R E P O R T

of the

ELEVENTH ALFALFA IMPROVEMENT CONFERENCE

August 20-21, 1948

Lincoln, Nebraska

Reported by

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United States Department of Agriculture

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Mr. C. O. Granfield, Chairman of the Executive Committee officially opened the Eleventh Alfalfa Improvement Conference at 9:00 A. M. on August 20, 1948 at the Nebraska Agricultural College. He introduced Dr. F. D. Keim, Chairman of the Agronomy Department at the host institution, who welcomed the group to Nebraska.

INTRODUCTORY REMARKS

F. D. Keim

Progress in agricultural development has been very rapid the past few years and the progress made in the many lines of agricultural research has played a very important part in a tremendously large production. The results of these researches came at a most opportune time. Superior technology which gave rise to such a large production was the important factor that tipped the scales of victory in our favor during World War II. This was done with 10 percent fewer workers on farms and no greater acreage of crop land than was available during World War I.

National groups such as this Alfalfa Improvement Conference can take much credit for the rapid advances made in plant breeding research. It is here in the next day or two that all the recent knowledge of alfalfa improvement will be placed on the table and become the common knowledge of all the important alfalfa breeders and geneticists of the nation. It is my pleasure in behalf of my colleagues to welcome you to Nebraska and wish you much success. My experience in the past causes me to believe that you will not only summarize the research findings of recent years, but will hew the path for alfalfa research for the future. Not only will paths be hewn for the practical alfalfa plant breeder but the basis principles of genetic and physiologic research will be likewise discussed and advanced.

PROGRESS, AIM, AND ACCOMPLISHMENTS OF THE ALFALFA IMPROVEMENT CONFERENCE

H. M. Tysdal

In February of 1934, several visitors at the University of Wisconsin discussed with staff members, the possibilities of integrating the Alfalfa improvement work which was being developed at several State Experiment Stations, and by the U. S. Department of Agriculture. This group recommended that "In view of the fact that current alfalfa problems are to an unusual degree regional in character and there is the utmost need for economy in the use of public funds, it is suggested that a conference of the workers interested in the pathology and breeding of alfalfa be held at Lincoln, Nebraska, in the latter part of May or early in June, 1934." Thus, while the first official and originating meeting of the Alfalfa Improvement Conference was held at Lincoln, Nebraska on June 1 and 2, 1934, the ground work was laid at the preliminary meeting at Wisconsin. Those present at this preliminary meeting were—D. W. Robertson, Fort Collins, Colorado;

H. M. Tysdal, Lincoln, Nebraska; F. R. Jones, L. F. Graber, E. M. Searles, H. R. Albrecht, R. A. Brink all of Madison Wisconsin.

Since 1934, the Alfalfa Improvement Conference has grown in size and importance. It now includes active cooperation with over forty states and at least six of the Canadian provinces, and the Dominion Department of Agriculture.

It is a great truth that anything of real and permanent worth in life requires ceaseless efforts on the part of those who wish to bring about such improvement. It is my opinion that it takes greater effort and perseverance for people to work together for the improvement of alfalfa, for example, than it would if each of us were to confine ourselves to our own little program. The results of the cooperative effort, however, are bound to be much more effective in obtaining desired objectives. If I were to try to put into words the aims of the Alfalfa Improvement Conference it would be this: "THROUGH A COOPERATIVE, INTEGRATED PROGRAM TO EXCHANGE INFORMATION AND MATERIALS WITH THE OBJECTIVE FIRST TO DEVELOP TEST AND ESTABLISH, AND SECOND TO PRESERVE AND TO MAKE AVAILABLE ON A NATIONAL BASIS SUPERIOR ALFALFAS FOR THE MAINTENANCE OF A PERMANENT AGRICULTURE AND FOR THE BETTERMENT OF THE SEED, FORAGE AND LIVESTOCK INDUSTRIES OF THIS AND OTHER COUNTRIES."

This aim is being accomplished. I know of no group which has worked more harmoniously together than this one to obtain its objectives. It is peculiarly fitting that this has been the case in a crop such as alfalfa which needs the cooperation of workers from the West and from the East, because seed is produced largely in the former area and much of it used in the latter area. Moreover, varieties which may be adapted in the Western states are not necessarily adapted to the more humid conditions of the Eastern states. It becomes more and more apparent, therefore, that for the best interests of the alfalfa industry of the nation as a whole, it is essential that the Western seed producers be cognizant of the fact that they must produce seed of alfalfas better adapted to the large seed consuming areas of the Central and Eastern states. Through the Alfalfa Improvement Conference the workers are now making selections for disease resistance and other desirable characteristics in those areas where the diseases are most severe, which in most instances is in the Eastern half of the United States, and these selections are being screened by workers in Western states for seed productivity and other desirable characters under their conditions. Thus, the result is much better adapted strains under both conditions.

It is not to be presumed that one alfalfa variety, or even two or three, will serve for the entire United States. All available data, however, indicate that within certain limits a given variety may be well adapted within latitudinal belts clear across the Country. To be sure it may be possible that a given variety will do slightly better in the northern half of Ohio for example as compared to the northern half of Indiana. It seems clear, however, at least at the present time, that practical difficulties more than out-weigh the slight advantage one variety may have over the other within these latitudinal belts. We have been in alfalfa fields in Utah which are from sixty to seventy-four years old. Admitting this to be extreme, it more or less points up the fact that the turn-over in introducing new varieties in seed producing sections must be slow. Seed growers cannot change from one variety to another in rapid succession. Thus, isolation problems and difficulties in growing many new varieties are very real.

The Alfalfa Conference, by its organization and membership, is ideally adapted to bringing about the coordination which is necessary to develop the types of varieties needed.

In a rather haphazard manner, Stations are finding that they can make certain disease eliminations under their respective conditions. It would seem that a more effective relationship could be established by agreement on rather specific "screening" stations. That is where one station might be looked upon as a center for the breeding of resistance to a specific disease or diseases. Thus material originating from each of these stations would be resistant to at least the disease which was the speciality of the station, and other workers could send material to such screening stations for readings on their strains or plants. I hope there will be more discussion of this particular item later in this Conference.

It is unnecessary to review the many phases of cooperation in which the Alfalfa Conference serves. In order, however, to bring the report up-to-date, I would like to briefly indicate those phases which are most outstanding. First of all the Conference serves as a medium for the interchange of information through personal acquaintance and the printed and spoken word. To date, the Alfalfa Conference has published, largely in mimeograph form, eleven Annual Uniform Alfalfa Nursery Reports, beginning in 1937 through 1947, and ten reports covering the ten Alfalfa Improvement Conferences. While the Project Leader of alfalfa in the Division of Forage Crops and Diseases of the Bureau of Plant Industry, has compiled these reports, they are of value only insofar as the cooperators, including both State and Federal personnel, have contributed toward these reports. The fact that they apparently have been of value, speaks well for the contribution of the various members.

A second and very important phase of the activity of the Conference, is the exchange and distribution of breeding stocks, including both seed and clones, and new strains for testing. The Conference has assigned numbers to 226 new strains or promising breeding material which originates from seed, that is the "A" numbers series. It has also assigned 254 numbers to clonal series, the latter including some of the most promising disease resistant material in the present breeding programs. All of this material, and others, have been exchanged between two or more States, usually from ten to twenty states being involved.

The Alfalfa Conference has had a definite part in determining the adaptation of new strains and the release and increase of such new varieties as Buffalo, Ranger, and Atlantic. The Conference has also had a definite part in the increase and maintenance of stocks of some of these new alfalfa varieties. I am especially referring to the formation of Committees to handle the allocation of foundation seed stocks which has materially helped in the more rapid increase of new varieties. The Alfalfa Conference has maintained close relationship with the International Crop Improvement Associations dealing with certified seed problems, and with the American Seed Trade Association on related problems. It has helped get the people who are working on these similar problems much better acquainted with each other, thus paving the way for closer relationship.

Looking into the future I believe the Alfalfa Improvement Conference will become much stronger, and will more fully realize its aims than ever before.

REPORT OF EASTERN REGIONAL GROUP

W. M. Myers, Chairman

The Eastern Alfalfa Improvement Conference held its fourth meeting at State College, Pennsylvania on September 16 and 17, 1947. Representatives were present from New Jersey, Pennsylvania, New York, North Carolina, Massachusetts, Ohio, Rhode Island, Virginia, West Virginia, and Nebraska. In addition there were representatives of the Central Experiment Farms, Ottawa, Canada, Division of Forage Crops and Diseases, Beltsville, Maryland, and Bureau of Entomology and Plant Quarantine, Washington, D.C.

Attention in the breeding programs is being given to selection for adaptation to a complex of conditions that limit survival and productivity of alfalfa in the region. These include such factors as foliage and other diseases and harmful insects. Although wilt resistance is desirable in a new variety, this is not a major disease in most of the Eastern Region. There is considerable interest in rhizomatous alfalfa, but as yet little real information on the importance of the rhizomatous character.

PENNSYLVANIA:

Selection in the breeding nursery has been for resistance to Pseudopeziza leaf spot and to black stem in addition to desirable agronomic characters. Several clones have been isolated that appear promising and these have been included in the clone exchange program.

One of the important uses of alfalfa will be in pasture mixtures. For that purpose, more tolerance to defoliation will be desirable. To test the possibility, about 200 clones were established in four replications, five plants per replication. After establishment, a uniform seeding of orchard grass will be made over the area. Two replications will be mowed at the normal hay stage and two replications will be mowed more frequently. It is anticipated that this will provide a preliminary screening of the clones for tolerance to frequent defoliation.

EASTERN CANADIAN EXPERIMENTAL FARMS
J. M. Armstrong, H. A. McLennan
and T. M. Stevenson, reporting

In Eastern Canada, the main objectives in the alfalfa breeding program are the production of hay types with higher forage and seed yields, and the development of a creeping-rooted pasture type. At experimental stations in the Maritime provinces, some effort has been made in the selection of types which are acid tolerant.

In the improvement of hay types at Ottawa, a breeding program was started in 1945 using highly self-sterile selections from Ladak. Eight selections were crossed in diallel fashion and F_1 progenies were grown and studied for self-sterility. Results indicated that self-sterility of the parents was transferred to a major degree to the F_1 progeny. Self-fertility was not restored as a result of hybrid vigor in F_1. Further data are being collected on combining ability before double cross or synthetic combinations are made.

The development of a creeping pasture type, and of an acid tolerant type is in an early stage of development. It is hoped that additional plant selections for each of these types can be obtained from introduction material now established in the nursery.

There are no outstanding diseases or pests of alfalfa in Eastern Canada. In the breeding nursery this past spring, however, Sclerotinia caused twelve percent killing or injury, but it is not a problem in farmers fields at present. Leaf-hopper may cause considerable injury in some years, and Lygus bug, and Chalcis fly cause minor losses to seed growers in some seasons.

Tests of Ranger and Buffalo varieties at Ottawa showed that they lacked the winter hardiness of Grimm and Ladak, but yields were as good as Grimm. If bacterial wilt becomes a problem in Eastern Canada, these varieties could be used.

MARYLAND - Beltsville: H. M. Tysdal reporting:

Observations of adaptation, including stand longivity, and recording of diseases in field plantings and artificial inoculations for rhizoctonia, Sclerotinia, fusarium wilt, bacterial wilt and Anthracnose in the greenhouse are among the chief activities in alfalfa research at Beltsville. Plantings of selected clones for other States, as well as a number selected in the local program, and from old fields during field trips, together with replicated field plot plantings of polycrosses are used for note taking. Special emphasis is given to leaf, stem and crown diseases, and leaf hopper yellowing. These, together with vigor, desirability, color of foliage and stand longevity are the chief points recorded. Yield data, at least to date, are not taken on the plots at Beltsville.

In the greenhouse plantings, which have been made in flats of the best wilt resistant polycrosses, and the plots inoculated with rhizoctonia, from this inoculation are then subjected to fusarium wilt, Corynebacterium and anthracnose. So far this program has been on a relatively small scale, but we would like to step it up to include many thousands of seedlings. The survival would then be compared in the field with other desirable clones for resistance to other diseases, including leaf spots and leaf hopper yellowing. It is hoped in this way to be able to supply the cooperative program with clones resistant to several specific diseases. During the past year, clones C255 and C256 Belts. have been entered in the Federal-State Alfalfa Improvement Conference program.

NEW JERSEY: W. R. Battle reporting:

Observations on plants artificially inoculated with the alfalfa wilt organism indicate that four or more years may be necessary in order to determine the true resistance of such plants to the disease. Twenty clonal cuttings of each of a number of lines were artificially inoculated and established in the field. One such line appeared extremely vigorous and completely free of wilt until the fourth season of growth, at which time all twenty plants suddenly developed marked symptoms of wilt, and many have since died. Most of the other lines had died from the effects of the disease in the first year or two, but one line still has shown no indication of wilt infection.

A new advanced nursery consisting of 21 lines and varieties was established in replicated 5-row plots in the spring of 1948.

Thirty plants each of the thirty-seven lines which were composited to form Atlantic are being grown in the greenhouse, as well as the same number of 22 additional lines. These will be artificially inoculated with wilt and established in the field this Fall. It is hoped that in this way any lines which are notably wilt-susceptible can be identified and eliminated from the Atlantic variety, and perhaps other, more resistant lines will be added.

NEW YORK - R. P. Murphy and S. S. Atwood, reporting.

The New York Agricultural Experiment Station at Cornell University is cooperating in the National Alfalfa Improvement Program with emphasis on the development of superior varieties for the Northeastern agricultural areas of the United States. Research on methods of breeding and on seed setting in relation to self- and cross-fertility is also in progress.

Characteristics of our present-day varieties which need improvement include, 1. persistence, 2. disease resistance, 3. insect resistance and 4. yield of hay.

Research now in progress includes the following given in brief outline form.

1. Evaluation of selected clones. About 125 C-clones and about 275 clones selected in New York from old fields and from single crosses are included. These clones are planted in replicated field plantings of individual plants in order to study their agronomic characteristics. In addition their reaction to bacterial wilt and to several insect pests including leaf hoppers, aphids and spittle bug are being determined under controlled conditions. The more promising clones selected in New York are sent to Lincoln, Nebraska for inclusion in the cooperative program.

2. Uniform nurseries have been seeded yearly since 1945 and the various notes and yields have been taken and summarized.

3. Performance of synthetic varieties. A study designed to evaluate the performance of succeeding generations of Ranger produced in several of the seed producing areas is in progress. Another study designed to evaluate the three new synthetics, A224, A225 and A226 is also in progress. The relationship of the performance of the clones and their polycross seed progenies to the performance of their synthetics will be studied.

4. Extensive plot yield trials of the varieties and synthetics now available are in progress at three locations and a selected group are in plot trials at several other locations.

5. Fundamental studies of self- and cross-fertility and on the cytogenetics of alfalfa are in progress.

These studies are carried on in the Department of Plant Breeding in cooperation with other departments including Entomology, Agronomy and Plant Pathology at the present time.

NORTH CAROLINA - C. H. Hanson reporting.

Alfalfa research in North Carolina includes the following phases: (1) Management and ecological studies, including above and below ground relationships of alfalfa - grass combinations, (2) nutritive requirements and fertilizer placement studies and (3) breeding.

In regard to breeding, we are participating in the uniform testing program and exchange of clonal material. During 1946 and 1947 uniform observational nurseries consisting of 106 polycrosses, single crosses and other experimental lots were established on Piedmont and Coastal Plain soils in 4-replicated, 2-row plots. Yield, diseases, survival and other data are being obtained. Observational notes are being taken on 47 clones recommended for testing by the Eastern Conference, as well as other clones selected locally. Striking differences among these clones have been noted in stand survival and general desirability. The French introduction, P. I. 158837, distributed last fall by Dr. Tysdal, has been superior in forage yields, leafiness and possibly resistance to leaf spots and should be further investigated as a source of superior germ plasm. No data has been obtained as yet on the new eastern synthetic, A226, but the polycross performances of the four clones from which it has been synthesized have been good.

In general, strains developed in the East have been the most productive under our conditions. Emphasis is being placed on exploiting old fields and the hybrid populations of some of the wilt resistant Mid-western clones for superior germ plasm. The best clones will be sent to Mr. Grandfield for evaluation and production of polycross seed for subsequent polycross performance tests. Our objectives are to participate with other states in the production of high yielding synthetics or hybrids which will be adapted to East and which will also be readily acceptable to the seed grower in the West.

PENNSYLVANIA:

Selection in the breeding nursery has been for resistance to Pseudopeziza leaf spot and to black stem in addition to desirable agronomic characters. Several clones have been isolated that appear promising and these have been included in the clone exchange program.

One of the important uses of alfalfa will be in pasture mixtures. For that purpose, more tolerance to defoliation will be desirable. To test the possibility, about 200 clones were established in four replications, five plants per replication. After establishment, a uniform seeding of orchard grass will be made over the area. Two replications will be mowed at the normal hay stage and two replications will be mowed more frequently. It is anticipated that this will provide a preliminary screening of the clones for tolerance to frequent defoliation.

RHODE ISLAND - T. E. Odland reporting.

Three uniform nurseries have been established at this Station. The first was planted in 1945, another in 1946 and the third in 1947. Another will be planted this year.

Nebraska hybrids that appear very promising include 57-C24 Ohio, 57-C41 Nebraska, 57-C21 Ohio, and 57-C48 Nebraska. Wisconsin A-187, Oklahoma A-194, New York A-196 and Atlantic also performed well. Rhode Island A-197 has been named Narragansett. It is the best of the local selections and hybrids. Through arrangement with the U. S. D. A. an increase seed plot of Narrangansett was established in Idaho with a seed grower. Last year, 1947, a total of 41 pounds of seed were obtained. This year a larger area will be planted for seed.

A polycross nursery was established last year. The chief objective in this project will be to combine the high yield of the best local material with wilt resistance from the Nebraska wilt resistant strains.

VIRGINIA - T. Jackson Smith reporting.

Alfalfa is not native to the more humid regions of the world and when grown in these areas, it must be "humored" for best returns. In Virginia we need more fertilizer and lime than is now necessary for successful alfalfa production in the western semi-arid regions of the United States. We in Virginia are not interested in a so-called "poor land" alfalfa--one that will grow on soils containing a low amount of the necessary plant food elements. We expect to use a high rate of fertilizer (more work is, of course, still needed on fertilizer requirements), and must have a consistent and high rate of production to make alfalfa growing profitable under these conditions.

Higher yielding varieties are desired but these are secondary at the present time. Profitable production of alfalfa can be grown with present yields of available varieties providing stands can consistently be obtained and maintained. Diseases, which will be discussed by Dr. Henderson, affect both the young seedlings, and older plants. Our present high rate of seeding in Virginia is necessary with high mortality of seedling plants. Quick recovery after cutting is needed without losing cold resistance. This allows better competition with weeds and grass especially after midsummer and in the fall when stands are often lost.

Good stands of Williamsburg alfalfa have persisted longer in Eastern Virginia than other varieties tested. This longevity is due in part to quick recovery of plants after cutting. Plants are better able to compete with late summer and fall weeds and grass. Atlantic alfalfa has shared top yields with Williamsburg in all tests where both were included. Atlantic has not been tested in Eastern Virginia nor has it been tested over a sufficiently long period to determine its longevity. Best results will not be obtained in the humid areas until alfalfas are developed which are more suitable to conditions in these regions. The increased value of both Atlantic and Williamsburg, the only varieties tested that have been developed in the humid areas, indicate that there is a need for a more planned and concentrated breeding program in the East. This program should, of course be closely correlated with the breeding programs in the seed growing areas of the West. Under this type of program, varieties that are developed for the East would also be suitable for the West

WEST VIRGINIA - Collins Veatch reporting.

The work at West Virginia has been confined primarily to the study of improved strains.

The Uniform Advanced Alfalfa Nursery was planted in 1946 so we have only one year's results. A modified nursery including the recently released varieties was seeded this spring.

In our previous alfalfa variety or strain trials at Morgantown, Grimm has been high in yield. In the present Advanced Alfalfa Nursery trials, several of the Nebraska selections are leading in production. Ladak thinned out seriously the first year. No appreciable disease or insect damage has as yet been noticed in this nursery.

Of the strains planted in 1946 for observation the following were especially thrifty:

Nebr. 56 C-2xC10, Nebr. 56 C-3xC17, Nebr. 57 C-43,
Nebr. 57 C56, Ohio, Atlantic and A 204, Nebr. 57 C-44

A few plants have been selected and used to make clonal plantings but no breeding program has been established.

REPORT OF THE CENTRAL REGIONAL GROUP

C. P. Wilsie, Chairman

The Central Alfalfa Improvement Group was organized at Columbus, Ohio, in March, 1946 and the first regular meeting was held at Manhattan, Kansas on June 10, 1947. Attendance was 37, including representatives from 13 states and the District of Columbia. The morning session was spent informally looking over the alfalfa experimental work at the Kansas Agricultural Experiment Station.

In the afternoon a formal discussion was held on the general topic of alfalfa breeding and regional strain testing. Different phases included sources of superior clones, evaluation of alfalfa clones using the polycross test, testing for wilt resistance, seedling performance as a measure of disease resistance, competitive ability of alfalfa strains and integrating efforts in the cooperative alfalfa breeding program. Exchange of breeding material among workers in different states, and particularly the exchange of desirable clones for wide spread testing under different environmental conditions was strongly urged. The State reports from this region follow.

INDIANA - R. L. Davis and H. H. Kramer reporting.

I. Polycross Nursery.

In October, 1947, 225 plants were selected from all available plantings on the Soils and Crops Farm, selections being based upon (1) wilt resistance, (2) leaf spot resistance, (3) vigor, (4) leafiness, (5) seed setting ability under open pollination, and (6) stem fineness. All available data were incorporated and used to facilitate selection based upon field appearance at that time. These plants were increased vegetatively in the greenhouse and established in a polycross nursery to further study general combining ability in relation to self and cross-fertility and vigor and agronomic characters of the parent clones.

