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DEPARTMENT OF AGRICULTURE
EXPERIMENTAL FARMS SERVICE

FORAGE CROPS DIVISION

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

FORAGE CROPS LABORATORY

SASKATOON, SASKATCHEWAN

W. J. WHITE, B.S.A., M.Sc., Ph.D.
Officer-in-Charge

PROGRESS REPORT
1949-1953

Test comparing various grass species, showing marked differences in the amount of growth by late May

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J. E. R. GREENSHIELDS, B.S.A., M.Sc., Ph.D...*In charge of investigations with clovers*

R. P. KNOWLES, B.S.A., M.Sc., Ph.D.............*In charge of investigations with grasses*

INTRODUCTION

The Forage Crops Laboratory, established in 1932, has a somewhat unusual physical setting. Most units of the Experimental Farms Service are located at some distance from provincial universities or agricultural colleges and serve a specified geographic region in the province in which they are situated. In contrast, the Forage Crops Laboratory, which is a unit of the Forage Crops Division, Experimental Farms Service, and directly responsible to the Chief of the Forage Crops Division, is located at the University of Saskatchewan. Its primary function is the breeding of grasses and legumes. While certain projects on breeding forage crops are carried by other units of the Service in the prairie region, the majority of such projects are concentrated at the Laboratory. Thus, on several breeding projects, the Laboratory serves the Prairie Provinces or a large portion of this region.

Several mutual advantages arise from the co-operative arrangement between the Forage Crops Laboratory and the University of Saskatchewan. One of these is that students in the College of Graduate Studies who are interested in forage crops may undertake research at the Laboratory on problems suitable for thesis purposes. A number of students have availed themselves of this opportunity. During portions of the period from 1948 to 1953 Messrs. J. E. R. Greenshields, D. E. Forsberg, and R. K. Downey were employed on a part-time basis at the Laboratory and successfully completed research for their M.Sc. thesis. Mr. B. E. Twamley was likewise employed while conducting research for a Ph.D. degree awarded in 1952. In 1953 Mr. J. E. R. Greenshields was awarded the Ph.D. degree by Iowa State College and his research was partially conducted at the Laboratory. Since completing their post-graduate training these men have all accepted employment in Canadian institutions in the field of forage crop investigation.

In 1949 Mr. R. G. Savage transferred from the staff of the Laboratory to the staff of the Experimental Station at Prince George. The vacated position was filled by Mr. J. E. R. Greenshields in the spring of 1950.

This report presents an account of the activities and progress of the Forage Crops Laboratory for the period 1949 to 1953. It is supplementary to the report of the Laboratory presented as a section of the Progress Report of the Forage Crops Division 1937-1948, published in 1950.

INVESTIGATIONS WITH ALFALFA

by J. L. BOLTON

Objectives and Progress in Breeding

Breeding for resistance to disease has been of primary concern during the past five years. Bacterial wilt, winter crown rot, and leaf and stem infections all are important diseases of alfalfa in the area served by the Laboratory. Special breeding projects are under way to obtain resistance to the above diseases. The climate of the Prairie Provinces is characterized by long cold winters. As a result, winter hardiness must accompany resistance to disease if any improved variety is to have economic importance. Similarly, seed and forage yield of new selections should at least equal that of standard varieties such as Grimm or Ladak. The creeping-root habit of growth is also being given consideration, particularly in an effort to combine it in disease-resistant, quick-recovery types.

Breeding for Resistance to Bacterial Wilt

This disease is confined largely to irrigated soils in Saskatchewan and Alberta and to the black soil areas of Alberta and Manitoba. Scattered fields infected with the disease have, however, been found in the northern areas of all three provinces. Thus, there are local conditions where a resistant variety would be welcomed. An important additional reason for breeding for resistance to this disease lies in the export market for Canadian alfalfa seed. It is estimated that about 70 per cent of the Canadian production is sold in the United States where wilt-resistant varieties sell at a premium. In this market a variety combining wilt resistance with the usual winter hardiness and high quality of Canadian seed would be highly desirable.

This breeding project was started in 1946 and is co-operative with the Experimental Station, and the Plant Pathology Laboratory, both at Lethbridge. In general, the Forage Crops Laboratory is responsible for general supervision of the project and particularly for initiating and carrying out breeding procedures. The Experimental Station does most of the screening for wilt resistance and the Plant Pathology Laboratory is responsible for the supervision and improvement of inoculation techniques. Co-operation between the three institutions has been excellent and it is believed that considerably more progress has been made than if any one institution had undertaken the project alone.

In breeding for resistance to bacterial wilt it is essential to have a reliable screening technique. The general procedure used at Lethbridge was originally developed for field tests. An area of wilt-infested soil was chosen as a disease nursery. All seedlings and clones to be planted in the nursery were dipped in a suspension of the causal organism just prior to transplanting. After the plants had become well established they were needle inoculated below the crown. This needle inoculation was repeated each year the plants remained in the nursery. Heavy irrigation and frequent cutting of the nursery were practised to aid development of the disease. Experience has shown that one season in the disease nursery is not sufficient to permit an accurate reading. At least two growing seasons should elapse before susceptible types can be satisfactorily determined. All selections were made on a disease-free basis. Recently a greenhouse technique has been tested. Seedlings are planted in 5- or 6-inch pots with 20 to 30 plants per pot. After about two months, when the roots are about one-eighth of an inch in diameter, the mass of roots and soil is cut transversely about half way down the pot. Inoculum is placed on the cut surfaces and the two sections returned to their original position in the pot. Readings for wilt symptoms are taken about four months later. The method gives results that check closely with the known reactions of resistant and susceptible varieties, and the short time required for the test is particularly promising.

The progeny-test method of selection has been used almost entirely in breeding for wilt resistance. Fifteen original parents were selected in 1947 after only one year of screening in the disease nursery. Progenies from these parents were planted and checked for wilt symptoms after two full years in the nursery. These progenies originated from intercrosses between the 15 selections and also outcrosses to non-resistant plants. Table 1 summarizes the reaction of the progenies.

TABLE 1—PROGENY REACTION TO BACTERIAL WILT AFTER INTERCROSSING AND OUTCROSSING PLANTS SELECTED FOR RESISTANCE

Parent Strain No.	Varietal origin	Intercrosses		Outcrosses	
		No. of progenies	Percentage wilt-free	No. of progenies	Percentage wilt-free
S-45-42	Turkestan	9	58	12	31
S-45-30	Viking	8	52	2	36
S-45-36	Turkestan	9	51	3	26
S-45-40	Turkestan	9	45	9	15
S-44-104	Grimm	2	44	20	13
S-42-96	Ladak	5	42	20	18
S-45-35	Turkestan	10	41	7	12
S-42-81	Ladak	3	39	22	29
S-45-38	Turkestan	8	36	2	7
S-45-45	Turkestan	10	30	13	11
S-45-23	Cossack	12	28	12	4
S-45-37	Turkestan	12	24	13	3
S-45-15	Cossack	9	20	6	13
S-44-50	Grimm	5	11	21	1
S-44-108	Grimm	4	8	19	2
Average—all parents			35	..	15
Average—10 best parents			44	..	20

NOTE: Each progeny contained approximately 40 plants.

It is evident from the results summarized in Table 1 that certain of the original selections were susceptible. This is not surprising since a considerable number of escapes can be expected after only one year of field testing. The data also illustrate differences between parents, and differences between the results of intercrossing and outcrossing. It is probable that resistance to bacterial wilt is dominant over susceptibility. This deduction received further support when selections from the above progenies were made and a second cycle of progenies tested. In the latter instance there were 9 progenies from parents originating from outcrosses and 48 progenies from parents originating from intercrosses. The average percentage wilt resistance was 74 and 80, respectively. There was no evidence of escapes. The data from this second cycle showed that where a rigorous screening technique was used high wilt resistance could be obtained in a progeny even though one parent was susceptible.

In 1951, 324 selections that were likely to produce wilt-resistant progenies were cloned, and planted in a polycross nursery near Saskatoon in 1952. These included selections obtained from the above studies and also various plants obtained from outcrosses for resistance to winter crown rot. A considerable number of plants obtained from the mass screening of varieties possessing some wilt resistance also were used. A small amount of seed from this nursery was obtained in 1952 and was tested for wilt resistance, using the greenhouse technique. About 200 parents produced progenies equal to or better than the wilt-resistant Ranger variety. In 1953 a considerable amount of seed was harvested and will be used to progeny-test the wilt-resistant parents for seed and forage yield. Thus, by the end of 1955, or at least 1956, enough information should be obtained so that groups of the parent plants can be combined for testing as synthetic varieties.

Breeding for Resistance to Winter Crown Rot

The organism responsible for this disease finds its best growing conditions at temperatures slightly above freezing. Damage takes place early in spring as the snow melts. The fungus attacks the crown buds and upper section of the root at this time and the effects are often confused with winter-killing from low temperatures. No epidemic conditions have occurred during the past five years but in almost every year there is a progressive killing of plants that finally results in thin and patchy stands that are unproductive.

Resistance was difficult to find and it appears that immunity is not obtainable. However, a considerable population of fairly resistant material has been built up since the project was started in 1942. Selection in the yellow-flowered species, *Medicago falcata* L. has been especially productive. The variety Viking has been a good source also, probably since it evidently contains *M. falcata* in its parentage. At present some 400 to 500 lines having more or less resistance to winter crown rot are available. About 100 of these have been progeny tested for seed and forage yield. Several lines are equal or better than Grimm for yield of seed and forage and for winter hardiness. A few compare favorably with Ladak. Thus, a good variety having a fair degree of resistance to winter crown rot probably can be set up from present stocks.

In setting up combinations of plants for a crown-rot-resistant variety, however, consideration must be given to resistance to bacterial wilt. This is especially important since the area in which such a variety would be grown is the one that produces most of the Canadian exports of alfalfa seed to the United States. As noted previously the United States market has become increasingly sensitive to the need for wilt resistance in alfalfa. Fortunately, there is some wilt resistance in certain lines selected for resistance to winter crown rot. Some 250 plants from crown-rot-resistant progenies have come through a rigorous screening for bacterial wilt. Results as quoted under the discussion of the wilt-resistance project suggest strongly that progenies from these selected plants will be highly wilt resistant. In addition seed and forage yield data are at hand for the parent progenies of the selections. This source of breeding stock, therefore, will form the basis of synthetic combinations to be started in 1954.

A major difficulty in breeding for resistance to winter crown rot has been the lack of a reliable screening technique. The method now in use appears greatly affected by environment. Thus, in the past five years good screening was obtained only in 1949 and 1951. In 1950 and 1952 no infection developed and in 1953 infection was so severe that no differential was possible. A promising development is some recent work done at the University of Wisconsin by J. B. Lebeau and J. G. Dickson and reported in Phytopathology, 43: 581-582, 1953. These workers report that the fungus responsible for winter-crown-rot damage produces HCN in concentrations sufficient to kill the buds and crown tissues of alfalfa. That is, the damage is a secondary effect of the fungus through the action of HCN. Apparently also, the HCN must be confined in close proximity to the alfalfa parts before damage occurs. This condition probably is fulfilled in the field by a suitable snow cover. In any case the above information suggests that it may be possible to develop a screening technique based upon exposure to a critical concentration of HCN in a closed chamber.

Breeding for Resistance to Leaf and Stem Diseases

Leaf and stem diseases of alfalfa are widespread in the northern districts of the Prairie Provinces. During the period 1949 to 1953, inclusive, light infections were noted only in 1949. In 1950, 1952, and 1953, the incidence was moderate to severe and in 1951 epidemic conditions were reached. The damage probably is not great where the crop is cut for hay. However, where a seed crop is harvested, losses may be extremely heavy and, in certain fields, complete. Several different fungi are concerned. The most important is the fungus resulting in black stem. Yellow leaf blotch is prevalent and in certain fields may be devastating. Common leaf spot is of relatively minor importance but it is usually present and adds to the total effect.

