

## NONDORMANT ALFALFA, PAST, PRESENT, AND FUTURE

W. F. Lehman  
Agronomy and Range Science, University of California, Davis  
(P.O.: 1004 E. Holton Rd., El Centro, CA 92243)

V. L. Marble  
Cooperative Extension, University of California, Davis 95616

D. C. Erwin  
Plant Pathology, University of California, Riverside 92521

M. W. Nielson  
Monte L. Bean, Life Science Museum  
Brigham Young University, Provo, Utah 84602

**Abstract:** Nondormant types of alfalfa are capable of producing forage through the year when grown in the mild climates of Southwestern United States. They were brought from Spain to Chile and then to California during the gold rush in 1850. Few problems existed during the early period of use. Growers solved most of the cultural problems during the first 100 years. Introduced varieties like California Common and Hairy Peruvian were used. The late 1940s and early 1950s were a transition period when many problems were found and the first varieties (Caliverde and Lahontan) were developed in a planned breeding program. The spotted alfalfa aphid was introduced into the USA in 1954 and essentially dominated alfalfa research for the next 10 to 15 years. Resistant alfalfa varieties solved the problem. Work on root rots started in 1952, progressed at a slower rate but to the point where the Phytophthora root rot problem was solved by resistant varieties and progress is being made on other root rots. Research has also been started on other diseases. When the blue alfalfa aphid was identified in 1975 varieties with resistance to it and a combination of other factors were soon developed. The stem nematode and root nematodes were found to be severe problems in the low desert valley areas in the 1970s and resistant varieties were also developed. Nondormant germplasm is being collected and placed in gene banks to be used as needed. Enough resistance is now available in nondormant varieties so many growers can grow the crop without insecticides. Mixed feelings develop when one tries to predict the future of nondormant alfalfa. However, I am optimistic. Many know of nondormant alfalfa and its value. New, imaginative ideas are being explored. Good resistance work will continue but rapid progress will be difficult until (1) chemical control is no longer available or (2) the environmentalists realize plant resistance is the safest, cleanest, and best form of biological control available.

**Keywords:** Alfalfa, Medicago sativa, Nondormant, Varieties, Breeding, Culture, Insects Diseases, Germplasm, Plant exploration, Salinity, Smog, Biotechnology.

### INTRODUCTION

Alfalfa (Medicago sativa) can be grown from the equator to about the Arctic Circle but no one variety will be adapted to all areas. Instead, varieties must change as the climate changes. The nondormant varieties are used in the warm climates of the world, usually found between 34° north and south latitudes. This includes much of California, the extreme southern part of the United States, and areas similar to this around the world. The nondormant types of alfalfa are capable of growing through the year when planted in mild climates. Another term generally used when referring to nondormant alfalfas is "nonwinter hardy". As the term indicates, these varieties are generally unable to survive extended periods of subfreezing temperatures. However, these varieties can be used in cooler climates if they are grown as summer annuals for green manure or summer forage production.

The main usage area for nondormant alfalfas in the USA is the Southwest from the Southern Rio Grande River Valley to Southeastern New Mexico, through Southern Arizona, Southern Nevada and much of California. These types of alfalfa have generally received limited research work because they were planted on only a relatively small area in the USA. However, the area of use outside the United States is relatively large. Some of these areas include Australia, South Africa, Saudi Arabia, Mexico, and Argentina.

Use of nondormant alfalfa has been limited because many countries where these varieties might be used are underdeveloped and have limited money to spend on research. In addition, many of the areas that might use nondormant varieties have poor environments for seed production and must purchase their seed from other countries such as the United States.

#### BEFORE 1950

Alfalfa was introduced into Southwestern USA from Chile during the gold rush in about 1850. This seed was generally called "Common" or "Chilean" alfalfa and often the name of the state where it was grown was given as a prefix.

The seed introduced from Chile was variable and types adapted to certain areas were naturally selected by repeated seed production in a particular area. For example, the types repeatedly replanted in cooler areas developed more dormancy than the types grown in the southern areas. This resulted in the gradual development of regional strains. In addition to these regional strains, varieties from other parts of the world were introduced and tried for possible use in the nondormant growing areas. Some of these introductions were Hairy Peruvian 1899, Arabian 1902, African 1924, Indian (no date available), and Argentine 1936-1940. Most of these failed to have the necessary combination of nondormancy, long life, and good production but Hairy Peruvian and African were acceptable and generally used. Despite the age of these varieties, many growers still remember using them or hearing about them. Some growers wish they could grow them again. However, I feel this would be a mistake because they lack the pest resistance found in all the varieties used today.