II. Disease Resistance:

A. Leaf spot:

Work is progressing on a program of breeding for leaf spot resistance. In addition to isolating plants resistant to the disease, controlled crosses have been made to determine the factors conditioning resistance. Since this work is discussed fully in another section, no further mention will be made at this time.

B. Bacterial wilt:

376 plants possessing some degree of resistance were selected in the spring of 1947 from twenty strains grown in a uniform nursery which had been established in 1941. In addition approximately 1400 plants were grown from seed of the three varieties, Ranger, Atlantic, and Buffalo. These were inoculated with the organism and transplanted to the field. Selections were made in the fall of 1947. As was expected, it was much easier to obtain resistant plants from Ranger and Buffalo than from Atlantic. Nevertheless, there was variation within the resistant varieties, indicating that the resistance in these varieties can be intensified. Also, same resistant plants were obtained from the susceptible Atlantic.

III. Clonal Nursery:

A clonal nursery or 30 clones was established in 1946. Observations are being made on type of growth, forage quality, hopper burn, recovery after cutting, and forage and seed yields are being taken.

IOWA - C. P. Wilsie reporting.

Testing of new strains and varieties in the Advanced Nurseries and Observational Nurseries has been continued. Some work has been done in evaluation of varieties grown in association with bromegrass as well as in pure stands. Ranger and Buffalo have produced forage yields approximately equal to, but not better than Grimm or Northern Common during the first two years of the stand. If left for four years these wilt resistant varieties show considerable superiority.

Clonal nurseries have included selections from old uniform nurseries, old fields and other sources. A considerable interest has developed in a number of low-crown selections taken from an abandoned golf course near Des Moines, where the alfalfa had persisted for many years. A number of three-way crosses involving an F_1 from a low-crown erect cross, and an unrelated line having a high degree of wilt resistance, have been made. Objectives in this study are to obtain a wide, deep set crown, erect growth and high seed set. Clonal and polycross tests of 64 selections from these hybrids are now in progress.

Studies of self-fertility as related to combining ability are being continued. Preliminary data have indicated that among some lines at least, general combining ability apparently is independent of the degree of self-fertility of the clones concerned.

Seed production as influenced by the use of insecticides, is being studied. During the past three years, promising results have been obtained using DDT for insect control.

KANSAS - C. O. Grandfield reporting.

The alfalfa improvement program for Kansas the past two years has been one of breeding and selection for a wilt resistant alfalfa with a wider range of adaptation than that of Buffalo. A cooperative program is now being developed with some of the eastern states in order that the material used in each program will be screened by the others, with the result that when a new variety is developed it will be one adapted to both areas.

While Kansas produces, on an average, more alfalfa seed than any other state, the seed production for most of the alfalfa growers is incidental to the production of hay for feeding livestock and only produce seed when conditions are favorable. Therefore, if Kansas is to maintain its market for the seed produced, we must produce a variety adapted to the market area of the East. The Kansas grower wants a variety that he can grow either hay or seed as the weather and price will permit. Kansas produced from 40 to 50 percent more alfalfa seed in 1946 and 1947 than was ever produced before, but today (August, 1948) there is no Kansas-grown seed on the farms or in the hands of local dealers. This is an indication that there is a market for all of the seed the state can produce if of the proper variety. If a variety can be developed adapted to both areas it will be a distinct advantage to all concerned.

Our seed production studies are being done in cooperation with the Entomology Department and a report will be given by Mr. Franklin later. Other work is being done on the effect of different fertilizer treatment on the nectar flow of alfalfa and an effort will be made to correlate this with bee visitations. In cooperation with the Chemistry Department a method of analysis of carbohydrates in small quantities and the extraction of the nectar from the flowers has been developed. Experimental results are not available at this time.

Some work has been done the past two years on methods of making and treating vegetative cuttings of alfalfa. Some growth substances have been used with good results, depending on strength used and growing conditions. Cuttings of different lengths were used.

Several fungi have been isolated from the cutting bed and plants and soil inoculated with the cultures before making the cuttings to determine the extent to which these organisms were killing the cuttings while in the process of rooting. Ascochyta imperfecta was perhaps the worst one with Rhizoctonia a close second.

MICHIGAN - H. M. Brown reporting.

The testing program this year involves not only the Uniform nurseries, both observational and advanced, but also a test to determine whether we really do have, in our certified fields, any real differences between Hardigan and Grimm. Samples of certified seed from four Hardigan fields and from three Grimm fields are in this test which was planted in August 1947. No readily observable differences were found in extent or type of flowering at time of blooming in June, 1948.

F_2 progenies from crosses between wilt-resistant lines and Hardigan or Grimm were inoculated with wilt cultures. These cultures were obtained from Dr. Fred R. Jones of the Wisconsin Station. Seed of plants surviving these inoculations is now being obtained for further testing.

MINNESOTA - H. L. Thomas and L. J. Elling reporting.

The Alfalfa Breeding program in Minnesota is at present primarily concerned with isolating superior clones, that excel in agronomic characteristics, disease and insect resistance, and in combining ability, and their combination to produce synthetic varieties or desirable single or double cross hybrids.

The work is being carried out in cooperation with the department of Plant Pathology at University Farm, St. Paul, at Rosemount, and near Williams, Minnesota in Lake of the Woods County. Studies carried out in each of the three locations will give opportunity to determine the relative desirability of these locations for conducting various phases of the program.

In addition to the breeding program, variety testing is being conducted at the Central and Branch Stations and nursery trials of strains and polycross progenies, made available from the Cooperative Alfalfa Breeding program, are being conducted at University Farm.

The present program for isolating superior clones is as follows: Individual plants are grown in an individual plant nursery. Selection of the more desirable plants is on the basis of Bacterial Wilt reaction, vigor of growth, seed setting ability and winter hardiness.

The selected plants are grown in the greenhouse during the fall and winter where they are increased vegetatively and planted in replicate clonal observation nurseries the following spring. Sources of clones that will be placed in the clonal observation nurseries are; old alfalfa fields, varietal trials where the stands have been greatly reduced over a period of years, polycross nurseries and clones introduced from other breeders.

In the clonal observation nurseries notes on self sterility, cross fertility, bacterial wilt reaction, winter hardiness, vigor of growth, flowering and type of vegetative growth are taken and are the basis for selection of clones to be planted in polycross nurseries the next year.

The seed from individual clones in the polycross nurseries is bulked and planted in replicated yield trials to give a measure of the general combining ability of these selected clones. Specific combining ability is determined by making specific crosses between two or more desirable clones and planting replicated yield trials of the crossed seed.

All plants are inoculated with Bacterial Wilt organism prior to transplanting to the individual plant and clonal observation nurseries by immersing the roots in a suspension of the organism for at least 20 minutes.

The following summary presents the present status of the work: In 1946 twenty-five plants from each of seven commercial varieties—Grimm, Ladak, Cossack, Ranger, Hardistan, Northern Common, and Orestan—were selected from a varietal yield trial at Morris in which the stand had been greatly reduced over a period of seven years. Bacterial Wilt was definitely identified as a cause of the reduction of the original stand. During the winter of 1946-47 these selected plants were cloned and planted in replicated clonal observation nurseries, at two locations in the state, in 1947. Notes on self sterility, cross fertility, vigor of growth, flowering and Bacterial Wilt reaction were taken during the summer of 1947 and were the basis of selecting 29 of these clones to be included in a polycross nursery which was established in 1948. In addition to these 29 clones, three clones introduced from the U. S. D. A., and one clone introduced from Canada were included in the polycross nurseries established in 1948.

Crosses in all possible combinations were made by hand in the greenhouse between eleven clones selected from those planted in the polycross nurseries. These crosses were planted in replicated yield trials in the spring of 1948. Yield data for forage and seed production will be taken in 1949.

A new individual plant nursery was established in 1948, containing seedlings grown from seed of several sources, including; the self sterility studies of 1947, seed from individual plants selected for high seed set from the Ladak variety, seed from plants of an old stand of Grimm alfalfa and seed from 14 commercial varieties.

Clonal observation nurseries were established at two locations in 1948 containing clones introduced from the U. S. D. A., several clones introduced from Canada, and plants selected from selection studies of Ladak variety at University Farm.

Studies have been made on rooting stem cuttings of alfalfa, with good results. The cuttings, of single node and internode length, are cut with scissors, leaving approximately one inch of the internode below the node and leaving all the leaves on the cutting. The cuttings are rooted in a Vermiculite product, "Unigro."

During the spring of 1948 it was noted that a considerable number of the cuttings were damping off during the rooting period. Isolations from these cuttings showed the presence of Rhizoctonia spp. and later studies confirmed the belief that the presence of this organism will completely inhibit rooting of the stem cuttings.

SOUTH DAKOTA - M. W. Adams reporting

At South Dakota we are in the first season of establishing an active alfalfa improvement program and hence are not in a position, at present, to discuss all facets of the work on hand and that proposed for the next few years.

We have available a number of clones isolated from Ranger, Grimm, Ladak and Cossack by an elimination test with soil-borne disease organisms effecting crown and root rooting.

Uniform alfalfa nursery work is being carried on at Brookings and Highmore and to a lesser extent at Cottonwood.

The initial phase of projected work is concerned with seed and clonal collections from locations in the state. Naturalized stands of M. falcata and of falcata-sativa hybrids have been located both in the east and in the west and will be utilized as one source of clones for the observation nursery.

WISCONSIN - Dale Smith and L. F. Graber reporting.

Alfalfa investigations of the Agronomy Department, Wisconsin Agricultural Experiment Station, include the evaluations of new varieties and strains with managerial treatments designed to hasten the time required for testing as well as to assure greater accuracy in the evaluations. These treatments include spring, summer and fall cuttings, burning, differences in fertility level, dusting with insecticides and others which tend to bring about differentials in the intensity of the natural hazards of summer and winter, such as, bacterial wilt, weeds, leafhoppers and winter injury. Competition in mixture with grasses, differences in root type and the reaction to the adversities of low temperatures both in field and laboratory, are likewise being studied.

R. A. Brink reporting.

Initial seed increase is being made in 1948 of a winter hardy, bacterial wilt resistant synthetic strain, provisionally termed Wisconsin Synthetic C, which is based upon 23 selected foundation lines. Since about three-quarters of the component lines are of Cossack origin and most of the remainder are from hardy common alfalfas, it is expected that the synthetic will be rather Cossack-like in type, but with a tendency to regenerate new shoots somewhat more rapidly after mowing than that variety. The synthetic appears promising for trial in the northern zone of alfalfa production. Pre-harvest prospects are good for sufficient seed in 1948 beyond stock needs to provide for small plot tests at a few locations.

WESTERN ALFALFA IMPROVEMENT GROUP
R. L. Matlock, Chairman

Dr. Matlock gathered the following reports from the Western group:

ARIZONA - W. E. Bryan reporting.

All the commercial varieties of alfalfa grown in Arizona, with the exception of certain northern varieties which are grown exclusively for seed, consist of the non-hardy, southern type composed of Hairy Peruvian, African, and India, and the Chilean or common type. The extensive variation in unselected commercial alfalfa varieties is well known. In a cross between Hairy Peruvian alfalfa and the falcata type, for example, the New Jersey Station found no greater variation with respect to most of the agronomic characters than that of Kansas common. In alfalfa breeding at the Arizona Station, attention has therefore been directed toward establishing a method whereby the variation in the Southwestern alfalfa varieties could be most rapidly and efficiently used in improving the alfalfa grown on Arizona farms. The characters selected for are: (1) high yield of hay, (2) high quality of hay (small stems and abundant leaves), (3) high seed yield, (4) non-dormant, southern type, (5) greater longevity of stand.

The procedure is as follows: From a large field of the variety from which selections are to be made, 500 to 1000 selections are taken at seeding time largely at random by stripping the seed from a single stem, care being taken that each stem stripped belongs to a different plant. Naturally each stem selected must have at least a fair set of seed in order to make the necessary progeny planting. The seed from each plant is planted in 10-foot progeny row. <u>It is in these progeny rows that the superior types begin to appear</u>, and from which selections are made for testing. While notes are taken the first year of growth for the characters listed above, it is during the second and third years that data are taken for the purpose of making the progeny selections. These selected progenies may be tested and used in various ways, but so far they have been tested by the following two methods:

<u>First Method</u>. Chilean or common selections.

(a) Selfed plant progenies are grown from each originally selected plant progeny obtained from the open pollinated plant selected in the commercial field.

(b) From the best "first self" plant progenies, "second self" plant progenies were grown.

(c) From the best "second self" plant progenies, "third" self" plant progenies were grown.

From the third self progenies, a progeny with high hay yield of fair quality with good seed production was isolated. The seed of this progeny was increased in isolation, and released through the Arizona Crop Improvement Association to the growers as Arizona 21-5. At present 16,000 acres of this strain are being grown in Arizona and California with 900 acres for the production of certified seed.

Second Method.

With the first method of selfing the originally selected progenies for three generations and then isolating a superior type, considerable time has been taken and the number of progenies studied has been restricted. Furthermore, progenies isolated after two or three generations of selfing, while sufficiently uniform for commercial production as a definite type, they are by no means homozygous for most of their agronomic characters. Since it has been shown by Dr. Tysdal and others that a productive alfalfa must be rather highly heterozgous, it would be desirable if superior hybrids could be isolated directly from the commercial fields. Here with thousands of plants to select from, it is believed that the chances of obtaining a superior hybrid are much greater than where an attempt is made to synthesize one from the comparatively small number of inbreds with which the breeder must work. Accordingly, approximately 2,000 plant selections from the African and India commercial alfalfa fields have been made in the manner described above, and planted in the usual 10-foot rows. A similar number of selections from these commercial fields will be made in succeeding years, till the full extent of the variation of these fields has been utilized. Instead of attempting to establish inbred lines from the selections of the original 10-foot progenies, they have been (and will be) planted in triplicate rows in order to test their hay yield, seed production and hay quality. After two years of testing in this manner the superior progenies will have proven themselves. The original progenies from which these tests have been made will be uprotted and planted singly in isolation and also by transplanting a number of them together. The seed from these isolations will be increased for further testing and distribution to the growers through the Crop Improvement Association.

Paul D. Keener reporting.

Alfalfa bacterial wilt (caused by Corynebacterium insidiosum (McCul.) Jensen) has been recognized as important in Arizona since 1941. Since that time between 85 and 100 varieties have been tested for their possible resistance to the wilt pathogen at the Arizona Agricultural Experiment Station at Tucson. With the exception of a single cutting from an F. C. 19,316 plant, inoculated once with the wilt organism in 1942, none of the varieties has shown any promise of wilt-resistance in Central or Southern Arizona. Certain other varieties, chiefly from North Africa and Central America, which have displayed some promise of being climatically adaptable to this State, are now being studied for their possible wilt-resistant qualities.

The so-called wilt-resistant alfalfas, such as Ranger and Buffalo, are available for the cooler, northern regions of Arizona. These varieties are not as well adapted to the Central and Southern portions of the State as are such forms as Hairy Peruvian, Chilean, African, Indian, etc. All of the last mentioned forms are susceptible to wilt under Arizona conditions.

Due to the absence of intensive surveys, the wilt situation throughout the State is not clear. The incidence of disease appears to be greatest in the northern sectors of the State, while the disease occurs rather sporadically and at widely scattered localities in the regions south of Phoenix, Safford and Duncan.

Infections of alfalfa by the wilt pathogen are not "pure." That is, wilt is usually accompanied by such root rot fungi as Phymatotrichum omnivorum, Rhizoctonia sp., and Fusarium sp. These microorganisms along with the bacterium, Corynebacterium insidiosum compose an "alfalfa root disease complex" in the State.

CALIFORNIA - E. H. Stanford and L. G. Jones reporting.

A. Breeding

1. Wilt resistance - The P factor for wilt resistance, discovered by Wilson in a Turkistan selection, is being combined into California Common by means of the backcross. The fourth backcross to Common has been made and tests show that the original California Common type has been recovered. The factor for wilt resistance, and also factors for mildew and leafspot resistance are now being stabilized in this material preparatory to its release as an improved variety.

2. Dwarf virus resistance - A number of selections from California Common have proved resistant to the dwarf virus. Crosses have been made to combine dwarf resistance with wilt resistance.

3. Crown rot - Several organisms are causing a crown rot in California. Their relative importance varies in different parts of the State. At present, selection of plants from fields where crown rot has seriously thinned the stand appears to be the best approach to the problem.

All work on disease resistance is being carried on in cooperation with the Plant Pathology Division.

4. Intervarietal hybrids - Preliminary tests of invervarietal hybrids, particularly those involving Nebraska clones C-54, C-52, C-53 and Africa (Hegazi) indicate unusual vigor.

B. Genetic Studies

Some populations segregating for flower color have been studied in the F_3. Inheritance of foliar characteristics is also being studied. Studies of resistance to bacterial wilt are being continued, as well as studies on mildew, leafspot and the dwarf virus.

C. Alfalfa Seed Production

Alfalfa seed production is dependent on insect pollination, and therefore, on bees. Since wild bee populations have diminished or are not available, and are not subject to management, the seed producer must rely on honey bees to produce crops approaching a maximum. The control of harmful insects by improved insecticidal practices such as dusting or spraying with DDT is now common practice and is directly responsible for much of the improvement in seed production. Timely and strategic placement of colonies within the field affects honey bee activity on the blossoms, which in turn affects seed production. The outstanding unsolved problems in alfalfa seed production in California are perhaps in management of seed fields, and cooperation between the seed producer and the beeman.

D. Weed Control in Alfalfa

Our greatest handicap to first year seed production is a lack of an effective and economical means of controlling weeds. The methods that are being tested are:

1. Cultivation
   a. cultivation + herbicides
2. Herbicides
   a. oil, oil + D. N. (Dinitro compounds)
   b. I. P. C. (Isopropyl-N-Phenyl Carbamate)
      I. P. C. + oil and D. N
   c. T. C. A. (Trichloracetate) and T. C. A. + oil + D. N.
   d. P. C. P. (Pentichlorophenol) + oil
   e. Selective herbicides (Dow and Sinox)

CANADA - MANITOBA - P. J. Olson reporting.

The work underway in Manitoba relating to the problem of seed setting in alfalfa may be described as follows:

1. Feeding bees alfalfa extract. By means of pollen traps it is hoped to determine whether bees fed alfalfa extract select alfalfa fields for their activity to a greater extent than those not so fed. It is hoped that it may be possible to identify the relative preference of pollen sources from a study of the pollen collected in the traps.

The weight of pollen collected in adjoining alfalfa by the fed and unfed bees is also being determined.

2. The activity of bees enclosed with alfalfa under large cages. For this purpose a large wire cloth cage, 32' x 50' has been constructed at the Brandon Experimental Farm. This cage is divided lengthwise in the middle so as to provide two compartments, each 16' x 50'. In one of these a colony of bees has been placed. A comparison of the amount of seed set in the compartment enclosing the bees, with that set in the compartment where there are no bees should provide a measure of the effectiveness of the bees under these conditions.

3. Survey of alfalfa fields with reference to insects prevalent in them. In this survey special note is taken of the relative numbers of certain insects known to be injurious, such as Adelphocorus sp. and Lygus sp., and of beneficial insects consisting mainly of wild bees as well as honey bees. An effort will be made to relate the prevalence of these insects to the amount of seed set. The survey is being conducted during two periods, one in midsummer at the height of the blossoming season and one later, after podding is well advanced. Some study is also being made of the nesting habits of the wild bees in the proximity of those fields where they are numerous.

4. A study of concentration of nectar gathered from various sources including alfalfa and sweet clover. This study is being made by means of refractometer readings applied to the contents of the stomachs of bees collected from the various sources. The bees are being collected during each of several fixed periods throughout the day. The purpose is to relate nectar concentration to source preference.

5. Alfalfa breeding for the purpose of improving seed setting capacity and ease of tripping. This work was just started last year. No results of any consequences, under any of these projects, can be reported at this time, since very little work has been done prior to this year.

This work represents a cooperative effort involving the following organizations: The Dominion Laboratory of Entomology; the Department of Entomology, University of Manitoba; the Dominion Experimental Station, Brandon, (Apiarist); the Manitoba Department of Agriculture (Provincial Apiarist); and the Division of Plant Science, the University of Manitoba.

DOMINION EXPERIMENTAL STATION - LETHBRIDGE, ALBERTA - R. W. Peake reporting.

1. Breeding Alfalfa for Resistance to Bacterial Wilt

The 1946 wilt elimination nursery at Lethbridge contained 99 clonal lines from the Dominion Forage Crops Laboratory, Saskatoon; 52 lines from the University of Wisconsin and 75 clonal lines selected at Lethbridge for both crown rot and bacterial wilt resistance. This material was carried over the winter of 1946-47 in the wilt nursery and was rated for both crown rot and bacterial wilt in the spring. The Lethbridge and Saskatoon lines free of disease in all replicates were kept for resistance in the 1947 wilt elimination nursery while the Wisconsin lines were selected and placed in the polycross nursery.

The procedure followed in the wilt elimination nursery is to administer the first inoculation by immersion in a suspensoid just before planting in May. A second inoculation is made in August by needle.

The 1948 wilt nursery contained 257 lines from the Experimental Farms at Swift Current, Saskatchewan, Agassiz, British Columbia, and Lethbridge, Alberta, the Forage Crops Laboratory, Saskatoon, the Dominion Laboratory of Plant Pathology, Edmonton, and the University of British Columbia. In addition 29 lines found wilt free in the 1947 tests were placed in the 1948 nursery for retest. Notes were taken on stand, yield, quality, and growth habit. Toward the end of July there was considerable indication of wilt in susceptible plants. Immediately following the needle inoculation in August there was a marked reaction to the disease and many plants died within a few days.

In the spring of 1948 the wilt free selections were placed in the polycross nursery.

The 1948 wilt nursery contains 280 lines which were planted in May immediately following the removal of the 1947 tests.

2. Uniform Alfalfa Nurseries

In 1947 two uniform nurseries were established at Lethbridge, one on irrigated land and one on dryland. Two advanced nurseries were established in May 1948. Excellent stands were obtained on all nurseries and complete notes are recorded each season.

BRITISH COLUMBIA - G. G. Moe reporting.