Little progress has been made in breeding for resistance. Much of the staff and funds of the Laboratory have been directed to the projects leading to resistance to bacterial wilt and winter crown rot and the problem of leaf and stem diseases has had to take a secondary place. Then, too, resistant plants are extremely difficult to find. A limited degree of resistance (to black stem) has been found, which suggests that further work may lead to a resistant variety. No resistance to yellow leaf blotch has been noted, in spite of a critical examination of several heavily infected fields.

Control of the disease complex through the use of fungicides offers some promise. In 1950 an experiment conducted by the Plant Pathology Laboratory at Saskatoon showed good control with Perenox, a compound containing 50 per cent cuprous oxide. Later experiments, however, did not confirm the effectiveness of this and other chemicals. Fungicide treatments are being continued and there is a distinct possibility that an effective compound may be located.

Breeding for Creeping-Rooted Habit of Growth

The greater part of the work on this project since 1948 has been carried on at the Experimental Station, Swift Current, Sask., where the breeding of a drought-resistant, creeping-rooted alfalfa has been actively pursued. This laboratory has co-operated closely with Swift Current by testing Swift Current lines for seed yield, extent of creeping, and behavior in mixture with grasses. It is expected that the Swift Current station shortly will have a variety suitable for release.

At Saskatoon some thought has been given to a combination of the creeping-root character with resistance to bacterial wilt and rapid recovery after cutting. Under drought conditions wilt resistance probably is unnecessary, and quick recovery may be undesirable under pasture conditions where a uniform grass-alfalfa mixture is wanted to counteract bloating. Where moisture conditions are better, and under irrigation, wilt resistance and quick recovery are required and creeping-rootedness may be useful in maintaining complete stands. In 1951 about 260 crosses were made between creeping-rooted parents and wilt-resistant parents. The resultant F_1 progenies were planted in the wilt nursery at Lethbridge and examined after two seasons of growth. A good proportion of the progeny plants were of the desired type; i.e. creeping rooted, wilt resistant and having quick recovery. Plants representing about 200 of the F_1 progenies were selected. If it is thought necessary these selections may be backcrossed to concentrate the wilt-resistant and quick-recovery characters. However, it may be possible to proceed directly to progeny tests for general agronomic value. In any case the objective is to combine the better plants from among the selections into a new variety.

Breeding for High Seed and Forage Yield

As stated in the introduction to this section high seed and forage yield should be characteristics of any new variety, especially if it is to be grown under good moisture conditions. Consequently, all selections eventually are screened for yield regardless of the primary objective of the breeding project. However, a few experiments on seed and forage yield have been conducted that are unrelated to other breeding projects.

In 1949 a number of crosses were made between selections from the variety Du Puits and high seed-setting selections from Grimm and Ladak. The F_1 progenies were grown and checked, particularly for seed yield. The results showed little advantage in seed setting through the use of Du Puits. The effect on forage type appeared more favorable. The progenies were taller and more erect than Grimm and suggested that the use of Du Puits might give considerable increase over the forage yield of Grimm. Unfortunately, a differential on winter hardiness was not obtained.

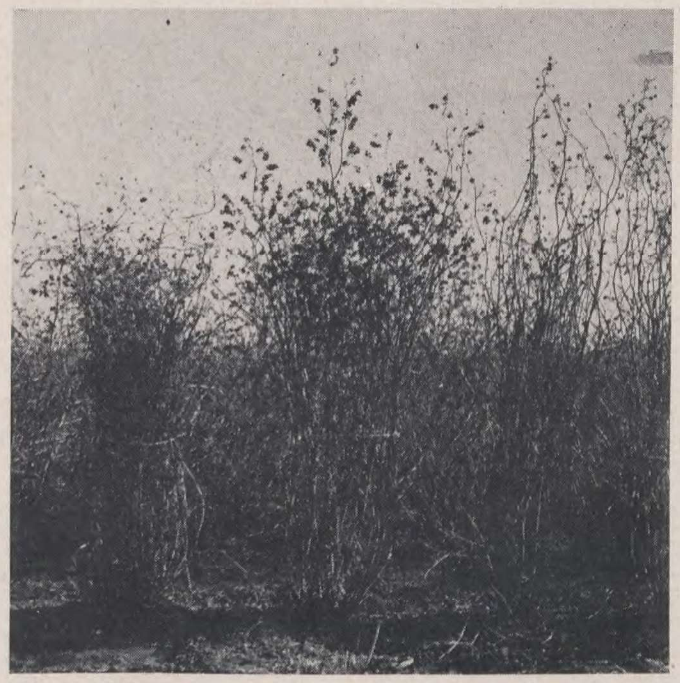

FIG. 1—Differences in seed-setting ability between plants derived from a cross betewen Grimm and Du Puits varieties of alfalfa.

Observations on seedling vigor also are of interest. Six selections were made in 1951 of plants that showed exceptional vigor in greenhouse flats. These plants later were intercrossed and their progenies grown. Again a marked advantage was shown in seedling vigor as compared with Grimm and Ladak. It is suggested that this character should receive further testing as it may prove a useful aid in screening for high forage yield.

Also in 1951 about 60 selections were made at Regina from the variety Grimm. All plants were selected for high seed yield and were taken from fields almost entirely pollinated by honeybees. It was hoped that in this way plants attractive to honeybees might be identified. In the following winter all selections were grown in the greenhouse and observed for self-tripping and self-fertility. These observations suggested that self-tripping, self-fertile types had been selected rather than types particularly attractive to honeybees.

Studies on Methods of Breeding

Cage Isolation versus Space Isolation

The objective was to determine whether alfalfa seed produced under cages and using honeybees as pollinators would be comparable to seed produced under space isolation where pollination was largely effected by wild bees. Previous studies at this Laboratory have shown that open pollination normally results in 90 per cent or more of cross-pollination. Using the white-flower character as a genetic marker, white- and colored-flowering plants were planted under screen cages and honeybees were introduced during the seed-setting period. At harvest time seed was collected from the white-flowering plants and the progeny grown to determine the extent of cross-pollination. The results obtained are summarized in Table 2.

TABLE 2—PERCENTAGE CROSS-POLLINATION ON WHITE-FLOWERING PLANTS WHEN CAGED WITH COLORED-FLOWERING PLANTS OF ALFALFA

Cage Number	Female parent	Male parent	Yield of cage in lb./acre	Number of progeny plants tested	Percentage cross-pollination
1	S-42-58	S-42-60	153	34	..
1	S-42-60	S-42-58	153	22	..
2	S-42-58	S-42-85	205	43	65
3	S-42-58	S-42-119	610	45	58
4	S-42-58	S-42-124	1145	24	38
5	S-42-58	S-42-172	735	43	56
6	S-42-58	S-42-179	520	28	25
7	S-42-58	S-42-182	307	18	28
8	S-42-60	S-42-85	344	28	36
9	S-42-60	S-42-119	378	43	81
10	S-42-60	S-42-124	428	26	35
11	S-42-60	S-42-172	1043	51	53
12	S-42-60	S-42-179	380	30	33
13	S-42-60	S-42-182	151	49	65

Average percentage cross-pollination on S-42-58	45
Average percentage cross-pollination on S-42-60	51
Average percentage cross-pollination on both white-flowering parents	48

The results given in the above table show somewhat more cross-pollination on S-42-60. This plant is slightly more self-sterile than S-42-58 although both are relatively self-sterile as compared with the general run of alfalfa plants. It would appear that honeybees under cages are not an effective cross-pollinating agent. However, rather small progenies were tested and the experiment should be repeated to obtain more conclusive data.

Companion Grasses for Spaced Alfalfa Plants

At various times there has been considerable winterkilling of spaced alfalfa plants at Saskatoon. This killing appears to bear little or no relation to killing in solid stands and it is thought that the spacing may be the cause. To obtain some experimental evidence spaced plants were over-seeded with (1) Kentucky blue grass broadcast, (2) crested wheat grass broadcast and (3) crested wheat grass seeded in a single row midway between the alfalfa plants. The latter were spaced 3 feet each way. At the end of four years the experiment was evaluated and the following conclusions were reached: (1) Broadcast seedings of crested wheat grass provide severe competition for the alfalfa and are not recommended. (2) Survival of the alfalfa was considerably better after a broadcast seeding of Kentucky blue grass as compared with planting with no grass. Growth of the alfalfa was comparable to the plots with no grass. (3) If crested wheat grass in rows is used it should be kept clipped to prevent re-seeding.

Delayed Pollination in Alfalfa

This experiment was conducted to find out whether or not it was necessary to emasculate alfalfa plants before crossing. Two white-flowering plants were used as female parents. A bulk sample from several colored-flowering plants provided the pollen source. Flowers were tripped and allowed to self-pollinate. The foreign pollen was applied at intervals up to 8 hours after tripping. Table 3 summarizes the data obtained.

The results in Table 3 show that cross-fertilization was almost complete when the foreign pollen was applied at the time of tripping. In fact a high degree of cross-fertilization occurred at all intervals tested with the possible exception of the 4-hour interval for S-42-60. No explanation is available for the apparent discrepancy in that observation. More detailed studies should be carried out using white-flowering plants with different degrees of self-fertility. However, in the meantime it would appear safe to use crosses made without emasculation unless the total elimination of selfed progeny is necessary.

TABLE 3—FLOWER COLOR OF THE PROGENY OF WHITE-FLOWERING PARENTS POLLINATED WITH POLLEN FROM COLORED-FLOWERING PARENTS AT INTERVALS AFTER TRIPPING

Parental Cross	Interval after tripping	Total number progeny plants tested	Number of progeny plants white-flowered	Number of progeny plants colored-flowered
S-42-58 (white) × S-42-60 (white)	0 hrs.	14	14	0
S-42-60 (white) × S-42-58 (white)	0	17	17	0
S-42-58 × colored	0	2	1	1
S-42-58 × colored	3	5	3	2
S-42-60 × colored	0	9	0	9
S-42-60 × colored	½	5	0	5
S-42-60 × colored	1	6	1	5
S-42-60 × colored	2	8	2	6
S-42-60 × colored	3	4	1	3
S-42-60 × colored	4	16	12	4
S-42-60 × colored	8	9	0	9

Morphology, Cytology, and Genetics

During the past five years it has been found possible to devote some effort to the solution of questions involving morphology, cytology, and genetics. In particular, information on the mode of inheritance in alfalfa has been secured through studies of a form having one-half the usual chromosome number, and on the development of twin seedings and the inheritance of flower color.

A Diploid Form of *Medicago sativa*

The normal chromosome complement of common alfalfa (*Medicago sativa* L.) is 32 in the somatic tissues. This situation, together with certain cytological and genetical evidence, has led to the belief that common alfalfa is a tetraploid and possibly an autotetraploid. This theory carries with it certain implications as to the segregation of characters of importance to the plant breeder. One flaw in this theory has been that no diploid race was known that might serve as a possible origin of the tetraploid species.

In 1947 a sample of seed was obtained from Erevan in southern Russia. It was labelled *Medicago sativa* and was assigned the Saskatoon accession number S-2128. Some 43 seedlings were established in the introduction nursery at Saskatoon in 1949. After the plants had reached the flowering stage they were recognized as a distinct type. The leaves and flowers were smaller and the growth more decumbent than in the normal species and plants generally were finer in quality and less vigorous than typical *M. sativa*, At the same time other characters such as flower color and pod type closely resembled common alfalfa. A cytological examination showed that the new type had a somatic chromosome number of 16. Crosses with common alfalfa and with a 16-chromosome form of *M. falcata* were attempted. As would be expected the new form was inter-sterile with common *M. sativa* and inter-fertile with the 16-chromosome form of *M. falcata*.

The discovery of the S-2128 form of *M. sativa* is another step forward in the analysis of the origin of common alfalfa and in the interpretation of its genetic and breeding behavior. A more complete description of S-2128 is contained in the following reference: J. L. Bolton and J. E. R. Greenshields. A diploid form of *Medicago sativa* L. Science 112: 275-277, 1950.

