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# REPORT OF THE TWENTY-NINTH ALFALFA IMPROVEMENT CONFERENCE

July 15-20, 1984
Lethbridge, Alberta, Canada

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Thirtieth North American Alfalfa Improvement Conference to be held
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University of Minnesota
St. Paul, Minnesota

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**TWENTY-NINTH NORTH AMERICAN ALFALFA IMPROVEMENT CONFERENCE**

Program Chairman - R. R. Kalton

Contents

## INTRODUCTION

## SPECIAL ADDRESSES



## ALFALFA DISEASES AND THEIR CONTROL

## ALFALFA NITROGEN FIXATION AND RHIZOBIAL STUDIES



## ALFALFA PRODUCTION, PHYSIOLOGY, MORPHOLOGY AND UTILIZATION



## ALFALFA INSECTS AND NEMATODES (Joint NAAIC and FIWC Session)

## ALFALFA GENETICS, CYTOGENETICS AND TISSUE CULTURE



## ALFALFA BREEDING

# Introduction

The 29th North American Alfalfa Improvement Conference (NAAIC) included three full days of paper and poster sessions, a tour of Agriculture Canada's Lethbridge Experiment Station, and a business meeting. The formal part of the conference was followed by two post-conference tours: 1) alfalfa production and utilization in Alberta and 2) a relaxation tour of scenic southwestern Alberta.

This report includes the opening address by D. G. Dorrell, Director of Lethbridge Experiment Station, and two other special addresses by H. B. McEwen and D. F. Beard. Also included are abstracts of paper and poster sessions, abstracts from scientists not attending the conference, committee reports, and information on distribution of conference reports and membership. Contributing authors and their organizations are responsible for the information they present in this report. Those who wish to reproduce any part of this report should consult the authors.

Some exciting changes occurred during this conference. Because of the large number of volunteer paper presentations, concurrent sessions were held for the first time in the NAAIC's history. Participation in the conference by workers in all disciplines of alfalfa science is continually increasing. This year the Forage Insect Workers' Conference was held concurrently with the NAAIC.

Three particulary important conference items were acted upon at the business meeting:

1) A set of bylaws for the NAAIC were adopted at the business meeting (see p. 140-142). Until this time the conference had operated without bylaws and with only two officers, Chairman and Permanent Secretary. The new bylaws identify four officers - President, Vice-President, Secretary, and Executive Secretary - and define the responsibilites of each.

2) The need for the NAAIC to fund its own mailing and proceedings printing costs was discussed. The NAAIC has been very fortunate to have had the USDA fund these expenses in the past. However, USDA will no longer do this. Therefore, the NAAIC Finance Committee will be formulating plans for covering these expenses (see p. 141).

3) The membership approved a name change for the conference from the National Alfalfa Improvement Conference (NAIC) to the North American Alfalfa Improvement Conference (NAAIC). This name change was considered appropriate to more accurately reflect the true character of the conference membership.

Executive Committee members for the 29th NAAIC were R. R. Kalton, Chairman, Webster City, IA; B. P. Goplen, Saskatoon, Sask.; D. K. Barnes, Permanent Secretary, St. Paul, MN; M. R. Hanna, Local Arrangements, Lethbridge, Alberta; J. B. Moutray, Ames, IA; B. A. Melton, Las Cruces, NM; D. L. Stuteville, Manhattan, KS; D. L. Smith, Woodland, CA; and S. A. Ostazeski, Highland, MD.

Requests for copies of this report should be made to J. H. Elgin, Jr., USDA-ARS, Field Crops Laboratory, Bldg. 001, Rm. 335, BARC-W, Beltsville, MD 20705.

## Joint Meeting of the NAIC and FIWC - Welcoming Address

Dr. D. G. Dorrell, Director
Lethbridge Research Station
Lethbridge, Alberta

Dr. Kalton,

I am pleased to be playing a small role in this joint meeting of the Alfalfa Improvement Conference and the Forage Insect Workers Conference. Especially as it is the 50th Anniversary of the Alfalfa Improvement Conference and the second time that the Conference has been held in Lethbridge. I think 34 years between conferences here is a bit long and I hope that after enjoying our weather and hospitality that you will agree with me.

I must say at the outset, Dr. Kalton, that I am most impressed with your Conference Committee and the local arrangements committee. A program involving 68 papers, 50 sponsors, poster sessions, concurrent sessions, evening sessions, business meetings, and a tour of the Research Station, all in three days, requires superb planning and speaks well of the vitality of both of your organizations. I've watched Mike Hanna and his arrangements committee scheme and plan for the past year and, based on the results so far, I now know whom to turn to for organizational talents.

Ladies and gentlemen, I was not just making polite statements when I mentioned the health of your organizations. It is probably more important than ever to have a strong forum to bring together all facets of your industry.

You are aware I am sure, of the negative factors now affecting forage research in both Canada and the United States. This decade will see the retirement of many key scientists in alfalfa breeding, agronomy, and entomology research. Restraint, re-assignment of resources, and competition from new priorities will mean that many of these positions will be lost or replaced with different disciplines. During times of food surpluses and government preoccupation with deficits, etc., we cannot expect strong public support. Research managers, scientists, and agro-businessmen alike will have to be more imaginative in balancing available resources against the many demands for more research. Some have suggested that we can no longer afford production and agronomic research, especially when conducted by individuals working in isolation. That may be so, but we must retain that portion of production research that leads to greater efficiency and productivity. In all cases, classical approaches to research will have to be balanced against potential opportunities afforded by such areas as somaclonal variation, molecular manipulation of resistance to pathogens and pests, etc., if we are to break away from the small incremental increases that we now expect.

I guess what I am saying is that the natural evolution in research will dictate fewer and larger research teams with several new specialties, probably without the word alfalfa in front. There will be trying but exciting times, and I am confident that both your conferences will continue to play their key roles.

Ladies and gentlemen, I wish you every success at this conference and I hope to see many of you during the week.

# An Address to the National Alfalfa Improvement Conference

H. B. McEwen
Deputy Minister, Alberta Agriculture
Lethbridge, Alberta

It is my real pleasure to speak at this luncheon on the 50th Anniversary of the Alfalfa Improvement Conference which first met at Lincoln, Nebraska in 1934. Alfalfa is an important agricultural crop and hence this is an important conference. I am only sorry that I will not be present on Wednesday when Dr. Beard will review 50 years of progress in alfalfa improvement.

Although national in name, this conference is obviously international with considerable involvement of Canadian alfalfa researchers for many years including, or especially, this year. Also, this is not your first time to meet in Canada as the conference was held at Lethbridge in 1950, at Saskatoon in 1960, and our nation's capital, Ottawa, in 1972.

I am pleased to know that the conference is not just a biennial exchange of research and other information but that much of the work of N.A.I.C. has been accomplished through various continuing or temporary committees. These committees provide coordination and continuity to the objectives and activities of the conference.

Although over-shadowed by oil and gas, agriculture is not just Alberta's number one renewable resource industry but a major contributor to the overall economy of the province. Farm cash receipts of $3.7 billion in 1983 when added to an essentially equal value of the processed food, feed and beverage industries make up an agricultural industry total of over $7 billion - 11-12% of Alberta's gross provincial product. More significantly the food, feed and beverage processors - secondary agriculture - employ more than ¼ million Albertans. These statistics are exclusive of contributions of businesses that supply and service agriculture in the province.

The strength or comparative advantage of agriculture in Alberta are the God-given abundant resources of land, soil and water. Development and management of these resources is a major thrust in Alberta agriculture. Other major functions of the department are 1) the provision of information on which farmers and farm families base technical and business decisions, i.e. research and technology transfer, 2) addition of more value to agriculture in Alberta by the further development of the province's food processing industry and 3) domestic and export marketing assistance.

Approximately 31 M acres of Alberta's land area is improved (cultivated) farm land. Unimproved farm land utilized in agriculture is about 16 M acres with the total area of farms in the province in the order of 47 M acres.

Water is abundant in Alberta, albeit not ideally distributed for agricultural use. Our premier has described water as Alberta's "oil", for primary resources of the future. Between 1.1 and 1.2 M acres is under irrigation here in southern Alberta with the potential of increasing to 2 M acres. Available water, not irrigable land, is the limiting factor.

Irrigation accounts for 4% of the province's arable land on which is produced 12% of the gross value of agricultural production. Major crops are wheat, barley, alfalfa, sugar-beets, potatoes and vegetables.

As stated earlier, Alberta farm cash receipts approach $4 billion. Receipts from livestock and livestock products normally exceed those from crops; however, the difference is usually not greater than $200 million, a reflection on the balance between livestock and grain production in the province. Cattle and calves is the largest livestock segment and wheat, barley and canola dominate crop production. These four commodities account for approximately $3 billion in farm sales annually.

## The Forage Industry in Alberta

Alberta's forage industry is conservatively worth in excess of $600 million on an annual basis, excluding any value which might be added by processing, feeding or transporting forages. Forage production conserves the soil through the reduction of wind and water erosion and by increasing soil organic matter. Also, nitrogen fixation by legumes reduces the fertilizer costs of forages and subsequent crops.

Tame hay has the highest commercial value of forages in Alberta. The provincial crop is estimated at around 3.6 million acres of perennial hay, annually yielding in excess of 5.6 million tons or averaging around 1.6 tons per acre. At an average value of $60 per ton, it is worth $340 million. There are an additional 700,000 acres of cereal silage and greenfeed, bringing the total value of conserved fodder to over $400 million. Approximately 40% of this fodder, over $160 million, is from alfalfa hay. Alfalfa is now mainly grown in pure stands but there are also significant acreages of alfalfa/grass hay mixtures.

Other significant contributors to Alberta's forage industry are pasture and forage seed production. The latter is mainly grown for export markets while pasture is an integral element of the province's cattle industry. While not marketed per se, pasture is generally valued at $11 per animal unit month. Production is estimated at 14.6 million animal unit months of grazing or 6.7 million tons of dry fodder worth over $160 million. Forage seed production is quite variable from year to year but typically ranges from 13,000 to 16,000 tons, valued at around $25 million.

## Forage Seeds

While low in farm value, compared to beef, wheat, barley, canola, dairy and hogs, forage seed production is an integral part of farming in a number of areas of the province. Alfalfa seed is important to southern irrigation farmers while grass and clover seed are significant cash crops for many Peace River farmers. Over 202,835 acres of forage seeds or 56% of the Canadian total were harvested in Alberta in the peak year of 1980. There were 2,107 farms reporting forage seed harvested in that year. Annually, Alberta produces 40% to 50% of the Canadian total.

While a substantial part of the forage seed crop is required to maintain the 7.5 million acres of hay and pasture grown in this province, Alberta has consistently led all provinces in Canada's continuous status as a net exporter of forage seeds. Between 50% and 80% of annual Canadian forage seed production is exported and at least half of this originates in Alberta. An estimated 10,000 to 15,000 tons of forage seeds valued at around $15 million are exported from Alberta annually, mainly to the United States and Europe. Creeping red fescue, alsike clover, single-cut red clover, timothy and bromegrass are Alberta's major exports. The contracting of foreign seeds for multiplication under the O.E.C.D. multiplication scheme is an important adjunct to the province's export marketing efforts. Alberta has a world wide reputation for production of high quality seed stocks at a reasonable cost.

In addition to serving the needs of Alberta users and export markets, Alberta provides significant volumes of forage seeds for users in other parts of Canada, from B.C. through Ontario and Quebec. Alfalfa seed, crested wheat grass, bromegrass, fescue and clovers for ploughdown are significant inputs to forage production in the other provinces.

## Alberta Forage Seed Council

The Alberta Forage Seed Council is a somewhat unique organization in which you may have some interest. It was established by ministerial order in 1978 with terms of reference;

1. to generally encourage and promote the grass and legume seed industry in Alberta.

2. to provide coordination and liaison between growers, processors, merchants and government.

3. to act in an advisory capacity to the minister of agriculture in matters of production, research and marketing.

Membership consisted of six individual producers, a representative of the Canadian Seed Trade Association, a representative of Agriculture Canada, two staff of Alberta Agriculture, a representative of the Canadian Seed Growers Association and a representative of the Alberta Alfalfa Seed Producers Association.

The council has been very beneficial to the industry and to the department these past 6 years. A revised mandate and membership is expected to be announced by the Minister in the near future.

In conclusion let me emphasize how pleased we in the government of Alberta are to participate in this conference and to sponsor this luncheon. However, as the saying goes, there is no free lunch - your cost or penalty has been to listen to me.

I wish you a very successful and productive conference. Thank you.

# Fifty Years of Progress in Alfalfa Improvement

D.F. Beard
W-L Research, Highland, MD

Fifty years and one month ago the first Alfalfa Improvement Conference was held at Lincoln, Nebraska. The second was held the same year in November at Washington, D.C. in conjunction with the American Society of Agronomy meetings. In 1935, an executive committee was named at the Third Conference in St. Paul, Minn., to guide the affairs of the group and plan programs for future conferences. The 5-member committee was to serve a two-year term, except for the permanent secretary who was to continue until replaced. The first executive committee was comprised of:

R.A. Brink, Chairman
T.A. Kiesselbach
H.B. Sprague
D.W. Robertson
H.L. Westover, Perm. Secretary

This committee was succeeded in 1937 by:

H.M. Tysdal
C.J. Willard
E.E. Downs
T.M. Stevenson
H.L. Westover, Perm. Secretary

A few of the discussions and comments offered at Conferences held in the 1930's should be of interest, particularly to newer participants at this 1984 conference, and serve as reference points in measuring 50 years of progress.

A survey of 50 reporting stations in 1934 indicated that 20 had alfalfa research projects under way, as follows:

| Project | No. Stations |
|---|---|
| Wilt (bacterial) | 10 |
| Cold tolerance | 10 |
| Leaf spots | 4 |
| Drought | 3 |
| Leafhopper | 3 |
| Other insects | 2 |
| Pea aphid | 1 |
| Stem blights | 1 |
| Nematodes | 1 |

| Methods Used | No. Stations |
|---|---|
| Selection within selfed lines | 9 |
| Hybridization | 9 |
| Vegetative propagation | 5 |
| Selection in open-pollinated lines and populations | 4 |
| Inheritance studies | 3 |
| Compositing desirable plants | 2 |

| Methods Used (Cont.) | No. Stations |
|---|---|
| Plant to row selection | 2 |
| Sib-combinations | 1 |
| Cytol. studies et. al. | 1 |

| Recommended Varieties | No. Stations |
|---|---|
| Grimm | 27 |
| Kansas common | 13 |
| Northern common | 13 |
| Ladak | 8 |
| Hardigan | 7 |
| Utah common | 6 |
| Hairy Peruvian | 6 |
| Ontario variegated | 6 |
| + 15 others | |

Discussions at these earlier conferences included the following statements.

"There is nothing needed more than to know what to strive for in alfalfa breeding."

"Grimm has had a very wide regional adaptation but now has one serious defect in its susceptibility to wilt. There is danger of having a multiplicity of alfalfa varieties. The ideal would be an alfalfa that would cover the northern and central areas of the U.S. ..."

"There is less alfalfa in the state today than at any time in the last 30 years ... wonder if we have anyone working on alfalfa and just what progress is being made. Compare (alfalfa) with other farm crops of importance. We have wheat varieties superior to those 30 years ago. Corn breeding progress has been made. Over 80% of the oats acreage in the state is now planted to varieties superior to those of 30 years ago."

"When I came to the state in 1906 I was shown fields planted in the 80's ... still in good condition. Today if we hold a field five years we think we have succeeded well. ... In the last 20 years we have had a couple of seasons when the pea aphid has almost completely ruined the alfalfa for the year and in some instances ... the stands lasted only a year or two."

"The same thing is perhaps true of bacterial wilt ... the one factor that is limiting length of stands of alfalfa, thus off-setting much of the improvement that had previously been made through breeding ... improved cultural methods and other things."

One of the first major activities of the NAIC was the development of uniform alfalfa nurseries. A summary report given at the Chicago, Ill. 1937 Conference revealed the following:

| | |
|---|---|
| Number planned | 44 |
| Number reports received | 36 |
| Number sown in spring (S) | 26 |
| Number sown in fall (F) | 10 |

| | | |
|---|---|---|
| Number with good stands | (S) | 11 |
| | (F) | 5 |
| Number with fair stands | (S) | 11 |
| | (F) | 4 |
| Number with poor stands | (S) | 1 |
| | (F) | 1 |
| Number failures | (S) | 3 |

"Seed too limited - one gram not enough; two grams/row was suggested."

"Uniform system of reporting still needed."

"Yields from duplicate rod rows make averaging across stations desirable. To average all tests would be undesirable because we know that a strain which will do well in the north may be inferior in the south and vice versa. Thus some grouping or zoning based upon general adaptation of varieties seems desirable. If someone will tell us where to draw the lines between these regions our problem will be solved."

Two issues were discussed repeatedly at the first 5 or 6 alfalfa improvement conferences: (1) The spreading problem of bacterial wilt and (2) The bottleneck in alfalfa research caused by inadequate supplies of good quality seed for testing and, ultimately, for multiplication of improved varieties.

The size of the NAIC has grown from the 27 who attended the first conference to over 200 at more recent conferences. Regional conferences were organized by 1950 to deal more specifically with problems of regional interest. More disciplines are now represented in the discussions and programs of the NAIC. The research on alfalfa has changed in source of support from 100% public to a mix of public and private, particularly in the areas of varietal development, seed production and market development.

ALFALFA VARIETY RELEASE TRENDS
1962-81 NCAVRB APPROVED

| | 1962-65 | '66-69 | '70-73 | '74-77 | '78-81 |
|---|---|---|---|---|---|
| Number | 24 | 32 | 28 | 42 | 59 |
| % Public | 50 | 34 | 25 | 21 | 10 |
| % Private | 50 | 66 | 75 | 79 | 90 |
| No. Public | 12 | 11 | 7 | 9 | 6 |
| No. Private | 12 | 21 | 21 | 33 | 53 |

As a result of this change, a new and stable alfalfa seed industry has emerged, an industry that has helped to smooth out some of the peaks and valleys in seed supplies of up-to-date, superior varieties.

## Measuring Progress

Paramount to any discussion of 50 years of progress is the yardstick we use to measure that progress. Perhaps one of the best measures is yield, or production per unit of land. Considering total output from the alfalfa hay acreage in the U.S. we see little change in the yield trend during the 1930's and 1940's. The yield per acre fluctuated somewhat from year to year due to weather, although the 5-year averages remained monotonously close to 2.2 tons. However, an unmistakable uptrend in average yield developed in the middle 50's.

| 5-Yr. Period | $\overline{M}$ Acres | T./Acre |
|---|---|---|
| <1951 | 13-21 | 2.2 |
| 1952-56 | 26 | 2.1 |
| 1957-61 | 28 | 2.4 |
| 1962-66 | 29 | 2.5 |
| 1967-71 | 27 | 2.8 |
| 1972-76 | 27 | 2.8 |
| 1977-81 | 27 | 3.1 |

Thus the gain of 0.9 ton/acre from 1950 to 1981 represents a 41% improvement in yield during the last 3 decades.

This upsurge in alfalfa yield followed closely the release, seed production and use of two winter hardy, bacterial wilt resistant varieties - Ranger (1942) and Vernal (1953). Though released 11 years apart, the same level of seed production (4.5 $\overline{M}$ pounds) of these two varieties was achieved within 5 years of each other. The National Foundation Seed Project established in 1949 by the USDA deserves much of the credit for increasing seed supplies of these bacterial wilt resistant varieties. By 1955 over 100,000,000 pounds of certified Ranger had been produced, and certified Vernal seed production reached 6.4 $\overline{M}$ pounds/yr. in 1956. Concurrently with the development of the NFSP was the acceptance of standards for the production of certified seed of winter hardy varieties outside their respective adapted areas of forage use. The combination of adequate Foundation seed and a highly specialized seed industry capable of producing up to 1000 pounds of clean seed to the acre caused a literal explosion in seed supplies of improved varieties in the early 1950's. Parsons and Waterman reported on these major changes in the seed industry at the 1982 Conference.

The movement of certified alfalfa seed production of winter hardy varieties into areas where non-hardy alfalfas were grown for hay did not come easily. From a very small trial acreage in California and Arizona in the late 1940's (mostly Ranger) the production of certified seed of four midwestern and eastern adapted varieties rose to about 60,000,000 pounds in 1957 in California alone. There was considerable skepticism about the performance of alfalfa seed produced in a warm climate for plantings to be used as forage in areas that frequently experience winter injury or winter killing. Some Wisconsin research helped to clear the air. First and second generation seed of "Regional strains" of Ranger, as they were called, were tested at Madison, Wisconsin in 1949-50 for fall dormancy and winter survival. The percent winterkill with first generation seed produced in Montana, Oregon, Idaho and Utah averaged 8%. Five lots from California averaged 12% and four from Arizona averaged 15%.

A few lots of second generation seed from Montana, Utah and Arizona were compared. Winter killing in these seed lots was 6%, 13% and 31%, respectively. Conclusions that recognized the need for further work were stated as follows: "Ranger alfalfa derived from certified California grown seed was a little less winter hardy than that from seed produced farther north, and Ranger derived from certified Arizona grown seed was somewhat less winter hardy than the California grown stocks. There was no evidence of any difference in the wilt resistance of the southern and northern stocks of Ranger alfalfa ... while all regional strains of Ranger alfalfa seem very suitable for hay in the principal alfalfa growing areas in Wisconsin, Northern grown stocks are to be preferred for seed production". From the start of hardy alfalfa variety seed multiplication systems in California and other non-hardy alfalfa areas, certified seed production of Ranger was limited to one generation outside its northern region of adaptation.

Concurrently with the widespread availability and use of seed of several new varieties in the 1950's, interest in better forage production practices increased. Improved management practices enabled research workers to significantly surpass the average yields obtained on farms. Whereas average yields of test plots 30 years ago seldom exceeded 3 to 4 tons per acre, today the yields from many tests average 8 tons or more. Record yields of 10 tons per acre have been reported by several investigators from 4 or 5 harvests a year in areas that formerly were harvested only 2 or 3 times a year. In 10-harvest irrigated areas, yields in excess of 20 tons have been reported.

This yield trend augurs well for the future. Experience with annual crops has shown that average farm yields for a state or region range from 1/3 to 1/2 the yields attained in well-run research tests or by top producers. The germplasm and know-how are now available to double the alfalfa forage yield on farms.

Another measure of progress can be found in the seed required to maintain alfalfa hay acreage. Though many factors have influenced alfalfa seed usage for various purposes over the years, it is significant that annual domestic consumption of alfalfa seed during the 1940's and '50's averaged between 5 and 6 pounds for each acre of hay. This has dropped to a little over 3 pounds during the most recent 5-10 year period, reflecting substantial improvement in seeding successes and longevity of alfalfa stands. Unfortunately, it is a measure, in part, of the trend away from alfalfa-grain crop rotations. It is doubtful, however, that seed requirements to maintain an acre of productive alfalfa would have fallen from the 5-6 pounds 30 years ago to 3+ pounds today without the contributions of alfalfa breeders, pathologists and entomologists in developing pest resistant varieties, and those of crop physiologists, management and soil fertility specialists in developing superior production practices.

Also, outstanding progress has been made in enhancing the dependability of the alfalfa crop. Disaster has not threatened alfalfa production to the extent witnessed in varieties of oats, wheat and soybeans and corn hybrids. Moreover, the germplasm diversity that has been maintained by alfalfa breeders, both public and private, has been sufficient to solve a number of potentially serious problems. An example is provided by the spotted alfalfa aphid flare-up which came as close to being a disaster as anything we have seen in the last fifty years. This pest nearly wiped out the southwestern U.S. alfalfa crop 25 years ago. The variety Lahontan, which had been developed and released for its combined stem nematode and bacterial wilt resistance, was found to have an acceptable level of resistance to the spotted alfalfa aphid (and Phytophthora root rot). Lahontan filled the gap as a spotted aphid resistant variety until additional resistant varieties could be developed for adjacent adaptation areas. With few exceptions, resistant germplasm has been available to meet everchanging demands for resistance to new pests. This plasticity of alfalfa germplasm has not only facilitated modification of the crop in developing good levels of pest resistance, but also in extending the range of adaptation and use (e.g. grazing and creeping rooted types). The trend of alfalfa acreage in Canada and in parts of the U.S. testifies to the broad germplasm resources available to breeders in the development of adapted varieties for new areas of production.

Growth in Hardy Alfalfa Acreage
Canada (Stevenson)

| Year | Acreage |
|---|---|
| 1930 | 744,000 |
| 1940 | 1,032,000 |
| 1950 | 1,547,000 |
| 1980* | 6,000,000 |

*Estimate of D.B. Wilson

Many programs, decisions and organizations have enhanced the progress in alfalfa improvement during the last half century. The National Foundation Seed Project in the U.S. (and Forage Seed Project in Canada) has been mentioned. The National Certified Alfalfa Variety Review Board, Association of Official Seed Certification Agencies, The Certified Alfalfa Seed Council and many others have played their parts - and well.

Hy-Queen, Inc. sponsored by alfalfa seed companies is a story in itself, but too long to relate here. Suffice to say, the honeybee is the major pollinator of alfalfa in a large part of the U.S. seed growing area. Reduced bee activity due to heavy commercial insecticide usage and other mismanagement practices threatened the pollination service required by alfalfa seed producers in the early 1960's. In 1965, nine seed companies underwrote a bee breeding program by the Dadant Co. to develop a superior honeybee for alfalfa pollination. Though discontinued 8 years later, the program was successful in improving both the honeybee and the management practices of beekeepers.

Perhaps the most dramatic gain in alfalfa improvement can be credited to the development of rapid screening techniques, necessary for the isolation of plants with resistance to both disease and insect pests.

At one of the early NAIC conferences when bacterial wilt resistance was being seriously discussed, Dr. R.A. Brink expressed the need for a good method, or screening technique, to develop resistant varieties. Since then, standard test and/or screening procedures have been developed for a dozen or more pests. The following slides illustrate the rapid progress that has been made in developing resistance to two pests - anthracnose and Phytophthora root rot.

Mass Selection for Anthracnose Resistance in Saranac
(Beltsville, MD)

| | Cycle of Selection | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| Score* | 4.1 | 3.6 | 2.0 | 1.7 |

*1=highly resistant, 5=dead

Phytophthora RR Resistance
As % of Agate

| Year | Top 10 WL Cultivars & Exps. |
|---|---|
| 1973 | 40 |
| 1983 | 113 |

Improved and expanded screening techniques have not only provided for the rapid solution of specific problems, but also for the development of multiple pest resistant varieties. Compare, if you will, the known pest resistance of our first bacterial wilt resistant varieties with the situation in 1981 when 5 Verticillium wilt resistant varieties were released after favorable review by The NCAVRB. First, let us define terms as used by the Board.

Pest Resistance Guidelines

| % Resistance* | Rating |
|---|---|
| 0-5 | Susceptible |
| 6-14 | Low resistance |
| 15-30 | Moderate resistance |
| 31-50 | Resistant |
| 51 or more | High resistance |

*Related to known values of approved checks

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Pest Resistance Characteristics of 5 Verticillium
Wilt Resistant Varieties - 1981

| Variety | MPR Characteristics* |
|---|---|
| A | 7 |
| B | 6 |
| C | 6 |
| D | 5 |
| E | 3 |

*With known moderate resistance, or greater

Topping the significance of numerous individual accomplishments in alfalfa improvement has been the fostering of harmonious working relationships among diverse, often competitive, groups and individuals in the interest of collective progress. In the absence of effective cooperation many of the developments that we take for granted would not have been realized. You may think of some projects that met this fate. Through wise and effective leadership, however, the necessary pieces were put together and held together to keep the central theme of alfalfa improvement on target. Much of this credit belongs to the "Permanent" secretaries of this conference, starting with the late H.L. Westover followed by Tysdal, Aamodt, Graumann, Hanson and Barnes. All of these individuals were alfalfa research leaders. With the decentralization and loss of commodity identity within the Agricultural Research Service of the USDA this sequence of leadership is threatened. To insure the continuity and future progress of the Alfalfa Improvement Conference, this situation was given careful consideration at the business meeting this morning and steps were taken to prevent the onset of diapause.

## Susceptibility of Certain Oilseed Crops to Verticillium albo-atrum from Alfalfa

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In Alberta, *Verticillium albo-atrum* was first found in alfalfa seed samples from Southern Alberta in 1978. Intensive province-wide surveys in 1980-83 confirmed that the incidence of Verticillium wilt (VW) in irrigated alfalfa stands used for hay, silage, pasture or seed was on the increase in Southern Alberta.

The fact that VW was widespread and well established in Southern Alberta, prompted scientists working for Alberta Agriculture and Agriculture Canada to undertake various short- and long-term co-operative research projects to study the development, spread, survival and control of VW under Alberta conditions.

Studies on host range of *V. albo-atrum* were initiated to determine type of crops susceptible to *V. albo-atrum* isolates from alfalfa, and should therefore, be omitted from crop rotation recommendations.

Inoculation results, with VW isolate Laws 82-055, showed that soybeans (*Glycine max*), safflower (*Carthamus tinctorius*), flax (*Linum usitalissimum*) and mustard (*Brassica* spp.), are susceptible to this isolate. The pathogen was recovered from inoculated plants.

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## The Use of Histochemical Analysis in Distinguishing Verticillium Wilt Resistant Alfalfa Plants from Tolerant and Susceptible

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There are few known mechanisms of resistance to Verticillium wilt in alfalfa. However, the resistance mechanism responsible for preventing the spread of the pathogen once it reaches the root xylem tissues is thought to be the most reliable (Talboys, 1972). Theoretically, detecting and incorporating this type of resistance into breeding material is relatively simple, but in practice is very difficult. Presently, genetic units conditioning plant responses to Verticillium wilt can be identified and manipulated only when disease symptoms point to their presence. Symptom development is a highly variable phenomenon and can create an inferior selection pressure in a breeding program. The most obvious consequence of this is the instability of the presumed resistance. In our laboratory, further testing of symptomless plants yields a significant number of susceptible plants (in one case about 50%).

Harrison and Beckman (1982) investigated the release of anti-fungal compounds in wilt resistant and wilt susceptible cotton cultivars. They concluded that the pattern of terpenoid aldehyde accumulation and distribution in resistant hosts is distinct and can be used to differentiate resistant plants from susceptible. In this study, a similar approach was used to investigate the pattern of phenolic compound accumulation and distribution in alfalfa. Phenolic compounds were shown by Khan and Milton (1975) to be important in the defence mechanisms of alfalfa.

Resistant and susceptible alfalfa clones used in this study were selected from North American and European cultivars. The results indicate that the rate of phenolic compound production and distribution in response to Verticillium infection is unique in resistant clones and can be used in reducing the number of escapes essential to breeding for resistance. Furthermore, these compounds appear to be genetically inherited. In addition to this work the initial and long term colonization pattern among selected clones was investigated. During the first two weeks the colonization intensity is only slightly lower in resistant clones compared to tolerant and susceptible. However, in the long term colonization dropped to near zero in the resistant clones while it remained high in tolerant. Therefore, long term colonization patterns can be used as criteria for distinguishing resistant clones from tolerant.

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# Verticillium Wilt of Alfalfa: Seed-borne Mechanism

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Verticillium wilt, caused by *Verticillium albo-atrum* Rke. & Berth., has become a serious threat to alfalfa production in parts of Western Canada, particularly in irrigated areas in British Columbia and Alberta. The spread of the disease via seed is a particular concern. Treatment of seed with the fungicide thiram has been mandatory in Canada since 1979. The pathogen can be both externally and internally seed-borne (1, 2, 3, 4, 5). Christen (1) demonstrated that the fungus can be carried within tissues of the seed-coat of seeds from artificially-inoculated or naturally-infected plants.

## Seed-borne V. albo-atrum from root-inoculated plants

The mechanism of infection of alfalfa seed by *V. albo-atrum* was investigated in the growth room in root-inoculated plants of the cultivars Vela, Vernal, and Anchor, and a plant of the cross Beaver x Lutèce. Following pollination of flowers on these plants, mature racemes were harvested from 31 stems that showed disease symptoms on leaves. The fungus was detected at the base, near the first raceme, and at the top of all 31 stems. However, its distribution was sporadic in peduncles, pedicels, pods, and seeds, and it was not present in every raceme. The percentage of infected tissues was invariably highest in peduncles and progressively lower in pedicels, pods, and seeds. The frequency of internally-infected seeds ranged from 0 to 4.8%.

## Seed-borne V. albo-atrum from flower-inoculated plants

When the stigmas of healthy plants of Vernal were inoculated with spores of *V. albo-atrum* at the time of flower tripping, infection occurred readily, resulting in a characteristic discoloration of the stigma and upper style. The fungal hyphae were present in the lumina of the parenchyma tissue of the style within 4 to 7 days after inoculation. The pathogen was confined to the style during all stages of seed development: it was not isolated from any of 247 pods with stylar infection, nor from any of the 804 seeds from these pods. However, the pathogen in the remnant style tissue of a mature seed pod was able to ramify and spread onto the pod and onto seed coats if the pod was incubated under humid conditions.

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## Potential for Biological and Chemical Control of Verticillium Wilt of Alfalfa

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Verticillium wilt of alfalfa was detected in New York State for the first time in 1981. In some fields the stands were uneconomical to maintain. By 1983 the disease was widespread, however the number of fields affected was relatively few.

An intensive breeding program is under way to incorporate Verticillium wilt resistance into New York-adapted cultivars. Since resistant cultivars become infected by *Verticillium albo-atrum* (Vaa), selection of strains pathogenic to resistant cultivars may occur. Measures were sought that could be used in combination with resistance to reduce the opportunities for infection and thereby prolong the effectiveness of resistant cultivars.

Dispersal of the pathogen within and between fields appears principally to be via equipment. During harvesting, spores from diseased stems are transferred on the cutter bar to freshly cut stems of healthy plants. The efficacy of several chemicals and biological agents to protect cut stems from infection was investigated as an alternative or complementary measure to resistance.

In growth chamber experiments, Iroquois alfalfa plants were cut 3.0 cm above the crown. The cut stems were inoculated with Vaa, then treated immediately with *Gliocladium roseum*, *Penicillium* sp., *Trichoderma* sp., isolates of bacteria, or a fungicide.

Wilt incidence was reduced by *G. roseum* ($8 \times 10^6$ conidia/ml) up to 4- to 5-fold. Lowering *G. roseum* concentrations to $10^4$ conidia/ml reduced wilt control down to 1.5- to 2.0-fold. Control was not achieved if treatment with *G. roseum* was delayed 2 min or longer or if Vaa concentration was $10^5$conidia/ml or higher. Isolates of *G. roseum* varied in their effectiveness; isolates of *Penicillium* were less effective and isolates of *Trichoderma* and bacteria were ineffective. *G. roseum* was as effective as thiram and two to three times more effective than benomyl, chlorothalonil, or maneb. Control with the fungicides was inconsistent in successive trials whereas control with *G. roseum* was consistent.

# Survival of Verticillium albo-atrum in Alfalfa Tissues Fed to Ruminants or Buried in Manure

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During 1982-83, a study was carried out to determine the survival of *Verticillium albo-atrum* in diseased alfalfa tissues fed to ruminant animals or buried in a manure pack.

## Survival of V. albo-atrum in digestive tracts of sheep

Alfalfa hay naturally infected with *V. albo-atrum* was fed to sheep in metabolism crates. Feces from each sheep were collected and examined for the presence of the pathogen. *V. albo-atrum* was present in feces collected within 2 days after feeding the animals diseased hay. The maximum number of *Verticillium* propagules in each dung ball was 19 and 29 for the experiments in 1982 and 1983, respectively.