You may recall that two years ago I referred briefly to the new variety that we had under development. Since that time this variety has been licensed for sale in Canada and accepted by the Canadian Seed Growers Association as a variety suitable for registration throughout the Dominion. Because of its unique origin it offers more than unusual interest to the alfalfa breeder, being the result of a natural cross between a falcata type and Grimm variety.

I am sending you a brief note descriptive of this variety for inclusion in your summary and would ask you to state that our

Department would be pleased to supply small quantities of seed to any plant breeder or experimental station who may wish to procure same from us. This variety has now been quite widely tested in Canada by Dr. Stevenson, Dominion Agrostologist, and reports are very favourable as to its behavior. It is quite possible that either Dr. Stevenson or Dr. White may attend the Conference and be able to give you further information on this variety. Dr. Brink, who is associated with me in the Department of Agronomy, has some very interesting material from the standpoint of seed setting, etc. which will be published in the very near future. I think that you will be interested in seeing these papers when they are published.

RHIZOMA

(A new variety of alfalfa produced at The University of British Columbia)

ORIGIN

The Rhizoma variety originated as a natural cross between a falcata strain designated as Don, and an unknown male parent of the media type---either Grimm or Ontario Variegated.

VARIETAL DESCRIPTION

The form of the plant is centered in a deep-set branching crown. Below this crown is a short neck from two to five inches in length. From the under surface of this deep-set crown and from the upper portion of the neck, rhizomes develop which grow horizontally beneath the surface attaining a length of from three to seven inches or more before breaking through the soil. In subsequent seasons new rhizomes arise from the underground portions of the old rhizomes thus slowly increasing the spread or width of the plant. In some cases, secondary plants are formed, and those may develop a secondary root system. Coarse and fine feeding roots also develop from the older rhizomes. The short neck branches at approximately six inches below the surface into a many-branched root system confined in the main to the upper three or four feet of soil. In older plants the original crown tends to disappear and to be replaced by a cluster of closely set multiple crowns.

Approximately 85% of the plants have variegated flowers, 10% purple flowers, and 5% yellow or cream flowers. The pods vary in shape from the tightly coiled pod of the <u>media</u> to the sickle shaped pod of the <u>falcata</u>. The percentage of rhizome-producing plants is approximately 80%.

ENVIRONMENTAL ADAPTATION

Wherever tested, the Rhizoma variety has shown a high degree of cold resistance. It has survived unaffected after being covered with an ice sheet for over three weeks. It is extremely resistant to heaving. It appears to possess a considerable amount of drought resistance.

It is now under test for resistance to wilt and crown rot. Whether or not it is disease resistant, it is possible that it may possess a considerable degree of recovery because of of its rhizome habit of growth.

While this variety has been tested throughout Canada by the Forage Crop Division of the Dominion Experimental Farms, its full range of adaptation and usefulness is still to be determined. It is expected that it will have particular value for pasture purposes and for growing with grasses. Also, it is possible that it may thrive better than other alfalfas on shallow soils. Yield tests to date in comparison with other alfalfas are very favorable. While this variety, RHIZOMA, has the possibility of being a very valuable addition to the alfalfas now grown in Canada, the final appraisal of its worth must await the judgement of the growers.

G. G. Moe,
Professor & Head
Department of Agronomy

N. B. <u>DISTRIBUTION OF SEED</u>

During the past year approximately 2000 pounds of this seed has been distributed throughout Canada, small amounts being distributed in the U. S. A. to various experimental stations. It is expected that a further distribution of approximately similar amount will be made this coming winter. The price of this seed last winter was $2.00 per pound for 25 pound lots and $2.50 per pound for small lots. Several growers have established from this seed a fairly large acreage and it is probable that seed of this new variety from the 1949 crop will be available through commercial agenices. Small amounts for test purposes are distributed as complimentary samples to plant breeders and experimental stations.

Dominion Experimental Farm, Agassiz, B. C.
M. F. Clarke reporting

Alfalfa breeding was started at this station in 1945 as a co-operative project with Dr. G. G. Moe of the University of British Columbia. The principal objective of the work at Agassiz is to study the breeding behavior of the hybrid (<u>M. falcata</u> X <u>M. sativa</u>) creeping rooted material originally developed by Dr. Moe at the University.

Work to date has been concerned with a close study of 28 selected lines that showed considerable promise from the standpoint of yield, self fertility and tripping habit. In addition 12 lines were subjected to diallel crossing and the remainder were crossed reciprocally on one especially outstanding line.

As a result of serious flood conditions during May and June of this year, the breeding nurseries were destroyed. However, all selfed seed and the seed resulting from controlled crosses was started in the greenhouses early in May and transferred to the field early in July. These latter plantings will be observed closely and further selections made with a view to setting up a strain building program.

The data obtained so far indicate a fairly high degree of self-fertility in the creeping rooted material, only six lines being highly self-sterile and the remainder ranging from moderate to very high self-fertility. Variations in combining ability as evidenced by seed set upon crossing were also noted. Tripping values were determined by the use of the alcohol series method as reported by Dr. Tysdal in the Journal of the American Society of Agronomy, vol. 38, No. 6, pp. 502-533, 1946. Some measure of correlation was apparent between tripping value and seed set. Further study is required, however, before definite conclusions can be drawn.

Dominion Forage Crops Laboratory, Saskatoon, Sask.,
J. L. Bolton and W. J. White reporting.

Research on alfalfa at this Laboratory is almost entirely concerned with breeding and improvement. During the war period considerable work was conducted on the effects of insects and fertilizers on alfalfa but this has now been taken over by agencies more directly concerned; viz, the Dominion Entomological Laboratory, Saskatoon, and the Soils Department, University of Saskatchewan, Saskatoon.

In the breeding and improvement program the work may be classed under three main projects: (1) Selection and breeding for disease resistance, (2) Selection and breeding for the creeping root character and (3) Breeding methods. This report will describe very briefly these three lines of work.

Selection and Breeding for Disease Resistance: The principal diseases affecting alfalfa in western Canada are Winter crown rot, Bacterial wilt and Blackstem.

Winter crown rot, caused by an unnamed Basidiomycete, attacks the crowns of alfalfa early in the spring when the plants are dormant. It is responsible for appreciable amounts of killing in all years and may reach epidemic proportions. A cooperative project with the Dominion Laboratory of Plant Pathology at Edmonton, Alta, resulted in the establishment of a disease nursery at Edmonton a few years ago. As a result approximately 300 plants more or less resistant to the disease have been selected. The best source of resistant material has been found in Medicago falcata, and hybrids with that species. No genetic data are available but crosses between resistant plants gives marked increases in the number of resistant plants obtained from a progeny. However, considering the large number of progeny plants tested it appears that resistance is certainly not dominant and probably is conditioned by more than one recessive gene. The resistant material is now being tested for other agronomic characters. Outcrosses are also being made on wilt resistant and high seed setting lines.

Bacterial wilt has only recently become a serious factor in this area. A wilt nursery has been established at the Dominion Experimental Station, Lethbridge, Alta. and all the Saskatoon breeding material has been, or will be tested there for wilt resistance. Some promising lines are being developed especially those which show resistance to both winter crown rot and bacterial wilt. Ranger and Buffalo show considerable resistance to the disease but are not sufficiently hardy for the prairie provinces.

Blackstem is widespread and is thought to cause heavy damage especially to stands left for seed. About twenty plants have been selected for resistance. Progenies resulting from selfing and intercrossing these selections are now under test at Saskatoon in cooperation with the Dominion Plant Pathology Laboratory at Saskatoon. Since this work was not initiated until 1946 no definite results are available as yet.

Selection and Breeding for the Creeping Root Character

Several years ago crosses between common alfalfa and Medicago glutinosa were made using the latter as a source of the creeping root character. The results were rather discouraging possibly (in view of later results) due to the selection of unsuitable parents. In 1942 creeping rooted plants from Medicago falcata were crossed with Grimm and Ladak. A study of the F_1 progenies showed as high as 75 percent strongly creeping plants. Selfed and inter-crossed progenies from selected F_1 plants are now being grown but have not been planted long enough to develop creeping roots. One of the F_1 plants was excavated to a depth of 6 feet. This plant showed an above-ground spread of 52" two years after planting. Its root system was strongly developed both horizontally and vertically and crown buds were found in great numbers at depths from 4" to 12" below the surface. Occasionally crown buds were found at a depth of 20". In addition to the M. falcata crosses a number of progenies resulting from crosses between Grimm and selected plants of M. glutinosa are being grown. Although only set out last year they now show unmistakable evidence of creeping and will undoubtedly serve as a further source of parental material.

Breeding methods: Very marked differences in combining ability have been found between different alfalfa plants for both seed and forage yield. As a result all breeding and selection material is being progeny tested before synthetic combinations are made. Comparisons are being made between commercial hybrids produced by vegetative propagation and the similar hybrids from selfed lined progenies. Studies are also being conducted on the effect of selfed and sibbed seed on the yield of commercial hybrids. A method of producing isolation plots using cages and honey bees has been tried out. Excellent sets of seed have been obtained but the amount of selfed or sibbed seed present has not been determined.

Dominion Experimental Station, Swift Current, Sask.
D. H. Heinrichs, reporting

The main objective of the alfalfa improvement work at this Station is to develop a drought resistant, creeping rooted variety that is resistant to grazing and will compete successfully with grasses when seeded in mixture with them. In addition, fair seed production is thought essential so that the variety is commercially feasible.

The original selections for the breeding work were made in 1938 from populations of Ladak (Medicago media) and Siberian (Medicago falcata) which survived the very dry years of 1934 to 1938. Desirable Ladak plants with a tendency to a spreading crown and creeping rooted Siberian plants, first observed in 1938, were selected for the breeding work. Siberian is quite resistant to grazing on dryland according to previous tests but it shatters its seed and it is impossible to produce seed of it on a commercial scale. Only several isolated plots of this species are found in the prairie region at present.

In the breeding work under way it is attempted to combine desirable characteristics of the two species by hybridization and selection. In 1940, Rhizoma stock was also used in the breeding program and more recently, crosses have been made between Ranger and Siberian. Results to date indicate that the choice of Ladak and Siberian as the original parents was a good one.

Breeding Methods

Hybridizing Ladak and Siberian, growing the progeny and selecting the most desirable plants from the best combination. Several courses have been followed with the F_1 selections, they are:

1. Intercrossing non-related F_1 plants.
2. Selfing F_1 plants.
3. Backcrossing F_1 plants to Ladak.
4. Backcrossing F_1 plants to Siberian.

The progeny are started in the greenhouse and grown in 3-foot spacings in the field. This spacing allows ample space for spreading of the plants and actual measurements of the spread of each plant are made with a "protractor like" instrument. Detailed notes are taken on other characteristics, such as type of pod, shattering resistance, forage value and flower color. Further breeding work entails intercrossing desirable unrelated or distantly related plants and test the progeny for specific combining ability in replicated tests (lattice designs are commonly used). All plants are started in the greenhouse and each plot consists of 12 plants spaced one foot apart in the row, the rows are three feet apart. Based on results from such tests, three to five good combiners are planted in isolated plots, the plants are cloned to give the desired number of plants for the isolated plot. An attempt is made not to combine plants that vary greatly for flower color. It is thought that a marker, such as flower color in a new variety would be useful to the farmer. Only the very best material goes into these combinations in early generations. Material, less desirable for certain characters is improved further in more advanced generations before being included in any combinations.

The seed obtained from the isolated plots is to serve for more extensive tests such as, (1) persistence under actual grazing, (2) persistence and yield under intensive clipping, (3) hay yields.

Three types of isolated plots are in use by this Station; (1) plots along the Railroad Right-of-way. These plots are spaced at least one-quarter of a mile from each other and they are generally fifty feet long and ten feet wide, (2) farmers' gardens, (3) bee cages.

Although bacterial wilt is not a serious problem in destroying alfalfa stands on dryland in this region, breeding for its resistance has been incorporated into the breeding program several years ago because of its international significance. All selections are now tested for wilt resistance at the Dominion Experimental Station, Lethbridge, Alberta. Only the more resistant lines are retained for further breeding work. The selections are also tested for crown rot resistance in cooperation with the Dominion Laboratory of Plant Pathology, Edmonton, Alberta.

Results and Discussion

The creeping rooted habit and seed shattering resistance are the two main characters we are concerned with in our breeding work and we have a number of lines that possess these characters in combination to a large degree. No detailed genetic studies of the inheritance of these characters have been made but there is considerable evidence that it is rather complicated. The creeping rooted habit would appear to be a quantitative characteristic with several factors involved. Shattering resistance may be simply inherited, it does not appear to be closely linked with pod type. Some plants with double coiled pods have been found to shatter their seed like the Siberian parent, and conversely, short sickle pods quite often hold their seed. All of our creeping rooted lines trace back to six Siberian parents. There is also evidence that certain Ladak plants combined much better for this characteristic than others. The creeping rooted habit showed up in the F_1 of certain crosses; however, there was considerable segregation in the F_1 progeny. The Creeping rooted plants of the hybrid material generally spread much more than the creeping Siberian parent and in addition the root stalks are coarser, resembling those of the Ladak parent more closely. The creeping rooted plants that are being selected very often spread to an extent that the diameter of plants measures fifty to sixty inches in the third year after planting. These plants spread by true rhizomes which are found two to ten inches below the ground surface.

Our most promising lines have been selected out of progeny resulting from F_1 plants backcrossed on Ladak. Seed production in these lines closely approaches that of the Ladak parent. Intercrosses of desirable F_1's have yielded excellent creeping rooted material but a large proportion of the progeny give very poor seed yields. Backcrossing on Siberian has produced very strongly creeping lines but these have to be improved for seed shattering resistance by crossing on Ladak. Inbreeding for one or two generations has been useful in producing plants quite homozygous for creeping rooted habit.

On the basis of results to date we believe that selections made from populations of second generation material may be intercrossed and tested for combining ability in replicated tests. Three or four good combiners even in this early generation may well prove to be a desirable synthetic. We are not so interested in uniformity of our new variety but are concerned in developing a variety with a high percentage of creeping plants and a fair seed set. The breeding work conducted at this Station indicates that this objective can be reached in relatively early generations. Close inbreeding does not seem to be desirable and possibly should be avoided.

The polycross nursery has not been used in our alfalfa breeding work. It is felt that more rapid progress can be made by hand crossing and determining the specific combining ability of the selected plants for the characteristics desired without first determining general combining ability.

When making selections, the breeder, invariably tends to select types pleasing to the eye, i.e. vigorous leafy forage types that come back quickly after cutting. When breeding for drought resistance that would be a particularly dangerous thing to do because drought resistant plants often are a bit dwarfed with small leaves (Siberian) and they are slow to come back after cutting. Therefore, in early selections, selecting for succulent growth is avoided and the creeping rooted habit is the chief yardstick for making selections.

We require a legume that will not die out when growing in competition with grass and subjected to heavy grazing. High yield of the legume itself, although desirable is of secondary importance. Of first importance is its longevity and the subsequent maintenance of soil fertility and high yield of the grass seeded in mixture with the alfalfa.

COLORADO - Kenneth G. Brown and D. R. Ward reporting.

Breeding Program

1. Meeker Baltic Maternal Line Selection - In 1940, 516 plants were selected and transplanted from a four year old stand of Meeker Baltic. Open pollinated seed was collected from 389 plants. Each of these 389 lines (MLS-1) were tested for bacterial wilt. 110 lines contained some resistant plants. Open pollinated seed from these MLS-1 plants was harvested in 1944. In 1947 plants from 144 MLS-2 lines were inoculated and read for wilt. The number of plants tested in each line ranged from 6 to 111, the average number of plants tested per line was about 40. 5 MLS-2 lines showed from 20-50% resistance.

The resistant plants were transplanted and in 1948 notes were taken on leafspot, mildew, and vigor. Notes will also be taken on seed set this year. It is felt we are getting a complex distinctly superior to the original variety. For example, in the 1947 wilt nursery Meeker Baltic showed no resistance. A composite of the open pollinated seed harvested in 1940 from the selected parent plants showed no resistance. However, Colorado Fr. No. 80, a composite of seed harvested in 1944 from the MLS-1 plants showed 23 percent resistance and an average green wt. of 182 g. Hardistan showed 7 percent resistance and 151 g. ave. wt., Ranger-Syn showed 20 percent resistance and 128 g. ave. green wt.

2. Hardistan Maternal Line Selection - In 1940 it was decided to attempt to improve the seed set of Hardistan by maternal line selection. Each generation was tested in the wilt nursery in an attempt to maintain the wilt resistance of the original variety. The project is in the second generation (MLS-2). Seed set readings last year indicate that we are making some improvement in seed setting. Thirty families were large enough for statistical analysis; of these families, using the rating 1 good seed set, 5 medium and 9 poor, 17 families were 5 or better and 13 families were 6 or worse.

3. Inbred lines - We are maintaining a program of isolating superior inbred lines.

Genetic Studies

Flower color - Crosses involving various white flowered plants were made. The F_1 segregation varied. Some F_1 progenies were all white. Some segregated for purple and white and one family was all purple. Last year twelve F_2 families from purple F_1's were read for flower color. In every case there was a segregation for purple and white. Twenty-eight more F_2 families will be read this year. In addition purple plants of one F_2 family were selfed for reading in the F_3.

Cultural Studies

Cultural studies and variety testing have been continued.

IDAHO - K. H. Klages reporting.

We do not have any definite alfalfa improvement projects in progress. We have done considerable work with the use of D.D.T. in the control of lygus, and find that our seed setting is greatly improved by the use of this material.

With regard to increase of alfalfa seed I may say that we have imported foundation stocks of Buffalo and Ranger alfalfas. Our certification work on alfalfa is increasing rapidly which is primarily due to the fact that growers are obtaining good yields with the use of D.D.T. in connection with seed production.

NEVADA - O. F. Smith reporting.

In Nevada, bacterial wilt and the stem nematode seriously injure alfalfa. Bacterial wilt is the more widespread and destructive but where the stem nematodes are present and environmental conditions are favorable to their development, they will kill a stand of alfalfa quicker than bacterial wilt. Other diseases are present and at times damage alfalfa but these two are the most effective in thinning stands and reducing yields.

Where bacterial wilt seriously injures susceptible varieties in three years, the wilt resistant varieties, Ranger and Buffalo, maintain full stands and high yields for at least six years. However, these varieties are susceptible to the stem nematode and are not satisfactory for areas where this nematode injures alfalfa. Since wilt is present wherever the stem nematode occurs, our present objective is to develop an alfalfa which will be resistant to bacterial wilt and the stem nematode, be a good seed producer, and give a high yield of forage. Nemastan is highly resistant to the stem nematode, is quite resistant to bacterial wilt but it is not a high producer of forage and seed. Some of our polycross progenies of selections from Nemastan are giving high yields of forage, are highly resistant to bacterial wilt and stem nematode, but some are not as high in seed production as desired.

Insects

We are doing no experimental work on the encouragement of beneficial, and the control of detrimental insects affecting alfalfa seed setting. However, we have found that dusting our seed plots with a 5 percent mixture of D.D.T. to control injurious insects, increases our seed production.

Nevada is not a high seed producing state but we are encouraging seed production with every possible opportunity.

NEW MEXICO - Glen Staten reporting.

Primary Objectives: Resistance to bacterial wilt, aphids and crown rot combined with the usual good Agronomic Characters.

Results: A few lines have been isolated which show promise. Consecutive inoculations given for wilt in attempt to pick highly resistant plants. Each plant used for breeding material has 4 to 6 inoculations behind it. Crown Rot must be given about as much consideration as wilt.

Testing techniques: Aphids; open pollinated seed grown in progeny rows in cold frame. Aphids introduced and allowed to feed 60 to 90 days.

Wilt: Apparently aphid tolerant lines and selected plants transferred to wilt nursery in field. Usual inoculation technique at transplanting time. Further inoculations made, by splitting large stems near crown and inserting wad of absorbent cotton after dipping into bacterial suspension. Technique appears quite effective. Field infection depended up for crown rot resistance.

Encouragement of beneficial insects: Bottles buried in terrace bank to provide nesting places for wild social or semi-social bees which trip flowers. Results to date: complete negative.

Foundation seed: None produced to date.

ALFALFA SEED DISTRIBUTION PROBLEMS AS INFLUENCED BY PRODUCTION

J. H. Withey of the Northrup, King Seed Company

Mr. Withey said in part: "The commercial distribution of alfalfa in the United States is somewhere between 50,000,000 pounds and 60,000,000 pounds. I suspect that 30 percent or 40 percent of the acreage should be planted with definite disease resistant strains. Without question, all seed production acreages should be gradually replaced with improved varieties. The problem is to have enough foundation stocks available for replacing production acres and working out some program of getting alfalfa seed growers to grow the improved strains having in mind that there is a very definite limitation on the price premium the consuming farmer will pay.

The problem is not so complicated but it can never be worked out with the individual states working alone. On the state basis the production seed stocks are scattered to a large number of small growers, many of whom have no ability or desire to grow seed. The problem can be whipped, but it won't be until it is approached as a national agricultural problem."

Mr. Withey urged that the State Experiment Station support the National Foundation Seed Stocks program, and pointed out the need of getting volume production in order that all may benefit. He assured the group the interest of the Seed Trade as a whole, not merely for themselves, as he did not expect any free "lunches" in the Alfalfa Program, but that all would work toward a common goal. The members of the Alfalfa Conference greatly appreciated the time and effort Mr. Withey spent in attending the meeting and discussing these problems.

HISTORY AND DEVELOPMENT OF THE POLYCROSS TECHNIQUE IN ALFALFA BREEDING

H. M. Tysdal

In 1928 a cooperative alfalfa breeding program was undertaken at Lincoln, Nebraska primarily to obtain resistance to the bacterial wilt disease. As a part of the program selfed lines were obtained from selected plants. Some of these lines were inbred up to six generations. As is now well known, the lines rapidly declined in vigor upon selfing. A few selfed lines appeared to hold their vigor from one to two generations, but eventually all showed great reduction. In some cases so great was the reduction that after four or five generations of selfing difficulty was encountered in propagating the lines from seed. This method of attack was a natural result of the phenomenal success corn breeders were obtaining by the use of selfed lines in corn. It was soon obvious that selfed lines in themselves were not the answer for commercial production.