Twin Seedlings in Alfalfa

The object of this study was to determine whether it was possible to obtain 16-chromosome forms of alfalfa by selecting among twin seedlings. Other workers, particularly with wheat and cotton, have found that one member of a twin pair frequently has one-half the normal complement of chromosomes. If this were true in alfalfa then it might be possible to break down the normal tetraploid types to diploid forms. These latter forms might be easier to purify for genetic characters. If vigor were lost in the process, presumably it could be restored by chromosome doubling to the tetraploid state.

The results of the study were disappointing so far as the main objective was concerned. Fifty-five pairs of twin seedlings were examined and each member of each pair proved to have the normal number of 32 chromosomes. It was decided that twinning in alfalfa generally resulted from cleavage of the zygote or else normal fertilization of double embryo sacs. Twinning was found to be directly proportional to the viability of the seed. Two sets of triplet seedlings were noted and many types of fusion were found. It was suggested that genetic tests and the selection of different types of fusion would eliminate twins due to multiple embryos and thus increase the possibilities of obtaining diploids. A full report of the study is contained in the following publication: J. E. R. Greenshields. Polyembryony in alfalfa. Sci. Agric. 31: 212-222. 1951.

The Inheritance of Flower Color in Alfalfa

Discussions on work given elsewhere in this report have noted the use made of white-flowering alfalfa plants as genetic markers. This use was based upon more or less fragmentary evidence at Saskatoon and from reports of other institutions. It was felt that careful study of the inheritance of flower color would yield information of value in assessing genetic markers and that it would also aid in refuting or supporting theories on possible autotetraploid segregation. Thus, during the period 1950 to 1952 a genetic study was developed and analyzed by a graduate student at the University of Saskatchewan. It is expected that his findings will be published but in the meantime a complete report is available in the following thesis: B. E. Twamley. Flower color inheritance in diploid and tetraploid alfalfa. 52 pp. (typewritten). University of Saskatchewan.

The principal results of the study show that the inheritance of purple anthocyanin pigments is governed by two complementary factors. Absence of one or both of these factors gives white flower color. Thus, crossing certain types of white-flowering plants will produce purple-flowering progeny. All yellow-flowering plants tested carried one of the factors responsible for purple flower color. In addition, they carried up to three or four factors governing the production of the yellow pigment. There appeared to be several factors responsible for the intensification of the purple pigment and some at least were independent of the factors for the production of pigment. The segregation patterns observed suggest that common alfalfa originated as an autotetraploid but that considerable chromosome differentiation has taken place since the time of origin. As a result the original tetrasomic patterns have been partially replaced by disomic and partially disomic patterns of inheritance.

Seed-Setting Studies

Previous to 1948 the work of this Laboratory on seed setting in alfalfa was concerned largely with the effects of wild bees on pollination and the control of injurious insects. Results of these studies were reported fully in the Progress Report, 1937-48. Further work was discontinued when the Science Service Field-Crop Insect Laboratory at Saskatoon assumed full responsibility. Since 1948, two studies have been originated on seed setting; one dealing with the effect of honeybees and the other with herbicides. It is expected that eventually each of these projects will be prepared for publication. The following accounts, however, describe the experiments and summarize results to date.

Seed Setting as Affected by Honeybees

This project was co-operative with the Field-Crop Insect Laboratory, Science Service, Saskatoon; the Apiculture Division, Experimental Farms Service, Ottawa, and the Experimental Substation, Experimental Farms Service, Regina. The objective was to find out if honeybees were responsible for setting appreciable amounts of alfalfa seed. Previous studies in northern Saskatchewan had indicated that they were largely ineffective. On the other hand, seed growers in the southwestern United States, particularly California and Arizona, were known to have had excellent results by using honeybees to pollinate alfalfa.

It was decided to locate the experiment south of Regina in southern Saskatchewan. This area is completely cultivated as farm land but only annual cereal crops are grown. The Regina farmers normally control weed growth by the use of 2,4-D. Thus, it was hoped that the effects of wild bees and competing flowers would be eliminated or at least greatly reduced. In 1950 eight plots, each 4 acres in area, were established in farmers' fields. Each plot was three to four miles distant from any other plots. In subsequent years two plots were used as checks and no bees were introduced. In the remaining plots concentrations of one, three, and five colonies per acre were introduced, with duplicate plots for each concentration. A further check was provided by placing three wire screen cages in each plot. Each cage was 4 by 4 by 4 feet in dimension. At harvest time 20 random samples each representing 24 square feet were taken and the average yield per acre was estimated from them. The growth under the cages was harvested at the same time. Table 4 summarizes the data obtained for the years 1951, 1952, and 1953.

TABLE 4—AVERAGE YIELD OF ALFALFA SEED IN POUNDS PER ACRE FROM DIFFERENT CONCENTRATIONS OF HONEYBEES

Number of colonies per acre	Yield per acre 1951	Yield per acre 1952	Yield per acre 1953	Yield per acre 1951-1953
0[1]	37[2]	56	13[2]	35
1	44	65	26	45
3	49	114	54[2]	72
5	52	151	147	117

[1] The average yield of the caged plots was 11 pounds per acre and varied only from 12 to 10 pounds for the different years.
[2] Only one plot harvested. (In 1951 a satisfactory stand was not obtained and in 1953 heavy hail damage occurred.)

It is evident that honeybees set appreciable amounts of seed during the three years the experiment was in progress. The yields, however, in no case reached a point where it would be feasible economically to use honeybees as the sole pollinating agent. In the United States yields of over 1,000 pounds per acre are often attributed to the use of honeybees. The discrepancy between these results and the ones reported here can be explained logically in terms of climate and competing flowers. In the United States where honeybee pollination is successful, daily temperatures are high, and the higher the temperature the easier it is to trip an alfalfa flower. Furthermore, their seed production areas are largely located in desert valleys under irrigation. The surrounding area is practically barren and there is no particular difficulty with competing flowers. Another important advantage is that the alfalfa pollinating season can be made to coincide with long periods of weather favorable to bee activity.

At Regina, all seed had to be set in July or early August if it was to mature. In every season considerably more pods were set than the seed yields would indicate but they were set too late in the season to mature seed. Again, at Regina, many days during the pollinating season were wet and cool and thus unsuitable for bee activity. Finally it was hoped that the location chosen would be reasonably free from competing flowers. These hopes were not realized. The three seasons were all very favorable for crop growth and in many instances farmers were unable to spray to control weeds. As a consequence wild mustard, in particular, flourished and proved to be a more attractive source of pollen and honey than the alfalfa.

In summary it can be said that the conditions at Regina that caused an economic failure for honeybee pollination will be encountered in any district in the Prairie Provinces. Yearly and locality difference will occur but the general picture will be the same. However, there is no evidence of any harmful influence on alfalfa seed setting. Thus, where economic necessities are fulfilled in other ways the presence of honeybees in alfalfa fields is desirable.

The Effects of Herbicides on Alfalfa Seed Setting

The main reason for starting this project was the prevalence of an annual weed, Russian pigweed, in many alfalfa seed fields. The seed of Russian pigweed is almost impossible to separate from alfalfa seed. As a result many growers were producing seed that was eventually degraded or even rejected. A demand arose for information on the value of herbicides.

Experiments were conducted from 1950 to 1953, inclusive. Most of the data obtained were secured in co-operation with the Department of Plant Ecology, University of Saskatchewan. During the four-year period a variety of experiments were carried out at Saskatoon and in different locations in northern Saskatchewan. Some were field experiments where field equipment was used and some were plot tests using a hand sprayer. In all cases alfalfa stands were at least one year old but different stages were tested from before growth started in the spring to when the alfalfa was about 10 inches high. Several different chemicals and formulations were used and very light to extremely heavy rates were tested. Careful observations were recorded on the control of Russian pigweed and other annual weeds, particularly lamb's quarters, and special attention was given to damage to the alfalfa, especially as it affected seed setting. While a more complete report of the work will be published elsewhere, a summary of results and conclusions is presented here.

Amine and ester formulations of 2,4-D and MCP were applied at rates from 2 to 32 ounces of active ingredient per acre. It was found that even the very heavy rates caused little or no damage if applied before growth had started or at least before the new shoots were 1 inch in length. The only evidence of damage was from the 16- and 32-ounce rates of the ester formulation applied to a one-year-old stand. In this instance growth may have been slightly more advanced than indicated above. Russian pigweed and lamb's quarters and to some extent Russian thistle were effectively controlled by the heavy rates applied at this stage. Later applications of the same herbicides and rates, when the alfalfa was 2 to 5 inches high caused extensive damage and, at the heavy rates, killing. This applied particularly to the ester formulations. Similar effects were noted from heavy rates of the amines except at the 2- and 4-ounce rates. The latter, however, did not give so good control of weeds as did the heavy rates of both amine and ester applied at the earlier stage of growth.

As a result, for the control of Russian pigweed it is recommended that 8 ounces of the ester formulations or 16 ounces of the amines of 2,4-D and MCP be applied very early in the spring. It is emphasized that the new growth must not be over 1 inch long otherwise serious damage to the alfalfa may occur. If later stages of growth are to be treated then not more than 4 ounces per acre of the amine formulations should be used.

Interesting information was obtained also on the use of dinitro compounds. Two were tested and one gave excellent results. Fair control of Russian pigweed and lamb's quarters was obtained at rates of 2 quarts of the chemical per acre, and excellent control at the 4- and 6-quart rates. No damage to the alfalfa was noted at harvest time although the chemical was applied when the alfalfa was 6 to 10 inches high. A disadvantage of the dinitro compounds is that they must be applied with about 80 gallons of water per acre. This involves problems in obtaining water and in providing suitable spraying equipment. In general, also, effective rates of dinitro are more costly than recommended rates of 2,4-D or MCP. Furthermore, dinitro compounds should be applied only on warm, sunny days when temperatures are relatively high and rain is not expected for at least a few hours. Otherwise their effectiveness may be greatly impaired.

As a general conclusion the most economical and most convenient treatments are the heavy rates of 2,4-D and MCP applied early in the spring. If later treatments are unavoidable then use 2 to 4 ounces per acre of the amine formulation of 2,4-D or MCP or, better still 4 to 6 quarts per acre of a dinitro compound.

Variety Tests

New varieties of alfalfa are constantly being released in Canada and the United States to fill various regional and local demands. Whenever these productions are likely to be of interest to Canadian growers, seed is obtained and tested against standard Canadian varieties. Several of these tests have been completed during the past five years and in all cases Ladak has been included for comparison. Since certain varieties were not included in all experiments in all years a comparison of any two of them should be made by comparing their performance in relation to Ladak. Table 5 summarizes information on forage yield, seed yield, and winter hardiness.

TABLE 5—AVERAGE DATA ON FORAGE YIELD IN TONS PER ACRE OF DRY MATTER, SEED RATING, AND PERCENTAGE WINTERKILLING OF ALFALFA VARIETIES IN EXPERIMENTS CONDUCTED DURING THE PERIOD 1949-53

Designated variety	Yield dry matter tons/acre				Seed Rating[1]			Percentage winterkilling		
	No. of tests	Yield of Designated variety	Yield of Ladak	Yield of designated variety in percentage of Ladak	No. of tests	Designated variety	Ladak	No. of tests	Designated variety	Ladak
Grimm, Sask.[2].	9	1.23	1.42	87	7	4.9	5.4	4	4	4
Grimm, U.S.A.	..	..	..	..	..	..	..	3	29	10
Ranger........	10	1.17	1.45	81	2	8.0	7.5	6	32	6
Buffalo........	7	.89	1.66	54	2	6.8	6.1	5	79	6
Atlantic.......	7	1.00	1.18	85	2	6.8	5.8	4	62	10
Rhizoma......	6	1.48	1.53	97	5	4.5	4.9	2	5	4
Ferax.........	4	1.40	1.66	84	5	2.6	4.9	2	18	4
Narragansett.	4	1.06	1.17	91	3	5.6	5.7	1	17	7
Vernal.........	3	2.09	1.99	105	1	6.7	7.7	2	1	1
Du Puits......	2	1.00	1.08	93	2	6.1	5.8	1	35	7

[1]A seed rating of 1 represents a very high yield; a rating of 9 represents a complete failure.
[2]The two sources of Grimm were combined for the calculation of forage yield and seed rating.