The finding that *V. albo-atrum* survives through animal digestive systems poses a serious problem if an alfalfa crop is used for grazing. The animal may eat diseased plants and thus, spread the pathogen within the field, or to other fields if moved, via contaminated feces. Therefore, it is recommended that an alfalfa field infected with Verticillium wilt should not be used for grazing, as the feces may become the main source of inoculum for the development of new infection loci in areas not yet affected.

## Survival of V. albo-atrum in manure

Alfalfa stems naturally infected with *V. albo-atrum* were buried in simulated cow manure packs (indoor experiment) and an actual manure pile (outdoor experiment). These stems were recovered at intervals over 6 weeks and examined for viable *V. albo-atrum* in the tissue. All *V. albo-atrum* in the stems were killed when buried at depths of 10, 30, or 60 cm for one week or longer but survived if the stems were near the surface of the manure pile. In the outdoor experiment, *V. albo-atrum* was viable in 93% of the stems near the surface of the manure pile after six weeks.

When diseased alfalfa is fed to animals, numerous infected stem segments and leaves may remain unconsumed by the animal and be incorporated into a manure pile. This may pose a great danger of introducing *V. albo-atrum* into alfalfa fields through manure application in the field. To avoid this danger, manure must be collected and piled up for at least one week to destroy the pathogen before it is spread in the field. Since *V. albo-atrum* survives well on the surface of the manure pile, the top 10-cm layer must be gathered and buried for another week before spreading in the field.

# Recent Studies at the Ottawa Research Station on Phytophthora megasperma f. sp. medicaginis Causing Phytophthora Root Rot of Alfalfa

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A wide range of pathogenicity was observed on 26 isolates of *Phytophthora megasperma* f. sp. *medicaginis* (*Pmm*) when tested individually on three resistant and three susceptible alfalfa cultivars at the Ottawa Research Station (2). Some isolates were differentiated into a highly pathogenic pathotype characterized by small oogonia (morphologic group 1 (G1)) measuring 20-42 µm in diameter. The remaining less pathogenic isolates have large oogonia (morphologic group 2 (G2)) measuring 43-60 µm in diameter. Furthermore, six isolates (two from G1 and four from G2) were tested individually for their levels of virulence on 15 alfalfa cultivars having varying degrees of Phytophthora root rot resistance. Disease severity stability parameters were studied following Eberhart and Russell's regression technique (1). The isolate X cultivar interaction was caused by differences between the isolates' fitted regression lines. It was clear that the response of G1 was different from that of G2 (3).

At seven temperatures (5,10,15,20,25,30 and 35°C) under *in vitro* conditions, the isolates showed varying growth patterns on pea agar. Data obtained indicate that cardinal temperatures for growth of the two groups are different: G1 has a minimum of 5°C, optimum of 25-30°C, and maximum of 35°C; whereas, G2 has a minimum of less than 5°C, optimum of 20°C, and maximum of 30°C.

Electrophoresis of the soluble proteins from the mycelia of the 26 isolates of *Pmm* was useful in identifying the six most pathogenic isolates, all belonging to G1. These isolates had protein patterns very different from those of the less pathogenic isolates of G2. Thus, the results from the pathogenicity, temperature and electrophoretic studies indicate that *Pmm* should be divided into two distinct species.

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# In Vitro Expression of Disease Resistance in Alfalfa to Colletotrichum trifolii

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Anthracnose of alfalfa is being used as a model system for the development of an *in vitro* disease resistance screening technique. The surface of detached cotyledons of resistant (Saranac AR) and susceptible (Saranac) seedlings were inoculated with conidia of *Colletotrichum trifolii* in petri plates. Inoculations were made either by applying an 8 µl drop containing 5,000 spores or by spraying a volume of liquid containing the same number of spores over the entire leaf surface. After incubation for 10-14 days at 24° C under a 16 hour light period (800 f-c) susceptible cotyledons had degraded and contained abundant acervuli of the fungus. Healthy or hypersensitive responses were considered resistant. The percent resistance for resistant and susceptible cultivars was 60-75% and 3-8%, respectively, which correlate with the seedling responses as inoculated by the conventional spray method in the greenhouse. Inoculation on the detached trifoliolate leaves also yielded a clear separation between the resistant genotypes and the susceptible genotypes. The older leaves became senescent more rapidly after detachment which usually resulted in more severe disease ratings. Callus tissue derived from the resistant and susceptible plants had a more variable reaction to inoculation which may be a function of experimental conditions. These results suggest that an effective *in vitro* disease resistance screen can be developed.

# The Influence of Water Potential on *Colletotrichum trifolii* In vitro and on Anthracnose in Alfalfa

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Plant pathogens as well as their hosts have optimal and minimal ranges of water potential necessary for normal growth and development. An area of recent scientific interest has been the relationship between water stress and host-pathogen interaction. Of particular interest is the possible impairment of plant resistance to disease when environmental factors unfavorable to the host exist. This paper reports information regarding the effects of water potential on the growth of *Colletotrichum trifolii* grown *in vitro* at potentials ranging from 0 to -10.0 MPa and on the development of anthracnose disease in inoculated alfalfa grown in soil columns under stress cycles of 0 to -0.033, 0 to -0.6, and 0 to -1.3 MPa water potential. The fungus was grown on V8 juice agar under 15, 20, 25, and 30 C where the water potential was controlled with KCl or sucrose. Water potential in soil columns was controlled gravimetrically in conjunction with psychrometric measurement, and stress cycles were selected on the basis of fungal growth characteristics as affected by water potential. *Colletotrichum trifolii* was found to grow at potentials as low as -10.0 MPa and optimally at -1.0 to -1.3 MPa for both KCl and sucrose-induced water stress. With sucrose as the osmoticum, however, there was a reduction in spore production at temperatures of 20, 25, and 30 C over the range of water potential for optimum vegetative growth of the fungus. This may have been the result of fungal metabolism of the sugar. As expected, there was a decrease in water uptake with increasing level of plant water stress in each treatment. A reduction in water uptake of 21.1 and 9.9% beyond that of the controls occurred in the inoculated treatments for the low and high stress cycles, respectively. There was no reduction in water uptake in the inoculated medium stress cycle. After the first of two inoculations, plants in the low stress columns showed the greatest wilting (67%), followed by medium (24%) and high (6%) stress. Subsequent to the second inoculation, percent wilt was approximately equal for the low and high stress cycles (30 and 25%). At completion of the study the percent death attributable to inoculation was 82, 46, and 93% for low, medium,and high stress cycles, respectively. Similar results were obtained for percent crown rot on living plants. Decline in total dry matter production as a result of inoculation with *C. trifolii* was greatest for the low and high stress columns (26.6 and 20.6%), with the least reduction in the medium stress (5.1%). There was a similar decline in top/root ratio attributable to inoculation. It appears the effects of anthracnose on alfalfa are related to level of soil moisture availability. Wet or dry extremes seem to increase disease.

# Effects of Harvest Frequency and Soil Fertility on the Development of Crown Rot of Alfalfa and the Implications on a Breeding Program

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Root and crown rot is considered to be a major factor in the decline of older stands of alfalfa (*Medicago sativa* L.). The objectives of this research were to determine whether crown rot is related to components of persistence and productivity and to determine whether its development is affected by various management systems.

'Honeoye' alfalfa was grown in the field (Tioga gravelly loam) under three harvest systems (normal 3-cut, 4-cut, late 3-cut) and three soil fertilization levels (0-30-30[1], 0-150-300, and 0-300-600 #/A $N-P_1O_5-K_2O$). The degree of crown rot, number of plants/$ft^2$, percentage of live plants, and root diameters were determined in the third and fourth production years (1983 and 1984). Forage yield was evaluated in 1983, and plants were scored for vigor after the first harvest in 1984.

Over fertilization levels, crown rot was significantly more severe under the 4-cut system than under the normal 3-cut system. The 4-cut system also showed the highest number of plants/$ft^2$, one of the highest percentages of live plants, and the smallest root diameters in both years. It had the lowest yield in 1983 and ranked intermediate for vigor in 1984.

The normal 3-cut system had the least severe crown rot in both years, had higher yield than the 4-cut system in 1983, and had the most vigorous plants in 1984.

The late 3-cut system showed low to moderate degrees of crown rot, with the lowest percentage of live plants and largest root diameters over both years. Its yield was about equal to the normal 3-cut system in 1983, but it had the least vigorous plants in 1984.

Fertilizer treatments had little or no effect on the traits measured except for a highly significant effect on forage yield in 1983. A slight, but nonsignificant, decrease in crown rot was observed with increasing fertilization levels.

Over all harvest systems and fertilization levels, correlation coefficients between crown rot and the other factors were low in both years, indicating that selection for resistance to crown rot will not strongly influence the other factors. However, under the recommended fertilization level, forage yield was negatively, but not significantly, correlated ($r = -.35$, $N = 24$) with crown rot in 1983. Under this fertilization level in 1984, crown rot was associated with a decrease in plant vigor ($r = .47$, $P = .02$, $N = 24$).

Resistance to crown rot may be desirable if a 4-cut system is to be implemented. Under the recommended fertilization level, resistance may have a significant effect on yield and plant vigor. Increased fertilization may compensate for the possible yield reduction due to crown rot. Field screening may be facilitated by increasing the harvesting frequency and possibly decreasing fertilization levels.

[1]Soil test recommendation.

# The Winter Crown Rot/Snow Mold Complex of Alfalfa in the Peace River region of Alberta and British Columbia

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The crown rot complex is the most serious disease of alfalfa in most parts of Canada. It is the disease component of plant and stand survival. It interacts with host vigor and resistance, with management practices, and pests; it may be primary or secondary to them. The make-up of the complex varies from place to place. Sooner or later it affects all plants not killed by weather or by more epidemic types of diseases or pests.

In northwestern Canada the crown rot complex is primarily a winter one (1,2). The main factors affecting winter survival are host vigor and tolerance, cold stress, crown rot, and desiccation which occurs when there is little snow, frozen ground and relatively warm drying winds. Crown rot is generally severest when there is deep and prolonged snow cover, whereas cold stress at the crown is greatest when there is little or no snow.

The term 'snow mold' is used to refer to plants or patches of plants killed outright in one winter, but the same causal organisms may attack and kill plants over more than one season. There are several low-temperature tolerant fungi involved that may be present singly or in various combinations with each other or with more heat-requiring fungi within a single crown. *Coprinus psychromorbidus*, the Low Temperature Basidiomycete (LTB), is known to be the cause of Winter Crown Rot (3) and is prevalent, but is perhaps less dominant than in southern Alberta. *Plenodomus meliloti* (syn. *Phoma sclerotioides*) causes Brown or Winter Root Rot (4), the only root rot of importance in the region. Evidence is mounting that it is also heavily involved in crown rot and even in disease of lower stems. *Fusarium nivale* (syn. *Gerlachia nivalis*) is also involved in crown rot. The pathogenicity of other *Fusarium* spp. and of other fungi prevalent in the crown has not been established in northern Canada.

Although all 3 of the above pathogens are referred to as snow molds, evidence indicates that *F. nivale* is active mainly in the fall, *P. meliloti* over a broad temperature range, and *C. psychromorbidus* at low temperatures in the crown.

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# Techniques Useful in Disease Studies with Alfalfa

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This paper describes techniques and methods that have been developed and used at the U.S. Regional Pasture Research Laboratory in various investigations of alfalfa diseases.

Foliar disease research and resistance selection is done with plants grown in metal utility carts (500/cart). Inoculation is done in a modular, 9-$m^2$ moist chamber that holds 12 carts. Temperature is maintained by temperature-regulated water that seeps across the chamber floor. No refrigeration is needed and no light is provided during the 48-hr moist period. Fungal spores are applied to the plants either as an aqueous spray or deposited directly from cultures suspended above the plants.

In selection of plants for resistance to root rot, roots are inoculated by placing polyester cloth squares covered with fungal hyphae against severed roots of potted plants in the greenhouse. This reduces escapes, and evaluation can be made 4 weeks later. For other studies into the pathogenicity of cortical rotting fungi, plants are grown in slant-boards, which are tray-like units that contain the plant roots between polyester cloth and provide easy access to the roots. A gnotobiotic version of this growth unit is used for organism-interaction research in which a contaminant-free environment is needed.

Basic studies with wilt pathogens are done using stubble-spray inoculations rather than root soaking, because this is more representative of natural field infection and permits resistance mechanisms in the plants an opportunity to be expressed.

A nutrient solution system of growing plants with roots supported by small, smooth pebbles, is being used to obtain root size-distribution profiles. This permits noninjurious removal of plants for disease and agronomic evaluations and is being used in a system to determine the effect of pathogenic fungi on the fibrous root system of forage legumes.

A system has been developed and used that permits rapid, minimum labor, indexing of plants for virus diseases. Leaf disks are punched from individual plants in the field or greenhouse and placed directly into reaction wells in microtiter plates for enzyme-linked immunosorbent assay (ELISA) of viruses. This system has worked well with BYMV in red clover.

A detailed write-up of the above methods with references is available from the U.S. Regional Pasture Research Laboratory.

# Selecting for Resistance to Alfalfa Sickness

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The term alfalfa sickness refers to poor growth of alfalfa in North and Central Alberta, a condition which was first observed in 1962 on light textured soils (3). Affected plants characteristically show stunted and spindly growth with yellowish necrotic leaves. There are irregular brown lesions on the roots, particularly the lateral roots, followed by a girdling and collapse of the root system. An alfalfa sick field typically contains irregular patches of healthy growth. It has been noted that the sickness develops in young alfalfa stands, particularly in fields which were previously cropped with alfalfa.

The casual factors of alfalfa sickness have not been ellucidated. Investigative studies (3) revealed that the sickness is not related to the nutrient and moisture status of the soil and that it is biological in nature. Darmirgi et al. (1976) isolated and identified *Phytophthora megasperma* as the primary pathogen of alfalfa sickness but *P. megasperma* is not consistently isolated from root lesions of sick plants, therefore this conclusion is incomplete.

In 1978 Faechner and Bolton demonstrated increased resistance to the sickness as a result of three cycles of recurrent selection. Their selection criteria were plant height, dry matter yield and root necrosis, and they obtained a 14 percent reduction in root necrosis, 39 percent increase in plant height which contributed to an 80 percent increase in dry matter yield. Plants selected in this way were used to develop six synthetic strains, four of which were tested in two types of yield trials. The yield of the synthetics is as good if not better than the variety Beaver, with Br-1 being particularly promising.

Current research at the University of Alberta is aimed at improving the crossing system and selection criteria in the breeding program and at establishing the genetic control of plant response to the sickness. A diallel cross analysis of the general and specific combining ability of certain clones is being used to study the underlying genotype of resistant plants. Existing synthetics have been developed by using phenotypic selection of existing resistant clones. Our aim is to produce synthetic strains in which due consideration has been given to plant genotype.

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# Relationship between Levels of Anthracnose Resistance and Performance of Alfalfa Cultivars

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Alfalfa cultivars are frequently rated for resistance to Colletotrichum trifolii, the cause of anthracnose, by the percentage of seedlings which survive a standard assay procedure (1). An objective of our research was to learn how accurately the seedling assay for resistance to anthracnose predicts the field performance of alfalfa cultivars in Wisconsin. Sixty-eight alfalfa cultivars were assayed for resistance by the seedling assay in a greenhouse (six replications). The same cultivars were planted in single rows spaced 76 cm apart and 4 m long at two field locations (four replications). Anthracnose was not observed in the seeding year (1982), but a natural epidemic occurred in the third harvest crop at each location in 1983. The incidence of anthracnose was determined by counting the number of stems which exhibited foliar symptoms of anthracnose within each plot. The cultivars Thor and Vista had the highest incidence of anthracnose with readings of 25 and 24 diseased stems per 3 meters of row, respectively. Disease readings were calculated as a percentage of the readings for Thor. Forage dry matter was determined for 20 of the 68 cultivars. Alfalfa stands were estimated by subjectively determining the percentage of plants which remained in each plot. Stand estimates were made after the third harvest in 1983 and in May, 1984.

The seedling assay accurately predicted the field performance of 55 cultivars, under-rated the field performance of 9 cultivars, and over-rated the field performance of 4 of the 68 cultivars that were evaluated in this study. The relationship of the seedling assay to field reactions was tested by using Pearson's Rank Correlation test. Seedling assays versus disease ratings for field locations 1 and 2 resulted in correlation values of $R = .67$ and $.57$, respectively. Disease measurements correlated well between the field locations ($R = .75$). All rank correlations values were statistically significant ($p = .01$).

Disease incidence was highly correlated with forage yield ($r = -.82$), but did not correlate as well with plant density in the fall and the spring ($r = -.60$ and $r = -.65$; $p = .01$). We estimate that anthracnose reduced forage yields by .2 to .5 tons of dry matter per acre. In addition alfalfa stands depleted 20% more for susceptible cultivars.

We conclude that 20% or greater resistance, as determined by the seedling assay, provides for control of anthracnose in the field. However, cultivars were identified that have less seedling resistance, but relatively lower disease under a natural epidemic of anthracnose. Such cultivars would not be identified by the standard seedling assay. In contrast, higher than expected disease incidence in the field was recorded for Saranac AR, Raidor, Trumpetor, and Vertus based on the high percentages of survival measured by the seedling assay. Currently, we can not explain these results, but we believe it has biological significance because this result occurred at both field locations. The standard seedling assay is an accurate method of predicting performance of alfalfa cultivars against anthracnose in the field. However, enough evidence was found to stress the importance of field evaluations to supplement the seedling assay.

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# Progress in Breeding for Resistance to Crown and Root Rot in Alfalfa

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Crown and root rot of alfalfa caused mainly by *F. oxysporum*, *F. roseum* and *F. solani* is an important factor in reducing yield and persistence of alfalfa stands in eastern Canada and in the northeast USA. None of the cultivars registered in North America have been selected specifically for this disease.

In a first study, twelve alfalfa cultivars were seeded at three locations in the spring of 1978 and evaluated for root rot infection in the fall of 1980. Fifty plants per cultivar were randomly selected from each of the six replicates in each location and scored individually for rot infection (% of diseased tissue) by cutting longitudinally through each crown. Most of the cultivars evaluated showed between 20 and 30% of diseased tissue. The frequency of disease-free plants was less than 1.3% of the plants evaluated.

Concurrently, a phenotypic recurrent selection program for resistance to *Fusarium* root and crown rot was initiated in the laboratory using one isolate of *F. roseum* var *acuminatum* and one isolate of *F. oxysporum* f. sp. *medicaginis*. Two cycles of selection were performed on the cultivars Iroquois, Saranac AR, Angus and Titan for resistance to each *Fusarium* isolate.

In the spring of 1981, the unselected populations (cycle 0) and the populations derived from the two cycles of selection for resistance to each *Fusarium* isolate were seeded in the field (one location) along with other cultivars which had been previously selected under field conditions either for persistence or root rot resistance. Root rot was evaluated in the fall of 1983 by scoring individually 50 plants per population and cultivar from each of the six field test replicates.

Selection for resistance to *Fusarium* root and crown rot in the laboratory was successful in reducing crown and root rot in the field. Both *Fusarium* isolates were equally effective. Generally the same type of response was obtained from selection in the four cultivars. When averaged over populations and *Fusarium* isolates, a constant reduction in the percentage of diseased tissue was observed through each cycle of selection (38.9, 35.6 and 31.6 for cycle 0, 1 and 2, respectively).

The cultivars selected in the field either for persistence under our conditions (indirect selection) or selected specifically for root rot resistance showed the least rot infection. Despite the time required for each cycle of selection, a selection program in the field should be initiated and fully evaluated.

## Inheritance of Resistance to Verticillium Wilt in Vertus Compared to Maris Kabul

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Many alfalfa (*Medicago sativa* L.) breeders have been using European cultivars as sources of resistance to Verticillium wilt (VW), caused by *Verticillium albo-atrum* Reinke & Berth., to develop cultivars adapted to North America. Several scientists have concluded that the inheritance of VW resistance in various germplasm sources is primarily additive. Hartman and Peaden (1) reported that the inheritance was multigenic and additive in 'Vertus', a Flemish type of cultivar from Sweden. Resistance in the English cultivar 'Maris Kabul' was derived from a different source, *M. hemicycla* Grossh. (2). The objective of this research was to determine by both qualitative and quantitative genetic analyses if the inheritance of VW resistance differed in these two cultivars.

Four sets of complete diallels ($S_1$'s, $F_1$'s, and reciprocals) were made within each cultivar, and two sets of Design II's were made by crossing parents from Vertus with those from Maris Kabul. Parents were chosen so that each of the five disease severity classes (1 = no topgrowth symptoms, 5 = dead plant) was represented by a single parent in each diallel set. Plants were grown in a greenhouse for 6 weeks, inoculated ($8 \times 10^6$ conidia/ml suspension) by the bare root-soak method, and incubated at 20C in a growth chamber for 6 to 7 weeks before evaluation for disease severity.

In Maris Kabul, many of the resistant X susceptible crosses had bimodal distributions. Therefore, we developed a model whereby resistance in Classes 1-3 was controlled tetrasomically by a single dominant gene, $VW_1$. Most of the progenies that did not fit the expected segregation ratios had too many plants in Classes 1-3. Also, most of the $S_1$ progenies of the susceptible, Class 5 parents segregated. Therefore, we propose that one or more additive genes as well as the dominant $VW_1$ gene conditions resistance in Maris Kabul. The dominant gene alone probably produces plants in Class 3. The additive genes are required for higher levels of resistance.

In contrast to Maris Kabul, Vertus progeny distributions were all unimodal. Our results support Hartman and Peaden's (1) conclusion that VW resistance in Vertus is conditioned by more than one additive gene.

Segregation patterns of Vertus X Maris Kabul progenies confirmed that the dominant $VW_1$ gene is present only in Maris Kabul. In the diallels, GCA effects were more important than SCA effects in both cultivars. However, SCA effects were four-fold more important in Maris Kabul than in Vertus, further supporting the dominant gene model in Maris Kabul. We do not know if the additive genes are identical in the two cultivars. Regardless, the dominant $VW_1$ gene from Maris Kabul in combination with the additive genes from either cultivar probably would enable the most rapid development of highly resistant cultivars.

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# Analytic Breeding of Alfalfa: Selection and Breeding at the Diploid Level for Resistance to Phytophthora megasperma f. sp. medicaginis

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Analytic breeding was first proposed by Chase (2) as an alternate approach to breeding of the potato. The technique involves ploidy reduction of an autopolyploid to the diploid level, selection and breeding at the diploid level, and repolyploidization. Although originally proposed for the potato, analytic breeding is readily applicable to autotetraploid alfalfa (1). In this research, we have demonstrated the feasibility of analytic breeding for disease resistance in alfalfa.

Genes for resistance to *Phytophthora megasperma* f. sp. *medicaginis* (Pmm) were transferred from the tetraploid (2n=4x=32) plant MsR-193 to the diploid (2n=2x=16) level by the use of a triploid bridge. Forty-six derived diploid progeny were generated. Inheritance of resistance to Pmm was studied in five derived diploids. Two different modes of inheritance were found: resistance conditioned by a dominant allele at both of two independently segregating complementary loci.

Diploid *Medicago falcata* was also evaluated for resistance to Pmm. Resistance was conditioned by a dominant allele at either of two independently segregating loci. Crosses were made between resistant *M. falcata* plants and derived diploids of *M. sativa*. Resistance in the progeny was conditioned by a dominant allele at three, possibly four, independently segregating loci. Therefore, resistance to Pmm in *M. falcata* is inherited independently of the loci conditioning resistance to Pmm in *M. sativa*.

Tetraploidization of resistant 2x germplasm was achieved by direct 2x-4x crosses, using an anthracnose-resistant 4x pollen parent. Flower color and anthracnose resistance are being used to identify tetraploid progeny.

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# Ineffective Root Nodules of Alfalfa: A Model System to Study Host-Microbe Compatibility

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The development of an effective $N_2$-fixing symbiosis involves complex specific interactions between the host plant and Rhizobium symbiont (2). Alterations in the environment and in either the host or symbiont genotypes may result in an ineffective association (1, 2). Strains of Rhizobium that induce ineffective nodules on normally effective host plants have been reported for a number of legumes (1, 3). In contrast, relatively few studies have examined plant-determined ineffective nodules and these have been structural studies (1, 3). Comparative histological, physiological, and biochemical studies of plant-determined ineffective nodules offer potential for understanding the molecular basis for symbiotic effectiveness.

Rhizobium - legume systems that result in ineffective nodules may be similar to plant diseases (3). Plant genotypes that condition ineffective nodule formation could be considered analogous to resistant genotypes, whereas ineffectiveness induced by Rhizobium could be considered analogous to incompatible microbes. The analogies imply a common matrix for studying disease resistance and Rhizobium - legume ineffective nodule formation.

In order to pursue the hypothesis that ineffective nodules are a form of plant disease, we have initiated studies in five areas, these include: 1) how does nodule morphogenesis and bacteroid development of ineffective nodules differ from that of effective nodules; 2) compare and contrast nodule carbon and nitrogen assimilation in effective and ineffective nodules; 3) evaluate specific nodule proteins in ineffective nodules and determine if they are similar to those in effective nodules; 4) determine if low molecular weight inhibitory compounds (phytoalexins) occur in ineffective nodules; and 5) initiate *in vitro* callus cultures from nodules as model systems for studies of microbe-host plant compatibility.

Plant controlled ineffective nodules are of two major phenotypes: 1) normal in exterior morphology and yet are $Fix^-$; and 2) large white tumor-like nodules that are $Fix^-$. In both types peribacteroid membranes are not closely affixed to bacteroids, bacteroid development is incomplete, nodule cells containing bacteroids senesce prematurely, and starch accumulation is enhanced. Compared to wild type nodules, ineffective nodules have reduced protein concentrations and reduced activity for enzymes of carbon and nitrogen assimilation. Tissue cultures were developed from the meristem of tumor-like nodules. These tissue cultures formed fungitoxic compounds in response to inoculation with *Rhizobium meliloti* and *Helminthosporium avena*. Fungitoxic compounds could not be detected consistently in ineffective nodules.

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# Immunological Studies of Rhizobium meliloti

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The inoculation of legume seed to improve crop production provides the opportunity for the selection of *Rhizobium* strains adapted to regional cultivars and environmental conditions. Such strain selection has, on this continent, largely been the province of inoculant product manufacturers who have attempted to provide quality strains on the basis of company experience. Inoculants and strains used in Canada are imported because Canada does not possess an inoculant manufacturing industry. The strains supplied are therefore recommended on the basis of a foreign, largely American, experience. It is unlikely that temperate rhizobial strains will prove to be superior when used with northern cultivars under climatic stress.

Alfalfa is a marginal performer in northern areas of Canada, and was therefore selected as the first legume to be studied intensively in relationship to northern *Rhizobium* strains. Two groups within Agriculture Canada have studied, selected and released for commercial production *Rhizobium meliloti* strains (1, 2). The strains are mass-produced as peat inoculants in the United States and shipped regionally to Canada. These strains are contained in over 90% of the alfalfa inoculant sold in Canada. Immunological techniques to allow for the quality control identification of the Canadian strains in inoculants have been developed, and strain identity tests are now routinely conducted along with viable cell counts on imported alfalfa inoculants. In addition, experience has shown that sufficient antigenic variability exists among *R. meliloti* strains to allow for strain identification of small nodules. This allows for mixed-strain nodulation competition experiments in both laboratory and field environments. Such experiments will allow the selection of further improved northern rhizobial strains.

Work to date has shown the feasibility of rapid immunological analysis of inoculants for quality control purposes (3); has defined the antigenic character of a number of commercial *R. meliloti* strains (4); and has demonstrated the undesirability of mixing regionally developed strains into a single inoculant for national distribution (5). Experiments are presently being conducted to define the effects of temperature and moisture effects of nodulating abilities of *R. meliloti* strains.

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# Effect of Population Crossing on Traits Associated with Nitrogen Fixation

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Strain or population crossing is a plant breeding method shown to be useful in increasing vigor and field performance of alfalfa (2). Barnes et al. (1) suggested that population crosses may be useful in overcoming inbreeding effects associated with breeding for improved nitrogen fixation of alfalfa. Our goal was to evaluate the usefulness of population crossing in a nitrogen fixation breeding program. The objective of this study was to determine the effect of crossing on subpopulations selected for traits associated with increased nitrogen fixation and for high and low levels of two nodule nitrogen assimilating enzymes.

Four subpopulations (BP, SP1, SP2H, and SP2L) obtained within each of six alfalfa germplasms (3) were used as parents of the population crosses. The germplasms were originally chosen because they exhibited good heterotic yield responses when crossed together. The SP1 subpopulation was derived from the base population (BP) in each germplasm by sequential selection for seedling vigor, large shoot, nodule, and root mass, and high acetylene reduction activity (ARA). The SP2H and SP2L subpopulations were developed by bidirectional selection for high and low activities of nodule phosphoenolpyruvate carboxylase (PEPC) and glutamate synthase (GOGAT), respectively, from the SP1 subpopulation. The enzymes PEPC and GOGAT are important in the assimilation of symbiotically fixed nitrogen in alfalfa (3).

Topcrosses were made between the four subpopulations in each of four germplasms to the respective subpopulation in two tester germplasms. The two germplasms were chosen as testers because they had previously undergone selection for traits associated with increased nitrogen fixation. The parents and cross progenies were evaluated under nil-nitrate glasshouse conditions for ARA, PEPC, GOGAT, nodule mass, nodule soluble protein concentration, and shoot, root, and total plant dry weight.

Crosses among the BP subpopulations exhibited significant midparent heterosis for ARA (+24.8%), nodule mass (+18.7%), and shoot (+26.3%) and plant (+22.1%) dry weight. Heterotic responses observed from crossing the base populations were not observed in the same crosses between the more highly selected SP1, SP2H, and SP2L subpopulations. There was essentially no midparent heterosis for nodule PEPC and GOGAT activities and soluble protein concentration for crosses among any of the subpopulations. This suggests that these traits are controlled by additive gene effects. The differences between subpopulations of the parent germplasms for shoot, root, and plant dry weight were diminished by crossing. We concluded that the best exploitation of the heterotic response of population crossing may occur by crossing parental material early in our breeding program, followed by multiple-step selection for traits associated with increased nitrogen fixation.

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# Nitrogenase Activity of Alfalfa Grown Alone at Different Seeding Rates and in Mixtures with Grasses

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In a field experiment, the nitrogenase activity (NA) of five alfalfa cultivars (*Medicago sativa* L.) was assessed in pure stands at seeding rates of 3.0, 6.5 and 13.0 kilograms per hectare, and in mixtures at 6.5 kilograms per hectare with bromegrass (*Bromus inermis* Leyss), timothy (*Phleum pratense* L.) or red fescue (*Festuca rubra* L.). NA was determined by the acetylene reduction assay.

Increasing the seeding rate in pure stands generally decreased the number of nodules per plant and NA. At the lowest seeding rate (3.0 kilograms per hectare), intraspecific competition was reduced and plants had greater top and root weights. These vigorous plants had more effective nodules producing the higher NA.

The greatest number of nodules per plant and the highest NA were obtained on alfalfa grown with red fescue. NA of alfalfa plants grown with timothy or bromegrass did not differ significantly from plants in pure stands at the same seeding rate. It is speculated that the presence of the relatively non-competitive red fescue stimulated NA in alfalfa. The dry matter yield per plant was reduced by 22% and 44% when the seeding rates were increased to 6.5 and 13.0 kilograms per hectare, respectively.

# Preliminary Evaluation of Yield and Nitrate Reductase Activity (NRA) Among Alfalfa Populations Selected for Differences in NRA

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Nitrogen assimilation in legumes is confounded by the ability of the plant to fix atmospheric nitrogen and to reduce soil nitrate (1, 2, 5). The amount of nitrogen derived from either soil sources or the atmosphere is dependent upon the species, the available soil $NO_3^-$ or $NH_4^+$ and the environment (4, 5, 6). It has been reported that red clover (*Trifolium pratense* L.), peas (*Pisum sativum* L.), and soybeans (*Glycine max* L.) derive between 25 to 60% of their total plant nitrogen from fixation (4, 5). In comparison alfalfa (*Medicago sativa* L.) was found to obtain 40 to 70% of total plant nitrogen from fixation (3).

Soil nitrogen is taken up by alfalfa as $NO_3^-$ and assimilated through the enzyme nitrate reductase (2, 3). Nitrate reductase catalyzes the two electron reduction of nitrate to nitrite. We have been interested in learning whether NRA in alfalfa affects forage yield. We have developed two experimental alfalfa populations, one with high rates of NRA and the other with low rates of NRA. We are using these populations and a series of single crosses between clones with high and low NRA rates. Our evaluation is being conducted both under ambient and elevated (100 kg N/ha) soil nitrogen treatments.

Results from only the first harvest are available at this time. Significant differences were observed for NRA and yield among entries selected for high and low NRA. The NRA response to applied N by alfalfas previously selected for high NRA was greater than that for alfalfas selected for low NRA. These preliminary results suggest that NRA activity in alfalfa is under genetic control and that NRA rates appear to be associated with forage yield when tested under elevated levels of soil nitrogen. We are planning to determine if it is possible to select alfalfas that have both high NRA rates and a high potential for increased $N_2$ fixation.

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# The Utilization of Nitrogen from $^{15}N$-Labelled Legume Residues by Barley

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A prime cause of the increased crop production where cereals and corn follow legumes in a rotation is the N returned to the soil system; however, the dynamics of the breakdown of the residues and recovery of the N by succeeding crops has not received extensive study. Unpublished data (1) for Ontario conditions indicate 120 to 140 kg N $ha^{-1}$, measured by dry matter accumulation and N analysis of top and root at plowdown, is returned to the soil system in the year of establishment. Direct estimates of the availability of the N to the succeeding crop is not available. However, field measurements of N response of barley following red clover plowdown credit the legume with supplying 35 to 45 kg N $ha^{-1}$, an empirical estimate of 29 to 32% utilization (2). Studies by Ladd (3) using $^{15}N$-labelled annual medics on wheat in Australia estimated 10 to 40% recovery of legume N in the year following incorporation.

In our studies under greenhouse conditions, increasing the decomposition time of red clover top material in soil from 0 to 16 weeks before planting increased the concentration of legume N from 0.65 to 0.83% in 4-week-old barley. In contrast root material applied on an equal weight per unit area basis increased the concentration of legume N from 0.20 to 0.41% of the dry weight. Recovery of N from the top material increased from 11.4 to 20% after 8 weeks decomposition, remaining constant with further decomposition time. Recovery of N from root material increased from 4.3 to 11.4% after 8 weeks, after which it likewise remained constant.

A comparison was made of root and top material from different types of alfalfa and red clover. Early maturing alfalfa top material, allowed to decompose in soil for 4 weeks prior to planting, provided 0.60% legume N content in 4-week-old barley tops in contrast to 0.39% from medium maturity alfalfa. Alfalfa root material produced barley with an average legume N content of 0.45%. Red clover top material resulted in barley containing 0.34% legume N, whereas single cut red clover root material produced barley with 0.47% legume N in contrast to 0.36% legume N from double cut red clover root material. Analysis of barley roots showed a legume N content ranging from 0.23 to 0.37% and followed the same pattern as shown for the barley tops.

Total recovery of legume N by barley top and root was significantly higher at 38.6% for early alfalfa top material than for all other legume materials. The lowest recovery was 20.6% for single cut red clover. Recovery by the barley tops ranged from 32.2% for early alfalfa top to 16.4% for single cut red clover top in contrast to 6.9% recovery in barley roots from early alfalfa top to 3.86% from single cut red clover top material.

Factors affecting the percentage utilization of legume N from tops and roots were species, type and plant part. The procedure used for producing the $^{15}N$ enriched material and the soil used in evaluation also play significant roles in the measurement of utilization of the legume N.

