DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
DOMINION EXPERIMENTAL FARMS

DIVISION OF FORAGE PLANTS

REPORT
OF THE DOMINION AGROSTOLOGIST

L. E. Kirk, Ph.D.

FOR THE YEARS 1934 TO 1936 INCLUSIVE

Published by authority of the Hon. James G. Gardiner Minister of Agriculture,
Ottawa, 1937

DOMINION EXPERIMENTAL FARMS BRANCH

PERSONNEL

DIRECTOR, E. S. ARCHIBALD, B.A., B.S.A., LL.D., D.Sc.

Dominion Field Husbandman ..... E. S. Hopkins, B.S.A., M.S., Ph.D.
Dominion Chemist ..... C. H. Robinson, B.A.
Dominion Horticulturist ..... M. B. Davis, B.S.A., M.Sc.
Dominion Cerealist ..... L. H. Newman, B.S.A., D.Sc.
Dominion Botanist ..... H. T. Güssow, LL.D.
Dominion Animal Husbandman ..... G. W. Muir, B.S.A.
Dominion Agrostologist .....
Dominion Poultry Husbandman .....
Chief, Tobacco Division ..... N. T. Nelson, B.S.A., M.S., Ph.D.
Dominion Apiarist ..... C. B. Gooderham, B.S.A.
Dominion Bacteriologist ..... Grant Lochhead, Ph.D.
Chief Supervisor of Illustration Stations..... J. C. Moynan, B.S.A.
Economic Fibre Specialist ..... R. J. Hutchinson.

ALBERTA

Superintendent, Experimental Station, Lacombe, F. H. Reed, B.S.A.
Superintendent, Experimental Station, Lethbridge, W. H. Fairfield, M.Sc., LL.D.
Superintendent, Experimental Sub-station, Beaverlodge, W. D. Albright.
Superintendent, Experimental Sub-station, Fort Vermilion.

BRITISH COLUMBIA

Superintendent, Experimental Farm, Agassiz, W. H. Hicks, B.S.A.
Superintendent, Experimental Station, Summerland, R. C. Palmer, M.S.A.
Superintendent, Experimental Station, Windermere, R. G. Newton, B.S.A.
Superintendent, Experimental Station, Sidney, E. M. Straight, B.S.A.

MANITOBA

Superintendent, Experimental Farm, Brandon, M. J. Tinline, B.S.A.
Superintendent, Experimental Station, Morden, W. R. Leslie, B.S.A.

SASKATCHEWAN

Superintendent, Experimental Farm, Indian Head, W. H. Gibson, B.S.A.
Superintendent, Experimental Station, Rosthern, F. V. Hutton, B.S.A.
Superintendent, Experimental Station, Scott, G. D. Matthews, B.S.A.
Superintendent, Experimental Station, Swift Current, L. B. Thomson, B.Sc.
Superintendent, Forest Nursery Station, Indian Head, N. M. Ross, B.S.A., B.F.
Superintendent, Forest Nursery Station, Sutherland, James McLean.

NEW BRUNSWICK

Superintendent, Experimental Station, Fredericton, C. F. Bailey, B.S.A.

NOVA SCOTIA

Superintendent, Experimental Farm, Nappan, W. W. Baird, B.S.A.
Superintendent, Experimental Station, Kentville, W. S. Blair, D.Sc.

PRINCE EDWARD ISLAND

Superintendent, Experimental Station, Charlottetown, J. A. Clark, M.S.A., D.Sc.
Superintendent, Experimental Fox Ranch, Summerside, G. E. Smith, B.A.Sc.

ONTARIO

Central Experimental Farm, Ottawa.
Superintendent, Experimental Station, Kapuskasing, S. Ballantyne.
Superintendent, Experimental Station, Harrow, H. F. Murwin, B.S.A.

QUEBEC

Superintendent, Experimental Station, Cap Rouge, C. E. Ste. Marie, B.S.A.
Superintendent, Experimental Station, Lennoxville, J. A. Ste. Marie, B.S.A.
Superintendent, Experimental Station, Ste. Anne de la Pocatière, R. J. Pelletier, M.Sc.
Superintendent, Experimental Station, Farnham, R. Bordeleau, B.S.A.
Superintendent, Experimental Station, L'Assomption, J. E. Montreuil, B.S.A.
Superintendent, Experimental Station, Normandin, A. Belzile, B.S.A.
Superintendent, Experimental Sub-station, Ste. Clothilde, F. S. Brown, B.S.A.

TABLE OF CONTENTS

DIVISION OF FORAGE PLANTS, CENTRAL EXPERIMENTAL FARM, OTTAWA

DOMINION FORAGE CROPS LABORATORY, SASKATOON, SASK.

DOMINION EXPERIMENTAL FARMS

E. S. Archibald, B.S., B.S.A., LL.D., D.Sc., Director
L. E. Kirk, Ph.D., Dominion Agrostologist

Senior Assistant

F. Dimmock, M.S.A.

Agrostologists

S. E. Clarke, Ph.D.
T. M. Stevenson, Ph.D.
R. M. MacVicar, M.S.A.
J. M. Armstrong, Ph.D.
F. S. Nowosad, M.S.A.
A. M. Ross, B.S.A.

DIVISION OF FORAGE PLANTS

REPORT OF THE DOMINION AGROSTOLOGIST

L. E. KIRK, Ph.D.

INTRODUCTION

The work of the Division of Forage Plants is diversified both with respect to crops and projects. It is concerned with all of the perennial, biennial and annual hay and pasture species, with corn, sorghum, sunflowers and field roots, and includes certain specialized crops, the most important of which are soybeans and sugar beets. The research work is mainly in the field of plant breeding and seed production, but many different field experiments, such as the testing of species, varieties and strains, pasture and range investigations, methods of seed production, seed increase and turf grass experiments, are continually in progress.

PLANT INTRODUCTION

Considerable attention is given to the matter of plant introduction. Central nurseries are maintained at Ottawa and at a Branch Laboratory at Saskatoon, Saskatchewan. The latter handles those species which are best adapted to relatively dry conditions and low winter temperatures. Plant introductions which show promise are sent to Branch Experimental Farms throughout Canada to obtain further information on regional adaptation.

During the last three years tests have been conducted with species and strains of herbage plants as follows:—

	Species	Strains
Perennial grasses	116	206
Perennial legumes	23	107
Annual grasses	4	9
Annual legumes	15	19
Other than grasses and legumes	8	9

COMPARATIVE STUDY OF VARIETIES

Varietal tests have been made during the last three years at Ottawa and at the Branch Experimental Farms in each of the provinces. These tests have been standardized with respect to varieties, source of seed, plot arrangement and procedure in crop management. Certain fundamental information is obtained in a uniform manner from each test. The yield results are submitted to statistical analysis. The crops tested, number of varieties and number of stations involved were as follows:—

Crops	Varieties	Stations
Alfalfa	6	16
Red clover	6	9
White clover	6	8
Sweet clover	10	15
Timothy	7	8
Slender wheat grass	7	6
Soybeans	6	12
Corn for silage	8	14
Corn for grain	7	15
Sunflowers	4	10
Mangels	6	13
Swedes	6	13
Club-root resistant swedes	12	4
Sugar beets	14	11

PLANT BREEDING AND SELECTION

ALFALFA *(Medicago)*

During the past three years improvement work with alfalfa has been directed towards the development of better seed-producing types. With the discovery of autogamous plants in the Grimm variety, a study was first made of their breeding behaviour. It was found that their exceptional seed-setting qualities were due to self-tripping, and that whenever any two autogamous plants were crossed the hybrid always possessed an exceptional capacity for seed-setting. On the other hand, inbreeding of autogamous plants invariably gave a progeny with a lower seed-setting capacity than the parents. It was decided, therefore, to combine synthetically, by intercrossing, eight of the best autogamous individuals in an effort to produce a strain which would retain its vigour of growth, and one which would be more or less independent of unfavourable environmental conditions for seed production.

The first hay and seed crop of a thorough-going comparison with other varieties was harvested in 1936. The new strain proved to have excellent hay quality, to be slightly superior in hay yield to all other varieties, and to be greatly superior in seed-yielding ability, giving 50 per cent more seed than the best standard variety in this test. This superiority in seed yield was due in that year mainly to the ability of the strain to set pods under adverse weather conditions. It is recognized that the maintenance of the high seed-setting character in succeeding generations will depend on the amount of cross-fertilization which takes place, because if all the seed were produced by self-fertilization the vigour of growth and yield of seed would quickly be lost. Through insect pollination, and to some extent through wind pollination, it is expected that considerable cross-fertilization will take place each season. Preliminary experimental results indicate that 30 to 40 per cent of the seed set in autogamous alfalfa strains under field conditions is the result of cross-fertilization. This is sufficient to insure a high degree of heterzygosity and high seed production.

To determine why a high percentage of autogamous alfalfa plants consistently produce pods when protected from insect pollinators, whereas most alfalfa plants produce little or no pods unless the flowers are artificially manipulated, a study was made of various factors having a bearing on the subject. Certain prerequisites to seed production apply for alfalfa plants generally. The most important of these is that the staminal column must be released from the keel, i.e., the flower must be tripped. In ordinary alfalfa plants in the greenhouse this must be done artificially, but in the autogamous plants it takes place automatically more or less independently of the environmental conditions. In the two types of plants morphological differences in the tripping mechanism were noted. Evidence was obtained that in the act of tripping, the stigmatic exudation initiates pollen germination. Pollen sterility is a factor in seed-setting in determining both the percentage of pods produced and the number of seeds per pod.

