeding and selection will continue in an effort to develop creeping-rooted material with more desirable seed and forage characters before any attempt will be made to synthesize a strain.

Ladino Clover Breeding.—Ladino, or Mammoth white clover, has received much attention in recent years because of its greater productivity than common white or wild white clovers in pastures. While it is not so winter-hardy as these forms of white clover it can be grown successfully in most parts of Eastern Canada where double-cut red clover is grown. There are no Canadian varieties of Ladino at present. Since it crosses readily with other forms of white clover, commercial seed of Ladino may contain a considerable percentage of off-type plants, so one advantage in producing a named variety is that it will ensure a supply of reliable seed. The main objectives in the breeding program of Ladino clover are improved winter-hardiness, disease resistance, increased forage yield and improved seeding habits.

Breeding methods used with Ladino clover are maternal line selection and controlled intercrossing. Neither has been entirely satisfactory. With the maternal line method it has been impossible to get satisfactory isolation from wild white and common white clovers in the area and from undesirable plants in the nursery.

With controlled crossing many of the selected plants brought to the greenhouse for crossing have either died or failed to produce many flowering heads. While attempts are being made to increase winter-hardiness, selection for this character is made difficult by the fact that volunteer reseeding makes it impossible to determine the original stand after one crop year. It is therefore of little use to keep a nursery more than two years from the time of planting to check on hardiness and persistence. In spite of the problems of breeding and of selection for hardiness progress is being made in selection for type, height of plant, leaf size, density of leaves and abundance of flowering heads. However much more breeding and selection will be necessary before a variety can be released.

Red Clover Breeding.—Red clover is one of the most important legume species used for hay and pasture in Eastern Canada. Because of this it has been given considerable attention in the breeding program for a number of years. As a result of early selection work the Ottawa double-cut variety was licensed in 1936 and has been maintained and improved by mass selection and by strain-building methods. In 1952 it was decided by the committee administering the Canadian Forage Seed Project to make a composite of the Ottawa and Dollard varieties and call the new variety Lasalle. The original varieties will continue to be improved and foundation stock produced for the blend.

The main red clover breeding program since 1948 has been concerned with the production of a variety of double-cut red clover resistant to crown-rot disease caused by *Sclerotinia trifoliorum* Eriks. This disease is responsible for considerable reduction in stand in years when weather favors development of the disease and particularly on land which is repeatedly sown to legumes.

Methods used in this breeding program have been to screen out resistant plants by creating epidemics on three-month-old seedling plants. The resistant survivors are crossed and seedling progenies are reinoculated with the disease organism. By repeating this process it is hoped to build up resistance.

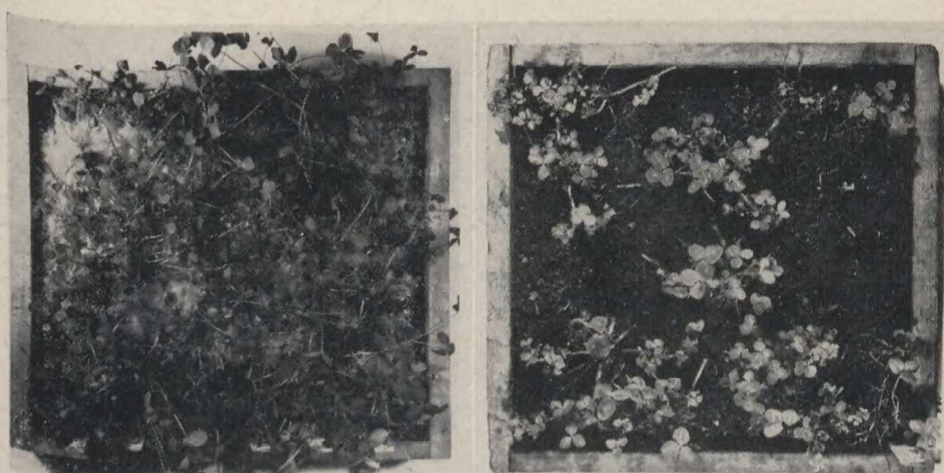

FIGURE 3. **Breeding for resistance** to Sclerotinia on red clover. The seedlings in the tray to the left have been inoculated with the pathogen while at right are the surviving plants.

Progress to date has been slow mainly because of difficulties encountered in creating a satisfactory artificial epidemic of the disease. This has been overcome and it is possible now to get a 90 per cent kill of seedlings in from 8 to 10 days. By using a controlled temperature chamber, seedlings can be inoculated at any time during the year.

Several thousand seedlings have been run through the disease test since 1948. To date no immune plants have been located but considerable difference in resistance has been shown when selected plants have been reinoculated as clonal lines. In tests involving a number of varieties there appeared to be little difference in their resistance to the disease. In tests of second and third generation progenies of plants selected for resistance there was some indication of improvement in resistance but this will have to be checked further.

RED CLOVER VARIETY TESTS

Variety tests of both single-cut and double-cut types of red clover have been established each year. However, yield data are available for 1952 and 1953 only since other stands were winterkilled too badly by ice-sheeting. Results for these two years are summarized in Table 9.

TABLE 9.—YIELD IN POUNDS OF DRY MATTER PER ACRE OF SINGLE AND DOUBLE CUT VARIETIES WHEN CUT FOR HAY

Variety and type	Seasonal yield 1952	Seasonal yield 1953
Single-cut types		
Craig Mammoth	—	4083
Siberian (Alaska)	—	2802
M.C. Late	3380	—
Thomas	3360	—
Altaswede	3240	—
Leon	3160	—
Mammoth	3140	—
Montgomery	2480	—
Double-cut types		
Dollard	3520	—
Ottawa	3300	4687
Wisconsin Mildew Resistant	3240	—
Kenland	3220	—
Redon	2500	—
Swedish	2480	—
Lasalle	—	5786
Purdue	—	5374
Penscott	—	5113
Cumberland	—	4976
Midland	—	4871
L.S.D. P =05 (Single-cut varieties)	400	—
L.S.D. P =05 (Double-cut varieties)	360	442

In the test of single-cut varieties all were about equal in the 1952 test except Montgomery which was considerably inferior. In the 1953 test Craig Mammoth was superior to Siberian, a strain from Alaska.

In the test of double-cut types, the varieties Dollard, Ottawa, Wisconsin M.R. and Kenland were about equal in yield in 1952 and all were superior to Redon and Swedish. In the 1953 test Lasalle, a new variety produced by blending seed of the Ottawa and Dollard varieties at the foundation stock level, gave the highest yield. The variety Purdue also yielded well. While yields of single-cut types were equal to those of double-cut types in 1952 this is unusual. Generally double-cut types yield higher than single-cut types and are better suited for hay in eastern Ontario.

MALE STERILITY IN ALFALFA

W. R. Childers

Studies have been made in this Division in recent years to determine the possibilities of using highly sterile alfalfa plants in the production of hybrid seed. Using highly sterile plants as the female or seed parents, the amount of selfing would be at a minimum and the progenies would be expected to exhibit the typical hybrid vigor of first-generation plants. Investigations have shown that any given population of alfalfa contains plants ranging from complete pollen sterility to complete pollen fertility. Studies have been made of typical plants to determine the cause of the complete and partial pollen sterility and the mode of inheritance.