A few explanatory notes with regard to the varieties represented in Table 5 may be useful in considering the data.

Ladak.—This variety consistently averages 10 to 15 per cent more forage than does Grimm. It is winter hardy and slightly resistant to bacterial wilt. Ladak is particularly recommended for areas where the crop is cut for hay and especially if only one cutting is likely to be harvested.

Grimm.—In the northern districts where seed production is concentrated Grimm is grown almost exclusively. Although the forage yield is not so good as Ladak, seed yield has been somewhat better. Northern-grown seed is winter hardy but seed lots from the United States show a loss of winter hardiness as indicated in Table 5. Grimm is susceptible to bacterial wilt.

Rhizoma.—This is a production of the University of British Columbia and was selected for a spreading root habit. However, this character is not exhibited in trials in the Prairie Provinces. Rhizoma produces a heavy crop of hay. It is highly susceptible to bacterial wilt. Seed yield has not been consistent. Some tests have shown it to be higher than Grimm or Ladak whereas in other trials it has yielded considerably less.

Ferax.—Ferax was bred at the University of Alberta where it was selected for high seed yield. It has consistently outyielded all other varieties in seed yield tests in the Saskatoon area. Unfortunately, the forage yield usually is slightly less than Grimm and there is some indication of lack of hardiness.

Ranger.—The variety Ranger was produced by the University of Nebraska and was selected for resistance to bacterial wilt. Although its wilt resistance is high Ranger does not yield so much hay as Grimm. In addition, it is somewhat lacking in winter hardiness.

Buffalo.—Like Ranger, this variety was selected for resistance to bacterial wilt. It was produced by the Kansas State Agricultural College, Manhattan, Kansas. It cannot be recommended in Western Canada because of a decided lack of winter hardiness.

Atlantic.—This variety was developed in the eastern United States for high forage yield. It is definitely not winter hardy and cannot be recommended in the Prairie Provinces. Atlantic is not resistant to bacterial wilt.

Narragansett.—The variety was selected at the Experimental Station in Rhode Island. In tests at Saskatoon it has not been very promising and there is a slight indication of lack of hardiness. Narragansett is not resistant to bacterial wilt.

Du Puits.—This is a variety introduced from France. In certain countries and in parts of the eastern United States it is noted for a tall erect growth, good forage yield and high seed yield. It is not resistant to bacterial wilt. Tests at Saskatoon show nothing exceptional in seed or forage yield and Du Puits definitely lacks winter hardiness.

Vernal.—Vernal is a production from the University of Wisconsin, and is highly resistant to bacterial wilt. The variety has performed very well at Saskatoon and at stations across the northern United States. It appears to be completely winter hardy. Foundation seed is being produced in Canada and if Vernal continues to perform well in test experiments it will probably be released to Canadian growers.

INVESTIGATIONS WITH GRASSES

by R. P. KNOWLES

Objectives and Progress in Plant Breeding

Brome Grass

Bred strains of brome grass have not been used extensively in the Prairie Provinces. The Parkland variety released by the Forage Crops Laboratory in 1935 was desirable because of the reduced creeping habit but seed production was inferior to that of the commercial type generally grown. Selection now is being made in both creeping and non-creeping material with emphasis on forage yields, seed yields, and resistance to leaf-spot diseases.

Plants selected in single-plant nurseries are divided into clones which are used to plant replicated clonal nurseries. Some elimination of selections is made on the basis of clonal performance and open-pollinated seed is used to seed replicated plot trails which allow critical evaluation. Synthetic strains are formed from clones of selections which give high yielding open-pollinated progenies. A few strains which have been tested in the first generation of synthesis have outyielded the northern commercial types. The most promising of these synthetics yielded 22 per cent more forage and 74 per cent more seed than the northern commercial type in 1953. Further generations of these synthetics will be tested on a more comprehensive scale at Saskatoon and other western Stations.

Crested Wheat Grass

Crested wheat grass is a highly productive, drought-tolerant grass that has found rather wide usage for grazing purposes in dry areas of the Prairie Provinces. The Fairway variety *(Agropyron cristatum)*, which is the type most generally used in Canada, has been criticized for the short habit of growth. This is especially noticeable in old stands. Crested wheat grass also tends to ripen off and become undesirable for grazing during July. The grass also may cause an objectionable flavor in milk when grazed in the early spring or fall.

In recent years several strains of the Standard or tetraploid type of crested wheat grass *(A. desertorum)* have been tested in comparison with the Fairway variety. A strain of the Standard type which has been under test since 1939 under the designation of S-131 was licensed as the Summit variety in 1953. This variety grows 3 to 4 inches taller than the Fairway variety and on the average of 27 tests at western stations has outyielded Fairway for hay by

FIG. 2.—Variation in height of single plants of crested wheat grass. Left: tall selection of the Standard type. Centre: Fairway. Right: tall selection of Fairway.

12 per cent. Seed yields are somewhat below those of Fairway. Tests are under way to determine whether the Summit variety causes taint in milk to the same extent as Fairway. Summit originated from an introduction from Omsk in the U.S.S.R. No attempt was made to alter the original material other than roguing of the single-plant plantings to eliminate off-types.

Selection is being continued in both the Fairway and Standard types. The possibilities of selecting taller-growing types are apparent from Fig. 2. Open-pollinated progeny testing along the lines described for brome grass is being carried out on a considerable scale. Several experimental synthetics have been formed that have shown forage yields above those of the Fairway variety and comparable to those of the Summit variety.

Intermediate Wheat Grass (*Agropyron intermedium*)

Intermediate wheat grass was brought under trial at the Laboratory in 1946 following reports of good performance of the Ree variety of this grass in South Dakota. Single-plant nurseries were established to find the range of variability of this grass. Great variation was found in plant color, leafiness, degree of creeping, seed production ,and resistance to the western wheat aphid (*Brachycolus tritici* Gill.). Aphid damage was severe in single-plant nurseries and also perceptible in solid seedings of this grass.

Breeding objectives include (1) high seed yields, (2) restricted creeping habit, (3) high forage yields, (4) leafiness and (5) resistance to aphis. Open-pollinated progeny tests of selected plants have shown variations in forage yields from 84 to 178 per cent of the Ree variety. Seed yields of clones of selections have varied from 11 to 152 per cent of Ree. Spread of selections has varied from 16 to 30 inches as compared with 24 inches for Ree. Aphid damage to progenies of selections have varied from zero to 31 per cent in comparison with 40 per cent for Ree.

A fruitful source of material arose from a top-cross of the Ree variety with an introduction from the U.S.S.R. This cross is being increased under isolation and further selection is being made in the cross. Three strains produced at this Station and two introduced strains are in the advanced stages of testing. One of these strains has shown promise of having good tolerance to saline soils.

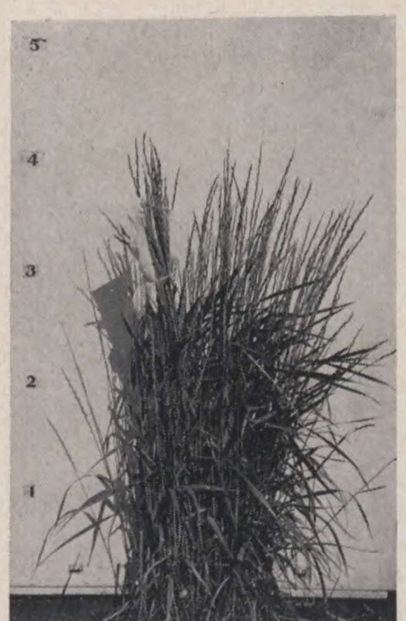

FIG. 3—Tall, leafy selection of intermediate wheat grass with restricted creeping habit.

FIG. 4—Single plant of intermediate wheat grass showing stunted growth caused by the western wheat aphid (*Brachycolus tritici* Gill.)

Studies on Methods of Breeding

Open-pollinated Progenies for Combining Ability Tests

At the Laboratory the hay- and seed-yielding ability of selected grass plants is being evaluated on the basis of open-pollinated progeny yield trials. To obtain sufficient seed for planting such trials it is necessary to increase original selections vegetatively. By randomizing clones in replicated nurseries more uniform pollination of clones is achieved. The number of replications required in colonal nurseries of this sort has been an open question.

Open-pollinated progenies of brome grass have been established using seed harvested from different replicates of clonal nurseries. Yields of these progenies have corresponded fairly well. Three tests have shown correlations of +0.73, +0.87, and +0.60 between progenies grown from different seed sources. Considerable confidence apparently can be placed in the performance of open-pollinated progenies grown from seed of a single plant or a single clonal row. For precise evaluation of selections, however, it appears that seed should be collected from two or more replicates of clonal nurseries.

Top-crossing Techniques

Top-crossing of selected plants is being done to provide more uniform pollination of selected plants than is possible from open pollination. Usually only sufficient seed is obtained to allow the planting of spaced nursery rows. As well as providing progeny tests of selections, top-cross progenies in themselves are a convenient source for re-selection. Top-cross progenies might be expected to be superior to open-pollinated progenies if the top-cross parent or parents are of proven high production.

FIG. 5—Crossing intermediate wheat grass with the pollen gun. Note large Kraft bag for the collection of pollen and small parchment bags for the production of top-crossed seed.

Top-crossing with a pollen gun apparatus gives fair amounts of seed with a minimum of effort. Selections of the current season are bagged with parchment bags a few days in advance of flowering. On the day when general flowering appears imminent large kraft bags are applied to the top-cross parent for the collection of pollen. Following field flowering, which generally occurs in the late afternoon for brome grass, crested wheat grass, and intermediate wheat grass, pollen bags are collected and the pollen bulked. Anthers are shaken off and by using a pollen gun the fresh pollen is blown into pollination bags applied to the selected plants. Pollinations are made with considerable haste as the viability of pollen deteriorates within two or three hours of collection. Top-crosses are repeated on two to three days within the flowering period. Table 6 gives seed-setting data for 1952 top-crosses.

TABLE 6—SEED SETTING FROM TOP-CROSSING IN RELATION TO THAT FROM SELF- AND OPEN-POLLINATION. 1952

Grass	No. of selections	Average number of seeds per head following		
		Selfing	Top-crossing	Open-pollination
Intermediate wheat grass	28	4.0	21	32
Brome grass.............	32	14.9	42	103
Crested wheat grass.....	37	0.8	31	70

Top-crossing over the last three years has resulted in one-half to one-third of the seed produced under open-pollination. This method of controlled crossing is particularly suitable for intermediate wheat grass and crested wheat grass as these grasses show low self-fertility. Brome grass plants show considerable variation in degree of self-fertility, and top-crossing without emasculation is satisfactory only with the more self-sterile plants.

Methods of Plot Testing

Careful planning and considerable work are involved in conducting open-pollinated progeny trials. Often yield advantages in the region of 10 per cent above those of present varieties are to be expected. This necessitates precise testing and a repetition of tests until confidence can be placed in yields obtained. Lattice designs and small narrow plots are helping to provide this needed precision.

Analyses of 27 lattice tests of crested wheat grass, brome grass, and alfalfa for hay indicated average gains in efficiencies of 51, 44, and 39 per cent, respectively, for the different crops over randomized block analyses. These gains were observed in tests containing as few as 16 strains. Single-row plots 20 feet long and spaced 2 feet apart have been used for tests of crested wheat grass strains. Plots 3 by 20 feet and consisting of three rows 1 foot apart have been used for brome grass and intermediate wheat grass strain tests.