Improvement work with the Ladak variety of alfalfa was begun for two reasons. Yield trials at the University of Saskatchewan and at the Dominion Range Experiment Station at Manyberries, Alta., previous to 1932, indicated the superiority of this variety. Furthermore, as it shows a wide variation of growth habit and flower colour, it offers an excellent source of material for selection. Breeding work was started on this variety in 1934 when 150 selections were made. By means of a progeny test these have been reduced to 60. Further reduction in the number of selections will be made after an experiment to measure the outcrossing ability of the plants has been completed. The final step in the breeding program will be to synthesize the best plants into strains by artificial crossing or isolation.

Although yellow-flowered alfalfa has little value as a hay crop it has promising possibilities for improvement as a component in pasture mixtures. In 1934 a sample of Siberian was received from the U.S.S.R. This sample was hand-collected from superior pasture types. A mass nursery was established from this seed and selection was made of promising plants on the basis of two characters. Those plants which showed a tendency to spread by underground stems were chosen, and from this group those which podded well and retained their seed were reselected. Progeny tests are now being conducted on these plants. Another species which is promising as a pasture plant is *Medicago glutinosa*. This possesses the spreading habit to a marked degree and is a fair seed producer.

Red Clover *(Trifolium)*

The improved varieties of red clover have reached their present status by mass selection over a period of years. Selection was started with the Ottawa variety in 1913. Spaced plant nurseries of from 10,000 to 15,000 plants have been periodically established and selection has been made of the best plants which survived two winters. Seed was harvested from the second cutting. In this way a hardy strain with a certain degree of perennialism has been obtained. In extensive field trials Ottawa has shown up favourably in comparison with other varieties. It has been distributed to growers in the Ottawa valley since 1933.

The limit of improvement of this variety by mass-selection methods has perhaps been reached. Since 1933 further improvement has been sought by composite crossing of superior plants.

Timothy *(Phleum)*

Forty-two local and introduced strains of timothy and one hundred selections are being studied in the grass garden. It is desired to isolate a sufficient number of unrelated strains of types suitable for pasture to form a synthetic variety. The strictly pasture forms of the diploid species appear to be better adapted to a maritime than to a continental climate such as obtains at Ottawa. On the other hand, leafy pasture forms are comparatively rare in hexaploid material. Nevertheless, a few promising selections have recently been obtained. Experience indicates that a combined hay and pasture variety with reasonably good capacity for seed production is likely to be the most useful. Selections that are most desirable from the standpoint of leafiness, strong tillering and continuity of growth are invariably late maturing.

Orchard Grass *(Dactylis)*

Various strains of this species have been introduced and tested. Improved indigenous strains from the Welsh Plant Breeding Station and the Akaroa variety from New Zealand are distinctly superior in leafiness to the stemmy orchard grass of commerce. The former is somewhat less winter-hardy than the latter. The strains which have shown the greatest resistance to frost injury are Ottawa selection No. 599, and Avon, the latter being a selection from Macdonald College. Neither strain excels in leafiness, but both are reasonably good hay types.

Bluegrass *(Poa)*

The grass nursery at Ottawa contains 29 strains of Kentucky bluegrass, *Poa pratensis*, and 5 strains of Canada bluegrass, *Poa compressa*. A number of the former have been introduced from England, Denmark, and Sweden. Both species exhibit variability to a remarkable degree, and strain tests are being made in pasture plots both with and without wild white clover. An

exceptionally tall-growing and early-maturing type was selected a few years ago and the seed has been increased, but its value for pasture in comparison with some of the later maturing strains is doubtful. Some of the selected strains of both species give promise of being distinctly superior to commercial material.

The somatic chromosome numbers of 20 species of *Poa* were determined. The species arranged themselves in a polyploid series from diploid to dodecaploid, with tetraploids and hexaploids being the most numerous. The chromosome variability and the mode of seed production were examined in *Poa pratensis* L. using selected uniform strains, indigenous plants and plants grown from commercial seed.

Perennial Rye Grass *(Lolium)*

Of several regional strains of perennial rye grass from foreign sources, the Swedish Victoria variety has shown the greatest winter-hardiness. A strain developed by this Division from numerous selections made some years ago out of Russian material exhibits still greater winter-hardiness. Except in the Pacific Coast area, however, considerable improvement in frost-resistance in this species must yet be secured before it is sufficiently dependable under Canadian conditions.

Hybridization of Wheat with Agropyron Grasses

A plant-breeding project involving the crossing of wheats with perennial Agropyron grasses was begun in 1935. The main objective of this work is the production of a new and superior forage plant adapted to the drier areas of Western Canada. Such a plant should be large-seeded to ensure ease in seeding and harvesting, and to adapt it to establishment in a dry soil; it should be perennial and resistant to drought and cold; it should have good soil binding properties, and should give a good yield of palatable, nutritious forage. The parents embrace, collectively, all of these qualities, and there seems to be no reason why hybrid types having more or less ideal combinations of parental characteristics should not be produced.

During the seasons of 1935 and 1936 crosses were attempted between seven species of wheat and ten species of Agropyron. A total of 54,385 wheat florets cross-pollinated with Agropyron pollen resulted in the production of 2,895 seeds, almost all of which were produced by crosses involving *Agropyron glaucum* and *Agropyron elongatum*.

Self-fertile plants were found in crosses involving *Agropyron elongatum* and the wheat varieties, C. A. N. 1835, Lutescens 0·62, Kharkov, and Mindum. No fertile plants were found in crosses involving *Agropyron glaucum*.

The first-generation hybrids are perennial and tend to be more like Agropyron than wheat in their general type. In the second generation, segregates range, in general, from intermediate to Agropyron-like types with very few forms approaching the wheat type. In order to increase the number of wheat-like segregates for selection, the first generation hybrids have been back-crossed to the wheat parent. The progeny of back-crosses tend to be more wheat-like in type; many are fertile and appear to have excellent agronomic possibilities.

The National Research Council is co-operating in this project by making cytological studies on the parental and hybrid materials and by investigating the fundamental causes of hybrid sterility.

The Branch Laboratory at Saskatoon, Sask., is participating in the breeding work of this project, a progress report on which may be found on page 20.

Soybeans

Selection has been carried on within a large collection of material obtained principally from Manchuria, and the United States Department of Agriculture. A number of selected strains are now undergoing tests in comparison with standard varieties and several of them appear to show considerable promise for production under Canadian conditions.

A large number of hybrids have been obtained by crossing between the following varieties: Manitoba Brown, Mandarin, Poland Yellow, A. K., and Selections I, 17, and 171. Progenies from the Manitoba Brown × Mandarin have been selected which, according to the results of comparative tests conducted in Eastern and Western Canada, show much promise for early maturity, high yield, and good plant type. Crosses between the other varieties are more recent, but already many of the selected progenies are outstanding in many respects.

Two new varieties of soybeans have been produced, namely, Mandarin (Ottawa), and Kabott.

Mandarin (Ottawa) is an improved strain of the old Mandarin variety. It is early in maturity and is an excellent yielder of grain. It is adapted particularly to eastern Ontario and Quebec, but because of its earliness and high yield it is becoming increasingly popular also in western Ontario.

Kabott was licensed as a new variety in March, 1937. It is a single plant selection which was obtained from a mixed sample of Manchurian seed, received and grown at Ottawa in 1933.

In comparison with Mandarin (Ottawa), Kabott is about ten days earlier in maturity but does not yield quite so much grain or forage. It is yellow-seeded and well adapted to areas in which the season is somewhat too short for the successful production of Mandarin.

Elite stock seed of Mandarin (Ottawa) was distributed to a number of selected growers in the Ottawa valley for the first time in 1935. Over 500 bushels of registered seed were produced as the result of this distribution. In 1936 the quantity of registered seed produced increased to approximately 2,000 bushels, all of which was disposed of readily for seed purposes. Mandarin (Ottawa) is now a well-established variety throughout eastern and western Ontario, as well as in certain parts of Quebec.

The first distribution of seed of Kabott was made in 1936, when about 15 pounds of seed was sent to the Dominion Experimental Station, Lennoxville, P.Q., to be grown for the purpose of increase. Approximately 6 bushels of seed were harvested and most of this was distributed to selected growers for further increase, while a portion was reserved to be multiplied on the Branch Farm at Lennoxville and the Central Experimental Farm, Ottawa. A good supply of Kabott seed should be available for distribution in 1938.

Corn

As a result of the breeding and selection work with corn, new strains of the following types have been obtained:—

8-rowed yellow flint—three strains, very early, early, and medium early.
12-rowed yellow flint—one strain, medium early.
14-16-rowed yellow dent—one strain, medium early.
12-14-rowed red dent—one strain, medium early.

These strains were obtained as the result of selection within synthetic crosses of inbred strains of the various types. More than 200 inbred lines had been selfed for periods varying from 4 to 10 years before the crosses were made.

The strains are all being compared in tests with standard varieties of similar types, and while these tests have not been concluded at this time, indications are that some of the strains will prove superior to the varieties from which they originated.

