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PARTITIONING AT THE WHOLE PLANT, BOLL AND SEED LEVELS IN RELATION TO GENOTYPE AND ENVIRONMENT FOR PREDICTING YIELD AND STRESS

R.S. Brown, D.M. Oosterhuis, D.L. Coker and L. Fowler
Department of Crop, Soil, and Environmental Sciences
University of Arkansas
Fayetteville, AR

Abstract

Cotton yields in Arkansas increased steadily throughout the 1980's, but leveled off and even decreased in the 1990's. Of more concern, however, is the increased year-to-year variability. A clear understanding of why yields have leveled off the past decade and why increased variability from year-to-year has occurred is urgently needed. It is speculated that the reason for this decrease in yield is a combination of adverse environmental conditions, particularly during boll development, coupled with changes in breeding objectives over the past few decades. Breeding over the past twenty to thirty years has resulted in the occurrence of smaller bolls with more seeds per boll which has increased yields under optimal environmental conditions, but may be the culprit for low and variable yields under sub-optimal growing conditions due to added carbohydrate stress. The main objective of this study is to investigate dry matter, carbohydrate and energy partitioning at the whole plant, boll and seed level in relation to genotype and environment. An extensive investigation of these partitioning factors should help in the development of an "early warning" signal for detecting low boll weight development in the field before yields are adversely affected. The second objective is to investigate methods for ameliorating a potentially low crop boll weight using foliar feeding and plant growth regulators that enhance translocation of carbohydrates.

In 2001, a field study was designed in northeast Arkansas to test the impact that contrasting environmental conditions coupled with genotypic differences had on partitioning in cotton. The study was planted May 10, 2000 in a randomized split-plot design consisting of 16 treatments replicated six times. The whole-plot factor was irrigation and consisted of either well-watered or water-stressed conditions, and the split-plot factor represented cultivar consisting of four obsolete and four modern cultivars. Each of the eight cultivars was subjected to both well-watered and water-stressed conditions to account for the 16 treatments tested in the study. The cultivars were chosen with the collaborative effort of breeders across the U.S Cotton Belt to insure that current germplasm pools from each region were represented. The cultivars included in this field study were ST474, DP NuCotn 33B, SG 747, Acala Maxxa (modern) and ST213, DP 16, Rex, SJ2 (obsolete). The current hypothesis is that modern cultivars produce smaller bolls with smaller and more seeds. Under adequate growing conditions this allows for more seeds per acre and more fiber per seed which aids in higher lint yields. However, under poor environmental conditions (mainly drought) the modern cultivars are unable to tolerate the added carbohydrate stress associated with trying to appropriately fill seed and produce fiber. Based on this hypothesis, the above mentioned field study was conducted to determine how modern versus obsolete cultivars would respond to changing environmental conditions. To evaluate dry matter, carbohydrate and energy partitioning at the boll and seed levels, approximately 80 first-position bolls were tagged at upper and lower canopy positions. From these tagged bolls, 10 bolls were collected at two, four and six week intervals and are currently being processed in order to determine dry matter of boll component parts, lint and seed indices and seeds per boll. This ongoing study will also evaluate lint nonstructural carbohydrates and seed protein and oil. Boll number and average boll weight collected from a $2m^2$ harvest area and final lint yield from mechanical harvest were also assessed to help explain partitioning at the whole plant level. Other in-season measurements including canopy temperature, photosynthesis, leaf water potential, nutrient concentrations, classical growth analysis and soil water status are currently being analyzed to further explain partitioning concepts related to genotypic and environmental interactions.

Results from the 2001 field study indicated no significant differences in lint yields between well-watered and water-deficit treatments when averaged over cultivars. The 2001 cotton season experienced below normal temperatures with normal rainfall which resulted in similar yields between wet and dry plots. However, there was a significant difference in yield between modern and obsolete cultivars when averaged over water, with the modern cultivars showing a significantly higher yield than the obsolete cultivars. A more important result is that there was a significant interaction between water and cultivar levels indicating that different cultivars responded differently to water in terms of yield potential. Final boll harvest supported the hypothesis that modern cultivars had more bolls per meter and more seeds per boll than obsolete cultivars. However, the obsolete cultivars had significantly larger bolls than the bolls from the modern cultivars. To better explain the yield results and boll development parameters measured at the whole plant level, individually tagged bolls at upper and lower canopy positions are currently being analyzed for dry matter, carbohydrate and energy allocations. This should help to explain partitioning at the boll and seed level as bolls of different genetic potential develop in the field under contrasting environments. This current and ongoing research project will continue to evaluate partitioning at the boll and seed level to gain insight into underlying principles of boll development as related to changes in genetics and the environment. If this research is successful it will permit producers to be able to make management decisions either to attempt to enhance boll development or reduce production inputs to save costs.