Isolation Requirements

As most of the perennial grasses grown in Western Canada are cross-pollinated by wind the isolation distance required for the maintenance of purity in new synthetics and seed increase plots is of importance. The amount of contamination in small isolations of grasses has been studied in a preliminary way. Unfortunately, genetic markers that might be of use in this study have not been noted in the grasses available.

Methods of study involved pollen counts at various distances from brome grass and crested wheat grass fields and seed setting of self-sterile plants of these grasses set out at the same isolation distances. Pollen counts were obtained by exposing greased microscope slides during the flowering period in a down-wind direction from the sources of pollen. Table 7 shows the abundance of pollen and seed setting of self-sterile plants at various isolation distances.

TABLE 7—POLLEN DISTRIBUTION AND SEED PRODUCTION OF SELF-STERILE PLANTS AT VARIOUS ISOLATION DISTANCES

Crop	Isolation distance—yards			
	100	200	300	400
Pollen count as percentage of that adjacent to the source				
Brome grass (15 days)	12	5	2	1
Crested wheat (12 days)	14	3	2	2
Seed setting as percentage of that adjacent to the source				
Brome grass (10 plants)	22	16	2	1
Crested wheat (11 plants)	22	4	2	2

These studies indicate a marked drop in pollen amounts at distances of 200 yards. Seed production, however, was fairly high in brome grass even with 200 yards isolation. It would appear that 300 or 400 yards isolation is needed for the isolation of initial breeding material to maintain purity.

Cultural Studies

Fertilizer on Brome Grass

A considerable portion of Canadian production of brome-grass seed is grown in a relatively small area in northwestern Saskatchewan. High seed prices during the period 1947 to 1950 resulted in increased interest in seed production in this area. As a result of grower demand for information on fertilizer use for brome grass a series of studies was started in 1947.

It was found that high nitrogen analysis fertilizers such as ammonium nitrate and ammonium sulphate gave fairly marked increases in seed yields. Time of application was important. Best seed-yield response came from applications made in August and September of the year preceding the seed crop. Forage responses were similar for fall and spring application. Rates of 20 and 40 pounds of elemental nitrogen per acre were more satisfactory than rates of 80 pounds per acre. In dry years little increase in seed or forage yields was obtained. Sandy soils which are commonly used for seed production of brome grass gave greater responses to fertilizers than loams or clay loam soils. No response to phosphorus was obtained.

A common practice employed by brome-grass-seed growers to obtain higher seed production is to rejuvenate old stands by shallow plowing every four or five years. This entails the loss of a seed crop for one season while the grass recovers but yields the following year are much improved. Plowing generally is done in the early spring and a crop of oats seeded to provide some return. Experiments are in progress comparing fertilizers and cultivation treatments in their effectiveness in improving the productivity of brome grass.

Effect of Row Spacing on Seed Production

Brome-grass seed generally is produced in solid seeded stands and crested wheat grass in from 3- to 4-foot-row plantings. Tests were established to find to what extent these grower practices are justified and to determine what spacings should be used for the recently introduced crops, intermediate wheat grass and tall wheat grass. Average seed yields of a test harvested for three years and one harvested for two years are given in Table 8.

Approximately 50 pounds more seed per acre were produced from brome grass at the 2- and 3-foot spacing than at the 1-foot and 6-inch spacings. In crested wheat grass the advantage for the wider spacings was approximately 75 pounds of seed per acre. For intermediate wheat grass and tall wheat grass all spacings gave similar seed yields. Average yields of grasses indicate intermediate wheat grass to be inferior in seed production with yields about half those of brome grass and one-third those of Fairway crested wheat grass. Tall wheat grass appears as high a yielder of seed as brome grass.

TABLE 8—SEED YIELDS OF FOUR GRASS SPECIES AT FOUR ROW SPACINGS. AVERAGES FOR ONE TEST HARVESTED FOR THREE YEARS AND ONE HARVESTED FOR TWO YEARS

Grass	Seed yields in pounds per acre for spacings of:				
	3 feet	2 feet	1 foot	6 inches	Average
Brome grass	224	237	176	168	201
Crested wheat grass (Fairway)	346	356	278	276	314
Intermediate wheat grass	100	122	101	110	108
Tall wheat grass	225	215	206	208	214

In establishing these tests three methods of weed control were followed (1) seeding with a nurse crop of wheat, (2) seeding without a nurse crop with weeds mowed periodically and (3) seeding without a nurse crop with weeds controlled with 2,4-D ester applied at 8 ounces acid equivalent per acre. For the two tests harvested above average yields of seed for all grasses per acre were 184, 220, and 221 for nurse crop, mowing, and 2,4-D treatments, respectively. It appears that the use of a nurse crop caused only a moderate reduction in seed yields in the first crop year and these were compensated for to some extent in subsequent harvests. Greatest depression from the use of the nurse crop was noted in crested wheat grass and the least in intermediate wheat grass.

Forage Crops for Saline Soils

Fairly extensive acreages in the Prairie Provinces are too saline for cereal production. Permanent cover with perennial forage crops is favored by farmers for these saline or "alkali" areas as they are commonly called. A series of greenhouse and field tests was undertaken to find the relative tolerance of various crops to saline conditions.

Field tests were seeded on nine problem areas in the Saskatoon district and soils from certain of these areas were transported to the greenhouse for tests under controlled moisture conditions. Several of the field trials were complete failures as a result of using soils that were too saline and because of the occurrence of drought conditions following emergence. The Department of Soil Science of the University of Saskatchewan co-operated in providing electrical conductivity ratings of the various saline soils.

D

A B C

FIG. 6—Test of alkali tolerance of grasses seeded 1950. Photograph taken August 1, 1951. Strips are A—alfalfa, B—Russian wild rye, C—slender wheat grass, and D—standard crested wheat grass. Note the good growth of slender wheat grass.

Slender wheat grass and tall wheat grass were the two most alkali-tolerant species tested. These grasses survived in soils with conductivity ratings of 15 millimhos. per cm. which indicates a level of salinity prohibiting the growth of ordinary crops. In field tests slender wheat grass gave higher yields than tall wheat grass perhaps as a result of greater drought tolerance of slender wheat grass. Moderately resistant crops were brome grass, Fairway crested wheat grass, and the "glaucum" strain of intermediate wheat grass. Russian wild rye grass, Canada wild rye grass, and sweet clover showed good tolerance in some tests while in others they showed mediocre salinity tolerance. These tests are being continued on a reduced scale.

Variety and Species Tests

Brome Grass Variety Tests

Brome grass grown by farmers in Western Canada is of the so-called "northern" type. In the United States, varieties of the "southern" type now are being recommended except for northern states where northern varieties still are favored. Northern and southern types of brome grass apparently originated from corresponding latitudes of Europe and Asia. Since a major portion of brome grass seed produced in Western Canada is exported to the United States it is imperative that the merits of all varieties used in the United States be considered here.

Studies of hay and seed production of northern and southern types from 1938 to 1949 have been reported. (Scientific Agriculture 29: 437-450. 1949). Table 9 presents a summary of more recent tests.

The performance of southern strains is in line with previous tests, that is, they are as high yielding of forage as northern strains but are lower in seed yield. Martin, Manchar, and Homesteader, of the northern type, compared fairly well in forage and seed production with the northern commercial strain. Parkland in these tests, as in previous tests, gave forage yields comparable with those of the northern commercial type but seed yields were low. A survey of all tests of Parkland brome grass at Saskatoon and other western stations showed seed yields of this variety to average 65 per cent of those of northern commercial (8 tests), and forage yields to average 102 per cent of those of northern commercial (15 tests).

TABLE 9—COMPARISON OF NORTHERN AND SOUTHERN STRAINS OF BROME GRASS 1949-1953. HAY YIELDS REPORTED IN TONS OF DRY MATTER PER ACRE AND SEED YIELDS IN POUNDS PER ACRE.

Strain	Block 407 1949–50		Block 807 1949–51		Block 1407 1952–53		Block 808 1953	
	Hay	Seed	Hay	Seed	Hay	Seed	Hay	Seed
Northern Type								
Commercial	2.45	218	1.29	200	1.47	287	1.37	137
Parkland	2.34	180	....	....	....	....	1.36	112
Martin (Minn.)	2.35	186	1.32	179	....	....	....	....
Manchar (Wash.)	....	....	1.25	259	1.25	246	1.39	174
Homesteader (S.D.)	....	....	....	....	....	....	1.53	107
Southern Type								
Achenback (Kan.)	2.02	80	1.23	84	1.52	157	1.52	186[1]
Lincoln (Nebr.)	2.48	124	....	....	1.63	233	....	....
Fischer (Ia.)	....	....	1.13	80	....	....	....	....
Lyon (Nebr.)	2.32	113	1.47	141	1.36	191	1.68	76
Lancaster (Nebr.)	2.32	123	1.15	120	....	....	....	....
L.S.D. (P-.05)	N.S.	54	N.S.	128	.17	84	.13	30

[1] Thin stand.

Comparison of Grasses for Hay Production

Brome grass and crested wheat grass appear to be the most suitable grasses for general use in the Prairie Provinces. Other grasses, however, are being observed to find if adapted species can be found for special conditions, such as alkali soils or flooded areas. Slender wheat grass *(Agropyron trachycaulum)* was formerly cultivated extensively but has now been replaced largely by crested wheat grass and brome grass. Slender wheat grass, however, has good tolerance to alkali and likely will continue to find a place on such soils. Intermediate wheat grass *(A. intermedium)*, tall wheat grass *(A. elongatum)*, Russian wild rye grass *(Elymus junceus)*, and Canada wild rye grass *(E. canadensis)* are recently introduced grasses that show good adaptation and vigor. These grasses yield well in relation to brome grass and crested wheat grass as is indicated in Table 10.

Although intermediate wheat grass, tall wheat grass, and Canada wild rye grass give high forage yields, these grasses are inclined to be coarse in habit of growth. Chemical analyses indicate tall wheat grass and Canada wild rye grass to be higher in fibre content than brome grass or crested wheat grass. Slender wheat grass has yielded as well as brome grass and crested wheat grass and the Primar and S-2095 strains appear as satisfactory as Mecca. Primar is resistant to smut while Mecca is often badly smutted.

TABLE 10—HAY YIELDS OF VARIOUS PERENNIAL GRASSES AT SASKATOON 1946 TO 1953 TESTS. YIELDS IN TONS DRY MATTER PER ACRE

Grass and Strain	Block 508 46-48	Block 508 47-48	Block 708 47-50	Block 308 49-50	Block 908 50-53	Block 508 1953	Block 708 1953
Intermediate wheat grass:							
Ree	....	1.56	1.33	.64	1.46	2.10	1.94
Glaucum	1.44	1.53	1.42	....	....	....	....
Tall wheat grass:							
S-64	1.39	....	1.24	....	....	2.04	....
Crested wheat grass:							
Fairway	1.02	1.20	1.30	1.12	1.52	1.84	....
Summit	1.30	....	1.46	.98	1.40	....	....
Brome grass:							
Commercial	1.04	1.23	1.15	1.01	1.43	1.70	1.69
Slender wheat grass:							
Mecca	....	1.24	1.25	....	1.58	....	....
Primar	....	1.33	1.19	....	1.58	....	1.69
S-2095	....	....	....	....	1.60	1.73	1.51
Russian wild rye:							
S-114	....	....	1.16	1.15	....	1.31	....
Canada wild rye:							
Mandan	....	....	1.39	1.26	1.51	....	1.92
L.S.D. (P-.05)	.17	.24	N.S.	.12	.23	.28	....

Comparison of Various Grasses for Pasture Production

Grazing trials are difficult to design and costly to conduct. An approach method commonly employed in lieu of actual grazing consists of clipping grasses periodically in well-replicated plot tests. Clipping tests are easy to perform and do demonstrate the response of crops to periodic defoliation. If the plot test area is opened to livestock following clipping of yield areas, it is possible to get fairly reliable palatability comparisons. Chemical analyses may be carried out to get indications of relative feed values.