Varietal hybrids have been made between early flints, Improved Yellow, Twitchell's Pride, Improved White, and White Flint (Ottawa), and late dents, Wisconsin No. 7 and Canada Golden Glow. These hybrids have been tested for ensilage production in comparison with the late parent varieties and with other recommended varieties and varietal hybrids, and have compared very favourably with them from a yield standpoint—particularly when earliness is taken into consideration. Twitchell's Pride × Canada Golden Glow appears to be an excellent cross, and larger quantities of seed of this combination are being produced so that more extensive tests may be made. Varietal hybrids of this type are particularly suitable for districts where the season is somewhat too short and cool for the production of the common ensilage varieties.

Millet

Two new varieties of millet have been obtained by selection out of seed imported from Manchuria in 1928. Seed was released to farmers first in 1936, and both varieties were licensed in 1937 under the names Crown and Empire.

Crown millet was obtained by mass selection. It is a relatively fine-stemmed panicle *(effusum)* type of Proso, which gives a fair yield of hay and a heavy yield of grain. The seed is broadly oval and grey in colour. This variety is slightly earlier in maturity than Hog or Early Fortune, the two varieties of Proso that are commonly grown.

Crown millet has been widely tested on the Branch Experimental Farms as well as at Ottawa, particularly for its grain-yielding ability. In all these tests it has given high yields of well-matured grain. Seeded at the end of June it has yielded up to 1,500 pounds of seed per acre, while oats and barley seeded at the same time were failures. Spring seedings in comparison with oats, barley, and Hog millet has shown clearly that Crown millet is much superior to Hog millet in yield of grain. In most of the tests it has outyielded oats, and in several it has been almost equal to barley. The quality of the hay also is superior to that of Hog millet.

Empire millet was developed by single plant selection. Several of the selected lines, very similar in type and all with bifurcate heads, were bulked together to form this variety. It is a tall, late-maturing strain of the foxtail type. The seeds are yellow in colour and almost round in shape. The variety may be readily identified in the field by the high percentage of heads which are divided at the tip. This bifurcate character is dominant, but the degree of expression depends to a considerable extent on environmental conditions.

Empire millet has been widely tested on the Branch Experimental Farms as well as at Ottawa. It has consistently outyielded all the commercial millets for hay, including Japanese, which matures about the same time. It is more leafy also than other late maturing varieties. High yields of mature seed are obtained from row seedings at Ottawa, and seed can be matured readily in western Ontario.

Field Roots

A new variety of Yellow Intermediate mangel, and a new variety of Purple Top swede, were licensed for sale and released to farmers in 1936 under the names "Tip-top" and "Acadia," respectively. The improvement work was begun under the direction of the late Dr. M. O. Malte, then Dominion Agrostologist. In later years the process of selection was carried on under the direction of the late Mr. R. I. Hamilton, to whom these varieties largely owe their development.

Tip-top Yellow Intermediate Mangel.—In 1913, 125 roots of Giant Yellow Intermediate, which was one of the best mangel varieties available, were selected for breeding work. During the following years a rigorous type of selection was followed, and at the same time all roots which did not show good feeding characteristics were discarded. In 1920 family breeding from individual isolated roots was started. In each of the following years only the very best families were retained. Roots were selected for high dry matter content by the brine method.

The outstanding feature of this variety is the high dry matter content of the roots. In all tests in which the variety has been included the percentage of dry matter has been much higher than those from all other varieties tested. This not only beneficially influences the keeping quality of the roots but also means reduced hauling costs and smaller storage space per feed unit. In addition to this characteristic, the variety has shown marked uniformity of shape, size, and colour, and excellent quality throughout. In comparison with other varieties, good yields of the new variety have been obtained in all places where it has been tested.

The Tip-top mangel has been carefully tested for a number of years at Ottawa and on several Branch Experimental Farms and Stations. In all of these tests the high dry matter content of the roots has been demonstrated, and total dry matter yields have been highly satisfactory. In the series of tests covering three years, and ending in 1935, the percentage of dry matter in the roots of this variety was significantly higher than those of all other varieties. It also gave the highest yield of dry matter, being significantly higher in this respect than all other varieties except Half Sugar White.

Acadia Purple Top Swede.—The selection of this variety was started in 1914. The parent roots were obtained from a good commercial strain of the Bangholm variety. Since that time a rigorous selection for trueness to type, short neck, firmness of flesh, and good quality, has been carried on. The new variety is considered to be superior in all of these particulars.

Acadia Purple Top swede has been included in the standard variety test in Ottawa and on Branch Experimental Farms for several years. In a three-year test ending in 1935, this variety gave the highest yield of dry matter, being significantly higher in this respect than all other varieties except Ditmars Bronze Top. In a comparison with Hall's Westbury, a purple top variety very popular as a table turnip, Acadia excelled in green yield, dry matter percentage, and yield of dry matter per acre.

Club-Root Resistant Varieties of Swedes.—Problems relating to the control of the club-root disease of swedes has been under investigation by a special committee of Dominion experimental station workers in the Maritime Provinces. Those phases of the project which relate to the work of the Division of Forage Plants have to do with varietal resistance and the selection of resistant strains. Following an extensive test of materials, which included most of the varieties and strains grown in Canada and imported, a thorough-going test was instituted of all those which appeared to possess a fair amount of resistance to the disease. This test has included about 12 varieties in each of the three years under review, and it has been conducted on each of the Branch Farms at Fredericton, Nappan, Kentville, and Charlottetown, and also on 11 Illustration Stations where the soil was known to be affected.

The results of this experiment indicate that the degree of resistance in all varieties was markedly different at each of the four stations, due, presumably, to a fundamental difference in the nature or virulence of the organism, or to soil factors which are not well understood. At Nappan the susceptible control variety was completely destroyed, while the resistant varieties varied

from good to excellent. At Charlottetown the control variety was badly affected, but not completely destroyed, while the resistant varieties were slightly less resistant than they were at Nappan. At Fredericton all varieties were badly affected with the disease, but there was sufficient difference to show that the resistant varieties possessed somewhat greater resistance than the control variety, and that there were differences in the degree of resistance between the different varieties. At Kentville all varieties were completely destroyed.

Taking into account also the results of tests on Illustration Stations, the most resistant material was found to be the Wilhelmsburger variety and certain strains of Bangholm. All strains of Wilhelmsburger were somewhat more resistant than any of the strains of Bangholm, but one strain of the latter in particular (Bangholm-Herning, D.L.F.), was almost as resistant as some of the Wilhelmsburger strains. Seed of the Wilhelmsburger variety, imported in 1935 from Hjalmar-Hartmann, of Denmark, has been at the top of the list for all three years, followed by Wilhelmsburger, D.L.F. The difference between strains of Wilhelmsburger is not great, but is well defined. Differences in the resistance between strains of Bangholm are much more pronounced than between strains of Wilhelmsburger. Bangholm-Herning, D.L.F., was definitely the best, followed by Bangholm-Herning, Hartmann.

The clear-cut and consistent results obtained in these club-root experiments during the last three or four years has provided information of great value both to farmers and seedsmen, so that the use of seed of resistant varieties is already widespread in certain sections where club-root disease had greatly decreased the value of this crop. In order to ensure a supply of home-grown seed of the best resistant strains which can be relied upon to retain their original disease resistance, the production of elite stock seed of the Wilhelmsburger variety is being undertaken at the Nappan station, and farmers in that vicinity are being encouraged to use fresh supplies of elite stock seed annually for seed production. Similar work is being undertaken at the Fredericton station with the Bangholm-Herning D.L.F. strain; in both varieties the elite stock traced from mother seed imported in 1935, as this has been found to be somewhat more resistant than seed of the same strain imported in 1936, or other strains of the same variety. Roots for elite stock seed production are being continually selected in order to maintain an improved stock.

Sugar Beets

During the three years 1934 to 1936, a comparative study was made of a number of sugar beet varieties and strains. The tests were conducted at Ottawa and on ten Branch Experimental Farms as follows: Nappan, N.S.; Fredericton, N.B.; Farnham, P.Q.; L'Assomption, P.Q.; Harrow, Ont.; Kapuskasing, Ont.; Morden, Man.; Lethbridge, Alta.; Agassiz, B.C.; Saanichton, B.C. The tests were standardized in plot arrangement, source of seed, experimental methods and statistical treatment. Apart from securing reliable data as to the adaptation of the sugar beet crop at each of these places, the chief interest lay in the comparison between the common commercial varieties and the more recently selected high sugar strains obtained from various countries, and their respective ability to produce a high yield of sugar per acre. Data were obtained with respect to yield of beets per acre, percentage of sugar and nitrogen in the beets, and finally the yields of sugar per acre.

The results for the three-year period were very consistent in each year and for all stations. They showed that the commercial varieties—R. and G. Normal, Zapotil, and Dippe "E"—gave the highest yields of both beets and sugar per acre. These varieties may be regarded as "high tonnage" rather than "high sugar" varieties. The specially selected "high sugar" strains—Homegrown "A," Stokes A1, and R and G "Z" type—were the lowest in yield of sugar per acre due to low tonnage production.

The tests indicated that high tonnage was the most important factor responsible for high yield of sugar per acre. The " high sugar " strains had the highest mean percentage of nitrogen, and the high tonnage producers were generally the lowest in this respect. Since the " high sugar " selections are low tonnage producers, the results indicated an association between the yield of beets and the percentage of nitrogen.