In completely sterile plants the tapetal layer of cells surrounding the anther pollen sacs becomes excessively swollen at an early stage in meiosis indicating a failure to transfer nutritive substances to the pollen mother cells. As a result

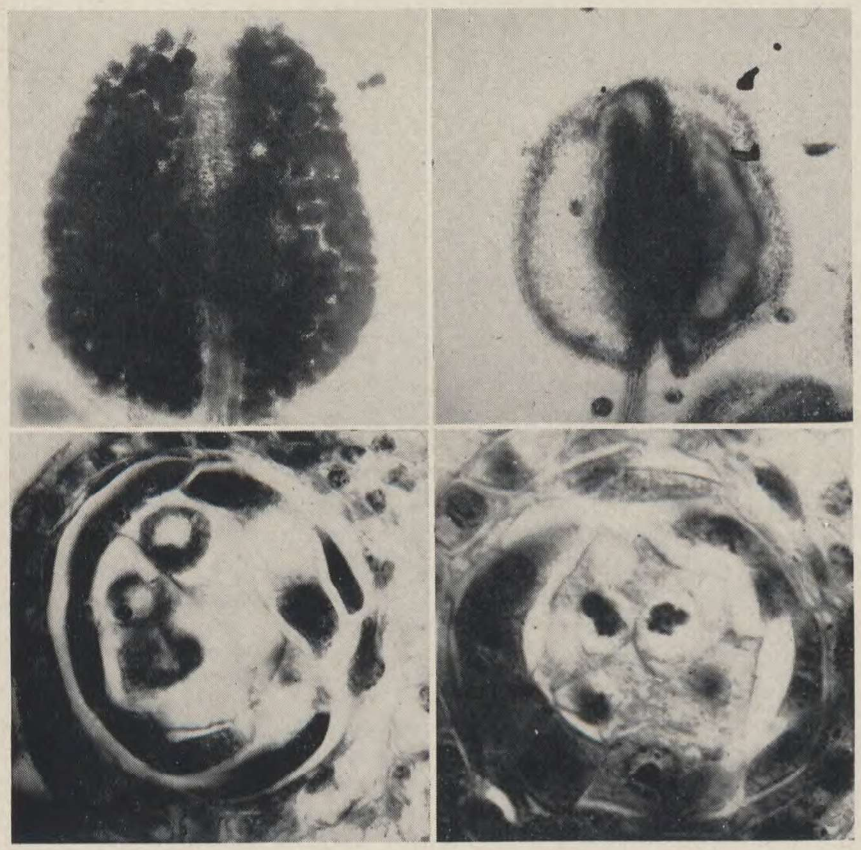

FIGURE 4. **Comparison of pollen development** in normal and male-sterile alfalfa. The mature, normal anther at upper left is filled with viable pollen while the male-sterile anther at upper right is empty. At meiosis a cross section of an anther locule at lower right shows the normal condition of the tapetal layer while in the male-sterile at lower right the tapetal layer is swollen.

these cells, which are the initial cells of the pollen, rapidly degenerate. In such plants the anthers fail to dehisce. These departures from normal behavior are illustrated in Fig. 4. From a cross of normal × male sterile, seven F_2 families showed two types of segregations; two with 3:1 ratios and five with 15: 1 ratios for dehiscence: non-dehiscence. This suggests the presence of duplicate genes controlling the inheritance of complete male sterility.

The partially male sterile plants studied varied in the percentage of aborted pollen from 5.5 to 81.0 per cent. In these plants the tapetal layer and meiotic behavior appeared normal up to the formation of the microspores or young pollen grains but in the course of pollen maturation varying proportions of pollen became shrunken and abortive. The tapetal layer of cells also varied in development and there was a close association between the degree of abnormal tapetal development and the percentage of abortive pollen. Inheritance studies with these partially fertile plants suggested that multiple genes with a cumulative effect condition the character.

The discovery of male steriles in alfalfa opens up the possibility for the use of double-cross hybrids in alfalfa in much the same manner as in hybrid corn. However the feasibility of such a breeding program remains to be determined. The complete report of this study was published in Sci. Agr. 32: 351-364. 1952.

SEED PRODUCTION INVESTIGATIONS

R. M. MacVicar

Research in grass and legume seed production methods is a major activity of the Division. Studies bearing on harvesting, crop desiccation, insect control, pollination, fertilization, etc., are in progress, while certain phases have been completed. Summaries are given of the results obtained from some of the investigations made during the past few years.

The Effect of Nitrogen Applications on Grass Seed Production

Detailed studies during the past few years have given data which show the influence of different methods of nitrogen application, types of nitrogen carriers and various rates of application on the seed yield of orchard grass and timothy.

Work with orchard grass was conducted in 1949 and 1950. In the experiment the sources of nitrogen used were as follows: ammonium sulphate (20%), sodium nitrate (16.3%), ammonium nitrate (33.5%) calcium cyanamid (21%) and urea (43%). These nitrogen fertilizers were applied at rates to give 0, 20, 40, 80, 160 and 320 pounds of elemental nitrogen per acre. Two methods of application were compared: (1) the total amount of nitrogen applied in one application during the first week of May and (2) half the amount applied during the first week of May and the remaining half 30 days later.

The main findings were: (1) the form of nitrogen fertilizer was not of importance. Comparable results were obtained from ammonium sulphate, sodium nitrate, ammonium nitrate, calcium cyanamid and urea; (2) seed yields in orchard grass were increased by approximately 35 per cent by the application of 80 pounds or more of nitrogen per acre. The 80-pound rate of application was as effective as rates of 160 or 320 pounds; (3) there was no advantage in a split application of nitrogen in the spring over a single application; (4) weight per 1,000 seeds was affected by nitrogen fertilization in a manner similar to that of seed yield.

A small experiment designed to compare the relative effect of nitrogen drilled in as a side dressing with an equivalent amount of nitrogen in the form of urea sprayed on the foliage was established on spaced rows of orchard grass. Treatments involved single and split applications of ammonium nitrate and of urea in solution, at a rate equivalent to 80 pounds nitrogen per acre.

All nitrogen treatments gave higher yields of seed than the untreated plots. The plots that received nitrogen in the form of a spray gave yields similar to those of the side-dressed plots. There was no measure of how the beneficial effect of the sprayed nitrogen was derived. The rapidity with which the vegetation changed color would seem to justify the conclusion that a considerable portion of the nitrogen was absorbed by the leaves. On the other hand consideration must be given to the possibility that substantial amounts of the fertilizing material fell to the grounds and was therefore available to the plants only through the roots.

It is possible that in dry areas, a foliage spray of nitrogen might be more effective than nitrogen applied in a solid form. It has been found that some grasses, and rhizomatous ones in particular, fail to give appreciable response to nitrogen under conditions where soil moisture is limited for a prolonged period after application.

As a corollary to work with orchard grass an experiment was conducted on timothy to assess the value of fall applications of nitrogen as opposed to spring applications for seed production. Results obtained over a three-year period showed that appreciably higher seed yields were obtained when 80 pounds of nitrogen was applied. Amounts of 20 and 40 pounds did not produce worth-while gains while there was no advantage in applications greater than 80 pounds. Similar seed yields were obtained when all the nitrogen was applied in the fall, all in the spring, and half in the fall and half in the spring.

Yields of dry matter increased as the rate of nitrogen application increased up to the 160 pounds rate. The 320-pound rate of application seemed to have a depressing effect on both seed yield and dry matter yield. A similar trend was noted in the orchard grass experiments.

Maturity in Grasses as Related to Time of Flowering

A study to provide information on the stage at which grasses should be harvested to provide the maximum yield of high quality seed was carried on over a five-year period. Data pertaining to the germination, weight per unit, and seedling vigor of the seed harvested at intervals after blooming were secured.

It was found that species varied widely in the number of days they required to mature after blooming. Seed of poor quality was obtained when the crop was harvested too early or too late. On the basis of the results secured from this test over a five-year period it would appear that the optimum time of harvest for the various species fall within the following ranges:

Species	Days after blooming
Timothy	20 to 30
Orchard grass	30 to 40
Brome grass	22 to 30
Meadow fescue	26 to 33
Reed canary grass	22 to 29
Red fescue	22 to 29
Meadow foxtail	25 to 37
Crested wheat grass	18 to 25
Tall fescue	18 to 25
Kentucky blue grass	26 to 33
Red top	18 to 25
Canada blue grass	10 to 17

The Control of Injurious Insects in Red Clover Production

The control of injurious insects in legume seed production has developed to such an extent in recent years that it is now general practice in many of the most important seed areas. While the amount of detailed experimental work has been limited, field trials have been extensive enough to establish beyond question the value of insect control in crops such as alfalfa, white clover and alsike. This has not been the case with red clover.

