NEW ALFALFA VARIETIES EXPECTED FOR CHANGING FARM CONDITIONS AND PLANT PESTS

W. F. Lehman
Agronomist
University of California, Davis
(P. O 1004 E. Holton Rd., El Centro, 92243)

Alfalfa, like most other low income crops, is being grown in increasingly less desirable locations because high income crops like vegetables, tree crops, or cotton are usually planted in the best areas. Other highly desirable crop land is being converted rapidly to urban areas. What remains is the poorer or less productive areas which include salty, poorly drained, or diseased soils and areas with smog, isolation, or climatic problems which also restrict the crops that might be grown.

Additional problems for alfalfa result from the importation of new insect pests. Faster world travel for humans sometimes seems to mean faster travel for problem insects For example, the blue alfalfa aphid was identified in the United States in 1975. Since then it has been identified in New Zealand, Australia, and Argentina.

Technology which comes to our aid when we have problems can also have the effect of creating some new problems. For example, plant pests are often able to overcome our efforts to control them by developing types which are more virulent and resistant to chemicals and new varieties. This means we must also constantly monitor old problems or they might also turn into new, important problems.

The problems mentioned above can be overcome and plant breeding is an excellent way to do it. This is because a resistant or improved variety will provide a built-in control a control that will stand by and become effective when the problem arises. In addition, there are no environmental problems, and you pay for this control when you buy your seed.

In this discussion I will try to cover some of the areas in alfalfa in which plant breeders are trying to work. However, I will limit my discussion to the nondormant and other types adapted to the southern half of California in an effort to avoid overlapping with other speakers. Much of the work I will mention is being done by many alfalfa plant breeders in California and the Southwest. Therefore, my objective in this paper is to give an overview of alfalfa breeding work and avoid the narrow approach of discussing only University of California work. The examples I will give, however, will be primarily from work at the University of California. The varieties used as examples cannot be a complete list since there are usually several other varieties with the same characteristics.

Insects

Within the past 20 years alfalfa has suffered as much or more than any other crop from new insects. The one imported insect that may have no equal in destructive capacity is the spotted alfalfa aphid (SAA). Those of you that suffered through the first few years of this insect know what I mean.

The spotted alfalfa aphid had some adverse effects on almost every phase of the alfalfa industry. It could kill seedlings and adult plants, populations survived all temperatures in the major producing areas of California, high populations could develop any time of the year, it produced copious amounts of honeydew, a sooty mold grew on the honeydew lowering hay quality, honeydew broke machinery by sticking to and building up on the working parts of equipment and, finally, it had the ability to develop biotypes which were resistant to insecticides and resistant varieties.

The SAA is under control now, but no plant breeder will release varieties for use in the major producing areas in California that do not have resistance to SAA. In addition, SAA populations are constantly watched for build up of new biotypes. For varieties used in areas where SAA resistance is unneeded for hay production, some resistance is needed for good seed production.

Recently, in 1975, the blue alfalfa aphid was identified as a new pest of alfalfa in California. It is still too early to know how severe it will be over the long term. It

has been a severe pest in the low desert valley areas during the spring of the year and variable in Central California. A nondormant variety, CUF 101, has been developed with resistance to this insect and additional resistant varieties are being developed and released. This rapid release of resistant varieties will help the control program.

Like the spotted alfalfa aphid and pea aphid we expect the blue alfalfa aphid will prove to be adaptable. One type of change many have felt will occur will be the development of types that are better adapted to climatic conditions of the Central Valley of California. Though no solid proof is available, the pea aphid appears to have changed several years ago from an aphid important in only limited times of the year to one that could attack during most seasons. The blue alfalfa aphid could do this also.

As was the case with the spotted alfalfa aphid and the pea aphid, another change that can be expected in the blue alfalfa aphid is the development of biotypes resistant to resistant varieties. This will be watched carefully by research workers and Farm Advisors In this regard, we hope growers and field men will also watch for any loss of control with chemicals or resistant varieties. If a loss of control is suspected, please call your Farm Advisor and he will obtain information from me or others on how to get your aphids tested for possible new biotypes. Of course, this same procedure would be followed if new biotypes are suspected for the spotted alfalfa aphid and pea aphid.