#### Culture

During the first 100 years in which alfalfa was grown in the Southwest, the farmers had to develop a system of culture suitable to the conditions of their growing area. The optimum time of planting had to be found along with good methods of planting. In Central California, planting was done prior to winter rains. In the low desert valleys where rains were unpredictable or untimely, the crop was irrigated up. Methods of irrigation were developed to fit the land where the farming was done. This varied from basins to borders of varying lengths and widths to rows and corrugations. Experiment stations helped where they could but help was limited or the problem was usually solved on the farm.

#### Varieties

The varieties of alfalfa generally used from 1850 to 1950 were susceptible to all diseases and insects. As alfalfa was grown over this period of 100 years and on an ever increasing acreage, diseases and insects started to increase and cause problems.

#### Water Management

One problem growers could partially combat without help was reduced stand life caused by root rots, high water tables, and salinity. Growers recognized that surface and sub-surface water was a large part of their problem and that salinity was a related problem. Growers started lowering the water table by digging deep drains and tiling. Attempts were also made to level the land with as much precision as possible and to do this with the correct fall so there would be little or no standing water after an irrigation. By improving the ability of the soil to absorb more water, the salts were easier to leach out because it was possible to apply more water.

#### Fertilizer

When alfalfa was first grown in the Southwest most soils were well supplied with the three major plant nutrients. After many years of farming it was found that phosphate was gradually being depleted. Most soils or irrigation waters provided good supplies of potash and alfalfa was able to produce its own nitrogen. Generally, it was only phosphate that had to be supplied to the alfalfa plants.

Prior to about 1950 growers tried to use organic fertilizers such as barnyard manure and green manure as much as possible. These fertilizers tended to have a good conditioning effect on the soils but salt and weed seeds applied with the barnyard manure were

problems

### Insecticides

Use of insecticides prior to 1950 was limited, especially when compared with the years that followed. However, the insecticides that were used tended to be those like DDT and Toxaphene which had long residuals.

### Machinery

In general, the machinery used prior to 1950 was smaller or had broad wheels or tracks. The negative effect on the soils from this equipment was minimal, especially compared with later years.

## 1950 TO 1955

This is the start of a new era for nondormant alfalfa varieties. Strains of Common or Chilean alfalfa and introduced varieties were grown for about 100 years until the period just before 1950 when the first purposely selected types were released, Arizona 21-5 and California Common 49. Arizona 21-5 was selected from Common alfalfa for better adaptation to Arizona. California Common 49 was selected for resistance to alfalfa dwarf. The first nondormant variety developed using a planned breeding program was Caliverde in 1952. It was selected primarily for resistance to bacterial wilt. This release was soon followed by Lahontan in 1954 which was selected for resistance to bacterial wilt and stem nematode. After the spotted alfalfa aphid was introduced into the USA it was found to be resistant to this aphid also.

## 1955 TO PRESENT

### Spotted Alfalfa Aphid

The spotted alfalfa aphid (Therioaphis maculata) was introduced into New Mexico in 1954 and by 1955 was causing damage throughout the Southwest. Everyone in agriculture seemed alarmed because of the great amount of damage it could do by killing stands, reducing yield and hay quality, and making baling difficult because the honeydew made the hay sticky. Many thought the alfalfa industry would be severely damaged or ruined. State legislators provided research money. New positions in alfalfa research were created. Because the spotted alfalfa aphid did most damage in the Southwest, considerable money was spent on nondormant alfalfas for the first time.

Lahontan was soon found to be resistant to this insect although the spotted alfalfa aphid was unknown when it was developed. This helped bring relief from the spotted alfalfa aphid wherever it was adapted. Lahontan was also tried in the low desert valley areas where it was unadapted but growers felt yields were too low and decided to control the aphid by spraying.

The nondormant variety Moapa was developed by Dr. Oliver Smith in Nevada and released in 1957. Resistance to the spotted alfalfa aphid was good, and production was similar to African, the best-adapted variety in the low desert valley areas. Moapa, and its slightly changed successor, Moapa 69, turned out to be two of the most widely planted varieties for 30 or more years. Moapa 69 is still widely planted today. Other varieties were released over the years starting with Zia 1960, Sonora 1962, and Mesa Sirsa 1965.