In order to determine the value of insect control in red clover seed production in the Ottawa Valley, field experiments were undertaken during 1950 and 1951.

In 1950 a large test involving the use of five treatments applied on a five replicate basis over an area of 68 acres gave useful seed yield data and specific information on the insect population before and after treatment. The most effective treatment appeared to be an application of DDT at the pre-bloom stage followed by toxaphene at full bloom. Yields from plots so treated averaged 170 pounds while the control area averaged 134 pounds seed per acre. This represented an increase of more than 25 per cent.

The toxaphene-sprayed areas gave approximately 18 per cent greater yield than areas not so treated, a matter of considerable interest. It would appear that grasshoppers alone can bring about marked decreases in seed yield in red clover since only toxaphene controlled them effectively in this experiment.

A survey made just previous to spraying revealed the presence of substantial numbers of clover head weevil *Tychius stephensi* (Schonh.); clover root curculio *Sitona hispidula* (F.), and grasshoppers, *Melanoplus* Spp. Surveys made after the spray applications indicated marked decreases in the populations of these insects.

A similar test conducted in 1951 did not show that insecticide treatments increased seed yield. Systematic sweeps before and after application indicated the insecticides gave a measure of control of the pea aphid and tarnished plant bug. However the clover seed midge which destroyed or damaged 70 per cent of the seed heads was not controlled in any degree.

An Evaluation of Certain Chemical Desiccants in Relation to Legume Seed Harvesting

The preharvest curing or desiccation of legume seed crops prior to threshing is a practice adopted in certain legume seed producing areas of the United States in recent years. This procedure is reputed to facilitate harvest to the extent that direct combining can be practised as opposed to the method of conditioning the crop in the windrow prior to threshing. It has been well established that when legume seed crops are windrowed, seed loss from shattering can be extensive. When conditions are such that direct combining is possible, harvesting losses are reduced.

During 1951-53, a number of small plot experiments and a few field trials were conducted at Ottawa with various crop desiccants. While it was not possible to conduct uniform tests during these years, it was possible by means of adequate replication to obtain data of some significance. From the data obtained and general observations made the following conclusions were arrived at:

1. An appreciable reduction in moisture content of legume herbage can be brought about by the use of various chemicals and oils. One of the most effective combinations is an application of two ot three pints of dinitro in 20 gallons of diesel oil to the acre.
2. The practice does not ensure higher seed yields.
3. Seed germination is not likely to be affected by the application of chemicals.
4. High shattering losses are apt to occur if there is undue delay in harvesting after the desiccant is applied. Such a delay may frequently occur in eastern Ontario due to weather conditions.
5. Upright vegetation of the nature of alfalfa may be cured better than dense, decumbent crops.
6. Alsike frequently becomes completely decumbent after chemical treatment, increasing the difficulties of harvest.

7. Recurrent growth in crops such as Ladino may destroy the effect of the desiccant in a matter of three to four days.
8. Head and pod shattering may be greatly increased in treated crops such as alsike and birdsfoot trefoil, if heavy rains or winds occur in the interval between application and harvest.
9. All seed in green pods affected by the chemical dry up and are rendered non viable. This may have considerable affect on seed yield in crops such as birdsfoot trefoil.
10. A mechanical loss of about 10 per cent of the seed crop will result from passing ground sprayers over the ripening seed fields.
11. Cost of application will range from seven to ten dollars per acre. This cost coupled with the seed loss mentioned above may be excessive in areas where seed yields are generally low.

Combine Harvesting of Red Clover Seed

It is generally recognized that high seed losses occur in the harvesting of red clover seed. Losses as high as 50 to 60 per cent are not uncommon.

Small-scale field experiments have been conducted to measure these losses and to determine the most effective means of overcoming them. In 1951 it was found that seed lost in the combine tailings alone ranged from 31 to 44 per cent. When direct combining was compared with windrowing and combining in the same series of tests, the windrowed areas gave yields 46 per cent lower and the direct combined areas yields 23 per cent lower than the field potential.

A field trial conducted in 1952 was concerned with the effect of combine travel and time of harvest on tailings seed loss.

Tailings loss was in excess of 25 per cent at speeds greater than 1 m.p.h. Combine #1 had significantly less loss at 1 m.p.h. than at the 2 and 3 m.p.h. rates. Time of harvest as represented by 1 p.m. and 3 p.m. did not have a significant effect on tailings loss, although the recorded average loss was 31 and 23 per cent respectively. In considering these data it must be appreciated that the density of the vegetation might influence tailings loss markedly at various speeds. In this case the field weight of the vegetation was between 1300 and 1400 pounds of dry matter per acre.

TABLE 10.—LOSS OF SEED IN COMBINE TAILINGS AFFECTED BY RATE OF TRAVEL

Rate of travel	Combine #1			Combine #2
	Time 1 p.m.	3 p.m.	Average	Average
	%	%	%	%
1 m.p.h.	18·0	15·0	17·0	25·0
2 m.p.h.	41·0	24·0	32·0	31·0
3 m.p.h.	34·0	30·0	32·0	31·0
Average	31·0	23·0	27·0	29·0
L.S.D.	—	—	10·0	None

Analysis of data obtained by measuring the amount of tailings seed loss in relation to the combine deck load revealed that tailings loss was significantly correlated with the amount of material passing over the decks in a given time. The value obtained was $r = .798$ with the level for significance being .708 for

(P. = .01). Thus the greater the deck load, generally gained by increased rate of travel, the greater the tailings loss.

Nectar Secretion in Red Clover

Detailed studies were carried on in 1950 and 1951 with a view to supplementing the information available on the relationship between volume and concentration of nectar in red clover as related to pollinator activity and seed yield.

The volume and concentration of nectar varied significantly between days, while during the day the volume was significantly higher in the morning and concentration was higher in the afternoon. Blooms in screen cages gave significantly higher values for both volume and concentration than uncovered blooms. Insecticide-sprayed plots showed significantly higher nectar concentration than the unsprayed (check) plots but there was no significant difference in the volume of nectar between these plots.

The nectar volume in fertilized and unfertilized flowers diminished rapidly after the fifth and seventh day, respectively. The third day after fertilization the percentage of total solids decreased, but this was not apparent in unfertilized flowers until seven days after full bloom. Wilting followed a similar trend.

The nectar secretion was extremely variable and apparently the flow was conditioned by a great many factors. The possibility exists that the trend toward higher per cent solids in the afternoon may explain the greater pollinator activity at that time. However, the reduced volume of nectar in the afternoon, in theory, should reduce pollinator activity. It is noteworthy that on numerous occasions the honeybees were found to be visiting the very young clover florets. It is possible that, since the corolla tubes of these florets had not grown to full length, the nectar present was more readily available to the honeybees.

Nectar in Red Clover as Influenced by Plant Nutrients

The volume of nectar in red clover florets and the percentage solids in that nectar vary widely from day to day and in different areas. It may be assumed also that the quantity and quality of nectar influence the activities of pollinating insects quite markedly. The length of the corolla tube in red clover presents an obstacle to the honeybee in its search for nectar. It follows therefore that the variation in nectar flow brought about by such factors as soil moisture, humidity, temperature and light may be of considerable significance in pollinator activity. Were it possible to stimulate nectar flow, or increase the solids in red clover nectar, the flowers might be more attractive to insect pollinators. Since the role of plant growth nutrients in nectar secretion has not been clearly established an investigation was undertaken under greenhouse conditions during the winter of 1950 to determine the effect, if any, of varying amounts of plant nutrients on red clover nectar flow and nectar solids. The study was developed in two phases, one involving nutrient solutions and the other soil fertilization.

Twenty-seven different nutrient solutions were used representing three distinct levels of nitrogen, phosphorus and potash. Nitrogen—N1—140.10 p.p.m.; N2—252.18 p.p.m.; and N3—364.26 p.p.m. Phosphorus—P1—77.60 p.p.m.; P2—139.68 p.p.m.; P3—201.76 p.p.m. Potash—K1—99.75 p.p.m.; K2—175.95 p.p.m. and K3—254.15 p.p.m. All other elements contained in the nutrient solutions were kept constant at a level high enough to ensure satisfactory growth.