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## Changes in Alfalfa Root Nodule $CO_2$ Fixation Products as a Result of Shoot Harvest and Nitrate Application

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It is estimated that 30% of the carbon gained through photosynthesis in annual legumes is transported to the nodules for use in nodule function and maintenance. Approximately 60% of that carbon partitioned to the nodules is believed to be lost as respiratory $CO_2$. Recent studies have shown that some of this respired $CO_2$ is recovered in the nodules via a nonphotosynthetic reaction catalyzed by the enzyme phosphoenolpyruvate (PEP) carboxylase. This $CO_2$ uptake by the nodules has been postulated to increase nodule efficiency and to provide an added source of carbon for the assimilation of fixed nitrogen.

Ineffectively nodulated alfalfa displayed substantially lower PEP carboxylase activity than effectively nodulated alfalfa. *In vivo* PEP carboxylase activity was shown to be positively correlated with *in vitro* glutamate synthase (GOGAT) activity and both were shown to be positively correlated with acetylene reduction activity, suggesting a link between $CO_2$ fixation activity and $N_2$ fixation activity. Shoot harvest and nitrate application, treatments that are known to inhibit $N_2$ fixation activity, significantly decreased both *in vivo* $CO_2$ fixation activity and *in vitro* PEP carboxylase activity. The distribution of nonphotosynthetically fixed $^{14}C$ in control (unharvested, ON) nodules was 73% in organic acids (OA) and 27% in amino acids (AA). In contrast, the distribution of $^{14}C$ in nodules from treated plants was more nearly equal.

Shoot harvest and N treatment reduced both the concentration of radioactivity in the xylem sap and the flow rate of the sap. The xylem sap of untreated plants contained 85% and 15% of the total $^{14}C$ recovered in the OA and AA fractions, respectively. In treated plants this distribution was 72% in organic acids and 25% in amino acids. Further analysis revealed a shift in the distribution of radioactivity in the two primary N transport amino acids, aspartate and asparagine. Treatments that reduce $N_2$ fixation concomitantly reduce nodule $CO_2$ fixation and alter the distribution of fixed carbon in both nodules and xylem sap.

The distribution of nonphotosynthetically fixed $^{14}C$ in the amino acid fraction of nodules, xylem sap and denodulated roots of alfalfa were significantly different. The five major radiolabeled amino acids in nodules and denodulated roots of alfalfa were aspartate, asparagine, glutamate, glutamine and alanine. In contrast, the majority of the labeled C in the amino acid fraction of xylem sap was distributed equally between aspartate (40%) and asparagine (36%) with a smaller amount found in glutamine (9%). The label was more equally distributed between the five major labeled amino acids in nodules and roots although in different proportions. Effective nodules contained a greater percentage of their total label in asparagine than did ineffective nodules or denodulated roots. Glutamine was the most prevalently labeled amino acid in roots.

# Predicting Nitrogen Mineralization from Soil-Incorporated Legume Residues

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Crop management on dairy farms often includes rotations of corn with alfalfa or some other legume. Interest in utilizing legumes as a source of "free" nitrogen (N) is expanding in this and other enterprises, because of recent increases in fertilizer N cost and potential problems of fertilizer availability. Accurate prediction of N release and consequent N fertilizer requirement is essential in maximizing N fertilizer use efficiency. The objective of this experiment was to develop regression equations to predict N accumulation in corn following various crops using N application rate, soil mineral N availability, and a N mineralization index as independent variables.

Saranac AR alfalfa, MN root N alfalfa (a high root and crown N synthetic), corn, soybeans, wheat, and fallow plots were established in spring, 1982, at Becker, Rosemount, Lamberton, and Waseca, Minnesota. Subplots of corn received from 0 to 224 kg N/ha. Alfalfa was harvested either 3 times during the season or only once, at 1/10 bloom. Wheat, corn and soybean grain was harvested when ripe. All plots were moldboard plowed in fall, 1982. Soil samples were procured from the plow layer ("surface") and throughout the solum in spring, 1983, and initial exchangeable $NH_4$-N and $NO_3$-N were determined. Surface soil samples were incubated aerobically for 12 weeks with periodic determination of mineralized N. In spring, 1983, corn was sown in all plots, 0 to 224 kg N/ha were applied to subplots, and total N accumulation was measured at physiological maturity. A stepwise regression technique was used with treatment means to produce prediction models for total N based on soil characteristics alone, applied N alone, or a combination of variables.

From 63 to 90% of the variability in total N uptake of unfertilized corn at each location could be accounted for using soil mineral N and aerobically-mineralized N. Over all locations, the best equation was:

$$\text{Total N} = 29.2 - 5.23\ (NH_4\text{-N}) + 7.71\ (NO_3\text{-N}) + 2.51\ (\text{TAE1}) \qquad R^2 = 0.81$$

where Total N was the uptake of N in corn at physiological maturity (kg N/ha), $NH_4$-N and $NO_3$-N were the concentrations of these forms in the plow layer (mg N/kg dry soil), and TAE1 was the cumulative N mineralized after 1 week of aerobic incubation (mg N/kg dry soil). When control and fertilized plots were included in the analysis, from 45 to 77% of the variablity in total N at each location could be accounted for using only N rate as the independent variable. Inclusion of initial soil mineral N and aerobically-mineralized N resulted in equations accounting for 70 to 96% of the variability in total N accumulation in corn. Over all locations, the best equation based on N rate alone was:

$$\text{Total N} = 96.0 + 0.386\ (\text{NR}) \qquad r^2 = 0.58$$

with NR equal to the rate of applied N (kg N/ha), and the best equation based on N rate and soil characteristics was:

$$\text{Total N} = 55.7 - 3.91\ (NH_4\text{-N}) + 4.88\ (NO_3\text{-N}) + 1.85\ (\text{TAE1}) + 0.393\ (\text{NR}) \qquad R^2 = 0.77$$

with variables as described above.

Inclusion of a N mineralization index and readily measured soil mineral values can improve the prediction of total N uptake by corn grown in rotation with other crops. Although prediction of N uptake was relatively good over locations, goodness-of-fit varied by location. Improvements may be achieved by incorporation of other indexes of N mineralization.

# Simultaneous Selection for Forage Yield and Nitrogen Concentration in Alfalfa

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Previous work on nitrogen fixation has focused on the selection of high N2-fixation potential by using the indirect acetylene-reduction assay (Seetin and Barnes 1977; Duhigg et al., 1978). The procedure evaluated plants grown with commercial mixtures of Rhizobium meliloti in the absence of mineral nitrogen. Populations developed by this method showed the desired traits under greenhouse conditions but not under field conditions (Heichel et al., 1981). Phillips et al. (1982) reported an alternative, and more comprehensive, direct selection technique which identified genotypic variants for dry matter production and forage N concentration on both $N_2$-- and $NH_4NO_3$-dependent conditions. Populations produced with that technique were used in the present study.

In the present study, populations were developed from either African or Hairy Peruvian germplasm for high dry matter production and high reduced nitrogen concentration. Plants were grown under greenhouse conditions for 3 harvests. During growth cycles 1 and 2 the plants were dependent on $N_2$ fixation and during harvest 3 plants were dependent on $NH_4NO_3$. Selection was based on forage dry matter production and reduced nitrogen concentration in both 2 and 3 using independent culling levels.

Following two cycles of phenotypic recurrent selection all selections responded in the desired manner under greenhouse conditions. Selections from Hairy Peruvian (HP32) averaged 52% better in forage dry matter production and 5.2% better in forage nitrogen concentration than the parental population. African germplasm (A32) pools averaged 17% and 5.2% better in forage dry matter production and reduced nitrogen concentration, respectively, than the parent.

Encouraging results have been obtained during the seeding year under field conditions at Davis, CA. Dry matter production of HP32, reduced nitrogen concentration of HP32 and total forage nitrogen of both HP32 and A32 was significantly greater than the parental populations.

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# Effect of Alfalfa Foliage and Alfalfa Soil Extracts on Alfalfa Seedling Vigor

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## Plant Extracts

Experiment 1: (Ground Foliage)

To investigate the effect of alfalfa (*Medicago sativa* L.) foliage on seedling vigor a series of replicated laboratory experiments were conducted. Concentrations of ground foliage extracts at 0, 1.25, 1.66, 2.50 and 5.00 g/100 ml water were used. Both percent and rate of germination were reduced at concentrations of alfalfa extract at 1.25 g/100 ml water or greater. The higher the concentration of alfalfa extract the greater reduction on percent germination. Higher reduction in percent germination was observed at 2 or 4 days than at 7 days after the trial was initiated. Germination at 25°C resulted in a greater inhibition from alfalfa extracts than at 20°C on 4th and 7th day observations. Autoclaving the extract also increased the inhibitory effect of the extract on percent germination and growth. Radical and hypocotyl length after 7 days were also reduced by alfalfa extract concentration of 1.66 g/100ml water or greater. Addition of activated carbon at the rate of .5 g/100 ml of alfalfa extract reduced or eliminated the inhibitory effect on rate and percent germination of alfalfa. When activated carbon was added there were no inhibitory effects of concentrations of extracts compared to the control except concentration of 5.0 g/100 ml water was inhibitory, but this effect was reduced. The effect of increased osmotic potential by the foliage extracts had little effect on percent germination as compared to the toxic effect of the foliage extracts, so we conclude the reduction in percent germination was not due to increased osmotic potential of the foliage extracts. The rate and percent emergence of germinated seed through a wax crust was reduced by concentration of alfalfa extract at 1.25 g/100 ml water or greater. These trials show there was reduced seedling vigor when germinating or growing alfalfa in alfalfa extracts. This reduction in this trial indicated autotoxicity of alfalfa extracts.

Experiment 2: (Intact Foliage)

In another series of experiments 5 g of intact alfalfa hay was submerged in 1 liter of distilled water for 15 minutes. The EC of the extracts, including the distilled water control, were brought up to the same EC as the foliage extract by the addition of sodium and calcium chloride. However, in these trials there was no inhibition of germination or seedling growth due to foliage extracts at the concentration used.

## Soil Extracts

Soils from a 12-year old stand and a 4-year old orchardgrass (*Dactylis glomerata* L.) stand and a field that had been fallow for 3 years were collected from the top 4 cm of the soil profile. One hundred grams of soil was extracted with 250 ml of warm (35°C) distilled water. The water was allowed to percolate through the soil by gravity after which suction was used to extract as much of the remaining water as possible. The EC of all extracts and the distilled water control was brought up to the highest EC obtained by addition of sodium and calcium chloride. Soil extracts did not significantly reduce alfalfa seed germination or seedling growth when compared to the distilled water control.

# Establishing Alfalfa after Alfalfa without Autotoxicity

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Autotoxicity occurs when a plant reduces the germination or growth of the same species during or after germination. National farm magazines have recently reported that alfalfa cannot be grown continuously with reseeding because of autotoxic problems attributable to harmful compounds in the existing run-out stand. The recommendations are based primarily on greenhouse data showing autotoxic effects of alfalfa tops on new seedlings. Farmer experiences in several states, however, do indicate that harmful autotoxic effects do exist, in some cases, when alfalfa is established by sod seeding into an old stand or on a plowed-under alfalfa stand.

The objective of this research was to determine if alfalfa could be reestablished, without an intervening crop or fallow, by sod seeding or conventional seeding on a plowed-under alfalfa stand. Five experiments were conducted between 1980-1984 on fertilized loam soils of pH 6.5 or above. Expt. 1 was seeded on 23 August 1980 on a prepared seedbed 9 days after plowing and 23 days after killing a 1-year old alfalfa stand with glyphosate. Yields for the next two years were similar for alfalfa after alfalfa (6.8 tons/per acre) or alfalfa after fallow (check, 6.7 tons). Expt. 2 was seeded on 23 June, 12 days after plowing alfalfa or bluegrass (check) or 19 days after sod seeding on a glyphosate-killed 5-year old stand 36 inches tall. Stand counts in August and yields in the first two years after seeding were similar among treatments indicating no autotoxicity if seedings were made 12 days after plowing or 19 days after sod seeding into a killed old stand. In Expt. 3, alfalfa established on 20 June, 1983, 7 weeks after plowing or 5 weeks after sod seeding in a glyphosate-killed alfalfa stand yielded 3.1 and 3.3 tons hay, respectively, in the first cut in the next year, similar to alfalfa established by plowing under corn stubble (3.1 tons). In Expt. 4, alfalfa seeded on 2 Sept, 1983, on a 7-year old stand plowed under 18 days before or on the same day as plowing yielded similarly (3.2 and 3.1 tons/acre) in the first cut in the next year, similar to alfalfa after plowed under Ky bluegrass (check, 3.3 tons). In Expt. 5, alfalfa sod seeded on 7 May 1983, two days after spraying a 1-year-old stand with glyphosate had fewer plants per sq. ft. and a lower yield in the first cut in the next year (8 plants, 3.1 tons) than when the alfalfa was sod seeded on alfalfa sprayed, and killed with glyphosate the previous fall (22 plants, 4.1 tons). This indicates autotoxicity if alfalfa is sod seeded two days after spraying to kill an old stand. In other experiments in three variety trials, the best varieties of alfalfa spring seeded 2 to 4 weeks after spring plowing or after fall plowing of 3-year old alfalfa stands produced yields of 8 to 9 tons per year for a 3-year period.

The four experiments and the variety trials (Central Alfalfa Improvement Conference, Annual Reports, 1974-1983) indicate no autotoxicity if an adequate period exists between seeding and killing an old stand with glyphosate or plowing under an old stand. One experiment (#5) indicates autotoxicity is severe if alfalfa is sod seeded into an old stand two days after spraying with glyphosate. It is suggested that the harmful autotoxic effects from extracts of/or tops or roots of alfalfa in the greenhouse will be insignificant under field conditions if the recommendations below are followed. Furthermore, harmful effects in stand establishment or growth in the field, sometimes attributed to autotoxicity, maybe due to (1) low pH, (2) excessive competition for water, light or nutrients by existing grass or alfalfa (particularly in sod seeding), (3) nematodes, (4) diseases and/or (5) insects.

Recommendations for growing alfalfa continuously without autotoxicity, based on the above experiments and experiments now in progress, are as follows: first choice -- spring seeding on a prepared seedbed after fall plowing of alfalfa; second choice -- spring or summer seeding two weeks after plowing an old alfalfa stand; third choice -- spring sod seeding on an alfalfa stand killed by fall spraying with glyphosate; and fourth choice -- sod seeding in spring or summer two weeks or more after spraying an old stand with glyphosate.

## No-till Alfalfa Establishment in Utah

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Alfalfa has traditionally been established in Utah with a deep plowing in the fall, followed by two disking in the spring - a harrowing, then packing. The number of trips over the field area has been usually four times minimum.

Producers are becoming very cost-conscious and need a better return for money invested. Recent Farm Bureau meetings indicated that min-till and no-till priorities were very high on the producer's list of research and demonstration priorities.

Ten acre demonstration plots were established in twelve counties with high alfalfa acreages production. Three drills were purchased for this activity with monies given to the Utah State Department of Agriculture (from the legislature). Trucks and trailers were purchased by extension, and plots established.

A micro-computer program was put together to help a producer determine his potential cost savings. All County Agents have this program written for their Apple II computers.

Field trials have been very successful - weed control has usually been accomplished with one quart of Roundup applied at 10 GPA water and .5% X-77 Surfactant v/v.

Seeding rates have been increased by 10% to 18 lb/acre. Starter fertilizer has been applied using Chevron Unipel 27-12-0 applied at time of planting with the fertilizer box on the drill.

Tye and John Deere 1550 drills were used, and both worked equally well in the established plots.

## Branching as a Factor in Alfalfa Yield

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Alfalfa (*Medicago sativa* L.) commonly branches in the main stem leaf axils. The nature of branching and percent branching (proportion of total forage weight in branch material) were determined from harvest to harvest over two seasons for several alfalfas in the field. Forage yield declined but percent branching increased in midseason compared with early season harvests. Four common alfalfa entries averaged 20.8, 27.3, 27.9 and 14.5 percent branch for the first through fourth harvests of four experiments. Within separate experiments involving a total of 68 cultivars and germplasms, entries showed significant differences in an overall range from about 17 to 27 percent in yearly average branching. Percent branching was positively correlated with per branch weight and, to a lesser degree, with numbers of branches per stem. Neither total forage weight nor stem numbers per meter of row showed a close correlation with branching.

# Root Development as Related to Spring Harvest Regimes

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Root weight can be an estimator of plant vigor, health, yield, and persistence of alfalfa (*Medicago sativa* L.). This study was conducted to determine how root dry weight changed within a cycle of growth and how it was influenced by cultivar and stages of growth at the first harvest under irrigated and dryland conditions in Oklahoma.

The top 10 cm of roots were weighed from three semi-dormant cultivars ['Arc', 'OK08' (Oklahoma Common), and 'WL 318'] harvested at four stages of growth (early and late bud and early and late bloom). The study was designed as a split plot with main plots (cultivars) arranged in a randomized complete block with six replications for the irrigated area and three replications in the dryland study. Root weights were recorded at the first two spring harvests in 1982, '83, and '84. First harvests were made from mid-April to mid-May, and the second harvests (at 10 - 25% bloom stage) were about 35 days later.

At first growth in the first spring, changes in root dry matter were similar to those obtained for total nonstructural carbohydrates. Thus, root weight could potentially be a good predictor of root carbohydrates in both dryland and irrigated conditions.

Interactions between cultivars and harvest management were not important under dry or irrigated conditions. Cultivars differed significantly for root weight in the irrigated alfalfa but not under dryland, although a similar trend was observed. WL 318 roots were much larger than OK08, which was only slightly larger than Arc.

During the seedling year, regardless of growing conditions, root weight significantly increased with time through late bloom. At the second harvest (10 - 25% bloom) the earlier the plots had been cut at first harvest, the larger the roots. In subsequent harvests and years, differences among root weights from different first harvest treatments were significant but without a consistent pattern. Correlations between root weights from one harvest to another were generally low.

WL 318 was selected for Phytophthora root rot resistance. There may have been simultaneous selection for large roots. Root rot resistance itself may have directly contributed to larger roots for WL 318.

Obviously, other factors contribute to alfalfa root weight. Temperature during regrowth varied greatly and could be responsible for the inconsistent weights related to the first harvest management treatments. Although strict statistical comparisons could not be made between the irrigated and dryland studies, it was noted that roots grown with irrigation weighed about the same in the first year and were 15% larger during the third year.

# Fall Harvest Management of Alfalfa in Minnesota

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Winter injury is a major cause of reduced yield and persistence of alfalfa in Minnesota. Harvest systems and time of fall harvest influence winter injury by altering cold acclimation and accumulation of carbohydrate reserves. Several studies have shown that the conventional recommendation to not harvest for 4-6 weeks before the first killing frost may not always be valid (1, 2). The objective was to determine the influence of harvest systems with different dates of fall harvest on the yield persistence and forage quality of alfalfa cultivars. In sourthern Minnesota (Waseca, Lamberton and Morris), two three-harvest systems (with final harvests on 1 or 15 September) and two four-harvest systems (with final harvests on 16 September or 15 October); and in northern Minnesota (Crookston and Grand Rapids), a two-harvest system (with final harvest on 15 August) and three three-harvest systems (with final harvests on 1 September, 15 September or 12 October) were applied to established stands of alfalfa.

Significant stand effects due to harvest managements did not occur until the third year at two locations (Waseca, Grand Rapids) or until the fourth year at the other three locations. In southern Minnesota, a harvest system with a third harvest on 15 September resulted in greater long-term dry matter yields at all locations, but ultimately lower final stands at Lamberton and Morris and lower forage quality at all locations than the standard three-harvest system with a final harvest on 1 September. A system with a fourth harvest on 15 September ultimately resulted in greatest stand loss at all locations, but long-term yields were not consistently different from those of the standard system. At Crookston, a system with a third harvest on 15 September had less long-term yield and more final stand reduction than a system with a third harvest on 1 September. However, at Grand Rapids, the two systems had similar final stands, and the system with a final harvest on 15 September had greater yields. Harvest management effects on persistence were similar for all cultivars, and winterhardy cultivars ('Ramsey', '520', 'Phytor' and 'Agate') had greater persistence than moderately winterhardy 'Saranac'.

Our studies confirm that the conventional recommendation for northern United States that alfalfa not be harvested for 4-6 weeks before the first killing frost is often not valid in the short-term (2-3 yr.) and sometimes not valid in the long-term (up to 4 yr.). Therefore, that recommendation should be considered as a low-risk alternative rather than an inviolable rule.

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# Vesicular-Arbuscular Mycorrhizal Effects on Alfalfa Growth in Limed and Sterilized Soil

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## Introduction

Although positive responses to vesicular-arbuscular mycorrhizal (VAM) inoculation are well established for a wide variety of crops, these studies are mostly concerned with annual crops or initial responses of perennials, and, in many cases, in soils devoid of indigenous VAM. A long-term experiment was performed to study the effects of VAM introduction into sterilized soil on alfalfa growth over nine harvests in the same pot of soil. A second study was designed to view the plant growth response of alfalfa in unsterilized limed acid soil to introduction of VAM adapted to a neutral pH.

## Materials and Methods

The VAM inoculum for both experiments consisted of a mixed culture of indigenous VAM isolated from under native vegetation in the SW part of the Canadian prairies and maintained in a mixture of soil and sand at a pH of 7.0-7.4. Roots and adhering soil were used as inoculum.

One-kilo samples of 1:1 sand:soil mixture were placed in plastic pots for the long-term experiment. VAM inoculum was added to half the pots and three alfalfa seedlings planted per pot. Seven replicates per treatment were used. The plant tops were harvested at flowering for nine successive periods. The shoots were dried, weighed, ground, and analyzed for P content. Roots from root cores were analyzed for VAM colonization and the soil analyzed for available P.

The second experiment utilized an acid soil (pH=5.2) with four levels of added lime as $CaCO_3$ (2.5, 5.0, 12.5, and 50.0 µg/g) with one level of added P (25 µg P/g). VAM were added to half the pot in each treatment. After 90 days and again after 45 days, the tops were harvested, dried, weighed, ground, and analyzed for P content. The roots were analyzed for VAM colonization.

## Results and Discussion

For the long-term experiment with sterilized soil, VAM inoculation resulted in a significant dry matter increase for harvest 1 and 3 and a nearly significant increase for harvest 2 and 4. Harvests 6, 7, 8, and 9 resulted in VAM plants producing less dry matter than non-VAM plants, however only harvest 8 resulted in a significant decrease. Plant P was only significantly higher for VAM plants in harvest 1 and 3. VAM root colonization remained above 80% for the entire experiment.

Growth in limed acid soil was increased by the addition of neutral pH-adapted VAM and by P addition. Generally, higher soil pH resulted in higher alfalfa dry matter production. Levels of indigenous VAM root colonization decreased with increasing pH, while levels of neutral pH adapted VAM increased with increasing soil pH.

# Alfalfa as the First-Phase Component in Minnesota Crop Rotations

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The practice of including forage legumes in crop rotations declined due to the increased availability and relatively low cost of N fertilizer. A renewed interest among producers in using forage legumes as inexpensive sources of N in crop production is due to the increasing price of N fertilizer (Heichel et al., 1981) and to the increasing interest in organic farming techniques. Barnes et al. (1978) first reported success in selecting alfalfas for high root N content which potentially could supply greater amounts of N for a subsequent non-legume crop when plowed under. By 1983, the selection program had resulted in experimental populations with a 45% greater total N yield in October of the seeding year than standard cultivars (Barnes et al., 1983).

The objectives of our research were: to compare effects of two harvest systems on forage yield and quality, and N incorporated from a non-dormant experimental ('MN ROOT N') and a moderately dormant cultivar ('Saranac AR'); and to evaluate effects of previous cropping (alfalfa, corn, or soybean) and fallow treatments on grain yield and N response of a subsequent corn crop. A field study was conducted at four Minnesota locations. First-phase rotation components included alfalfa (grown for the seeding year only), corn, soybean, or fallow, and the second-phase component was corn. Alfalfas were subjected to two harvest systems that resulted in different amounts of herbage removal and phytomass incorporation. Four or five rates of N fertilizer were applied to corn across all first-phase treatments.

The two alfalfas did not differ in total forage production, but Saranac AR tended to have higher CP and IVDDM concentrations than MN ROOT N. MN ROOT N had greater root dry matter yield and N concentration than Saranac AR. Greater plant N was available for soil incorporation when fewer forage harvests were removed. The difference between harvest systems for N incorporation was greater than the difference between alfalfas within a harvest system. With no N applied, second-phase corn grain yields were greater after all first-phase alfalfa treatments than after first-phase corn. Differences in second-phase corn yields were not associated with differences in first-phase alfalfa N incorporation at three of four locations. On the Webster clay loam, second-phase corn grain yield with no N applied was greater following MN ROOT N than after Saranac AR. Differences in N incorporation between alfalfas used in this study were small. Harvest management was more important than cultivars in increasing yields of subsequent crops.

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# Glandular Trichomes on Medicago: Building Self Defense Against Insects

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Trichomes vary widely in configuration and size. We found two types of glands (erect, procumbent) among the *Medicago* species studied (Kreitner and Sorensen, 1979a). The small procumbent glands generally are composed of a basal cell embedded in the epidermis, a single stalk cell, and a gland head of four cells in two tiers. The stalk of erect glands is composed of four to six cells, including an enlarged basal cell arising from the epidermis. The gland head contains numerous cells arranged in distinct tiers.

Both types of glands exhibit secretory activity (Kreitner and Sorensen, 1979b). Procumbent ones produce only a small amount of secretion, which soon becomes dry and hard. Erect, capitate-stalked glands produce copious secretions, apparently on an intermittent basis during the life of the shoot. Ultrastructural studies show that secretory-cell plastids are a probable origin of material secreted by erect glands (Kreitner and Sorensen, 1983). Final secretion collects under the cuticle on the gland head before emerging to the surface.

The defensive roles of trichomes have been demonstrated to be trapping, poisoning, and repelling insects. No poisonous compounds have been detected in the secretions of erect glands on *Medicago* species. The secretion is a viscous, nonvolatile fatty substance with five major compounds, including a C-21 Ketone, a C-20 ester with one double bond, a C-20 diene, a C-16 monoene, and a C-16 diene (Triebe et al., 1981). In preliminary analyses, forage quality (IVDMD and crude protein) of the perennial glandular-haired species was equal or superior to that of *M. sativa* L.

Procumbent glands are not known to deter or resist insects. In the laboratory and greenhouse, first instar alfalfa weevil larvae [*Hypera postica* (Gyllenhal)] (Shade et al., 1975, Johnson et al., 1980a) and potato leafhopper nymphs [*Empoasca fabae* (Harris)] (Shade et al., 1979) were immobilized by the sticky secretion of erect glands. Although adult alfalfa weevils (Johnson et al., 1980b), potato leafhoppers (Shade et al., 1979), pea aphids [*Acyrthosiphon pisum* (Harris)] (Shade et al., 1983), and spotted alfalfa aphids [*Therioaphis maculata* (Buckton)] (Ferguson et al., 1982) were not trapped by the secretion, annual and perennial *Medicago* species showed varying levels of resistance. The alfalfa weevil (Johnson et al., 1981), potato leafhopper, and spotted alfalfa aphid demonstrated antixenosis for the erect glandular-haired species. Pre-contact cues (olfactory or visual) and contact cues (chemotactic or mechanical) appeared to be used by adult weevils in rejecting *M. rugosa* Desr. in favor of *M. sativa* (Johnson et al., 1980c). Density and length of erect glandular hairs on seed pods were negatively correlated with seed chalcid [*Bruchophagus roddi* (Gussakovsky)] infestations. No infested seeds were found on an *M. glandulosa* David. clone that contained long glandular hairs densely distributed on the seed pods (Brewer et al., 1983). Generally, only procumbent glands occur on *M. sativa* cultivars used for production of hay. We transferred erect glands from the perennial diploids, *M. glandulosa* and *M. prostrata* Jacq., to tetraploid *M. sativa* via 2x - 4x crosses. Erect glands from perennial tetraploid *M. glutinosa* M.B. also were transferred to the cultivated alfalfas. Annual tetraploid *M. scutellata* (L.) Mill. was crossed with *M. sativa* but we have not used the annual species in our breeding program (Sorensen et al., 1983).

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# Maintaining High Productivity of Leafcutter Bees--A Challenge for the Future

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The alfalfa leafcutter bee is the only bee in Canada that can be relied upon to efficiently and effectively pollinate alfalfa. The development of the loose-cell system of management for this bee has had a tremendous impact on seed production in Canada. Seed supplies are the highest in 30 years and are approaching the total Canadian market requirement. In 1960 about 3200 acres were in pedigreed seed production and by 1984 this had increased to about 34000 acres.

The loose-cell system of management was developed to manage the large populations of bees required to pollinate the crop. This system places the optimum number of bees onto the crop at the appropriate time to obtain a high seed set and an adequate return of viable bees for the following year. The system enables easy removal of the bee cells from laminated grooved nesting materials for storage over the winter. Control of parasites and predators is through various management procedures, including hive construction, incubation, and removal and tumbling of cells from the hives. It makes efficient use of cold storage and incubation facilities to synchronize bee emergence with the beginning of flower bloom. The system permits beekeepers to take samples of cells from their current production to accurately estimate numbers of intact cocoons, females, and parasites. By these estimates, improvements in beekeeping practices can be monitored and guidelines provided when bees are bought, sold, exported, and rented by seed growers. The system requires substantial financial investment in specialized equipment and demands intensive and proper handling of bees, careful managers realize profits from the sale of excess bees that are often equal to the sale of the seed.

Samples of cells submitted by beekeepers since 1970 indicate a gradual increase in the quality of bees produced. The number of live bees/kilogram increased from 7300 in 1970 to 8600 in 1983. Incubation tests show that about 33% of the incubated cocoons consistently contained females and mortality of prepupae during incubation or due to chalcidoid parasites (less than 2%) was consistently low. These productivity indicators show that beekeepers are incorporating new and recommended procedures into their operations. Canadian beekeepers are the world's leading suppliers of quality leafcutter bees. Recently about 150 million surplus bees have been exported annually, mainly to the United States, but also to Argentina, the USSR, and other European countries.

Constraints, such as parasites and predators, plant foliar molds and bee diseases, or pesticide-pollinator interactions are and will be future research challenges to Canada if it is to maintain its high productivity of bees. Control of pest insects will require new or modified equipment and management techniques. The following are examples. The use of 5 mm thick polyurethane foam reduces the excess space around the back of hives and the entry of chalcidoid parasites. Tumblers used to remove debris-feeding insects, predators of the bee, excess leaf pieces, debris, and plant foliar molds from cells were compared. A hand-cranked tumbler removed significantly more material than did the motor-driven tumblers. It also removed more debris as the initial sample weight increased. The use of species-specific sex attractants have a role in monitoring moth populations and possibly controlling them. Sixteen pheromone-like compounds were identified from the sex pheromone glands of female driedfruit moths. Male moths were attracted to a synthetic blend of chemicals. The use of insecticide vapor strips (Vapona) in incubators is moderately effective in controlling chalcidoids.

# Spotted Alfalfa Aphid Resistance as Affected by Seedling Age and Duration of Exposure

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Screening different expressions of resistance to the spotted alfalfa aphid (SAA) (*Therioaphis maculata* Buckton) was investigated using two cultivars of alfalfa (*Medicago sativa* L.). Three seedling ages and five durations of infestations were employed to develop new screening techniques to identify the manifestation of different types of resistance.

The experiment was a 5X3X2X2 factorial (RCB) with 8 reps. Factors included: durations of infestation (2, 4, 6, 8, and 10 days); age at infestation (0, 4, and 8 days); cultivars ['Riley' (resistant) and 'OK08' (susceptible)]; and infested and noninfested levels of SAA.

After each exposure all plants were sprayed with an insecticide. At 25 days after planting, the experiment was terminated and stem length, shoot weight, and root weight were measured. Number of surviving plants was also recorded.

The effect of each treatment on stem length was highly correlated to its effect on stem weight and root weight. Duration and age at infestation were highly significant for all variables measured for OK08, except survival, which was not affected by age. However, duration was much more important than age at infestation. Differences between cultivars were highly significant. The only significant interaction was cultivar X duration. Age at infestation was the only factor to be significant on Riley for all variables measured except survival. In OK08, however, duration of exposure significantly affected plant development much more than did age at infestation.

At termination of the 8 and 10 day exposure, plants of OK08 had approximately fourfold the initial number of aphids per plant; however, Riley usually had fewer aphids than the initial infestation. This decreased reproduction, and aphid death began after the unifoliolate stage.

During 6 days exposure, highly susceptible plants were eliminated in both cultivars. After 6 days of exposure, tolerance was expressed in OK08. Differences in stem length identified different levels of tolerance, and its high correlation to stem weight and root weight suggest that stem length may be used in future screening for tolerance. Early infestations (cotyledon stage) may override the expression of antibiosis or nonpreference in Riley due to the ability of the aphids to reproduce before the unifoliolate stage. Exposing 4-day-old seedlings for eight days to SAA was the most effective way to identify different types of resistance in alfalfa.

# Some Aspects of the Biology and Distribution of *Lygus* sp. Infesting Alfalfa Seed Grown in the Peace Region of Alberta

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From 1981 to 1983 *Lygus* sp. were monitored weekly, using a sweep net, in 21 alfalfa seed fields located in the Peace River Region. Primarily three species comprised the populations; *Lygus borealis* (75%), *Lygus elisus* (14%) and *Lygus lineolaris* (10%). Damage assessments of each field were carried out to determine a percent damage as well as to determine the relationship between the number of insects and damage.

Damage within fields varied significantly between plants (P=.002). This was explained by the negative binomial distribution of the insect. Damage also varied within individual plants (P=.006). The top part of the plant incurred significantly more damage than did the middle or bottom part of the plant. This indicates that more damage is taking place in the later part of the season. Damage estimates ranged from 1.8% to 32% loss of seed over the 4 years (84 fields). There was a positive correlation ($r^2$=.821) between the number of insects and the amount of damage which occurred in the fields. Lygus numbers were converted to LDU units (1) and compared to damage. It was determined that 1 LDU unit accumulated per week resulted in 0.55 lbs. loss of seed, per acre, per week.

District to district variation in damage was found to be nonsignificant (P=.331), indicating that a region wide program was possible. Field to field variation, on the other hand, was significant (P=.000) indicating that management practices and weather modified damage. Further investigation indicated that damage was modified by the amount of weeds in the field, the plant condition, and the amount of moisture.

Early spraying (first week of June) resulted in a significant reduction in damage compared to no spray or spraying in the later part of June.

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# Effects of Genotypes, Seeding Dates and Carbofuran Treatments on Alfalfa Stand Establishment in the Presence of Root Lesion Nematodes

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Difficulties in establishment and maintenance of alfalfa stands at the North Central Experiment Station in Grand Rapids, Minnesota have been associated with large populations of the root-lesion nematode, *Pratylenchus penetrans* Cobb, Filipiev and Schur-Stekh (1, 2). Sheaffer et al. (2) observed that nematicide application resulted in greater yields in both the seeding and following year compared to the untreated control. Because it may be a more important pest of alfalfa than currently recognized, we conducted the following studies.

Study I. The effects of seeding date, carbofuran treatment and alfalfa genotype on alfalfa stand establishment in the presence of *P. penetrans* were studied at Grand Rapids, MN. The experimental design was a randomized complete block with treatments in a split-split-plot design with four replicates over two years (1982, 1983). Whole plots were four seeding dates established at two week intervals beginning in mid-May. Sub-plots were the alfalfa cultivars Baker and WL-219, which were identified as being susceptible and more resistant to *P. penetrans* respectively than other varieties evaluated to date. Significant differences were observed for seeding dates, carbofuran treatment and cultivars for plant numbers and nematodes $g^{-1}$ fresh root. There were greater numbers of plants in the carbofuran treated plots than in the untreated plots for the first 2 seeding dates. There were more nematodes $g^{-1}$ fresh root in the untreated Baker plots than in either the WL-219 plots or the treated Baker plots.

