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PHYSIOLOGICAL RESPONSE AND GENETIC DIVERSITY OF TETRAPLOID COTTON TO SALT STRESS

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Abstract

Lowered crop productivity and quality can occur where adverse environmental factors, such as high soil salinity are present. It is important, therefore, to determine which cotton cultivars might be better adapted to specific environments and also where yield can be kept at acceptable levels. This study was conducted to determine how a number of cultivars of different tetraploid cotton performed under salt stress.

A pilot study, to determine whether reduction in plant height was a valid, quantitative measurement for identifying salt sensitive and tolerant varieties was conducted. The pilot study included 6 varieties of Upland and Pima cottons (DP33B, SG747, Acala Phytagen 72, Acala 1517-88, JinR422 and Pima 57-4) which were planted in 4-inch pots and allowed to grow under normal watering conditions for 2 weeks. The plants were then arranged in a randomized complete block design. Salt treated plants were treated daily with 100 ml of 200 mM NaCl while control plants were watered with 100 ml of tap water.

Plant height was recorded at 0, 7, 14 and 21 days after treatment (DAT). At 21 DAT, plants were measured for height, chlorophyll content and fluorescence before a destructive harvest for fresh weight (stems, leaves, roots), leaf area, dry weight (leaves) and mineral content (leaves).

All six cultivars showed a measurable response with regard to height reduction as earlier as 7 DAT; however two cultivars, SG747 (67%) and 57-4 (48%), showed the greatest reduction in height, while two cultivars, Acala 1517-88 (27%) and DP33B (32%), showed the least reduction at 21 DAT. Reduction in leaf area at 21 DAT was greatest in SG747 (46%) and 57-4 (67%), with Acala 1517-88 (37%) also showing a significant decrease while DP33B (19%) showed the least reduction in leaf area. This suggests that genotypes with larger leaf area such as Acala 1517-88, 57-4 and SG747 may have a greater response to salt treatment than those with smaller leaf area, such as Phytagen 72, JinR422 and DP33B. Leaf color in salt treated plants appeared greener as early as 3 days after beginning treatment, which was reflected by an increase of chlorophyll content index (CCI). However, fluorescence readings, under light conditions, did not significantly differ between salt treated and control plants. In general, the results presented suggest that reduction in height is a reliable phenotypic gauge to determine salt tolerance/susceptibility in cotton. In addition, it can be concluded that Acala 1517-88 and DP33B, along with Acala Phytagen 72, appear to be more salt tolerant than the other cultivars in this preliminary study.

Mineral analysis was conducted on total leaves from all six cultivars in the pilot study. All six varieties exhibited similar trends with regard to changes in element content after salt treatment. Based on the trends, the changes in element content can be classified into 3 categories: (1) increased – nitrogen (N), manganese (Mn), zinc (Zn), sodium (Na), and chloride (Cl); (2) unchanged – phosphorus (P), sulfur (S), and calcium (Ca); and (3) decreased – potassium (K), magnesium (Mg), iron (Fe), and copper (Cu). Even though both chloride and sodium increased significantly in all six cultivars after salt treatment, SG747 and 57-4, which appear to be more salt susceptible based on reduction in plant height at 21 DAT, had the greatest accumulation of both elements in leaf tissue. The two cultivars, Acala 1517-88 and DP33B, which appear to be more salt tolerant, accumulated both sodium and chloride to lower levels. This suggests that there might be mechanisms in salt tolerant cotton cultivars that either exclude or eliminate sodium and chloride ions better than in salt susceptible cultivars.

Based on the results obtained from the pilot study, it was determined that measuring for height represented a reliable, phenotypic measurement for salt sensitivity/tolerance. Eighty-eight commercial, exotic and older accessions of cotton, representing five different tetraploid species, were subjected to 21 days of salt treatment. Plant height and fresh weight were measured as an indicator of salt tolerance or sensitivity.

Statistical analysis of the reduction in height of the 94 accessions studied revealed that there is a great deal of heterogeneity in response by the different tetraploid species and cultivars. Correlation between reduction in height and fresh weight across three trials was 0.470 and was highly significant ($r_{0.01}$ = 0.271). It also appears that cultivars from the same species may react differently to salt treatment. Thissuggests that salt tolerance/susceptibility is not determined by species but conferred on a genotype by genotype basis. From the results, it can be concluded that there are cultivars which appear to be more salt tolerant. Specifically, most Acala cotton bred in the semi-arid or arid southwest region appear to be more salt tolerant. These results indicate cultivars developed in more arid or saline regions may be better suited to saline conditions.

In the southwestern and western Cotton Belt the soil is relatively high in salt that can ultimately lead to reduced crop productivity and quality. Determination of salt tolerance among different cotton varieties is important in developing genotypes better adapted to specific environments while also maintaining yield at acceptable levels. This study was the first comprehensive investigation to deal with salt tolerance in multiple species of cotton and provides important information for future salt stress studies.