The possibilities of sugar beet seed production was also investigated during the same years and at the same Branch Farms. While the tests were conducted on a relatively small scale, the results during the three years were fairly consistent, and showed that good yields of sugar beet seed were possible at Nappan, N.S., Ottawa, Ont., and Saanichton, B.C. An average production of 1,900, 1,822, and 2,200 pounds of seed per acre, respectively, was obtained at these stations. Good yields were also obtained at Lethbridge, Morden, and Kapuskasing, although at the latter station the seed produced was low in germination, indicating that the season was rather too short for proper maturity. There were indications that good yields of seed may also be obtained at Fredericton, and possibly L'Assomption. When low yields have been obtained at these stations they have usually been due to the poor conditions of the mother beets, resulting from unsatisfactory conditions during the winter storage. Seed production at Harrow and Agassiz was not satisfactory, being consistently low in all years at both places.

PASTURE INVESTIGATIONS

Cutting and Sampling Technique

The pasture experiments have consisted of several series of 1/100-acre plots, clipped periodically to simulate grazing, and of grazing trials with cattle and sheep conducted in larger fields. The frequency with which the plots were clipped was either five or nine times per season. Both frequencies were commonly used on the same series in order to get a comparison between what would correspond to heavy and normal grazing. The implement used for this purpose was a Planet Junior tractor-mower with a centre drive cutting bar in front of the tractor, and with a pan attached immediately behind the cutting bar to catch the herbage as it was cut. This device avoided the loss of fine leaves and reduced the amount of soil and silt picked up by eliminating the raking which is necessary when the herbage is cut with an ordinary horse mower. The permanent pasture plots were sometimes clipped with a lawn mower to simulate very close grazing.

The yield of herbage on grazed pasture experimental fields was obtained from wire cages, each covering one square yard. It was found that the use of ten cages per acre provided a comparison between mixtures of a standard error of less than 10 per cent, and that a standard error as low as 2·5 per cent was obtained between fields with different fertilizer treatment when the data from the different mixtures in each field were combined. The herbage under the cages was cut with the same tractor-mower as was the plots, and all of the herbage was removed directly from the pan of the mower into paper bags. These were taken direct to the dehydrator without weighing and were reduced to absolute dry matter.

Botanical Analyses

Botanical analyses of the herbage in each of the mixtures was made every year in the spring before clipping or grazing was started, and in the fall after growth had ceased. Different systems of estimation, such as the ground-cover method, the point-quadrat method, and estimation and separation by weight, have been tried, but the first-mentioned method was finally adopted. In this method the botanical composition is determined by estimating the degree to

which any particular species covers the ground as expressed by the collective crown-spread of all individual species. A quadrat one-half by one-half metre was used, the quadrat area being divided into 25 equal squares by means of fine steel wires. When a ground-cover was calculated, a count was taken of all plants in the quadrat by expressing them first in units of 1 to 10 per small square, and then in percentage of the total area. Four such quadrats were permanently located in each $\frac{1}{100}$-acre plot. In many analyses both the ground-cover method and the estimation-by-weight method were used in the same plots. The relative contribution of different species was estimated by the latter method on all of the cages before every clipping.

Tests with Pure Species

A number of grass species were grown in pure stands in order to obtain data on relative yield, palatability, nutritive value, winter hardiness and persistence; and series of plots were laid down for both clipping and grazing trials with sheep and cattle. The yields of a number of these species are given in Table 1.

TABLE 1.—FOUR-YEAR AVERAGE YIELDS OF DRY MATTER IN POUNDS PER ACRE OF PURE SPECIES, CLIPPED FIVE TIMES PER SEASON

Species	Yields
Timothy	2,674
Red top	2,383
Meadow foxtail	2,167
Meadow fescue	2,115
Reed canary grass	2,110
Canada bluegrass	2,044
Orchard grass (Akaroa)	1,905
Kentucky bluegrass	1,710
Tall oat grass	1,683
Crested wheat grass	1,615
Red fescue	1,801
Perennial rye grass	1,077

The following notes on these species of grasses give a general idea of their adaptation for pasture purposes at Ottawa:—

Timothy *(Phleum pratense)*.—This is the most widely adapted of all the grasses. The yields of timothy have been higher than those of any other grasses grown alone at the Central Experimental Farm, Ottawa. It is winter-hardy and grows well in association with other species. Its chief disadvantage is that it is short-lived if grazed very closely.

Red top *(Agrostis alba)*.—Yields of red top have been consistently high, but this grass is only of secondary value for pasture because it is less palatable and less nutritious than some of the better grasses. Under favourable conditions it quickly crowds out the other species. It is sometimes included in mixtures to provide bottom in the pasture.

Meadow foxtail *(Alopecurus pratensis)*.—This grass has been yielding well and has been exceptionally winter-hardy at Ottawa. However, it is not very palatable; neither is it compatible with other species, and its seeding habits are very unsatisfactory.

Meadow fescue *(Festuca elatior)*.—This is a tall-growing species of fescue. It has been sufficiently winter-hardy for all practical purposes, although on certain soils it does winter-kill occasionally. Meadow fescue is fairly palatable and grows well in association with other grasses and legumes.

Reed canary grass *(Phalaris arundinaceae)*.—A hardy and vigorous grower, this species has given heavy yields under favourable conditions. It is perfectly winter-hardy, and thrives best under moist conditions. It is readily grazed by cattle and to a lesser extent by sheep.

CANADA BLUEGRASS *(Poa compressa)*.—This species of bluegrass is indigenous to Ontario. It is better suited than Kentucky bluegrass on light soils subject to drought. Canada bluegrass does not form as dense a turf as Kentucky bluegrass under the conditions at Ottawa, and for this reason wild white clover has persisted better with it than with Kentucky bluegrass. For the past four years Canada bluegrass has consistently yielded more dry matter and has been more palatable and nutritious than Kentucky bluegrass.

ORCHARD GRASS *(Dactylis glomerata)*.—This grass makes an early vigorous growth in the spring and after each cutting. The young growth is relished by livestock, but it soon becomes coarse and very unpalatable. Orchard grass grows equally well under moist and droughty conditions, but it is not sufficiently winter-hardy to be depended upon to produce a crop every year.

KENTUCKY BLUEGRASS (*Poa pratensis*).—This grass is the dominant species in natural pastures on non-acid soils of Eastern Canada. In seeded plots, Kentucky bluegrass by itself has proved to be relatively unproductive and less palatable than most other grasses. Seeded in a mixture with other species on land to which it is highly adapted, it crowds out most other species in three or four years.

TALL OAT GRASS (*Arrhenatherum elatius*).—This species is not winter-hardy and for this reason it is less productive than a number of other species of grass. However, it is reasonably palatable and nutritious.

CRESTED WHEAT GRASS (*Agropyron cristatum*).—Experimental work with this species indicates that it is not adapted to conditions in Eastern Canada. It appears to be fairly winter-hardy, but it does not thrive well and produces low yields.

RED FESCUE (*Festuca rubra*).—Creeping red fescue is essentially a bottom grass. When grown alone it has not been especially productive at Ottawa, nor is it readily eaten by live stock. It has greater promise in pasture mixtures.

PERENNIAL RYE GRASS (*Lolium perenne*).—This grass has not been productive in Eastern Canada because of its lack of winter-hardiness. It grows well in association with white clover and is readily grazed by all classes of livestock.

Strain Tests.—A large number of plots were seeded down in 1935 to test the relative value of different strains and varieties of the same species of grass. Only one season's results of this experiment are yet available.

Legumes.—A number of legumes were tested in pure stands and were clipped periodically to determine their relative yields. Some of the data are given in Table 2.

TABLE 2.—FOUR-YEAR AVERAGE YIELDS OF DRY MATTER IN POUNDS PER ACRE OF PURE SPECIES, CLIPPED FIVE TIMES PER SEASON

Species	Yields
Alfalfa	5,424
Alsike	3,116
White clover (Common)	3,279
White clover (Wild)	1,983
White clover (Morso)	3,174
White clover (Mammoth)	4,743

The above species of legumes should always be grown for pasture in mixtures, but the data presented give an indication of their relative productivity at Ottawa when they are grown alone.

Tests with Mixtures

There is ample evidence to indicate that legumes have a direct beneficial effect on the growth of grasses associated with them. At Ottawa, mixtures of grasses and legumes have consistently outyielded pure species. The yield of pasture herbage from ten cultivated grasses grown separately for a period of three years varied from 1,077 to 2,415 pounds moisture-free herbage per acre, with an average production of 1,953 pounds; whereas the yield of ten grass-legume mixtures in the same test varied from 4,016 to 5,712 pounds, with an average production of 4,924 pounds per acre. The legumes were lucerne, red clover and alsike. The yields of these legumes grown alone were all appreciably less than those of the mixtures.

Another series of plots comprising four different grasses grown separately and three grass mixtures were clipped eight times per season, and averaged 1,023 pounds per acre of moisture-free herbage; whereas a comparable series consisting of the same grasses and mixtures sown with wild white clover averaged 2,866 pounds per acre. Wild white clover grown alone in the same experiment gave 2,475 pounds per acre.

Space does not permit a report on the numerous pasture mixtures which have been tested. It will be of interest, however, to compare the results from four fundamentally different mixtures, cut five times per season for a three-year period. The yields of herbage for each of the seasons 1934, 1935, and 1936, and the three-year average, are given in Table 3.

TABLE 3.—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF DIFFERENT MIXTURES, CUT FIVE TIMES PER SEASON

Pasture Mixtures	Pounds dry matter per acre			
	1934	1935	1936	Average
1. Timothy, red clover and alsike	4,777	3,181	3,769	3,909
2. Same as No. 1 plus bottom grass*	5,243	3,463	3,521	4,076
3. Same as No. 2 plus alfalfa	6,586	4,761	5,778	5,708
4. Timothy, Kentucky blue and wild white clover	3,603	3,332	1,451	2,795

* Kentucky bluegrass, red top and white Dutch clover.