Three pasture clipping trials were conducted from 1946 to 1953. Yields of different grasses in these tests are given in Table 11. Palatability ratings from one of the tests were obtained by noting the amount of each grass remaining following grazing by dairy cows.

Intermediate wheat grass and Russian wild rye grass compared very favorably with brome grass and crested wheat grass in pasture production. Tall wheat grass also yielded well in two of the three tests. Tall wheat grass and Russian wild rye grass were desirable in that they gave good summer production in contrast to most of the other grasses which gave higher production in May and June. Quite wide variations were apparent in the palatability of these grasses. Tall wheat grass, slender wheat grass, and the three wild rye grasses appeared much less palatable than brome grass.

Chemical Analyses of Grass Hays

Chemical analyses for the laboratory have been carried out by the Chemistry Division, Central Experimental Farm, Ottawa. Hay portions for one or two of the regular grass species tests have been submitted for analysis each year. Variety tests generally were cut for hay according to the stage of growth, but occasion-

TABLE 11—ANNUAL YIELDS AND PALATABILITY RATINGS OF GRASSES IN PASTURE CLIPPING TESTS, SASKATOON, 1946-1953

Grass and Strain	Pasture yields in tons dry matter per acre			Palatability rating—percentage grazed[1]
	Paddock sown 1946 1948—2 cuts	Block 708 sown 1950 3 yr.—7 cuts	Block 508 sown 1952-53—2 cuts	
Intermediate wheat:				
Ree	.59	1.25	1.29	70
Glaucum	1.08	1.19	....	57
Tall wheat:				
S-64	.45	.98	1.13	47
Crested wheat:				
Fairway selection	.87	1.18	1.02	58
Summit	.91	1.16	....	65
U.S. Standard	.82	....	....	68
S-2284	....	....	1.20	..
Brome:				
Commercial	.81	.95	.94	68
Achenbach	.61	....	....	70
Parkland	.66	....	....	67
Slender wheat:				
Mecca	.53	....	.93	53
Russian wild rye:				
S-114	.85	1.31	1.10	22
Canada wild rye:				
Mandan	.42	.94	....	50
Virginia wild rye:				
S-1267	.27	....	....	37
Timothy:				
Commercial	.18	....	....	90
L.S.D. (P-.05)	.22	.21	.16	..

[1] Average consumption on paddock test September 26, 1947 and May 20, 1948.

ally all grasses were harvested on the same date. Table 12 provides a summary of chemical analyses for protein and fibre for all tests from 1945 to 1953. Since averages do not represent the same tests they should be considered approximate only.

TABLE 12—AVERAGE PROTEIN AND FIBRE CONTENT OF THE HAY OF VARIOUS GRASS SPECIES, 1945-1953

Grass	Strain	No. of tests	Average percentage	
			Protein	Fibre
Brome	Commercial	11	12.5	27.0
Crested wheat	Fairway	11	11.3	26.7
" "	U. S. Standard	4	11.2	26.5
" "	Summit	9	10.6	27.0
Tall wheat	S-64	8	10.6	32.8
Intermediate wheat	Ree	7	10.7	28.2
" "	Glaucum	5	9.6	30.7
Slender wheat	Primar	1	10.9	33.3
" "	Mecca	1	12.5	29.8
" "	S-2095	1	10.7	31.0
Russian wild rye	S-114	6	13.6	29.7
Canada wild rye	Mandan	6	11.0	29.8
Virginia wild rye	S-1267	2	10.5	29.1

Brome grass and crested wheat grass showed similar fibre contents but brome grass averaged one per cent higher in protein than crested wheat grass. These two grasses showed slightly lower fibre contents than any other grass tested. Tall wheat grass was slightly lower in protein content than brome grass and considerably higher in fibre content. Intermediate wheat grass and slender wheat grass appeared slightly lower in protein and higher in fibre than brome grass or crested wheat grass. Russian wild rye grass had a higher protein content than any other grass tested. This was apparently the result of the high proportion of leaves to stems in this grass.

INVESTIGATIONS WITH SWEET CLOVER

by J. E. R. GREENSHIELDS

Objectives and Progress in Breeding

Sweet clover is an important legume in the Prairie Provinces. It is difficult to estimate accurately the acreage grown for hay, pasture, green manure, and seed production, but based on observation the interest in sweet clover has been on the increase. The main part of the breeding program at the Forage Crops Laboratory has been directed toward the elimination of two undesirable characteristics, namely, coumarin content and impermeable seed. While a variety free of coumarin and another variety having permeable seed will soon be available the ultimate goal will be to combine these two characters in a single, well-adapted variety.

Breeding a Permeable-seeded Variety

Sweet clover normally produces a large proportion of hard seeds, that is, the seed coat is impervious to moisture. The seed must therefore be processed to cause chipping or cracking of the seed coat without damage to the remainder of the seed. Without this scarification process 98 to 99 per cent of the seed is unable to germinate at the time of planting. Consequently, if seed is poorly scarified it retains its ability to germinate and will volunteer persistently for many years, as a small portion becomes permeable each spring after freezing and thawing. Moreover, when sweet clover is harvested for seed some seed is bound to shatter causing a pollution of the ground with "hard" seeds. From one shattered seed crop or poorly scarified planting of sweet clover seed volunteer plants may appear over a period of at least 15 years. A variety of sweet clover having naturally permeable seed would eliminate this serious volunteer problem without depending upon mechanical scarification.

A breeding program was started in 1931 with the idea of selecting more permeable strains of sweet clover. The results of selection have been most gratifying. Permeability was found to be associated with dark brown spots on the back of the seed. Recent tests show a positive correlation of +.97 between dark brown sunken spots and permeability. Some of these spotted seeds are shown in Fig. 7.

In 1950 all the existing strains of permeable-seeded material were crossed in the greenhouse and in the spring of 1951 two replicates were planted in the nursery for a forage yield test and two replicates were planted in isolation. The varieties Pioneer and Arctic were used as checks. In isolation the lines and checks were scored for vigor and just before flowering time the checks and all but the

FIG. 7—Spotted seeds typical of those produced by permeable-seeded plants, seeds on the right showing dorsal surface .×10.

six best lines were dug up. The remaining plants were allowed to intercross and Syn. 1 seed was obtained in the fall of 1952. The seed was analyzed on a single-plant basis for permeability and the results are presented in Table 13.

TABLE 13—AVERAGE PERMEABILITY OF SEED OF SELECTED CROSSES COMPARED WITH THE VARIETY ARCTIC. HARVESTED 1952

Strain No.	Average Permeability of Seed in Percentages
C-50-PP-1	91.7
C-50-3	98.2
C-50-6	98.6
C-50-7	98.9
C-50-9	92.3
C-50-10	90.3
Arctic	2.0

Many of the plants gave 100 per cent permeable seed. Only seed of over 98 per cent permeability was used to plant the isolation plot from which Syn. 2 seed will be obtained in 1954. Although some of the F_1 lines yielded as much forage as the variety Arctic in 1952, it must be pointed out that all of these lines come from only two sources of germ plasm and therefore the yield will be expected to drop somewhat in Syn. 2. The Syn. 1 seed was planted in the spring of 1953 and the answer should be available in 1954. If the genetic base proves to be too narrow, other lines of permeable-seeded material now available will be added to future synthetic generations with a view to increasing the yield of advanced generations.

Breeding for Low Coumarin Content

Sweet clover contains the compound coumarin which in recent years has been found to be indirectly responsible for hemorrhagic sweet clover disease in cattle. Investigations have revealed that when sweet clover becomes spoiled in the curing process, coumarin is converted to dicumarol. Dicumarol causes the clotting time of the blood to go up to the point where wounds will not stop bleeding or indeed the animal may bleed to death without injury if the condition has progressed far enough. From time to time rather heavy losses have been reported from this cause and the problem must therefore be regarded seriously.

The so-called "Melilot taint" of wheat is due to the absorption of sweet clover juices by the grain in the threshing process. Coumarin contained in the juice is responsible for the odor and flavor imparted to the grain. This flavor will carry over in the bread made from the flour of such wheat. Because of this taint many carloads of wheat from the prairies are graded rejected each year, resulting in a loss of several cents per bushel to the farmer.

The desirability of a variety free of coumarin is further emphasized by the fact that coumarin is the compound responsible for the bitter stinging taste of sweet clover. This characteristic makes sweet clover less palatable to stock than it otherwise would be. The relationship between coumarin and palatability is evidenced in the breeding nurseries by the fact that rabbits will forage on the particular plants that are low in coumarin and leave high-coumarin plants untouched. The nurseries must be fenced each year to keep the rabbits out.

The low-growing, coarse, non-economic species *(Melilotus dentata)* is coumarin-free. Ordinarily it is impossible to cross dentata with the common white sweet clover, but Dr. W. K. Smith of the University of Wisconsin, by the use of a special technique, was able to make the cross. In 1946 a few seeds were supplied to this Laboratory. The plants were rather undesirable in type but very low in coumarin content. This low coumarin material has been outcrossed several times and some of the low-coumarin lines derived are agronomically very desirable. Many low-coumarin lines will be planted in isolation in 1954 and if the recombination is promising they will form the base of a new coumarin-free variety.

Because of the urgent need for a coumarin-free variety, it may be desirable to put out a variety as quickly as possible, and a few years later after more extensive testing, an improved variety of the same material. The urgency is emphasized by the fact that sweet clover has become one of the main green manure crops in northeastern Saskatchewan and farmers also like to use it as a forage legume. Several farmers have started using sweet clover as a silage crop. Preliminary investigations have shown that, when properly ensiled, sweet clover does not develop dicumarol, but under aerobic conditions a dark brown type of silage results, and dicumarol will be present in sufficiently large quantity to cause a steady rise in the clotting time of the blood. A coumarin-free variety will remove this danger and make sweet clover a much more useful legume.

Large and Small Seed Studies in Sweet Clover

Sweet clover has relatively small seed compared with the cereal crops that are often used as a nurse crop. Due to the practice of mixing the cereal and sweet clover seed the latter is often sown too deeply, resulting in low emergence and a poor stand.

Workers at the Forage Crops Laboratory at Saskatoon noticed that there was a considerable range of seed size in sweet clover. It was reasoned that a larger seed might have the ability to emerge from greater depths and thus give better stands even though the seed had been sown deeper than optimum.

In 1940 a program was initiated where selection for the largest and the smallest seed was carried out. The selected plants were selfed and further selection was based on the weight per thousand of the open-pollinated seed. After five generations of selection the large seed weighed 3.0 grams per thousand while the small seed weighed as low as 1.5 grams per thousand with commercial sweet clover averaging 2.0 per thousand seeds.

Preliminary tests in the greenhouse on the emergence of seedlings of large- and small-seeded strains sown at various depths have given the results shown in Table 14.

TABLE 14—THE PERCENTAGE EMERGENCE OF LARGE, SMALL AND COMMERCIAL SWEET CLOVER SEED SIXTEEN DAYS AFTER PLANTING

Depth of Seeding	Average percentage emergence			
	Arctic Variety	Small-Seeded Strain	Large-Seeded Strain	Average
¾″	40.1	64	67.0	57.3
1½″	35.1	35.5	45.5	38.6
2¼″	11.6	2.6	31.6	15.3

L.S.D. depth—10.28, size—4.96, size x depth—8.16.

As the depth of seeding increased the advantage of the larger seed was evident. However, some other factors must be considered. Although selection was originally made in commercial sweet clover seed stocks and no attention was given to any character other than seed size, the small-seeded strains were about three weeks earlier in maturity than the large-seeded strain with most of the commercial varieties intermediate in maturity. Not only was there an association between seed size and maturity but the large-seeded strains were more vigorous throughout the whole season and would yield considerably more fodder than the small-seeded strains.