When watching resistant varieties for new biotypes, it is important to understand that aphid resistant varieties can have aphids on them. Due to the breeding behavior of alfalfa, we will be unable to get varieties which are 100% resistant. However, resistant varieties can tolerate higher populations than susceptible varieties. This is because the plants contain a type of resistance which allows them to grow and produce under higher aphid populations. If you grow resistant varieties or advise growers, this fact should be considered before insecticides are applied. Under most conditions larger populations can be tolerated before spraying. No data are available on how much larger the populations can be on resistant varieties.

Diseases

Like insect resistance, advancements have been made in breeding for disease resistance. However, the diseases with which we have been working are native to California and their true importance has been difficult to discover.

Phytophthora root rot was first described by Dr. D. C. Erwin in 1954, but it took time to develop breeding methods and resistant varieties. Today most varieties being released have resistance to this disease in them and varieties with higher levels of resistance can be expected in the future.

Obtaining resistance to Phytophthora root rot should help improve production on certain problem soils such as those with water penetration problems and temporary water tables. On the other hand, there are limits to the amount of water any alfalfa plant can tolerate before it will be killed. You will have to continue practicing good irrigation management with these varieties, but their survival will be better when an irrigation mistake is made or when planted in more difficult soils.

Southern anthracnose is a disease which has been known for a long time but good methods of selection were discovered in the late 1960s. Plant pathologists and plant breeders are now able to select highly resistant strains of alfalfa. It has been possible to select these strains from most variety types and almost all plant breeders are doing some work with it. To the best of my knowledge, no resistant varieties have been released as yet for use in California. Plant breeders either have placed this resistance in their best material or are in the process of doing this. They are also trying to determine where varieties with this resistance might perform best. I feel varieties with anthracnose resistance can be expected to be released within the next few years in areas where this is a problem.

A relatively new disease being investigated by Dr. D. C. Erwin, UC Riverside, and Dr. D. G. Gilchrist, UC Davis, is Stagonospora. This appears to be a problem which develops during the cool wet winters found in the Central Valley. Selection of resistant plants and release of resistant varieties seems possible. If resistant varieties can be developed, this could mean that alfalfa will be better able to survive in a greater range

of soi types and environments in California.

Rhizoctonia and scald or flooding injury are two diseases we have been struggling with for many years. They are important over a wide area, but as yet we have no good testing procedures or selection methods available. It is possible some of the newer varieties will have some resistance to these diseases. If they do, this will be more a result of selecting where the diseases are prevalent than any program where resistance to these diseases are major objectives. I hope these conditions can change in the near future.

Considerable progress has been made in developing varieties with disease and insect resistance in the past 10 to 15 years. This, no doubt, has been a factor in improved alfalfa yields and the reduced need for control of certain insects. We should be able to look forward to an even faster rate of progress during the next 10 to 15 years.

Broader Adaptation

Alfalfa varieties can be classified as being nonwinter hardy, medium winter hardy, and winter hardy. In the past, plant breeders have stayed largely within the type of germplasm with which they were working, and there was little mixing of types. The nondormant or nonwinter hardy types were always characterized as being rapid growing and short-lived. On the other extreme, the winter hardy alfalfas were very dormant, had slow recovery after cutting, and generally resistant to bacterial wilt.

For the past 10 to 15 years plant breeders have been trying to broaden the area of adaptation and increase pest resistance by adding germplasm from outside the area of adaptation. This has been slow work because only small amounts of germplasm can be added without running the risk of adversely affecting the plant type with which the plant breeder is working.

Alfalfa breeders from private companies have probably been as responsible as anyone for the introgression of new germplasm into old variety types. Unlike most University employees with narrow geographic responsibilities, for example, the private plant breeder wants his material to be resistant to problems in both the hay and seed producing areas which are often in widely separated geographic locations. He is also constantly traveling over much of the United States and has a greater opportunity to see and select a wide variety of germplasm.