It may be seen that the addition of Kentucky bluegrass, red top and white clover increased the yields somewhat of mixture No. 2 over mixture No. 1 for the first two years. This was largely due to the red top. By the third season the yield of mixture No. 2 was lower than that of mixture No. 1 due to the fact that Kentucky bluegrass had occupied the ground so completely that it began to suppress the other species.

Mixture No. 3, which was the same as mixture No. 2 with the addition of 4 pounds of alfalfa seed per acre, had the highest yields throughout. It is interesting to note that alfalfa was able to withstand the clipping treatments for three years. Alfalfa, being a deep-rooted crop, was able to withstand drought conditions and persisted in spite of competition with the bottom grasses.

Mixtures 1, 2 and 3 yielded considerably more than mixture No. 4, thus clearly emphasizing the fact that, in a short ley, red clover and alfalfa are important in producing high yields. The sharp drop in the yield of mixture No. 4 in 1936 was the result of the disappearance of wild white clover in this year, and a marked increase of Kentucky bluegrass. This would not have occurred had the bluegrass been less aggressive, and could probably have been prevented by very early grazing or by cutting in the early spring while the white clover was establishing itself. Although the grass was clipped to a height of approximately one inch and was never allowed to reach a height

of more than five or six inches, the Kentucky bluegrass was able to suppress the white clover because of its rapid and vigorous growth before the clover got started.

In order to determine whether more frequent clipping would favourably effect the persistence of wild white clover, one-half of each plot was cut nine times instead of five times. The yields from the same four mixtures shown in Table 3 are given in Table 4.

TABLE 4.—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF DIFFERENT MIXTURES CUT NINE TIMES PER SEASON

Pasture Mixtures	Pounds dry matter per acre			
	1934	1935	1936	Means
1. Timothy, red clover and alsike	4,440	2,609	2,654	3,234
2. Same as No. 1 plus bottom grasses*	4,669	3,458	2,264	3,464
3. Same as No. 2 plus alfalfa	5,746	2,781	3,042	3,856
4. Timothy, Kentucky blue and wild white clover	3,759	3,362	1,622	2,914

* Kentucky bluegrass, red top and white Dutch clover.

It may be seen by comparing Tables 3 and 4 that mixtures 1, 2, and 3 yielded less and mixture 4 yielded slightly more under the nine clippings than under the five. The desirability of close grazing or clipping for the development of wild white clover is apparent. Nevertheless, in mixture 4 the same sharp reduction occurred in 1936, showing that the more frequent clipping treatment still did not ensure the persistence of wild white clover. More frequent clipping throughout the season did not compensate for the need of close clipping of the bluegrass at the very early stages of growth.

The dominance of Kentucky bluegrass *(Poa pratensis)*, in conjunction with the exceptionally rapid early spring growth, and the dry, hot weather at mid-summer, is believed to be mainly responsible for the paucity of wild white clover on the better classes of soils in southern and eastern Ontario.

It is evident also that with mixtures 1 and 3 more frequent clipping greatly reduced the yields in 1935 and 1936. This effect was most prominent in the mixture containing alfalfa, which shows that alfalfa does not tolerate too frequent defoliation by cutting or grazing.

Pasture Mixtures—Grazing Trials

In the spring of 1933 a field experiment was started in co-operation with the Divisions of Field Husbandry, Animal Husbandry, and Chemistry for the purpose of comparing various pasture mixtures under actual grazing conditions and fertilizer treatments.

A field of twenty acres which had been cropped for many years was fenced into three fields of equal size. The fertilizer treatments were applied before seeding as follows:—

Field NPK—Complete fertilizer
100-50 lbs.—Sulphate of ammonia annually
400 lbs.—16 per cent Superphosphate } every three
100 lbs.—Muriate of potash } years
Field Nil—No fertilizer
Field PK—Mineral only
400 lbs.—16 per cent Superphosphate } every three
100 lbs.—Muriate of potash } years

Seven fundamentally different mixtures were seeded with a nurse crop of oats in each field. The composition of the mixtures and the rates of seeding are given in Table 5.

TABLE 5.—RATE OF SEEDING OF PASTURE MIXTURES IN POUNDS PER ACRE

Species	Mixtures						
	A	B	C	D	E	F	G
Timothy	12	10	10	10	4	4	5
Red clover (early)	9	9	.....	5	2½	2½	5
Red clover (late)	.....	.....	9	.....	2½	2½	.....
Alsike	2	2	2	2	2	2	2
Alfalfa	.....	.....	.....	4	4	4	4
Kentucky bluegrass	.....	5	5	5	4	10	2
Red top	.....	3	3	3	.....	.....	2
White Dutch clover	.....	2	.....	2	2	2	2
English wild white clover	.....	.....	2	.....	.....	.....	.....
Orchard grass	.....	.....	.....	.....	10	4	4
Meadow fescue	.....	.....	.....	.....	.....	.....	4

This pasture was grazed by milch cows in 1934, 1935 and 1936. Each year the yields were determined by placing ten wire cages, each covering one square yard, on every mixture in each field, i.e. 210 cages in all. The herbage was harvested as described in the section under *Technique*. Five cuttings were made each season, and after every clipping the cages were moved to fresh areas which had been grazed continuously, thereby approximating pasture conditions as much as possible and at the same time getting a more random sample of the vegetation from each mixture.

Table 6 shows the average dry matter yields of seven different mixtures under different fertilizer treatments. The data were statistically analyzed each year in order to determine the effect of the fertilizer treatments on the yield of dry matter.

In 1934 the field with treatment PK was significantly higher in yield than the other two fields. In 1935 both PK and NPK were significantly higher than the untreated field. In 1936 the field with the PK treatment was significantly higher in yield than the field with NPK treatment. The average yields of the three years indicate that only the field with PK treatment was significantly higher in yield than the untreated field.

TABLE 6.—YIELDS OF DRY MATTER IN POUNDS PER ACRE OF SEVEN MIXTURES UNDER DIFFERENT FERTILIZER TREATMENTS—PRESCOTT HIGHWAY FIELD. SEASONS 1934, 1935, 1936 AND AVERAGES

Seed Mixtures	Treatment=P K			Treatment=Nil			Treatment=N P K			Means per treatment			Means per year			Average of three years
	1934	1935	1936	1934	1935	1936	1934	1935	1936	P K	Nil	N P K	1934	1935	1936	
A	5,141	3,559	2,603	5,089	4,011	2,791	5,162	5,658	4,048	3,768	3,964	4,956	5,131	4,409	3,147	4,229
B	5,236	4,306	3,220	4,438	4,048	2,972	4,381	6,017	4,400	4,254	3,819	4,933	4,685	4,790	3,531	4,335
C	5,142	5,057	3,469	4,077	4,387	3,417	4,043	6,082	3,821	4,556	3,960	4,649	4,421	5,175	3,569	4,388
D	5,515	6,285	4,856	4,758	6,753	4,920	4,364	5,542	3,530	5,552	5,144	4,479	4,879	5,860	4,435	5,058
E	4,822	5,822	4,384	4,550	5,122	3,628	4,695	4,380	3,054	5,009	4,433	4,043	4,689	5,108	3,689	4,495
F	5,223	6,364	4,843	4,040	5,164	4,288	4,176	5,033	3,011	5,477	4,497	4,073	4,480	5,520	4,047	4,682
G	4,897	6,263	4,427	4,690	5,597	4,540	5,083	5,604	3,310	5,196	4,942	4,666	4,890	5,821	4,092	4,935
Means	5,139	5,379	3,972	4,520	4,869	3,794	4,558	5,474	3,596	4,831	4,394	4,543	4,739	5,241	3,787	4,589

Necessary differences for significance

For comparison of	P = ·05
Mixtures in entire experiment in 1934	317 lbs. per acre
" " 1935	462 "
" " 1936	469 "
" " three-year averages	470 "
Fertilizer treatments in 1934	243 "
" " 1935	302 "
" " 1936	307 "
" " three-year averages	308 "

There were great differences between the yields of mixtures, particularly mixtures A, B, and C, from 1934 to 1935 and to some extent in 1936. Red clover was dominant in these mixtures, whereas alfalfa was dominant in mixtures D, E, F and G. (See Table 5 for composition.)

The average yields of all the clover vs. all the alfalfa dominant plots are summarized in Table 7.

TABLE 7.—AVERAGE YIELDS OF CLOVER-DOMINANT VS. ALFALFA-DOMINANT MIXTURES IN POUNDS DRY MATTER PER ACRE UNDER DIFFERENT FERTILIZER TREATMENTS

Mixtures	Three-year average			Average of all treatments		
	PK	Nil	NPK	1934	1935	1936
Red clover dominant	4,193	3,914	4,846	4,746	4,791	3,416
Alfalfa dominant	5,309	4,754	4,315	4,735	5,577	4,066

It may be seen that the average yields from the two types of mixtures were equal in 1934, but in 1935 the red clover decreased considerably and the alfalfa was actually responsible for an increase in the yields. In 1936 both types of mixtures were lower in yield, but the mixtures containing alfalfa were still higher in production. The plots with NPK treatment showed an increase in yield in the mixtures with red clover. This was due chiefly to an increase in the stand of grasses in mixtures B and C. The dominant grass in these mixtures was red top, which developed rapidly after the red clover was reduced.