In the fall of 1953 enough open-pollinated seed of both strains was obtained to test large and small seed on a field scale with the commercial varieties. Whether or not large seed has much advantage over commercial seed has not yet been determined, but it does appear to be considerably more desirable than small seed with respect to emergence and vigor.

Genetic and Embryological Studies

The Nature and Inheritance of Seed-Coat Spotting in Permeable Strains of Sweet Clover (*Melilotus alba* L.)

As mentioned elsewhere in the report it was shown that permeability of certain lines of sweet clover depended on the occurrence of brownish, sunken spots in the seed coat (Fig. 7).

Histological observations of the spot showed the Malpighian cells to be shorter than normal, distorted, and the lumen filled with a brown pigment. The osteosclerid cells appeared collapsed or crushed and the nutrient layer was absent (Fig. 9 and 10). Cotyledons were shown to be pressed against the seed coat at one or more places in the spotted area. These observations suggest three possible causes of spotting.

(a) The embryo may be feeding on the seed coat tissue or nutrient intended for the seed coat causing the distortion of cells of the seed coat.

(b) The cotyledons have the inherent ability to grow too large for the seed coat in certain areas thus crushing and distorting the seed coat cells at the points of contact.

(c) The seed coat may be inherently smaller in some areas in relation to the cotyledon size, which is suggested by the fact that regardless of pollen source all the seed will have the spot indicating that it is primarily an effect of the maternal parent rather than of the hybrid embryo.

FIG. 8—Section of spotted seed showing spots on both sides where cotyledons press against the seed coat.

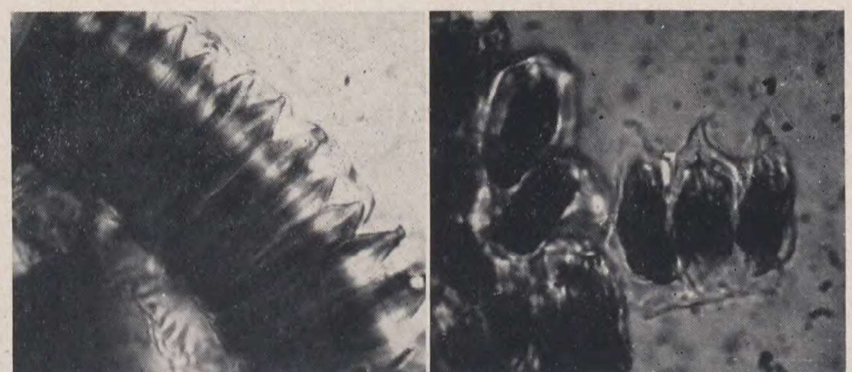

FIG. 9—Left: Normal Malpighian cells. Right: Malpighian cells from the spotted area showing distortion and pigment.

An inheritance study indicated that the spot was controlled by one major, recessive gene but influenced by one or more modifying genes. Environment had a marked effect on the expression of the spotted character. The percentage of spotted seed (penetrance) and the degree of expressivity (size of spot) were reduced under cotton selfing bags. Permeability was found to be dependent on the penetrance of spotting but was independent of the size of the spot. The controlling environmental factor affecting spotting was not determined but appears to be associated with favorable growing conditions.

Upon making reciprocal grafts between permeable and non-permeable seed plants it was determined that the spot was not transmitted systematically to non-spotted material. It was also shown that the spot was not transmitted directly by the pollen.

This study was carried out by R. K. Downey as an M.Sc. thesis problem and for further information, an article by Downey, Greenshields and White, in press with the Can. Jour. of Agr. Res., may be consulted.

Fig. 10—Left: *M. officinalis* × *M. alba* cross 18 days after pollination. The ovule is collapsing from the chalazal end and the embryo is showing necrosis. Right: *M. alba* × *M. dentata* showing a dead embryo and coencytic endosperm 8 days after pollination.

Embryology of Interspecific Crosses in *Melilotus*

For many years the Forage Crops Laboratory at Saskatoon has been interested in hybridization between species of *Melilotus*. Kirk and Stevenson, in a study reported in Sci. Agr. 15: 580-589, 1935, obtained hybrids between some species, but noted a high degree of incompatibility among other species. However, they observed a degree of compatibility between *M. officinalis* and *M. alba*, but obtained only aborted seeds that were not viable. In view of these results and the agronomic desirability of making some of these crosses a study of embryology of hybrids between species of *Melilotus* was undertaken in co-operation with Iowa State College. The compatibility of interspecific crosses is summarized in Table 15.

The results of these embryological studies may be summarized as follows:

Between partially compatible crosses, *M. officinalis* × *M. alba* produces the most advanced embryo (Fig. 11). Growth of the embryo proceeds normally until about eight days, and more slowly thereafter until the 12th or 13th day, when growth is completely inhibited and the embryo aborts. The reciprocal *M. alba* × *M. officinalis* embryo does not grow so large or differentiate so much before aborting by the 11th day. Other crosses, including *M. officinalis* × *M. suaveolens* and *M. alba* × *M. messanensis*, form a normal proembryo that grows slowly to about the sixth day. The proembryo then loses polarity, organ development becomes abnormal and aborts about the 12th day. Aborted embryos are also produced in the cross *M. alba* × *M. dentata*. Reciprocal crosses of *M. suaveolens* and *M. altissima* and *M. altissima* × *M. polonica* produce essentially normal embryo to eight days. These crosses may be sources of economically important germ plasm. Crosses of *M. altissima* × *M. alba* and *M. italica* × *M. altissima* exhibit embryo abortion. The suspensor becomes necrotic in four or five days and the proembryo floats into the ovule cavity, which contains abundant noncellular endosperm. In the cross *M. officinalis* × *M. altissima*, neither zygote nor the primary endosperm nucleus divides. When *M. atissima* is used as the female

TABLE 15—INTERSPECIFIC COMPATIBILITY RELATIONSHIPS AMONG *MELILOTUS* SPP.

	M. officinalis	M. alba	M. suaveolens	M. messanensis	M. altissima	M. dentata	M. hirsutus	M. polonica	M. taurica	M. sulcata	M. italica	M. speciosa
M. officinalis	S	E	E	O	EM	..	EM	..	O	..	EM	O
M. alba	E	S	S	E	EM	S-A	O	S*	E	..	EM	O
M. suaveolens	E	S	S	O	E	O	O	..	..	..	..	O
M. messanensis	E	E	O	S	..	..	..	..	..	..	..	..
M. altissima	EN	A	E	..	S	A	A	E	..	O	O	O
M. dentata	..	E	..	..	..	S	..	..	..	..	..	..
M. hirsutus	O	..	O	..	..	O	S	..	..	..	..	..
M. polonica	..	S*	S*	..	..	..	..	S	..	..	..	..
M. taurica	..	..	..	..	..	..	..	..	S	..	..	..
M. sulcata	..	EM	..	..	..	..	..	..	..	S	..	EM
M. italica	EM	O	..	S*	EM	..	..	..	..	..	S	EM
M. speciosa	..	..	..	..	..	..	..	..	..	..	..	S

S—Mature seed.
E—Embryo and endosperms develop for more than eight days.
A—Embryo disintegrates before eight days.
EM—Embryo or zygote present, but no endosperm division.
EN—Endosperm division, but no zygotic division.
O—No fertilization occurred.
*—Seed not taken to maturity in this study.

parent the zygote does not divide but the endosperm proliferates. In the cross *M. italica* × *M. officinalis* neither the zygote nor the endosperm divides. Embryos of *M. italica* × *M. sulcata* grow for four or five days, but the primary endosperm nucleus does not divide. The hybrid seed of *M. alba* × *M. suaveolens* is 54 per cent by weight of the seed of either parent. Although developing ovules are smaller than those of *M. suaveolens* × *M. alba*, the embryo of the former is much larger and more differentiated, and endosperm is more abundant. This relationship between these two compatible species is of particular theoretical interest. Although many of the crosses do not mature viable seed, some embryos develop normally to a point where they would be worthy subjects for culture on nutrient agar.

The results of this study will appear in more detail in an article in Canadian Journal of Botany 1954.

The Effect of Feeding Sweet Clover Silage on the Prothrombin Time of Blood of Cattle

In northeastern Saskatchewan sweet clover is extensively used for forage and soil improvement. Although it is one of the highest yielding hay crops, weather conditions in the region are often such that curing is often difficult. Mainly to circumvent the curing problem a few farmers in the region preserved sweet clover as silage in 1953. It is well known that spoilage of sweet clover hay in the curing process may result in conversion of coumarin to dicumarol, which acts as an anticoagulant of the blood. Whether dicumarol would develop in sweet clover silage or not was not definitely known. It was therefore decided to attempt to determine whether this compound occurred in sweet clover silage. The farmer's cattle which were being fed sweet clover silage as practically the sole ration for a period of at least a few weeks were treated as the experimental animals. This approach had the advantage that if the clotting time had been affected the farmer could be warned to take corrective measures.

Approximately one month after the feeding of silage was commenced blood samples were taken from cows in each of two herds on a silage ration and one herd on a hay ration. Results are shown in Table 16.

TABLE 16—PROTHROMBIN TIME OF BLOOD FROM TWO HERDS OF CATTLE AFTER FEEDING 4 TO 6 WEEKS ON SWEET CLOVER SILAGE COMPARED WITH THAT FROM A HERD NOT FED SWEET CLOVER

Designation of herd	Roughage ration	No. animals tested	Prothrombin time	
			Average	range
A	Silage	6	22.90 ± 0.42	22.0 – 25.0
C	Silage	6	25.23 ± 2.10	19.8 – 33.8
D	Hay	6	24.27 ± 0.26	23.2 – 25.0

Analysis of the data by the t-test revealed there were no significant differences between herds ($P < 0.05$). However, two of the cows in the C herd had prothrombin times of 30.3 and 33.8 seconds, respectively. These two animals were the only ones among those tested that were not milking and were without shelter at night. Other workers have shown that the susceptibility of rabbits to dicumarol is increased by exposure to cold and they have shown also that the prothrombin time of rats may go up due to exposure to cold. Furthermore the possibility existed that dry animals normally had higher prothrombin times than milking animals or that milk secretion provided an avenue for at least partial elimination of an anti-coagulant that might be present in the ration.

In order to secure information on the possible effects on prothrombin time of the state of lactation and exposure to cold, 25 animals of the University of Saskatchewan herd were tested. These animals were not being fed sweet clover in any form. There was no difference among groups of milking versus non-milking and exposure to cold versus non-exposure to cold, however, this did not give any indication whether or not exposure to cold would make animals more susceptible to dicumarol if it were present.

When the animals had been on sweet clover silage for approximately two months the herds were again sampled. The results are given in Table 17.

TABLE 17—COMPARISON OF PROTHROMBIN TIME OF ANIMALS FED SWEET CLOVER SILAGE FOR 2 TO 2.5 MONTHS WITH CHECK ANIMALS

Designation of herd	Roughage ration	No. of animals tested	Prothrombin time in seconds	
			Average	Range
A	Silage—stack silo No. 1	20	44.05 ± 1.77	31.1 to 65.3
B	Silage—stack silo No. 2	15	33.75 ± 0.90	28.9 to 39.9
C	Silage—trench silo	30	29.44 ± 0.74	24.4 to 42.6
D	Hay and/or oat sheaves	19	30.25 ± 0.92	23.8 to 40.1

Use of the t-test revealed that highly significant differences ($P < .01$) existed between the prothrombin time of the check (D) and the A and B herds. The difference between A and B herds was likewise significant. The C herd did not differ significantly from the check herd.

The significantly higher prothrombin time of certain herds and certain animals within herds being fed a roughage ration of sweet clover silage is definite evidence that an anticoagulant was present in the silage.