The spotted alfalfa aphid continued to be an important insect in the Southwest until about 1970. New biotypes of the spotted alfalfa aphid developed that were able to attack resistant varieties and were difficult to kill with insecticides. In response to resistant biotypes, plant breeders placed greater amounts of resistance into the varieties. By 1970 it appears the alfalfa growing areas became saturated with highly resistant varieties. Essentially no highly susceptible varieties remained to produce large quantities of aphids and the few aphids that remained were quickly controlled by predators and parasites.

The last problem with the spotted aphid occurred in the San Joaquin Valley where seed is produced on varieties with either low or no resistance. Plant breeders working on varieties intended for areas where the spotted aphid was not a problem found they had to place some resistance to the spotted aphid into these varieties if they intended to

produce seed in California

Development of resistant varieties is generally credited with solving the spotted alfalfa aphid problem because new biotypes of this aphid which were resistant to chemicals developed rapidly. The predators and parasites worked only under wet conditions or developed too slowly to be useful and cultural methods of control like strip cutting or sprinkler irrigation enjoyed only moderate success at best.

### Root Rots

A parallel problem with the spotted alfalfa aphid was root rots. In fact, at the time when the spotted alfalfa aphid was at its peak, some very knowledgeable individuals were saying root rots were a greater problem. Unlike the spotted alfalfa aphid, root rots are still an important problem because only limited funding has been directed toward solving the problem. Archie Desert and others in the California Crop Improvement Association have recognized this and are helping as much as they can. Other factors contributing to the slow progress in root rots are: (1) there are three diseases involved and (2) roots are underground and difficult to work with. In addition, it appears growers seldom see the damage being done by root rots and have accepted this damage.

### Phytophthora Root Rot

The three root rot problems are Phytophthora root rot (Phytophthora megasperma), Rhizoctonia root canker (Rhizoctonia solani), and flooding injury or scald. The Phytophthora root rot problem is essentially solved, but higher levels of resistance are needed in the nondormants. Solution to the Phytophthora root rot problem was started in 1952 in California by D.C. Erwin when the disease was reported to have been isolated from a California alfalfa field (Houston et al. 1960). The disease-causing organism was investigated and resistance was first found in Arabian, a variety introduced into the United States in 1902. The disease and resistance to it have since been found in other varieties and locations in the United States.

### Flooding Injury (Scald)

Flooding injury which is commonly called scald is a severe problem in the low desert valley areas during the hot summers. Flooding can also be a problem in other areas but plants die at a much slower rate in cooler temperatures. Work was first conducted in the late 1950s, about 30 years ago (Erwin et al. 1959). At that time it was found that the disease was primarily caused by excess water but action of an organism could not be ruled out.

It was found that flooding or saturated soils of about 30 hours or more were needed to cause scald. This appears to be a long time but field examples are easy to find. A second important point learned was that the first irrigation after cutting should be delayed until some regrowth had occurred.

Work on scald was discontinued for many years but resistance work was started in the mid 1980s with the support of the California Crop Improvement Association. It was found that the nondormant alfalfa types performed better under scald conditions than the northern and eastern varieties, even though some of the eastern varieties had been selected under cool temperature flooding conditions.

From this work it also appears varieties can be selected with resistance to high temperature flooding (scald). The work is slow but should be very beneficial to growers of nondormant alfalfas.

### Rhizoctonia Root Canker

Rhizoctonia root canker is the third important root rot affecting nondormant alfalfas. Work on the biology of this disease was done in the early 1940s by O.F. Smith in the Yuma area (Smith 1943). A breeding program designed to develop varieties with resistance to this disease was started by Drs. E. H. Stanford and B. Houston in the Imperial Valley in the early 1950s. Significant progress was being made but when the spotted alfalfa aphid arrived in 1955 it was found that all this germplasm was highly susceptible to the new insect. Since the spotted alfalfa aphid research superseded almost all other work, the

Rhizoctonia work was dropped.

The Rhizoctonia root canker research was revived in about 1980. Progress was slow primarily because good disease epidemics were difficult to create. However, some advancement has been made in developing breeding methods and resistant germplasm. This work was also supported by the California Crop Improvement Association.