Botanical analyses of the mixtures taken in the spring and fall of each year clearly showed the different changes that took place in the flora. The grasses and the weeds increased and the alfalfa decreased from year to year. This change was most pronounced in the field with NPK treatment.

Compatibility of Species

In addition to relative production of dry matter of different pasture mixtures under clipping, a critical study was undertaken to learn the compatibility of the different species in these mixtures. Data on the botanical composition are accumulated from year to year and will be available for analysis. Similar mixtures were also studied under actual grazing conditions, so that the compatibility of different species could be observed under different treatments.

Palatability of Species

A number of grasses and legumes and mixtures were seeded in plots and grazed by sheep. No attempt was made to record the number of days of grazing, except that a sufficient number of sheep were available to graze off the vegetation fairly closely. Selective grazing was observed. The sheep had a decided preference for the clovers. Alfalfa was hardly touched when there was other forage. Of the legumes the order of preference was: white clover, red clover, alsike, and alfalfa.

The pure species of grasses were not grazed very uniformly, but it was seen that certain of them were especially liked by the sheep. Timothy and Canada bluegrass were the first grasses to be eaten. The order of preference of some of the more common grasses was as follows: timothy, Canada bluegrass, reed canary grass, brome grass, perennial rye grass, meadow fescue, meadow foxtail, red top, Kentucky bluegrass and red fescue. This order was only slightly different from year to year, and appeared to be the same for dairy cows.

Annual or Emergency Hay and Pasture Crops

Special tests have been conducted to determine the relative value of different annual crops for emergency hay and pasture purposes. About forty different crops and combinations of crops have been compared during the past three years both by clipping the herbage in test plots and by grazing with dairy cows under field conditions. These crops included varieties of oats, barley, fall rye, several types and varieties of millet, sudan grass, early amber cane sorghum, Italian and Wimmera rye grass, Teff grass, soybeans, sweet clover and several combinations of these crops.

Oats and sudan grass were found to be best crops for supplementary pasture. Oats seeded at 3 bushels per acre between May 20 and 30, or sudan grass at 30 pounds per acre between June 1 and 10, gave excellent results from the standpoint of both yield and palatability. These crops when tested in a mixture of 2 bushels of oats and 25 pounds of sudan grass per acre and seeded about June 1 produced very satisfactory results.

DOMINION FORAGE CROPS LABORATORY, SASKATOON, SASK., IN CO-OPERATION WITH THE UNIVERSITY OF SASKATCHEWAN

By T. M. Stevenson

WORK OF THE LABORATORY

In a broad way the work of the laboratory divides itself into four main branches: plant breeding, experiments relating to methods of establishing stands of grasses and legumes under dry land conditions, trials relating to seed production of various species, and experiments to test the relative value of the various grasses and legumes in mixture and in pure culture for hay and pasture purposes.

Plant breeding is the major activity, and emphasis is placed upon the production of drought-resistant, hardy grass of high quality which will produce maximum yields under existing conditions. Introduction of new species, varieties and strains is an important phase of the plant breeding work. Extensive selection work is being done in an effort to produce improved strains of species already under cultivation. Hybridization is being employed in an effort to combine the desirable characters of the various species, varieties or selections.

Much has been learned about the effect of soil preparation and time, depth and method of seeding on the establishment of satisfactory catches of the various grasses and legumes under dry land conditions. Fall seeding, especially with crested wheat grass (*Agropyron cristatum*) has proved very successful and is now considered the surest means of establishing stands of this species on the dry prairie area. The practice of seeding the grasses into a firm seed bed which carries a protective covering of stubble or weed growth is becoming generally accepted.

The increasing of seed of the various species is an important phase of the work. Experiments have shown that seedings made in spaced rows and cultivated throughout the growing season give higher seed yields than solid seedings under dry land conditions. When moisture conditions are more favourable the solid seedings have been more satisfactory. In general, the greatest seed yields, even of the most drought-resistant varieties, are being obtained in the more northern prairie areas and it appears as though seed production should be encouraged, especially in the park belt area.

The improvement of hay and pasture yields through the use of certain mixtures of grasses and legumes has been definitely demonstrated. Brome-alfalfa mixtures have been particularly high yielding for hay purposes and show many advantages over the pure cultures of either species. The development of a pasture alfalfa of the creeping-rooted, turf-forming type which will yield a reasonable amount of seed is a pressing problem; some progress has been made in this development. Crested wheat grass (*Agropyron cristatum*) has proved to be of inestimable value in producing early spring pasture, especially in the northern areas where the growth of native species in the spring of the year is slow. Stockmen have reported that pastures of this species are ready to graze about three weeks before any other pasture. This early grazing, at a time of the year when the stock is not troubled with flies, results in rapid gains and reduces the length of time when indoor feeding is required. Dairymen, too, have recognized the value of this species for early pasture.

PLANT INTRODUCTIONS

The following new species and strains were tested:—

Saskatoon Accession Number	Common Name	Scientific Name	Habit of growth
S-270	Brome grass	*Bromus inermis*	Perennial
S-398	Crested wheat grass	*Agropyron cristatum*	"
S-329	Hungarian spinach	*Atriplex hortensis*	"
S-339	Dune grass	*Calamavilfa longifolia*	"
S-271	Highland reed canary grass	*Phalaris arundinaceae*	"
S-228	Indian rice grass	*Oryzopsis hymenoides*	"
S-345	Wild pea	*Astragalus rusbyii*	Annual
S-227		*Hedysarum americanum*	Perennial
S-347	Safflower	*Carthamus tinctorius*	Annual
S-353	Bluejoint	*Andropogon furcatus*	Perennial
S-355	Beardless wheat grass	*Agropyron inerme*	"
S-357		" *griffithsii*	"
S-358	Beardless wild rye	*Elymus triticoides*	"
S-359	Meadow barley	*Hordeum nodosum*	"
S-374	Strawberry clover	*Trifolium fragiferum*	"
S-281	Sweet clover	*Melilotus italica*	Annual
S-283	"	" *indica*	"
S-344	"	" *parviflora*	"
S-370	"	" *segetalis*	"
S-284	"	" *sulcata*	"
S-326	"	" *alba*	Biennial
S-268	"	" "	"
S-279	"	" *messanensis*	"
S-280	"	" *speciousus*	"
S-283	"	" *wolgica*	"
S-369	"	" *gracilis*	"
S-372	"	" *altissimus*	"
S-371	"	" *dentata*	"
S-402	"	" "	"
S-403	"	" "	"
S-408	"	" "	"
S-410	"	" "	"
S-411	"	" "	"
S-412	"	" "	"
S-413	"	" "	"
S-414	"	" "	"
S-415	"	" "	"
S-416	"	" "	"
S-417	"	" "	"
S-418	"	" "	"
S-419	"	" "	"
S-420	"	" "	"
S-421	"	" "	"
S-422	"	" "	"
S-423	"	" "	"

COMPARATIVE STUDY OF VARIETIES

Randomized block tests, consisting or either four or six replicated plots of each variety, have been laid down each year to the perennial grasses, alfalfa, sweet clover, corn and sunflowers. In addition to these standard variety tests, the most promising lines of the perennial grasses and legumes which originated from selections made at Saskatoon have been tested in a similar manner. Varieties tested include:—

Brome grass

Commercial
Parkland—S-29
Strain S-23-7-1-2-3

Crested wheat grass

Fairway—S-10
Strain S-11
Commercial

Slender wheat grass

Commercial
Mecca S-1
Grazier S-3
Fyra S-2
Scott No. 28
Scott No. 97
Scott No. 77

Alfalfa

Cossack S-327
Grimm S-328
Ontario Variegated S-136
Grimm S-135
Grimm S-39
Ladak S-137

Sweet Clover

Arctic S-13
I.H.C. Yellow S-142
Arctic "A" S-18
Alpha S-14
Alpha S-16
Brandon dwarf S-141
Grundy County S-140
Redfield Yellow S-143

Corn

Manalta (Lethbridge) S-222
Sask. White Flint S-150
Gehu (Swift Current) S-152
Early Yellow Flint (Ottawa) S-221

Sunflowers

Mammoth Russian
Manchurian
Mennonite
Ottawa No. 76

NEW VARIETIES PRODUCED

New varieties produced include Parkland brome grass, a new pasture type alfalfa and an annual sweet clover.

Parkland brome.—The Parkland variety of brome is a selection from common brome grass (*Bromus inermis*). It is the result of selection within inbred lines for several successive generations. It differs from common brome grass essentially in that the plants lack the strongly spreading underground stems, and the general type of plant which composes the strain is dense and leafy, as opposed to the more open, stemmy types found in Commercial brome. The plants are, on the average, slightly shorter than Commercial plants. Yield tests at Saskatoon indicate that the yields of hay from Parkland and Commercial brome are about the same. The higher percentage of leaf in the Parkland makes a better quality hay. Tests at Saskatoon have shown that Parkland is capable of producing a much heavier aftermath than Commercial under dry conditions and shows greater promise as a pasture grass. Seed yield per acre is usually about the same as for Commercial brome. Plants of the Parkland variety are extravaginal in habit of growth with short underground stems which emerge relatively close to the mother plant. They are not strictly non-creeping. Seed is being increased at several experimental stations and by a number of selected growers throughout the western provinces.