We have also been interested in developing a broad germplasm base in our germplasm. UC Salton, released in 1971, was largely composed of nondormant germplasm but also had a small percentage of germplasm from more northern varieties such as Vernal, Cody, and Lahontan.

The U. S. Department of Agriculture has a program of mixing a wide range of varieties and variety types into very wide germplasm pools. The main objective of this type of work is to get a large number of characteristics in one seed lot. Theoretically, this seed lot can then be screened when a new, damaging pest is found and the chances of finding resistance there is expected to be good. Of course, these broadbased germplasm pools also contain a range of dormancy types which is obvious when observed under certain conditions.

We have obtained seed of one broadbased germplasm pool called BIC from Dr. D. K. Barnes, USDA, University of Minnesota. This was crossed with UC Cargo and closely related nondormant types in an effort to obtain a light-insensitive, temperature-sensitive (LITS) type of alfalfa adapted to most of the State of California. We have been growing this seed on the northern (Tulelake) and southern (El Centro) borders of California. At Tulelake we select the most dormant types in October. At El Centro we select the types out of the same germplasm pool that grow best during midwinter. In this manner we hope to develop a variety that will not be affected by day length but be forced to go into dormancy or nondormancy only by temperature. We are now in about the second generation. The shift has been more rapid than expected toward the intermediate or nondormant types. We will apparently have to spend more time selecting and testing between generations in order to obtain a better balance. This work is expected to take 10 to 20 years before we see much progress, but we feel it must be started.

Another positive effect of introgression of new germplasm is to reduce the vulnerability of our varieties should a new insect or disease affect our alfalfa. If a wide

range of varieties is being grown in an area, the chances of all varieties being completely susceptible are reduced.

Nondormancy

One factor of great importance to growers in low desert valley areas and areas further south is greater nondormancy. More nondormant alfalfa would provide more winter production and may also grow faster between cuttings.

Individuals working with alfalfa in the tropical areas close to the equator tell us the highly nondormant varieties like Mesa Sirsa and UC Cargo show some dormancy compared to the types with which they are working. The germplasm (Mexson) developed by Dr. Schonhorst (University of Arizona) from selections made in Mexico is some of the fastest growing, nondormant material we have seen. Dr. Schonhorst recently spent a sabbatical leave in Mexico, and nondormancy was one of the projects on which he cooperated with the research workers in Mexico. We hope this project will prove successful.

Germplasm or varieties can be imported from countries near the equator that should have greater nondormancy. However, this material has the disadvantages of being shorter-lived than our present varieties and lacking in resistance to the spotted alfalfa aphid and other important plant pests. One additional problem we have found is that it has been difficult to select for this greater nondormancy under our climatic conditions. It seems we should have the most success selecting in the more tropical countries or selecting in growth chambers where all factors can be controlled.

Some initial progress has been made in selecting for greater nondormancy More progress can be expected, but changes may be slow.

Soil Salinity

High soil salinity is one of the conditions frequently found in the poorer or marginal soils of California and on which an increasing amount of alfalfa is being forced to grow. Alfalfa and most other important crop plants have been tested by the USDA Salinity Laboratory at Riverside to determine their possible reaction to soil salinity. In this work alfalfa was found to be moderately affected by soil salinity. Crops like barley or sugar beets were found to be tolerant and beans were classified as susceptible.

Increasing the tolerance of alfalfa to soil salinity would broaden the adaptation of alfalfa in California and insure improved results in saline areas where alfalfa is now grown.

Improved tolerance to salinity can probably be divided into two parts: tolerance of the very young plant and tolerance of the mature plant. Tolerance at the time of germination and early growth might allow a higher germination percentage of stronger plants, the ability to develop a good early root system, and growth into areas of the soil mass where better conditions can be found. Mature plant tolerance would mean the plant can tolerate and grow better through its entire life in saline soils.

