

IMPACT OF NEW TECHNIQUES AND TECHNOLOGIES ON
ALFALFA VARIETIES FOR THE 1990's

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Abstract: There are a number of new techniques and technologies which will favorably impact alfalfa variety development in the 1990's. Breeding for new disease and nematode problems will lead to varieties with improved persistence and productivity. Selection for better forage quality using NIR instrumentation will lead to varieties with significantly greater crude protein and TDN. Identification of alfalfa lines that are water use efficient and/or salt tolerant will allow these varieties to be grown in areas formerly considered marginal for alfalfa production. Finally, the introduction of new technologies (e.g. genetic engineering) will allow breeders to incorporate unique traits into alfalfa and thus develop varieties that are not possible through conventional breeding. The successful utilization of these new techniques and technologies in the 1990's will require more sophisticated and comprehensive breeding approaches than those which were successful in the past.

Keywords: Alfalfa disease, insect, and nematode resistance; forage quality; water use efficiency; drought tolerance; salt tolerance; genetic engineering; herbicide resistance; bloat-safe alfalfa.

INTRODUCTION

Breeders of southwestern adapted alfalfas have a real challenge ahead of them in the 1990's. Yield and pest resistance improvements to date have been relatively easy. However, new challenges such as incorporating nematode resistance, improving forage quality, developing water use efficient and/or salt tolerant varieties, and utilizing the new biotechnologies will require significantly more sophisticated breeding approaches than were used in the past.

MULTIPLE PEST RESISTANCE

Alfalfa breeding in the 1980's focused primarily on improving forage yield potential with a secondary emphasis on incorporating multiple pest resistance into new varieties. Improved forage yield will continue to be of primary importance in the 1990's but new efforts will be made to increase the "scope" of multiple pest resistance in new varieties. Alfalfa breeders have attempted to incorporate economic levels of resistance to Fusarium wilt and phytophthora root rot into western adapted cultivars. Diseases receiving secondary attention include bacterial wilt and anthracnose. Verticillium wilt has now been identified in California, but the distribution and impact of this disease on production is still unclear. However, several breeding companies are actively working on incorporating verticillium wilt resistance into southwestern adapted varieties. Other diseases that will receive greater attention in the 1990's include Rhizoctonia, Stagonospora, and several of the foliar pathogens.

Progress has also been made in incorporating resistance to nematodes. The primary nematode problems in the southwest include stem nematode (Ditylenchus dipsaci) and northern root knot nematode (Meloidogyne hapla). Even though nematode damage can be sporadic over a geographic area, these pests can nonetheless be devastating in specific fields. As such, breeding efforts to significantly upgrade nematode resistance in southwestern adapted cultivars are already underway. Additional nematode types (e.g. Meloidogyne arenaria) also occur in the southwest, and these potentially destructive pests will receive attention from alfalfa breeders in the 1990's.

FORAGE QUALITY

Alfalfa varieties now available in California and the Southwest often display small but significant differences in forage quality (crude protein [CP], acid detergent fiber

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[ADF], neutral detergent fiber [NDF], and total digestible nutrients [TDN]). It is surprising that these differences exist, since until recently there has been little breeding work on improving forage quality per se in alfalfa. One possible reason for these differences is that breeders have indirectly improved forage quality by selecting for increased resistance to leaf diseases. Leaves are much higher in quality than stems, and healthy leaves are more likely to stay on the stems prior to and during harvest, thus increasing the forage quality of the harvested product. Alfalfa breeders will significantly increase research aimed at improving resistance to leaf diseases such as common leafspot and downy mildew.

The most significant development in the alfalfa forage quality story was the introduction of near infrared reflectance (NIR) instrumentation in the early to mid-1980's. This technology allows rapid, inexpensive, and accurate analysis of forage quality samples for CP, ADF, and NDF. It has been shown that a properly calibrated NIR machine can characterize a hay sample for forage quality parameters as accurately as wet lab analysis. The power of the NIR machine is in its ability to process a large number of samples in a relatively short time. This feature of the NIR technology lends itself to forage quality breeding, since scientists will require thousands of measurements per line before high quality selections can be made. The result of this selection will be new lines that are significantly higher in CP and TDN than currently available varieties. Several breeding programs now have NIR labs in place, and work in this area should significantly increase in the next decade. It is anticipated that varieties of the future will be routinely evaluated for forage quality much as they are now evaluated for yield potential.

STRESS TOLERANCE

Alfalfa varieties in the southwest will likely be subjected to two important stresses in this decade: limited water and excessive salt. Several years of drought and increasing urban usage have decreased water supplies to agriculture. Alfalfa grown for forage is a relatively inefficient user of water and requires significant amounts of irrigation to produce good tonnage. Researchers at Utah State and New Mexico State have been looking at ways to improve water use efficiency, or drought tolerance, in alfalfa. Water use efficiency implies that a variety can produce a greater tonnage per unit of water than other available varieties. Water use efficient varieties could allow growers to produce acceptable seasonal yields with 1-2 less irrigations, or apply less water per irrigation. Drought tolerance implies the ability to survive under very limited water supplies, and probably has little or no application to alfalfa hay production in irrigated agriculture. Public and private breeders will focus on improving water use efficiency in alfalfa in the 1990's, but the task is not easy. Starting with a relatively water use inefficient crop like alfalfa that also possesses minimal variability for water use efficiency suggests that progress will be slow. However, the development of more water use efficient alfalfas would insure that this forage crop has a secure future in southwestern agriculture.