Eighteen plants selected at random were used as plant material. Cuttings were made of these plants and rooting was initiated by the use of naphthyl acetic acid (50. p.p.m. in talc). By means of these cuttings it was possible to have each of the 18 plants represented under each of the 27 nutrient solutions.

In the phase involving soil fertilization 21 plants divided clonally were grown in soil of relatively low fertility supplemented by fertilizer treatments. Eleven treatments were used involving rates of nitrogen ranging from 0 to 24 pounds, phosphorus from 0 to 144 pounds and potash from 0 to 72 pounds.

In this study it was not possible to satisfactorily control growth factors such as temperature, humidity and light which influence nectar secretion. However, by making suitable control readings from day to day and a number of daily readings on nectar volume and percentage solids from each treatment, useful comparative data were obtained. On the whole the data were quite uniform. It was found on analysis that the treatments as applied did not have a significant effect on either the volume of nectar or the percentage solids in the nectar. European workers found that high potassium applications lowered the nectar yield and the volume of nectar and lengthened the corolla tube. When the nectar volumes for the three levels of potassium K1, K2 and K3 used in this experiment were averaged it was found that K1 and K2 gave an average of 16.1 μls. per 100 florets while K3 gave 14.9 μls. The difference here was not significant but was in fairly close agreement with that found by the other workers.

An interesting sidelight was developed from this investigation. It was found that variations existed between plants with regard to nectar secretion. Among the 39 plants used, variations in volume ranged from 7.6 μls. per 100 florets to as high as 23.7 μls. per 100 florets. Percentage solids ranged from 52.4 per cent to as high as 68.7 per cent. The necessary significant value for volume of nectar was 2.9 μls. and for solids 2.7 per cent. The significant variations found indicate that there is a possibility of plant selection to obtain strains capable of yielding a high volume and concentration of nectar.

HAY AND PASTURE INVESTIGATIONS

F. S. Nowosad

In keeping with the important position occupied by hay and pasture production in the agricultural economy, a heavy program of research is being constantly carried on with hay and pasture species. This entails testing on a comparative basis numerous species, varieties and strains alone and in mixtures in a large number of small plots as outlined here.

The plots are usually 50′ x 50′ or 30′ x 5′; replicated and randomized. Sown in the spring with a nurse crop of cereal grains which is usually removed as silage, these plots are arranged in groups or series as "comparative variety tests" of various species and grown in pure stands or simple mixtures. All plots are clipped four to five times annually to simulate grazing or cut twice when treated as hay. Harvesting is done by means of a small power mower with a cutting-bar in front and a specially designed pan attached directly behind the cutting-bar. Green weights are recorded for each plot at the time of harvest and representative samples are taken for dry-matter determinations and used for certain chemical analyses. Simple mixtures are usually separated to obtain the percentage by weight of component species which are saved for chemical analyses.

The yield data in this report are in pounds of dry matter per acre, thus equivalent hay weights may be obtained by adding approximately 15 per cent to the weight of dry matter recorded. In conducting these tests three separate practices are usually followed:

(1) Hay crops harvested for first two 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.

The species, varieties and mixtures which persist and perform well under clipping tests are later included in actual grazing trials with livestock under field conditions. The results provide a basis for recommendations to the farmers in this area.

"Bottom" Species in Hay-Pasture Mixtures

Over several years tests have been conducted to obtain data on the value of the so-called "bottom" species in hay-pasture and pasture mixtures. These included Kentucky blue grass, Canada blue grass, red top, creeping red fescue, wild white clover and white Dutch clover, used in various combinations and added to simple mixtures with and without alfalfa.

A summary of the yields obtained from a number of tests is presented in Table 11. These yields show clearly that: (1) mixtures containing alfalfa outyielded the mixtures without alfalfa; (2) meadow management influenced production and (3) the addition of the "bottom" species to simple mixtures appears to be justified only when the mixtures contain no alfalfa and when the meadows are used primarily for pasture.

Alfalfa Outyields other Legumes for Pasture

For many years the results of experiments conducted at Ottawa have indicated conclusively that in short-term hay-pasture or pasture mixtures alfalfa is the most productive legume.

A small replicated test was laid down in 1950 to obtain yield data on the various perennial legumes that might be suitable for pasture. These legumes were sown at the rates shown in Table 12, in a mixture with timothy at six pounds per acre.

Alfalfa gave more than double the yield of some birdsfoot trefoils and white Dutch clover. Empire was the best variety of birdsfoot trefoil under test.

TABLE 11.—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF SIMPLE MIXTURES WITH OR WITHOUT "BOTTOM" SPECIES. (PERIOD 1945 TO 1952)

(a) Mixtures with alfalfa—left down 3 years

Used for	with "bottom" species	without "bottom" species
Hay 2 years, pasture 1 year	8215	9099
Hay 1 year, pasture 2 years	7926	8414
Pasture only, 3 years	6856	6784

(b) Mixtures with alfalfa—left down 4 years

Used for	with "bottom" species	without "bottom" species
Hay 2 years, pasture 2 years	7545	7859
Hay 1 year, pasture 3 years	6686	6716
Pasture only, 4 years	6488	6034

(c) Mixtures without alfalfa—left down 4 years

Used for	with "bottom" species	without "bottom" species
Hay 2 years, pasture 2 years	5175	5457
Hay 1 year, pasture 3 years	4795	4183
Pasture only, 4 years	5102	3796

TABLE 12.—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF VARIOUS LEGUMES FOR PASTURE PURPOSES

Rates, lb. per acre	1951	1952	2-Year average
Grimm alfalfa, 12	6214	7925	7070
Birdsfoot trefoil, broad, 7	5285	6684	5985
Birdsfoot trefoil, narrow, 7	4090	4455	4273
Birdsfoot trefoil, var. *villosus*, 7	3196	3159	3178
Birdsfoot trefoil, var. *glabriusculus*, 7	2901	2939	2920
Ladino, Comm., 4	4886	3940	4413
Ladino, U.S.D.A., 4	4639	3956	4298
White Dutch clover, 4	3624	2886	3255
Sainfoin (hulled), 30	2995	3872	3434
Crown vetch, 30	3149	3242	3196
L.S.D. at 5% point	155	225	—

Sainfoin and Crown vetch were present only in trace amounts and made little contribution to the yield. It is possible however, that the rates of seeding should be increased to ensure a better stand.

Alfalfa Varieties for Hay-Pasture

The importance of alfalfa in hay and pasture makes it necessary to have a continuous testing program of standard and new varieties and strains. Some tests remain down as long as four years, others have to be discontinued and begun again if severe winter conditions render the test valueless. In line with the general farm practice throughout the area, alfalfa is sown in combination with a grass, usually timothy. Sometimes more complex mixtures are used.

Data presented here are on different varieties of alfalfa sown at 12 pounds with timothy at six pounds per acre. The first year two cuts of hay were harvested and exceptionally high yields obtained (see Table 13). During the second year these plots were cut five times to simulate pasture. There was considerable icing of the plot area in 1952-53 and some reduction of the stand of alfalfa.

During this test it was observed that in the fall most of the Canadian varieties went into a dormant stage shortly after the last clipping in September. The southern and imported varieties, particularly those from French origin like Du Puits and M-50, made considerable regrowth and were quite green at or near the freeze-up date on November 8, 1952.

Hay yields the first year were highest for M-50 variety, an Ottawa selection from Du Puits. The latter was second in production when cut for hay. Canadian varieties as a whole were not so productive as the imported sorts.

TABLE 13.—VARIETIES OF ALFALFA GROWN WITH TIMOTHY FOR HAY TO BE FOLLOWED BY PASTURE. YIELDS OF DRY MATTER IN POUNDS PER ACRE. OTTAWA, ONT.