Study II. A second study was conducted to substantiate the differences in resistance observed between alfalfa cultivars in Study I and to compare them with alfalfa populations selected by Nelson et al. (1) for resistance to the root-lesion nematode. The experimental design was similar to Study I except that whole plots were two seeding dates, 13 May and 22 June, 1984 and sub-plots were four alfalfa entries: Baker, WL-219, MN-GRN-2 and MN-GRN-4. Significant differences were observed over seeding dates, carbofuran treatments and entries for plant numbers and nematodes $g^{-1}$ fresh root. Plant loss was more severe in the June seeding compared to the May seeding. The number of nematodes $g^{-1}$ fresh root weight was 253 for the treated plots and 518 for the untreated plots. The MN-GRN-4 population had the greatest stand and the lowest numbers of nematodes in the roots as compared to the other entries.

We concluded that: 1) date of seeding influenced alfalfa stand establishment in the presence of *P. penetrans*, 2) carbofuran treatment effectively increased alfalfa plant numbers and decreased *P. penetrans* numbers within plant roots for a period of approximately six weeks, and 3) selection for alfalfa plant resistance to the root lesion nematode had been effective.

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# Transmission of Verticillium albo-atrum to Alfalfa by Leaf-chewing Insects

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Alfalfa leaves infected with Verticillium albo-atrum were fed to leaf-chewing insects - grasshoppers (Melanoplus sanguinipes and M. bivittatus), alfalfa weevil (Hypera postica), and woolly bear (Apantesis blakei - to determine survival of the pathogen after passage through the digestive tracts. V. albo-atrum survived in the digestive tracts of all tested species, usually first appearing in the feces one day after feeding. The percentage of V. albo-atrum-contaminated feces varied among individuals within species and was related to the duration of feeding on diseased tissues. The average percentage of contaminated feces in adult M. sanguinipes was less than 14% after one day of feeding the insects with diseased tissue but increased to 49% after three days of feeding.

V. albo-atrum was eliminated from the digestive tracts of grasshoppers by changing the diet to uninfected alfalfa leaves. The time required for complete removal of the pathogen appeared to be related to the level of contamination in digestive tracts, averaging 1.6 days for individuals with less than 25% of pathogen-contaminated feces and 6.8 days for those with more than 75% of contaminated feces in their digestive tracts.

When the V. albo-atrum-contaminated feces from grasshoppers were buried near roots of alfalfa seedlings, 20.8 and 13% of plants were infected and developed wilt symptoms after 6 weeks in experiments 1 and 2, respectively.

Previous reports indicate that alfalfa pests and predatory insects (1,2) are effective agents for spreading spores of V. albo-atrum produced on old infected stems in the field. This study demonstrates that where field conditions are not conducive to spore production, the pathogen can still be transmitted via the feces of leaf-chewing insects, grasshoppers in particular. The high mobility of grasshoppers increases the risk of spreading this disease within and between alfalfa fields.

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# Effects of Potato Leafhopper Reducing Yield and Quality of Alfalfa Forage

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The potato leafhopper, currently considered the major insect pest on alfalfa in the northeast and north central United States, migrates to these regions annually from its overwintering habitat along the gulf coast. Spring and early summer storm systems carry the gravid females northward. These adults and their progeny feed in the vascular tissue of the alfalfa. Preference for phloem feeding has been demonstrated and plugging of these pathways for transport of photosynthates results in yellowing or "hopperburn". Potato leafhopper feeding reduces both yield and quality of the alfalfa plant including percent total nonstructural carbohydrates which we observed declining in both crown and root tissue. The relationship between insect number and annual plant damage is nonlinear. Damage per insect decreases as insect number increases.

Biotic factors that influence damage potential are insect number, insect age and sex, and stage of alfalfa maturity at time of attack. All of our studies have used insect/stem ratio as a standard quantitative relationship for pest and plant populations.

Alfalfa height, dry weight and percent crude protein were standard growth parameters when assessing this pest's impact on both seedling and established stand alfalfa. In general, alfalfa height and dry weight were always affected most. However, no correlation exists between these two growth parameters. Percent crude protein was always least affected but, the response was always significantly greater than in the undamaged control plants. Reductions in percent crude protein generally preceded the traditional yellowing or "hopperburn" symptomatic of potato leafhopper injury in alfalfa. Thus, a caution to researchers selecting for resistance only on the basis of yellowing and not measuring other quality parameters, ex. reductions in percent crude protein. Late instar nymphs and adult female potato leafhoppers were more damaging than early instar nymphs and adult males. Female leafhoppers killed 18 cm tall seedling alfalfa when contained two per stem for six days. An inverse relationship was recorded between age of plant at time of attack and degree of injury by potato leafhoppers. Thus, management decisions should be made as early as possible in the crop's development for this pest.

Long range effects by potato leafhopper on alfalfa production are currently being examined in an interregional project (NC-149). Recent studies indicated that percent TNC was highly affected in both the crown and root. Hence, regrowth potential may be adversely affected. Action thresholds have been established for the potato leafhopper in a few states. In Pennsylvania, the threshold number varies in relation to value of crop, cost of insecticide application and maturity of crop. Research is underway to develop a more dynamic management system for this pest. A model of the population dynamics of the potato leafhopper has been developed and validated on second and third crops of a four-cut system in Pennsylvania. The model uses a Leslie Matrix format and assesses survivorship through each stage of insect development at intervals of ten Fahrenheit degree days. The model predicts development of the nymphal population through harvest. Nymps in essence do not survive harvest and do not influence initial population growth. Investigations are currently underway to examine how potato leafhopper influences photosynthesis and respiration in the alfalfa plant. Potato leafhopper and alfalfa growth models interfaced through these pathways should provide management systems for this pest which are more dynamic and predictive.

## Effects of Burning Seed Alfalfa for Insect Control

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With the development of the philosophy of pest management in alfalfa, there is a renewed interest in cultural controls. These are usually the most economical and widely applicable of all pest control measures. However, pest control is only one factor to be considered. Cultural control methods (such as burning alfalfa stubble) require a thorough knowledge of crop production in order to integrate the techniques for pest control into proven agronomic procedures for alfalfa crop production. These changes in agronomic procedure should not lead to other problems.

Fire is a powerful and rapidly acting force in the modification of the environment. It is of universal importance in natural and man-managed ecosystems both as a destructive force and a management tool. In the early part of the 1900's, fire was generally considered a destructive and undesireable force in ecosystems, but in more recent times, critical scientific evaluation indicates its potential for use in the management of agricultural systems.

Experiments conducted by the Lethbridge Research Station, using fire as a pest control strategy, have shown that burning alfalfa stubble in the spring controls alfalfa plant bug, reduces lygus and alfalfa weevil populations, and increases plant growth and yield during the year of the burn, but not the year after the burn. This study will be continued for several years to evaluate the long-term effect of burning on each of these factors.

## Improved Somatic Embryogenesis from Cell Cultures of Alfalfa

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Recent reports of regeneration of alfalfa from cell cultures have used a medium developed by Saunders and Bingham (Crop Sci. 12:804. 1972) which is based on a formulation by Blaydes supplemented with yeast extract and inositol. The ammonium concentration in Blaydes was shown to be a critical factor for alfalfa regeneration (Walker and Sato Plant Cell Tissue Organ Culture 1, 109. 1981). Here we report on methods which can improve somatic embryo yields by 4 to 5-fold and embryo conversion to plantlets by at least 2-fold. The amino acid L-proline stimulates embryo formation by 3-fold when used during regeneration of alfalfa. Proline interacts synergistically with ammonium during regeneration with 100 mM proline and 25 mM $NH_4^+$ yielding the highest numbers. Other amino acids were tried in the regeneration assay; alanine, glutamine, arginine, and asparagine improved embryo yield over ammonium ion but gave lower yields than proline. These amino acids yielded higher quality embryos than proline. However, as measured by size and conversion to plantlets, combinations of amino acids can be used for high embryo yield and quality. This method works on a variety of alfalfa genotypes as well as other species and hence, may be generally applicable to somatic embryogenesis from cell culture.

# Influence of Breeding Background on the Tissue Culture Response of Commercial Alfalfa Varieties

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Commercial varieties of alfalfa were screened in vitro for their ability to form callus and regenerate into whole plants via somatic embryogenesis. The study was undertaken to fulfill three objectives: First, to provide information on the tissue culture response and regeneration capacity of specific cultivars. Second, to isolate a range of high regenerating plants which could be used in genetic manipulation studies. Third, to document the relationship between high regenerating cultivars and their germplasm source. We were particularly interested in determining whether a particular genetic background was associated with a superior in vitro response.

The 13-week procedure included the following steps: a) sterilize seeds with 0.2% HgCl and germinate on $B_5$ basal medium at 25°C under a 16-h photoperiod for 14 days, b) conserve the epicotyl region of seedling in meristem tip culture under low temperature conditions, c) induce callus formation on the isolated cotyledon and hypocotyl tissues on a modified B5 medium, d) after 28 days, transfer to a "high" 2,4-D (11 $mgl^{-1}$) Schenk and Hildebrandt medium to induce embryo formation for 21 days, e) transfer to a Blaydes medium lacking growth regulators to allow embryo development, f) recover "high regenerating" donor plants from meristem tip culture or germinate somatic embryos on basal $B_5$ medium.

Wide variation in callus production and somatic embryo formation was observed amongst the cultivars tested. All 76 cultivars formed callus and about one-third showed some degree of somatic embryo formation. Western creeping-rooted alfalfas respond particularly well with cultivars such as Rangelander, Kane, Rambler, Heinricks and Spreader responding with 80%, 45%, 41%, 38% and 34%, respectively, of the plants tested in these cultivars showing in vitro somatic embryo formation. All of these cultivars have a high level of two of the nine possible germplasm types available; *M. falcata* and Ladak. Cultivars which lack these germplasms tend to show a low somatic embryogenesis response (e.g. Anchor - 18% embryogenic, Saranac - 17%, Algonquin - 10%, Angus - 5%, and Banner - >1%.

The pattern of in vitro response appears to be largely independent of medium protocol or explant source but choice of culture medium can modify the response of both high and low regenerating cultivars in a parallel manner. That is, under some medium conditions "high regenerating" cultivars may respond poorly but they respond in a superior manner compared to "low regenerating" cultivars in all cases tested. The plants recovered from meristem tip culture showed a similar in vitro embryogenesis response to that of the cotyledon and hypocotyl response when petioles, leaves, shoot tips or ovaries were used as explants. Somatic embryos germinated when isolated on B5 or Schenk and Hildebrandt medium with a frequency of about 65%.

# A Biosystematic Study of Medicago scutellata

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Medicago scutellata (snail medic) is an annual species, taxonomically belonging to the subgenus Spirocarpos, Section Rotatae. Its geographic distribution is limited to the Mediterranean region. Other members of the section Rotatae include M. bonarotiana, M. noeana, M. rotata, M. rugosa, and M. shepardii. M. scutellata is characterized as having gland-tipped hairs covering the entire plant with large, spineless, cup-shaped pods (Lesins and Lesins, 1979). The glandular hairs are a mechanism for insect resistance.

There appears to be three distinct growth habits in this species: 1) non- vigorous plants which flower approximately 1 month after planting and have one flower per inflorescence, 2) vigorous plants that flower 2 months after planting and have 3 flowers per inflorescence, and 3) plants which have short internodes, flower 2 months after planting and have 3-4 flowers per inflorescence.

In the literature, M. scutellata and M. rugosa are cited as the only tetraploid (2n=32) annual species. Critical examination of root tip chromosomes revealed that M. scutellata possesses 4 satellited chromosomes (SAT-chromosomes) and M. rugosa possesses 2 SAT-chromosomes, which lead to a new chromosome number for these species, 2n=30. (Bauchan and Elgin, 1984) The observation of 15 bivalents at metaphase I gave support to this conclusion. The possibility exists that M. scutellata arose through the hybridization of a 2n=16 species and a 2n=14 species (there are 5 Medicago species which have 14 chromosomes). Because M. rugosa contains only 2 SAT-chromosomes, it is plausible that this species arose by the loss of one pair of SAT-chromosomes. All of the other species in the section Rotatae contain 16 chromosomes.

Intraspecific hybridization between the accessions with the different growth types appeared to be very difficult when crosses were made in the greenhouse. Observation of the pollen germination and pollen tube growth using fluorescence microscopy showed that very little germination occurred. However, if pollinations were made in a growth chamber with constant temperature and high humidity, pollen germination and pollen tube growth were not inhibited. This phenomenon also occurred when the interspecific cross M. scutellata x M. sativa was attempted. Embryo rescue of these potential hybrids is now being undertaken. Hopefully, these hybrids will lead to the incorporation of the glandular haired trait into cultivated alfalfa (M. sativa).

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# Interspecific Hybrids of Perennial *Medicago* Species Produced Via Ovule-Embryo Culture

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Recent research at Reno has been directed toward methodology for recovering interspecific hybrids between alfalfa (*Medicago sativa* L.) and perennial *Medicago* species. Our approach has been to sample reproductive mutants and ploidy levels of *M. sativa* in crosses with the other species. This approach led to the direct recovery via seed of hybrids between diploid *M. sativa* (homozygous for the mutant *jp*) and tetraploid *M. dzhawakhetica* (McCoy and Smith, 1984). This approach was unsuccessful for recovering interspecific hybrids of several other species; however, cytological examination of these interspecific crosses indicated fertilization occurred and was followed by post-zygotic breakdown. Initial attempts to recover interspecific hybrid embryos using published methods failed. In this report an ovule followed by embryo culture methodology will be described that has been successful in recovering several new interspecific hybrid combinations.

Basically, the ovule-embryo culture method consists of culturing the fertilized ovule seven to twenty days post-pollination depending on species. The ovule is cultured for five to eight days and then the embryo is removed. The interspecific hybrid embryo is placed on fresh medium where it develops directly into a plant. Importantly, placement of the hybrid embryo directly onto culture medium is unsuccessful; the interim ovule culture is essential.

For several interspecific hybrid combinations ovule-embryo culture was essential; whereas, for other combinations ovule-embryo culture increases the frequency of hybrid recovery. Cases where ovule-embryo culture was essential were: 1) *M. sativa* (2x) x *M. rupestris* (2x), 2) *M. sativa* (2x) x *M. rhodopea* (2x), 3) *M. sativa* (2x) x *M. papillosa* (2x), 4) *M. sativa* (2x) x *M. marina* (2x), and 5) *M. sativa* (2x) x *M. hybrida* (2x). Ovule-embryo culture was also necessary for the production of the first backcross of *M. sativa-M. rupestris* $F_1$ hybrids back to *M. sativa*. In addition, ovule-embryo culture was essential for the production of hexaploid, trispecies hybrids between triploid $F_1$'s of *M. sativa* x *M. dzhawakhetica* and the naturally occurring hexaploid species, *M. cancellata* and *M. saxatilis*.

Cases where ovule-embryo culture was found to improve the recovery of hybrids were: 1) Diploid $F_1$ hybrids of *M. sativa-M. rhodopea* backcrossed to diploid *M. sativa*, 2) Diploid $F_1$ hybrids of *M. sativa-M. papillosa* backcrossed to diploid *M. sativa*, 3) Triploid $F_1$ hybrids of *M. sativa-M. papillosa* backcrossed to tetraploid *M. sativa*, and 4) Triploid $F_1$ hybrids of *M. sativa-M. dzhawakhetica* backcrossed to tetraploid *M. sativa*.

Twenty or more $F_1$ hybrids of *M. sativa* (2x)-*M. rupestris* (2x), *M. sativa* (2x)-*M. rhodopea* (2x), and *M. sativa* (2x)-*M. papillosa* (2x) have been produced by the ovule-embryo culture method, and in most cases the hybrids have flowered. However, only two hybrids of *M. sativa* (2x)-*M. marina* (2x) and one hybrid of *M. sativa* (2x)-*M. hybrida* (2x) have been recovered and none of these has flowered.

Where possible detailed meiotic pairing studies and cross fertility studies have been conducted on the interspecific $F_1$ hybrids. Results of these studies demonstrate that *M. dzhawakhetica*, *M. papillosa*, *M. rhodopea*, and *M. rupestris* can be considered potential germplasm donors for alfalfa improvement.

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# Effect of Linkage on Approach to Equilibrium in Autotetraploid Random Mating Populations

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Most research on linkage in autotetraploid populations was done more than 30 years ago (1-6). The work that was done dealt with either inheritance studies or with changes in chromosome segment frequencies. Methods that permit calculation of gamete and zygote frequencies from an initial starting point are not available.

Our research project on linkage in autotetraploids was initiated because of increasing evidence indicating that single-locus quantitative genetic models were inadequate for explaining some of the observed responses to breeding methods in alfalfa. More must be known about the behavior of chromosome segments in autotetraploid populations before we can fully understand the breeding behavior of alfalfa.

Computer programs were written to calculate gamete frequencies from a zygote array and form a new zygote array by random combination of the gametes produced. Any number of generations and any recombination value for two linked loci can be studied, but we have concentrated on recombination values of 0.0, 0.125, 0.25, 0.375, and 0.50. The simulations are done under the DeWinton and Haldane (2) model, which is equivalent to random chromosome segregation with only bivalent formation. Attempts to obtain workable algebraic expressions for transitions from one generation to another have so far been unsuccessful.

Two types of disequilibrium values were found in the computer simulation studies; a) a disequilibrium due to differences between actual gamete frequencies and the product of gene frequencies, and b) one due to differences between actual gamete frequencies and the product of chromosome segment frequencies. When the recombination value, r, is zero, the type-a disequilibrium is permanent for some initial populations. The type-b disequilibrium disappears more rapidly and is less affected by values of r than the type-a disequilibrium. For values of $r < 0.25$, the type-a disequilibrium can persist for more than 10 generations. Gametes produced by some zygotes and the approach to equilibrium when $r = 0.5$ is different from that observed when the two loci are on different chromosomes.

The effect of the type-a disequilibrium on the population mean depends on the genetic model. However, the persistence of this type of disequilibrium provides at least one justification for limiting the number of seed increase generations in the production of alfalfa synthetics.

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# Genotypic Differences in Alfalfa Regrowth

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When alfalfa is harvested, there is a period when no regrowth is apparent while old buds start to differentiate and begin growth. Until new leaves are produced the plant lives largely on its assimilate reserves in the root and stubble. Photosynthesis by the new leaves gradually takes over from the reserves until the plant eventually attains the growth rate of uncut plants. In grasses there are marked genotypic differences in the rapidity of this early regrowth (1) and a casual glance at a field of alfalfa a few days after harvest would suggest that the same is true for this species. If genotypes differ in their speed of early regrowth, and this affects their yield at a later harvest, then this would provide a technique plant breeders could use to help select for high forage yield.

To determine whether genotypes differ in regrowth rooted cuttings of 7 alfalfa clones were grown in controlled environment facilities. When established, 1/3 of the plants were cut 3cm above soil level, 1/3 were harvested to determine root and stubble weights and the rest were allowed to continue growing. After 2 weeks all plants were harvested to determine the changes in root, stubble and herbage weights. Although clones did not differ in their uninterrupted growth rates, there were considerable differences in the regrowth of cut plants. The weight loss by the stubble and the root was not related to the weight of regrowth.

In a second experiment using a total of 31 clones, differences in the amount of early regrowth were again found. There were also differences in the uninterrupted growth rates, but there was no correlation with the amount of early regrowth. This indicates that the two traits could be independently selected.

Rapid regrowth is probably associated with efficient and rapid mobilization of carbohydrates from the roots and stubble. Rapid mobilization may occur primarily in those plants which start growth early in the spring and are less winter hardy. Small plots of alfalfa clones have been established in the field to get information on winter survival and to see if there is any relation between early regrowth and final harvest yield.

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# Productivity of Selected Alfalfa Cultivars in Hawaii

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A yield trial consisting of fifteen non-dormant cultivars was planted December 17, 1981 at the Kohala research farm. The farm is located near the northwestern tip of the island of Hawaii, at slightly over 20° N latitude.

The plot area was limed and fertilized before planting with triple superphosphate, K-mag and granusol. Top dress fertilizer consisted of muriate and sulphate of potash. They were applied alternately after every third harvest at a rate totaling 450 lb/A/year of $K_2O$.

The trial was harvested at approximately five-week intervals over the 26-month period from 22 March 1982 until 8 May 1984. During this time interval there were 23 harvests.

Dry matter yields for the first eleven harvests, or approximately one year, are as follows: Florida 77 - 22.9 T/A; WL600 - 22.5 T/A; Granada - 21.5 T/A; WL515 - 21.4 T/A; Florida 66 - 21.4 T/A; adn the lowest yielding cultivar was Amador - 18.2 T/A. The difference between the top cultivar, Florida 77, and the lowest cultivar, Amador, was 4.3 T/A.

In the second year, Florida 66 was the highest yielding cultivar with 23 T/A of dry matter. It was followed by: WL600 - 21 T/A; WL514 - 20.2 T/A; Florida 77 - 19.9 T/A; and Hayden was the lowest yielding cultivar with 12.1 T/A. The difference between the number one and number fifteen cultivars was 11 T/A.

Over the 23 harvests the total dry matter yields were as follows: Florida 66 - 44.4 T/A; WL600 - 43.6 T/A; Florida 77 - 42.8 T/A; Granada - 40.8 T/A; WL515 - 39.8 T/A; and the lowest yielding cultivar, Hayden - 31.5 T/A. The difference in yield between the number one and number fifteen cultivars was 12.9 T/A.

In summary, this trial has shown that based on plot research, several cultivars of alfalfa have the potential for yielding 22 T/A/year of dry matter in Hawaii.

## Use of Soil Nitrogen Levels and Cutting Frequency to Evaluate the Performance of Alfalfa Genotypes in a Breeding Program

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It is important for alfalfa (*Medicago sativa* L.) breeders to use evaluation methods that will effectively and efficiently characterize performance over a range of environments. Some of the important factors that influence alfalfa performance include temperature, moisture, diseases, insect pests, and harvest management. We have been interested in determining if biological nitrogen fixation is limiting alfalfa productivity under field conditions.

The type of management that is used during the evaluation of breeding material can influence which genotypes give the best agronomic performance. Most alfalfa breeding programs have evaluated genotypes in generally favorable environments using high fertility and low stress cutting managements over a period of several years. A few breeders have suggested that selection in unfavorable stress environments would better identify faulty phenotypes, thereby increasing the chances of selecting superior genotypes. We have been interested in determining if a short term stress test could be used in a breeding program.

The objectives of this study were to: 1) determine the effect of high, medium, and low soil nitrogen concentrations on the field performance of alfalfa populations, and 2) determine the effect of different levels of stress due to cutting managements which were superimposed on the nitrogen concentrations. The experimental design was a randomized complete block with a split-plot treatment arrangement. Whole plots were the six management treatments (3 nitrogen levels and 2 cutting managements). Subplots were thirty entries representing subpopulations from four winterhardy germplasm sources. Four replications of hill plots (7 plants/plot) were established at each of three locations. The three nitrogen treatments were ambient nitrogen, excess nitrogen (450-560 kg/ha of ammonium nitrate applied in split applications, and no nitrogen (produced by applying 11,210 kg/ha finely ground straw incorporated prior to planting). The two cutting managements consisted of a normal three-cut system and a four-cut system which is considered a high-stress type of management in Minnesota (Sheaffer 1983, Sheaffer and Barnes 1983). Plants were started in conetainers in the greenhouse about April 1, 1983 and transplanted without disturbing the root system to the field in mid-May. The cutting management treatments were applied during the establishment year and a residual cutting was taken in early June the following year to measure cutting management effects.

Results indicated that there were significant differences for nitrogen levels, cutting management, and nitrogen levels x cutting managements. High nitrogen levels prevented nodulation and significantly increased forage yield during the establishment year, thus indicating that biological nitrogen fixation was limiting forage production. A significant cutting management x entry interaction was also observed, thus suggesting that the type of management used to evaluate alfalfa populations will influence their rank in performance.

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# Survival and Vigor of Alfalfa Cultivars and Experimental Strains Space Planted into Rangeland and Grazed by Sheep

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Few detailed comparisons have been made among alfalfa cultivars or strains in a grazed situation in semiarid, rangeland environments. Heinrichs (1) has pointed out that most alfalfa breeding has emphasized high forage yields and that very limited selection has been practiced for persistence and sustained yield of alfalfa used for grazing. The present study compares establishment, survival, and vigor of 11 winterhardy alfalfa cultivars or strains that have widely different genetic backgrounds. Individual plants were spaced on 0.9 m centers within replicated plots that were grown in association with cool-season, rangeland grasses on a harsh rangeland site and grazed by sheep for three seasons. Survival percentages and vigor scores of the 11 entries are presented in Table 1.

Table 1. Percentage survival of 3-month old transplants in the establishment year, percentage of the original stand surviving after three seasons of grazing, and vigor scores of surviving plants after three seasons of grazing.

| | Percentage Survival | | |
|---|---|---|---|
| Cultivar or Strain | Establishment year | Grazed 3 Seasons[1] | Vigor Score[2] |
| C-6 Composite | 93.7 | 56.0 | 6.4 |
| KS-10 | 91.8 | 44.7 | 6.7 |
| Roamer | 91.8 | 65.0 | 6.7 |
| Mandan Composite I | 91.0 | 76.8 | 6.0 |
| Drylander | 90.1 | 69.6 | 6.2 |
| Mandan Composite II | 89.8 | 77.6 | 6.1 |
| SD Border Composite | 89.2 | 81.0 | 6.1 |
| Ladak 65 | 88.9 | 45.1 | 6.5 |
| Spredor II | 73.8 | 54.8 | 6.7 |
| Ramsey | 63.0 | 44.1 | 7.2 |
| Alaska | 58.2 | 81.0 | 6.2 |
| $S\bar{x}$ | 2.4 | 3.0 | 0.2 |
| $lsd_{.05}$ | 6.8 | 8.8 | 0.6 |

[1] Percentage of original stand surviving.
[2] 1-9 where 1=most vigorous.

Alaska, Ramsey, and Spredor II had lower survival in the establishment year than other entries. Entries with slow regrowth and early fall dormancy, typical of *Medicago falcata*, had a higher percentage of surviving plants under grazing pressure than entries with rapid regrowth typical of hay-type cultivars. After three seasons of grazing, composite strains derived from open-pollinated seed of plants selected from old local plantings had higher survival and vigor than current cultivars developed for rangeland grazing. These data indicate that it should be possible to develop new cultivars with improved persistence and vigor for use in grazing interseeded rangeland or pastures seeded with grass-alfalfa mixtures.

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# Seedling Year Selection for Seed Yield in Alfalfa

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Few reports in the literature address either the methodology or effect of selection for alfalfa seed production. Melton (1969) reported significant increases in seed yield of single crosses based on two years data under New Mexico conditions. Kehr et al. (1976) also reported disappointing progress in phenotypic recurrent selection for seed yield after either 1 or 2 cycles of phenotypic recurrent selection for seed yield in Idaho.

In 1978 we initiated a study to determine the effect of selection in the seedling year for seed yield and number of seeds per pod on seed yield and components of seed yield. Populations derived from one of three cultivars, 'CUF 101', 'Team', and 'Vernal', were developed through two cycles of bidirectional phenotypic recurrent selection. Within each cultivar paired (high and low) populations were made for one of two selection criteria: number of seeds/pod and seed yield. Selection was conducted at both the West Side Field Station and Davis, California. Following selection the 12 cycle-2 populations were planted at the West Side Field Station, Davis, and Prosser, Washington. At each location seed yield and components of seed yield were determined for each of two years.

Significant selected-population x environment interactions were detected for some of the selections. However, none of these interactions resulted in changes in relative rank of high and low populations within selection criteria. Selection at both the West Side Field Station and Davis resulted in significant differences between high and low selections in both seed yield and number of seeds/pod in each of the respective germplasm sources.

These data demonstrate that significant improvement can be made in seed yield when selection is conducted in the seedling year under well controlled field conditions in a good seed producing area. Selection for number of seeds per pod increased seed yield in all environments, but selection response was only about 60% of that for seed yield per se and selection response at Davis was significantly less than at the West Side Field Station. We do not recommend indirect selection for seed yield using number of seeds per pod.

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## A Stress Test for Assessing the Winter Hardiness of Alfalfa in Northwestern Canada

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The ability to survive a "test winter" is essential in recommending new alfalfa cultivars for northwestern Canada. A "test winter" is one which is of such severity to kill the plants of most tender cultivars but will only damage those of intermediate hardiness. Although "test winters" are common in this region, their frequency and intensity are insufficient at any one location to be used reliably for assessment purposes. A rapid and accurate means of assessing winter hardiness in the field would be invaluable in developing new cultivars for this region.

The first step to develop a meaningful screening procedure is to define the primary factors responsible for winterkill during a "test winter." Low soil temperatures in early winter and low food reserves have been identified as the two primary factors responsible for winterkill during the 1977-1978 winter in this region (1). These parameters were used to develop a method for assessing the winter hardiness of alfalfa cultivars in the field. The method consisted of defoliating test plants at frequent intervals prior to autumn then removing snow cover in early winter. Frequent defoliation reduced food reserves while removing snow exposed the plants to low soil temperatures. Eight experiments were conducted from 1979 to 1984.

Frequent defoliation during the growing season plus removing snow cover in early winter separated the winter hardiness differences among alfalfa cultivars particularly when winter stresses were intermediate in their severity. However, under severe cold stress, survival differences were apparent without the frequent clipping treatment. Cultivar rankings for winter hardiness following severe stress induced by snow removal only were significantly correlated ($r = .944$) with the mean survival observed at five locations following natural winter stress in this region.

It is recommended that the following procedure be used to stress plants: (A) One year old plants should be clipped in mid-June, late July and early September. (B) Cold hardiness of control plants should be assessed 2-3 weeks prior to the cold induced stress period in order to determine the limits to which soil temperatures can drop before differential winterkill will occur. (C) Snow cover should be removed once during early winter on the first day that -30°C air temperatures are forecasted. (D) Soil temperatures should be monitored to assess whether freezing temperatures are sufficient to damage the cultivars. If soil temperatures do not drop close to the cultivar's $LT_{50}$ during the first snow removal, snow cover can be removed again provided air temperatures are near -30°C.

Several limiting factors became apparent during the course of the study. The test is entirely dependent upon natural winter conditions, there is little control on the degree of stress to which the plants are exposed and food reserves are not always depleted by the cutting treatment. Thus successful employment in every winter is not always possible and results must be interpreted accordingly. However despite these limitations the stress induced procedure has real merit in rapidly evaluating the winter hardiness of cultivars, in screening winter hardy genotypes and in assessing management techniques to reduce the effect of stressful winter environments on alfalfa production in northwestern Canada.

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# Breeding Alfalfa for Phosphorus Concentration in Southern New Mexico

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Alfalfa grown in most areas of New Mexico has phosphorus (P) concentrations ranging from 0.15% to 0.25%. These levels are below those considered to be adequate for efficient hay and dairy production. The addition of several forms of P fertilizers has not increased P concentration. As a result, in 1981, a program was initiated at New Mexico State University to determine the possibility of breeding alfalfa for increased P concentration.

Initially, 90 spaced plants from each of 10 diverse genetic sources were evaluated for mean P concentrations and plant-to-plant variability. Results indicated that there were no significant differences among the genetic sources for P concentration. However, there was a large degree of plant-to-plant variability which was considered sufficient to initiate a divergent selection program. Selection was based on P concentration in the first harvest. The selection intensity was 5% with the selection differential being 32% of the unselected population for the high P and 26% for the low P.

Evaluation of intercross progeny from each of these selected groups versus specific checks indicated that selection was effective in changing P concentration. In the first harvest, high P progeny was 5% greater, and low P progeny 5% lower than their respective checks. The realized heritability estimate was 0.17. These differences were consistent across four harvests.

Second cycle selected populations for high P exceeded the first cycle population by 9% but second cycle populations selected for low P did not result in a significant decrease when compared to the cycle 1 low P population.

Selection for increased P concentration did not depress forage yield as had been suggested in other studies. Calcium (Ca) concentration and the Ca:P ratio were lowered by selection for increased P concentration. These results indicated that hay from the high P population would be more desirable for dairy production.

Phosphorus fertility studies involving the selected populations and Mesilla, again indicated that there were no differences among these populations for forage yield. However, the high P populations were more responsive to P fertilization than the unselected populations resulting in higher P concentrations and lower concentrations of Ca, and the Ca:P ratio.

Selection for P concentration significantly increased concentrations of zinc (Zn), manganese (Mn), boron (B), iron (Fe), and aluminum (Al) but did not affect magnesium (Mg) and copper (Cu). In each case where the elements were affected, populations selected for increased P concentration were higher for all elements than check populations or populations selected for low P. Changes in Mn and B were small and not considered to be of biological significance. Changes in Zn concentrations were more obvious in the cycle 2 high P populations. Differences among populations were most obvious for Fe and Al late in the growing season.

Based on data obtained in these studies, the development of a high yielding cultivar of alfalfa which is higher in P concentration than existing cultivars is feasible for New Mexico.

# Selection Methods to Improve Alfalfa Productivity under Less Than Optimum Moisture Conditions

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Eventhough more water is used by agriculture than any other industry, available moisture is the most limiting factor in U.S. and world agriculture. Alfalfa production in the western United States is possible only through extensive use of surface and groundwater sources for irrigation. Due to the relatively high water requirement of alfalfa, irrigation must be used to produce an economically stable crop. Problems with the availability of water for irrigation have arisen due to erratic supplies of surface water, depletion of groundwater reservoirs, competition from non-agricultural sources, and water-limiting legislation. These pressures have prompted the development of an alfalfa breeding program with the goal of improving the ability of alfalfa to grow with less than optimum moisture.

Seven selection techniques have been evaluated for their ability to identify genotypes that survive and grow when water is the major limiting factor. The following selection techniques were evaluated: leaf temperature, percent drymatter, dry down, polyethylene glycol (PEG), wilt, field capacity, and stress tests. The leaf temperature and percent drymatter tests were used as an indicator of genotype water status. The dry down test evaluated the ability of cut stems to hold water against evaporation. Cut stems of individual genotypes were placed in an osmoticum of PEG 6000 and scored for wilting in the PEG test. The wilt test evaluated genotypes for survival and regrowth after release from severe moisture stress. Forage yield of genotypes grown in soil watered to 40 or 60% of soil field capacity was evaluated in the field capacity test. The stress test evaluated the ability of genotypes grown in the field to survive and grow without supplemental irrigation.

The leaf temperature, percent drymatter, and dry down tests were discontinued due to the lack of variability among genotypes. The PEG, wilt, field capacity, and stress tests identified possible drought productive genotypes. Recurrent selection populations were evaluated for forage yield in field plots receiving low, medium, and optimum levels of irrigation.

Populations developed by the PEG and field capacity tests produced 16 and 12% higher yields than their checks at the medium irrigation level, respectively. Populations developed by the stress test produced 41% higher relative yields at the low irrigation level. Populations developed by the wilt test produced only a slight yield increase at the optimum irrigation level. Forage yields of second cycle populations developed by the PEG and field capacity tests exceeded the forage yields of the first cycle populations by 4 to 19% at the low and medium irrigation levels. The PEG, field capacity, and stress selection techniques have produced populations that have high relative yields in field tests with less than optimum irrigation. These populations should increase forage production potential in environments where limited water availability decreases plant growth.