Crosses were made between these inbred lines with varying results. In some cases very vigorous F_1 hybrids were obtained, while in others the vigor was only mediocre. The average yield of all the hybrids was practically the same as the open-pollinated varieties. The difficulty was that even if a desirable hybrid was obtained from a given cross, there seemed to be no practical way of producing such a hybrid in quantity, because of the low yield of seed and poor vegetative growth of the inbred lines. Moreover, the hybrids themselves usually had some short-comings even though they were highly vigorous.

While there appeared to be several ways in which these inbred lines could be used, it seemed possible this crop might lend itself to a slightly different approach than corn.

In discussing these things with Dr. T. A. Kiesselbach, who was extremely helpful in working out such problems, there seemed to be two important considerations involved relating to the use of inbred lines vs. non-inbred plants. The first fundamental difference between corn and alfalfa is that in corn it is necessary to have inbred lines in order to perpetuate the genotypes which have been found to produce desirable hybrids. In alfalfa this is not the case because a given genotype can be increased indefinitely by the use of vegetative propagation. The second point was not as readily demonstrable, but evidence is accumulating that is theoretically sound. This point is whether a cross between inbred lines is more vigorous than a cross between non-inbred plants. It seems clear that given the proper genotype just as high a yielding F_1 can be obtained between two open pollinated plants as between two selfed lined.

If these two points are accepted, then all of the advantages of using non-reduced populations can be immediately utilized in the selection program. Larger numbers of plants can be combed through for the desired characters. If it becomes necessary to utilize inbreeding to stabilize certain characters, this is not ruled out, but by recrossing or natural hybridization, the vigor could be regained before final selection is made.

One of the chief problems in setting-up such a breeding program was the method of testing these individual plants, and how they should be used eventually in the production of the commercial crop. It seemed obvious that such determinations as disease resistance could be made to a considerable extent on the plants themselves, including their vegetative cuttings. It was also realized, however, that there would be inherent qualities in the plant which would not be obvious from the plant itself. This seemed to be particularly true with respect to the combining ability of the plants. We were convinced that in order to make maximum improvement in alfalfa it was necessary to incorporate combining ability, as well as other desirable characteristics in the eventual product.

At that time the top crossing test in corn was becoming well established, but it did not seem feasible to apply the same techniques in alfalfa, because of the difference in flowering habit. As a result of a number of studies, the so-called polycross test was found to give a satisfactory test of the combining ability of the individual plants themselves, as well as a test on many other characteristics. The term polycross was used because any given clone might be crossed with a large number of pollen parents, and to differentiate it from the top-cross because there may also be some selfing, depending upon the self-fertility of the clone. The principle of the polycross is to have each clone pollinated by approximately the same pollen sources represented by a randomized pollination from other clones grown in the same plot. In practice as many as 50 or 60 selected clones can be propagated to give as many plants as desired for replication and to obtain the amount of polycross seed which is required for testing. Perhaps more clones could be used, but in practice it would seem desirable to eliminate the plants by many other characters before entering in the polycross, and thus only a relatively few highly selected plants need be put in this test. Several replications with different arrangements in each are necessary to obtain satisfactory random samples of pollen sources. It is also desirable that the blooming period come at about the same time. The seed is harvested from each clone separately.

Evidence is accumulating that a great many desirable characteristics can be selected for in the plants themselves. Thus, the polycross test need be utilized only in the final stages of selection. At this stage the method offers the opportunity to obtain as much seed as required for the necessary tests, something which has been a real problem not only in alfalfa, but many other forage crops.

Coincident with the development of the polycross idea was the finding that under natural, open pollinated conditions progeny of plants low in self-fertility yielded higher than those from highly self-fertile plants. This fitted in well with the theory and use of the polycross plan because this test would automatically take the amount of selfing into consideration through the vigor of progeny from any given clone.

The seed produced in the polycross nursery is subjected to thorough testing preferably in different regions in order to determine the inherent disease resistance, adaptation, longevity, prepotency and combining ability of the individual clones. As shown in a recent paper by Mr. Crandall and myself, the polycross test appears to successfully select high combining and desirable clones.

At the present time there appears to be at lease two ways to proceed after high-combining clones of superior disease resistance are selected. Originally it was suggested that the clones with low self-fertility could be planted in alternate rows after having been vegetatively propagated to produce single, or perhaps double crosses. It is my opinion that a single cross produced in this manner will produce the maximum in alfalfa improvement. It is admitted that the production of such a single cross hybrid would be a little more expensive. It should, therefore, be undertaken commerically only if specially desirable hybrids are produced. A vigorous single cross which would consistently reproduce a strong rhizomatous habit, for example, might be worth using as a single cross. I doubt if we have at present such a single cross. In the meantime, however, an alternative appears to be promising. Tests have shown that when four or five high-combining clones are vegetatively increased and planted together in an isolation block, their progeny can be expected to reflect the high combining ability of the clones. Moreover, the progeny from the seed, in other words, a second generation from the clones continues to exhibit within a very narrow percentage the original high yield. This appears to indicate that a synthetic variety produced by compositing 4 or 5 high combining clones will result in a highly superior variety. In addition, when such high-combining desirable clones are once selected, they themselves can be improved by a back crossing program to add resistance which they do not have to other diseases. It may be worth while to consider this approach for the future improvement program - as well as obtaining entirely new material.

It is interesting to note that in recent programs for breeding for leaf spot resistance there have been two approaches to the problem. At one station selected plants have been selfed to obtain resistance, at another, larger populations have been selected for resistance with actually less labor involved and as far as can be observed both have been equally successful in obtaining resistant plants. Moreover, the selfed plants cannot be used as effectively as non-inbred plants in hybrids or synthetics because of lack of vigor. Naturally, where the character is entirely lacking in the commercial variety or selected strain, it would be necessary to make the required crosses and then select in the segregating population. Highly selected, disease resistant plants of low self-fertility that prove to be high-combining in the polycross test are excellent material for hybrids or synthetics. It may be desirable to study specific combining ability between the clones which are promising for a synthetic. This undoubtedly will be desirable for maximum improvement. On the other hand, from preliminary observations, general combining ability appears to play an important role in alfalfa relatively more than specific combining ability, providing unrelated material is used, and the polycross test appears to give a good measure of general combining ability, as well as many other characteristics of the clone.

COMMENTS ON POLYCROSS TESTING

R. A. Brink

When the gene frequency for a desired character is very low in a population, e.g., for bacterial wilt resistance in commercial Cossack alfalfa, mass methods of eliminating unwanted genotypes are necessary to accumulate significant numbers of plants worthy of more intensive evaluation. Experience at the Wisconsin Station with artificial inoculation for bacterial wilt of commercial Cossack seedlings versus the testing of survivors in old, naturally infested and severely depleted fields of this variety has demonstrated the advantage of the latter procedure. Presumably the same advantage holds in using survivors from old fields in raising the frequency of genes conditioning "hardiness" as well. Cloning (replication of the individual) provides an effective means of evaluating all characteristics of the plant which are inherited additively. Theoretically, the only information which the polycross test can add to that from clonal trials relates to non-additive characters. Since yield potential is non-additive in part the polycross test is an essential step in selecting for increased productivity. Cloning is expensive and hence can be used efficiently only on populations containing a relatively high proportion of desirable individuals. This fact points to the importance of effective mass methods of eliminating undesirable plants preceding clonal propagation and testing. Once clones are established the opportunity for evaluating the genotypes which they represent is greatly expanded by the polycross technique. The variety and extent of the testing which may then be undertaken for both additive and non-additive characters is limited only by the seed supply.

The bottleneck in current breeding procedure is an insufficient range of screening techniques which may be efficiently applied to mass, clonal and polycross populations. Much further research on the biology of alfalfa is needed to overcome this limitation. Reaction to the bacterial wilt organism may now be confidently measured artifically thanks to the thorough understanding of the wilt disease which F. R. Jones' work has afforded. This shows what can be achieved and is illustrative of a class of work which is in need of stronger encouragement. There is growing recognition of the fact that there are critical factors other than bacterial wilt which affect persistance and productivity of alfalfa in some areas and that too little is known about these phenomena to enable the breeder to deal with them effectively. Winter injury in the northern and central alfalfa area is an example. The nature and sequence of the changes occurring in the winter injured plant under a given set of circumstances remain largely obscure. The respective roles of physical factors and pathogenic organisms are still to be worked out. So long as the major elements involved are not understood, any artificial method of screening for winter hardiness adapted to the handling of large amounts of breeding material encounters the risk of giving misleading results. Winter injury is but one of several factors which might be mentioned pointing to the need for expanded research effort in the interests of a continuously productive breeding program.

DISCUSSION FOLLOWING POLYCROSS PAPER

Grandfield: In the discussion some have indicated that the polycross may be an expensive way to obtain the desired information on combining ability. Our results indicate that the polycross progeny tests measure much more than the combining ability. Such characteristics as disease resistance and adaptation can also be measured, and this method allows us to test these characteristics in more places because we can readily obtain as much seed as necessary.

Myers: It is my opinion that the polycross is a big step forward, not only in alfalfa breeding, but in other forage crops. The principle can be applied to strains as well as clones. It does not preclude the use of inbreeding where desirable, or making specific crosses to obtain the desired genotypes. In these crops where it has always been the problem to get enough seed, this method gives us that opportunity.

Crandall: Rather than stressing the expense of the polycross procedure, I think we should emphasize its economy. It is relatively easy to obtain the desired seed in one isolation block as can be done with this system.

Tysdal: Some mention has been made of the desirability of more fundamental work. I quite agree. At the same time it is very evident that there is a crying need for new and better adapted alfalfas. It is our duty to produce these for the American grower as soon as possible and we cannot wait until all the fundamental problems are solved to get them. On the other hand, there is a large amount of fundamental work being done now, in cytogenetics, seed production, and disease. I entirely agree that there should be more if possible - the two must go together.

SUMMARY STATEMENT PREPARED FOR THE REPORT OF THE ELEVENTH ALFALFA IMPROVEMENT CONFERENCE

CYTOGENETICS OF ALFALFA

Sanford S. Atwood and Paul Grun
Cornell University

This review paper summarized the cytogenetic literature for alfalfa, especially as it relates to (1) the evolutionary concepts of the genus Medicago and (2) the genetic principles fundamental to breeding of alfalfa. A mimeographed summary, including tables of (1) the major contrasting characters of several Medicago species, (2) evolution of the Conospecies, M. sativa, from Sinskaya (1940), (3) major characteristics differentiating wild and cultivated alfalfas, from Sinskaya (1940), (4) interspecific crosses, and (5) a review of genetic studies, together with a list of the 118 references included, was distributed at the Conference. Extra copies of this mimeograph are available from the authors upon request.

Some of the most important conclusions derived in this paper were as follows:

1. M. sativa and the species closely related to it are not distinct taxonomically. From a breeding standpoint, however, this range of forms appears to offer a potential source of hybrid vigor and specific characters that might add much to common alfalfa.

2. Two theories have been formulated to account for the origin of M. sativa. Trabut's (1917) theory considered M. sativa to be a hybrid product of M. gaetula and M. falcata. The evidence for such a derivation is limited, however, and criticism of it is found in the fact that Ufer (1933) obtained no sativa-like segregates from such a cross, as well as the fact that the distributions of the supposed parents do not overlap. The more recent theory of Sinskaya (1940) suggests that most of these closely related forms were derived from M. hemicycla. The evidence is based on the continuous natural variation from one form to the next.

3. Apparently as a result of the cultivation of alfalfa for many centuries, fundamental differences have evolved between the wild and cultivated types. Many of the agronomically desirable characters, however, are not typical of the wild forms.

4. The existence of self-sterility, which may be conditioned in large part by somatoplastic sterility, appears to have been an important factor in the ease with which adaptive mixing took place and gave rise to this array of forms, among which M. sativa may exist only rarely in pure form.

5. Evidence from chromosome numbers has not been greatly helpful in problems of alfalfa evolution. Only diploid (2n=16) and tetraploid (2n=32) forms are known. Within some species only diploids are known, within some, both diploids and tetraploids exist, and within some only tetraploids are known.

6. Studies of meiotic pairing have indicated a low multivalent frequency with the most frequent type of pairing being 16 bivalents. Disturbed anaphases, aneuploids, and abortive pollen have been found in most material.

7. The 4n hybrids from M. falcata x M. sativa studied by Ledingham (1940) and the hexaploids (2n=48) studied by Julen (1944) suggest that the two M. sativa genomes are very similar so that the species might be considered mostly an autoploid.

8. In all 34 genetic studies (including 22 characters) where an interpretation has been suggested, only disomic ratios have been proposed. This suggests that (1) alloploidy may be the basis of M. sativa evolution and (2) relatively simple ratios may be expected for many characters of practical interest to breeders.

9. Some genetic ratios are suggestive of tetrasomic inheritance, but no example now exists that can be interpreted only on a tetrasomic instead of on either basis.

10. Although many characters have been studied in alfalfa, only a small sample of the genetic variability in the genus has been studied intensively, so that further studies, particularly of interspecific hybrids and of inbreds, should be fruitful in obtaining more useful mutants.

11. The sterilities often met in genetic studies can be circumvented by analyzing F_1 plants separately, instead of waiting for homozygous parents and by using critical backcrosses, obtained by hand-pollination, rather than F_2 and F_3 generations.

12. Vegetative cuttings might also be used, especially in studies of physiological characters, to estimate more accurately the heritable variance.

13. No ready explanation is apparent at present for the apparent contradiction of cytological and genetical evidence on alfalfa evolution.

NAMING GENETIC CHARACTERS OF ALFALFA

W. M. Myers

I. General Principles

1. Give character a name suggestive of one of its chief attributes.
2. Assign as a symbol the initial letter of the name of the character plus, if necessary, some other appropriate letter. Use capital first letter or $+$ to designate the dominant condition.
3. Give phenotypically similar characters the same name and differentiate by subscript numbers.
4. Give allelic series a common basis symbol and differentiate alleles by superscript letters.

These principles were outlined by Emerson, Beadle and Frasier for their maize summary. Later they were adopted by Robertson, Wiebe and Immer for barley and by the Crops Division, A. S. A., Committee on "Nomenclature for Genetic Factors in Wheat."

II. Some Difficulties with the System:

1. In maize, yellow seedlings have been called "yellow green," "aurea," "xantha," "luteus," and "virescent." In some cases, characters under different names have been proved to be identical, for example, yellow green-2 and virescent - 14.
2. Different workers may describe characters that are phenotypically the same. Only crossing tests will determine whether the two characters are conditioned by the same or different genes. The character described second might be given the symbol x-1 or x-2. If it is called x-1 and later proves to be a different gene the records will be confused. On the other hand, if it is called x-2 and is later proved to be the same as x-1, a correction will be necessary.

Published data remain published for a long time. It would seem preferable, whenever a character resembling phenotypically an already recorded one is described, to assign only the letter symbol. Subsequently, a number would be added when the relationship has been clarified by genetic tests.

III. Preservation of Genetic Characters.

1. Genetic characters are often lost.

   a. The original investigator, having satisfied his needs, discontinues his work with the character. A program, with limited facilities, often becomes overcrowded with material that must be saved but is not currently useful. Something must be discarded.
   b. The original investigator moves to another job. His research program and materials are taken over by a new man who has ideas of his own.

2. Even after a gene has been lost, its name remains on the records.
3. There is needed a central depository for genetic characters in alfalfa, such as Dr. Emerson operated for so many years for the corn geneticists.

SOME AGRONOMIC FACTORS AFFECTING ALFALFA PRODUCTION IN THE HUMID REGION

by Robert B. Carr

In the U. S. D. A. Yearbook of 1941, "Climate and Man", Dr. O. S. Aamodt made the following statements regarding alfalfa:

"The wide distribution of alfalfa in the world indicates a remarkable adaptability to various climates and soils. Though the crop requires considerable moisture to produce profitable yields, it does best in a relatively dry climate where water is available for irrigation. It will survive a long period of drought, but is not productive under such conditions. Alfalfa is not so well adapted to a humid climate, partly because acid soils are developed under heavy precipitation and partly because diseases are most destructive in humid regions."

The last sentence of this quotation, briefly but effectively, describes a problem that has confronted the research workers in alfalfa in the humid region for some time and to date challenges us to a herculean task. With the growing interest in the dairy and beef cattle industry, alfalfa can play an important role in the agricultural program of this region and in the economy not only of the farmers but of a large sector of the entire population.

As the alfalfa problems of other areas of the humid region have been, or will be discussed by others on this program, I will confine my remarks to the southern area. This area lies entirely within the Cotton Belt and is the states of Alabama, Arkansas, Florida, Georgia, Louisiana and Mississippi.

Important Climatic Factors

Atmospheric humidity and its direct relationship to plant life is of great importance. A conservative estimate, based on the 1899-1938 U. S. Weather Bureau maps in the 1941 Yearbook of Agriculture, shows that the average relative humidity for comparable seasons is from 10 - 15 percent higher in the southern area of the humid region than in the main alfalfa areas of the West.

A similar comparison of the temperatures of the two regions provides interesting figures;

	REGION	
	Southern Area	Western Area
Av. January	52	27
Av. July	80	70
Av. Annual	66	48
Av. annual maximum	99	95
Av. annual minimum	15	-22
Av. - Highest ever recorded	106	108

You will note that the average January temperature in the southern area is higher than the average annual for the western area. Both the average July and the average annual maximum are higher in the southern area than in the western area. The average annual minimum is 37 degrees higher in the southern area than in the western area.

It would appear from these climatic data that the low winter temperatures and the resultant long period of dormancy of alfalfa in the West would have a quite different effect upon the longevity of stands than would the relatively short periods of dormancy, or semi-dormancy, interspersed with frequent periods of growth in the humid area. The fact that alfalfa is alternating frequently between dormant and growing cycles during the winter months in the South must affect the plant metabolism and be an important factor in its adaptation and longevity.

The numerous alfalfa failures reported from time to time in various areas of the humid region are ample justification for the current opinion of many that alfalfa is not climatically adapted to this region. Certainly, if alfalfa is to be economically produced in this climatic area, favorable soil conditions must be provided, if they do not exist naturally.

Soil and Fertilizer Factors

Alfalfa thrives best when grown on deep loam soils having a high level of fertility, good drainage and a neutral reaction. In the Cotton Belt most of the tillable fertile soils with good drainage are planted to cultivated crops such as cotton, corn, small grains, soybeans, tobacco, vegetables, etc. The less productive areas are planted to pastures and hay crops, including alfalfa.

To produce profitable yields of alfalfa, the productive capacity of these soils must be improved through the use of drainage, fertilizer, lime, etc.

The soils of this southern area may be generally divided as follows:

1. The alluvial soils of the river valleys.
2. The brown-loam soils, extending through central Mississippi into Tennessee.
3. The Black Belt or Prairie soils of east-central Mississippi and west-central Alabama.
4. The coastal plains and light sandy soils generally extending over the remainder of the area.

On the alluvial soils of the Mississippi River Delta, covering portions of Arkansas, Louisiana, and Mississippi, the level of fertility appears not to be the major factor in alfalfa production. In tests conducted on Sharkey clay soils at the Delta Experiment Station, Stoneville, Mississippi, 1931-37, Henson found that the increase in yields as a result of liberal applications of manure, nitrogen, potash, and phosphorus was not significantly higher than the yield on the untreated plots.

Insufficient drainage is a problem on many of the Delta soils. Improving this drainage has increased the life of the stand and increased the yield in a number of instances. However, even with what appears to be adequate surface drainage, alfalfa failures are frequently reported.

On the brown-loam soils, fertilizer treatments of potash and phosphates together with lime as needed will likely pay dividends, but I have no data to indicate the most profitable rates.

The Alabama Experiment Station and Extension Service reports phenomenal increases in alfalfa yields in response to liberal fertilization on the Black Belt or the Houston clay type of soil. The acreage in alfalfa in this area increased almost ten-fold (from 2,200 to 20,000 acres) in four years, 1944-47. The yields increased from an average of 1 - 1-1/2 to as much as 3 - 5 tons per acre. These increased yields were obtained with applications of from 600 - 2,000 pounds of basic slag or its phosphate equivalent in superphosphate; 200 - 400 pounds muriate of potash; and 10 - 20 pounds of boron per acre within the twelve months preceding the planting of the alfalfa.

Similar, but less phenomenal results were obtained on comparable soils at the West Point, Mississippi, station. The acreage in alfalfa in six counties of the prairie section of Mississippi increased from approximately 6,000 in 1909 to 14,000 in 1919. Then in five years, or by 1924, the acreage dropped to less than 2,000. In tests conducted at the station from 1926-32 with liberal applications of basic slag or superphosphate, limestone, and manure, the yields were increased from 1 - 1½ tons on the non-treated plots to 2½ and 3 tons per acre on the heavily fertilized plots. As a result, the acreage in alfalfa in these counties increased more than 100 percent between 1924 and 1939. However, the planting is still confined to the fertile alluvial soil and even on these soils, liberal applications of potash, phosphorus and boron are necessary for high yields and longevity of stand.

Data obtained on the coastal plains or sandy soils at Auburn, Alabama, and Athens, Georgia, and on the silt loam soil at the Sand Mountain Station at Crossville, Alabama, also indicate that low or exhausted fertility has been a major factor in the lack of profitable yields on these soils. The average yield has been increased from approximately one to as much as four tons annually and the longevity extended from one or two years to five and six years. These yields and the persistency of stands are the result of fertilizer treatment as follows:

Prior to planting:	1 - 3 tons of limestone per acre
	200 - 800 pounds of superphosphate per acre
	0 - 400 pounds of muriate of potash per acre
	0- 30 pounds of Borax per acre
Annual applications:	500 - 1000 pounds of limestone per acre
	200 - 600 pounds of superphosphate per acre
	100 - 400 pounds of muriate of potash per acre
	10 - 20 pounds of Borax per acre

Diseases and Insect Factors

Later on in this program there will be a general discussion of alfalfa diseases and insects, so I will make only a brief reference to them at this point.