Variety or strain and source of alfalfa	Hay 1952	Pasture 1953	Average
Narragansett (Kingston, R.I.)	7899	5926	6913
M-50 (Ottawa, from Du Puits)	8182	5469	6826
Rhizoma (Univ. B.C.)	7788	5665	6727
Du Puits (France)	7959	5282	6671
Canauto (Ottawa, Ont.)	7560	5715	6638
Ontario Variegated (Ont.)	7645	5614	6630
Ranger (Malta, Mont.)	7712	5327	6520
Grimm (Ontario)	7440	5585	6513
Ladak (Manitoba)	7412	5572	6492
Buffalo (Kansas)	7818	5165	6492
Atlantic (Buffalo, N.Y.)	7863	5071	6467
Ferax (Univ. of Alta.)	7217	5523	6370
L.S.D. at 5% point	248	n.s.	—

Pasture yields, however, did not follow the same ranking as the hay yields. While there were no significant difference between the pasture yields of different varieties, the Canadian varieties were the most productive. The exception was the variety Narragansett.

Date and Frequency of Cutting Alfalfa

The results of numerous tests conducted at the Division indicate clearly that alfalfa is one of the most productive legumes when used in short-term pasture mixtures. Such mixtures, however, become devoid of alfalfa in a few years if grazing is continued. There seems to be a critical time during the year when grazing or clipping is more harmful than at other times.

An experiment was begun in 1950 to study the effect of frequency and time of cutting on the performance of two varieties of alfalfa. Grimm and Rhizoma sown at 12 pounds with timothy at eight pounds per acre had yearly treatments

TABLE 14.—YIELDS OF TWO VARIETIES OF ALFALFA GROWN WITH TIMOTHY HARVESTED AT VARIOUS TIMES AND FREQUENCIES.* YIELDS OF DRY MATTER IN POUNDS PER ACRE

Treatment No.*	Variety of alfalfa	1st year cut at different dates	2nd year cut at different dates	3rd year all cut June 15	3-year average
A	Grimm	6094	6664	3827	5528
A	Rhizoma	6413	7193	4801	6136
	Average	6254	6929	4314	5832
B	Grimm	6410	7939	4122	6157
B	Rhizoma	6378	7603	4469	6150
	Average	6394	7771	4296	6154
C	Grimm	5864	7226	4385	5825
C	Rhizoma	6121	7924	4946	6330
	Average	5992	7325	4665	5994
D	Grimm	6155	7438	4267	5953
D	Rhizoma	6163	7149	4340	5884
	Average	6159	7294	4304	5919
E	Grimm	6663	7698	3303	5888
E	Rhizoma	6479	7595	3792	5955
	Average	6571	7646	3547	5921
F	Grimm	6884	7946	3249	6026
F	Rhizoma	6745	8166	3478	6130
	Average	6814	8056	3364	6078
G	Grimm	7072	8712	3386	6390
G	Rhizoma	6991	8284	4101	6459
	Average	7032	8498	3744	6425
L.S.D. at 5% point:					
	Between treatments	328	646	479	—
	Between varieties	n.s.	n.s.	137	—
All treats.	Grimm	6449	7600	3791	5967
" "	Rhizoma	6470	7702	4275	6149

* Treatments:
A = 2 cuts as hay.
B = 3 cuts as hay.
C = 4 cuts as pasture.
D = 5 cuts as pasture, last cut on August 30.
E = 5 cuts as pasture, last cut on September 12.
F = 5 cuts as pasture, last cut on October 1.
G = 5 cuts as pasture, last cut on October 15

over two crop years as follows: A—two cuts as hay; B—three cuts as hay; C—four cuts as pasture; D—five cuts as pasture, with the last cut on August 30; E—five cuts as pasture, with the last cut on September 12; F—five cuts as pasture, with the last cut on October 1; and G—five cuts as pasture, with the last cut on October 15.

In the third year all plots were harvested only once, June 15, to observe the effects of two years' clipping at various dates and frequencies. At this harvest "grab" samples were taken from each plot, separated into component species, dried and weighed.

A summary of the yield data is presented in Table 14. It was found that each year there were significant differences between the yields of alfalfa-timothy due to different treatments. The treatment involving three cuts of hay was more productive in the first and second year than was the two-cut treatment. This effect carried into the third year. Pasture yields were progressively higher when the last clipping was delayed during the first two crop years only. However, the third year crop from plots so treated was not quite so good as when treated more leniently.

In the first two years both varieties of alfalfa were similar in productivity. In the third year, following a winter of considerable icing, Rhizoma significantly outyielded Grimm variety. The over-all average is slightly higher for Rhizoma than for Grimm.

The effect of various treatments on the persistence of alfalfa is reflected in the botanical composition of the herbage harvested on June 15, 1953, as shown in Table 15. Alfalfa survived best in plots cut twice for hay. The least alfalfa was found in plots clipped five times to simulate pasture, when the last cut was August 30. The percentage of alfalfa was slightly higher in the case of Rhizoma. This may have been the reason for a significantly higher yield obtained for this variety.

TABLE 15.—PERCENTAGE WEIGHT OF ALFALFA, TIMOTHY AND WEEDS JUNE 15, 1953 WHEN DIFFERENT TREATMENTS WERE FOLLOWED DURING 1951 AND 1952

Components from plots subjected to various treatments*

Variety of alfalfa	Treatment							Average for variety
	A	B	C	D	E	F	G	
Alfalfa component								
Grimm	78	70	40	25	33	35	41	46
Rhizoma	89	69	43	26	38	41	43	50
Average	84	70	42	26	36	38	42	48
Timothy component								
Grimm	11	15	47	61	47	47	42	39
Rhizoma	4	20	47	62	49	43	35	37
Average	8	18	47	62	48	45	39	38
Weed component								
Grimm	11	15	13	14	20	18	17	15
Rhizoma	7	11	10	12	14	16	22	13
Average	9	13	12	13	17	17	19	14

* Treatments A to G as in footnote to Table 14.

Timothy for Pasture

Timothy (*Phleum pratense* L.).—This grass is widely adapted and under average growing conditions produces as much or more herbage than most other grasses used for similar purposes in Eastern Canada. Because of its importance experiments to determine the most productive and most desirable varieties of timothy from the standpoint of resistance to disease, leafiness, speed of recovery and other valuable characteristics are being conducted.

Yields obtained over a six-year period indicate that Climax variety produced the highest yield of herbage per acre. S-48 and Paton were the lowest in production under the conditions of this test. Data obtained over a six-year period indicate that Climax produced the highest yields.

TABLE 16.—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF DIFFERENT VARIETIES OF TIMOTHY GROWN WITH WHITE CLOVER AND TREATED AS PASTURE (1946-48 and 1949-51)

Variety or strain	3-year average 1946-48	3-year average 1949-51	6-year average
Climax	4883	3448	4166
Drummond	4324	3476	3900
Commercial	4628	3016	3822
Marietta	4448	3181	3815
Medon	4377	3089	3733
Milton	4619	2728	3674
S48	4118	2944	3531
Paton	3804	2762	3283
Cornell 1777	4542	—	—
Dural	4522	—	—
Boon	4488	—	—
Ottawa 1956–14	4484	—	—
Cornell 4459	4459	—	—
Swallow	4295	—	—
Ottawa 1956–19	—	3507	—
Lorain F.C. 15167	—	3460	—
Ottawa 1956–64	—	3232	—
Ottawa 674	—	3075	—
Ottawa 757	—	2954	—

Varieties of Brome Grass for Hay-Pasture

Brome grass (*Bromus inermis* Leyss.) has been grown in Eastern Canada for a number of years but has never become as widely used as timothy. There are several reasons why brome grass is not generally grown. The seed is large and cannot be sown through the usual grass seed box adapted for small seeds. Successful establishment depends largely upon shallow seeding into a firm seed-bed. Once established, it compares favorably with timothy for hay or hay-pasture.

In areas where brome grass is used for hay or hay-pasture purposes, the question of suitable varieties becomes important. In recent years a number of varieties originating in the United States have received some attention. During 1949-51 these were compared with commercial and Parkland produced in Canada sown with white clover as the associated legume. Yield data from these tests are given in Table 17.