## Population Shifts in 32 Seed Lots of Arc Alfalfa

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Concern is often expressed that changes in plant growth habit or levels of disease or insect resistance may be occurring during seed multiplication of alfalfa cultivars from pre-breeder to the certified generations. Several studies of these shifts have been reported in the literature. In the study reported herein 32 seedlots of 'Arc' alfalfa, representing up to three generations of increase, from a single pre-breeder seedlot and produced from 1971 to 1976 at Tehachapi and Shafter, CA; Prosser, WA; and Echo, OR, under field cages using honey bees or leafcutter bees as pollinators were collected for evaluation of four growth habit traits and anthracnose resistance for which Arc was bred.

The growth habit traits (fall growth, winter injury, date of flowering, and regrowth after cutting) were taken on a total of 120 plants per entry arranged in a 6 X 6 triple lattice design with three reps (repeated) in field plots established in 1977 at Lafayette, Ind. Anthracnose evaluations (race 1) were made at the Beltsville Agricultural Research Center in 1977. Between 100 and 120 total plants represented each seedlot and were planted in single rows in soil-filled flats in a randomized block design with four reps. Seedlings were spray inoculated using standard procedures with conidia of race 1 of *Colletotrichum trifolii* Bain and evaluated for percentage of resistant plants.

Results of the evaluations revealed no consistent indication of significant shifts in cultivar characteristics over generations of seed increase at any of the three locations. However, some indication was noted of a trend toward a shift in fall growth and regrowth after cutting in the third generation of increase at the Shafter location.

## Advanced Generation Performance of Narrow-based Alfalfa Varieties

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Effects of generation advancement on agronomic performance and pest resistance of narrow-based synthetic varieties of alfalfa should be of concern to breeders, seed growers, seedsmen and the ultimate forage producers. Yet, little information is available on performance of the commercial or certified generation (Syn 3) as it relates to the breeders (Syn 1) or foundation (Syn 2) performance. To obtain information on such effects, the Syn 1, Syn 2 and Syn 3 generations of several commercial alfalfa varieties were evaluated in 3 forage (Test I and II, Webster City, Ia. and Test III, Sparta, Wisc.) and single seed, pea aphid and bacterial wilt trials from 1979 to 1983. Varieties included in some or all tests were Valor, Pacer, Blazer, 120, Peak, and Epic which are 9, 8, 10, 9, 9 and 10 clone synthetics, respectively. Breeders seed in all cases was produced on the parental clones in isolation and grown in Idaho as was all foundation seed. Some certified seed was grown in the Pacific Northwest and some in California. Highlights of the results are summarized briefly in the following sections.

Overall, the forage yield trend from Syn 1 to Syn 2 to Syn 3 varied from variety to variety and from test to test. Yield trend for Pacer was stable in Test I, down slightly in Test II and up in Test III. For 120 it was down significantly from Syn 2 to Syn 3 in Test I, stable in Test II and up in Test III. Blazer yields trended down with generation advancement in Test I and II and stable in Test III. Similarly, Peak and Valor yield trends were down in Test II and stable in Test III. Of a possible 180 statistical comparisons among the 3 generations, only 6 were significant at the 5% level. Syn 3 (certified) yields of all varieties in most instances were above the Vernal, Saranac and Agate checks.

In a seed yield trial at Caldwell, Idaho in 1980-81 containing 5 varieties, 12 of 45 generation comparisons were significant at the 5% or 1% levels. Valor and 120 showed substantial losses in seed yield from Syn 1 to Syn 2 or to Syn 3, while Peak and Pacer were stable. For Blazer, the Syn 3 was significantly above (5% level) the Syn 1 and Syn 2.

All 6 varieties were evaluated in a pea aphid test and no significant differences among generations for percent resistance was noted. In a bacterial wilt trial, Blazer, Pacer and 120 were stable for resistance over generations, while Valor lost some resistance. Peak and Epic dropped significantly in resistance from Syn 1 and Syn 2 to Syn 3. Seed of the Syn 3 for the latter two was grown in California.

Results from these tests provide some interesting information on performance of narrow-based synthetic varieties of alfalfa in advanced generations. Possible interpretations that might be made or questions raised from these findings are as follows:

...Parent clone number or diversity may not be an accurate predictor of advanced generation agronomic performance.

...Genetic theory predictions of advanced generation performance based on one test at one location for one or two years could give highly misleading information.

...Accurate evaluation of potential Syn 2 or Syn 3 performance of a narrow-based synthetic should be based on results for that variety only.

...With good seed production practices, most narrow-based synthetics hold up well for forage yield in the Syn 2 and Syn 3.

...Advanced generation performance for seed yield in alfalfa synthetics may be harder to maintain or predict than forage yield.

...Pea aphid resistance, which was at a fairly high level in all entries, appears to be quite stable and less subject to genetic shift from Syn 1 to Syn 3 than forage or seed yield.

...Bacterial wilt resistance appeared subject to considerable genetic shift (loss) with generation advancement in certain varieties. Results indicate that commercial seed production in California may result in a rather dramatic loss in bacterial wilt resistance.

...Indications herein of improved performance with generation advancement, as noted in certain other studies, were rare.

## Tannins and Legume Pasture Bloat

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In plants, the term "tannin" is used to describe phenolic compounds which have the ability to precipitate proteins. The two broad classes found in plants are hydrolyzable tannins and condensed tannins. These compounds occur in the leaves, stems, flowers and seeds.

Our interest in condensed tannins in the bloat program stems from the knowledge that forage legumes known to contain these compounds are also nonbloating. After herbage is ingested by ruminants, the rapid initial digestion of cell walls with the ensuing release of intracellular foaming agents are prerequisites for the onset of bloat. Experiments using dry matter disappearance have shown that initial digestion is retarded when herbage containing condensed tannins is digested in the rumen of a fistulated animal. The evidence indicates that if alfalfa (*Medicago sativa* L.) leaves contained the same type of condensed tannins found in sainfoin (*Onobrychis viciifolia* Scop.), it too would be bloat-safe. To date, however, no alfalfa plant containing condensed tannins in the herbage has been found.

In birdsfoot trefoil (*Lotus corniculatus* L.), condensed tannin synthesis in the herbage is an inherited trait thought to be controlled by a single, dominant gene. In alfalfa, the condensed tannins found in the seed coat are probably maternally derived and do not appear until the seed pod begins to curl. This suggests a mechanism, possibly hormonal, which switches on tannin synthesis during seed development. Other investigators have suggested that the number of reducing equivalents present in the metabolic pathway might be important in promoting tannin synthesis. These two ideas require further attention.

Two new approaches, both involving tissue culture techniques, are being investigated in our laboratory. First, intergeneric somatic hybridization may provide a method for transferring the tannin synthesizing capability from sainfoin herbage to alfalfa herbage. The second approach would make use of the inherent somaclonal variation which occurs when callus tissue is allowed to grow for an extended period of time and is then induced to produce embryos. This technique could be used as a screening method in the search for tannins in alfalfa herbage.

The goal of obtaining an alfalfa plant which contains condensed tannins in its herbage should be pursued as an alternate approach in our breeding program to produce a bloat-safe alfalfa. A knowledge of tannin biology and chemistry combined with current biotechnology methods will aid in achieving this goal.

# Progress in Breeding a Bloat-safe Alfalfa Cultivar

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Continued progress has been made toward the development of a bloat-safe alfalfa cultivar. The basic strategy of this project is to produce a 25% reduction in the initial rate of digestion (IRD) by recurrent phenotypic selection. Divergent strains with fast and slow IRD are being selected. The strain with increased rate of digestion serves as a check on the progress of selection, and it may have practical value by way of improved silage-making characteristics. Several laboratory procedures for the assessment of individual plants have been developed and assessed. The greatest progress has been achieved using the modified nylon bag technique. Dry matter disappearance (DMD), from fresh herbage, is measured after a 4 hour period of digestion in fistulated cattle. Typical DMD values for alfalfa are 40-70%.

The effectiveness of selection by nylon bag IRD has been verified by independent tests at a different location, the Lethbridge Research Station, where progeny from first cycle selections had DMD values of 46.5% and 52.3% for the slow- and fast-digesting strains, respectively (1). The second cycle selections appear to give further divergence, but data from second cycle progeny are not yet available. A third cycle of selection has been initiated. Present plans are to conduct a bloat incidence test with cattle, after three cycles of selection.

An unexpectedly high heritability value was obtained from a heritability study of the IRD characteristics. This study will be repeated. Our experience during selection of plants suggests a moderate heritability. Environment variation has been observed. Careful evaluation and several samplings of individual plants are essential. The vegetative and bud stages of development show the widest range of differences among alfalfa genotypes. All selections have been based on field-grown plants. IRD values from potted plants in the greenhouse have not been correlated with values from subsequent field growth.

The principal disadvantages of the nylon bag IRD method are: (1) the requirement for fresh herbage, (2) cost due to the time required for sampling, chopping and weighing, and (3) lack of suitable reference standard. For these reasons, alternative approaches to a bloat-safe cultivar are still under investigation: (1) selection for greater cell wall strength using a sonication technique, (2) an in vitro cellulase-pectinase digestion technique, and (3) the introduction of tannins into alfalfa herbage through biotechnology. Nevertheless, the nylon bag IRD has consistently shown the expected relationships with bloat and thus we believe it is the shortest and fastest route to a bloat-safe alfalfa cultivar.

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# A Preliminary Evaluation of Annual Medics at Two Northern Great Basin Locations

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Annual medics originated in the Mediterranean Region. In that environment they grow over a wide range of soils, temperature regimes, and growing seasons (Ewing 1983). Medics were introduced into Australia in the 19th century as contaminants of hay purchased in North Africa (Breth 1975). Since that time, their agricultural importance has been widely recognized, cultivars of several species have been bred, and a wheat-legume ley rotation system developed in Australia. In the Negev desert herbage yields of 4 to 6 ton/ha dry matter have been obtained from medics under waterspreading conditions in an 80 to 100 mm winter rainfall range site (Tadmor et al. 1971). Medics have not been widely used in agriculture in the United States. Recently Koala and Sims (1982) reported that black medic (*Medicago lupulina*) increased wheat yields 92% and water use efficiency 81% at Bozeman, Montana. Our objective was to determine the feasibility of using annual medic species as reseeding range legumes in the northern Great Basin area.

Two replicate plantings of 589 accessions representing 35 species of *Medicago* were sown in clean-tilled nurseries in Cache Valley, Utah, and Curlew Valley, Idaho, on April 6, 1981, and April 14, 1981, respectively. Twenty-five seeds were planted in meter long plots spaced one meter apart within rows and two meters apart between rows. All seeds were inoculated with appropriate *Rhizobium meliloti* strains immediately prior to planting. Data were obtained during 1981 to 1983.

Most of the non-perennial species of *Medicago* were easily established in nurseries at the two test sites. Many grew more rapidly during the seeding year than did the perennial check species, *M. falcata*. However, no annual or biennial species was as well nodulated or reduced acetylene on a per plant basis as well as *M. falcata*. None of the populations were able to mature, reproduce, and initiate a soil seed bank at the droughty Curlew Valley location. *M. laciniata*, *M. lupulina*, *M. murex*, and *M. muricoleptis* excelled in the numbers of seedlings per meter obtained by natural reseeding in the fall of the first year of test. However, only *M. lupulina* (black medic) produced significant numbers of seedlings during the second year following establishment. We concluded that *M. lupulina* could develop a soil seed bank more rapidly than the other species. It also had superior ground cover characteristics during the second and third years after sowing than the other species tested. We believe that adapted populations of *M. lupulina* will prove to be of long-term value for forage production on Great Basin range sites with soil and climatic conditions similar to those of Cache Valley, Utah.

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# Alfalfa Seed Increase Project at Reno, Nevada

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The alfalfa seed increase project at Reno, Nevada is charged with raising perennial alfalfa accessions to increase the amount of seed of many worldwide accessions. This is a cooperative project between the University of Nevada-Reno Plant Science Department and the USDA's North Central Region Plant Introduction Station at Ames, IA. The Plant Introduction Station has seed from approximately 1400 alfalfa accessions. Seed is sent from Ames to Reno on a yearly basis. It is the task of the Alfalfa Seed Increase Project to increase the original seed to 30 grams production within 2 years. Starting in 1984 and continuing in subsequent years, the project will plant 200 varieties each year. In the near future these and previous Reno seed increase accessions will be tested for resistance to anthracnose, *Phoma*, Verticillium wilt, Fusarium wilt, *Phytophthora*, stem and root know nematode, alfalfa weevil, leafhopper, seed chalcid, and various aphids.

Original seed is planted in Conetainer flats in early January of each year. Two hundred seeds per accession (if that many are available) are planted and maintained in a greenhouse. Plants are clipped, fertilized, and sprayed for pests for approximately 4 months. In late April through May, 100 plant populations are transplanted to 3m x 2.4m plots in the field. When the plants come into bud, the plots are caged and covered with Saran Shade Cloth or fiberglass cloth over a metal tubing frame. Plots are caged to prevent outcrossing. Leafcutter bees, *Megachile pacifica*, are used as pollinators. These bees nest in small (100-200 hole) drilled wooden blocks, which can be moved between cages. Insecticides are applied in the field to prevent damaging populations of aphids (pea and spotted), lygus bugs, and mites. The detrimental effects of pesticide application to bees can be minimized by removal of leafcutting bee nesting blocks to non-sprayed cages. In late summer and early fall, after pollination is completed and the alfalfa seed matures, the alfalfa plots are sprayed with defoliants, cut, and dried in the greenhouse. Each accession is run through a thrasher and the seed is cleaned, labeled, weighed, and sent back to Ames.

From 1979 to 1983, 555 accessions have been grown for seed in Reno. The origins of these accessions include 44 different countries. The bulk of perennial accessions increased in Reno are *Medicago sativa* ssp. *sativa*; other subspecies include *falcata*, *caerulea*, *glandulosa*, and *ambigua*. Yields of accessions have ranged from 0-730g from 1979-83. Over 90% of the accessions have attained the 30g goal for two years of production. In 1984 the project in Reno will have 382 accessions in seed production: 202 first year, 167 second year, 11 third year, and 2 fourth year.

## Plasmid Profile of Selected *Rhizobium meliloti* Isolates

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The genetic information for nodule initiation (NOD) and Nitrogenase (NIF) in *Rhizobium meliloti* resides on extrachromosomal DNA fragments known as plasmids. The plasmid encoding for NOD and NIF in *R. meliloti* is large and has been referred to as the megaplasmid. Since bacterial plasmids contain the genetic information of many traits in addition to NOD and NIF, we thought it important to evaluate plasmids in *R. meliloti*.

Large MW plasmids were observed in most of the 27 isolates of *R. meliloti* from nine locations examined in this study. Molecular weights ranged from 42 to 331 x $10^6$ daltons with the majority of the isolates exhibiting one plasmid of MW greater than 200 x $10^6$ daltons. Only the four isolates from Kansas failed to exhibit any plasmids. Further examination of these isolates demonstrated a loss of the ability to nodulate alfalfa, providing circumstantial evidence that nodulation genes are a plasmid borne character. The presence of a large plasmid in an isolate of *R. meliloti* does not assure the establishment of an effective symbiosis. Isolate 102F26 forms ineffective nodules with alfalfa. The inability to establish an effective symbiosis could be the result of either a deletion of the NIF genes from the plasmid or an insertion of DNA into this region of the plasmid. Unfortunately, from our investigations, it is not possible to determine why this isolate is ineffective.

The greatest degree of homology for plasmid profile (number and MW) was observed for the isolates of *R. meliloti* obtained from Canada and Hawaii. The Canadian isolates all exhibited one plasmid with MW of 288 x $10^6$ daltons or greater. Less similarity was observed when comparing the MW of the second and third plasmids in these isolates. Two of the Hawaiian isolates exhibited similar MW for both the first and second plasmid indicating that these isolates might be closely related. The third isolate from Hawaii did not appear to be as closely related to the other isolates from Hawaii. Plasmid profile comparisons for the other isolates of *R. meliloti* failed to detect any strong patterns of similarity.

The genetic information contained on these very large plasmids offers a significant increase in the amount of genetic information available to these bacteria. For example, a plasmid of MW 140 x $10^6$ daltons carries sufficient genetic information to code for 200 genes (Davis et al., 1973). A plasmid of 300 x $10^6$ daltons contains genetic information equivalent to approximately 10% of the total chromosome of *Escherichia coli* (2.7 x $10^9$ daltons) (Hardy, 1981). Since plasmids frequently carry the genetic information for accessory traits such as NIF, NOD, antibiotic resistance and bacteriocin production, they may be very important in determining the success of these isolates in the environment. Because they code for NOD genes, they may act to determine how competitive an increase is in nodulating alfalfa in the field.

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## Growth Analysis of Alfalfa Compared to Three Other Forage Legume Species

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A growth analysis of 'Iroquois' alfalfa (Medicago sativa L.), 'Norcen' birdsfoot trefoil (Lotus corniculatus L.), 'Monarch' cicer milkvetch (Astragalus cicer L.), and common source Montana sainfoin (Onobrychis viciofolia Scop.) was conducted at Rosemount, MN. The objective of the study was to determine whether the four forage legumes have different morphological patterns of dry matter and feed nutrient accumulation and different forage quality deterioration in leaves and stems from initial spring growth until maximum dry matter accumulation of the first crop.

All species were sown in July 1981. Beginning on May 10, 1982 and 1983, total forage was harvested from 1.0 $m^2$ in each of four replicates for each species except cicer milkvetch. It was sampled only in 1983. Harvests continued on a weekly basis until the final sample on June 28. Samples were separated into stem, leaf, and reproductive components, dried and weighed. Crude protein (CP) and in vitro digestible dry matter (IVDDM) were determined using near infrared reflectance spectroscopy.

All species achieved maximum dry matter accumulation on June 21. Sainfoin accumulated the most total dry matter with 8510 kg/ha during growth of the first crop. The other three species did not differ in dry matter accumulation and ranged from 6969 kg/ha for birdsfoot trefoil to 6238 kg/ha for cicer milkvetch. The four legumes differed in their relative proportions of leaves to stems over time. Alfalfa reached a leaf to stem ratio of 1.0 on May 10, birdsfoot trefoil on May 24, sainfoin on May 30, and cicer milkvetch on June 10.

On June 21 (maximum dry matter accumulation) cicer milkvetch had the highest total forage IVDDM concentration at 67.6 dag/kg, followed by birdsfoot trefoil at 64.1 dag/kg, alfalfa at 61.8 dag/kg, and sainfoin at 59.6 dag/kg. Leaves maintained a high concentration of IVDDM whereas stem IVDDM decreased with time. Total forage IVDDM concentration usually followed that of the dominant stems. Alfalfa and birdsfoot trefoil had leaf IVDDM concentrations greater than that of stems throughout the study. Cicer milkvetch and sainfoin had stem IVDDM concentrations greater than that of leaves until the first week in June.

Accumulation of IVDDM was similar to that of dry matter. All legumes reached maximum IVDDM accumulation on June 21. Sainfoin accumulated the most, 5070 kg/ha, followed by birdsfoot trefoil at 4441 kg/ha, alfalfa at 4300 kg/ha, and cicer milkvetch at 4211 kg/ha.

On June 21, alfalfa and birdsfoot trefoil had the highest CP concentrations at 17.2 dag/kg and 16.5 dag/kg, respectively. Cicer milkvetch was intermediate at 14.5 dag/kg and did not differ statistically from birdsfoot trefoil or sainfoin. Sainfoin had the lowest total forage CP concentration of 12.6 dag/kg. Leaves of all four species contained a greater concentration of CP than did stems throughout the experiment. The stems decreased in CP concentration at a faster rate than did the leaves.

CP accumulation did not follow dry matter accumulation as closely as did IVDDM accumulation because the quality advantage for leaves over stems was much greater for CP. On June 21, alfalfa, birdsfoot trefoil, and sainfoin had similar CP accumulation values of 119 kg/ha, 114 kg/ha, and 107 kg/ha, respectively. Cicer milkvetch had least CP accumulation at 91 kg/ha, but differed only from alfalfa.

# Effects of Protocloning in Regen S Alfalfa on Somatic Chromosomes and on Mitochondrial and Chloroplast DNAs

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Populations of alfalfa protoclones regenerated from nonmutagenized mesophyll protoplasts of two Regen S clones, RS-K1 and RS-K2, exhibited phenotypic variation and chromosomal changes following regeneration (1). Protoclones significantly superior, equal, and inferior to their parents in dry weight forage yields were obtained. The latter two classes greatly predominated. Considerable morphological variation occurred, much of it possibly explainable through observable chromosomal changes. Seventy and 55% of the RS-K1 and RS-K2 protoclones, respectively, deviated from normal karyotype (2n=4x=32), including increased ploidy, aneuploidy, and translocations. Octoploidy or near octoploidy was the most frequent change.

Phenotypic variants also occurred among protoclones without distinct karyotypic change. Because the mitochondrial genome can also change following tissue culture (2, 3), we examined selected protoclones of both normal and abnormal karyotype for possible changes in organelle DNAs. Following organelle isolation, mitochondrial DNA (mtDNA) and chloroplast DNA (cpDNA) were extracted, digested with restriction endonucleases, and the fragments separated by agarose gel electrophoresis (3).

The mtDNAs of both parents and 20 protoclones were indistinguishable after restriction with Bam HI, Bgl II, Eco RI or Xho I. Lack of observed changes does not preclude either large rearrangements in other protoclones or smaller undetected changes, but does suggest that mtDNA rearrangements as a result of protocloning, if they occur at all, are less frequent in alfalfa than in maize (2) or potato (3).

The same restriction endonucleases also could not distinguish the cpDNAs of the parents and 23 protoclones. However, when the endonuclease Xba I was used, the two parents and one protoclone had an approximately 8.4 kb fragment that the other 22 protoclones lacked. Hpa II and Mbo I digestion confirmed that both parents and one protoclone differed from the other 22. The progenitors of Regen S [Saranac and DuPuits], and bulked progeny from selfed RS-K1 but not RS-K2, also possessed the fragment. We found no indication of cpDNA rearrangement following protocloning, but rather saw evidence that the two cpDNAs found in the protoclones were initially present in the Regen S parents. The two cpDNAs may differ by the presence or absence of an approximately 700 bp fragment. Possible factors explaining our results include a preferential selection of cpDNAs during protocloning, possible shifts in parental cpDNA composition with time, or both.

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# Reaction of Eight Glandular-Haired *Medicago* Species to Four Alfalfa Pathogens

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The shoots of several *Medicago* species are invested with erect capitate-stalked secretory glands. They provide highly effective resistance to two very destructive insects via entrapment of first instar alfalfa weevil larvae, *Hypera postica* (Gyllenhal) and potato leafhopper nymphs, *Empoasca fabae* (Harris). To facilitate the development of multiple pest-resistant germplasms, we evaluated the reaction of eight annual and perennial glandular-haired *Medicago* species and *M. sativa* to four foliar pathogens of alfalfa. Standard test (1) procedures were used, except for *P. trifoliorum* evaluation.

| *Medicago* species | Chromosome No. (2n) | *Peronospora trifoliorum* I-7[a] | I-8[a] | *Cercospora medicaginis* Range[b] | Avg. | *Colletotrichum trifolii* (*Race 1*) Range[b] | Avg. | *Uromyces striatus* Range[c] | Avg. |
|---|---|---|---|---|---|---|---|---|---|
| Perennial | | | | | | | | | |
| *M. glandulosa* David. | 16 | 2 | 3 | 2–5 | 2.7 | 1–5 | 3.8 | 2–3 | 2.7 |
| *M. prostrata* Jacq. | 16 | 100[d] | 100[d] | 2–5 | 4.3 | 1–5 | 3.8 | 4–5 | 4.4 |
| *M. glutinosa* M. B. | 32 | 55 | 3 | 3–5 | 3.9 | 1–4 | 1.5 | 3–4 | 3.6 |
| *M. sativa* L.'Saranac' | 32 | 49 | 24 | 2–5 | 3.7 | 1–5 | 3.9[e] | 3–5 | 4.1 |
| Annual | | | | | | | | | |
| *M. blancheana* Boiss. | 16 | 0 | 0 | 5 | 5.0 | 5 | 5.0 | 4–5 | 4.8 |
| *M. disciformis* DC | 16 | 0 | 0 | 4–5 | 4.8 | 3–5 | 4.6 | 2–3 | 2.2 |
| *M. intertexta*(L.)Mill. | 16 | 0 | 0 | 3–5 | 4.1 | 1 | 1.0 | 5 | 4.6 |
| *M. rugosa* Desr. | 30 | 0 | 0 | 3–5 | 3.6 | 3–5 | 3.5 | 4–5 | 4.6 |
| *M. scutellata*(L.)Mill. | 30 | 0 | 0 | 5 | 5.0 | 4–5 | 4.8 | 4–5 | 4.8 |

[a] % of plants with sporulation. [b]Scale of 1 (no symptoms) to 5 (dead). [c]Scale of 1 (no symptoms) to 5 (many medium to large open pustules). [d]All plants were killed. [e]'Arc' Avg. = 1.6.

Of the perennial species tested, *M. glandulosa* showed a high degree of resistance to all pathogens whereas *M. prostrata* showed little or none. *M. glutinosa*, the only glandular-haired species that readily crosses with tetraploid *M. sativa*, was equally or more resistant than *M. sativa* (Saranac) to all pathogens. All of the annual species were highly resistant to *P. trifoliorum*. Resistance of *M. disciformis* to *U. striatus* and of *M. intertexta* to *C. trifolii* was high (see table).

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# Selection for High Seed Production in Medicago sativa L. - Preliminary Results

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Alfalfa varieties must be good seed producers because low seed yield does not ensure adequate supplies of seed at reasonable prices (4,5,9). Yet in ranking alfalfa varieties seed yield has never constituted an important criterion and breeders have not done a great amount of work aimed at improving seed yield in this species (1). Besides, much of the published data has been concerned with the elucidation of component factors that together make up seed yield, with only a few examples of studies carried through a selection phase (3).

The present research was conducted at Perugia (Italy) with the desire to initiate a breeding program to increase the seed yield potential of the Italian synthetic variety "Adriana".

Three hundred plants were collected at random in a 2-year old stand of "Adriana" during the spring 1980 and space transplanted in a field experiment. Two hundred seventy plants survived the 1980-81 winter. In 1981 data were collected on green matter yield (1st cut) and seed yield per plant on 2nd regrowth. Open-pollinated (O.P.) seed from each one of 72 plants superior in seed yielding capacity was sown along with 9 entries of "Adriana" as systematic controls, in April 1982 (2 square-meter plots with 4 rows at 25 cm distance and seeding rate of 20 kg/ha). Due to the large number of entries, a double lattice design was adopted. In 1982-83 data were collected on total dry matter yield (sum of 4 cuts) and seed yield per square meter (1983 2nd cut).

The initial population showed normal frequency distributions for forage yield and seed yield; on the contrary, a distribution skewed to the right was evident for Harvest Index (H.I.) determined as seed yield/(straw + chaff + seed). The linear correlation coefficient between seed yield and forage yield in the initial population was positive and significant ($r = 0.60$) but not very high, as already evidenced in alfalfa by other authors (2,6). The Spearman's rank correlation coefficient ($r_s$) between seed yield and H.I. showed a value of $r_s = 0.81$. It is interesting to note that the five plants with the highest seed yield showed a H.I. = 0.31 compared to an average H.I. = 0.17. These plants might be physiologically able to supply the developing seeds with a higher quantity of food. The table shows the results of selection for seed yield at different selection intensities. The responses obtained with selection for seed yield seem to be quite remarkable. In connection with the highest intensities of selection ($i = 2.47$ and $i = 2.90$) the O.P. progenies showed average seed yields of 44.1 and 60.4 g/m$^2$ which are 17% and 61% higher than the seed yield of the control (37.6 g/m$^2$). The O.P. materials never showed significant differences in forage yield compared to the control (see Table).

Our data, which must be verified through further experiments, support the opinions of several authors (1,3,5,7,8,10) about the possibility of obtaining positive results with breeding programs aimed to the increased alfalfa seed yield without negative correlated responses on forage yield.

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Average seed yield (g/plant) and green matter yield (g/plant) of the initial population, selected plants, and O.P. progenies. (S = selection differential, i = selection intensity, R = response to selection.)

| % of the initial population in the selected groups | Initial population (n = 270) | Selected plants | | | | O.P. progenies of selected plants | Control | R | |
|---|---|---|---|---|---|---|---|---|---|
| | x ± sd | x ± sd | No. of plants | S | i | x ± sd | x ± sd | Absolute values | % |
| | seed yield (g/plant) | | | | | seed yield (g/m$^2$) | | | |
| 28 | 14.7 ± 9.7 | 26.7 ± 5.7 | 72 | 12.0 | 1.23 | 39.7 ± 13.1 | 37.6 ± 10.8 | 2.1 | 6 |
| 13 | " " | 30.8 5.4 | 36 | 16.1 | 1.65 | 39.1 14.7 | " " | 1.5 | 4 |
| 7 | " " | 34.7 5.3 | 18 | 20.0 | 2.06 | 38.6 18.6 | " " | 1.0 | 3 |
| 3 | " " | 38.7 4.7 | 9 | 24.0 | 2.47 | 44.1 22.4 | " " | 6.5 | 17 |
| 2 | " " | 42.9 3.8 | 5 | 28.2 | 2.90 | 60.4 15.3 | " " | 22.8 | 61 |
| | green matter yield (g/plant) | | | | | dry matter yield (Kg/m$^2$) | | | |
| 28 | 367.3 ± 148 | 482.4 ± 117 | 72 | 115.1 | 0.78 | 1.43 ± 0.10 | 1.37 ± 0.06 | 0.06 | 4 |
| 13 | " " | 495.8 137 | 36 | 128.1 | 0.87 | 1.41 0.09 | " " | 0.04 | 3 |
| 7 | " " | 551.7 157 | 18 | 184.4 | 1.25 | 1.42 0.10 | " " | 0.05 | 4 |
| 3 | " " | 614.4 183 | 9 | 247.1 | 1.67 | 1.41 0.08 | " " | 0.04 | 3 |
| 2 | " " | 642.5 118 | 5 | 275.2 | 1.86 | 1.44 0.09 | " " | 0.07 | 5 |

# Winter Survival and Production of Alfalfa as Influenced by Establishment Method

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Alfalfa suffers considerable winter damage on soils which are imperfectly drained. Often the loss, which is a combination of heaving, desiccation and disease, occurs the first winter of an establishing stand. This study was conducted to determine if seeding method influenced soil properties and survival of alfalfa.

Alfalfa was seeded in August, with and without prior tillage, and with and without an associated grass. Grasses seeded with alfalfa were timothy and perennial ryegrass. A split-plot design with seeding methods as main plots and seeding mixtures as subplots was used. Alfalfa seedling density, percent survival, heaving, and yields were determined. Soil temperature and moisture and progressive vertical movement of wooden stakes over the winter were monitored.

All treatments resulted in acceptable seedling densities the October following seeding. Seedings into tilled seedbeds resulted in greater winter losses than those under no-till conditions. Frost heaving was less under no-till, compared with tilled treatments, and was associated with less soil temperature fluctuation and greater ground cover. Most heaving occurred during the week of March 10-16. Vertical movement of stakes was significantly related to plant heaving ($r = .76$).

# Lucerne Pollen Contamination by Leafcutter Bees in Greenhouse Cages

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Leafcutter bees have been used in New Zealand to produce seed of breeding lines in greenhouse cages. Bee colonies are established in the cages and flowering plants of breeding lines are introduced each day. However there is a lack of information on pollen contamination or isolation times when using leafcutter bees in cages. Such information is important if the breeder is to ensure purity in his lines.

Contamination of lines with different isolation treatments was studied using white flowered female parents. White flowers is a homozygous rcessive condition of the C gene controlling production of anthocyanin pigments (1). The C gene controlling anthocyanin production is epistatic over the P gene (purple flowers) and the Rd gene (red hypocotyls). The lack of a dominant C gene results in white flowers and green hypocotyls (2). Purple flowered plants were pollinated and after isolation periods of 0, 2, 4 and 16 hours (overnight) white flowered plants were introduced. Levels of contamination were measured by the frequency of red hypocotyls or purple flowers in the progeny of the white flowered plants.

Isolation periods of 16 hours or less were inadequate in preventing pollen contamination. Isolations longer than 16 hours were not tested because of the effect on the bees. Periods of over 2 hours isolation in bright sunlight resulted in the bees becoming disorientated and normal nesting behavior ceased.

Use of an alternative flowering species during isolation periods was tested to overcome these problems. Periods of 0, 2, 4, 18 and 24 hours isolation with white clover, red clover or sanfoin as an alternative species were tested. Only the 24 hour interval with normal bee activity ensured that there was no contamination of the progenies. If bee activity slows or ceases, cleaning activity is also reduced. Pollen is therefore carried for greater lengths of time. If bees are inactive, isolation with an alternative species may have to be extended beyond 24 hours.

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# Presence of Colletotrichum trifolii Race 1 in Argentina

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Anthracnose (Colletotrichum trifolii Bain) is a serious disease of alfalfa in most places where alfalfa with a flemish background is grown (2).

The disease has been successfully controlled by planting resistant cultivars (3) although new races capable of attacking certain formerly resistant cultivars have been found (1, 4, 5). For this reason, the race or races present in different geographic areas should be known before new anthracnose-resistant cultivars are released or developed.

Three isolates of C. trifolii were obtained from diseased plants collected at three widely separated locations of Argentina.

Based on the disease reaction (percent seedling resistant) of 4-week-old seedlings of alfalfa cultivars "Saranac AR" and "Arc", the three isolates were all race 1.

Alfalfa cultivars with resistance to race 1 should be resistant when grown in the areas where these isolates were obtained. Cultivar "Cuf 101", which is increasingly grown in Argentina, was susceptible to the three isolates.

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# Effect of Anthracnose on the Yield and Persistence of Some Alfalfa Cultivars

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Anthracnose, caused by Colletotrichum trifolii Bain, is one of the most frequently observed diseases of alfalfa in the subhumid region of the Argentine Pampas. Nevertheless, the incidence of this pathogen on the yield and persistence of alfalfa in Argentina is still unknown. This is mainly due to the presence of other parasitic organisms that directly or indirectly affect the life of the plant and, therefore, the longevity and productivity of the alfalfa crop (1, 2, 3).

This study was carried out in an alfalfa cultivar trial established at Manfredi Agricultural Experiment Station, Córdoba, Argentina.

A close correlation (r = + 0.88) between C. trifolii-infected plants and stand losses measured as number of empty spaces in the row, was observed. The results of this experiment show that anthracnose infection on susceptible cultivars was the main cause of forage yield decrease and stand decline.

The cultivars "Kanza" and "Cordobesa INTA" were significantly less affected by the disease and maintained their stands throughout the 4-year trial. This would suggest the existence of a certain level of field resistance in these two cultivars that provided some protection from anthracnose infection. Both cultivars are considered susceptible when inoculated using artificial infection produced under laboratory conditions.

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# Foreign Travel Report: Collecting Plant Germplasm in the U.S.S.R.

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Country Visited: Soviet Union

--Russian S.F.S. Republic
Kalmyk A.S.S.S. Republic
Leningrad Oblast
Moscow Oblast
Smolensk Oblast

--Ukranian S.S. Republic

Kherson Oblast
Kiev Oblast

--Uzbek S.S. Republic
Samarkand Oblast
Tashkent Oblast

Period of Travel: Ausust 16-September 14, 1982

| | |
|---|---|
| Moscow | August 16-17 |
| Stavropol | August 18-21 |
| Elista | August 22-25 |
| Kiev | August 26 |
| Kherson | August 27-29 |
| Kiev | August 30 |
| Tashkent | August 31-September 3 |
| Samarkand | September 4-9 |
| Leningrad | September 10-13 |
| Moscow | September 14 |

Purpose of Trip:

1) To collect seeds and *Rhizobium* nodules of *Astragalus*, *Medicago*, and other legumes adapted to arid and semiarid rangelands.