Alfalfa S-274.—This is a vigorous growing, hardy strain of *M. media* which originated by mass selection out of material introduced from an unknown source more than twenty years ago. This strain is the only one which survived the severe winter of 1933-34 without injury. Many of the varieties and strains, including some of the hardier Grimm selections, killed out completely in the single plant nurseries during the same winter. This strain contains a high percentage of semi-falcata types. The plants are strong and vigorous, are semi-upright in habit of growth, and produce pods which are only slightly more coiled than the true falcata type. The pods differ from those of the true falcata in that they do not shed their seeds readily.

In flower colour more than 50 per cent of the plants produce shades ranging from white to yellow tinged with purple. This strain produces an abundant second growth when cut for hay. Due to its hardiness, drought resistance, high seed production and semi-decumbent habit of growth, it gives promise of being valuable, especially for pasture purposes. Seed of this strain is being increased at Saskatoon.

Annual Sweet Clover.—This is a true annual of the Alpha or dwarf-branching type. It originated from a single plant selected out of *M. alba* S-26-3 at Saskatoon in the summer of 1932. At Saskatoon this variety has matured seed each year—although in much smaller quantity than the commonly grown *M. alba* varieties. It begins flowering about one month earlier than Hubam. Hubam rarely ripens seed at Saskatoon. Flowering begins when the plants are from 8 to 10 inches high, usually in early July at Saskatoon, and the plants continue to grow and flower profusely until killed by fall frosts.

This variety, in addition to providing late summer and autumn pasture, gives much promise as a bee pasture plant for Western Canada. It provides bee pasturage at a season of the year when the main crop of sweet clover has passed the blossoming stage. Seed is being increased as Saskatoon.

PLANT BREEDING AND SELECTION

Alfalfa.—Breeding work with alfalfa has centered around the production of suitable pasture types. With this in mind, a large number of introductions and new selections, especially of the hardy, falcata types, have been studied.

Selections have been made on the basis of creeping root-stocks, hardiness, drought resistance and seed production. Several promising strains are now being tested.

In addition, some artificial crossing has been done with *M. falcata, M. media* and *M. glutinosa*. The last-named species has proved quite hardy at Saskatoon. It is a low-growing, leafy type with well-developed rhizomes. It is not a good seeder, but some of the hybrid plants appear to set seed reasonably well. This species has one outstanding advantage over the falcatas in that it produces tightly coiled seed pods which hold their seeds reasonably well.

Sweet Clover.—Through the co-operation of the Chemistry Department, University of Saskatchewan, a simple colorimetric test for coumarin in sweet clover has been developed. The use of this test has made possible the selection of plants with low coumarin content in breeding material. Progenies are at present in the field nurseries from coumarin-free individuals.

Attempts to produce coumarin-free lines through hybridization between the agriculturally important species, all of which are bitter, and some of the non-bitter species, such as *M. dentata,* have not been successful. Crosses between *M. alba* and *M. dentata* and between *M. officinalis* and *M. dentata* have failed to produce normal hybrids. A large number of new species and selections have been grown and tested for coumarin content. Much variation in coumarin content has been noted within certain lines of *M. alba,* and it appears as though coumarin-free selections of agricultural value may be obtained from that source.

Some progress has been made in the production of Alpha or dwarf-branching type strains which possess greater vigour of growth than is characteristic of the Alpha variety. Crosses made between Alpha and Redfield Yellow, a late maturing, vigorous growing, yellow-flowered type, belonging probably to the *M. suaveolens* group, have produced Alpha type lines having much greater vigour than the Alpha variety. These lines are at present being increased and will be tested against the standard varieties when sufficient seed becomes available.

Attempts to isolate lines of sweet clover, *M. alba,* which produce seeds having naturally permeable coats that do not require scarification before seeding have met with some success. Examination of over twelve thousand single plant selections showed the average percentage of seeds having naturally permeable coats to be about 0·64 per cent. A few plants were found which produced as high as 80 per cent permeable seeds. By a process of inbreeding and selection it has been established that this character is inherited and selfed lines have been isolated which produce seed that does not require scarification to permit it to germinate. These lines have not yet reached the stage where they are ready to increase.

Brome grass.—The development of non-creeping strains of brome grass (*Bromus inermis*) through selection and inbreeding has occupied much attention. Parkland, a weakly creeping type, has been distributed, and further selections of types which are entirely free from creeping roots have been made. There has been a decided loss in vigour as a result of several generations of inbreeding and selection within some of the lines. An effort is being made to restore the vigour and at the same time to retain the bunch habit of growth. With this in view, a number of inbred lines have been crossed in different combinations. The F_1 plants of certain combinations appear promising and are being increased as rapidly as possible.

Crested wheat grass.—The improvement of crested wheat grass through selection within inbred lines has been largely abandoned because of the enormous loss of vigour brought about through this practice. Not a single one

of the hundreds of inbred lines which are available is as vigorous or as desirable from a hay and pasture standpoint as the original material. In addition, some of the selections produced over 60 per cent albino seedlings when inbred for two successive generations.

A number of promising types have been selected and increased. Some of them appear to be much more vigorous than the Fairway. Six promising strains are at present being increased.

Slender wheat grass.—Work with slender wheat grass has consisted chiefly of selecting materials from various sources which appear to be longer lived and more persistent than the types usually grown. This species has become quite unpopular in the drier areas and is being replaced by brome grass and crested wheat grass.

Tests of the varieties and strains at present available indicate that there is little to choose between them so far as drought-resistance and persistence are concerned.

Wheat-Agropyron hybrids.—Crossing of *Triticum* species with Agropyron was begun at Saskatoon in the summer of 1935. The wheat species used were:—

T. dicoccum
T. polonicum
T. durum
T. vulgare.

These species all yielded hybrid seeds when crossed with *Agropyron elongatum.* Negative results were obtained in crosses using *A. pauciflorum, A. cristatum* and *A. repens* with these species.

A large number of F_1 plants were grown in the field nursery in 1936, all of which were perennial in habit of growth. Some of these proved to be self-fertile and produced selfed seeds freely. Most of the plants, however, were completely self-sterile, and it was necessary to resort to back-crossing with the *Triticum* parent in order to get seeds. All the self-fertile F_1 hybrids originated from *T. vulgare* × *A. elongatum* crosses.

More extensive crossing was done in 1936. This crossing included *A. glaucum* and the following *Triticum* species in addition to those named above:—

T. monococcum
T. dicoccoides
T. turgidum
T. polonicum
T. timopheevi
T. compactum
T. beotricum
T. sphaerococcum
T. orientale
T. pyramidale
T. villosum

and two wheat-rye hybrids. Of the new wheat species used, all except *T. monococcum* gave hybrids when crossed with *A. elongatum,* and most of them crossed readily with *A. glaucum.* Some of the hybrids from *A. elongatum* × *T. orientale* and *A. elongatum* × *T. compactum* crosses were partially self-fertile. Hybrids from all other new combinations were self-sterile. All the F_1 hybrids again were perennial.

F_2 progenies were grown from selfed seeds and from seeds obtained from backcrossing.

The F_1 generation backcrossed plants showed varying degrees of self-fertility.

F_1 plants from *Triticum* × *A. elongatum* have wintered over in the field nursery at Saskatoon and appear to be quite hardy. Some of the *Triticum* × *A. glaucum* hybrids winterkilled in the field nursery, and many of them did not appear to possess the same hardiness as the *Triticum* × *A. elongatum* plants.

Sunflower seed production.—Several hundred single-head selections of Mennonite sunflowers were made in the fall of 1936 in the Rosthern area with the object of starting single plant lines in 1937. These selections were made from fields grown by German Mennonite farmers who brought the seed to Canada twenty-five to thirty years ago.

These farmers have grown their own seed each year and have in each case selected toward a preferred type of plant. This continuous selection has resulted in the production of several different types by the various growers. All the fields matured seed early, but marked differences were noted in height of plant, size of head, colour of seed and other characters. It appears as though this is excellent material from which to make selections for seed production purposes. A nursery will be established from this material in 1937.

SEED PRODUCTION STUDIES

Factors affecting seed-setting in perennial grasses under greenhouse conditions.—During the past two years experiments have been conducted in the greenhouse during the winter months to determine the effect of various factors on seed-setting of perennial grasses. Breeding work with cultivated species of perennial grasses has been handicapped because of failure of many of these species to set seed in the greenhouse.

The following factors were studied in relation to their effects upon seed-setting:—

(1) Soil temperature,
(2) Atmospheric temperature,
(3) Fertilizers,
(4) Age of plants,
(5) Size of containers in which plants are grown,
(6) Freezing prior to bringing into the greenhouse,
(7) Artificial lights.

The results obtained indicate that seed-setting on several species can be increased by the following treatments:—

(1) Using plants less than one year old,
(2) Bringing plants into the greenhouse after the ground is thoroughly frozen in the fall,
(3) Applying nitrogen and phosphate fertilizers,
(4) Using relatively large size containers,
(5) Maintaining relatively low soil temperatures.

The above treatments invariably resulted in stronger, more vigorous plants which produced larger inflorescences and better developed spikelets than did the check plants.

Agropyron cristatum failed to set seed under any conditions in the greenhouse when self-pollinated, but when pollen from plants growing in the field was used on flowers produced on plants growing in the greenhouse, seed set reasonably well. With *Bromus inermis* very few seeds were obtained from plants growing in the greenhouse irrespective of the treatment used. Artificial pollination, using pollen from the same plant, increased the seed-setting considerably; and when pollen from field-grown plants was used the seed-setting was increased tremendously.