Highest in the hay-pasture test were Achenback, Nebraska B-9 and Fischer. In the pasture test Fischer, Parkland and Nebraska B-9 were the best. In both series, commercial brome was at the bottom of the list of yields.

Meadow Fescue and Tall Fescue for Hay-Pasture or Pasture

Meadow Fescue (*Festuca elatior* L.) and Tall Fescue (*Festuca elatior* var. *arundinacea*) are fairly well adapted to most well-drained soils in Eastern Canada.

TABLE 17.—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF VARIETIES OF BROME GRASS (1949–51)

Variety	Hay-pasture				Pasture			
	1949 Hay	1950 Pasture	1951 Pasture	Average	1949 Pasture	1950 Pasture	1951 Pasture	Average
Commercial	2922	2480	2637	2680	2209	2908	3342	2820
Parkland	2582	3222	3533	3112	2406	4017	4411	3611
Lincoln	3348	3082	3280	3237	2216	3077	3936	3076
Fischer	3575	3143	3287	3335	2853	3597	4420	3623
N.E. Nebraska	3063	2955	3194	3071	2381	3153	3986	3173
Nebraska B-9	3614	3175	3481	3423	2789	3180	3970	3313
Achenback	3580	3332	3419	3444	2575	3076	4100	3250
Martin	3089	3021	2902	3004	2333	2698	3393	2808
L.S.D. at 5% point	282	n.s.	202	336	158	300	256	279

Tall fescue is somewhat coarser and less palatable than meadow fescue. The performance of different varieties available was investigated during 1949-51 and yields are given in Table 18.

All varieties were similar in yield in the hay-pasture test, (three-year average) but in the pasture series Ensign meadow fescue was significantly the most productive variety.

In 1952, Ensign meadow fescue was grown in comparison with tall fescue varieties. The yield results are given in Table 18A.

TABLE 18.—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF MEADOW FESCUE VARIETIES COMPARED WITH TALL FESCUE (1949–1951)

Species and variety	Hay-pasture				Pasture			
	1949 Hay	1950 Pasture	1951 Pasture	Average	1949 Pasture	1950 Pasture	1951 Pasture	Average
Commercial meadow fescue	2202	1643	2396	2080	1992	1679	2785	2152
Ensign meadow fescue	2206	1554	2468	2076	2407	1739	3890	2679
Mefon meadow fescue	2307	1387	2567	2087	2256	1457	2998	2237
Sturdy tall fescue	2478	1529	2544	2184	2519	1578	3044	2380
L.S.D. at 5% point	202	74	n.s.	n.s.	145	n.s.	286	277

TABLE 18A.—YIELDS OF TALL FESCUE VARIETIES IN COMPARISON WITH MEADOW FESCUE. POUNDS OF DRY MATTER PER ACRE.

Variety and source	Hay	Pasture
Kentucky 31, T.F.	5823	6895
Alta T.F.	5926	6682
Ottawa 38, T.F.	5455	5971
Ottawa 39, T.F.	5335	5997
Ensign M.F.	5538	5860
Average all varieties	5615	6281
L.S.D. at 5% point	n.s.	182

This test was located on highly fertile land, and the growing conditions were very favorable as judged by the yields obtained. The plots clipped frequently to simulate pasture were more productive than when harvested for hay. Some varieties of tall fescue, particularly Kentucky 31 and Alta, outyielded Ensign meadow fescue in this test.

Creeping Red Fescue for Pasture

Creeping Red Fescue, (*Festuca rubra* L.) is sometimes used as a "bottom" grass in pasture mixtures. It is completely winter-hardy and can withstand considerable drought, and like most grasses it grows best in fertile soils. It produces considerable herbage in the spring and in the fall when adequate moisture is available.

A few available varieties have been tested at Ottawa in association with white Dutch or wild white clover. The yields were consistent and the productivity increased over the three-year period. The varieties yielded in the same order or rank each year. The Olds variety was the highest in yield. It was not only the most productive but seemed to be quite dense and uniform.

TABLE 19.—YIELDS OF CREEPING RED FESCUE VARIETIES. DRY MATTER IN POUNDS PER ACRE.

Variety	1949	1950	1951	3-year average
Olds	2304	3117	3330	2917
Refon	2180	2782	3074	2679
Duraturf	1862	2477	2860	2402
Illahee	1547	1972	2520	2013
L.S.D. at 5% point	143	110	153	153

Tests with Blue Grasses for Pasture

Both Canada blue grass (*Poa compressa* L.) and Kentucky blue grass (*Poa pratensis* L.) occur naturally in most areas of Ontario and certain sections of Quebec. The latter is also found in areas in the Maritime Provinces. These grasses are usually "bottom" species, and it has been shown in this report that these are not essential in short-term pasture mixtures. Mixtures designed for long-term pasture or where no hay crops are taken may advantageously contain Kentucky blue grass.

The performance of different varieties of these grasses has been under investigation for a few years. The blue grasses were grown in tests mixed with white clover, the legume found growing in long-term pastures. In addition to Canada and Kentucky blue grass, two other species of blue grass, Big blue grass (*Poa ampla*) and Wood blue grass (*Poa nemoralis*) were tested. Yield data are given in Table 20.

It was also found that, as during the period of 12 years previously reported on, Canada blue grass had been again more productive than Kentucky blue grass when grown with white clover for pasture.

TABLE 20.—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF DIFFERENT BLUE GRASSES FOR PASTURE.

Kind of variety	1949	1950	1951	3-year average
Delta Kentucky blue	1242	2895	3737	2625
Kénon Kentucky blue	1259	1532	2209	1667
Commercial Kentucky blue	1170	1593	1969	1577
Canon Canada blue	1225	2821	4315	2787
Chieftain Canada blue	1241	3014	3933	2729
Big blue grass	1390	3839	4509	3246
Wood blue grass	1164	3446	4459	3023
L.S.D. at 5% point	94	272	236	246

Birdsfoot Trefoil Grows Well with Timothy

Broad-leaved birdsfoot trefoil (*Lotus corniculatus* L.) has been grown for several years in various tests. In most cases this legume is intended for hay-pasture or pasture purposes and a mixture with a suitable grass is often desirable. Trefoil was grown with timothy and brome over a three-year period as shown in Table 21. Timothy was sown at eight pounds and brome grass at 16 pounds per acre. The plots were managed in two different ways. One group was cut for hay the first year and cut to simulate pasture during two subsequent years. The other group was clipped for three years to simulate pasture and no hay crops were taken.

All lots of the broad-leaved trefoil out-yielded the narrow-leaved variety. The latter was particular low-yielding in the first year of harvest. The three lots of Empire variety of the broad-leaved type of birdsfoot were close in average yield. The trefoils were more productive when grown with timothy than with brome grass. Apparently brome was too aggressive for a good stand of birdsfoot trefoil. Plots harvested for hay during the first crop year were more productive than those clipped off continuously to simulate pasture.

FIGURE 5. **Alfalfa stands** are quickly reduced by frequent cutting or close grazing. Alfalfa in plot B was harvested three times and plot E five times per year. By the third crop year alfalfa has almost disappeared under the five-cut treatment while under the three-cut treatment the alfalfa stand is still good.

FIGURE 6. **Hay test** of birdsfoot trefoil and grasses; right timothy and left brome. Timothy and trefoil grow well in association while brome grass is too competitive and there is little birdsfoot in the mixture.

TABLE 21.—VARIETY AND STRAIN TEST OF BIRDSFOOT TREFOIL GROWN WITH TIMOTHY OR BROME FOR HAY-PASTURE AND PASTURE PURPOSES. YIELDS OF DRY MATTER IN POUNDS PER ACRE. (1949–51).