2) To collect seeds of *Agropyron*, *Elymus*, *Hordeum*, and related species; particularly *A. cristatum*, *A. desertorum*, and *E. junceus*.

SUMMARY

A 30-day plant collecting trip to the U.S.S.R. by K. H. Asay and M. D. Rumbaugh resulted in 412 accessions being added to USDA plant germplasm resources. These included 168 forage legume and 171 forage grass collections. The remainder of the accessions consisted of grain and horticultural crop seed samples. A total of 79 genera were represented by the collection. Twenty-two accessions of legumes included Rhizobium bearing nodules from the roots of plants from which seeds also were obtained.

Areas visited were near the cities of Stavropol, Elista, Kherson, Tashkent, Samarkand, and Leningrad. Thus, a number of ecosystems were examined. Accessions collected near Elista in the Kalmyk Republic may prove to be well adapted to the Great Plains of the United States, those from Stavropol and Kherson to more humid regions, and those from Tashkent and Samarkand to more arid zones. The collections obtained from Leningrad were of populations which had been tested and found to be superior in one or more attributes. The time at which the trip necessarily took place (August 16-September 14) prevented the collection of many species of desirable forage grasses and legumes which had matured and shattered.

Although the expedition was successful, certain changes in time, routing, and procedures would have maximized the opportunity to obtain additional germplasm of value to plant breeders in the United. States. Our recommendations follow:

1) The geographic region in the U.S.S.R. of most promise for plant materials adapted to the semiarid and arid rangelands of the United States extends from the Tien-Shan Mountain Range westward to the Aral Sea and northward within the Kazakh S.S.R.

2) The desert flora of the U.S.S.R. includes many shrubs of value for rangeland improvement. More than 150 ecotypes of Kochia prostrata have been catalogued by Soviet botanists. Plant materials experts from the United States should collect seeds of desert shrubs in the southeastern U.S.S.R. during the months of October and November.

3) Future trips to obtain seeds of forage grasses and legumes in the southern part of the U.S.S.R. should take place in late May and June.

4) All expeditions should be planned to include U.S. scientists, specialists from the N. I. Vavilov Institute at Leningrad, and botanists from the region in which the collecting is to take place. Expeditions should be equipped with four-wheel drive vehicles and/or horses to permit obtaining of germplasm in more remote areas. Most of the previous collections have been made near urban centers and adjacent to highways where the flora may not adequately represent the germplasm of more remote and less heavily used sites.

## TRAVEL DETAILS

August 13: Traveled from Logan, Utah, to Washignton, D. C. We were met and briefed on the arrangements and itinerary of the trip by Eric Erickson of the OICD Staff.

August 14-16: Traveled from Washington, D. C., to Moscow with a 1-day layover in Frankfurt, Germany.

August 17: The USDA wheat study and the plant germplasm collection teams met with a delegation from the U.S.S.R. Ministry of Agriculture and the Vavilov Institute to discuss our respective itineraries. Those in attendance included:

U.S. Team Members:

1) Keith R. Severin, FAS, USDA, Washington, D. C.
2) Arthur F. Shaw, Agronomist, Montana State University, Bozeman, MT
3) Don Loeslie, Spring Wheat Farmer, Warren, MN.
4) Kay H. Asay, Research Geneticist, USDA, Logan, UT.
5) Melvin D. Rumbaugh, Research Genetiicst, USDA, Logan, UT.
6) Dale M. Posthumus, Agricultural Officer, U.S. Embassy, Moscow.

N. I. Vavilov Institute of Plant Industry:

1) Enver T. Meshcherov, Head, Plant Introduction Dept., Leningrad.
2) Stanislav V. Kuznetsov, Head, Division for Foreign Relations, Leningrad.

U.S.S.R. Ministry of Agriculture:

1) Alexander A. Konygin, Chief, Main Administration for Foreign Relations, Moscow.
2) A. I. Zholohov, Chief, Administration for Grains, Moscow.
3) Y. Buryakov, Deputy Chief, Administration for Grains, Moscow.
4) Valery K. Merzlov, Executive Secretary-Counselor, U.S.S.R. Secretariat, U.S.S.R.-U.S. Joint Committee on Agricultural Cooperation, Moscow.
5) Valentina V. Gorobets, Scientific Worker, Science and Technical Information Department, AURRI, Krasnodar.

I pointed out that I expected to collect nodules as well as seeds of the legumes and this was acceptable. Mr. Konygin repeatedly stated that we were to have access to the seed collection of the institutes we were to visit. We also learned that Mr. Kuznetzov was to accompany us and to act as interpretor. He subsequently proved to be both very capable and diligent and contributed greatly to a successful collecting trip. His command of English is excellent, he has experience in breeding forage sorghum and is an excellent administrator.

August 18: Traveled by air from Moscow to Stavropol. At Stavropol we met members of the staff and toured the grounds and laboratories of the Agricultural Research Institute. The most important contacts here were:

1) Alexander Kitaev, Assistant Director and Head of the Selection Program.
2) Victor Kravzov, Head, Division of Perennial Grasses. Dr. Kravzov traveled with us throughout our stay in the Stavropol area.

The Institute is conducting research with forage crop rotations and mixed species plantings. There is considerable interest in using plantings of corn and soybeans for silage in a ratio of two rows of corn to one row of soybeans.

August 19-21: We met the staff of the Stavropol Botanical Garden.

1) Stanisla Ledovskoi, Director of the Botanical Garden.
2) Vadim Tanfiljev, Botanist.
3) Djantemir Dzibov, Botanist.

Professor Tanfiljev is a very competent botanist and maintains an extensive plantings in the Botanical Garden. However, he is 79 years old and only works part of the time. Mr. Dzibov accompanied us during our collections in the vicinity of Stavropol. Plantings on the grounds of the garden have been established by mass seeding of collections from the virgin steppe lands and by transplanting sod. The flora is quite rich with as many as five legume species within one square meter.

We were permitted to collect seeds within the Botanical Garden and at three locations near Stavropol. Two locations were steppe grasslands on a large state farm 20 km west of the city. The most frequently observed legume was Medicago romanica (2-3 plants/$m^2$) with Coronilla varia, Lathyrus silvestris, Lotus cancasicus. Vicia angustifolia, and Vicia tetrasperma also being abundant. The grasses included several species of Agropyron, Bothriochloa Brachypodium, Dactylis, Phleum, and Stipa. The third location was a game preserve 20 km south of Stavropol. Elevation was 800 m and the annual precipitation was said to be above 600 mm. There were few legumes but Astragalus falcatus, Lotus caucasicus Medicago lupulina, Trifolium repens, and Vicia tenuifolia were obtained. Species of grasses still bearing seed included Brachypodium rupestra, Festuca valesiaca, Lolium perenne, Melica transivanica, and Phleum pratense. A number of forb, shrub, and tree species also were collected here. Dr. Tanfiljev added to the collection by contributing 8 accessions of legumes and 18 of grasses. I requested samples of Hedysarum and Sanguisorba but they were not included. Although our work at Stavropol resulted in 108 accessions being added to the USDA Plant Introduction System, we were concerned that many of these accessions duplicate previous collections. Douglas R. Dewey, A. Perry Plummer and other USDA scientists previously have collected in the vicinity of Stavropol and the vegetation in these ecosystems has been adequately sampled.

August 22-25: Traveled by car to Elista in Kalmyk Republic. We were met at the border by a delegation of the following people:

1) V. I. Usalko, Deputy Minister of Agriculture, Kalmyk Autonomous S.S.R. An aggressive administrator who would do well in the United States.
2) P. D. Bakaev, Director, the Kalmyk Scientific Research Institute of Meat Cattle Production.
3) E. M. Bayanov, Director, Chernozemelsk Experimental Farm.
4) Olga A. Lachko, Botanist. An excellent taxonomist who was very helpful and who is an authority on Kochia prostrata.

We later met and had discussions with the following:

1) I. E. Bugdaev, Minister of Agriculture, Kalmyk Autonomous S.S.R.
2) I. A. Abushinov, Director, State Farm "Sorok Let Komsomola."
3) U. S. Karibov, Director, Collective Farm "Lenin."
4) I. G. Chub, Agronomist, Collective Farm "Novii Mir."

The area along the highway nearest Stavropol is irrigated and intensively managed. Irrigation systems observed were of the "Frigate," "Valley" center pivot, and moveable line sprinkler types. A high percentage of the crop land is used for silage crops including corn, sorghum, and sunflowers. As we approached the Kalmyk Republic the land form and vegetation changed to superficially appear to be much like that of the drier parts of the Great Plains. According to the Minister of Agriculture, livestock products account for 70% of the total agricultural output of the republic. In 1981 the Kalmyk Republic produced 58,000 tons of red meat of which 40-43% was beef, 30-35% mutton, 6-8% pork, and the remainder horse. Wool production was 21,900 tons. There are 64 million hectares of native grasslands, 25,000 hectares of irrigated alfalfa, 37,000 hectares of irrigated and dryland sudan grass, and 7,000 hectares of irrigated rice. Only local populations of alfalfa are seeded and all irrigation water is from two rivers draining from the Caucasus. Little high quality ground water is available and there is no possibility of a substantial increase in the irrigated crop area. The major factor limiting agricultural production is a shortage of water. Much of the republic has soils with high salt content and water in some of the larger lakes is not suitable for irrigation of crops because of salt.

The Kalmyk Republic has one major research facility, the Kalmyk Scientific Research Institute of Meat Cattle Production, and smaller substations investigating problems in forestry and in the production of rice and other irrigated crops. The institute has crossed the local strain of cattle with the Santa Gertrudis and Limousin breeds to achieve a 30-35 kg increase in body weight at 18 months of age. Plant species included in breeding and agronomic research programs are corn, millet, rape, rice, and wheat. The institute is responsible for seed produciton of all species. Bromus inermis yields 2-3 centners of seed per hectare when grown in 300 mm precipitation areas. Irrigated alfalfa is cut 4 times and yields 80-90 centners/ha.

We only observed rangelands to the north and west of the capital city of Elista. All were in good conditions and rotational grazing was practiced. We were told that approximately 40,000 ha of rangelands have been reclaimed by sowing species such as Colliginum aphyllum and Eurotia ceratoides. Other species cited as being of value for range improvement were Artemisia austriaca, A. lercheana, A. pauciflora, Eurotia ceratoides, Glycyrrhiza glabra, Haloxylon aphyllum, and Kochia prostrata. More than 150 ecotypes of Kochia prostrata are recognized. Haloxylon aphyllum from the Uzbek Republic is being evaluated in

200 mm annual precipitation areas. Eurotia ceratoides is highly valued for sites with sandy soils. The locations where we collected received 250 mm precipitation annually and often were dominated by Echinopsilon sedoides (Syn. Bassia sedoides or Kochia sedoides). Legumes species observed were of the genera Coronilla, Glycyrrhiza, Lathyrus, Medicago, Melilotus, Trifolium, and Trigonella. Grass collections included Agropyron, Bromus, Calamagrostis, Elymus, Elytrigia, Eragrostis, Festuca, Poa, Puccinellia, and Poa. A total of 89 accessions of all species were collected. Many should be of value for pasture and range improvement in semiarid regions with salty soils.

August 26: Traveled by air to Kiev.

August 27-29: Traveled by air to Kherson and visited the Ukranian Scientific Research Institute of Irrigated Farming. We met the following staff:

1) V. I. Ostapov, Director
2) S. A. Gladkov, Alfalfa Breeder
3) T. B. Nemolovskaya, Corn Breeder
4) V. I. Zaveryukhin, Head, Division of Agrotechnics and Soybean Breeding

Mr. Gladkov is 70 years old but maintains an aggressive alfalfa breeding program. He is very much interested in research on saponin content. Mr. Zaveryukhin speaks english very well and has traveled to the United States. He would be an important contact person for any soybean scientist planning to visit the U.S.S.R. Although we asked for seed samples, none were received.

We also visited the Ukranian Scientific Research Institute of Animal Breeding for Steppe Regions and the Askania Nova Nature Preserve located approximately 150 km east of Kherson. Scientists who assisted us there were:

1) P. S. Golovanyev, Deputy Director
2) E. P. Veden'kov, Head, Division of Virgin Steppe Lands
3) L. H. Panova, Botanist

This institute has developed four breeds of sheep, two breeds of swine, and some improved lines of cattle. It maintains a large arboretum and zoo as well as 11,000 ha of virgin steppe grasslands. We arrived too late in the season to collect most of the species growing here. Only a few accessions of Agropyron pectiniforme, Bromus inermis, Elytrigia repens, Koelaria gracillis, Poa angustifolia, and Stipa capillata were obtained. The non-grass components of the vegetation consisted primarily of coarse forbs of limited value. Legumes were scarce although Coronilla varia, Medicago romanica, and Trifolium diffusum were observed. If this site were to be re-visited it should be during May-June with the objective of obtaining germplasm of grasses.

August 30: Traveled by air to Kiev.

August 31-September 3: Traveled by air to Tashkent in the Uzbek Republic. Near Tashkent we met the following people:

The Central Asian Branch of the N. I. Vavilov Institute of Plant Industry.

1) I I. Pugachev, Director
2) L. S. Kolokol'tseva, Alfalfa Specialist

The institute appeared to be staffed with qualified people and to have ample laboratory and field space, but lacked appropriate equipment to conduct highly technical research. The biochemistry laboratory seemed quite primative with the exception of a spectrophotometer and two centrifuges. Several basement rooms in the laboratory were equipped with shelving and were said to be climatically controlled for seed storage but were not being used. We were told that the seeds were sent from Leningrad. The institute has developed over 200 cultivars of fruit, flowers, cotton, and vegetables.

We viewed the alfalfa field plots which consisted of a single replicate planting of 35 U.S. and 35 Spanish cultivars and populations for forage yield measurements with a duplicate planting being used for a seed yield trial. These were irrigated and it was obvious that water application had not been uniform throughout the test and that the data were unreliable. Many of the cultivars being evaluated are adapted to Canada and the northern United States rather than the southwestern states which have a climate more like that of Uzbek. The two highest yielding U.S. cultivars were 'Salton' and 'WL-508'. The seed yield trial was severely damaged by powdery mildew (pathogen not identified), lacked pollinating insects, and showed evidence of improper water management. We also viewed plots of forage soybeans, cow peas, field beans, and sesame. The grape research program was more impressive with 1,500 populations under test. We recommend that an exchange of grape breeders from Tashkent and the United States be initiated. We were not shown any plots of forage grasses. Seeds of two alfalfa cultivars were obtained from the institute. These were the only seeds made available to us. Repeated requests for additional materials were answered by saying that all seeds came from Leningrad and we could obtain them there.

The third day we were taken to the headquarters of the Chatkal Mountain Forest Reservation in the village of Parkent, 50 km southeast of Tashkent. We met the following scientists:

1) V. M. Yesikov, Director
2) O. V. Savitch, Deputy Director
3) Yu. G. Bululookov, Head, Division of Mountain Land Reclamation.

The preserve was founded in 1947 and is Uzbekistan's oldest protected territory. It consists of 35,200 ha on the western spurs of the Chatkal Ridge of the Tien-Shan Range. Elevation varies from 1,100 to 4,000 m. Precipitation at the lowest and highest elevations averages 600-700 mm annually but the zone between 2,500 and 3,000 m received 900 mm from clouds and mists. It soon became apparent that the headquarters personnel were not prepared for our visit. No 4-wheel drive vehicles were available to take us into the forest. When we inquired about horses we were told that they had 50, but none were made available to us. At 2:00 p.m. we drove to a small village near the reserve and walked approximately 6 km to the reserve boundary. Our guide stated that this was a typical area and that we were to collect there. However, it was badly overgrazed, very dry, and we had arrived too late in the season to collect most of the forage species. It is known that 91 legume and 101 grass species occur within the reserve over a wide range of ecosystems. An expedition to obtain this germplasm should be considered.

September 4-9: Traveled by air to Samarkand. We were met by the Minister of Agriculture who had arranged our program. It consisted of a series of visits and interviews with no arrangements for collecting seeds. Mr. Kuznetsov asked that the program be revised and this was attempted. We did go to the Uzbek Grain Research Institute located about 75 km northeast of Samarkand and met the following people:

1) M. A. Amanov, Director and Physiologist
2) D. P. Baigulov, Head, Division of Forage Production
3) P. P. Olenyk, Grain Legume Breeder
4) Yu. A. Arinov, Head, Division of Barley Breeding

We participated in the customary briefing about the activities of the institute but were not able to obtain any seed samples there. We collected in parks within the city of Samarkand, purchased seed samples at the Farmer's Market within the city and collected at two outlying locations. One location was approximately 75 km west of Samarkand and 10 km south of the town of Kattakurgan. The major crops are pistachio and wheat. We examined the pistachio orchards thoroughly but they had been grazed and few forage plants escaped. A large irrigation reservoir is located near Kattakurgan. As the water was used and receded, crops were planted in the bed of the reservoir. Beans, melons, sunflowers, sesame, and forage grasses were being grown in that way in an area that would otherwise have been too arid. We also collected in a mountainous region about 25 km south of Samarkand. This region also had been intensively grazed, was very dry, and we arrived too late to obtain very many desirable accessions.

September 9: Traveled by air to Leningrad.

September 10-13: Our contacts in Leningrad were scientists on the staff of the N. I. Vavilov Institute of Plant Industry. These included the following:

1) Dr. Vesvolod L. Vitkovsky, Deputy Director
2) Dr. Enver T. Meshcherov, Head, Department of Plant Introduction
3) Dr. J. N. Shsherbakov, Plant Breeder
4) N. A. Mukhina, Clover Breeder
5) Z. P. Shutova, Grass Breeder
6) Anatoly A. Tiurin, Foreign Relations. He speaks German but not English.

Dr. Vitkovsky briefed us on the organization and activities of the institute. The major tasks relate to the collection, preservation, and evaluation of plant germplasm. Both crop species and wild plants are obtained and the collection now contains more than 300,000 accessions. A network of 18 research stations have been established as a part of the institute to evaluate and characterize the collections. The most promising accessions are increased and made available to plant breeders. Breeders are acquainted with this material through publications and "field seminars." As many as 2,000 accessions of wheat are grown out of one location at one time. Breeders are provided an opportunity to examine each accession and to request those that they wish to use in their research programs. The institute has a staff of 6 Academicians, 40 Doctors of Science, 400 Candidates of Sciences, and adequate support personnel.

We were given a copy of the 1982-85 seed list published by the institute and told to indicate those accessions that we wanted to acquire. We requested all available accessions of Astragalus, Hedysarum, and Medicago legumes and a number of Agropyron, Dactylis, Elymus, Elytrigia, Festuca, Hordeum, Lolium, and Psathyrostachys grass species. The grass plots at the Field Laboratory near Pushkin were visited and some superior populations and cultivars of Festuca, Lolium, and Poa noted. Seeds also were requested of those populations.

We were given 112 accessions of Medicago species and 43 accessions of grasses. It was understood that other accessions will be mailed at a later date. Dr. Meshcherov gave us a list of plant cultivars developed in the United States and requested that we send seed of them to him.

September 14: Traveled from Leningrad to Moscow by overnight train. We made an oral report on the trip to Dr. V. K. Merzlov at the U.S.S.R. Ministry of Agriculture and then traveled to London, Great Britain.

September 15: Returned to Logan, Utah.

Table 1. Alfalfa seed and nodule collections obtained in the Soviet Union in 1982 by K. H. Asay and M. D. Rumbaugh

| | Number of collections | | |
|---|---|---|---|
| Species | Nodules only | Seeds and nodules | Seeds only |
| Medicago carstiensis | | | 1 |
| " falcata | | 1 | 2 |
| " lupulina | | 3 | |
| " romanica | 1 | | 4 |
| " romanica X M. sativa | | 1 | |
| " sativa | | 2 | 7 |

# Foreign Travel Report: Collecting Plant Germplasm in Morocco

M. D. Rumbaugh and W. L. Graves
USDA-ARS, Utah State University, Logan, UT
University of California, San Diego, CA

Country Visited: Morocco

Period of Travel: July 1 - August 13, 1983

| | |
|---|---|
| Rabat | July 2-6 |
| El Jadida | July 7 |
| Rabat | July 8-10 |
| Souk el Arba du Gharb | July 11 |
| Chefchaouen | July 12-14 |
| Al Hoceima | July 15 |
| Oujda | July 16 |
| Taza | July 17 |
| Azrou | July 18-21 |
| Midelt | July 22-24 |
| Rabat | July 25 |
| Errachidia | July 26-29 |
| Ouarzazate | July 30-August 2 |
| Taroudant | August 3-4 |
| Marrakech | August 5 |
| Rabat | August 6-7 |
| Tanger | August 8-9 |
| Rabat | August 10-13 |

Purpose of Trip:

1) To collect seeds of cultivated forage legumes, especially strains of alfalfa (*Medicago sativa* L.).

2) To collect seeds of forage legumes, grasses, and shrubs suited for arid and semiarid rangelands.

3) To collect nodules of all legumes for subsequent isolation and culture of their nitrogen fixing *Rhizobium* bacteria.

## SUMMARY

The 6-weeks-long plant collecting trip to Morocco by M. D. Rumbaugh and W. L. Graves resulted in the acquisition of 855 accessions which will be added to USDA plant germplasm resources. More than 60 genera and 130 identified species are represented in the collection. These consist primarily of forage plants but seeds of barley, corn, millet, sorghum, and wheat also were obtained.

The geographic, edaphic, climatic, and vegetation regions of Morocco are extremely diverse. Elevation varies from sea level to more than 4,000 m in the interior mountains. While much of the country is dominated by a Mediterranean type climate, the higher elevations are colder and accumulate considerable snow in the winter. The 400 mm (16 inches) precipitation isohyet corresponds roughly with the limit between the Mediterranean and Steppe regions, while the 100 mm (4 inches) isohyet is the best approximation to the boundary of the Sahara. All cultivation without irrigation requires more than 200 mm (8 inches) of precipitation. Semi-nomadic pastoralism is the major form of land resource utilization throughout the steppe lands and a large part of the mountains as well.

The annual legume species within Morocco are now adequately represented in USDA germplasm holdings. This is also true of the indigenous perennial grasses and legumes. The alfalfa collection is very complete except for the extreme southeastern and southwestern parts of the country where military activity precluded travel. Some of these ecotypes may have immediate use in pasture and rangelands of the western United States. Other accessions will be used in breeding programs to incorporate desirable attributes such as salt tolerance into improved cultivars.

## TRAVEL DETAILS

July 1-10: The first 10 days were spent in traveling from our duty stations to Rabat, visiting a herbarium, locating and meeting contacts, and in making local collections in the vicinity of Rabat and adjoining coastal areas. Many people were helpful during this initial phase of the collection as well as at later times. These included the following persons:

Mr. Hamidou Bouyayachen, Assistant to the Agricultural Attache, U.S.A. Embassy. Mr. Bouyayachen is fluent in Arabic, Berber, English, and French. He has extensive contacts throughout Morocco and was most cordial and helpful throughout our stay in that country. His assistance was highly valued.

Dr. Günter Jaritz, Research Leader, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). A very competent Senior Scientist who is keenly aware of the importance of germplasm exchange and preservation. His team of scientists works closely with those of the Institute National de la Recherche Agronomic (INRA) in the development of superior forage crop cultivars and management systems. Team members provided significant help to us at several times.

Dr. Albrecht Glatzle, a GTZ team member who is experienced in rhizobiology. He collected with us on the route from Rabat to Oulmes via Tiflet.

Mr. Mustapha Bounjemate, a forage agronomist and head of the INRA forage research program who generously shared both his seeds and a technician.

Mr. Abodelkader Qazi, a technician for INRA who traveled with us for two weeks. Mr. Qazi speaks Arabic, Berber, and French, and was very influential in obtaining alfalfa seeds in the southern part of the country.

Dr. Richard S. Aro, Acting Chief-of-Party, U.S. AID Range Management Project. Dr. Aro provided information and suggested certain modifications of our preliminary travel plans. He also actively assisted with the collection effort in the areas of Azrou and Timahdite.

Mr. John Harding, U.S. AID Range Management Project. Mr. Harding is the manager of a seed farm southeast of El Jadida and helped us collect in that vicinity as well as around Chefchaoven at a later date.

Mr. Pierre Roumet, Plant Breeder, Institute Agronomique et Veterinaire, Hassan II University. Mr. Roumet works on an alfalfa breeding project directed by Mr. Birouk who was in France during this time.

Like much of Morocco, the region extending from Kenitra north of Rabat to El Jadida south of Casablance and east to Oulmes has a Mediterranean climate. However, summer temperatures are moderated by proximity to the Atlantic Ocean. Irrigated truck farms under intensive management are very productive. Small grain, corn, and grapes are important dryland crops. Extensive pasturage supports sheep production and some areas have large cork-oak (*Quercus subra*) forests. The part of Morocco north of the mountains generally has deeper and more fertile soils than that part of the country south of the mountains. Annual precipitation exceeds 300 mm and supports a luxuriant annual vegetation during the rainy period. Legume species constitute an important component of the vegetation on most sites. We were able to collect samples of the following legume genera: *Astragalus*, *Biserrula*, *Cicer*, *Coronilla*, *Medicago*, *Ornithopus*, *Scorpiurus*, *Trifolium*, and *Vicia*. The *Medicago* and *Trifolium* genera were especially well represented in these ecosystems with 13 and 15 species, respectively, included in the collection. The grasses on which we could find seeds included several species of *Agropyron*, *Dactylis*, *Hyparrhenia*, and *Phalaris*.

At most sites it was impossible to obtain large quantitites of seeds. The preceeding three rainy seasons had been much below the normal precipitation and this extended drought had drastically reduced both the numbers of plants and the amount of seed per plant. The intense grazing of all available vegetation also made the task of locating pods and seed heads very time consuming. This problem was encountered throughout our travels in Morocco and even affected the collection of irrigated crops such as alfalfa (*Medicago sativa*). Established stands were being used for forage rather than seed production because of the shortage of irrigation water and consequently livestock feed.

July 11-17: Our route in the second major segment of the collection extended from Souk-el-Arba-du-Rharb northward through the Rif mountains to Chefchaouen, eastward through the coastal plains and foothills to Al Hoceima and Oujda, southerly to the high plateau region near Ain-Beni-Mather, and then back to the west to Taza, and through the Moyen Atlas to Azrou. Many natural ecosystems and types of agriculture were observed in these areas.

Again, drought was severe throughout the country and greatly restricted the kinds of sites in which we could find seeds. Nevertheless, in this region we obtained 122 accessions representing 12 genera and 37 species of forage legumes, 13 genera and 15 species of grasses, and 5 genera of trees, shrubs, and forbs. Many of these are of very desirable forage species growing in unusually arid habitats. The *Dactylis glomerata* collections, for example, were from sites that were much drier than the regions in which this species is habitually used for forage in the United States. We believe that the germplasm collected in Morocco can be used in breeding programs to considerably extend the range of Dactylis. Several of the subterraneum clover (Trifolium subterraneum) accessions were obtained from relatively high elevations. Such germplasm may be of value in extending the range of this useful species further into the mountains of California and Oregon, and in the southeastern United States.

July 18-25: This very productive week was spent collecting in the Moyen Atlas mountains around Azrou and in the Plain de l'Arid in the vicinity of the city of Midelt. In addition to several accessions of cultivated alfalfa (Medicago sativa) we obtained seeds of M. glomerata and M. suffruticosa. M. glomerata has not previously been reported from this region and, if the identification is substantiated, this collection represents a significant extension of the range of the species. We also made several collections of M. suffructicosa in the high elevation cedar forests south of Azrou. This is a perennial species which has not previously been available to scientists in the United States. While it has many traits of agronomic interest as an intact species, perhaps its greatest value will be realized through interspecific crosses with M. sativa.

The Moroccan Forest Service (Eaux et Forets) has extensive reforestation plantings in the Moyen Atlas and other regions of the country. These are excellent sites in which to collect plant germplasm since they are usually protected from grazing during establishment. At one such site near Azrou, we obtained seeds of 11 forage grasses and legumes while adjacent areas had been so heavily pastured that few seeds were available. A similar situation was encountered on the Plain de l'Arid. Drought combined with intensive utilization of the forage resource made seed collecting very difficult. However, at a hillside site which had received some protection from grazing, Coronilla minima, Hippocrepis scabra, Lotus creticus, and Onobrychis argentea plants and seeds were plentiful. This location had received only 140 mm precipitation since September 1982. It is our opinion that these drought resistant legumes should be included in seed production projects in Morocco and then used for range reseeding and improvement. Only grasses and a few shrubs have been included in the few range plantings that have been attempted in Morocco.

Scientists who assisted in the collection on the Timahdite Perimeter and the Plain de l'Arid were the following:

Mr. Mohammed Atiqi, Range Scientist, Direction Provinciale de l'Agriculture, Meknes.

Dr. Alan Gray, Range Scientist, U.S. AID Range Management Project, Midelt.

July 26-August 6: The major emphasis during this segment of the collection was to obtain seeds of local indigenous populations of alfalfa (Medicago sativa). Alfalfa was brought to Morocco from the east by Arabs during the expansion of Islam in the 8th Century. This germplasm resource is now being diluted and threatened by the introduction of modern cultivars, primarily those from the southwestern United States. We believe that our collection of the local Moroccan landraces of alfalfa was very timely and that much of this material would otherwise have been lost within the next 10 years.

Mr. Abodelkader Qazi accompanied us during this time period. His knowledge of the Berber language and culture was essential in many of the villages and oases. Throughout our travel in the southern part of Morocco, we solicited assistance from local scientists and officials. Persons who were especially helpful and who might be contacted in preparation for any future germplasm collections included the following:

Mr. El-Mostafa Darfaoui, Range Management Specialist, Errachidia. Mr. Darfaoui speaks english and assisted us in the Tafilalt area.

Mr. Hajjaji, Agronomist, O.R.M.V.A. du Tafilalt, Errachidia. He is responsible for many aspects of the management of a large irrigation project. Mr. Hajjaji does not speak english but wants to exchange information and germplasm and also would like to participate in cooperative research programs.

Mr. Abdelaziz Maghroaui, Agricultural Officer and Range Management Specialist, Livestock Service, Ouarzazate. Mr. Maghroaui speaks english, is a range scientist, and impressed us with his managerial skills as well as his scientific expertise.

Approximately 150 accessions of alfalfa were collected from southern Morocco. We attempted to obtain seeds from more than one farmer within each village of each oasis and to sample all oases along the major rivers. Because of political unrest, border disputes, and military activity, we were not able to collect in the southeastern and southwestern parts of Morocco. We were permitted to pass through a military blockade to collect south of Zagora to M'Hamid in the Draa River valley oases. Because the time required would have been excessive, we did not attempt to reach many of the smaller and more isolated oases although the alfalfas in these villages would be of great interest to plant breeders. During our mountain collection trips we found *Agropyron elongatum*, not previously known to exist in this region.

At the present time we recognize five broad classes of Moroccan alfalfas. These are designated by the geographic areas in which they are grown.

Draa: Primarily grown in the drainage of the Draa River in southcentral Morocco but extending northward to the Anti Atlas, eastward to the divide with the Tafilalt area, and westward toward a merger with the Sous drainage. The boundary between the Sous and the Draa areas is not well defined and we were not able to adequately sample the alfalfas from these oases.

Tafilalt: The Oued Ziz is the most important river in this area. The Tafilalt extends eastward from the Draa toward the Algerian border. The northern limit is not sharply defined but meets the mountain type materials south of Errachidia (El-Ksar-es-Souk). Many of the alfalfa fields showed a high proportion of plants that were stunted, had viral symptoms, physiological problems, or were infected with witches-broom. "Black aphid" is the major insect pest on alfalfa in these oases.

Sous: The Sous alfalfas extend along the watershed between the Haut- and Anti-Atlas mountains to and along the coast west of the mountains. At the higher elevations this germplasm may merge with the mountain type as exemplified by the Demnate populations. Near the coast, the type location may be Massa. Mature plants are 1-2 m tall with thick, hollow stems, large leaflets, and abundant seed. It may be possible to differentiate two subtypes within the Sous based on whether or not the stems are hollow or solid and other morpohological characteristics.

*Mountain*: These alfalfas are less robust than those from lower elevations and usually have solid stems. Well known seed sources are the regions around Demnate east of Marrakech and around Rich north of Errachidia. Since this is a very large geographic region including all of the Rif and Atlas chains, a major detailed examination of these accessions should permit further subdivision of these types into germplasm pools with a greater degree of homogeneity.

*Haouz*: These alfalfas come from the region north and west of the mountains centered around Marrakech. They are grown on the steppes as well as the coastal plains along the Atlantic Ocean.

*August 7-9*: This 3-day period was used to extend our collection of *Medicago marina* and *Hedysarum coronarium*. We traveled a circuitous route from Rabat to Tanger and back to Rabat. Mr. Qazi accompanied us as a guide. Thirty-one accessions, which included both target species, were obtained.

*August 10-13*: All accessions of all species in which INRA or Hassan II University staff had expressed an interest were divided and aliquots shared with those scientists. The seeds were than packaged and shipped to quarantine in the United States with the assistance of Mr. Bouyayachen and Mr. Geerken at the Embassy. We completed our business and financial arrangements and left Morocco.

Table 1. A summary of alfalfa germplasm accessions collected in Morocco in 1983.

| Plant species | No. of accessions |
|---|---|
| *Medicago arborea* | 2 |
| " *ciliaris* | 4 |
| " *constricta* | 1 |
| " *glomerata* | 2 |
| " *intertexta* | 5 |
| " *laciniata* | 38 |
| " *littoralis* | 28 |
| " *lupulina* | 10 |
| " *marina* | 6 |
| " *minima* | 17 |
| " *murex* | 2 |
| " *orbicularis* | 6 |
| " *polymorpha* | 12 |
| " *rigidula* | 19 |
| " *sativa* | 155 |
| " *scutellata* | 2 |
| " sp. | 10 |
| " *suffruticosa* | 4 |
| " *tornata* | 14 |
| " *trunc.* X *litt.* | 8 |
| " *truncatula* | 40 |
| " *turbinata* var. *aculeata* | 31 |

## Report of the Committee on Available Breeding Lines of Alfalfa

This report contains a listing of 72 officially released alfalfa germplasms plus two unofficial releases not previously reported in NAIC conference reports (Tables 1 and 2, respectively). Thirty-two of these were made available upon termination of the alfalfa project at Lincoln, Nebraska.

The number of alfalfas submitted for storage to the National Seed Storage facility at Fort Collins increased by 174 since 1982. Of these 110 were new releases and/or were recently registered in Crop Science (storage at NSSL required). This indicates an increased concern and awareness among alfalfa workers for the importance of conserving germplasm.

Table 3 contains a listing of cultivars which have been discontinued (in practice). The National Certified Alfalfa Variety Review Board has not received documentation to this effect on all cultivars listed.

Table 4 enumerates the current status of stored seed and current seed production of older cultivars based on responses from questionnaires sent to public and private alfalfa developers and State seed certification agencies.

The committee recommends that:

1. the conference should continue to place strong emphasis on the registration of released alfalfas in Crop Science, and storage of all releases, past and forthcoming, at the National Seed Storage facility at Fort Collins, Colorado.

2. a supplement to the publication "Improved Breeding Lines of Alfalfa" ARM-W-5/Sept. 1978, be prepared for distribution to the 1986 NAIC conference. The supplement should include a listing of released germplasms for which seed or clones are no longer available and an updated list of persons or organizations responsible for distribution of seed of older released germplasms.

3. this committee work with the authors of the forementioned supplement to compile a current listing of breeding lines not included in previous NAIC conference reports, ie., those which may be released subsequent to the final draft of the supplement for the 1986 conference. This list should also include lines not officially released but available for limited distribution.