#### Other Diseases

Leaf and stem diseases are a group of disease problems which are relatively unimportant in dry, desert areas but more important in the wetter growing areas like the Central Valley of California. In addition, if nondormants are to expand into the Southeastern USA and the wetter tropical and subtropical areas of the world, they must have resistance to leaf and stem diseases.

Downy mildew (Peronospora trifoliorum) is a very common, widely distributed disease. Plant breeders have been gradually selecting for resistance. Most new varieties have resistance to it.

Southern anthracnose (Colletotrichum trifolii) is a disease that can be found on nondormants at some time through every year. It seems to slowly reduce the stand. Good resistance and breeding methods are available.

Common leaf spot (Pseudopeziza medicaginis) is relatively unimportant in the low desert valley areas but can be very important in the spring in the Central Valley of California and other wetter areas where nondormant alfalfas are grown. Germplasm with resistance is available.

Stemphylium leaf spot (Stemphylium botryosum) and Stagonospora crown and root rot and leaf spot (Stagonospora meliloti) are two diseases that are also important in the wetter areas where nondormant alfalfas are grown. Germplasm with levels of resistance to both of these diseases is available.

Fusarium wilt (Fusarium oxysporum) is a very important disease on nondormant alfalfa but one for which we have very high levels of resistance in all varieties.

Bacterial wilt (Corynebacterium insidiosum) was considered a serious disease at one time but it has not been a problem for the last 30 years. However, varieties and germplasm with low to moderate levels of resistance are available if it should become a problem in the future or if foreign seed buyers should request varieties with this resistance.

#### Stem Nematode

Work has been done on resistance to the stem nematode (Ditylenchus dipsaci) by different groups at different times during the past 30 years. At first interest was focused on central California coastal and interior areas. Germplasm and varieties (UC SW44 and WL451) were developed for use in these areas during the late 1960s. Lahontan was also available for the Central Valley. A few years later workers in Arizona found stem nematodes were causing severe problems in the unlikely area of the Salt River Valley near Phoenix (Nigh 1983). The variety Lew was developed and released in 1976. In addition, work was done on the biology of the nematode. This same nematode was later found in the Welton-Mohawk Valley on the lower reaches of the Salt River Valley.

#### Soil Salinity

Resistance to soil salinity has been an interest of scientists working on alfalfa as well as many other crops (Francois 1982). Most interest has been in the drier areas where soil salinity is a problem. This work has been done in several locations for a long period of time but most work on germplasm development started after Dotzenko and Haus (1960) demonstrated the heritability of salt tolerance. The first salt tolerant germplasm was released in Arizona in 1983 (Dobrenz et al. 1983).

#### Blue Alfalfa Aphid

The blue alfalfa aphid (Acyrtosiphon kondoi) was first identified in the Imperial

Valley of California during the spring of 1975. At the time all varieties were susceptible, damage (stunting, discoloration, and misshapen leaves) was severe, and it was difficult to control with insecticides. It appeared this insect might become as damaging as the spotted alfalfa aphid. However, many of the damaged fields appeared to contain a few normal-appearing plants. Selections were made in one of these fields during the spring of 1975 and combined into a new synthetic variety called CUF 101 (Lehman et al. 1983). Subsequent testing showed it was highly resistant to the blue alfalfa aphid as well as the pea and spotted aphids. It also had a good combination of other characteristics and was released as a new variety in 1976. This aphid has since been reported to have been found in many countries around the world. Good control is being obtained by using resistant varieties.

#### Pea Aphid

Of the three aphids attacking alfalfa in the United States, the pea aphid (*Acyrtosiphon pisum*) has been a problem for the longest period of time. It is also the least damaging. The first work on resistance to the pea aphid was done in 1934. More work was done about 1950, but like many alfalfa problems, work on pea aphid resistance was impeded by the serious problem of the spotted alfalfa aphid. The first resistant, nondormant variety (Mesilla) was released in 1967, about 33 years after the first resistance to the pea aphid was reported (Nielson and Lehman 1980). Numerous resistant varieties are now available.

#### Egyptian Alfalfa Weevil

The Egyptian alfalfa weevil (*Hypera brunneipennis*) was first introduced into the United States near Yuma, Arizona in 1939. It was confined to the low desert valleys until the 1960s when it started to move into the Central Valley of California (Lehman and Stanford 1975). A small program designed to develop varieties resistant to the Egyptian alfalfa weevil was started in California in 1965. This work was later expanded, but by 1975 funds for this work had been essentially eliminated. Breeding techniques and germplasm with resistance were developed (Summers and Lehman 1976) but this resistance proved to be too low to be of practical value.