Grass species and variety or strain of birdsfoot trefoil	Hay-pasture				Pasture			
	1949 2 cuts	1950 4 cuts	1951 4 cuts	Average	1949 5 cuts	1950 4 cuts	1951 4 cuts	Average
Timothy plus:								
Empire, Cornell strain, broad-leaved	2252	4930	6100	4427	1479	4365	6018	3954
Empire, Ontario grown, broad-leaved	2756	4782	5951	4496	1758	4424	5876	4019
Empire, G.L.F. broad-leaved	3074	5286	5852	4737	2009	4568	5986	4188
Narrow-leaved, Cornell strain	1469	4323	5186	3659	1344	4330	5595	3979
Average				*4330*				*3979*
Brome grass plus:								
Empire, Cornell strain, broad-leaved	2723	3902	5147	3924	1214	3363	4993	3190
Empire, Ontario grown, broad-leaved	2813	4362	4936	4037	1065	3536	5160	3254
Empire, G.L.F. broad-leaved	2214	4110	5024	3783	1952	3861	5046	3500
Narrow-leaved, Cornell strain	1926	3380	4695	3334	1333	3078	4872	3094
Average				*3770*				*3260*
L.S.D. at 5% point	461	333	248	406	151	243	189	226

GENETIC AND CYTOLOGICAL RESEARCH

J. M. Armstrong

Induced Polyploidy

Since the discovery of the use of colchicine as a means of chromosome doubling the possibilities of obtaining improved varieties by this means has been widely explored in many economic crop species. Some of the objectives sought are increased yield and vigor, greater hardiness and longevity and favorable modification of the chemical constitution. Crops that have been or are being investigated with respect to the value of induced polyploids are field roots (swedes, mangels and sugar beets), oil-seed rape, red clover, alsike, alfalfa and birdsfoot trefoil. Work has also been initiated in three grasses: meadow fescue, tall fescue and reed canary grass. Use has also been made of the colchicine technique in the hybridization program with wheat-agropyron hybrids. The results with field roots were given in the 1937-48 Progress Report while the Triticum-Agropyron investigations are reported in this report. Results with the other crops will be briefly summarized.

Oil-Seed Rape.—Annual oil-seed rape known as German or Polish, *Brassica Rapa Annua Oleifera* Metzg., has long been cultivated in Europe as a source of edible oil. Together with Argentine rape, *Brassica napus oleifera annua* Metzg., these crops were introduced to Canada in 1942 with a view to overcoming the shortage in vegetable oils. They proved well adapted to certain areas in Western Canada and by 1948 the acreage had increased to 80,000 acres with a total yield of 64,000,000 pounds. A period of decline in the use of rape oil occurred from 1949 to 1951 as it had not yet established a place on this continent in competition with other vegetable oils. Research in the processing and refining of rape oil has overcome this difficulty and its use is once more increasing. There still remains a problem of eliminating the toxic principle in the meal which makes it objectionable as a stock feed. When this problem is overcome the future of the rape oil industry is assured. Due to its higher yield, Argentine rape is the main variety grown while Polish rape is of secondary importance. However Polish has these factors in its favor: it is earlier in maturity and ripens evenly. It might prove of value in the northern areas of Western Canada or in wet late springs where delayed seeding is compulsory.

Polish rape is a diploid species (2n = 20) while Argentine is a polyploid (2n = 38). Due to the lower chromosome number the former has proved more favorable material for chromosome doubling than the latter which yields only dwarfish, highly sterile plants when the chromosome number is doubled. In Polish rape on the other hand tetraploid strains have been produced which slightly excel the diploid in yield and are 25-50 per cent greater in seed size. These tetraploid strains are cross-sterile with the diploid which simplifies the problem of isolation of seed increase plots.

Cytological studies showed that the tetraploid strains suffered only slight impairment in fertility due to chromosome irregularities. Induced doubles did not produce any marked chemical differences from that of the diploid. Argentine rape yields about 40 per cent oil from the seed as compared with 35 per cent for Polish. The iodine values are approximately 110 and 102 for Argentine and Polish respectively. The variability in the tetraploid strains indicates that further selection would be effective. The main breeding problem in both Argentine and Polish at present is to select strains with lower toxic properties in the meal in order that it may be more readily marketed.

Red Clover and Alsike.—The results in doubling the chromosome numbers in red clover and alsike are similar. Red clover (2n = 14) and alsike (2n = 16) are diploid species and tetraploid plants were readily produced by treating them at the seedling stage with colchicine and identifying double branches on the basis of pollen size. Tetraploid heads were then intercrossed and lines established. Tetraploid plants show a marked increase in vegetative vigor but are greatly decreased in fertility. By the selection of the more fertile plants in successive generations this fertility can be gradually restored and is probably associated with the increasing stability in cytological behavior initially disturbed by the double chromosome complement. The following table shows the increase in fertility brought about by selection.

TABLE 22.—MEAN FERTILITY IN TETRAPLOID RED CLOVER AND ALSIKE IN SUCCESSIVE GENERATIONS.
(Seeds per head)

Generation	Red clover	Alsike
F2	8·1 + ·56	20·4 + ·44
F3	14·1 + ·47	—
F4	25·7 + 1·11	32·0 + ·84

The mean fertility in normal red clover and alsike averages 75-100 seeds per head. While the tetraploid material may never reach this level, progress is steadily upward in successive generations. It is hoped that the increased forage yield will compensate for a lower seed yield. In chemical constitution, analyses showed no significant differences. The diploid forms are highly self-sterile while the induced tetraploids show a low frequency of partially self-sterile plants. Diploid and tetraploid plants do not readily intercross which will facilitate the problem of keeping tetraploid strains pure.

Alfalfa.—Common alfalfa, *Medicago sativa* L., and variegated alfalfa, *M. media* Pers., are tetraploid species having a somatic chromosome number of 32. During the past five years a series of polyploids have been produced in this species which have been studied both cytologically and in regard to agronomic characters. Plants from the Du Puits variety and wilt-resistant selections were subjected to colchicine treatment and octoploid plants (2n = 64) were obtained. The octoploids and normal tetraploids were then intercrossed to produce hexaploids (2n = 48). In addition diploid forms (2n = 16) secured in plant introductions were available for comparison. In Table 23 some field data have been summarized showing comparisons of these four tetraploids.

TABLE 23.—COMPARISON OF HEIGHT, TILLERING, STEM THICKNESS AND GREEN YIELD OF ALFALFA POLYPLOIDS.

Polyploid type	Number of plants	Average height	Number of tillers	Stem thickness	Yield per plant
		(in.)		(mm.)	(oz.)
Tetraploid (selfed)	76	30·8	20·3	4·6	13·6
Tetraploid (crossed)	78	30·1	33·1	4·1	15·8
Octoploid (crossed)	108	30·2	17·4	4·7	12·9
Hexaploid	14	35·5	24·3	4·2	15·1
Diploid	10	27·8	15·0	3·7	6·7

The induced octoploids, while as tall as the tetraploids and thicker stemmed, tiller less profusely resulting in a plant which yields on the average only 80 per cent as much forage as the tetraploid. The hexaploids on the other hand are somewhat taller than the normal, tiller less profusely but yield approximately as much forage. Both octoploids and hexaploids are poor seed producers in comparison with the normal. The prostrate-growing diploid forms yielded less than half the forage of the tetraploid. It would appear that the present polyploid level in common alfalfa is the most favorable one from the standpoint of forage and seed production.