Submitted by:

Boyd Hartman
John Kugler, Chairman
Real Michaud
Richard Peaden
M. Schonhorst
Edgar Sorensen
L.R. Teuber

Table 1. Alfalfa Germplasm Releases Subsequent to the 1982 National Alfalfa Conference Report. 

| State/Agency /Company | Contact | OFFICIALLY RELEASED<br>Name of Germplasm | Stock (seed or clone) | Stored at NSSL* Yes/No | Description/ Journal Reference and Reg. Number |
|---|---|---|---|---|---|
| UC AES | D.C. Erwin | A-77-10 B | Seed | Yes | Crop Sci. 22:1267, 1982. Reg. No. GP 118. |
| UC AES<br>Kansas, Dept. of Plant Path.<br>USDA ARS, Tucson | W.F. Lehman | UC 123 and UC 143 | Seed | Yes | Crop Sci. 23: 403, 1982. Reg. No. GP 124 and GP 125. |
| Kansas/USDA | E.L. Sorenson | KS 80 | Seed | Yes | Crop Sci. 23:599. 1983. Reg. No. GP 126. |
| UC Davis | L.R. Teuber | UC 1249 | Seed | Yes | Crop Sci. 23:805, 1983. Reg. No. GP 127. |
| UC Davis | L.R. Teuber | UC 1250 | Seed | Yes | Crop Sci. 23:805, 1983. Reg. No. GP 128. |
| Arizona AES<br>U of Az | A.K. Dobrenz | AZ-GERM SALT-1 | Seed | Yes | Crop Sci. 23:807, 1983. Reg. No. GP 132. |
| Kansas/USDA | E.L. Sorensen | KS 167 | Seed | Yes | Crop Sci. 23:1224, 1983. Reg. No. GP 133. |

*National Seed Storage Laboratory, Fort Collins, Colorado.

| State/Agency /Company | Contact | OFFICIALLY RELEASED<br>Name of Germplasm | <br>Stock (seed or clone) | Stored at NSSL* Yes/No | Description/ Journal Reference and Reg. Number |
|---|---|---|---|---|---|
| USDA, Calif., Nevada | B.D. Thyr<br>W.F. Lehman | CUSN-242 CLS$_4$ | Seed | Yes | Non-dormant, common leafspot resistant. Crop Sci. 24:387, Reg. No. GP 137. |
| USDA, Nevada | B.D. Thyr | BIC-6 CLS$_5$ | Seed | Yes | Dormant, common leafspot resistant. Crop Sci. 24:380. Reg. No. GP 138. |
| | | MSE6-CLS$_6$ | Seed | Yes | Crop Sci. 24:380. Reg. No. GP 139. |
| | | MSF6 CLS$_6$ | Seed | Yes | Crop Sci. 24:380. Reg. No. GP 140. |
| | | Wash. SNI CLS$_4$ | Seed | Yes | Crop Sci. 24:380. Reg. No. GP 141. |
| USDA, Nevada | B.D. Thyr | NMP-14 | Seed | Yes | Dormant, common leafspot resistant Crop. Sci. 24:388-389. Reg. No. GP 142. |
| ARS, USDA | J.H. Elgin, Jr. | W10AnWFuPy3, (B2An4 x Arc) AnWFuPy3, & B28 | Seed | Yes | Crop Sci. 24:623, 1984. Reg. Nos. GP 143, GP 144, GP 145. |
| ARS, USDA | J.H. Elgin, Jr. | B6An1AC3, B7AC3, B9Fu3AC3, B11Fu3AC3, B14V1Fu2, B16AC3, B19AC2, W10 (Syn 3) AC3, Saranac AR-AC3, BMP8 (Syn 4) AC3, & B27 | Seed | Yes | Crop Sci. 24:623, 1984. Reg. Nos. GP 146 through GP 156. |

*National Seed Storage Laboratory, Fort Collins, Colorado.

Table 1. Alfalfa Germplasm Releases Subsequent to the 1982 National Alfalfa Conference Report.

| State/Agency /Company | Contact | OFFICIALLY RELEASED Name of Germplasm | Stock (seed or clone) | Stored at NSSL* Yes/No | Description/ Journal Reference and Reg. Number |
|---|---|---|---|---|---|
| Nebraska AES/ USDA | Dept. of Agronomy | A169 | Seed | Yes | 4 clone synthetic (M. *falcata*, M. *glutinosa*, a Turkish sel. and PI 107298. |
| | | A224 | Seed | Yes | 4 clone synthetic-rhizomatous. |
| | | A603 | Seed | Yes | 5 clone synthetic--creeping rooted. |
| | | A604 | Seed | Yes | 10 clone synthetic--creeping rooted. |
| | | N.S. 31 | Seed | Yes | 7 clone synthetic--creeping rooted. |
| | | N.S. 33 | Seed | Yes | 12 clone synthetic--creeping rooted. |
| Nebraska AES/ USDA | Dept. of Agronomy | N.S. 46 | Seed | Yes | Open pollinated, 10 clone, creeping rooted. |
| | | N.S. 47 | Seed | Yes | 50 plant synthetic--creeping rooted. |
| | | N.S. 76 P2PA1 | Seed | Yes | 76 plant population, leaf-hopper yellowing tolerant. |
| | | N.S. 86 | Seed | Yes | 63 plant population, leaf-hopper yellowing tolerant. |
| Nebraska AES/ USDA | Dept. of Agronomy | N.S. 62 | Seed | Yes | 12 clone yellow flowered pasture alfalfa. |
| | | N.S. 66 | Seed | Yes | 10 clone, high seed yield, yellow flowered. |
| | | N.S. 67 | Seed | Yes | 14 clone, high seed yield, yellow flowered. |
| | | N.S. 80 | Seed | Yes | 9 clone, yellow flowered. |

*National Seed Storage Laboratory, Fort Collins, Colorado.

Table 1. Alfalfa Germplasm Releases Subsequent to the 1982 National Alfalfa Conference Report.



| State/Agency /Company | Contact | OFFICIALLY RELEASED Name of Germplasm | Stock (seed or clone) | Stored at NSSL* Yes/No | Description/ Journal Reference and Reg. Number |
|---|---|---|---|---|---|
| Nebraska AES and Minnesota AES | Dept. of Agronomy | N.S. 72 P2 | Seed | Yes | Winterhardy germplasms resistant to Phytophthora root rot, bacterial wilt, pea aphid and spotted alfalfa aphid. |
| | | N.S. 75 P2 | Seed | Yes | |
| | | N.S. 78 P2 | Seed | Yes | |
| | | N.S. 81 P2PA1SAA1 | Seed | Yes | |
| Nebraska AES and Nevada AES/ USDA | Dept. of Agronomy | N.S. 77 SN2AN2 | Seed | Yes | Winterhardy germplasms resistant to stem nematode, anthracnose, pea aphid, spotted alfalfa aphid. |
| | | N.S. 79 SN2AN2 | Seed | Yes | |
| Nebraska AES/ USDA | Dept. of Agronomy | N.S. 93 | Seed | Yes | Improved BIC-7. |
| | | N.S. 94 | Seed | Yes | Improved NC-83-1. |
| | | N.S. 95 | Seed | Yes | Improved NC-83-2. |
| | | N.S. 83 | Seed | Yes | 54 selections from 29 P.I.'s. |
| | | N.S. 84 | Seed | Yes | N.S. 83 outcrossed to 7 superior clones. |
| | | N.S. 85 | Seed | Yes | Intercross of 37 vigorous P.I.'s. |
| | | N.S. 89 | Seed | Yes | Argentine variety 'Paine' X N.S. 72 SN2AN2. |
| | | N.S. 90 | Seed | Yes | Argentine variety 'Paine' X N.S. 79 AN2. |
| | | N.A. 91 | Seed | Yes | Argentine variety 'Paine' X N.S. 82 P2. |

*National Seed Storage Laboratory, Fort Collins, Colorado.

Table 1. Alfalfa Germplasm Releases Subsequent to the 1982 National Alfalfa Conference Report. 

| State/Agency /Company | Contact | OFFICIALLY RELEASED Name of Germplasm | Stock (seed or clone) | Stored at NSSL* Yes/No | Description/ Journal Reference and Reg. Number |
|---|---|---|---|---|---|
| Nebraska AES Minnesota AES So. Dakota AES USDA AES | Dept. of Agronomy Lincoln, NE | DANEB I | Seed | Yes | 70 clones, leafspot resistant, root proliferating. |
| | | DANEB I BW 1 | Seed | Yes | Bacterial wilt resistant DANEB I. |
| | | DANEB I P2 | Seed | Yes | Phytophthora root rot resistant DANEB I. |
| Wisconsin AES | E.T. Bingham | W2xiso-1 W4xiso-1 | Seed Seed | No No | Isogenic populations of diploid and tetraploid cultivated alfalfa. Eight cultivated diploid clones were colchicine-doubled to produce eight isogenic autotetraploid clones. Clones at both ploidy levels were used in identical matings to produce the respective diploid and tetraploid populations. |
| Minnesota AES | D.K. Barnes | MNHCRR-3 | Seed | Submitted | Winterhardy, selected for resistance to crown rot. High resistance to bacterial wilt and moderate resistance to Phytophthora root rot. |

*National Seed Storage Laboratory, Fort Collins, Colorado.

Table 1. Alfalfa Germplasm Releases Subsequent to the 1982 National Alfalfa Conference Report.

OFFICIALLY RELEASED

| State/Agency /Company | Contact | Name of Germplasm | Stock (seed or clone) | Stored at NSSL* Yes/No | Description/ Journal Reference & Reg. No. |
|---|---|---|---|---|---|
| Minnesota AES USDA | D.K. Barnes | | | | Germplasms resulting from selection and intercrosses among 12 European, Verticillium wilt resistant lines. |
| | | MNVW-BW2 | Seed | Submitted | 2 cycles recurrent selection for resistance to bacterial wilt. |
| | | MNVW-FW2 | Seed | Submitted | 2 cycles recurrent selection for resistance to Fusarium wilt. |
| | | MNVW-PRR2 | Seed | Submitted | 2 cycles recurrent selection for resistance to Phytophthora root rot. |
| | | MN NN-1008 | Seed | Submitted | Non-nodulating germplasm. |
| | | MN IN-3226<br>MN IN-3811 | Seed<br>Seed | Submitted<br>Submitted | Ineffective nodulating germplasm from MN NC germplasm pool. |
| | | MN IN-SAR | Seed | Submitted | Ineffective nodulating germplasm from Saranac. |
| | | MN 3419-CMS | Seed | Submitted | Cytoplasmic-male-sterile (CMS) winterhardy germplasm. |

*National Seed Storage Laboratory, Fort Collins, Colorado.

OFFICIALLY RELEASED

| State/Agency /Company | Contact | Name of Germplasm | Stock (seed or clone) | Stored at NSSL* Yes/No | Description/ Journal Reference & Reg. No. |
|---|---|---|---|---|---|
| Minnesota AES USDA | D.K. Barnes | MN 3419-MA | Seed | Submitted | Cytoplasmic-male-sterile maintainer (MA), also winterhardy. Both have high resistance to Fusarium wilt, susceptible to bacterial wilt and Phytophthora root rot. |
| | | MN 1139-CMS | Seed | Submitted | CMS and MA developed from same source as MN 3419. |
| | | MN 1139-MA | Seed | Submitted | MN 1139-MA is more inbred and less self-fertile. Moderate resistances to Fusarium wilt and Phytophthora root rot and susceptible to bacterial wilt. Fall dormancy like Vernal. |
| | | MN 1291-CMS | Seed | Submitted | CMS and MA develcped from flemish source. Moderate resistance to bacterial wilt, resistance to Fusarium wilt, susceptible to Phytophthora root rot--Fall-dormancy like Saranac. |
| | | MN White-CMS<br>MN White-MA | Seed<br>Seed | Submitted<br>Submitted | White-flowered CMS and MA from Turkish origin. Susceptible to bacterial wilt, Fusarium wilt and Phytophthora root rot. Fall-dormancy like DuPuits. |

*National Seed Storage Laboratory, Fort Collins, Colorado.

Table 1. Alfalfa Germplasm Releases Subsequent to the 1982 National Alfalfa Conference Report.

OFFICIALLY RELEASED

| State/Agency /Company | Contact | Name of Germplasm | Stock (seed or clone) | Stored at NSSL* Yes/No | Description/ Journal Reference & Reg. No. |
|---|---|---|---|---|---|
| Minnesota AES USDA | D.K. Barnes | MN NS-MA | Seed | Submitted | Male-sterile maintainer developed from maintainer clones of U-1292.germplasm. Sources were flemish and *M. varia*. |

Table 2. Germplasms available for distribution though not officially released.

| State/Agency /Company | Contact | Name of Germplasm | Stock (seed or clone) | Stored at NSSL* Yes/No. | Description |
|---|---|---|---|---|---|
| Wisonsin AES | E.T. Bingham | CADL | Seed | No | Cultivated alfalfa at the diploid level (CADL) derived from cultivated tetraploids by haploidy and triploid bridge-crosses. Populations change each year as new germplasm is added. |
| Florida | E.S. Horner | Fla. G83 | Seed | No | Developed by 13 cycles of natural selection for persistence at Gainesville, Florida. Highly resistant to Fusarium wilt and root knot nematode. Very persistent stands in Florida. |

Table 3. Discontinued cultivars of alfalfa.

A-24
Apalachee
Apex
Bonanza

Bonus
Cayuga
Cherokee
Conquest

Dawson
Florida 66
Fremont
Mark II

Multileaf
Progress
Ramsey
Scout

Stride
Team
WL 202
WL 210

WL 214
WL 216
WL 303
WL 305

WL 306
WL 307
WL 308
WL 309

WL 310
WL 451
WL 501R
WL 504

WL 508
WL 600
183
521
525

Table 4. Availability of basic seed stocks and current seed production of older alfalfa cultivars.

| Name | Location of seed | Class of seed | Amount stored | Acreage in production |
|---|---|---|---|---|
| A-59 | none reported | | | |
| African | U. of AZ, Tucson | Fnd. | 50 lbs. | 0 |
| | UC Davis | Increase of MN check | 125 lbs. | |
| Alfa | none reported | | | |
| Atlantic | So. Dak. S.U. | Br./Fnd? | 100 g. | 0 |
| Baltic | none reported | | | |
| Beaver | So. Dak. S.U. | Br./Fnd? | 100 g. approx. | 0 |
| | Idaho | Certified | | 23 A |
| | Saskatoon Res. Sta.) | Br. | 50 Kg. | |
| | Ontario, Canada | Cert.? | 40,168 Kg. | |
| Buffalo | So. Dak. S.U. | Br./Fnd? | 100 g. approx. | 0 |
| Caliverde | UC Davis | Fnd. | 7.5 lbs. | |
| Canadian (Ontario) Variegated | none reported | | | |
| Chilean 21-5 | U of Az. Tucson | Fnd. | 50 lbs. | 0 |
| Cossack | S. Dak. S.U. | Br./Fnd? | 100 g. | 0 |
| Culver | none reported | | | |
| DuPuits | S. Dak. S.U. | Br./Fnd. | 100 g. | 0 |
| Grimm | S. Dak. S.U. | Br./Fnd? | 100 g. | 0 |
| | U. of Sask., Saskatoon | unspecified | | |
| Hairy Peruvian | U. of Az., Tucson | Fnd. | 50 lbs. | 0 |
| Hardigan | none reported | | | |
| Hardistan | none reported | | | |
| Indian | none reported | | | |
| Kaw | none available from KS | | | |
| Ladak | Idaho | Certified | | 228 A |
| | S. Dak. S.U. | Br./Fnd? | 100 g. | 0 |
| | Montana | Certifed | 24,957 lbs. | 320 A |
| | | (Ladak will be removed from Certification in Montana following fall 1985 harvest) | | |

Table 4.. Availability of basic seed stocks and current seed production of older alfalfa cultivars. (continued)

| Name | Location of seed | Class of seed | Amount stored | Acreage in production |
|---|---|---|---|---|
| Lahontan | Reno, NV | Certified | 20 lbs. | 0 |
| | Idaho | Certified | | 52 A |
| | Delta, UT | Certified | | 54 A |
| Macsel | none reported | | | |
| Meeker Baltic | none reported | | | |
| Moapa | Reno, NV | Certified | 30 lbs. | 0 |
| Narragansett | S. Dak. S.U. | Br./Fnd? | 5 lbs. | 0 |
| Nemastan | none reported | | | |
| New Mexico 11-1. | New Mexico | Reg. & Cert. | 1000 lbs. (Cert.) | 50 A |
| Nomad | Oregon | Foundation | 1000 lbs. | 8 A |
| | S. Dak. S.U. | Br./Fnd? | 100 g. | 0 |
| Orestan | none reported | | | |
| Rambler | Idaho | Certified | | 53 A |
| | S.Dak. S.U. | Br./Fnd? | 100 g. | 0 |
| | Regina, Res. Sta., Sask. | Breeder | 48 Kg. | |
| | Ag. Can. Res. Sta., Swift Current, Sask. | Breeder | 70 Kg. | 0.78A |
| | Ontario, Canada | Certified | 49,574 Kg. | |
| Ranger | Reno, NV | Certified | 20 lbs. | |
| | Idaho | Certified | | 822 A |
| | Washington | Certified | | 116 A |
| | Oregon | Registered | | 3 A |
| | Delta, UT | Certified | | 103 A |
| | California | Certified | | 52 A |
| Rhizoma | S. Dak. S.U. | Br./Fnd? | 100 g. | 0 |
| Sevelra | none reported | | | |
| Socheville | none reported | | | |
| Talent | Oregon | Registered | | 5 A |
| Team | BARC | Breeder | 100 lbs. | |
| Teton | S. Dak. S.U. | Br./Fnd? | 20 lbs. | 0 |
| Turkestan | none reported | | | |

Table 4. Availability of basic seed stocks and current seed production of older alfalfa cultivars. (continued)

| Name | Location of seed | Class of seed | Amount stored | Acreage in production |
|---|---|---|---|---|
| Vernal | Reno, NV | Certified | 35 lbs. | 0 |
| | Idaho | Certified | | 1925 A |
| | Wapato, WA | Foundation (CCC stocks) | 25,389 lbs. | |
| | Washington | Certified | | 3515 A |
| | Tremonton, UT | Certified | | 150 A |
| | Montana | Certified | 42,314 lbs. | 630 A |
| | Ontario, Canada | Certified | 19,325 Kg. | |
| Williamsburg | none reported | | | |
| Zia | New Mexico | non-certified | (ample Cert. stored) | 500 A |

## Committee on Use of Tissue Culture Research in Alfalfa Improvement

This report summarizes current tissue culture research on alfalfa in North America and cites important findings from other parts of the world. D. C. W. Brown at the Ottawa Research Station (Agriculture Canada) is using *in vitro* techniques in the following areas: (1) studies on the parental gene base in cultivated varieties and its relationship to their *in vitro* somatic embryogenesis response; (2) survey of the physiological and biochemical changes associated with somatic embryogenesis in callus, cell suspensions and at the protoplast level; (3) studies to define the requirements and improve the efficiency of meristem, node and somatic embryo culture; (4) transformation of protoplasts via Ti plasmid microinjection - B. Miki, cooperator; (5) cytoplasmic and amino acid analog mutant isolation from cell suspensions - S. Molnar, cooperator, and (6) cold adaptation in cell suspension cultures - J. Singh, cooperator.

B. McKersie (University of Guelph) has initiated studies with callus, cell suspensions and protoplasts of Regen-S and Rangelander aimed at investigating cold, anaerobic and atrazine tolerance. G. L. Lees at the Saskatoon Research Station (Agriculture Canada) is working on bloat-safe alfalfa using tissue culture approaches. These include the eventual goal of transferring the condensed tannin - producing capability in herbage from sainfoin or birdsfoot trefoil to alfalfa using protoplast fusion. He also will survey the somaclonal variation typically observed among regenerated plants for the presence of condensed tannins in leaves and stems.

Lowell Johnson and his associates (Kansas State University, Manhattan) have been studying variation in protoclones derived from two tetraploid Regen-S alfalfa clones. Extensive phenotypic variation was observed. S. E. Schlarbaum (now at the University of Tennessee) documented numerous karyotypic changes among regenerates, including octoploidy and near octoploidy, aneuploidy, and chromosomes bearing translocations. Ray Rose, while on sabbatic leave from the University of Newcastle, Australia, examined the chloroplast and mitochondrial DNA of a number of protoclones, seeking evidence of variation in these genomes following regeneration. Restriction endonuclease analysis revealed identical changes in chloroplast DNA restriction patterns with three enzymes for 22 of 23 protoclones examined. It appears that the two types of chloroplast DNA found in the protoclones were already present in the Regen-S. In contrast, no changes in mitochondrial DNA restriction patterns were detected in twenty protoclones. Efforts to obtain somatic hybrids between alfalfa and certain sexually incompatible *Medicago* species by protoplast fusion are in progress, as are efforts to regenerate these species from protoplasts.

At New Mexico State University, Gregory C. Phillips and collaborators Bill Melton, John Hubstenberger, Anita Lujan, and Ian Ray are focusing on two main areas: regeneration phenomena and cell selection. They have completed screening 320 lines of alfalfa adapted to the southwestern growing conditions, with 11% regenerating plants from callus. Selected regenerator lines are being characterized and intercrossed to generate the first cycle recurrently selected population for reevaluation. Some evidence suggests there may be genotype by regeneration scheme interactions, and genetic tests are being initiated to investigate this further. Grant support was recently obtained to initiate studies aimed at devising appropriate cell selection pressures to recover water use efficient and phosphorus use efficient variants through cell selection. The initial experiments will investigate the degree of correlation of cellular responses compared with known whole plant responses among selected populations.

At the University of Nevada, Reno, T. J. McCoy (USDA/ARS) and T. R. Knous (Dept. of Plant Science) are continuing research on cell lines resistant to culture filtrates of *Fusarium oxysporum*. Two clones of Regen-S, both known to be susceptible to *Fusarium* at the whole plant level were used in the selection experiments. Plants regenerated from cell lines selected for resistance to a toxic component(s) of the filtrate have demonstrated whole plant resistance to *Fusarium* in greenhouse and field (summer 1983) experiments. Plants from long-term selections (approximately 15 months) had elevated ploidy levels (predominantly octoploid with a few hexaploids); however, plants regenerated from short-term selections (seven months) were tetraploid. Inheritance studies of the resistance response both *in vitro* to toxin(s) present in the filtrate, as well as *in vivo*, are being conducted. Preliminary data indicates the selected *in vitro* resistance response is genetically transmissible, and possibly due to a single dominant mutation, although the exact genetic control has not been determined. A culture technique for recovering interspecific hybrids of perennial *Medicago* species has been identified. Culturing ovules 7 to 21 days post-pollination (depending on species) for 4 to 6 days, followed by embryo excision and direct culturing of the hybrid embryo results in successful interspecific hybridization.

Dwight T. Tomes, Sally Sulc, and Mary Welter at Pioneer Hi-Bred International, Inc., Johnston, Iowa are identifying regenerator genotypes among Pioneer germplasm, and developing shoot-tip culture methodology to store clonal genotypes for breeding or for other *in vitro* studies. Regenerator genotypes were identified in most Pioneer varieties (dormant and semidormant types), but at a frequency of 10% using the same general methods as Walker et al. For shoot-tip storage, the primary objectives of little or no callus growth, excellent viability and modest shoot proliferation with a large genotypic array have been accomplished. Some genotypes produce callus on SH mineral salts with low levels of either of the cytokinins benzyladenine or kinetin. Sensitive genotypes respond to kinetin (2 mg/l) by producing significantly fewer new shoots and significantly shorter shoots. Nonsensitive genotypes respond with an expected increase in shoot proliferation. Lowering sucrose from 2.0% to 0.5% and substituting adenine sulfate at 50 mg/l for cytokinin resulted in a satisfactory growth medium for maintaining shoot-tip cultures in a healthy condition without callus formation. Several clonal genotypes were propagated by *in vitro* shoot-tip culture and stem cuttings and placed in field locations in the U.S. To date, the tissue culture-derived genotypes appear to be identical to the stem cuttings, with somewhat better survival of tissue culture-derived plants in the year of establishment.

At the University of Wisconsin, Madison, E. T. Bingham and W. P. Kojis are completing genetic analysis of several spontaneous and induced variants of the diploid alfalfa clone HG2. Spontaneous changes in the clone in order of decreasing frequency include polyploidy, aneuploidy, and recessive mutations for simple leaves, abnormal flowers, and growth habit. Changes induced by chemical mutagens and the methionine analog ethionine, include dominant mutations for semi-dwarf growth and leafiness and recessive mutations affecting flower morphology and pigmentation. A comprehensive study by R. W. Groose on spontaneous variation in tetraploid alfalfa in culture using four genetic markers indicated that aneuploidy was a major source of spontaneous variation in culture, but the study also identified a reversible single gene change in anthocyanin synthesis. Research on basic genetic phenomena is continuing using alfalfa tissue culture.

At Plant Genetics, Inc., in Davis, California, efforts in cell biology and breeding predominate. A group headed by David Stuart is concentrating on methods for improving somatic embryogenesis by using model lines derived from Regen-S which range from high to no regeneration. Certain amino acids, especially proline, stimulate embryogenesis by five fold over published procedures. This effect is being actively studied at the physiological and biochemical level. From these results it was also evident that improvements in embryo quality, as measured by size and conversion of embryos to plantlets, is enhanced by amino acid treatment. Thus, we have been able to improve by 100 to 200%, the one for one, embryo for plantlet recovery from culture. A group headed by Keith Redenbaugh is focusing on embryo conversion issues by studying "embryo maturation". The group has also encapsulated somatic embryos of alfalfa as an analog to true seed, and is also starting work on alfalfa protoplasts. In the breeding area, researchers at Plant Genetics have screened germplasm for the ability to undergo embryogenesis. Approximately 2,500 parent clones have been screened to date with about 12% regenerating. Three synthetics have been produced from regenerable parent clones to underpin future research.

Several laboratories in Europe are using alfalfa in tissue culture research similar to that in North America. The first known somatic hybrid in alfalfa was reported in 1983 by Evelyne Teoule (France). Tetraploid _M. sativa_ protoplasts were fused with protoplasts of tetraploid _M. falcata_ and a near-octoploid hybrid was regenerated.

Respectfully submitted by:

| | |
|---|---|
| E. T. Bingham | T. J. McCoy |
| D. C. W. Brown | G. C. Phillips |
| L. B. Johnson | D. T. Tomes |
| T. R. Knous | K. A. Walker |
| G. L. Lees | |

## Industry Committee Report

Jim Moutray
NAPB
Ames, Iowa

A. Through Mike Hanna the committee arranged for the noon luncheon sponsored by 14 U.S. seed companies (listed in Resolutions Committee report).

B. Recommended closer liaison and increased input from various segments of the industry such as:

| | |
|---|---|
| American Alfalfa Processors | Fertilizer Industry |
| Certified Alfalfa Seed Council | Herbicide Industry |
| American Forage & Grassland Council | Machinery Industry |
| American Seed Trade Association | Inoculant & Seed Treatment Industry |

Recommend that representatives of 2-3 of these industries give a 15 minute update at the next conference.

C. Recommend expansion of cooperation between public and private breeders and others to include uniform tests where possible for additional pests such as alfalfa weevil, anthracnose, stem nematode, species of root knot nematode and others.

Additional areas for cooperation could include forage tests in the southeast, uniformity of tests and seed treatment trials.

D. Recommend that industry contribute money to help with conference mailings or volunteer to handle certain functions such as updating and mailing the directory.

E. Recommend that the new industry representative be Mark McCaslin and that his industry committee be continued with the same members.

# Review and Description of Alfalfa Varieties

D.K. Barnes and Donald L. Smith
USDA-ARS and University of Minnesota, and Cal/West Seeds
St. Paul, Minnesota and Woodland, California

Questionnaire (Letter sent to U.S. alfalfa breeders and scientists utilizing variety descriptions)

The National Certified Alfalfa Variety Review Board (NCAVRB) requested that we determine if a need exists for modifying the activities of the board. We are sending this memo and questionnaire to persons familiar with alfalfa varieties. Each memo is coded according to NAIC number to avoid duplication of responses. Results of the survey will be summarized according to public and private responses and by area of expertise. We urge all persons to complete the questionnaire and return them in the enclosed self-addressed envelope to Burt Ray, Chairman of the 1983 NCAVRB.

The NCAVRB first met in 1962. The objectives of the NCAVRB were to provide a forum where public and private agencies could have their cultivars reviewed and described according to the same criteria.

The composition of the NCAVRB is as follows with one voting member representing each: Associate of Official Seed Certifying Agencies; American Seed Trade Association - Research; American Seed Trade Association - Management; National Alfalfa Improvement Conference; USDA Agricultural Research Service; and Ex Officio - USDA Plant Variety Protection Office. The NCAVRB does not judge cultivars on merit. Favorable action by the NCAVRB indicates that the cultivar is described accurately according to the available data. The cultivar description then becomes an open record. This description is forwarded to AOSCA for use by seed certifying agencies and to the National Alfalfa Improvement Conference (NAIC) for distribution to members on the mailing list who have requested information on cultivars and germplasm release.

Changes have been made in the information required by the NCAVRB as new breeding procedures and pest resistance have been developed. A copy of the present form used for cultivar application is enclosed. After a cultivar receives favorable action a seven item summary is prepared for distribution to AOSCA and the NAIC. A copy of the contents of this summary and an example are enclosed for your information. (Copies were not included in this report.)

## Summary of Responses

A total of 162 questionnaires were mailed in September 1983 to the NAIC membership. There were 90 respondents and they were grouped according to employer and expertise into the following categories: breeder-industry, breeder-University, breeder-USDA, production-University, extension-University, marketing-industry, production-industry, production-USDA and other employer/expertise.

Summaries of the responses by professional occupations were developed. The combined summaries across all employer/expertise groups along with significant deviations by a specific group are presented on the attached copy of the questionnaire. The composition of the respondent population is also indicated. The summary results as presented clearly demonstrated the confidence of respondents in the review board system and identified specific areas of concern. Thirty respondents added short comments whereas 18 added detailed comments. These comments were divided into 21 distinct areas with 3 topics receiving comment from 9, 7 and 6 respondents, respectively. These 3 topics were as follows: add Verticillum resistance to the list of characteristics, update descriptions of cultivars presently eligible for certification, and the unacceptibility of pest resistant data without recognized check varieties, appropriate statistical analysis and/or incorrect pest classification.

The survey results, summary of comments and an analysis was presented to the December 13 meeting of the National Certified Alfalfa Variety Review Board. The Board took the following actions: Voted to add Verticillum resistance to list of pests on the application and directed Chairman Burt Ray to appoint two committees of the Board. One committee was directed to study and to prepare recommendations on variety description updating and the other was directed to determine the feasibility of standardizing the reporting of variety pest reactions. These preliminary committee reports are included as part of this report.

NATIONAL CERTIFIED ALFALFA VARIETY REVIEW BOARD QUESTIONNAIRE 90 respondents

(CHECK THE MOST APPROPRIATE DESCRIPTION)

EMPLOYER: Industry 38%, USDA 13%, University 37%. Misc. Employ. 12%

EXPERTISE: Breeding 69%, Extension 7%, Production 11%, Marketing 1%
Other expertise 12

Have you, or are you, serving on the NCAVRB? Yes____ No____

Do you use the NCAVRB descriptions in your work? Yes____ No____

KEY --- ○ - over 50% of respondents marked class.
△ - over 50% of industry breeders marked class.

Circle the most appropriate response:

1. Your opinion on the present need for a cultivar review system.

| 1 | 2 | 3 | 4 | ○5 |
|---|---|---|---|---|
| Not needed | | Useful | | Critical need |

2. If you believe a need for a cultivar review system exists, how well does the NCAVRB meet this need?

| 1 | 2 | 3 | 4 | ○5 |
|---|---|---|---|---|
| Not at all | | Needs some modification | | Very well |

3. What is your assessment as to the relative importance of the seven types of data requested by the NCAVRB and its description in the summary statement.

| | Not needed | | Useful | | Critical |
|---|---|---|---|---|---|
| a) statement on germplasm origin | 1 | 2 | 3 | ○4 | 5 |
| b) breeding procedures | 1 | 2 | 3 | ○4 | 5 |
| c) area of probable adaptation | 1 | 2 | 3 | 4 | ○5 |
| d) states and areas where yield tested | 1 | 2 | 3 | ○4 | 5 |
| e) primary purpose (hay, grazing, etc.) | 1 | △2 | ○3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| f) fall dormancy | 1 | 2 | 3 | 4 | 5 |
| *g) flower color | 1 | 2 | 3 | 4 | 5 |
| h) level of resistance to anthracnose | 1 | 2 | 3 | 4 | 5 |
| i) " " to bacterial wilt | 1 | 2 | 3 | 4 | 5 |
| j) " " to fusarium wilt | 1 | 2 | 3 | 4 | 5 |
| k) " " to pea aphid | 1 | 2 | 3 | 4 | 5 |
| l) " " to Phytophthora root rot | 1 | 2 | 3 | 4 | 5 |
| m) " " to stem nematode | 1 | 2 | 3 | 4 | 5 |
| n) " " to spotted alfalfa aphid | 1 | 2 | 3 | 4 | 5 |
| o) procedure for maintaining seed | 1 | 2 | 3 | 4 | 5 |
| * p) when will certified seed be sold | 1 | 2 | 3 | 4 | 5 |
| * q) will application be made for PVP | 1 | 2 | 3 | 4 | 5 |

4. What is your assessment of the general quality of the information supplied the NCAVRB by applicants?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Poor | | Good | | Excellent |

5. What is your assessment of the NCAVRB's integrity in making decisions describing cultivars?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Poor | | Good | | Excellent |

6. What is your assessment of the NCAVRB's system of describing cultivars?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Poor | | Good | | Excellent |

7. Do you believe that there is a need to update cultivar descriptions after the cultivars are described by the NCAVRB?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Not needed | | Useful | | Critical need |

8. What is your assessment of the need for a national uniform description of cultivar dormancy and pest resistances?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Not needed | | Useful | | Critical need |

* - information of special importance to Certification officials.

9. What is your opinion about asking the NCAVRB to assume the responsibility for review of cultivar descriptions and for the annual updating of a uniform description list?

| 1 | 2 | 3 | (4) | 5 |
|---|---|---|---|---|
| Poor | | Good | | Excellent |

10. Do you believe that there is a need to update recommended pest check cultivar lists?

| 1 | 2 | 3 | 4 | (5) |
|---|---|---|---|---|
| Not needed | | Useful | | Critical need |

11. If you have comments or suggestions about the NCAVRB and/or alfalfa cultivar descriptions, please describe them. Please elaborate on this question or any of the other questions raised on this questionnaire. Use a separate sheet for your expanded comments or suggestions. ______________________

______________________

______________________

Committee on Variety Description Updating

The Certified Alfalfa Seed Council is interested in publishing a pamphlet on alfalfa varieties. Descriptions of certified varieties currently available will be included in the publication. The NCAVRB has been asked to help in the characterization of varieties for this project. The NCAVRB appointed a committee at its 1983 meeting to come up with a proposal for accurately describing alfalfa cultivars. The committee consists of Craig Grau, University of Wisconsin; Bill Knipe, Northrup King & Co.; Bill Lehman, University of California; and Mark McCaslin, Cal/West Seeds. The committee has endorsed the following recommendations:

We recommend that each company or public institution that has submitted a variety before the NCAVRB be contacted and asked to supply the following information:

1. A list of current varieties developed or marketed by that organization and approved for certification by AOSCA. Current varieties are those that will be available for sale in 1985.

