PROGRESS IN DEVELOPING SALT TOLERANCE IN ALFALFA

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Salinity is a problem in many alfalfa soils in California. This will be aggravated as salinity increases in irrigation waters, water supplies for leaching are reduced, and planting of alfalfa is shifted to poorer soils. Even in relatively trouble-free soils, a short-term buildup of surface soil salinity during germination and seedling growth can have adverse effects. Observations indicate alfalfa is moderately tolerant to soil salinity. It can be grown individually or in a rotation sequence where moderate levels of salinity are present in the soil (3, 5). Increasing the resistance to salinity would broaden adaptation of alfalfa and expand its use.

In experiments at Riverside, California, the alfalfa varieties California Common and India produced more forage under saline conditions than the varieties Ladak and Atlantic (1). However, since these higher yielding varieties were also better adapted to the warmer climate of Riverside, it seemed possible the higher yields might be more closely related to their adaptation to Southern California conditions than to the salinity treatments. When the same varieties were compared by expressing yield on a saline soil as percent of yield on a nonsaline soil, the relative reduction in yields of all varieties was similar. No significant differences were found among the varieties tested when plant survival was compared.

Seeds from two diverse alfalfa varieties, UC Salton and Ladak 65, were compared at Tucson, Arizona, for reaction to levels of salinity and germination temperatures (4). UC Salton, developed in the desert climate of the Imperial Valley of California, was found to germinate at significantly higher temperatures and salinities than Ladak 65, a variety developed in Montana. This work indicated progress could be made in breeding alfalfa for resistance to higher temperatures and salinities at germination.

In a review of crop tolerance to salinity, Maas and Hoffman (2) discussed the factors influencing salt tolerance. They concluded that tolerance to salinity tended to be enhanced by high soil fertility, good soil aeration, optimum plant growth temperatures, high humidity, and moderate levels of ozone. Stages of plant growth were variously affected by salinity. Since many saline soils are found in areas which have hot, dry climates during part of the year, heat and humidity are important factors in breeding alfalfa for resistance to salinities in these areas. The seedling stage appears particularly vulnerable to damage.

For several years we have been conducting experiments on the reaction of alfalfa plants to salinity. The work has focused on plant reaction to salinity, development of plant breeding techniques, and selection of alfalfa plants with possible tolerance to salinity. In one experiment seeds were germinated from a limited number of alfalfa varieties at different temperatures and salinities. Significantly higher germination percentages were obtained for the variety UC 124 which resulted from one cycle of selection for tolerance to salinity than for CUF 101, UC Cargo, and Mesa Sirsa. Decreases in percent germination were obtained for all varieties as temperature and salinity were increased. About 2% of the strongest seedlings were saved from the high salinity and temperature treatments for later selection in the greenhouse.

Plants selected for resistance to salinity during germination were planted in the greenhouse and allowed to grow to maturity by watering with

tap water. When mature, the plants were irrigated with water having an EC of 15 mmho/cm. About 25% of the best appearing plants from this treatment were saved and planted in crossing blocks in the field. Two experimental varieties have been produced which have had one cycle of this type of selection for salinity and one experimental variety has been produced with two cycles of selections. Only one of the varieties with one cycle of selection has been tested.

Greenhouse experiments were also conducted to provide information on the reaction of about 20 adult plant characters in different varieties at three levels of salinity. Preliminary results indicate that the varieties CUF 101 and Mesa Sirsa reacted similarly in most instances. When UC 124, the variety selected for tolerance to salinity, was included in one experiment, total production tended to be slightly lower than the other varieties. However, when characteristics of the UC 124 plants grown on saline soils were compared on the basis of the percent of reduction for the same character measured on plants growing in nonsaline soil, it appeared UC 124 could tolerate slightly higher levels of salinity. The differences were smaller than those observed for germination tests in the laboratory.

A second important objective in the greenhouse experiments was to determine the alfalfa plant characters that might be most useful in screening of adult plants for resistance to salinity. At present, the most significant characters seem to be dry weight of all stems at each cutting, root weight at termination of experiments, and stem number at termination of the experiment. However, dry weight of all cuttings involves considerable work and may not be useful in selection work where large numbers of plants are needed. Yield of specific cuttings with the highest predictive value may have to be found. Yield at the termination of these experiments was too variable because of reduced plant vigor and plant loss. Stem number was taken only at the termination of the experiment, but might be a good indicator of reaction to salinity at other times. Further studies are planned to test these hypotheses.

Characters appearing to be of reduced value in salinity studies and selection work were plant height, regrowth, root diameter, and root length Plant viability appeared to be a useful character in observations on other work, but seemed to be of reduced value when taken at the termination of these experiments because plant loss led to increased variability in the experimental data. The causes of this loss were unknown.

Care was taken through the life of the experiment (six to eight months) to apply an excess of water when irrigating in order to provide some leaching of the excess salinity. However, when soil extracts were measured at the termination of the experiments, the EC values were found to be about 10 times higher than the salinity of the water applied.

These greenhouse experiments will be continued using improved techniques and other experimental varieties selected for resistance to salinity.

Since use of field selections has been very rewarding for such organisms as alfalfa weevil and root rots, we are also using field selection as an important part of the salinity resistance work. Fields are being used with EC = 7 mmho/cm or higher. Much of the germplasm in our program at El Centro is exposed to these salinity conditions at some time in the development process. High temperatures of over 100 degrees and low humidities prevalent during the summer months place additional stress on the plants weakened by salinity. These weakened plants often succumb or are discarded from the program. One experimental variety (UC 150) was obtained from a 4-year-old stand of alfalfa growing in a 1.7 acre field with high soil salinities. No tests have been made as yet on its reaction to salinity.

A large body of data on the reaction of alfalfa and alfalfa germplasm to soil salinity is available for our reference. Progress in our program to develop alfalfa selection methods and germplasm with resistance to salinity has been very encouraging. Conducting this work in an area like El Centro, California, should be a very valuable asset because soil salinity is a major problem and high summer temperatures and low humidities apply additional selection pressure. Selection experiments and testing of new experimental alfalfa varieties with possible resistance to soil salinity will continue.

LITERATURE CITED

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