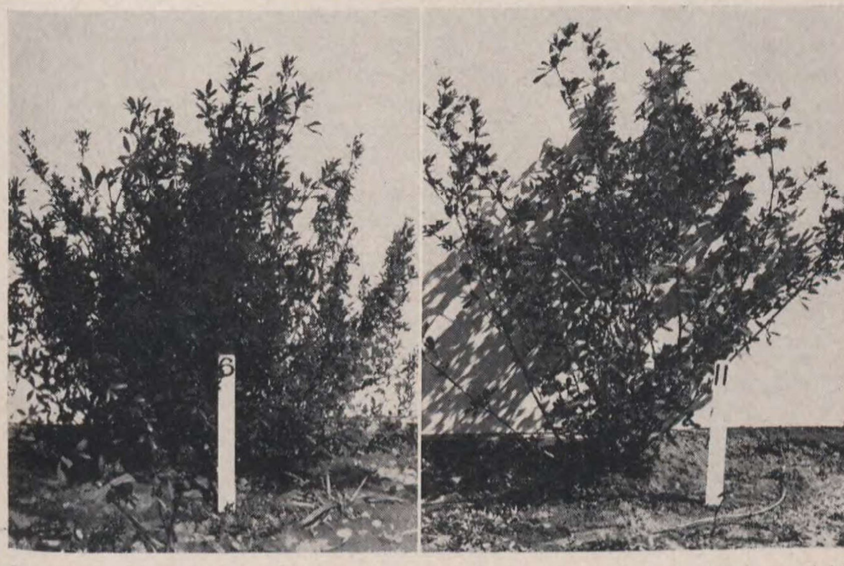

FIGURE 7. **Comparison of normal tetraploid** (at left) and the induced octoploid (at right) alfalfa. While the octoploid is as tall as the normal it possesses thicker stems and tillers less profusely.

Birdsfoot Trefoil.—Work was initiated in the summer of 1950 with *Lotus* spp. to determine the value of induced polyploids. The species investigated were:—*Lotus corniculatus* L., Broadleaf trefoil, $2n = 24$; *L. tenuis* Gaud. narrowleaf trefoil, $2n = 12$; *L. uliginosus* var. *glabriusculus* Bab., Big trefoil, $2n = 12$; *L. uliginosus* var. *villosus* (Thuill) Lamonte, Hairy trefoils, $2n = 12$. Formerly narrowleaf was considered as a sub-species of broadleaf but on the basis of cytological and cross-fertility studies it is now considered to be a distinct species. Tetraploids were readily obtained in the above species by colchicine treatment.

Crossing attempts were made of induced tetraploids with *L. corniculatus* but these crosses were incompatible. The induced octoploid in *L. corniculatus* could not be successfully backcrossed to its normal tetraploid. Studies were continued with *L. corniculatus* in 1952, with the other species being discontinued. The sub-species of *L. uliginosus* have proved non-hardy while *L. tenuis* is low in forage productivity. Results to date show that the octoploids of varieties such as Empire, Granger and Cascade, have a variable increase in vegetative vigor. The loss in fertility is not so marked as in the clovers. It offers promise for further selection.

Cytology of Forage Species

In addition to the routine cytological examination of the principal grasses and legumes, extensive studies have frequently been made to obtain fundamental information on a group of related species in a genus. This affords basic information on possibilities of inter-specific crosses. When such projects are undertaken cytological work must be of a continuing nature to keep pace with breeding problems. The work with induced polyploidy has entailed considerable cytological study and has helped to explain sterility-fertility relationships. Progress in some of this work will be reviewed here.

Alfalfa.—Cytological studies were made on the series of induced polyploids. Four plants of each polyploid were examined and the average percentage frequency of univalents, bivalents and multivalents at first metaphase of meiosis is shown in Table 24.

TABLE 24.—COMPARISON OF THE PERCENTAGE FREQUENCY OF UNIVALENTS, BIVALENTS AND MULTIVALENTS AT MEIOSIS IN ALFALFA POLYPLOIDS.

Type	Univalents	Bivalents	Multivalents
Tetraploid	1·1	88·6	10·3
Octoploid	1·9	65·8	32·3
Hexaploid	2·2	52·2	45·6
Diploid	—	100·0	—

Normal tetraploid alfalfa is not characterized by regular chromosome pairing but always has in addition to bivalents a varying frequency of univalents and multivalents. Some investigators have suggested this meiotic behavior indicated that alfalfa is an autoploid, that is, it originated by chromosome doubling of a simple diploid. Genetic ratios are, however, for the most part disomic rather than tetrasomic in type. The frequency of multivalents in the octoploid is not so high as might be expected indicating that the mechanism of chromosome pairing in alfalfa favors bivalent rather than quadrivalent formation.

If the chiasma frequency at pachytene is low this would be expected. The low frequency of univalents in the hexaploid indicates that the two genomes are sufficiently homologous to permit pairing. The explanation for the origin of alfalfa that best fits both cytological and genetic results is that tetraploid alfalfa originated by the crossing of two diploid species followed by chromosome doubling. The chromosome genomes in the two diploid species were partially homologous to permit pairing. Distinct specific character would be disomic in inheritance while characters common to both species would show tetrasomic inheritance patterns.

Alsike.—A cytological study was made of 15 plants from the tetraploid strains in the fifth generation. The chromosome behavior at first metaphase of meiosis was essentially similar in all plants. The average frequencies of chromosome associations were: univalents 0.37 per cell; bivalents 5.95; trivalents 0.14; and quadrivalents 4.80. The high frequency of quadrivalents, 60 per cent of the total, exceeds any induced tetraploid previously studied and indicates high chiasma frequency at pachytene. These quadrivalents disjoin normally at anaphase and are not a source of meiotic irregularity.

The occurrence of univalents and trivalents can cause defective pollen. However, the mean frequency of these chromosome configurations was very low. All plants showed more than 90 per cent good pollen compared with 90 per cent for the diploid check plants. Seed setting under field conditions ranged from 46 to 76 seeds per head. This range, when the similarity of meiotic behavior is considered, indicates that one or more other factors are operating to affect fertility in the tetraploid plants. Selection of the more fertile plants should therefore prove effective.

Oil-Seed Rape.—The tetraploid of Polish oil-seed rape (2n = 40) was characterized by good fertility from the early generations. Eight plants were examined cytologically in the third generation at first metaphase. The mean frequency of chromosome associations was: univalents 0.03 per cell; bivalents 8.92; trivalents 0.03 and quadrivalents 5.51 per cell. The quadrivalent frequency of 5.51 per cell is high indicating a high chiasma frequency at pachytene. Part of the unusually high fertility for this induced tetraploid is apparently due to the very low frequency of univalents of one per 33 cells. The plants produced on the average 94 per cent good pollen. Polish rape is an attractive source of pollen for honeybees at flowering time. These facts of meiotic regularity and good opportunity for cross-pollination would account for the good seed production of this tetraploid.

PLANT INTRODUCTIONS

R.W. Robertson

At the inception of the breeding program of forage crops it was realized that the work would be greatly facilitated by a free exchange of plant materials and seed with Research Institutions in foreign countries. During the past 20 years the extent of the number of plant introductions received and tested is apparent from the following summary:—

Standard grass species	2869
Standard legume species	2531
Miscellaneous grasses	5579
Miscellaneous legumes	4055
Miscellaneous species	1838
Total	16,872

Some of these introductions have proved of immediate value. A few of the more important introductions now commonly grown are: crested wheat grass, brome grass, alfalfa, Ladino clover, soybeans and oil-seed rape. Some others which have shown promise in tests under special soil and climatic conditions are: intermediate wheat grass, tall wheat grass, Russian wild rye, trefoil and annual lupines. Other introductions have proved of great value in breeding work.

Many of the best licensed varieties have been built up by incorporating good material received as plant introductions. Seed firms in other countries are often anxious to promote a Canadian market for seed of their varieties but before they can be licenced in this country they must be tested here. Much of this material upon testing has proved of little value and hence losses to agriculture are prevented by withholding licences for unadapted varieties.

In addition to the testing nursery at Ottawa other experimental farms and stations carry out comparable tests and a fund of information is built up as to the adaptation of species and varieties to farming areas with distinctive soil and climatic traits. 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 experimental stations at Agassiz and Saanichton test the less hardy species such as *Lolium*. Maritime experimental stations carry out tests with legume species such as the lupins which are acid tolerant and have possible value as an orchard cover crop or as a green manure crop.

MAIN PROJECTS

Plant Breeding, Genetics and Cytology.

Plant Introductions.

Plant Physiology.

Comparative Tests.

Turf Research.

Seed Production Research.

Hay and Pasture Research.

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EXPERIMENTAL FARMS SERVICE

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