2. A current description of each variety based on the best research information currently available. This description should include a winterhardiness rating and characterization of resistance to the following pests, if available: bacterial wilt, Fusarium wilt, Verticillium wilt, anthracnose, Phytophthora root rot, spotted alfalfa aphid, pea aphid, blue aphid and stem nematode. Characterization of resistance to other pests is invited, but descriptions should be limited to those pests for which support data is available. Winterhardiness and pest resistance categories recommended by the NCAVRB should be used (see enclosed NCAVRB recommendations). All this descriptive information should come from the organization responsible for the development of the variety. We ask that the organization include and clearly indicate the winterhardiness and pest resistance classifications originally approved by the NCAVRB. Descriptions would be submitted to the NCAVRB committee. If the level of resistance to a particular pest

is to be upgraded from the original NCAVRB description, support data should be included. If the description submitted is clearly contrary to current research information, the committee would ask the organization to reconsider their characterization. If an organization questions an opinion of the committee, it can appeal to the NCAVRB as a whole. If the board fails to rule in favor of the organization, their description can still be published by CASC, however, the description would be noted "not endorsed by the NCAVRB." Submission of variety descriptions to the NCAVRB and inclusion in the CASC publication are voluntary.

Mark McCaslin, Chm.

Committee on Standardization of Reporting Variety Pest Reactions

After reviewing the results of the "Review and description of alfalfa varieties" survey conducted by D.L. Smith and D.K. Barnes, the National Certified Alfalfa Variety Review Board determined it appropriate to assess the need for improving the report of pest resistance evaluations used as supporting information in applications for variety certification and for Plant Variety Protection.

During the past several meetings of the National Certified Alfalfa Variety Review Board difficulties have been encountered in assessing data supplied by applicants. These problems generally fall into three categories. 1) Failure to report data obtained from evaluations run according to the standard tests. 2) Failure to report results from standard check cultivars along with data from the cultivar under consideration. 3) Lack of agreement among board members and/or lack of documentation on the average disease severity and percentage resistant plants for resistant and susceptible check cultivars.

The following are the recommendations of the National Certified Alfalfa Variety Review Board to the National Alfalfa Improvement Conference to remedy these shortcomings.

1. Failure to Use Standard Tests

   In 1974 standard evaluation procedures for assessing pest (disease and insect) reaction were published by Barnes, et al. in standard tests to characterize pest resistance in alfalfa varieties (ARS-NC-19). It is recommended that only data from trials run according to these procedures be accepted when considering new cultivars for approval by the board. This committee is aware that the previously named publication is under revision, however, the NAIC should also take action on the following items. Standard evaluation procedures should be published for accessing the reaction of alfalfa to new traits including genetic markers, physiological characteristics, and agronomic traits such as stand density and forage and seed yield (several procedures may need to be considered acceptable for the latter two traits). Some of the procedures are not as well controlled as they might be and therefore do not provide consistent results. A standing committee should be established on standard tests. The responsibilities should be collection of new and improved testing procedures, collection of problems with existing procedures, establishment of statutes on old procedures, and regular (5 years) updating of the standard procedures.

2. Failure to Use Standard Check Cultivars

Again, the board feels that data supplied for documentation of the reaction must be accompanied by the results for the approved standard checks in the same trial. Again, however, we are also aware of the difficulty which this presents. Some of the standard checks are germplasm releases which are in limited supply and others are old cultivars which are either available in limited supply or must be questioned as to genetic purity. This committee further recommends that the responsibilities of the committee on standard tests be extended to include recommendation of appropriate checks and making provision for sufficient quantities of this seed to be placed in long-term storage.

Additionally, this committee recommends that the isolate(s) or biotype(s) used in evaluations be included in both the standard test procedures and as part of the documentation required for varietal certification.

3. Establishment of Acceptable Range for Checks

At present all pest and disease reactions are classified as Susceptible, 5%; Low Resistance, 6-14%; Moderate Resistance, 15-30%; Resistant, 31-50%; High Resistance, $\geq$51%; with the same criteria being used for all characters -- except when a member of the board or the applicant can argue successfully that these values are not realistic for the trait in question. The board feels it is necessary to 1) establish acceptable ranges for pest reaction to each of the pests and 2) to develop a procedure for determining the validity of test procedures. We have been presented several suggestions as to how this might be accomplished. Briefly, these include 1) establishment of ranges based on historical trials and basing pest reaction categories on standard deviation from these means, 2) setting up standard testing centers for impartial testing of all materials to be submitted to the board, and 3) developing a series of blind checks to be used in all trials conducted in a given year and using these in some manner to message the results from all trials so that all data are reported with means adjusted to some standard.

It is the impression of this committee that while each of these approaches has certain merits that each also has some important limitations. The foremost question in any method of standardization are: 1) what to do with data that fall well beyond the norm for most trials conducted to evaluate a given trait? and 2) within the "acceptable range" what is the shape of the function which could be used to equate results and does this function take into account both the genetic control of the trait, the effect of inoculum, inoculum concentration, and environment in which the trial was conducted?

We, the National Certified Alfalfa Variety Review Board, request that the National Alfalfa Improvement Conference consider each of these items and make recommendation back to this Board.

Committee Report by:

L.R. Teuber, Chairman
M.D. Rumbaugh
J. Peterson

# Central Alfalfa Improvement Conference Report

Donald L. Stuteville
Department of Plant Pathology, Throckmorton Hall
Kansas State University, Manhattan, KS 66506

The Eighteenth Central Alfalfa Improvement Conference was held June 8-10, 1983 at Manhattan, Kansas. Sixty three registrants and 14 guests attended. In addition to field research tours, 21 papers were presented in sections on breeding, cytology and morphology (9), nitrogen fixation (3), diseases (4), insects (2) and management (3). Copies of the proceedings may be obtained from Don Stuteville.

Officers elected for 1984-1985 were Don Stuteville (Kansas), Chairman; John Caddel (Oklahoma), Vice-Chairman; and Mark McCaslin (Cal/West Seeds), Secretary.

Bill Kehr, who collected, assembled and distributed alfalfa yield data from the north central states from 1955 to 1982, retired. Future reports will be prepared by the Conference Vice-Chairman, currently John Caddel.

Chairman Mike Tesar, appointed a committee to study the standard check varieties for variety trials in the north central states and report at the 1985 meeting. He appointed Edgar Sorensen (chairman) to represent USDA, Don Graffis to represent institutions, and Jim Moutray to represent industry.

The 1985 meeting will be in Oklahoma.

The CAIC held a business meeting at 8:15 p.m. July 16, 1984, at the Sandman Inn, Lethbridge, Alberta, and transacted the following business:

John Caddel, Vice-chairman and therefore responsible for the CAIC Report (primarily yield data from the north central states), stated that the report could be published more economically and with less effort if only the original copy was sent to him. He volunteered to continue to compile and distribute the reports for an indefinite period if financial assistance was available. Mark McCaslin indicated a willingness from the seed industry to support this effort.

A motion passed to accept only nontreated seed (including Rhizobium) for yield trials in the north central states.

The CAIC passed a motion to recommend that the NAIC form a committee to study anthracnose resistance, specifically to determine why field scores often indicate higher levels of resistance than do the standard test ratings for seedlings, and to develop a standard test for evaluating anthracnose resistance in the field.

The North Central Region 138 committee on alfalfa diseases will meet with the CAIC in 1985. Roy Wilcoxson (Minnesota) is chairman of NCR-138.

John Caddel reported that the 1985 CAIC meeting would be in late April or early May at Stillwater or Oklahoma City.

# Report of the Chairman, Eastern Forage Improvement Conference

July 6-8, 1983

The Fifth Eastern Forage Improvement Conference was held at Macdonald College of McGill University, Ste. Anne de Bellevue, Quebec, Canada, July 6-8, 1983. There were 54 registered participants at this meeting.

The meeting was called to order at 1:15 p.m. by the Chairman, Dr. Jack Winch. The Chairman recounted some of the origins and history of E.F.I.C. for the benefit of newcomers to the group. Previously we were known as the Eastern Alfalfa Improvement Conference serving workers in the United States and Canada. A decision was made in 1972 to widen the scope to cover all forage crops and to attempt to hold meetings every two years, alternately in Eastern Canada and Eastern U.S. The E.F.I.C. meetings were hosted as follows: -

| | | |
|---|---|---|
| First | 1975 | University of Guelph |
| Second | 1977 | Pennsylvania State University |
| Third | 1979 | Carlton University, Ottawa |
| Fourth | 1981 | Beltsville, Agric. Research Center |
| Fifth | 1983 | Macdonald College, Montreal |

The organization has continued with a tradition as a valuable forum for informal, informative communication at minimal cost to the members who reside and work in a large geographical area of Northeastern North America.

The minutes of the Fourth E.F.I.C. Conference were adopted as was the agenda for this Fifth E.F.I.C.

Reports were made on the 1982 Alfalfa Improvement Conference held at Davis and on the 1984 Alfalfa Improvement Conference to be held at Lethbridge, Alberta.

A proposal to have a Permanent Secretary for E.F.I.C. was moved and seconded (Hanson-Steppler). There was lively discussion on the long time advantages of having a person with facilities and resources to assist in permanent record keeping and to act as a repository for past Proceedings and other documents. The idea was widely acclaimed and the motion was carried unanimously.

Locations for future meetings were considered. Invitations from Don Viands for Cornell in 1985 and from Lucien Bordeleau for Quebec City in 1987 were unanimously accepted.

The following committees were appointed by the chairman:-

| Nominations | Resolutions |
|---|---|
| Ken Leath, Chairman | Jim Elgin, Chairman |
| Howard Steppler | Gary Bauchan |
| Gus Hanson | |

The nominations committee proposed the following slate of officers:-

| | |
|---|---|
| Chairman: | Stan A. Ostazeski, USDA, Beltsville |
| Vice-Chairman: | Norman C. Lawson, Macdonald College, Ste. Anne de Bellevue, Quebec |
| Permanent Secretary: | James H. Elgin, USDA, Beltsville |

There were no further nominations from the floor and the above executive was approved unanimously by the conferences.

The following report from the Resolutions Committee was adopted unanimously:-

Inasmuch as the Macdonald College, Ste. Anne de Bellevue, Quebec, Canada, served as hosts for the Fifth Eastern Forage Improvement Conference and whereas Drs. Bruce E. Coulman and Norman C. Lawson and their staffs did an outstanding job of organizing and handling the conference, the field tour of the Macdonald College research areas, and evening Barbeque (special thanks for liquid refreshments at the barbeque are extended to Dr. Lew Lloyd, Dean of Faculty of Agriculture and Vice-Principal of Macdonald College) be it resolved that we, the participants of the conference, extend our sincere thanks to these individuals for their efforts in making our stay at Macdonald College enjoyable and productive.

The outgoing chairman, Jack Winch, thanked the speakers for the high quality of their papers and the members for their positive attitude towards the organization. Power was transferred to Stan Ostazeski, who in the absence of any further business adjourned the meeting at 3:00 p.m.

Respectfully submitted by:

Stanley A. Ostazeski, Chairman
Eastern Forage Improvement
Conference

SAO:jpj

## Minutes of the Western Alfalfa Improvement Conference Business Meeting
July 16, 1984 Lethbridge, Alberta

The meeting was called to order by James Force and the minutes of the previous meeting were read and approved.

The Regional Standard Variety Test Program committee report was presented by committee chairman I.I. Kawaguchi. Following discussion on plot size and check varieties,planting sites and cooperators were assigned.

In order to assure uniform seed lots of check varieties for the plantings the following individuals were assigned the responsibility of securing 20 pound samples of check varieties and forwarding their sample to Cliff Currier, Dept. of Crops and Soils, Box 3Q, New Mexico State University, Las Cruces, New Mexico, 88003.

| | |
|---|---|
| CUF 101 | W.F. Lehman |
| Moapa 69 | B.D. Thyr |
| Mesilla | B. Melton |
| Lahontan | B.D. Thyr |
| Saranac AR | M. Walton |
| Ranger | L. Stockton |
| Vernal | B.D. Thyr |
| Ladak 65 | R.L. Ditterline |

The seed will be distributed by Cliff Currier. With no further discussion the committee report was approved.

The status of development of an annual publication summarizing yield test results from WAIC members was reported on by V. Marble. Response has been slow in providing data in sufficient quantity for the publication. The deadline for submitting data (200 copies of each page) was extended August 1, 1984 at which time it will be compiled and distributed. The committee report was approved.

A report from the nominating committee was given by Bill Knipe. Nominations were as follows:

| | |
|---|---|
| President | F.A. Gray |
| Vice President | J.L. Force |
| Sec./Treas. | L.R. Teuber |

Being no further nominations from the floor, an election was conducted and the 1985 officers were approved.

Under new business a letter from R.R. Kalton, Chairman NAIC, concerning Treated Alfalfa Seed for Uniform Tests was read and lengthy discussion followed. A resolution was made by M. Walton: That any seed supplied for forage and/or disease or insect tests will be provided uninoculated and untreated.

The resolution was defeated following another discussion.

The consensus of the members present was to leave the inclusion of treated seed into uniform test up to the discretion of the individual conducting the uniform test.

Location and time for the 1985 WAIC meeting was presented and discussed. Locations chairman, Jim Bushnell, suggested that the meeting be held in Logan, Utah on September 10 and 11, 1985. The location and time of the 1985 WAIC meeting was approved.

Being no further business the meeting was adjourned.

Minutes respectively submitted by James L. Force

# Alfalfa Crop Advisory Committee

Increases of the perennial *Medicago* PI accessions are proceeding on schedule at Reno, Nevada. As of the end of 1983, 555 accessions of the 2087 presently on hand at the NC Regional Plant Introduction Station at Ames, Iowa, have been grown for increase. Over 90% of the accessions grown to date have produced greater than 30 g of seed. Increase of 300-400 annual *Medicago* accessions is nearing completion at Ames.

Evaluations of the first 350 PI's increased at Reno is underway. Morphological traits are being evaluated at Ames; insect, disease, and nematode evaluations are being conducted at locations where expertise in pest evaluation is available.

Arrangements have been made to include with the PI's at Ames the Karl Lesins' collection of approximately 3000 annual and 600 perennial Medicagos. The collection is presently housed at the Devonian Botanic Gardens at Edmonton, Alberta. Initial seed increases of the annuals are presently underway (500/year) in the greenhouse at Beltsville, Md. The perennials will be increased in field cages at Reno, Nevada, beginning in 1985.

Germplasm collection trips to the USSR and Morocco were completed in 1982 and 1983, respectively. One-hundred thirty-five accessions of *Medicago* species were collected in the USSR; 416 (including 155 *M. sativa*) were collected in Morocco. A collection trip to Romania is planned for August 1984. Plans for future trips include northern USSR and northwestern China.

The Germplasm Resources Information Network (GRIN) is now operational. Information about the accessions in the PI system is accessible through a modem by most computer terminals. To obtain information regarding use of the system contact Mr. Jimmie Mowder, Database Manager, at the Beltsville Agricultural Research Center (301-344-3318).

An alfalfa varietal seed repository has been established at Beltsville to aid U.S. alfalfa scientists in filling foreign requests for U.S. varieties. Approximately 750 g of certified seed of each of the following varieties were gathered for the repository:

| | | |
|---|---|---|
| Agate | Iroquois | Spredor II |
| Amador | Kanza | Team |
| Answer | Ladak 65 | Tempo |
| Apalachee | Lew | Thor |
| Arc | Liberty | Travois |
| Atlas | Marathon | Trident |
| Apollo | Maxidor | UC Cargo |
| Baker | Mesa-Sirsa | UC Cibola |
| Blazer | Mesilla | UC Salton |
| Cherokee | Matador | Valador |
| Citation | Moapa 69 | Valor |
| Classic | Nugget | Vancor |
| CUF 101 | Olympic | Vangard |
| Dawson | Pacer | Voris A-77 |
| Defender | Peak | Washoe |

| | | |
|---|---|---|
| Deseret | Perry | Weevlchek |
| El-Unico | Phytor | Vernal |
| Epic | Polar II | Lahontan |
| Florida 66 | Primal | Moapa |
| Florida 77 | Prowler | Narragansett |
| Gladiator | Raidor | Ranger |
| G 777 | Ramsey | Roamer |
| G 7730 | Riley | Talent |
| Hayden | Saranac AR | Teton |
| Hi-phy | Sonora-70 | Williamsburg |
| | | Cody |

U.S. scientists receiving foreign requests for a small sample of a variety available in the repository are invited to forward the request to: Dr. George A. White, Plant Introduction Officer, Germplasm Resources Laboratory, Rm 322, B-001, BARC-West, Beltsville, MD 20705, for filling and forwarding to the requesting foreign scientist. Please note the repository is for filling foreign requests only. Domestic requests can not be accepted.

Respectfully submitted by:

Donald K. Barnes
George R. Manglitz
Tim Woodward
William F. Lehman
Tom McCoy
Raymond Clark
Robert R. Kalton
Don R. Viands
Melvin D. Rumbaugh
James H. Elgin, Jr. (Chairman)

# By-Laws of the North American Alfalfa Improvement Conference

R. R. Kalton, Chairman of NAAIC
Land O'Lakes
Webster City, Iowa

Letter sent to members of the National Alfalfa Improvement Conference (now North American Alfalfa Improvement Conference):

It may surprise you to know that the NAIC has been conducting its business for 50 years now without a set of ByLaws. The Chairman, Permanent Secretary (or Secretary) and Executive Committee have conducted the conference meetings and affairs in a very commendable manner throughout this period. Now, however, with a mailing list upwards of 700 and biennial conference attendance in the 150-200 numbers or more, it appears the time has come to spread out the conference workload and formalize operations. A start was made in Davis in July, 1982 when a Vice Chairman was elected along with a Chairman and a Secretary. Most other organizations our size have developed a set of ByLaws for continuity of operation and to spell out responsibilities. I believe the time has come for the NAIC to do the same.

To get things underway, I attempted to formulate a set of ByLaws for the NAIC utilizing those developed by similar organizations. This first draft was sent out to the NAIC Executive Committee for their suggestions and criticisms which were then incorporated in the enclosed proposed draft. The key aspects of the proposed ByLaws include a President, Vice President, Secretary and Executive Secretary for handling the affairs of the Conference on a formalized basis with specified duties for each office. Other articles necessary for conducting the affairs of the Conference also are included.

Please look over these proposed ByLaws and consider any desirable changes. We will vote on the adoption of these ByLaws, as may be amended, at the business meeting of the 29th NAIC at Lethbridge on July 18, 1984. Hopefully, if adopted, these ByLaws will help chart a strong realistic course for future activities of the NAIC.

BY LAWS

NATIONAL ALFALFA IMPROVEMENT CONFERENCE

Article 1. Name. The name of this organization shall be National Alfalfa Improvement Conference (changed at the business meeting to the North American Alfalfa Improvement Conference, NAAIC).

Article 2. Objectives. The objectives of the Conference are:

1. To provide a means for exchange of information among researchers involved in alfalfa improvement in North America and other countries around the World.

2. To serve as a voice for alfalfa scientists in matters pertaining to local, regional, national and international organizations and interests.

3. To encourage the collection, preservation, evaluation, and enhancement of cultivated and wild alfalfas and related species for use in alfalfa improvement.

4. To encourage the efficient production of seed of improved alfalfa cultivars and the maintenance of their genetic integrity while so doing.

5. To encourage basic research in alfalfa breeding, genetics, pathology, microbiology, entomology, physiology, production, tissue culture, recombinant DNA and related sciences and the exchange of information derived therefrom.

6. To encourage the efficient production and utilization of alfalfa.

Article 3. Membership.

1. Active membership is open to all individuals, whether public or private, who are interested in alfalfa improvement. Membership is maintained by keeping NAIC (NAAIC) address and activity descriptions current and by participating in NAIC (NAAIC) activities. Each individual is entitled to only one vote at the biennial business meeting or on mail ballots.

2. Honorary membership may be conferred on individuals in recognition of outstanding contributions to alfalfa improvement during their career. Nomination is made by the Executive Committee and approved by the general membership. The number of nominees shall not exceed 0.5% of the current membership total at any biennial business meeting.

Article 4. Meetings. Biennial meetings of the NAIC (NAAIC) shall be held during the growing season at a location where alfalfa improvement research is underway. A business meeting shall be held in conjunction with the biennial conference and shall include written reports from officers, committees, and regional alfalfa conferences.

Article 5. Finances. The Conference has authority to collect biennial dues and/or special assessments from its members for the purpose of financing Conference activities. Amounts of dues and/or assessments are to be voted on at the preceeding biennial business meeting. Registration fees adequate to cover costs of holding the Conference meetings may be assessed by the hosting institution.

Article 6. Officers. The officers of the NAIC (NAAIC) shall be selected from the membership at large, by election at the biennial business meeting, serve from the close of one business meeting to the close of the next business meeting and consist of:

1. The President who is responsible for conducting all business meetings, appointing all necessary committees and representatives, and serving as chairperson of the biennial Conference and Executive Committee.

2. The Vice President who shall preside in the absence of the President and be responsible for planning and executing the meeting program of the Conference in cooperation with the local host and arrangement committee.

3. The Secretary who is responsible for Conference minutes, collecting reports, and assembling and editing the Conference Proceedings.

4. The Executive Secretary who is responsible for general correspondence, maintaining archives and the membership list, duplicating and distributing Conference Proceedings, maintaining financial accounts and records, paying bills, and serving as contact person for matters concerning the NAIC (NAAIC).

5. The Secretary shall be elected by majority vote of the Conference and shall serve for consecutive terms as Vice President and President. The Executive Secretary shall serve an indefinite term, be nominated by the Executive Committee, and be approved by majority vote of the Conference.

Article 7. Executive Committee. The Executive Committee shall consist of the President, Vice President, Secretary, Executive Secretary, Past President, Chairman of the Industry Committee, Chairman of the Local Arrangements Committee, Chairman of the Central Alfalfa Improvement Conference, President of the Western Alfalfa Improvement Conference and Chairman of the Eastern Forage Improvement Conference.

Article 8. Committees and Representatives.

1. The President, in consultation with the Executive Committee, shall appoint any committees and their chairpersons necessary to conduct the affairs of the association and any persons needed to represent the NAIC (NAAIC) in outside organizations including a public scientist on the National Certified Alfalfa Variety Review Board.

2. Standing Committees shall include the Industry Committee, Germplasm Advisory Committee, Committee on Available Breeding Lines, and Location Committee.

3. The Nominating Committee shall consist of the three immediate past presidents, with the immediate past president serving as chairman.

Article 9. Vacancies. In case any office of the Conference be vacated for any reason the vacancy shall be filled by a majority vote of the Executive Committee.

Article 10. Amendments. ByLaws of the Conference may be amended at any business meeting by a two-thirds vote of the attendants provided that the membership has been advised of the proposed changes in writing at least 30 days before the meeting.

## Secretary's Report

The NAIC has now served the alfalfa scientists of North America for fifty years. The national conferences have grown from a group of 27 scientists meeting in Lincoln, NE in 1934 to this meeting in 1984. This fiftieth year is being celebrated by this special conference. There are more scientists and families in attendance than ever before. There are more papers covering a wider range of topics than ever before. I am also certain that a greater percentage of scientists attending are representatives of private industry.

My activities as secretary of the 29th NAIC involved printing the report of the 28th NAIC. This is noteworthy because it was the first report not published by the USDA. The NAIC mailing list was updated and a new (1984) address directory prepared. This was the first complete update since 1979. It was possible to reduce the number of persons receiving NAIC mailings in North America by about 80. The non-North American list remained about the same.

| | Number of Scientists Receiving NAIC Mailings | | | | |
|---|---|---|---|---|---|
| Source | 1976 | 1978 | 1980 | 1982 | 1984 |
| United States | 168 | 225 | 294 | 334 | 257 |
| Canada and Mexico | 28 | 51 | 59 | 65 | 47 |
| Non-North American | 30 | 53 | 102 | 138 | 144 |
| Total | 226 | 329 | 455 | 537 | 458 |
| Libraries (receive only NAIC Reports) | | | | | 55 |

The NAIC financial report describes the printing costs that were required to continue our information system. The only source of income was the Registration fees from the 28th NAIC and interest. The 28th NAIC income did not keep pace with the 29th NAIC activities primarily because of the costs of publishing the 28th NAIC report and the 1984 Address Directory. The cost of the Address Directory included secretarial costs that had been available at no charge for the 1981 directory. In closing the books on the 29th NAIC I have sent a check for $200.00 in the name of the National Alfalfa Improvement Conference to James H. Elgin, Jr. (the new NAIC Secretary) for him to open a new account in Beltsville, MD. A deficit in NAIC of finances has occurred during both of the last two conferences. The deficit was underwritten by non-USDA monies in the Minnesota Alfalfa Breeding Project. I chose to write the deficit off the books in 1984.

### Secretary's Financial Report for NAIC

| | | |
|---|---|---|
| Balance in account 6-23-82 | | 157.12 |
| Indebtedness to MN Alfalfa Breeding Project 6-23-82 | | (865.70) |
| **Income** | | |
| Interest 6-23-82 to 7-11-84 | 215.00 | |
| Registration Fees 28th NAIC | 2,735.79 | 2,950.79 |
| **Disbursements** | | |
| Printing Costs | | |
| Announcements of regional meeting, 1983 | | |
| Chairman's report of NAIC status | | |
| National Certified Alfalfa Variety Review (5-2-83) | (98.65) | |

| | | |
|---|---|---|
| Printing 28th NAIC Report | (1,071.00) | |
| Notice 29th NAIC and request for papers (12-17-83) | (89.84) | |
| Information for 29th NAIC Registration, program and preparation of reports (4-9-84) | (691.05)* | |
| National Review Board Report and Questionnaire Summary (6-9-84) | (186.90) | |
| Printing and typing of 1984 Alfalfa Scientist Directory (7-5-84) | (1,291.00) | |
| Total secretarial expenses 29th NAIC | | (3,428.44) |

| | |
|---|---|
| *Expenses paid by M. Hanna, Lethbridge | 691.05 |
| Expenses paid from savings | 2,907.91 |
| Indebtedness forgiven by MN Alfalfa Project | 895.18 |

| | |
|---|---|
| Balance on hand 7-11-84 | 200.00 |

(Note: The NAIC account was closed 7-11-84 and the balance transferred to J.H. Elgin, Jr. to open a new account in Beltsville, MD.)

It was a pleasure to work with Bob Kalton, Chairman and Mike Hanna, Local Arrangements. They were especially diligent in pursuit of their respective duties. It was fortunate for the NAIC that Bob Kalton has been serving as chairman during this time of transition. The changes in organizational structure that have been initiated are timely and they take into account the many changes taking place in the total alfalfa industry. I believe the NAIC is continuing its long tradition of anticipating and acting on current issues.

The last item in this report is just that. After 10 years and six national conferences I have chosen to step down as NAIC secretary. I have enjoyed watching the NAIC grow in many ways and in being a part of the changes. Many more changes will occur. Some of them will result from the establishment of the NAIC bylaws, the need to consider new sources of funding, the reduced role of USDA leadership in crop commodities, and the changing balance of industry and public research. I believe that it is time to put in a new team with new ideas and directions. The spirit and accomplishments of the NAIC have been based on the combined talents, ideas, and actions of all those working on the crop. This combination will insure a bright future for the NAIC. Best wishes to each of you and thanks for the help and support during the last ten years.

Sincerely,

Don Barnes

DONALD K. BARNES
Secretary

## Resolutions Committee Report

Be it resolved that the 29th Alfalfa Improvement Conference in session at Lethbridge, Alberta on July 15-20, 1984 adopts the following:

1. Our sincere appreciation is extended to Agriculture Canada, to Alberta Agriculture and to the Lethbridge Research Station for providing staff and arranging facilities to make this conference possible.

2. Our appreciation is expressed to Dr. D. G. Dorrell for his words of welcome to the conference, to Mr. H. B. McEwen for being the guest speaker at the Province of Alberta Luncheon on July 16, and to Dr. D. F. Beard for being the guest speaker at the Industry Luncheon on July 18.

3. Our most sincere appreciation is extended to Dr. M. R. Hanna and others on his Local Arrangements Committee for their great efforts in making this a most memorable conference. Their extra efforts in making our stay enjoyable, such as meeting out-of-town guests at the airport, is most appreciated.

4. Furthermore, we express our appreciation to many organizations for supporting special functions of the conference. Special appreciation is expressed to the following:

   The Province of Alberta and Alberta Agriculture for their support of the luncheon on July 16.

   To Arnold-Thomas Seed Service, Inc., Cal/West Seeds, Dairyland Seed Co., Inc., DeKalb-Pfizer Genetics, FFR Cooperative, Farm Seed Research Corporation, Great Plains Research Co., Inc., Land-O-Lakes, Inc., Lovelock Seed Co., Inc., North American Plant Breeders, Inc., Northrup King & Co., Pioneer Hi-Bred International, Inc., Plant Genetics, Inc., and W-L Research, Inc. for their support of the Industry Luncheon on July 18.

   To other organizations for their contributions that made the Social on July 15 and refreshments at breaks throughout the conference possible. The contributors include the Alberta Alfalfa Seed Committee, Alberta Agriculture, Alberta Alfalfa Seed Producers Association, Alberta Forage Seed Council, Alberta Public Affairs Bureau, Alberta Soil & Feed Analysis, Ltd., Alberta Sugar Company, Alberta Wheat Pool, BASF Canada Inc., CIBA-GEIGY Canada Ltd., Calgary Exhibition and Stampede, Canada Seed Growers Association, Canadian Seed Trade Association, Cominco Ltd., Dawson Seed Company Ltd., Green Acres Fertilizer Services, Ltd., Hoechst Canada Inc., Kenneth C. Long Seeds Ltd., Lethbridge Convention Bureau, Manitoba Pool Elevators, Niagara Chemical, Northrup King Seeds Ltd., OSECO Inc., Otto Pick & Sons Seeds Ltd., Parks Canada, Prairie Seeds Ltd., Rohm & Haas Canada Inc., Saskatchewan Wheat Pool, SeCan Association, Sherritt Gordon Mines Ltd., Travel Alberta, Uniroyal Chemical, and United Grain Growers.

5. Our appreciation is also extended to the many people who arranged the field tours on July 17, the post conference tours on July 19 and 20, and the special arrangements and tours for persons who accompanied members to the conference.

6. We express our appreciation to the Executive Committee for organizing an interesting program and other efforts to make this one of the best meetings in the history of our conference.

7. And finally, we extend our thanks to the management and staff of the Sandman and El Rancho Inns for their cooperation and hospitality.

Respectfully submitted,
B. R. Christie
D. W. Graffis
R. R. Hill, Jr., Chair

## Committee on Location of 1986 North American Alfalfa Improvement Conference

Previously an invitation was received from the University of Georgia to host the 1986 NAAIC. The committee later received a letter from Dr. J. H. Bouton to withdraw their previous invitation.

An invitation was received from the University of Minnesota to host the 30th NAAIC in 1986. The proposed dates are July 27-31. Dr. D. K. Barnes will be the contact person for the Local Arrangements Committee. The invitation was accepted by the NAAIC.

Minnesota will be an ideal location as it has been 30 years since NAAIC met in Minnesota. They will have a new Agronomy-Plant Pathology-Soils building completed by that time. In addition, it is a known fact that the University of Minnesota is one of the most active institutions involved in alfalfa research.

The location committee consisted of R. E. Howarth, Cheryl Fox, Don Brown, A. A. Hanson, and D. A. Miller, Chairman.

## History of the North American Alfalfa Improvement Conference

| No. | Year | Location | Chairman | Secretary |
|---|---|---|---|---|
| 1 | 1934 | Lincoln, NE | T. A. Kiesselbach | H. M. Tysdal |
| 2 | 1934 | Washington, D.C. | A. J. Pieters | H. M. Tysdal |
| 3 | 1935 | St. Paul, MN | H. L. Westover | H. L. Westover |
| 4 | 1936 | Madison, WI | R. A. Brink | H. M. Tysdal |
| 5 | 1937 | Chicago, IL | R. A. Brink | H. L. Westover |
| 6 | 1938 | Manhattan, KS | H. M. Tysdal | H. L. Westover |
| 7 | 1939 | New Orleans, LA | H. M. Tysdal | H. L. Westover |
| 8 | 1940 | Fort Collins, CO | L. F. Graber | H. L. Westover |
| 9 | 1942 | St. Louis, MO | L. F. Graber | H. L. Westover |
| 10 | 1946 | Logan, UT | J. W. Carlson | H. M. Tysdal |
| 11 | 1948 | Lincoln, NE | C. O. Grandfield | H. M. Tysdal |
| 12 | 1950 | Lethbridge, Canada | T. M. Stevenson | O. S. Aamodt |
| 13 | 1952 | Raleigh, NC | R. P. Murphy | O. S. Aamodt |
| 14 | 1954 | Davis, CA | O. F. Smith | H. O. Graumann |
| 15 | 1956 | St. Paul, MN | C. P. Wilsie | H. O. Graumann |
| 16 | 1958 | Ithaca, NY | C. H. Hanson | H. O. Graumann |
| 17 | 1960 | Saskatoon, Canada | J. L. Bolton | C. H. Hanson |
| 18 | 1962 | Davis, CA | E. H. Stanford | C. H. Hanson |
| 19 | 1964 | Lafayette, IN | R. L. Davis | C. H. Hanson |
| 20 | 1966 | Univ. Park, PA | H. L. Carnahan | C. H. Hanson |
| 21 | 1968 | Reno, NV | W. R. Kehr | C. H. Hanson |
| 22 | 1970 | Urbana, IL | R. R. Hill, Jr. | C. H. Hanson |
| 23 | 1972 | Ottawa, Canada | D. H. Heinrichs | C. H. Hanson |
| 24 | 1974 | Tucson, AZ | Dale Smith | C. H. Hanson & D. K. Barnes |
| 25 | 1976 | Ithaca, NY | M. W. Pedersen | D. K. Barnes |
| 26 | 1978 | Brookings, SD | M. D. Rumbaugh | D. K. Barnes |
| 27 | 1980 | Madison, WI | E. L. Sorensen | D. K. Barnes |
| 28 | 1982 | Davis, CA | B. A. Melton | D. K. Barnes |
| 29 | 1984 | Lethbridge, Canada | R. R. Kalton | D. K. Barnes |

North American Alfalfa Improvement Conference (NAAIC)
Mailing List Questionnaire

Returning this questionnaire indicates that you would either like to be added to the NAAIC mailing list or that you have an address or activity change.

Please check one of the following:
New member ___
Activity change ___

1. Name: ______________________________ 2. Date: ______________________________

3. Mailing Address: ____________________ 4. Office Telephone No. ______________

______________________________

______________________________

5. Present activities with alfalfa: Check appropriate blank(s):

| Research Activities | Non-Research Activities |
|---|---|
| A ____ Breeding | J ____ Administration |
| B ____ Entomology | K ____ Extension |
| C ____ Nematology | L ____ Forage Producer |
| D ____ Pathology | M ____ Marketing |
| E ____ Physiology & Microbiology | N ____ Seed Producer |
| F ____ Forage Production | O ____ Student |
| G ____ Seed Production | P ____ Teacher |
| H ____ Utilization | Q ____ Certification & Variety Protection |
| I ____ Chemical & Quality Analysis | R ____ Writer or Publisher |
| | S ____ Other ______________________ |

6. Would you like new variety and germplasm release information?

Yes ____ No ____

For Canadian and USA Scientists Only:

7. Which Regional Alfalfa Improvement Conference(s) would you like to receive information about? ____ Eastern, ____ Central, ____ Western

8. What best describes your employment situation: ____ USDA, ____ SAES, ____ U.S. Private Industry, ____ Canadian Public, ____ Canadian Private

NOTE: Please call this questionnaire to the attention of your colleagues and employees who you think should be on the NAAIC mailing list.

Return to: J. H. Elgin, Jr.
USDA-ARS
Field Crops Laboratory
Bldg. 001, Rm. 335, BARC-W
Beltsville, MD