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COTTON YIELD AND QUALITY GENETIC VS ENVIRONMENTAL AFFECTORS

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Abstract

Cotton yield and quality across most of the Cotton Belt has been below average since 1998. Historical average annual yields for the Cotton Belt suggest stagnation for nearly the last 20 years with large year-to-year variation and large regional differences in both yield and quality. The question being asked among many within the cotton industry is "Have we exhausted our genetic potential or has the environment been the major factor affecting both yield and quality the past few years?" In my opinion the environment includes not only the soils and weather, but also management. One of the major causes of US cotton yield stagnation over the past 20 years has been the 2.5 million acres of dryland on the Southern High Plains and neighboring Rolling Plains of Texas having essentially no yield increases for the past 30 years. Weather analyses in major production regions reveals above average temperatures and below average rainfall in July and August since 1997. Irrigated crop yields, where water supplies are adequate to meet crop requirements, have been average or above average during the same time period. In order to assess genetic vs environment effects on yield and quality, I have analyzed the official variety test data generated by the Cotton Breeders within the Texas Agricultural Experiment Station. I have used data from 1990 through 2000 from tests conducted across the entire state of Texas. Texas' climate provides more environmental variability than the entire Cotton Belt from the Carolina's to California. Cotton is planted in the Lower Valley in February and harvested in July. Boll development occurs during the hottest part of the year. On the Southern High Plains, cotton is planted in mid-May and harvested in October and November. Boll development begins under warm conditions in late July and ends under cool conditions in early October. Water supplies range from 30-40 inches during the growing season along the Upper Gulf Coast to less than 12 inches during the growing season under dryland conditions in West Texas. Yields in the variety tests ranged from less than 200 pounds per acre to nearly 2000 pounds per acre. Cotton varieties were separated into stripper-types and picker-types. Regression analysis was used to determine genotype by environment interactions by regressing individual variety means on the mean of all varieties in a specific test. Individuals were compared for mean yield, intercept and slope. The analyses allowed the following conclusions to be drawn. There is exceptional yield potential in existing cotton cultivars. Based upon the number of fruiting sites in a well-managed cotton field at peak bloom, the yield potential exceeds 10 bales per acre ($>1.5 \times 10^6$ fruiting sites per acre). There is only minor genetic variation in cultivar response to changing environment. As the environment changes to support various yield levels, the slopes and intercepts of existing cultivars are very similar. Only a few cultivars had intercepts significantly different from zero. The range in slopes ranged from 0.88 to 1.10 with only a few cultivars having slopes significantly different from 1.0. The results of this analyses convince me that environment is the dominate controller of yield. Analyses of yield components reveals that boll number accounts for over 85% of the yield variability and boll size about 15%. Boll number was highly related to the percent of the plant population that had a harvestable fruit between nodes 8-12 rather than to the number of mainstem nodes producing fruit or the relative contribution of first position and second position fruit. Boll size had about equal contribution from seed/boll and lint/seed.

Fiber quality, especially length and strength, were strongly affected by genetics with some moderation by environment. Large genetic differences were observed in mean length (ranging from 30 to 37) and strength (ranging from 23 to 30). The G x E analyses revealed that length changes due to environment were different among cultivars. The mean environmental change in fiber length was about 3/32 inch; however, some cultivars varied less than 2/32 and some varied more than 4/32 in response to changing environmental conditions (primarily water supply). Micronaire was largely a function of the environment. Genetic variation existed in mean micronaire, however, the range within a cultivar across environments was two fold. Temperature conditions during the cellulose deposition phase of an individual boll, has major impact on cellulose density and degree of crystallinity. Warm to hot night temperatures during boll development cause high micronaire; whereas, cool nights, commonly found on the High Plains, results in lower micronaire values.

In summary: Tremendous genetic potential exists for yield. The plant easily produces 4-5 times the fruiting forms that it retains as mature fruit. Due to the inherent biology of cotton (woody, indeterminate, perennial) its priority is survival rather than productivity when it senses an impending environmental limitation. We must understand the development of the plant, where yield is derived, and develop management strategies to reduce the risk of environmental stress if we are to capture more of the inherent yield potential. Fiber quality, on the other hand, has a strong genetic influence. Fiber length, strength, and circumference or diameter are largely genetically controlled. Today, when we are selling to a world market, we must place more emphasis in our breeding programs on fiber quality. We must devote more effort to understanding the regional environmental limitations to achieving productivity and develop strategies to reduce the risk of yield-reducing stresses occurring at critical developmental stages.