Bacterial wilt, *Corynebacterium insidiosa*, which is quite destructive in the main alfalfa area of the west and is common in the northeastern United States, has not become a major problem in the South. Leaf spot, *Pseudopeziza medicaginis*, is probably the most extensively spread disease over the humid region. Other diseases that are reported from this area are: anthracnose, *Colletotrichum trifolii*; black stem, *Ascochyta imperfecta*; downy mildew, *Peronospora trifoliorum*; Fusarium root rot, Fusarium oxysporum var. medicaginis; rust, Uromyces striatus; and stem rot, Sclerotina trifoliorum.

To date the use of fungicides as a disease control measure has not become a general practice. Breeding for resistance appears to offer the most promise as a control measure for alfalfa diseases.

The following harmful insects are frequently reported in scattered local areas (but not always in epidemic numbers): alfalfa caterpillar, Colias philodice eurytheme Bdvl; fall army worm, Laphygma frugiperda; garden webworm, Loxostege similalis (Guen.); pea aphid, Macrosiphum pisi (Kltb.); potato leafhopper, Empoasca fabae (Harr.); three-cornered alfalfa hopper, Stictocephala festina (Say); Say stink bug, Chlorochroa sayi stal; tarnished plant bug, Lygus oblineatus (Say); blister beetles and grasshoppers.

During the past spring, observations on the second growth of a four year old rod-row nursery at Stoneville, Mississippi, indicated a striking difference between strains and varieties in leaf yellowing or injury by the potato leafhopper. In the third cutting these differences were not so evident. If there is an inherited resistance to insects, especially the tarnished plant bugs and the potato leafhopper, plants carrying this resistance should remain healthier and in a more vigorous growth balance. Thus, they may also be more resistant to diseases and consequently more productive. Their yield would certainly be expected to exceed the average of the field.

The use of new organic insecticides for cotton insect control is expanding rapidly. As a result of the large number of beneficial insects killed in this way, alfalfa seed production may continue to be a serious problem in the southeastern belt. Until the true destructiveness of these new insecticides can be determined, it will not be possible to measure their influence on alfalfa seed production.

Breeding Procedure for the Humid Areas

Methods of breeding for the improvement of alfalfa have been discussed by a number of workers. In 1933, Kirk concluded that selfed-line breeding was not too effective. At about the same time, Jenkins described a strain building method in which he used both selfed and cross-pollinated progenies. In 1939, Fryer proposed a maternal line selection method. More recently, Bolton, Tysdal, and others have concluded that plants having high combining ability for both forage and seed yields may be obtained in both inbred and open-pollinated lines.

After considering the many factors involved and these numerous methods of procedure, it appears that the most promising and logical approach, from the breeding standpoint, to this problem of increasing the longevity of stands and the productiveness of alfalfa in the humid areas may be as follows.

1. Select healthy, vigorous-growing plants in old fields.
2. Grow these selections in isolation plots to check for self-sterility.
3. Propogate the nursery selections by vegetative clones or seed or both. It may become necessary to grow some of the clonal progenies under western conditions in order to get sufficient seed increase.
4. Insect and disease resistance, high nectar concentration, and combining ability for forage and seed yield should be considered in the final selection of the parental lines.
5. Make liberal use of self-sterility and increase the progenies of these lines in polycross nurseries if and when sufficient seed setting can be obtained.
6. There should be an integration or unifying of our efforts and resources, probably a defining of specific problems to definite areas in the humid region, if we are to efficiently solve the alfalfa problem.

AGRONOMIC OBJECTIVES FOR ALFALFA BREEDING IN HUMID AREAS

John G. Dean

The general traits that are desirable for alfalfa varieties in Ohio are little different than those desired in other areas. We want increased yield, particularly in the second and third cuttings; high quality; resistance to disease, insects and winter injury; and better seed production. Improved cultural practices will help us attain our goal of more efficient production, but many problems can best be solved by breeding better alfalfas.

One of the most important problems of alfalfa production in Ohio is to establish a good stand. If it were not for uncertainty of getting a satisfactory stand, alfalfa would have largely replaced red clover in much of our area by this time. Our difficulties can be alleviated by proper cultural practices but there is definitely a breeding problem as well.

In Ohio, alfalfa is most often seeded in the spring with a companion crop of oats or winter wheat. If it is sown alone, it must compete with a companion crop of weeds. Late summer seedings are practical as far north as Columbus, but summer seeded alfalfa must also compete with weeds and it is more subject to heaving during the first winter than is spring sown alfalfa. In most cases then, the young alfalfa plants must withstand severe competition for water, light and mineral elements from germination to small grain harvest. Water is seldom a limiting factor during this period in Ohio, and most farmers who grow alfalfa have a pretty good fertilizer program. Alfalfa seedlings would benefit if the companion crop were clipped or pastured, but this makes additional labor for the farmer and frequently decreases the yield of the small grain crop. These practices are not popular with farmers and are usually not followed. There is a real need for an alfalfa that has greater seedling vigor and more tolerance to shade. As we study this problem more thoroughly we will undoubtedly find some diseases that are important in this phase of establishment.

Combines have become increasingly popular in Ohio, and at the present time much of the small grain is harvested in this manner. It was soon noticed that it was much more difficult to obtain stands of alfalfa and red clover when the companion crop was harvested with a combine than when it was harvested with a binder and thresher. Frequently the stand of legumes was good at the time the companion crops were harvested, but the next spring the legumes were practically gone. Willard and Lewis (1) found that the stand of legumes could be maintained if the crop residues were removed as soon as possible after combining. They report that the major loss of stand occurs between September 1 and March 1 and attribute the loss of stand to a disease complex. Alfalfa has proved to be more tolerant of the "disease" than red clover.

Similar loss of stand has been noticed in the advanced alfalfa nurseries at Columbus during 1946 and 1947. These nurseries were sown alone and had good stands until approximately September 1. Fusarium wilt, *Fusarium oxysporum* var *medicaginis*, and anthracnose, *Colletotrichum trifolii*, have been isolated from diseased plants in these nurseries, but there were unidentified organisms present too.

Other diseases such as leaf spot, *Pseudopeziza medicaginis*, and the effects of the attacks of insects such as the potato leafhopper, *Empoasca fabae*, are usually not directly lethal to alfalfa plants. However, the cumulative effect of these disorders weaken the plants and make them more subject to winter injury.

In summary of the establishment complex, we can breed for tolerance to shade and leafhoppers, resistance to the lethal disease complex associated with combine straw, and resistance to sub-lethal diseases which weaken the young plants.

We definitely need a legume for use in pasture mixtures for summer grazing. A pasture type alfalfa would help fill that need in Ohio. In addition to the traits already discussed, such an alfalfa should be tolerant to full season grazing, long lived, tolerant to renovation practices, and compatibility with grasses and other legumes. Renovation usually consists of a rather thorough dicing and the addition of fertilizer. The area may or may not be reseeded following these operations. The cultivation is necessary to allow the placement of the fertilizer at depths of five to six inches.

Top dressing with commercial fertilizer has given good results with shallow rooted plants such as Kentucky bluegrass, but only mediocre results with the deeper rooted species.

References

1. Willard, C. J. and Lewis, R. D.
1947. Reduction of stands and yields of clover and alfalfa after combined wheat. Ohio Agr. Exp. Sta. Bimonthly Bul. 32: 245; 64-70.

THE AGRONOMIC REQUIREMENTS OF AN ALFALFA FOR THE HUMID AREAS

C. H. Hanson

Since there are several who will participate in this discussion, I have listed the requirements or objectives which we in North Carolina consider to be important.

1. High forage yields. A variety producing high forage yields in the East, must also produce satisfactory hay and seed yields in the West. At the 1946 Logan meetings, data was presented showing that a positive correlation exists between hay and seed yields in alfalfa.

2. Quality
   (a) Resistance to diseases and insects. Next to failure to provide the plant with proper nutrients, diseases and insects are probably the most important factors causing low quality and yield in our section. At times, leaf spots, leaf blotch and downy mildew cause severe defoliation. Stand and quality are also affected by other diseases such as black stem, Rhizoctonia, Sclerotinia, and southern anthracnose. The method of control of insects, as a group, may be largely chemical or management but certain insects such as aphids, leafhoppers and even army worms show preference for certain types of alfalfa.

   (b) Leafiness

   (c) Dark green foliage. There seems to be an association between dark green foliage and resistance to attacks from certain insects.

   (d) High protein and other nutrient qualities.

3. High mid-summer productivity. Northern strains show greater decline in productivity during mid-summer months than more southern types.

4. Closely associated with high mid-summer productivity is competitive ability. Weeds offer alfalfa severe competition during the summer months. They are less troublesome in Atlantic and some of the better adapted lines.

5. Rapid recovery after cutting.

6. Persistance - long lived stands reduce the cost of production.

7. Response to fertilizer and other cultural treatments.

8. Deep root penetration. When diseases or insects are not limiting factors, the yield of any one of the first three cuttings in any one season is roughly proportional to the amount of moisture available. It is difficult to say what extent the selection for root penetration can be practiced but performance data during dry seasons and possibly information on the characteristics of root and crown that one could obtain by examining their growth in the upper two feet of soil would be helpful.

As for attaining these objectives, the rate of progress will undoubtedly be accelerated as breeding programs in the East become more intensive and more and more materials are introduced into the program by the eastern states. In testing the experimental material from various states we have found that although some of the polycrosses and synthetics have performed very well, Atlantic has usually been the most productive. However, wilt has not been a factor in any of these tests. The superior performances of Atlantic in the East, as well as in the West where wilt has not been a factor, lends encouragement in attaining our goal in developing varieties adapted to broad latitudinal belts.

BREEDING AN ALFALFA FOR THE HUMID AREAS
REQUIREMENTS OF DISEASE RESISTANCE

R. G. Henderson
Va. Agr. Expt. Station

The importance of alfalfa diseases cannot be overemphasized. Practically every report presented at this conference has related directly or indirectly to the story of how destructive diseases are limiting the production of alfalfa. Many of the diseases which occur in the humid sections of the United States are the same ones that are reported in the arid sections, but in most instances their destructiveness is greatly accentuated by the humid environment. The following diseases are reported, by the several plant pathologists located in the humid area, as being important on alfalfa:

Sclerotinia stem rot (S. trifoliorum). General in states from North Carolina to New Jersey.

Black stem (Ascochyta imperfecta and Cercospora zebrina). General, especially destructive in 1948.

Bacterial wilt (Corynebacterium insidiosum). Prevalent in North, isolated reports in South.

Leaf spots (Pseudopeziza medicaginis, Stemphylium botryosum and other fungi). General.

Damping-off of seedlings, root and crown rot of older plants. (Rhizoctonia solani and probably other organisms). Serious injury observed in Virginia and Kentucky. Extent of distribution undetermined.

Mildew (Peronospora trifoliorum). General

Anthracnose (Collctotrichum trifolii and other species). South, extent of damages undetermined.

Fusarium wilt (F. oxysporum f. medicagnisis). Reported more frequently in the South.

Several other diseases, such as those caused by nematodes, Pythium, and Sclerotinia rolfsii, are known to be very destructive in some instances over a wide area, but these diseases have received little attention. The question of resistant varieties for these several diseases has received only meager attention by workers in the humid area.

Definite breeding programs to develop disease resistant varieties of alfalfa for use in the humid areas are in progress at only a few experiment stations. The observations on differences in susceptibility of common varieties to certain diseases, together with the progress that has been made in developing bacterial wilt resistant varieties by workers in the West, should encourage more extensive investigations. For example, the Kansas Common, Atlantic, and Buffalo varieties are more tolerant to the Stemphylium leaf spot disease than are Ranger, Hardistan, and Ladak varieties. Preliminary tests indicate that there are wide differences in the susceptibility of varieties to the black stem diseases and that individual plant selections would undoubtedly lead to strains with an even higher degree of resistance. Similar examples could be cited with other diseases. These examples will serve to show that at least certain degrees of resistance to some of the important diseases exists in the present varieties. By careful selection and testing, it appears probable that improved varieties could be obtained. But resistance to only one or two diseases is not enough; a variety is needed that is resistant to a large number of diseases. To obtain such a variety it will be necessary to make crosses and test the progeny for resistance to all the important diseases. Such a breeding and testing program, to be successful, will require the full cooperation of the workers in the eastern hay growing areas and those in the seed producing areas. Two new varieties, Atlantic and Williamsburg, which appear to be resistant to certain diseases prevalent in the eastern states, have not been evaluated in the western seed producing area. Thus, it may be impossible for the farmers to obtain seed of these improved varieties if they should prove unadapted or susceptible to diseases prevalent in the seed producing area.

The need for resistant varieties is fully recognized and the probability of procuring them in a breeding program is favorable. It is expected therefore that the alfalfa breeders and plant pathologists will pursue this line of work more extensively in the near future.

COMMON LEAF SPOT OF ALFALFA CAUSED BY <u>PSEUDO PEZIZA MEDICAGINIS</u>

R. L. Davis
Indiana Experiment Station

This disease, common leaf spot, has long been known as a destructive disease of alfalfa. As early as 1891, Combs, Iowa, "stated at this time the leaf spot caused by <u>P. medicaginis</u> is the most destructive disease of alfalfa." In 1908, Stewart, et. al. referred to the disease as the most important fungus attacking alfalfa in New York. The early method of control was to cut the alfalfa premature before defoliation. However, this will not prevent the loss of leaves after cutting. Too, such treatment over a period of time can result only in reduced vigor and loss of stand due to decreased food reserves.

At times, especially in the spring and fall, there is as much as 50 percent defoliation, often more. This results not only in a decrease in yield, but more significantly, in a lower quality. Approximately two-thirds of the protein and 80 - 90 percent of the carotene are found in the leaves. The loss with 50 percent defoliation is obvious.

With the increasing seriousness due to bacterial wilt, it is necessary to breed for wilt resistance in order to maintain stands. Unfortunately, the group of alfalfa that carries the highest degree of wilt resistance, Turkistan, is the most susceptible to leaf spot. Even with short-rotation alfalfas such as Atlantic, it is still essential that the plants retain the leaves since it is desirable to breed for quality as well as quantity. At present, there is no obvious reason why an alfalfa cannot be resistant to bacterial wilt, and also carry a high degree of resistance to <u>Pseudo peziza medicaginis</u>.

In 1946, 36 plants that showed resistance to leaf spot were selected from a space planted nursery of about 1000 plants of Cossack, and Cossack and Ladak. This material was from open-pollinated seed obtained from Dr. Brink and was out of wilt resistant material.

These clones were increased vegetatively in the greenhouse and transplanted into flats. In addition to the clones, each flat contained a susceptible check-Ranger. Preliminary results had shown that the inoculated seedlings were susceptible at an early age - $1\frac{1}{2}$ to 2 months old.

The flats containing the resistant clones along with the check were inoculated in the greenhouse. Pieces of the sporulating culture from a culture tube were placed on a plate glass and suspended over the plants to be inoculated. Previous work showed that glass was better than merely laying the "plugs" of the organism on cheesecloth. The greenhouse bench containing the flats was then surrounded with burlap bags and sprayed with water to keep the humidity up and the temperature low.

Following two such inoculations the cuttings were rated according to the amount of spotting, 1 - no spotting, 5 - medium, 10 - severe spotting. By this time the disease was prevalent on a few of the original plants. These were also rated.

In the spring the cuttings were transplanted into the field in a space planted nursery of ten plants per row. Every fifth row was a check - Ranger - so that no clone was more than two rows from the susceptible check. This was done not only to have a check on the incidence of leaf spot, but also to build up an epidemic.

Also, in the winter of 1946 - 47 remnant seed from the 1946 Uniform Nursery was seeded in flats and inoculated. One or two plants in a few of the strains showed little or no spotting. These few plants were also planted to the leaf spot Nursery previously described.

In addition cutting from six resistance clones obtained from Dr. F. R. Jones along with selfed seedlings from these clones were transplanted into the nursery.

Fortunately, there was a high incidence of leaf spot on the checks in the fall. Ratings were made on all the material. The ratings 1 to 10 on the cuttings inoculated in the greenhouse were correlated with those made on the same clones in the field. Even though the clones that were the most susceptible in the greenhouse were also susceptible in the field, the correlation coefficient was not significant. However, when the ratings made on the mature plants - the ones from which the cuttings were made - were correlated with the ratings made in the leaf spot nursery, the correlation coefficient was significant. However, this probably does not mean that the greenhouse inoculations were not comparable to field infections, but more likely, that the system of classification was not adequate. Also, since all the clones carried considerable resistance, most of the ratings were telescoped toward the lower end, 1 to 4. This reduces the range and tends to decrease the correlation coefficient.

As for sources of resistance, Ladak, and Cossack have given the highest percentage of resistant material. However, work up to now indicates that by using large populations, some resistant plants can be found in about any strain or variety. In addition to the material listed above, two Ranger plants and two Buffalo plants have been found that show a high degree of resistance. At present it is believed to be more desirable to isolate a few lines from many sources than many lines from a few sources of material. With the present method of breeding, observations indicate that it is necessary to maintain a wide variety of germ plasm in order to insure maximum combining ability.

The work is being carried still further to try to determine what factor or factors condition resistance to P. medicaginis. Controlled crosses were made in the greenhouse using two resistant plants, two somewhat intermediate, and two susceptible plants. Crosses were made in all possible combinations and the progeny will be carried into the F_2 population. All of the progeny, both F_1 and F_2 will be inoculated with the organism in the greenhouse.

SYMPOSIUM ON BENEFICIAL AND HARMFUL INSECTS IN ALFALFA SEED PRODUCTION.

F. E. Todd and R. L. Parker, Chairmen

BENEFICIAL INSECTS IN RELATION TO ALFALFA-SEED PRODUCTION IN UTAH

By George E. Bohart 1/

1/ Bureau of Entomology and Plant Quarantine, Agr. Res. Admin., U. S. D. A., in cooperation with the Utah Agricultural Experiment Station.

Parasites and Predators of Injurious Insects

Except for pollinators, insects beneficial to alfalfa have received scant attention in Utah. However, the effect of DDT dusting for weevils on the braconid wasp Bathoplectis, a parasite of the alfalfa weevil, has been studied by F. V. Lieberman and S. J. Snow. Their findings are included in the report delivered to this group by C. M. Packard.

The following parasites and predators are commonly encountered in alfalfa-seed fields, but their significance has not been evaluated:

(1) Blister beetles (Epicauta spp.): Predators as larvae on grasshopper egg masses; feeders as adults on alfalfa flowers.

(2) Flesh flies (Sarcophaga spp.) and tachina flies (Larvaevoridae): Parasites of cutworms, army worms, and grasshoppers.

(3) Predaceous bugs (Nabis ferus Linn): Predators on Lygus bugs and pea aphis.

(4) Minute pirate bugs (Orius insidiosus Say): Predators thrips and red spiders.

(5) Syrphus flies (Syrphus, Sphaerophoria, etc.): Predators on pea aphis.

(6) Ladybird beetles (Coccinella, Hippodamia, etc.): Predators on pea aphis.

(7) Thrips (Thysanoptera): Several genera have been observed, some of which are probably predators on red spiders and injurious thrips.

Special study would greatly expand the number of species in this list and elucidate their value as enemies of injurious insects. Studies on the effect of various insecticide applications on populations of many of the predaceous and parasitic insects in alfalfa fields should also be undertaken.

Insect Pollinators 2/

2/ In Utah these studies are being carried on primarily by the U. S. Department of Agriculture, Legume Seed Research Laboratory, at Logan. Honey bee investigations are carried on by F. E. Todd and W. P. Nye, wild bee investigations by G. E. Bohart, and the relation of the plants to pollinators by M. W. Pedersen.

In Utah and southern Idaho bees are the only effective cross-pollinators of alfalfa. Blister beetles (Meloidae) and sand wasps (Bembicidae) have been seen to trip blossoms, but in these instances cross-pollination may not have been effected. East of the Rockies in scattered localities effective pollination by the soldier beetle (Chauliognathus) has been reported, and at various localities, mostly southern, a genus of scoliid wasps (Campsomeris) has been reported as a scarce but fairly efficient pollinator.

About 50 species of bees have been found to visit alfalfa in Utah and southern Idaho. Only about 20 of them are considered either actually or potentially significant in the production of seed crops. Numerous species of very small bees, such as Hylaeus and the smaller Halictus, are not considered to be important, because they visit only flowers already tripped. When these flowers have already been cross-pollinated, no advantage is to be gained by the additional visits. The possibility remains, however, that mechanically tripped flowers may be cross-pollinated by these bees. Other bees, such as Agapostemon spp. and Melissodes spp., are of little importance, because the males, although often abundant on alfalfa, trip few flowers and the females are rarely seen on alfalfa.

Of the wild pollinators, bumble bees (Bombus spp.), leaf-cutter bees (Megachile spp.), and alkali bees (Nomia melanderi Ckll.) have been the most consistently present in significant numbers.

Honey bees (Mostly from commercial hives) have been by far the most abundant pollinators in nearly all fields observed.

Pollination by Honey Bees

Honey bees generally collect nectar and pollen in separate field trips and thus may be classified as nectar collectors or pollen collectors. Nectar collectors usually take nectar by entering the flower from the side without tripping it. However, they trip a variable, but usually small, percentage (commonly from 0.5 to 2 percent) of the flowers visited. Under certain conditions this rate is radically increased. Pollen collectors enter the blossom through the throat and nearly always trip it. In some fields they may visit a number of flowers in succession for nectar but confine most of their visits to pollen-collecting.

In some areas, as for example certain fields in Millard County, Utah, pollen collectors may represent 20 percent of the total honey bee population in the field, but in most of the northern Utah and southern Idaho areas this percentage is much smaller, usually less than 1 percent.