The Egyptian alfalfa weevil, unlike the aphids, is a chewing insect. If good resistance could be found to this insect we might develop methods which would enable us to develop resistance to other chewing insects such as the armyworm and the alfalfa caterpillar.

#### Other Insects

Limited resistance research has been conducted with nondormant alfalfas on the insects not mentioned above such as the leafhopper, alfalfa seed chalcid, and lygus bugs (Nielson and Lehman 1980). The leafhopper (*Empoasca* spp.) is a problem in parts of Arizona almost every year and only occasionally in the rest of the Southwest. All research on nondormant alfalfas on this insect has been done with insecticides.

Limited resistance research has been done in Arizona on the alfalfa seed chalcid (*Bruchophagus roddi*) during the late 1960s and early 1970s and on lygus bugs (*Lygus* spp.) in the mid 1970s. Germplasm was developed but resistance was too low to be of practical value. However, because these are seed insects, considerable work has been done with chemical control.

There are many other insects of importance such as spider mites, armyworms, three-cornered alfalfa hopper, and leaf roller attacking alfalfa but only limited resistance work, if any, has been done on them.

#### Smog or Air Pollution

Smog or air pollution can be an important yield-reducing factor near large metropolitan areas like Los Angeles, Bakersfield, Fresno, and Phoenix. Often the symptoms of air pollution are hard to see or measure. Smog can be expected to increase as urban populations increase in size. The only comprehensive work on this problem in nondormant alfalfa was done by Kats, Thompson, and others at Riverside, California (Kats and Thompson 1976) during the early 1970s. Unreleased germplasm with possible resistance

to smog was developed by Lehman and Isom

### Increased Nondormancy

Most growers in the low desert valleys and other areas using highly nondormant alfalfas would like to see alfalfa grow better during the winter. When berseem clover was commonly grown as a forage crop, growers would often say they wanted an alfalfa capable of growing in the winter like berseem. One of the objectives of our work has always been to obtain better winter growth. This has been a difficult objective to meet because good sources of highly nondormant germplasm were unavailable and because there have always been more pressing problems like aphids and root rots. However, over the years improvement has been made. One of the biggest advancements was made in the development of CUF 101 (Marble et al. 1985).

Recently a group of alfalfa introductions from the Near East have been found to have very rapid recovery and better winter growth. However, these types are susceptible to almost all diseases and insects and production is low. In addition, since the cutting frequency is greater it is more expensive to produce hay. Breeders are now making crosses with these types and selecting out improved types.

### Biotechnology and Wild Alfalfas

Biotechnology research on nondormant alfalfas and crosses of nondormants with wild alfalfa species is very new and usable results may be years in the future. However, as can be seen many times in this paper, it often takes 30 or more years from the start of work to application of the results. Quick results like those obtained for the spotted and blue alfalfa aphids are the exception. On the other hand, quick results could occur. This work is too new to make predictions.

Most of the present research with nondormants on biotechnology and new species is being done at the University of Arizona (McCoy and Smith 1987). Part of the work on biotechnology involves techniques on problems like tissue culture, embryo recovery, and fusing cells. When successful, this could lead to improved resistance to salinity, drought, diseases, and insects.

### Collecting Alfalfa in Foreign Countries

Alfalfa is an imported crop which is thought to have originated in the area of the world where the countries of Afghanistan, Iran, and Turkey are located. All alfalfa varieties in the Americas had to be introduced from Asia, Africa, and Europe where they had been widely disseminated prior to the discovery of America. These areas are still the best sources of cultivated varieties, ecotypes, and wild alfalfas. However, a wide variety of types have evolved in the Andes Mountains of South America since alfalfa was introduced into that region by the Spanish. Most of these types are nondormant. One, Hairy Peruvian, was used for over 50 years as a variety in the low desert valley areas.

Much of the foreign alfalfa germplasm is becoming endangered as more land is farmed and as farmers change to better, more productive varieties. For example, it is now very difficult to collect pure, native seed of varieties in Saudi Arabia because much of the seed is imported from the United States. In addition, since native varieties bring a higher price, the native seed is heavily diluted with the less expensive seed from the United States.

