

Salinity x Temperature Interactions on Germination Salt Tolerant Alfalfa

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ABSTRACT

Continued irrigation with saline water on Arizona's already salty farm lands will increase the need for crops that are able to maintain yields under stress. We investigated responses of germination salt-tolerant alfalfa (Medicago sativa L.) to salt and temperature stress interactions in comparison to Mesa-Sirsa. Significant interactions were found for the populations, salts and temperatures and their effects on percent germination. The germination salt-tolerant cycles proved to be more cold and heat tolerant under salt stress than Mesa-Sirsa.

INTRODUCTION

Increasing concentrations of salts found in soils and irrigation water in Arizona have prompted breeding of germination salt tolerance, which can help maintain high crop yields. In the southwest, interactions between temperature and salinity are two of the most limiting factors in the seedling germination process. These two environmental conditions stress the germinating alfalfa seed and decrease germination. Studies have been conducted on temperature and salinity and their combined effects on germination of alfalfa (Ungar , 1967; Stone et al., 1979). However, these studies were conducted on alfalfa cultivars that expressed low levels of germination salt tolerance. Stone (1979) showed that a cultivar showing some germination salt tolerance performed better under salt and temperature stress than a non-salt-tolerant cultivar. This suggests that cultivars with a high degree of salt tolerance may perform better under the environmental stresses of warm and cold temperatures and salinity than non-salt-tolerant alfalfa cultivars.

MATERIALS AND METHODS

We used the seed from Mesa-Sirsa, and germination salt-tolerant Cycles 1, 4 and 7. Cycles 1, 4 and 7 represent three separate cycles of recurrent selection in salt solutions for improved germination salt tolerance and were derived from the Mesa-Sirsa (Dobrenz et al., 1983).

Salinity stress was simulated using sodium chloride (NaCl) at concentrations of 0 mmol and 249 mmol. Each solution was treated with fungicide to control disease. Thirty seeds of each germplasm were planted on filter papers in 60 x 15 mm petri dishes containing 3 ml of each salt treatment. Individual dishes were sealed with high vacuum grease to reduce evaporation.

The seeds were germinated on a thermogradient plate in a dark, temperature-controlled chamber. The thermogradient plate (on loan courtesy of the U.S.D.A., Watershed Department, Tucson, Arizona) is a device which produces extremes of hot and cold temperatures; radiant heat produces the intermediate ranges. Plate temperatures were monitored daily using a Scanning Tele- Thermometer for maintenance of constant temperatures of 15, 21, 27, 33 and 39 C in non-randomized strips on the plate surface.

Germination, defined as the protrusion of the radicle through the seed coat, was measured every day for 10 days over 3 separate replications. Data analysis was performed to determine percentage germination, germination speed index (GSI) and temperature x salinity interactions using a modified split-plot design.

RESULTS AND DISCUSSION

Percent germination was significantly different for the populations, temperatures and osmotic potentials, with significant interactions between all three. Also, a significant difference was found for populations and osmotic potential effects on GSI.

Generally, the populations bred for germination salt tolerance germinated better than Mesa-Sirsa across all temperatures, with and without salt stress (Figure 1). Under no salt stress at 15 C, Mesa-Sirsa had an average of 91% germination while Cycle 7 had an average of 98% germination. At 39 C, Mesa-Sirsa showed only 14% germination while cycle 7 showed 53% germination, which is a 4-fold difference over that of Mesa-Sirsa.

Under 249 mmol NaCl stress (Figure 2), significant differences in germination between populations occurred across all temperatures. No seed germinated at 39 C. Cycle 7 exhibited 13% germination at 33 C while Mesa-Sirsa showed only 3% . Even at the more optimal cool temperatures, the salt tolerant cycles exhibited greater germination than the original parent, Mesa-Sirsa.

Selection for germination salt tolerance has improved the response of alfalfa seed to salt stress across a wide range of temperatures. In Arizona, where many environmental extremes can be found, this alfalfa breeding program could help increase germination under salt stress in both cool and warm climatic conditions. This information contributes to our knowledge about the physiological mechanisms of tolerance to various environmental stresses.

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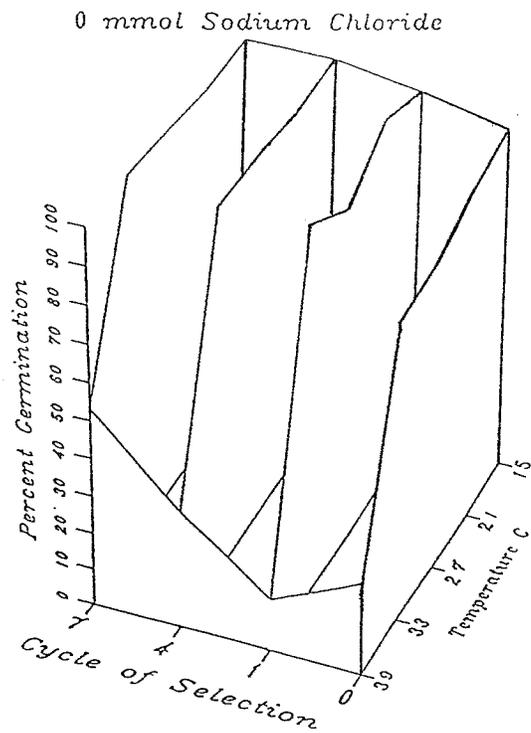


Figure 1. Percent germination at 5 temperatures of Mesa-Sirsa (0) and cycles 1, 4 and 7 germination salt-tolerant alfalfa under no salt stress.

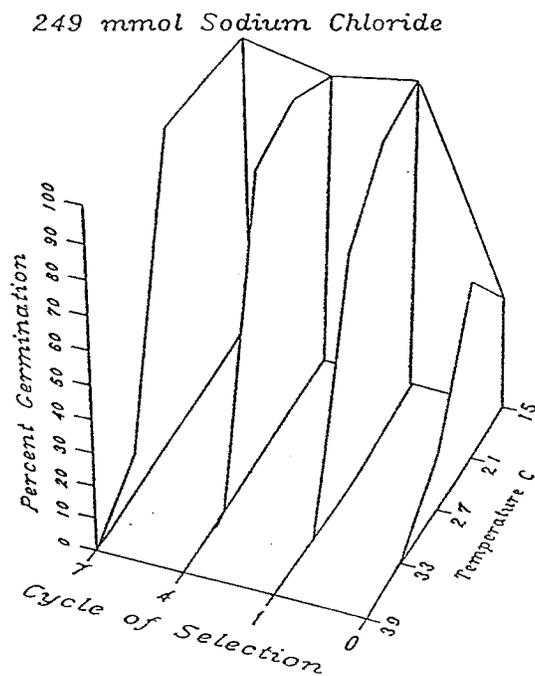


Figure 2. Germination of the same populations at 249 mmol NaCl stress.