Competition from flowers more attractive than alfalfa as a pollen source is generally considered to be the reason for the rarity of pollen-collecting from alfalfa. In Cache Valley, Utah, and farther north, gumweed, sweetclover, mustard, corn, goldenrod, and aster are common sources of pollen. In central Utah pollens of greasewood, <u>Iva</u>, <u>Dondia</u>, salt grass, and sunflower are usually collected along with alfalfa pollen. Scattered stands of corn and gumweed also compete as a source of pollen in this area. At Delta as much alfalfa pollen is collected in small seed areas surrounded by wild competitors as in the center of large acreages of clean alfalfa.

Why do honey bees collect alfalfa pollen so readily at Delta in spite of the presence of many competing pollens? Perhaps the competitors are about on a par with alfalfa in attractiveness, or perhaps the alfalfa pollen itself is more attractive at Delta than it is farther north. Weed eradication for a 1-mile radius around an apiary in Cache Valley apparently failed to effect a significant increase in the amount of alfalfa pollen collected. Therefore, competition is apparently not the only factor involved in the difference between Delta and Cache Valley areas. That competition is the ultimate factor, however, has been demonstrated this year in Cache Valley, where 75 percent of foraging bees continuously confined to caged plots of alfalfa became pollen collectors.

The significance of the foregoing discussion may be pointed up by the following questions and answers:

1. Can nectar-collecting honey bees alone give adequate pollination?

   <u>Answer</u>: Yes, provided that the field is supplied with as many bees as it has nectar for, and that it is kept in good condition for the long period such pollination requires.

2. What are the principal advantages of pollination by pollen collectors?

Answer:

(a) Fewer bees are required.
(b) The time required for protection from drouth and injurious insects is shorter.
(c) Plants mature more evenly. There is generally less lodging and regrowth.
(d) There may be less danger of frost damage to late crops. However, early pollination may not advance the date of seed maturity.
(e) With less blossom drop there is likely to be more ultimate set of pods.

3. What can be done to increase tripping by nectar collectors?

Answer: No answers have appeared. However, the following observations are suggestive:

(a) Flowers which have been protected from bees increase the supply and sugar concentration of their nectar. Upon subsequent exposure they attract more bees and the tripping rate is somewhat higher than before the protection period.
(b) Tripping is sometimes greatest close to the hives.
(c) Tripping is often greatest at the beginning and at the end of the flowering season.
(d) Some varieties of alfalfa attract more nectar collectors than others, but "easy-tripping" varieties do not seem to get increased cross-pollination.

4. What can be done to increase the proportion of pollen collectors?

Answer: No definite answer has appeared, but the following thoughts may be pertinent:

(a) Elimination of competing pollen sources would have to be complete and far-reaching.
(b) In some areas bloom could be timed with periods of competitor scarcity.
(c) Some evidence that the alfalfa pollen itself may vary in attractiveness to bees suggests possibilities of altering its properties by agronomic practices or selective breeding.

The Relation of Beekeeping to Seed Growing

Through a gradual educative process seed growers are coming to realize their need for bees. Beekeepers in turn depend largely upon alfalfa-seed fields for honey production in areas where alfalfa seed is a major crop. Mutual financial benebit is therefore essential, but the burden of creating such a condition rests primarily with the seed grower, since the migratory beekeeper can move elsewhere when his profits disappear.

Seed growers can conduct insecticide programs in such a way as to benefit instead of damage bee colonies and honey yields. DDT, chlordane, benzene hexachloride, parathion, arsenicals, and several other poisons have caused marked damage to bees when applied to alfalfa in bloom. Generally the three most destructive insects, i.e., weevils, Lygus bugs, and grasshoppers, can be controlled before the bloom stage, and with adequate pollination a good crop can be set before additional control is necessary.

There may be an inverse ratio between honey yield and seed yield. In other words, a rapid seed set tends to restrict blooming and should thus tend to limit the honey crop. If this proves to be a valid and generally applicable ratio, some form of subsidization or profit sharing may have to be devised.

Pollination by Wild Bees

Most of the work on pollination by wild bees has concerned the abundance, distribution, and tripping efficiency of the various species. These studies have clearly shown that, although many species are efficient alfalfa pollinators, they cannot be depended upon to appear in effective numbers where and when they are needed. Some of the better pollinators--Megachile, for example--always collect pollen and may trip as many as 40 flowers per minute. On this basis, bee for bee, the wild bees may be 100 to 200 times as effective as nectar-collecting honey bees and 2 or 3 times as effective as pollen-collecting honey bees. It speaks eloquently for wild bee scarcity that, in most areas we have observed, honey bee pollination predominates.

In Utah and southern Idaho about 20 species of wild bees have been found to be sufficiently abundant and efficient as pollinators, at least in certain fields, to increase pollination materially (table 1.) Members of the genera Bombus (bumble bees), Megachile (leafcutter bees), and Nomia (alkali bees) are generally the most important. Osmia seclusa Sandhouse and Halictus rubicundus Christ rank next. It can be seen that each of these bees has its areas and seasons of greatest abundance. Most of them have also fluctuated in abundance from year to year. Consequently, wild bee pollination in a particular field is usually accomplished primarily by one or two species. In a few fields as many as half a dozen species were involved.

Table 1 - Principal wild bee pollinators of alfalfa in Utah and southern Idaho

Species of Bee	Areas where most abundant on Alfalfa	Seasons of greatest abundance on alfalfa
Apidae:		
Bombus mormonorum Franklin	Cache Valley, northward	Late July, August
morrisoni Cresson	All areas	Late July, August
huntii Greene	All areas	Late July, August
occidentalis Greene	Cache Valley, northward	Late July, August
Anthophoridae:		
Anthophora urbana Cresson	Millard County	July
Tetralonia edwardsii Cresson	Cache Valley	June
Melissodes spp.	Scattered areas near virgin country	Early, late July
Megachilidae:		
Megachile perihirta Ckll.	Cache Valley, northward	July, August (esp. Aug)
dentitarsis Sladen	Millard County	July, August
onobrychidis Ckll.	All areas	July, August
texana cleomis Ckll.	Chache Valley, near Downey, Idaho	July
coquilletti Ckll.	Cache Valley	July, August (esp. Aug)
Osmia seclusa Sandhouse	Cache Valley, near Downey, Idaho	June, July
Halictidae:		
Halictus rubicundus Christ	Cache Valley	June, early July
sisymbrii Ckll.	Scattered areas near virgin country	June, early July
Agapostemon cockerelli Crawford	Millard County	June, early July
virescens Fabr.	Cache Valley, southern Idaho	July
Nomia melanderi Ckll.	Flat lands of all major areas	Late July, August (sometimes early July)
Andrenidae:		
Andrena prunorum Ckll.	Cache Valley, near Downey, Idaho	June, early July

How May Alfalfa Seed Fields be Better Supplied with Wild Bees?

The following are some of the obvious lines of approach. Details have not been worked out for accomplishing any of the methods with out species of bees and some of them will be likely to prove impractical with certain species.

1. Grow seed in areas where wild bee species exist in effective numbers. Acreage might need limitation to avoid "spreading the bee population too thin." Avoid destroying natural nesting sites by cultivation and irrigation practices.
2. Time the alfalfa bloom to coincide with maximum wild bee populations.
3. Increase the numbers of wild bees in existing seed-growing areas by the following methods:
   (a) Prepare and maintain ideal nesting sites; stock these sites, if necessary.
   (b) Increase bees for stocking purposes by off-season breeding in the absence of natural enemies.
   (c) Increase the range of valuable species by introducing them to new areas.

When one considers that each species of bee has its own habits and living requirements, and that these have not been carefully studied for any species, it is apparent that any solution to the problem of increasing pollination by wild bees must have many aspects and require considerable time. Consider, for example, Osmia seclusa. This small greenish-black bee is an efficient pollinator of first-crop alfalfa bloom in most parts of Cache Valley. At first it was thought to nest in dense aggregations in certain road cuts, but in 1947 the road-cut bees were found to belong to three other species. Osmia seclusa was identified in the winter of 1947-48, but no literature concerning its habits could be found. Late in June 1948 it was seen to cut small leaf pieces from a genus of mallow (Sphaeralcea) which grew adjacent to an alfalfa field. Careful search in the area revealed one bee entering the nest of a turret-making bee (Diadasia), a pollinator of Sphaeralcea. Of 30 Diadasia burrows examined 6 contained nests of Osmia seclusa. Suggestions for means of increasing this Osmia are at once evident, but following them up with trials would require several seasons of intensive work. Such trials, even if attended with some success, would shed little, if any, light on problems concerning other wild bee pollinators.

The following brief résumés indicate the present status of our studies and some of the lines of attack we have employed:

1. Nomia melanderi: A gregarious species, which nests in moist, flat lowlands.

Blocks of soil containing overwintering larvae were successfully moved from Idaho to Cache Valley, and emergence in the new locality was satisfactory. Individual larvae were also transported in small holes drilled into wood blocks. Good emergence was obtained from a set of holes that were lined and sealed with beeswax.

Attempts to establish new aggregations of the bees in soil of various types in Utah were generally unsuccessful. Addition of various amounts of calcium chloride and sodium chloride to the soil raised the moisture content slightly, but did not attract the bees for nesting purposes. Most of the bees that emerged in the experimental area either disappeared or nested in the small soil blocks from which they emerged.

2. Bumble bees: Colonial species the colonies of which die out in the autumn and are built up each spring by fertilized, overwintered queens.

Fifty-four domiciles of various constructions and containing various nesting materials were placed in the field in the spring to attract queens for colony establishment. Eighteen of the domiciles were accepted by the following species:

Bombus huntii Greene - 9	Bombus fervidus Fabricius - 2
Bombus morrisoni Cresson - 3	Bombus occidentalis Greene - 1
Bombus nevadensis Cresson - 2	Bombus rufocinctus Cresson - 1

About half of the colonies reached maturity and produced males and new queens at the end of the season. The others fell victim to flooding, parasites, vandalism, and death to the queens from unknown causes.

One vigorous colony of Bombus morrisoni was utilized in a large cage to test the attractiveness of various clones of alfalfa. This colony performed perfectly in the cage, responded well to feeding with diluted honey, and produced about 35 queens which were promptly fertilized by males.

3. Megachile (leaf-cutter bees): Solitary bees which line their brood cells with leaf pieces. Some species nest in bettle burrows and other holes in timber.

Slabs of wood drilled with holes of various diameters and depths were set in likely locations in the field to attract these bees for nesting. Although several species known to nest in wood were seen in some of the locations chosen, none of the slabs were utilized by them. Several species of bees of the genus Osmia (but not alfalfa-pollinating species) nested in them readily.

Effect of Insecticides on Wild Bees

Only a few specific tests with insecticides have been made on wild bees. Results from field tests are generally inconclusive because a sufficient number of nests of bees visiting the treated fields cannot be put under observation. Counts of bees in the fields before and after treatment may measure nothing more than repellency of the material.

More complete measurements were made on the toxicity of DDT to Nomia melanderi Ckll. near Delta, Utah, in 1947 and 1948. Although results of this year's test have not yet been analyzed, it can be stated that definite kill was caused by an early morning application of 3 percent DDT dust at the rate of 20 pounds per acre, as indicated by the appearance of dead bees at the nest entrances and by a sudden dropping off of about 15 percent in the number of active nests. Field counts in the tests showed that the DDT, as applied, was less repellent to Nomia than to honey bees.

Bumble bees and leaf-cutter bees are apparently not repelled by DDT, according to field counts made before and after dustings. However, after a sufficient contact period they show the same uncoordinated behavior as honey bees. Consequently, it appears likely that they are even more endangered by dusting operations. In solitary genera such as Megachile, it is also significant that death of a female field bee stops progress on her nest and generally leaves it unprotected.

SOME OF THE OBSERVATIONS OF BEE CULTURE

Columbus, Ohio
A. W. Woodrow

Rather extensive studies have been made of the comparative numbers of the various pollinating insects present in red clover and alsike clover fields during the blossom periods.

In some instances honeybees were the only pollinators present, while at other times bumblebees and solitary bees constituted as much as 18 percent. These figures varied greatly with local conditions but in nearly all instances honeybees greatly predominated and the other pollinators were completely inadequate.

In various red clover fields, periodical averages of from 429 to 1636 bees per acre (WED)* were observed. It has been estimated that 1667 bees per acre (WED), working constantly, can accomplish fall pollination of a good stand of red clover.

Honeybees on red clover blossoms collected nectar as well as pollen when it was available. However, in some locations little nectar could be found and activity was largely confined to pollen collection. The sugar concentration of red clover nectar ranged around 30 percent.

No conclusions have been drawn on the baiting of bees for increased activity on the blossoms.

* Observations by Dr. W. E. Dunham

DDT, chlordan, and benzene hexachloride are very toxic to honeybees that come in contact with them. Chlordan and BHC are several times as poisonous as DDT, although their action is slower and more easily overlooked.

The Relative Effectiveness of the Various Species of Pollinating Insects Observed at Columbus, Ohio, during 1948

John Dean

Species	Number of Individuals	Flowers Visited Total No.	Flowers Visited Per min.	Tripped %	Effective Visitations per minute
Agapostemon sp.	1	8	4.0	50.0	2.0
Apis melifera					
(nectar)	33	1087	15.7	1.1	0.2
(pollen)	0				
Bombus spp.	22	619	21.2	47.2	10.0
Halictus spp.	5	54	5.1	0.0	0.0
Megachile spp.	28	773	16.4	92.9	15.2
Melissodes spp.	1	22	11.0	77.3	8.5
M. bimaculatus	1	9	18.0	66.6	12.0

HARMFUL AND BENEFICIAL INSECTS IN ALFALFA SEED PRODUCTION

Ralph L. Parker
Kansas Agricultural Experiment Station

Insects which occur on alfalfa may be placed in three categories: (1) injurious, (2) beneficial, and (3) neutral, which includes the accidental visitors and species of such small importance that they do not belong properly in either of the first two groups. Injurious insects prevent or retard the normal growth of the plant and reduce seed production. Beneficial insects are those of importance in pollinating the alfalfa flowers.

Injurious Insects

Some of the more important injurious insects which occur annually on alfalfa and are rather widespread are given here in brief outline in a chronological order of their occurrence as follows:

1. The pea aphid, Macrosiphum pisi (Kltb.), is one of the first insects to cause extensive damage to alfalfa fields in the spring. Meteorological conditions are a factor as to whether this insect occurs in outbreak numbers.
2. Lygus plant bugs, of which there are three principal species, Lygus oblineatus (Say), L. hesperus Knight, and L. elisus Van Duzee, are often the most destructive to the buds and flowers of alfalfa. Lygus hesperus and L. elisus are western species while L. oblineatus occurs extensively in the United States and Canada. These insects have two to four generations each year so attain large populations during the late summer.
3. Rapid plant bug, Adelphocoris rapidus (Say), is a less abundant which occurs most abundantly east of the Rocky Mountains during middle and late summer.
4. Alfalfa plant bug, Adelphocoris lineolatus (Goeze) is a comparatively new insect to the United States and has been increasing in numbers from year to year. It was first found in the vicinity of Des Moines, Iowa about twenty years ago and has been spreading from that center. In the vicinity of Manhattan, Kansas for the past two years, this bug has become of considerable importance in alfalfa fields. It attains its largest population during middle and late summer.
5. Potato leafhopper, Empoasca fabae (Harr.), infests alfalfa during the middle and late summer after potatoes have been harvested. In some sections, particularly northern areas, this insect is not as important a pest as it is in the mid-latitude and southern areas.
6. Grasshoppers, several species. These species occur at different times during the growing season but only certain species become abundant during the middle and late summer to cause injury to alfalfa racemes. In some regions, however, grasshoppers are considered the number one pest in alfalfa seed production.
7. Blister beetles, several species. These insects, as a general rule, may appear in large numbers feeding upon the flowers and thus destroying the potential seed crop. Blister beetles rapidly migrate from other crops to alfalfa and are voracious feeders. These insects are most abundant during middle and late summer.
8. Garden webworm, Loxostege similalis (Guen.), beet webworm, L. sticticalis (L.) and alfalfa webworm, L. commixtalis (Wlkr.), may occur together or singly in alfalfa fields and under certain weather conditions rather suddenly during the late summer.

9. Clover-seed chalcid, Bruchophagus gibbus (Boh.), attacks the soft ripening seed during the late summer. Much of the infested seed does not reach the seed bin since the light, empty seeds are blown out with the straw. Serious damage occurs from this insect when both first and second crops of alfalfa are used to produce seed in the same community.

The alfalfa grower, whether he is producing forage or seed, would do well to know the insect situation in alfalfa during the early as well as late season. If the early generations of insects are reduced extensively, then later there may be less injury caused to the plants. In forage production, this would result in greater tonnage of forage since the plant would be growing without being stunted or partially destroyed by insect attack. Insect control in seed production is especially necessary in the pre-bloom stage of the crop. It is especially essential that during seed production the beneficial insects be protected from injury by insecticides applied to control injurious insects. Protection to the beneficial insects is provided by application of insecticides 10 to 7 days previous to the blooming of the alfalfa.

The insecticides used to control these various insects are somewhat varied due to the specificity of the insecticide or the susceptibility of the insect. DDT, however, in 10 percent dust or 4 pounds of 50 percent wettable DDT to 100 gallons of water as a spray will bring about control of many of these injurious insects such as the various plant bugs and leafhoppers.

Early work of the past two decades in the effective control of injurious insects in alfalfa seed production was done in Utah and then in recent years in California, Iowa, Kansas and Nebraska. In several of these states, work is also being done with beneficial insects. In 1946, following the National Alfalfa Improvement Conference, Logan, Utah, there were established two stations with cooperating agencies in the USDA. The two field laboratories established are known as the Legume Seed Production Laboratories, one established at Logan, Utah to study primarily alfalfa and one established at Columbus, Ohio to study alfalfa and red clover. These laboratories include in their work the study of injurious insects and their control as well as beneficial insects in the pollination of legume crops. Agronomic problems in plant improvement and crop production are also a part of the work.

Beneficial Insects.

The beneficial insects which bring about the pollination and tripping of alfalfa belong to the social and solitary groups of the order Hymenoptera. The principal insects involved are leafcutter bees, Megachile brevis (Say), M. perihirta Ckll., M. mendica, M. coquilletti Ckll., M. onobrychidis Ckll.; hairy flower bees, Melissodes spp.; bumblebees, Bombus spp.; soil mining bees, Nomia melanderi Ckll., Calliopsis andreniformis Smith and honey bees, Apis mellifica L..

These beneficial insects primarily visit flowers for pollen and nectar collection. Some of these insects are effective in the tripping of the alfalfa flower whereas others, because of the food collecting habits, do not trip the stamens when gathering nectar. Populations of these insects vary from year to year, depending upon climatic conditions and nesting opportunities. The studies of beneficial insects is being carried on in Utah, California, Nebraska, Kansas and Ohio.

As most biologists and agriculturists realize, legume seed production is a complicated inter-relationship of plants and several groups of bees. Some of the work in connection with the study of beneficial insects is entirely new and entomologists must find out how each species of solitary Hymenopterous insect visiting alfalfa lives and collects food. This part of the work might be stated as being in an entirely new field for the specialist studying legume seed production.

BENEFICIAL AND INJURIOUS INSECT STUDIES IN KANSAS

W. W. Franklin and R. L. Parker
Kansas Agricultural Experiment Station

During July, 1947 observations were made on three plots of DDT dusted Buffalo alfalfa on the Kansas Agricultural Experiment Station Agronomy Farm with the following results: A single dusting of 3 percent DDT gave 90 percent control of the alfalfa plant bug, 92 percent control of rapid plant bug nymphs, 76 percent for rapid plant bug adults, 79 percent for tarnished plant bug nymphs, 57 percent for tarnished plant bug adults, 94 percent for leafhoppers, and no control of garden webworm adults or larvae. A 10 percent DDT dust applied at the same time gave 94 percent control of alfalfa plant bugs, 92 percent for rapid plant bug nymphs, 62 percent for rapid plant bug adults, 97 percent for tarnished plant bug nymphs, 77 percent for tarnished plant bug adults, 98 percent for leafhoppers, and no control for the garden webworm adults or larvae.

The untreated check plot yielded 2.2 bushels of seed to the acre, while the 3 percent DDT plot yielded 4.1 bushels of seed to the acre, an increase of 184 percent, and the 10 percent DDT plot yielded 5.5 bushels of seed to the acre, an increase of 246 percent.

Field observations made during 1945, 1946 and 1947 in the vicinity of Manhattan, Kansas showed that the most efficient pollinator of alfalfa in Kansas was the leafcutter bee, Megachile brevis (Say) which species tripped 98 percent of the florets visited. Three different species of Melissodes; a brown species, a black and white species, and a black species, tripped 51 percent, 50 percent and 47 percent respectively of the florets visited. Bumblebees tripped 34 percent of the florets visited. The most numerous and least efficient pollinator present was the honeybee, which tripped an average of only 4.13 percent of the florets visited. The nectar gathering honeybees tripped 1.18 percent of the florets visited, but the pollen gathering honeybees tripped 64 percent of the florets visited.

The honeybee visited an average of 16.86 alfalfa florets per minute, tripping 0.83 of them. The nectar gathering honeybee visited an average of 17.04 florets per minute, tripping 0.22 of them. The pollen gathering honeybee visited an average of 14.18 florets, tripping 10.13 of them. The bumblebee visited an average of 24.07 alfalfa florets, tripping 8.49 of them. The leafcutter bee, M. brevis, visited 19.22 alfalfa florets per minute, tripping 19.16 of them.

INSECTS AS A FACTOR IN ALFALFA SEED PRODUCTION IN NEBRASKA

C. A. Sooter and E. Hixson

Special work on control of insects affecting alfalfa seed production in Nebraska during the past two years have revealed some interesting data but as yet these are not conclusive enough to warrant overall recommendations. The problem is a complex one and not easily answered with preliminary research. The 1947 season was apparently a good alfalfa seed production year in Nebraska and the 1948 season was not so favorable for seed production, all factors considered. However, the 1948 season studies indicated that considerable seed may be produced even during somewhat unfavorable years if all factors are considered and those that can be controlled are handled properly.