Several alfalfa plant exploration trips have been made recently to collect as many foreign varieties as possible. Trips have been made to Chile, Turkey, Bolivia, Peru, Equador, Morocco, Russia, and Pakistan. More are planned. Much of the material collected on these trips has been nondormant. There were about 2000 Medicago entries in the alfalfa world collection in 1986. An estimated 26% of these were nondormants in 1975 (Barnes et al. 1975).

### Quality

Quality is a character in which there is considerable interest but one where progress has been slow. Work has been done on reducing saponins and increasing branching and leaflets. New research is in progress at U.C. Davis on breeding for increased protein and

yield. Promising results have been obtained. The improved plants also increased  $N_2$  fixation by all strains of Rhizobium bacteria tested (Phillips et al. 1985).

### Nitrogen Fixation

Considerable work has been in progress on nodulation and nitrogen fixation in alfalfa during the past 10 years. Strains of Rhizobium bacteria having increased ability to fix  $N_2$  have been identified. Rhizobium nodules have been collected on plant exploration trips to different countries and collections made in various parts of the United States have been characterized.

### Culture

Many changes have occurred in the culture of alfalfa during the past 30 years. During the early part of this period growers gradually stopped completely renovating fields and using alfalfa as an annual because varieties were longer-lived and better land leveling techniques were available. Lazer leveling was introduced late in this period. This allowed for frequent, precise leveling but it also resulted in the growers reducing the slope of their fields. Water often stayed on these fields longer and tended to take away some of the longer stand life plant breeders put in their varieties. More irrigation ditches were cement lined. This saved water, helped lower the water table and reduced salinity. Growers changed to chemical fertilizers almost completely because they were more cost-effective and contained no weed seeds. During this period machinery became heavier and more damaging to the soils.

## THE FUTURE OF NONDORMANT ALFALFA

The future is always very difficult to predict. It has been my experience after making predictions in the past and reading them later that events move much more slowly than we expect. Because of this, my predictions may seem very conservative.

It is very encouraging to see that two scientists in Arizona have recently begun work on alfalfa. When Dr. Stanford retired at U.C. Davis several years ago he was replaced by Dr. Teuber who is also working on alfalfa. Some loss of federal alfalfa scientists has occurred, but it seems most state positions are being retained. However the type of work being done by the new scientists has generally been changed.

Plant breeding and variety improvement will continue. It appears the nondormant alfalfas will get their share of attention. Most alfalfa scientists are now aware of the merits of nondormants, unlike 30 years ago. They will use nondormant traits to increase the value of dormant lines and increase the area of adaptation of nondormant lines. When improvements are made, they will involve resistance to diseases and insects, and improvements of other characteristics which will be beneficial to all users of nondormant alfalfas.

Improvements in alfalfa varieties will be slow in coming. This is mainly because plant breeding is a slow process. Some of the first results that can be expected are increases in resistance to Phytophthora root rot, anthracnose, and root nematodes because this work is now in most breeding programs and because selection methods have been perfected. Slow in coming will be resistance to chewing insects like the weevil, alfalfa caterpillar and armyworms.

Resistance to Rhizoctonia root canker, scald, leafhoppers, lygus, and leaf and stem diseases will also be slow. The time interval between the start of work on a problem and placing the resistance into a usable variety can be reduced if enough effort is placed into the work. It does not seem this will happen at the present time. It seems progress in breeding for resistance to plant pests will be slow until (1) chemicals used to control a particular pest are no longer available or (2) the environmentalists finally realize that plant resistance is the safest, cleanest, and best form of biological control available. It is possible for one or both of these to happen more quickly than we expect.

Since the nondormant varieties generally originated in the desert regions of the world or were developed in desert areas, they are usually susceptible to leaf and stem diseases. I see lack of resistance to these diseases and only limited resistance to



root rots as the main limiting factors to the increased use of nondormant varieties

I feel one area of great promise for improvement of nondormant alfalfas and alfalfa in general is the use of wild alfalfas in the improvement of common alfalfa. These wild alfalfas have resistance factors not found in common alfalfa. If we know how to utilize this germplasm, many difficult problems might be solved. It is possible this work may proceed slowly until a breakthrough is made. After this, considerable effort will be placed in this area of work.

Plant explorers will continue in their efforts to get as much of the world's germplasm into gene banks. Some countries are closing their borders to plant explorers because they feel this is exploitation. Other countries allow only limited exploration or germplasm exchange. However, exploration or world events change and plant explorers may be able to enter a country at a later date or arrangements might be made for germplasm exchanges. Money is becoming available for this type of work because it is supported by public opinion. Considerable effort might be expected in the next few years. In addition to exploration, plans are being considered to improve or enhance this germplasm so it will be more useful to plant breeders and ultimately growers.