The results from these tests indicate that failure to set seed on these species in the greenhouse is due largely to failure of the pollen grains to function. The cause of this condition has not been determined.

Factors affecting seed-setting in Sweet Clover.—Investigations of the effect of variations in flower structure, such as short style, long stamen filaments and amount of pollen, have revealed that seed-setting under selfing bags or cages is very much higher on those plants which, due to certain types of flower structure, automatically self-pollinate. Plants which have either long stamen filaments or short styles invariably self-pollinate before the flowers open. In some plants in which the distances between the styles and stigmas are relatively great, self-pollination takes place because of the production of enormous amounts of pollen. Pollen production is not a constant factor, however, and efforts to isolate lines producing plentiful supplies of pollen have not been successful.

Lines have been isolated which breed true for stamen filament and style lengths.

Under normal field conditions the lines possessing long stamen filaments or short styles, which permit the pollen to reach the stigmatic surface readily, produce more seed than those which do not automatically self-pollinate, although the latter are open to visits by insects.

MISCELLANEOUS PROJECTS

Root Development in Perennial Grasses.—A study of root development in slender wheat grass *(A. pauciflorum)*, smooth brome grass *(B. inermis)*, and crested wheat grass *(A. cristatum)* has been conducted for the past several years with the object of determining the value of these grasses for soil binding purposes. Data obtained to date indicate that crested wheat grass *(A. cristatum)* not only produces the greatest amount of root fibre but has roots which are stronger than those of slender wheat grass and brome grass and which persist as useful fibre in the soil for longer periods. Land put down to crested wheat grass and left down for four years contained as much root fibre in the top twelve inches of soil as was found in the average natural prairie sod at Saskatoon.

The following table gives the weight in pounds of dry matter per acre of root material in the top twelve inches of soil for each of the species studied:—

Species	Variety	Age of grass			
		1 year	2 years	3 years	4 years
A. cristatum	Fairway	2,359	4,254	5,002	6,121
B. inermis	Commercial	2,590	3,683	4,954	5,164
A. pauciflorum	Mecca	1,685	2,591	3,683	2,220

Additional data on root development of these species were obtained from root systems of single plants (3 years old) which were excavated and washed from the soil in a manner which preserved the entire root systems. The following data were obtained from these single plants:—

Species	Variety	Top Growth		Root System		
		Height	No. of tillers	Longest root	Greatest penetration	Total length of crown roots
						Inches
A. cristatum	Fairway	24	1,106	66"	64"	19,881,270
A. pauciflorum	Mecca	24	155	68"	64"	629,396
B. inermis	Parkland	22	288	67"	65"	4,137,000

HAY AND PASTURE INVESTIGATIONS

Tests of the various perennial grasses and legumes in pure culture and in mixtures for hay and pasture purposes have been continued. Some of these plots laid down more than ten years ago are being carried along to give information on relative values for permanent meadows. New stands have also been established. In the older plots particularly the advantages of grass-legume mixtures have been clearly demonstrated. Mixtures of brome grass and alfalfa have been outstanding. As compared with pure cultures of brome and of alfalfa, the mixtures have yielded higher and have continued to yield reasonably well throughout the drought years when the pure cultures have yielded almost nothing.

Mixtures of western rye grass and alfalfa have yielded very well for about three years after seeding. By the end of the fourth year the western rye grass had completely disappeared and weeds and native grasses began to get a hold. Crested wheat grass—alfalfa mixtures have been seeded but have not been down long enough for comparisons to be made with other mixtures.

Much valuable information regarding rates of seeding and the effect of soil moisture conditions during the year of seeding upon development of the plants —and, consequently, upon future yields—has been obtained from these tests.

TURF GRASSES FOR SEMI-ARID CONDITIONS

Tests have been conducted to determine the relative values of various perennial grasses for lawn purposes under dry land conditions when not watered artificially. The following grass species were included:—

Agropyron pauciflorum—variety Mecca,
Agropyron cristatum—variety Fairway,
Agropyron cristatum—Commercial,
Poa pratensis,
Poa compressa,
Festuca rubra,
Festuca rubra (fallax),
Agrostis alba.

The Fairway variety of *A. cristatum* has shown itself superior to all the others for unwatered lawns under conditions at Saskatoon. The plots of this grass have improved greatly with age. The turf has become more dense and the growth much finer and more leafy. The plots of this species have been the first to become green in the spring of the year and the last to remain green in the fall. In the summer the grass becomes brown and dormant during prolonged hot dry periods, but green growth appears quickly following light showers. In weed control the plots of Fairway have far surpassed any of the other species or varieties. Not a single dandelion has appeared in these plots, whereas this weed has taken control of the plots of *A. pauciflorum* and is gradually becoming established in plots of the other species. It is worthy of note that similar plots of Fairway located nearby which have received artificial watering have become infested with dandelions.

Poa pratensis and *Poa canadensis* have made a fairly good showing and have persisted in spite of the dry conditions. The fescues have made a clumpy growth and have not been able to form a good covering. Weeds became established early in these plots. *A. alba* completely disappeared after the second year and the plots were discontinued.

PUBLICATIONS 1934-36 INCLUSIVE

1. L. E. Kirk and J. M. Armstrong.
   1934—A Single Factor Mutation in *Melilotus alba* Desc. Having Multiple Effects on Homologous Structures. Can. Jour. Res. 10: 787-792.
2. L. E. Kirk, T. M. Stevenson, and S. E. Clarke.
   1934—Crested Wheat Grass. Dom. of Can., Dept. of Agric. Pamphlet No. 157.
3. F. Dimmock.
   1934—Soybeans. Dom. of Can., Dept. of Agric. Pamphlet No. 155.
4. L. E. Kirk, J. G. Davidson, and Stella N. Hamilton.
   1934—Cereal Grain Crops for Annual Pasture. Sci. Agric. 14: 569-579.
5. L. E. Kirk.
   1934—Report of the Dominion Agrostologist, 1930 to 1933 inclusive.
6. J. M. Armstrong and W. J. White.
   1935—Factors Influencing Seed-setting in Alfalfa. Jour. Agric. Sci. 25: 161-179.
7. T. M. Stevenson.
   1935—The Improvement of Sweet Clover, *Melilotus*, in Western Canada. Herb. Rev. 3: 123-127.
8. T. M. Stevenson and L. E. Kirk.
   1935—Studies in Interspecific Crossing with *Melilotus* and in Intergeneric Crossing with *Melilotus medicago* and Trigonella. Sci. Agric. 15: 580-589.
9. R. M. MacVicar.
   1935—Inheritance of Seed Colour in Alfalfa. Sci. Agric. 15: 314-328.
10. L. E. Kirk.
    1935—Forage Crop Production in Dry-land Agriculture and on Ranges in Western Canada. Empire Jour. Exp. Agric. 3; 319-330.
11. T. M. Stevenson and W. J. White.
    1935—Growing Crested Wheat Grass for Seed Production. Dominion Forage Crops Laboratory, Saskatoon, Sask.
12. S. E. Clarke.
    1935—Forage Crop Production in a Dry Farming Program. Sci. Agric. 16: 161-164.
13. T. M. Stevenson and J. S. Clayton.
    1936—Investigations Relative to the Breeding of Coumarin-free Sweet Clover, *Melilotus*. Can. Jour. Res. 14; 153-165.
14. J. M. Armstrong.
    1936—Hybridization of *Triticum* and *Agropyron*. Can. Jour. Res. Sec. C. 14: 190-202.
15. L. E. Kirk.
    1936—Forage-crop Improvement in Western Canada for Dry-land Agriculture. Empire Jour. Exp. Agric. 4: 255-262.
16. F. S. Nowosad, *et al.*
    1936—The Identification of Certain Native and Naturalized Hay and Pasture Grasses by Their Vegetative Characters. Macdonald College, Technical Bul. 16.
17. L. E. Kirk.
    1936—Agriculture and Farming in Canada. World Book Encyclopedia.
18. L. E. Kirk.
    1936—Improvement of Pasture Grasses and Legumes. Spragg Memorial Lectures on Plant Breeding. Michigan State College, 1937.
19. F. Dimmock.
    1936—Seed Mottling in Soybeans. Sci. Agric. 17: 42-49.
20. S. E. Clarke and E. W. Tisdale.
    1936—Range Pasture Studies in Southern Alberta and Saskatchewan. Herbage Reviews 4: 51-64.
21. T. M. Stevenson and J. Mitchell.
    1936—Alfalfa Seed Production on the Gray Wooded Soils of Northern Saskatchewan. Univ. of Sask. Agr. Ext. Bul. No. 78. In press.

Imperial Bureau Bulletin Series on Seed Production. In press.

22. L. E. Kirk and R. M. MacVicar—Production and Geographic Distribution of Forage Crop Seed in Canada.
23. ———————————Alsike Seed Production.
24. ———————————Red Clover Seed Production.
25. O. McConkey and L. E. Kirk—Alfalfa Seed Production.
26. T. M. Stevenson and L. E. Kirk—Brome Grass Seed Production.
27. ———————————Crested Wheat Grass Seed Production.
28. ———————————Slender Wheat Grass Seed Production.
29. L. E. Kirk and T. M. Stevenson—Sweet Clover Seed Production.

OTTAWA: Printed by J. O. PATENAUDE, I.S.O., Printer to the King's Most Excellent Majesty, 1937.