Many workers including ourselves have germinated alfalfa varieties at different levels of salinity. This is easy to do because it only involves germination on paper soaked with saline water. Differences have been found, but the results have tended to be variable and it is hard to know what these results mean on a practical basis.

The other aspect of selection for resistance to soil salinity involves growth of the adult plant in saline soils. This work is more difficult to conduct. Plants must be grown in saline soils and measurements must be made on characters which are good indicators of resistance to salinity.

During the past two years we have selected seedlings which were germinated on paper soaked with water having an electrical conductivity (EC) of 30 mmho/cm. These plants were later irrigated in the greenhouse with water having an EC of 7.5 to 15.0 mmho/cm. Seed was produced this summer on the best appearing plants from the greenhouse test. We are also making selections from fields which have soils with high salinity content. A third approach is to grow germplasm pools on soils with a high saline content and then save all the seed from the area. The resulting seed can then be planted back on these

soils for more cycles of natural selection. At present it seems this latter approach might provide the most progress, but it is slow. One of the cycles of natural selection in the development of UC Salton was grown on highly saline soils, EC 7 to 9 mmho/cm in the first three feet of soil. Other cycles were grown on soils with reduced levels of soil salinity.

Breeding alfalfa for increased tolerance to soil salinity is not new, but it is possible that we will see an increased amount of work in this area and that this work will proceed on a continuing basis. It is also possible some practical, useable results will be found in varieties released in the next several years.

Smog

One of the conditions few alfalfa growers have been concerned about is the effects of smog. However, in a talk given to this group last year, Dr. C. R. Thompson reported losses of 17 to 37% for six alfalfa varieties when subjected to heavy smog attack in the Los Angeles basin from 6-29 to 9-7. Losses were also recorded at times when smog was less severe. From this it seems losses are possible under conditions of no apparent physical damage. In the work done by Dr. Thompson and his cooperators, Isom Polycross performed best and Mesa Sirsa poorest. This, and other work, strongly indicated it would be possible to select plants for resistance to smog and that this resistance might be important over a greater geographic area than expected.

In cooperation with Drs. Thompson and Isom at University of California, Riverside, we have been able to identify plants suffering little damage from smog. These plants were combined into an experimental synthetic this past summer and will be evaluated as soon as possible. In addition, more selections are being made for smog resistance when favorable conditions exist.

In our smog resistance work we have also identified plants suffering medium and heavy smog damage. These plants will be used as indicator plants to be placed among unknown plants to determine the severity of conditions under which future selections are made and the resistance level in these selections.

Yield

Yield is one character we are constantly measuring and are continuously improving by various means such as use of resistant varieties, better soil fertility, and improved land leveling. However, all of these improvements are on factors which affect yield and not on yield as a character. Most of the work being done now on yield as a character seems to be in the form of basic studies where activity centers on studies which deal with subjects such as cell components, photosynthesis, and reaction to carbon dioxide. One reason plant breeders have not been working on yield may be because we are making significant progress in improving yield through work in other areas and, therefore, do not receive pressure to improve yield per se. A more important reason may be that there is no time left to do this work after funds and time have been allotted to resistance work and other important problems that must be solved now. My hope is that one of the international organizations that has helped with the wheat, rice, and vegetable programs will also set up a forage research center where all aspects of the world's important forages will be studied. A research center of this type could be expected to look at all components of yield and offer predictions or suggestions on where improvements in yield might be most likely to occur and how the problem might be approached. The factors affecting forage yield in alfalfa are much different than those for wheat, rice, cotton, and sorghum because in alfalfa we utilize the vegetative portion of a plant grown in a solid stand.

Conclusion

Progress in breeding improved alfalfa varieties has been good in the last 20 years. Work on resistance to the spotted alfalfa aphid is generally used as a good example of breeding for insect resistance. In disease resistance, excellent methods have been developed for mass screening of diseases attacking all parts of the plant. Developments are also being made over a wide range of other problems. The caliber of the individual research worker in alfalfa is high. He knows his subject matter, and I am sure he will continue to try to give the grower varieties which are as good as possible and he will try to do this as soon as possible.