Alfalfa research has met with considerable success in the past. More progress has been made on breeding for pest resistance in alfalfa than any other crop because it responds well to research. Some growers are able to go through the year without using pesticides in hay production. Continued advancement in the traditional areas can be expected but work will be done in entirely new areas that should lead to greater productivity and expanded use such as protein for human consumption or redesigning the plant. Alfalfa research workers are optimistic, but like all other work, results may seem to be slow in coming.

#### LITERATURE CITED

- Barnes, D.K., E.T. Bingham, R. P. Murphy, O.J. Hunt, O.F. Beard, W.H. Skrdla, and L.R. Teuber. 1975. Alfalfa germplasm in the United States: genetic vulnerability, use, improvement, and maintenance. USDA, ARS Technical Bulletin 1571. 21 pp.
- Dobrenz, A.K., M.H. Schonhorst, J.E. Stone, R.K. Thompson, S. Allen, and D. Smith 1983 AZ-Germ Salt I nondormant alfalfa germplasm. Crop Science 23:807.
- Dotzenko, A. D., and T.E. Haus. 1960. Selection of alfalfa lines for their ability to germinate under high osmotic pressure. Agronomy Journal 52:200-201.
- Erwin, D.C., B.W. Kennedy, and W.F. Lehman. 1959. Xylem necrosis and root rot of alfalfa associated with excessive irrigation and high temperatures. Phytopathology 49:572-78.
- Francois, L.E. 1982. Managing alfalfa under saline conditions. Proceedings of the Twelfth California Alfalfa Symposium, Fresno, California, December 8-9, 1982. pp 53-57.
- Houston, B.R., D.C. Erwin, E.H. Stanford, M.W. Allen, D.H. Hall, and A.O. Paulus. 1960 Diseases of Alfalfa in California. California Agricultural Experiment Station Extension Service Circular 485. 10 pp.
- Kats, G., and C.R. Thompson. 1976. Comparison of six cultivars of alfalfa for tolerance to photochemical oxidants. Proceedings of the Sixth California Alfalfa Symposium, Fresno, California, December 8-9, 1976.
- Lehman, W.F., and E.H. Stanford. 1975. Possibilities for developing alfalfa varieties for resistance to the Egyptian alfalfa weevil (*Hypera brunneipennis*). Proceeding of the Fifth California Alfalfa Symposium, Fresno, California, December 10-11, 1975. pp 53-59
- Lehman, W.F., M.W. Nielson, V.L. Marble, and E.H. Stanford. 1983 Registration of CUF 101 alfalfa (Reg. No. 119). Crop Science 23:398.
- Marble, V.L., W.F. Lehman, L.L. Ede, R.W. Hagemann, F.F. Laemmlen, and J.D. Radewald. 1985. 1983 Summary of alfalfa variety, brand and experimental selection trials conducted in the Imperial and Palo Verde Valleys of Southern California. Agronomy Progress Report No.161. 82 pp

McCoy, T.J., and S.E. Smith. 1987. Improving alfalfa genetically. *Arizona Land and People* 38:2-3.

Nielson, M.W., and W.F. Lehman. 1980. Breeding approaches in alfalfa. In: *Breeding Plants Resistant to Insects*. F.G. Maxwell and P.R. Jennings (Eds.), John Wiley and Sons, New York. 13:277-312.

Nigh, E.L. Jr. 1983. *Ditylenchus dipsaci*, a pest of alfalfa in Arizona. Proceedings of the Thirteenth California Alfalfa Symposium, Holtville, California, December 7-8, 1983.

Phillips, D.A., M.W. Demment, and L.R. Teuber. 1985. Breeding for increased forage yield and quality in alfalfa. Proceedings of the Fifteenth California Alfalfa Symposium, Fresno, California, December 11-12, 1985. pp 40-44.

Smith, O.F. 1943. *Rhizoctonia* root canker of alfalfa. *Phytopathology* 33:1081-1085.

Summers, C.G., and W.F. Lehman. 1976. Evaluation of nondormant cultivars for resistance to the Egyptian alfalfa weevil. *Journal of Economic Entomology* 69:29-34.