Much heavier lygus bug and grasshopper populations were encountered in 1948 than in 1947, in addition to the weather conditions not being as favorable. The highest lygus bug county in 1947 was an average of 7 per sweep with a 15 inch net. The highest lygus bug population encountered in 1948 was on a check plot where 28 per sweep were taken with a 15 inch net.

Some of the major points of interest from the 1947 investigation were: (1) There were no noticeable increases in plant growth in the treated plots, although a large population of pea aphids were controlled. (2) There was a fair seed set on the first crop. No good quality seed was produced, therefore yield data were not taken. (3) Control of insects in the first crop had no effect on seed yield of the second crop.

(4) Insect control during the second crop growth did reduce the lygus bug population, however there was no significant increase in seed yield. (5) The only important pollinators at the two test plots near Lincoln were wild bees, mostly Megachile species known as leafcutter bees. (6) Honeybees placed within about 250 yards of one of the test plots showed no interest in the alfalfa during full bloom. Competition from clover was a factor early, but during the mid-summer period when clover was not in bloom the honeybees showed no interest.

The 1948 seasons work indicated that dusting on small plot basis is a hazardous procedure when other plots are close by even though the dusting is done during calm weather. It appears that the use of sprays in testing different materials will give a better limitation of the drift affect. The 1948 dusting experiments indicated that drift was probably an important factor in the 1947 studies. Insignificant yield differences on treated plots over untreated plots during the 1947 season was very probably due to dust drift onto check plots.

Techniques for following the insect populations trend in alfalfa experimental plots need refinement. Portions of large fields used as test plots apparently do not give a true picture of controlled situations because of insect population shifts during haying activities. It appears that to obtain a true picture of the situation the work needs to be done on small isolated fields where control of the situation is more certain and there is less chance of surrounding influences. Also this isolation would enable the observer to obtain a better knowledge of the pollinator populations and influences.

INCREASED SEED PRODUCTION IN ALFALFA THROUGH HARMFUL INSECT CONTROL

C. P. Wilsie, Iowa State College

Alfalfa seed production under Iowa conditions has been, until recently at least, a hazardous enterprise. The reasons for this are not difficult to find. First, the climate is not ideal for seed production. Bright, clear, dry weather favors pollinating insect activity as well as proper ripening and favorable harvesting conditions. The normal rainfall in Central Iowa for July is 3.42 inches, for August, 3.70 inches, and for September, 4.28 inches. Secondly, the damage to the growing crop and to the developing buds and flowers, caused by destructive insects, is great. Potato leafhoppers, aphids, grasshoppers, alfalfa plant bugs and several species of Lygus all help to prevent the realization of a good seed crop. A third limiting factor, at times, is a lack of pollinating insects.

Beginning in 1945, following the lead of the U.S.D.A. and state workers in Utah, efforts were made to increase seed production by controlling some of the destructive insects with DDT and other new insecticides. Initial experiments were begun through the joint efforts of the Departments of Agronomy and Entomology and Economic Zoology with the Agricultural Engineers being brought into the picture the following year.

Promising results were obtained in 1945 using four varieties, Ranger, Buffalo, Cossack and Ladak, seed yields up to two bushels per acre being obtained. Weaknesses of the small plot technique, so useful for much of our agronomic work, were soon apparent, due to drift of the insecticides and migration of insects from plot to plot.

In 1946 a cooperative experiment conducted by the Departments of Agronomy, Entomology and Economic Zoology, and Agricultural Engineering was established on the Agricultural Engineering Research Farm in a 13-acre field of alfalfa. The first crop was harvested for hay the last of June. Plots of approximately one fourth acre in size with six replicates, were used for the seed production trial. Treatment consisted of two sprays, the first applied July 20, using approximately 1 pound of DDT per acre in 100 gallons of water, and the second applied August 6, using two to three pounds of DDT per acre in 150 gallons of water. As an average of six replicates, the yield of recleaned seed from the treated areas was 77.5 pounds per acre, while that from the acres not treated was 14.1 pounds per acre. The percent of plump seed in thresher run was 77.5 for the sprayed areas and 31.7 for the areas not sprayed.

Forage yield also was increased by the use of DDT by approximately one half ton per acre. Until now, however, it has been considered unsafe or at least not advisable to feed such forage, so spraying has not been recommended for the production of hay..

In 1947 on the Agricultural Engineering Research Farm, 10 acres dusted with 1 pound of DDT per acre (by airplane) produced 215 pounds per acre, while 3 acres not treated produced 50 pounds per acre.

On the Agronomy Farm in 1947 two plots each one half acre in size were dusted, using a ground machine and applying approximately two pounds of DDT per acre just prior to blooming, and two plots of the same size were left without treatment. Seed yields were 243 pounds per acre from the areas dusted and 120 pounds per acre from the areas without treatment. The 1947 season was dry and warm, probably much better than average for seed production in this region. In spite of the favorable season in 1947, however, dusting increased seed production by as much as 100 percent in one experiment and by 400 percent in the other.

Cooperative experiments initiated in 1948 include comparisons of DDT with Chlordane and Toxaphene, the two latter mentioned insecticides being used because of their possible value in reducing grasshopper damage. The grasshopper problem has been serious in many parts of Iowa this season and DDT alone is not effective for their control. Spraying instead of dusting as a method of application is rapidly being adopted in Iowa.

More information is needed with regard to the kinds and populations of insects affecting alfalfa growth and seed setting. The management practices, particularly the time of cutting the first crop, may be of considerable importance. Then too, we need more complete information on the pollinating insects. The principal species doing this job of pollination may vary from place to place, as do the conditions either favorable or unfavorable for the building up of populations adequate for the most effective results. Local areas, particularly favored for seed production, may depend largely upon this factor of an adequate number of pollinating insects.

In summary, it is apparent that the control of harmful insects is a promising means of increasing alfalfa seed production under Iowa conditions.

INSECTS INJURIOUS TO ALFALFA

By F. V. Lieberman, U.S.D.A.
Agr. Res. Adm.
Bureau of Entomology and Plant Quarantine

In the Cache Valley in Utah *Lygus* spp. were not abundant on first crop alfalfa during 1947, but injurious populations occurred during the latter half of the season. The alfalfa weevil, (*Hypera postica* (Gyll)) was extremely abundant on the first crop and severe injury resulted on untreated areas. Economic control of the alfalfa weevil was obtained under the adverse weather conditions existing May 29 to June 19 with twenty pounds of five percent DDT dust per acre. A 20-pound dosage of ten percent DDT did not give enough additional control to justify use of this higher dosage in 1947, but the same dosages applied under different growing conditions during 1948 indicate that the higher dosage is required for effective control. In tests on small plots to evaluate other promising insecticides for control of larvae of the alfalfa weevil during 1947 and again during 1948, chlordane, benzene hexachloride, chlorinateol camphene and parathion were more effective than DDT, or the previously recommended calcium arsenate, considering both the amount of active ingredient per acre applied and percent control obtained.

Observations on the influence of crop dusting upon the overwintering population of the alfalfa weevil parasite (*Bathyplectes curculionis* (Thoms)) seemed to indicate that the reduction in numbers of this parasite corresponds with the effectiveness of the insecticides in killing weevil larvae on first crop seed alfalfa. Further study of disturbances in weevil-parasite relationships in alfalfa treated with the various new insecticides is imperative.

Tests on first crop seed alfalfa at Delta and at Logan during 1948 to compare the effect of two prebloom applications of insecticide with the one standard bud-stage application to control both the alfalfa weevil and Lygus spp. indicate worthwhile improvement in the control of both insects on the slow maturing first crop seed alfalfa on areas where the two treatments were applied. The economic feasibility of multiple-application protection will be determined when records on yields of seed obtained in these tests are available.

INSECTS INJURIOUS TO ALFALFA

By F. W. Poos, U. S. D. A.
Agr. Res. Adm.
Bureau of Entomology and Plant Quarantine

The major insect pest of alfalfa in Maryland during the past two years was the potato leafhopper, (Empoasca fabae(Harris)) which causes losses in quality and quantity of the second and/or third crops during most seasons. Tests at the Agricultural Research Center at Beltsville, in cooperation with the Bureau of Dairy Industry, indicate that one application of 0.5 pound of DDT per acre, in the form of an atomized concentrated emulsion, will give adequate control of heavy populations of this insect in alfalfa of average height and density of growth. Treatments with DDT provide an excellent residual effect against this leafhopper. A minimum of residue will remain on the forage at harvest time if applications are made about midway in the development of the crop. More research is needed before DDT can be recommended on forage that will be fed to dairy animals or animals that are being fattened for slaughter.

The meadow spittlebug, (Philaenus leucophthalmus (L.)) has been very abundant on alfalfa in Maryland during the last three seasons. Preliminary tests against the adults in which twelve formulations, involving seven insecticides, were applied to small areas of third-crop alfalfa with hand equipment gave satisfactory kill in several instances, but the residual effect was inadequate at the concentrations used. Studies on the control of this insect should be directed at the nymphal or immature stages, which develop within the spittle masses on first crop alfalfa. One application of an insecticide may control this spittlebug and also the pea aphid (Macrosiphum pisi (Kltb.)), which occurs abundantly on first-crop alfalfa in Maryland during cool dry seasons.

INSECTS INJURIOUS TO ALFALFA

By Ray T. Everly 1/, U. S. D. A.
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Bureau of Entomology and Plant Quarantine

Among the insects attacking the reproductive structures of the alfalfa plant, the plant bugs Adelphocoris lineolatus (Goeze), A. rapidus (Say), and Lygus oblineatus (Say) were the most important in Ohio during 1947. In northwestern Ohio in many fields which came into bloom in mid-August, these insects reduced the flowering by 75 to 90 percent. In preliminary tests against these pests in which DDT at the rate of two pounds benzene hexachloride (1 pound of gamma isomer), and chlordane at one pound per acre were applied with hand equipment, significant control of these plant bugs was indicated and yields of seed from plots treated with an emulsion of each of these insecticides were from 84 to 100 percent more than from untreated check plots.

The potato leafhopper (Empoasca fabae (Harris)) did not become very abundant in northwestern Ohio until mid-August. Of the insecticides applied against plant bugs, as reported above, DDT was by far the most effective against this leafhopper.

The meadow spittlebug, (Philaenus leucophthalmus (L.)) caused damage to alfalfa at Columbus, Ohio in the spring of 1948. The populations of nymphs averaged 132 per square foot. Tests in which several formulations of insecticides were applied by means of hand equipment indicated that benzene hexachloride at the rate of one pound of gamma isomer per acre, applied as a wettable powder solution or as an emulsion, gave excellent control and appeared to be significantly more effective than the other materials applied in these tests.

GRASSHOPPER CONTROL TESTS IN IRRIGATED ALFALFA IN ARIZONA, 1945 - 1948

By O. L. Barnes, M. H. Frost, Jr., N. J. Nerney, and I. R. Laird, U.S.D.A., Agr. Res. Adm.
Bureau of Entomology and Plant Quarantine

Tests were conducted in plots of alfalfa located in Maricopa County, Arizona. Different toxicants were compared in baits,

1/ Resigned June 30, 1948; now associate in Entomology, Department of Agricultural Extension, Purdue University Lafayette, Indiana dusts and sprays. Melanoplus mexicanus (Sauss.) and M. differentialis (Thos.) were the dominant grasshopper species.

In baits, two quarts of liquid sodium arsenite per 100 pounds of carrier gave slightly higher grasshopper kills than six pounds of sodium fluosilicate, and six pounds of sodium fluosilicate was superior to 4 pounds. Benzene hexachloride containing 0.3 pound of the gamma isomer, chlordane at 0.5 and one pound, and chlorinated camphene at one and two pounds per 100 pounds of carrier gave average kills eleven to seventeen percent higher than was obtained with six pounds of sodium fluosilicate. Results with one pound of parathion and six pounds of sodium fluosilicate were approximately equal. Wet baits and dry baits were equally effective. As a carrier in baits a 1-1 mixture of bran-sawdust was as effective as 3-1 and more effective than 1-3.

In dusts or sprays chlordane at one pound per acre gave grasshopper kills of 90 to 100 percent in green alfalfa during the spring and early summer, but only 27 to 68 percent in sparse or short, dry alfalfa in late summer. One pound of chlorinated camphene was less effective than one pound of chlordane in green alfalfa during the spring. Chlorinated camphene at two pounds per acre gave kills of 93 percent in early June and 78 to 92 percent in August and early September. Kills with benzene hexachloride at 0.3 to 0.4 pound of the gama isomer per acre ranged from 68 to 97 percent; with parathion at 0.4 pound, 83 to 98 percent. Residual effectiveness of chlordane and chlorinated camphene often continued for 5 to 21 days after treatment in green alfalfa during the spring and early summer. Vegetation treated with these new insecticides as dusts or sprays should not be fed to dairy animals or to animals that are being fattened for slaughter, nor should the insecticides be applied to legumes when in bloom.

CONTROL OF HEMIPTEROUS INSECTS IN IRRIGATED ALFALFA GROWN FOR SEED, 1945-1948

U. S. D. A., Agr. Res. Adm.

By E. E. Russell, Bureau of Entomology and Plant Quarantine

Field tests have been conducted on 10- to 40-acre plots with airplane equipment and on 1/4 to 2 1/2 acre plots with ground equipment in the Salt River Valley and adjacent areas in southcentral Arizona, to determine the effectiveness of DDT and other insecticides against mirid and pentatomid plant bugs in seed alfalfa. Important economic species are Lygus hesperus Knight, Chlorochroa sayi Stal., and Euschistus impictiventris Stal., although several other species are also present. The work has been greatly extended through the cooperation of alfalfa growers, the Arizona Agricultural Experiment Station, insecticide manufacturers and distributors, and commercial crop dusting and spraying services.

Lygus spp. were effectively and economically controlled with one treatment of 1.25 pounds of DDT (technical grade) per acre applied to prebloom seed alfalfa. This dosage was effective when applied as 25 pounds of five percent dust or as five gallons of spray, in the form of either an emulsion or a suspension. Crops infested with both Lygus spp. and grasshoppers may be protected by applying one pound of chlordane or 1.5 pounds of chlorinated camphene per acre as dust, emulsion spray, or suspension spray in formulations as indicated for the DDT. Pentatomid bugs have not been abundant enough in seed alfalfa in this area since 1945 to obtain conclusive results on their control with insecticides, but higher dosages than those satisfactory for controlling Lygus spp. and grasshoppers will apparently be required. Vegetation treated with these insecticides should not be fed to dairy animals or to animals that are being fattened for slaughter, nor should the insecticides be applied to legumes when in bloom.

INSECTS INJURIOUS TO ALFALFA

By T. R. Chamberlin and J. T. Medler, U.S.D.A.
Agr. Res. Adm., Bureau of Entomology and Plant Quarantine
Wisconsin Agricultural Experiment Station

In Wisconsin during 1947 populations of the meadow spittlebug (Philaenus leucophthalmus (L.)), were greater than those of the potato leafhopper, (Empoasca fabae (Harris)) the tarnished plant bug, (Lygus oblineatus (Say)) or the alfalfa plant bugs, (Adelphocoris lineolatus (Goeze)) and A. rapidus (Say). All these insects are considered of economic importance on alfalfa, red clover, and Ladino clover in Wisconsin, although the density of the populations of each may vary considerably from year to year or from area to area during each year.

Experiments conducted by the Wisconsin Agricultural Experiment Station (Scholl and Medler 1947) showed that significantly increased yields of alfalfa seed were obtained by one application, in the late-bud stage, of about 40 pounds per acre of five percent DDT dust or a dust mixture containing 2.5 percent of DDT and five percent of sabadilla. Tests along similar lines were conducted by Chamberlin, Medler, and O'Neal during 1947. Single applications of various formulations of insecticides increased seed yields of red clover by 26 to 76 percent and of Ladino clover by 7 to 34 percent. Tests with insecticides against the small nymphs of the meadow spittlebug on alfalfa during 1947 indicated that 5 percent chlordane dust at the rate of twenty pounds per acre was effective. Development of this insect on alfalfa was much retarded by dry weather in the spring of 1948, especially in areas where the deficiency in precipitation was extreme and soils were shallow and of poor moisture-holding capacity.

ALFALFA SEED INVESTIGATIONS IN WISCONSIN

H. E. Thompson

The control of injurious insects is desirable in both first and second growth alfalfa that is saved for seed. The major pests of first growth alfalfa are the spittlebug, alfalfa plant bug and tarnished plant bug. Nineteen forty-eight experiments demonstrated that a practical control of the spittlebug nymphs could be obtained by treatment with chlorinated camphene and chlordane. DDT emulsion also appeared to give control when applied early in the season. DDT in the form of dust, wettable powder, or emulsion has given consistent control of the alfalfa and tarnished plant bug. These insects are controlled also by chlorinated camphene and chlordane.

The potato leafhopper, alfalfa and tarnished plant bug, adult spittlebug, grasshopper and cricket all damage second crop alfalfa. DDT has been the recommended insecticide for the protection of pre-bloom alfalfa. When grasshoppers and crickets are present chlordane and chlorinated camphene should be used to control these pests.

DDT and chlordane are applied at the rate of one pound technical toxicant per acre when used in sprays, $1\frac{1}{2}$ pounds of chlordane and two pounds of DDT per acre when used as dusts. Chlorinated camphene is applied at a 50 percent greater dosage than the above.

Results of experiments since 1945 have shown that increased yields of alfalfa seed are obtained when insecticides are applied. Treatment has been recommended in a pre-bloom stage of growth but our recent observations show that earlier treatment may be desirable.

The control of injurious insects is only a part of obtaining a seed crop. Many fields have been observed where low bug populations were present, yet seed was not obtained. This is due in large part to lack of pollination. Studies in Wisconsin have shown that the honey bee is not to be relied upon for pollination of alfalfa. A small percentage of honey bees have been observed pollinating alfalfa under certain conditions, but most honey bees we have observed in the fields of Wisconsin appear to be collecting nectar only.

A species of wild bee, Andrena wilkella has been collected commonly in first crop alfalfa and appears to be the major pollinator of that crop. Several species of wild bees are found in second crop alfalfa, principally species in the genus Halictus. A soldier beetle appears to be an important pollinator in the area around Green Bay and Lake Winnebago. Bumble bees are no doubt important, but red clover is a strong competitor. Sweet clover is a competitor of alfalfa for all species of wild bees collected in alfalfa fields.

There is considerable seasonal variation in the production of alfalfa seed. This variation has commonly been attributed to the affect of the weather upon plant growth. Our observations indicate that the variable seed production is caused more directly by the influence of weather on the populations of injurious and beneficial insects. For example, 1947 had a cold rainy spring and alfalfa had a heavy rank growth in some fields. An abnormally large crop was produced. We observed heavy pollinating activity and a very low population of injurious insects. Second crop seed in 1947 was generally a failure, and this was correlated with high insect populations, and an almost total lack of pollinating activity. Weather conditions in plant growth were not abnormal during this period.

In 1948, the first crop of seed is generally poor except in fields with low Adelphocoris population, or where insecticides were applied. In one field treated with DDT the yield is estimated to be higher than yields obtained in the same field in 1947. The 1948 season has been abnormally dry. We have concluded that alfalfa seed production in Wisconsin generally is not strictly dependent on wet or dry seasons, but is more dependent on the populations of injurious and beneficial insects. In general the second crop has given the lowest yields of seed for the years 1946, 1947 and 1948.

FOUNDATION SEED PROGRAM FOR IMPROVED FORAGE CROPS

M. A. McCall - Assistant Chief of
Bureau of Plant Industry, Soils, and Agricultural Engineering

During the past few years, we in the Department of Agriculture have been gravely concerned by the critical problem involved in building up adequate seed stocks of improved small seeded legumes and grasses for widespread general use on farms. There is no question but that new varieties now available if widely grown would step up the efficiency of our agriculture in a very substantial way. Farmers who have used these varieties are convinced of their values and it seems evident that a great majority of farmers would use them if seed in quantity were available. Unless we can get seed supplies to make this possible there is a serious question as to the justification for continued expenditure of public funds on improvement of these crops.

The new varieties, valuable because of resistance to disease, cold, or other factors, cannot be identified in the seed state. The only presently available system of insuring identity is through "Certification." Amounts of certified seed now produced are woefully inadequate. For example, only a little more than 1,250,000 pounds of "certified" Cumberland and Midland clovers combined were produced in 1947, and less than a million pounds of certified seed of Ranger and Buffalo alfalfas combined are available from the 1947 crop. All of these varieties have been out for some years and by now each should be in general use to the extent of at least 20,000,000 pounds annual seed requirement. As a matter of fact, less than two percent of the legume and grass seed currently produced is of the certified, improved varieties. This is not a happy situation either for the plant breeders or the consumer.

We feel that this problem merits the most earnest consideration by both State and Federal agencies. It involves not only the final stages of research responsibilities, but in an equal degree Extension responsibilities as well. The final measure of success is widespread use on farms which all of us must strive to attain. Because it involves both seed producing and seed using areas clear across the country, the problem can be attacked successfully only on a national basis, all of us joining in a cooperative program for its solution.

One of the most critical stages in developing seed production of these new varieties large enough to meet the country's needs has been the increase and maintenance of foundation seed stocks required to keep up a continued flow of these valuable seed supplies. Demand for the seed in forage producing areas has resulted in draining away early generation seed stocks which should have been used to build up commercial seed acreages. Inability to accumulate foundation seed stocks has been prevented by lack of a feasible plan to organize and finance production and distribution under conditions which insure use of foundation seed for sowing commercial seed acreage and at the same time maintain varietal integrity. This need should not be confused with the problem of seed production as such, which must be solved and which is being attacked by research under way or planned.

In summarizing the purpose of the proposed project, it is intended as only the first step in a greatly expanded seed production program to make possible the most widespread and effective use of improved crop materials in American agriculture. Without foundation seed in quantities greater than ever have been available in the past this cannot be done. In order to serve American agriculture effectively, we must think and operate on a scale infinitely greater than in the past. Seed supplies of these essential crops must be made available in quantity to all channels which supply seed to farmers. We are confident it can be done to the profit of both seed producer and seed user, and on a basis ultimately to pay its own way.