Silage of three qualities was evident in all silos. The surface layer to a depth of a few inches was moldy. Interior to this moldy layer the silage was a dark brown color for from 1 to 3 feet in thickness. Inside this dark brown silage was dark green silage of good quality. The moldy silage was almost entirely rejected by the animals. In a trench silo from which the C herd was being fed the dark brown layer was confined to about 1 foot of the upper surface. The silage was being fed in vertical layers, hence animals received brown silage only about one day per week. For a 10-day period prior to obtaining the data given in Table 17 the animals in the A herd had been fed silage removed in horizontal layers from the top of a stack silo. Thus for the feeding period their ration consisted largely, if not entirely, of dark-brown silage. The animals in B herd were being fed from a stack silo that had been open for two months, hence were getting a mixture of good silage and dark-brown silage.

Considering the quality of the silage being fed, it is evident that the degree of rise in prothrombin time is positively associated with the proportion of dark-brown silage consumed. It is therefore important to minimize the amount of dark-brown silage when using sweet clover as the silage crop. Other things being equal a trench, horizontal, or well-constructed upright silo will result in a lower portion of silage of inferior qualities than will be the case in stack silos. The employment of well-established practices of silage manufacture, such as controlling the moisture content of the crop as it is ensiled, chopping finely, and packing heavily, should be aids to this end. Finishing off the silo with a layer of at least two or three feet of silage from some other crop should largely, if not completely, prevent the moldy and dark brown layer from developing in the sweet clover silage.

The ultimate solution of the problem lies in the development of a coumarin-free variety of sweet clover.

The Effects of 2,4-D Spray Drift on Sweet Clover Plants in the Second Year of Growth

In recent years Saskatchewan farmers have complained of low yields of sweet clover seed in spite of apparent good weather and adequate bee populations. Also, it has been observed that the seed set in the Laboratory plots at Saskatoon has been late and very light. From a seeding made in 1952 approximately 250 plants of the variety Arctic were dug and transplanted to 7-inch pots in the spring of 1953. When about 25 per cent of the flowers were open the plants were taken to a large field of summerfallow and arranged in 5 replicates with 5 plants per plot. The distance between replicates was two rods. Treatment 1 was taken in from the field before spraying commenced to be used as a check. The plants in treatment 2 were placed at right angles to the wind as close as possible to the spray area. Plants in treatments 3, 4, 5, 6, and 7 were located 4, 12, 24, 48, and 96 rods, respectively, from the area to be sprayed and parallel to those in treatment 2. Spraying was carried out parallel to treatment 2 at a rate of 6 ounces of acid equivalent to 2,4-D butyl ester per acre for one hour, at wind velocities of 17 to 13 m.p.h. from the south-east.

The 2,4-D spray drift resulted in shedding of leaves, distortion of leaves and stems, and shedding of flowers. Even at 96 rods the effects were clearly discernible. The effects were sub-lethal in all cases, the primary effect being the delay of maturity of the seed. Seed yields taken 51 days after spraying were significantly different at the one per cent level of probability. The check yields averaged 25.1 grams per plot, while the other treatments yielded 2.3, 9.3, 9.8, 17.0, 17.2 and 18.9 grams respectively. The yield of seed does not reveal the complete picture. Seed quality improved with distance from the sprayed area but even at

96 rods was inferior to the check. This experiment probably underestimates possible damage from 2,4-D drift on sweet clover, because spraying was only for one hour at an average wind velocity of 15 m.p.h., but many farmers spray larger areas at higher wind velocities.

This work is reported more fully in an article in press in The Canadian Journal of Agricultural Science.

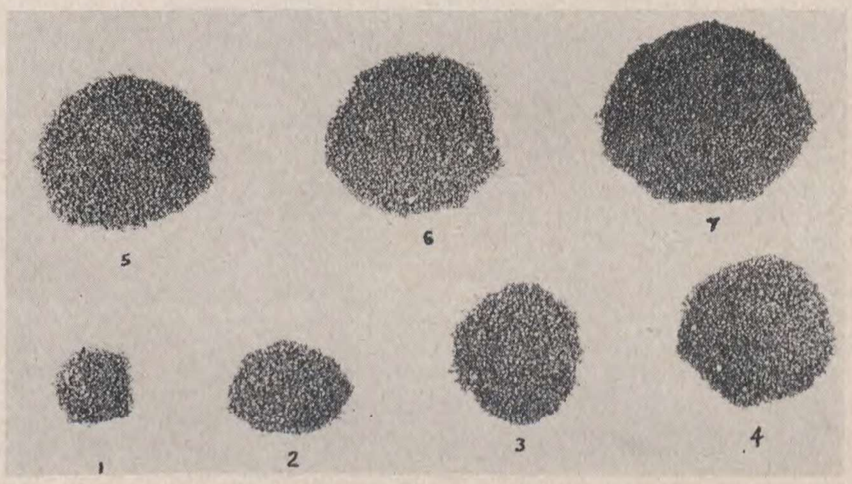

FIG. 11—Relative amounts of seed from five plants of sweet clover placed down wind at (1) zero rods (2) 4 rods (3) 12 rods (4) 24 rods (5) 48 rods (6) 96 rods from an area sprayed with 2,4-D butyl ester at 6 ounces per acre, at a wind velocity of 15 m.p.h. Number 7 is the check.

INVESTIGATIONS WITH SUNFLOWERS AND RAPE

by W. J. WHITE

Objectives and Progress in Breeding Sunflowers

The Advance hybrid variety which has come into general use in southern Manitoba has many desirable characteristics but, like most varieties, it has some shortcomings. Its lateness is one of its most undesirable features. This characteristic restricts use of the variety to areas having a fairly long growing season. It is considered possible for sunflower production to expand northward and westward if a suitable earlier maturing variety was available. Even in the area where sunflowers have been grown commercially for a few years an earlier variety would be welcomed. Consequently, a breeding project was undertaken in 1947 designed to develop an earlier maturing variety.

The breeding procedure followed was to cross S-37-388 and Sunrise (the two parents of the Advance hybrid) to Early Saratov. Early Saratov is 15 to 20 days earlier than S-37-388 or Sunrise. Then backcrossing to S-37-388 and to Sunrise for two or three generations was resorted to. This was followed by one or two generations of selfing. Throughout the program selection for earliness was practised. By 1953 a total of 29 lines of S-37-388 parentage and 17 lines of Sunrise parentage had been developed. The majority of these lines were increased in a small way in 1953. Commencing in 1954 these lines will be included in natural crossing plots to secure top-cross seed that will be used to test the combining ability of each of the lines.

The breeding procedure followed has effectively developed lines that are from 10 to 20 days earlier in reaching the flowering stage than S-37-388 or Sunrise. This is shown by the 1953 data on the date of commencement of flowering of individual plants which is presented in Table 18. The data presented are typical of those obtained each year for the past few years.

TABLE 18—FREQUENCY DISTRIBUTION OF 1953 FLOWERING DATE OF SUNFLOWER PLANTS IN SELECTED LINES COMPARED WITH PARENTAL VARIETIES

Date of Flowering	No. of plants flowering within specified dates				
	S-37-388 Parent	Backcrosses of S-37-388	Saratov Parent	Backcrosses of Sunrise	Sunrise Parent
July 16-18	..	1	5	..	..
" 19-21	..	1	32	4	..
" 22-24	..	21	20	9	..
" 25-27	..	15	33	5	..
" 28-30	..	11	48	1	..
" 31-August 2	..	5	9	..	..
August 3-5	..	1	6	..	..
" 6-8	3	..	..	..	1
" 9-11	15	..	..	..	7
" 12-14	35	..	..	..	5
" 15-17	23	..	..	..	7
Average	August 10	July 26	July 25	July 23	August 14

In the selection program attention has been given to vigor, strength of stems, and freedom from branching. No testing or selection has been done for oil percentage or iodine value because it was hoped to retain the desirability of the S-37-388 and Sunrise parents by means of the backcrossing procedure. Elimination of the lines for yielding ability and oil characteristics will be made on the basis of the performance of the top-crosses.

Objectives and Progress in Breeding Rape

The production of rape increased rapidly in Saskatchewan during and immediately after World War II. The varieties used by farmers were introduced into Canada from Europe and from Argentina. It was considered possible and desirable to attempt to develop a superior variety. The work was commenced in 1944 with about 40 single plant lines of Argentine type selected in 1943 by H. G. Neufeld of Nipawin and with unselected Argentine. The objectives in the selection program were high seed yield, high oil content, and both high and low iodine value.

By 1949 a few lines appeared sufficiently promising to warrant including them in yield trials. These tests were conducted at Saskatoon from 1949 to 1953, at the Experimental Station at Melfort, Sask., and the Co-operative Vegetable Oil Plant at Altona, Man., in 1952 and 1953. Altogether data from 9 different tests are available and are summarized in Table 19.

It is evident from Table 19 that the selected strains are all slightly higher in yield and oil content and lower in iodine value than unselected Argentine. The major improvement effected was in oil content. Selection for lower iodine value was effective but for higher iodine value was ineffective. On the basis of these results it is considered that the S-1221-18-1-2-4 strain is sufficiently outstanding to warrant release of it. This strain will be increased and named in 1954.

TABLE 19—SUMMARY OF YIELD AND OIL CHARACTERISTICS OF STRAINS OF ARGENTINE RAPE FROM 1949 TO 1953

Strain Number	Average Yields of seed in lb. per acre	Average oil content percentage	Average iodine value
S-1221-8-2-4-1	1424	40.50	101.2
S-1221-9-2-5-3-2	1399	41.28	99.5
S-1221-9-2-5-3-3	1446	40.56	98.4
S-1221-8-2-5-4-1	1410	40.06	99.3
S-1221-18-1-2-4	1437	41.61	101.7
Argentine	1298	38.51	102.7

In the early years of the selection program no control of pollination was practised. The distinct differences between lines and the relative uniformity of lines indicated that a fairly high degree of selfing occurred naturally. As the breeding progressed it was recognized that within open-pollinated lines considerable variation existed in oil characteristics in particular. For this reason selfing was practised. About 80 selfed lines were available by 1953 which were very uniform for oil characteristics. Since selection for yield of seed on the basis of single plants is probably relatively inefficient it was decided to include all of these lines in a yield test in 1953 using open-pollinated seed. A hail storm destroyed the test, however, and progress was delayed a year. From among this material it is hoped to secure lines that are distinctly higher yielding and at least as superior in oil characteristics as those for which data are given in Table 19.

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Miscellaneous Publications

W. J. White. Developments in Forage Crops 1950. Lectures and Addresses, University of Saskatchewan Farm Week. January 1951.

J. L. Bolton. Recent Developments in Forage Crop Seed Production. Report of C.S.G.A. Annual Meeting, June 1951.

W. J. White. Cultivated Forage Crops in Saskatchewan Yesterday, Today and Tomorrow. Lectures and Addresses, University of Saskatchewan Farm Week. January 1953.

ACTIVE PROJECTS

Breeding Projects

Breeding of improved varieties in brome grass, crested wheat grass, intermediate wheat grass, Russian wild rye grass, miscellaneous grasses, alfalfa, sweet clover, red clover, alsike clover, white clover, sunflowers, and annual rape; testing of introductions from world sources.

Techniques and Systems of Breeding

Studies on methods of crossing and selfing, and on effectiveness of various types of progenies for evaluating breeding material; evaluation of space isolation for preventing contamination.

Genetics and Cytology

The cytology of species, interspecific and intergeneric hybrids; the mode of inheritance of various characters in various forage crops.

Plant Physiology

The effect of date of seeding on establishment and growth; determination of adaptation to saline soils; determination of the value of species for soil erosion control; study of the root development of perennial grasses.

Comparative Tests

Comparison of yield performance of varieties and species of corn, rape, sunflowers, alfalfa, sweet clover, brome grass, crested wheat grass, and miscellaneous grasses. The perennial grasses are evaluated alone and in mixtures with alfalfa for hay and pasture yields.

Seed Production

Study of row spacing and fertilizer practices; study of alfalfa seed setting as affected by honeybees; a study of the effect of herbicides on weed control in, and seed setting of, alfalfa.

Herbarium

Collection, identification, mounting and cataloguing of plant specimens.

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