Salt tolerance is another stress factor which will become of increasing importance in the 1990's. The quality of irrigation water in some parts of the southwest is declining and there is a need to identify adapted germplasm which can germinate and grow under moderately saline conditions. Researchers at Arizona State have identified alfalfa germplasms which germinate and grow under saline conditions. Workers at Utah State, Montana State, and the University of California have also contributed knowledge to this area. This salt tolerance research is very important to alfalfa since the quality of irrigation water available to hay crops may decline over the years. However, researchers have not made significant improvements in salt tolerance to date. Both public and private breeding efforts in this area will probably increase in the 1990's, but a truly "salt tolerant" alfalfa may be elusive.

NEW TECHNOLOGIES

Many of the economically important disease, insect, and nematode pests which attack alfalfa have been and will continue to be controlled through conventional breeding for genetic resistance. In addition, tolerance to certain crop stresses (e.g. salinity) could be improved through breeding. However, despite these plant breeding successes a significant percentage of our alfalfa acreage is still adversely affected by pests, stresses, and

climatic extremes. Molecular biology, genetic engineering, and other "new" technologies may offer unique solutions to these production problems in the 1990's. The genetic engineering of alfalfa is still in its infancy, but several areas of active research will be discussed.

Insect Resistance - Alfalfa breeders have been able to incorporate impressive levels of resistance to many of the major insect pests through conventional technologies. However, certain major insect pests such as the alfalfa weevil remain largely untouched by conventional breeding strategies. Genetic engineering has now provided a technology which might allow alfalfa breeders to incorporate alfalfa weevil resistance into varieties by the late 1990's. The first approach involves the use of protinease inhibitors which have been identified in plants and microbes. By inserting these protinease inhibitor genes into alfalfa through genetic engineering techniques, the breeder could develop a plant that literally starves the insect to death. The presence of the protinease inhibitor in the plant will prevent digestion by the insect that feeds on it, eventually killing the insect pest. Insect feeding studies to examine the efficacy of this approach are just now being conducted, but the technique could have widespread applicability in alfalfa.

A second approach to developing insect resistance in alfalfa involves the incorporation of genes coding for "modified" forms of the Bacillus thuringensis (Bt) toxin. Bt has demonstrated activity against a wide range of insect pests. Unfortunately, Bt does not demonstrate activity against important pests such as the alfalfa weevil. However, efforts are now underway to identify modified Bt strains which display activity against these insects. Once identified, the appropriate genes could be cloned and inserted into alfalfa, thus producing a plant which is toxic to the target insect.

Herbicide Resistance - Several projects are underway aimed at developing alfalfa varieties with resistance to herbicides. Resistance genes are often obtained from plant species or microbes which have displayed tolerance to these chemicals. The target herbicides usually possess a broad spectrum of activity. Thus, genetically engineering an alfalfa to be resistant to these materials would allow growers to simplify their chemical weed control programs, e.g. controlling broadleaves and perennial grasses with a single herbicide application. Field trials are now underway to determine whether plants that have been genetically engineered with the herbicide resistance gene(s) will demonstrate resistance to the herbicide at application rates that control target weeds.

Bloat-Safe Alfalfa - Animal losses attributed to pasture legume bloat are estimated to be \$100 million annually in the United States alone. Development of a bloat-safe alfalfa would be a major step forward in reducing these losses and could significantly increase the use of alfalfa as a pasture legume. Research on breeding a bloat-safe alfalfa has been underway for almost 20 years. The current focus of this research is on the introduction of tannin-producing gene(s) into alfalfa. Tannins have been shown to precipitate rumen foaming agents (soluble proteins), thus destabilizing the foam and allowing rumen gas to escape. The best source for these tannin gene(s) appears to be sainfoin, a non-bloating legume which contains palatable tannins in high concentrations. An alfalfa made bloat-safe with tannin genes from sainfoin would be expected to be highly palatable and completely bloat-safe.

CONCLUSIONS

Growers in the non-dormant and intermediate dormant areas of the U.S. have come to expect high yield and excellent persistence in the newer alfalfa releases. However, there are a number of new challenges which alfalfa breeders will tackle in the 1990's aimed at improving the productivity and quality of this important forage crop. Research areas that will receive increased emphasis include breeding for resistance to new disease and nematode problems, selection for higher forage quality, identification of water use efficient and salt tolerant types, and the utilization of new technologies (e.g. genetic engineering) to incorporate unique traits into future varieties.