A few minutes ago a telegram was received from Washington indicating that both the Research and Marketing Administration, and the Commodity Credit Corporation have approved the Foundation Seed Project.

The Research and Marketing Act Project carries a small appropriation for our Bureau to enable us to employ a Project Leader with one or two assistants who will be able to spend all their time on Foundation Seed problems.

The Commodity Credit Corporation has approved the Docket which will enable us to purchase Foundation Seed from growers under contracts.

In order to make this program a success, however, every state will have to lend it real support. It is our hope that the men connected with the project together with the State people will work in such an effective way that seed of the improved varieties will be available for early, widespread use.

PRIMARY PLANT INTRODUCTION STATION AT AMES, IOWA

by M. M. Hoover

Several phases of the work of the Primary Plant Introduction Station at Ames, Iowa are very closely related to the objectives of the Alfalfa Improvement Conference. This opportunity to discuss the work of the Primary Introduction Station is appreciated for it permits personal acquaintance with you who are interested in one of our most important forage crops and exchange of information on activities of mutual interest.

The program of the Primary Plant Introduction Station will be discussed in three parts: (1) The organization and objectives of the Division of Plant Exploration and Introduction, (2) Research and Marketing legislation of 1946 as it affects the work of the Division, and (3) Proposed work of the Primary Plant Introduction Station.

The Division of Plant Exploration and Introduction was established in 1898 by the U. S. Department of Agriculture to encourage the introduction of economic and ornamental plants and to centralize such activities for the Federal government. Over 160,000 introductions have passed through the Division since its organization. Some of these introductions have made major contributions to large agricultural areas of the United States, and others have found use mainly as tools of plant breeders. The economic value of this work is reflected in the reports by the Bureau of Agricultural Economics which lists nearly eighty field, fruit and nut, and truck crops with a total estimated annual value of near four billion dollars ($4,000,000,000) with only about ten of the crops native to the United States. All of these crops had their beginning in this country in small quantities of seed or propagating material obtained in plant explorations of the Department of Agriculture by trained specialists searching the four corners of the earth for new trees and plants that may be of value to American agriculture.

The purposes of the Division are the introduction into cultivation of new plant material from all parts of the world, and the preliminary testing of this material for potential use in the agriculture of the United States. Such research as is conducted within the scope of the Division's work is directly related to one or the other of these basic purposes.

Most plant materials introduced from foreign and domestic sources are obtained by exchange, purchase, or correspondence. Organized explorations have accounted for a relatively small amount of the total. However, the most valuable introductions, the wild relatives of our cultivated crops and improved strains and varieties most useful to plant breeders have come from plant explorations organized and directed for a specific purpose.

The Bureau of Entomology and Plant Quarantine performs the inspection and regulatory functions for the Department of Agriculture. Plant materials entering the United States pass from the port of entry into the Inspection House of the U. S. Department of Agriculture. Inspectors of the Bureau of Entomology and Plant Quarantine may (a) order the plants grown in quarantine, (b) provide fumigation, or (c) order the material destroyed if found too badly infected. Specially constructed greenhouses for growing plants in quarantine are maintained at the U. S. Plant Introduction Garden at Glenn Dale, Maryland.

Introduction Gardens are also maintained in Florida, Georgia, and California for placement and initial testing of plant materials that cannot be handled directly by the technical subject matter Bureaus of the Department or by State Experiment Stations.

The Division has a staff of botanists at the Beltsville, Maryland, Headquarters for determining the correct classification and identification of introduced and native plants submitted for naming by the Department of Agriculture or cooperating institutions. A complete inventory of plant introductions is maintained by the Division at Beltsville.

II - Research and Marketing Act of 1946

The Research and Marketing Act of 1946 provides funds under Title I, Section 10b, for the Division of Plant Exploration and Introduction to conduct explorations for new plants and coordinate their subsequent testing on a national scale. From the money made available to the Division, four expeditions were organized during the past year. One went to Mexico to obtain native potatoes and related species, one to Argentina to obtain peanuts, one to India for winter hardy barley and other cereals and a fourth to Turkey for forage grasses and legumes.

The Division in cooperation with the various State Experiment Stations has planned the establishment of Primary Introduction Stations, one in the Northeast, the Northcentral, the West, and the South.

The Division has leadership in the exploration, introduction, placement, and propagation of plant materials and gives assistance in their evaluation and testing. Specialized study and research required to bring these plant materials into general agricultural use are the function of the State Experiment Stations and the subject matter Divisions of the Department. The Division of Plant Exploration and Introduction does not perform this work except for those species that cannot be evaluated by cooperating agencies.

Title I, Section 9b3 of the Research and Marketing Act provides funds to the several states for testing introduced plant material, for cataloging genetic stocks already available and for preserving germ plasm that is deemed essential for plant breeding programs now and in the future.

III. Primary Plant Introduction Station

The North Central Region includes the states of North Dakota, South Dakota, Nebraska, Kansas, Missouri, Iowa, Minnesota, Wisconsin, Michigan, Illinois, Indiana, and Ohio. A technical advisory committee consisting of one representative from each state appointed by the Experiment Station Director, plans the technical program, prepares the annual budget and recommends the work projects for the region.

The Primary Plant Introduction Station has been established at Ames, Iowa, to serve the twelve states of the North Central region. The physical facilities of this station consist of, (1) greenhouse for plant propagation, (2) field acreage for observation and increase of plant materials, (3) Arboretum for placement and study of woody and ornamental species, and (4) storage with temperature and humidity control for preservation of seed stocks.

The Primary Station will have leadership in preparing and keeping current an inventory of plant materials available at the Experiment Stations of the Region. Plant materials and information concerning their performance will be summarized and made available to plant breeders of the several states by the Primary Station. Initial propagation and observation of introduced plant materials obtained by the Division of Plant Exploration and Introduction from foreign and domestic explorations will be conducted at the Primary Station. The central seed storage will serve the needs of all states of the region and contribute directly toward the preservation of superior germ plasm for the use of plant breeders now and in the future.

Arrangements will be made by the Technical Advisory Committee and the interested State Experiment Stations for the propagation and care of plant species that cannot be grown at the Primary Station.

Approximately 750 accessions have been received at the Primary Station. As plant breeders you no doubt have an interest in these introductions, particularly those having potential value for forage use. We hope that this brief statement of the objectives and program of the Primary Station may be of value to your respective breeding programs. As the work of the station develops, we believe there will be many opportunities for exchange of information and plant materials that will be mutually helpful.

Policies for Foundation Clones or Seed Stocks:

The Secretary raised the question regarding the distribution of Foundation Seed Stocks with particular reference to policies for the distribution of clones for hybrid or synthetic alfalfas, stating that such questions might come up before the next National meeting in 1950. After some discussion it was moved, seconded and carried that the Alfalfa Conference empower the Executive Committee to act, with due consideration to the interests of the Alfalfa Improvement group, to handle the problems which may arise in connection with the Foundation Seed Stocks Program, whether it be clones or primary seed.

OFFICERS AND COMMITTEES

The Nominating Committee composed of Dr. Matlock, Chairman, Dr. Aamodt, and Dr. Keim, presented the name of Dr. T. M. Stevenson of Ottawa, Canada to serve as Chairman of the Alfalfa Improvement Conference for the next two years.

Although, Dr. Stevenson said he would rather see someone else serve as Chairman, the motion was seconded and unanimously approved.

In accordance with the motion (seconded and carried) that a Committee be appointed to study the naming of alfalfa genes, to suggest modifications and present a suggested "genetic language" which can be used by all workers. The following committee was named:

Dr. W. M. Myers, Chairman
Dr. S. S. Atwood
Dr. H. M. Tysdal
Dr. E. H. Stanford

It was also suggested that this Committee should contact the standing Committee on this subject of the American Society of Agronomy and possibly the FAC to see if the plan for alfalfa can be set up on the same basis as for other field crops.

After considerable discussion a motion was also made (seconded and carried) that a committee be appointed by the Chairman to study the problem of screening centers to determine where such work is now being done not only in relation to diseases, but also insects and other characteristics of alfalfa, and prepare a suggested program to be made available for discussion and possible adoption at the 1950 meeting of the Conference.

The following Committee was appointed:

Dr. R. G. Henderson, Chairman
Dr. M. W. Cormack
Dr. R. P. Murphy
Dr. F. W. Poos
Dr. H. M. Tysdal

REPORT OF RESOLUTIONS

Be it resolved that the International Alfalfa Improvement Conference express sincerest appreciation to Dr. F. D. Keim, Mr. Hugo Graumann and other members of the Staff of the Nebraska Agricultural Experiment Station who have served as hosts at this eleventh meeting, and who have contributed so much to the success of the Conference and to our individual enjoyment of it.

J. W. Carlson
C. P. Wilsie
W. M. Myers, Chairman

NEXT MEETING

The Executive Committee of the Alfalfa Improvement Conference accepted the invitation of the Canadian Government (see attached letters) to hold their next meeting at Lethbridge, Alta, Canada in 1950.

Mr. Palmer, Superintendent of the Lethbridge Experiment Station gave a cordial invitation to all to attend the meeting at Lethbridge.

Ottawa
March 24, 1947

Dr. H. M. Tysdal
Permanent Secretary, Alfalfa Improvement Conference
Division of Forage Crops and Diseases
Bureau of Plant Industry
United States Department of Agriculture
Beltsville, Maryland
U. S. A.

Dear Dr. Tysdal:

I have pleasure in extending to you, and through you to the Executive and members of the Alfalfa Improvement Conference, a cordial invitation to hold the 1950 meeting of your Conference in Canada.

From time to time a number of our plant breeders have gratefully accepted the kind invitation of your organization to attend meetings of the Alfalfa Improvement Conference in the United States. This has provided an opportunity for useful discussion, and for an exhcange of ideas and of plant breeding material, all of which has been most helpful. Similarly, I believe that the members of your organization might be interested in securing first-hand information on Canadian problems relating to alfalfa production and improvement, and on the methods and procedure employed in our alfalfa breeding programme.

The question of where, in Canada, a meeting of the Conference might be held has been considered at some length. Since many of our major alfalfa breeding problems are in Western Canada, and since much of the breeding work is being conducted there, it is believed that the meeting should be held in the prairie provinces. Furthermore, since there are problems relating to both the irrigated and dryland production of alfalfa it is believed that the most suitable place of meeting would be at the Dominion Experimental Station, Lethbridge, Alberta, where both these conditions are represented.

It is our sincere hope that the Executive and members of the Alfalfa Improvement Conference will do us the honour of accepting our invitation to hold their 1950 meeting at the Dominion Experimental Station, Lethbridge, Alberta.

Early advice as to your decision on this matter would be appreciated.

Yours very truly,

(signed) H. Barton
Deputy Minister

April 9, 1947

Dr. H. Barton
Deputy Minister
Department of Agriculture
Department of Agronomy
Ottawa, Canada

Dear Dr. Barton:

It is indeed a pleasure to report to you that the members of the Executive Committee of the Alfalfa Improvement Conference voted unanimously to accept your kind invitation to hold the meeting of the Alfalfa Improvement Conference at Lethbridge, Alberta in 1950. The exact date of the meeting can be arranged later.

We greatly appreciate the invitation and are certain that the meeting will provide an excellent opportunity for the workers from the two countries to profit by an interchange of information, and to build a better program for the future.

Very sincerely yours,

(Signed) H. M. Tysdal
Principal Agronomist
Permanent Secretary
Alfalfa Improvement Conference

Members of the Executive Committee
of the Alfalfa Improvement Conference

C. O. Grandfield, Chairman - U.S.Department of Agric., Kansas
C. J. Willard of Ohio
C. P. Wilsie of Iowa
R. L. Matlock of Arizona
H. M. Tysdal, Permanent Secretary

CC: T. M. Stevenson

Ottawa
April 15, 1947

Mr. H. M. Tysdal
Principal Agronomist
Permanent Secretary
Alfalfa Improvement Conference
Division of Forage Crops and Diseases
U. S. Department of Agriculture
Washington, D. C.
U. S. A.

Dear Mr. Tysdal:

I have your letter of April 9 and am very glad to know that the members of the Executive Committee of the Alfalfa Improvement Conference have accepted our invitation to hold the meeting of the Alfalfa Improvement Conference at Lethbridge, Alberta, in 1950, the exact date of the meeting to be arranged later.

I am bringing this to the attention of the senior officers of the Department who are particularly interested and I am sure they will be delighted to know the decision of the Executive Committee and will look forward to meeting representatives from the United States at the Alfalfa Improvement Conference.

Yours very truly,

(signed) H. Barton
Deputy Minister

FIELD TOUR OF THE ALFALFA IMPROVEMENT CONFERENCE
AUGUST 20, 1948

COOPERATIVE ALFALFA BREEDING AT THE
NEBRASKA AGRICULTURAL EXPERIMENT STATION

The Program in General

The alfalfa breeding project involves primarily the selection, evaluation, and utilization of promising genotypes. Selected plants are evaluated for general combining ability by testing their polycross progeny for yield, resistance to diseases, cold, and harmful insects, and for any other characters which may contribute toward the general desirability of the breeding material. The uniform observation and advanced nursery tests as conducted by many experiment stations, through the Alfalfa Improvement Conference, greatly facilitate these evaluations. Clonal lines proving superior by the polycross method are tested further for specific combining ability by their performance in single-cross hybrids, seed of which is produced in isolated natural crossing blocks. Superior germ plasm thus isolated may be made available commercially either through synthetic varieties or specific F_1 hybrids. This approach is believed to be theoretically sound, as is evidenced by the progress which has been made, but it is subject to revision as further investigations may warrant.

Nurseries and isolations representing each of the steps in the breeding program will be observed during the field tour. Because of their location, it is impracticable to visit them in the order that potential breeding material is advanced through the program. Therefore the following brief outline has been prepared to aid in visualizing their normal sequence.

Specific Steps of the Program

I. Wilt Epidemic Nursery

Each year from 20,000 to 30,000 seedlings are inoculated by immersion in a water suspension of the wilt organism (inoculum is supplied by Dr. F. R. Jones) and then transplanted into either greenhouse or field wilt tests. In order to assure maximum infection of susceptible plants the transplants are kept growing vigorously by frequent watering and by maintaining a high level of soil fertility, while at the same time the root reserves are held at a low level by frequent clipping.

Material for the wilt nurseries usually traces to the following sources:

A. Open-pollinated seed harvested from old fields, wilt-resistant varieties, and breeding blocks

B. Polycross seed harvested from the various clonal lines included in the polycross nursery

C. Hybrid seed produced from the crosses made for determining specific combining ability

D. Seed from synthetics involving superior clonal lines

E. A limited number of inbred lines

F. Seed from outside sources (supplied from other experiment stations)

G. Plants selected from old fields and alfalfa nurseries

II. Breeding Nursery

All healthy plants discovered through the wilt epidemic tests are space planted into the breeding nursery. At the close of the growing season a maximum of 300 of the most desirable appearing plants in this breeding nursery are selected for the purpose of cloning and further detailed studies.

III. Clonal Observation Nursery

Approximately 30 rooted cuttings from each of the plants transferred from the breeding nursery, and from clones supplied by other experiment stations are transplanted into duplicate rod-row plots in this nursery. Detailed observations are made as to plant type, plant color, habit of growth, vigor, resistance to leaf and stem diseases (especially Pseudopoziza leaf spot and Ascochyta black stem), leaf-hopper resistance, and any other characters of interest.

In addition, approximately 15 rooted cuttings from each clonal line are inoculated with the wilt organism and transplanted into the clonal wilt nursery. Wilt reactions are noted for each entry. Escapes in the original wilt test may thus be identified and discarded.

IV. Polycross Nursery

The 25 to 50 most desirable appearing lines grown in the clonal observation nursery are transplanted into a polycross nursery. A large number of rooted cuttings, approximately 300 of each line, are required to produce the quantities of seed needed for widespread progeny testing. Maximum assurance for the same general random source of pollen for all entries is obtained by using at least 6 or more replications and restricting randomization so that each clone will occur in the vicinity of every other clone somewhere in the nursery.

In addition to again making observations for the same characters studied in the clonal observation nursery, forage and seed yields and percentages of self-fertility are determined for all polycross entries.

To assure preservation of its desirable genotypes, each polycross nursery is maintained until its entries have been evaluated through polycross progeny tests. Genotypes found to be meritorious in the progeny tests which follow, are transferred to the permanent nursery.

V. Progeny Tests

Observation and yield tests of polycrosses, synthetics, and hybrids are established and maintained for two-year periods. Wilt and cold resistance are also determined by means of special controlled tests for the more important material.

VI. Isolation Blocks

Each year from 30 to 60 isolation blocks are established on vacant lots in Lincoln and vicinity. Seed of various single-cross hybrids required for determining specific combining ability, and synthetics involving different combinations of clones is produced in these plantings. Such isolations are also extremely valuable for making combinations intended for technical genetic and breeding studies.

Synthetic strains and single-cross hybrids involving clones of high combining ability, as determined by the polycross method, have generally given satisfactory yields as compared to the standard check varieties. Data for such combinations from two cuttings of hay for 1948 have been summarized and are shown in Tables 1 and 2.

ATTENDANCE RECORD

ARIZONA

Matlock, Robert L.	Agronomy Dept., University Arizona Tucson

CALIFORNIA

DuBois, Francis B.	(Buffalo growers), Woodland
Madsen, M. A.	California
Madson, B.A..	University of California, Davis
Stanford, Ernest H.	Agronomy Department, Agricultural Experiment Station, Davis

CANADA

Bolton, J. L.	Forage Crops Laboratory, Saskatoon, Sask.
Hill, K. W.	Experimental Station, Lethbridge, Alta
McKenzie, R. E.	Experimental Station, Swift Current, Sask.
Olson, P. J.	The University of Manitoba, Winnipeg
Palmer, A. E.	Experimental Station, Lethbridge, Alta
Stevenson, T. M.	Central Experimental Farm Service, Ottawa, Ont.

COLORADO

Brown, K. G.	Agricultural Experiment Station, Fort Collins
Wood, D. R.	Agricultural Experiment Station, Fort Collins

ILLINOIS

Heckendorn, William	American Seed Trade Association, Chicago

INDIANA

Davis, R. L.	Purdue University, LaFayette
Kramer, H. H.	Agronomy Department, Purdue University LaFayette

Mott, G. O.	Agronomy Department, Purdue University, LaFayette
Payne, Kenyon T.	Purdue University, LaFayette
Salama, S. I.	Botany Department, Purdue University, LaFayette

IOWA

Hoover, M. M.	Plant Introduction Station, B.P.I., Ames
McAllister, DeVere R.	Iowa State College, Ames
Sawyer, R. H.	Earl May Seed Co., Shenandoah
Wilsie, C. P.	Agronomy Department, Iowa State College Ames

KANSAS

Brackney, C. T.	Kansas State College, Manhattan
Franklin, W. W.	Kansas State College, Manhattan
Grandfield, C. O.	Agronomy Department, Kansas State College, Manhattan
Myers, H. E.	Agronomy Department, Kansas State College, Manhattan
Nickelson, R. S.	Kansas State College, Manhattan
Parker, R. L.	Entomology Department, Kansas State College, Manhattan

MINNESOTA

Elling, Laddie J.	University of Minnesota, St. Paul (1)
Folsom, Stanley	Twin City Seed Company, Minneapolis
Kernkamp, M. F.	Plant Pathology Division, University of Minnesota, St. Paul (1)
Withey, J. H.	Northrup King Seed Co., Minneapolis

MISSISSIPPI

Carr, Robert B.	Delta Experiment Station, Stoneville

NEBRASKA

Baltenspengen, A.A.	University of Nebraska, Lincoln (1)
Bell, F. J.	University of Nebraska, Lincoln (1)

Brim, Charles A.	University of Nebraska, Lincoln (1)
Gardner, C. O.	University of Nebraska, Lincoln (1)
Graumann, Hugo O.	Agronomy Department, University of Nebraska, Lincoln (1)
Gross, D. L.	Agronomy Department, University of Nebraska, Lincoln (1)
Keim, F. D.	Agronomy Department, University of Nebraska, Lincoln (1)
Kemmitz, Glenn	Bloomfield
Kiesselbach, T. A.	Agronomy Department, University of Nebraska, Lincoln (1)
Larkin, Roger A.	Graduate Student, University of Nebraska, Lincoln (1)
McGill, D. P.	Agronomy Department, University of Nebraska, Lincoln (1)
Newell, L. C.	Agronomy Department, University of Nebraska, Lincoln (1)
Pedersen, Chris	Hardy
Porter, C. R.	Nebraska Crop Improvement Association, Lincoln
Sander, David A.	University of Nebraska, Lincoln (1)
Staten, Raymond D.	University of Nebraska, Lincoln (1)
Stewart, Paul	J. C. Robinson Seed Co., Waterloo
Webster, G. T.	Agronomy Department, University of Nebraska, Lincoln (1)
Wolfe, Henry	University of Nebraska, Lincoln (1)

NEVADA

Smith, O. F.	U.S.D.A. Agricultural Experiment Station, Reno

NEW YORK

Atwood, Sanford S.	Plant Breeding Department, Cornell Univ., Ithaca

Henson, Ralph D.	Eastern States Farmers Exchange, Buffalo
Murphy, R. P.	Plant Breeding Department, Cornell University, Ithaca

NORTH CAROLINA

Hanson, Clarence H.	Bureau of Plant Industry North Carolina State College, Raleigh

NORWAY

Nissen, Oivind	Agricultural College of Norway, Vollebekk

OHIO

Dean Jr., John G.	U.S.D.A. Department of Agronomy, Ohio State University, Columbus 10

OKLAHOMA

Canode, Chester L.	Oklahoma A. & M. University, Stillwater

PENNSYLVANIA

Albrecht, H. R.	Agronomy Department, Pennsylvania State College, State College
Myers, W. M.	U. S. Pasture Research Laboratory, State College

SOUTH DAKOTA

Adams, M. W.	South Dakota State College, Brookings
Ross, J. G.	South Dakota State College, Brookings

TEXAS

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UTAH

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