Release of a Nondormant Alfalfa Population with Improved Forage Yield in Saline Environments

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Abstract

Salinity is a persistent problem for alfalfa growers in Arizona that will likely worsen over time. Plant breeding may offer a relatively low-cost short-term solution: varieties bred to remain productive in the presence of moderate levels of salinity. We have developed and released AZ-90NDC-ST, a broad-based, nondormant alfalfa population with increased forage yield in greenhouse trials under moderate NaCl stress. AZ-90NDC-ST was derived from two cycles of selection for increased forage yield under NaCl stress from AZ-88NDC, a composite nondormant population previously released by the experiment station. AZ-90NDC-ST was developed to provide a source of alfalfa with increased forage production under moderate salt stress and is the only population with these characteristics in existence. This population, which has been made available to the alfalfa breeding community, will provide the basis for improved high-yielding and pest-resistant varieties for use in areas in subject to salinity stress.

Selection Methods

Since 1985 we have been involved in research to develop efficient selection methods that can be used to improve survival and forage yield in alfalfa under saline conditions. Below we describe the application of the results of this research in the development of a nondormant alfalfa population with improved forage yield in saline environments.

In November 1987, 2500 seed of AZ-88NDC were germinated in dishes containing a 60 mM (3.5 g L^{-1}) NaCl solution. Germinated seedlings from each dish were transplanted into individual 40-mm by 0.2-m cylindrical containers containing equal amounts of a soil medium and covered with sand. Seedlings were irrigated individually with 25% Hoagland nutrient solution plus 3.5 g L^{-1} NaCl as needed. Each container was thinned to one plant 14 days after transplanting. Eight replicates each with 98 plants were designated. Screening was conducted in a greenhouse at 19.8 ± 0.2°C.

Seedling forage growth was harvested and discarded at 77 days. Forage fresh weight was determined for each plant 112, 140, and 168 days post planting. To minimize salt accumulation, containers were flushed with 0.1 L non-saline water immediately after each harvest. This was followed immediately by irrigation with the saline nutrient solution. In May 1988, selection was conducted based on total forage produced in the three harvests. The 152 highest yielding plants (20%) that remained after selection (19 plants from each replicate) were randomly arranged and interpollinated by hand in the greenhouse. Equal amounts of seed were bulked from 130 of the 152 interpollinated plants to form the Syn-1 of the first cycle of selection (="Cycle 1").

The screening procedure for cycle two was modified by planting five Cycle 1 seeds per container. These were thinned to one plant per container 10 days after planting. The established seedlings were irrigated as before. Seedling forage growth from all plants was harvested and discarded at 50 days. Forage fresh weight was determined for each plant after 77, 104, and 132 days growth as before. Screening was conducted in a greenhouse with 24 h fluorescent lighting at 22.8 ± 0.4°C. Salinity level was monitored and controlled as in the first cycle.

In January 1989, selection was practiced as before. The 162 highest yielding plants (20%) were randomly arranged and interpollinated by hand in the greenhouse. Equal amounts of seed were bulked from 160 of the 162 interpollinated plants to form the Syn-1 of the second cycle of selection, which was released as AZ-90NDC-ST.

Results and Conclusions

In a greenhouse trial using the same conditions as used for selection, total forage yield of AZ-90NDC-ST was consistently higher than AZ-88NDC in all environments: 0 mM NaCl, +18.8%; 30 mM NaCl, +4.9%; 60 mM NaCl, +13.1%; and 80 mM NaCl, +13.3% (Table 1). Yield of Cycle 1 did not differ significantly from AZ-88NDC. These data indicate selection under moderate NaCl levels improved yield under moderate salt stress and did not decrease forage yield in low or non-saline environments. Winter growth and forage yield of AZ-90NDC-ST is similar to CUF 101 when grown at Tucson.

This research has established that straightforward selection procedures can be used to breed for increased forage yield in alfalfa under salt stress. Our work has resulted in a population that may be further improved by commercial alfalfa breeders for use on farms in areas subject to salinity in the near future. This research has also yielded much valuable basic information on the genetic controls of response to salinity that may be helpful for plant scientists attempting to understand or improve salt tolerance in other species.

It is important to recognize that salinity problems are rarely self correcting. Salt tolerant varieties will provide only the opportunity to continue growing alfalfa while measures are taken to reduce salinity in the soil or water. Only when such steps are taken will it be possible to consider long-term agricultural productivity in areas of high salinity.

Table 1. Regrowth forage yield (Mean ± standard error in g plant^{-1}) of AZ-90NDC-ST and its parental populations (AZ-88NDC and Cycle 1) at four salt levels (N=56 for each population).

	NaCl level (mM)*					
Population	0	30	60	80	Mean	Mean-% of AZ-88NDC
AZ-88NDC	2.9 ±0.2	3.3 ±0.2	2.2 ±0.1	2.1 ±0.1	2.6 ±0.1	100
Cycle 1	3.1 ±0.2	2.9 ±0.1	2.3 ±0.1	2.1 ±0.1	2.6 ±0.1	99
AZ-90NDC-ST	3.5 ±0.2	3.4 ±0.2	2.5 ±0.1	2.4 ±0.1	3.0 ±0.1	113

* 30 mM = 1.75 g L^{-1} NaCl; 60 mM = 3.51 g L NaCl; 80 mM = 4.68 g L^{-1} NaCl.