Cotton Seedling Vigor: Genotypic variation and identification of underlying physiological mechanisms

M. A. Remley[1], S. Liu[1], F. M. Bourland[2], W. Stevens[3], A. Phillips Jones[3], R. L. Nichols[4], and F. B. Fritschi[1]

[1]Division of Plant Sciences, University of Missouri, Columbia, MO; [2]Department of Crop, Soil, and Environmental Sciences, University of Arkansas, Fayetteville, AR; [3]Division of Plant Sciences, Delta Center, Portageville, MO; [4]Cotton Incorporated, Cary, NC

Abstract

Seedling emergence and early season growth are critical for cotton stand establishment. Early vigor, resulting in greater and more rapid seedling growth, allows plants to better tolerate detrimental effects from biotic and abiotic stresses, setting the stage for healthy reproductive growth and a successful cotton crop. However, very little is known about the genetics and the physiological mechanisms determining early vigor in cotton. As an initial step, this project evaluated seedling vigor among 144 cotton genotypes, including modern cultivars, advanced breeding lines, and plant introductions from the national germplasm collection. Significant variation in seedling vigor, as measured by seedling biomass and leaf area development, was identified in both field and greenhouse conditions. Among 144 genotypes, differences greater than 1.75X in total plant dry weight and total leaf area were found in greenhouse conditions. In field conditions, greater than 1.5X differences in total plant dry weight and total leaf area were found among 48 advanced lines. Further evaluations of selected genotypes have indicated differences in root development, cotyledon expansion, individual leaf development, and leaf photosynthetic rates. Additionally, carbon assimilation, partitioning, and allocation dynamics are currently being measured to identify underlying physiological mechanisms that may play an important role in cotton seedling vigor.

Materials and Methods

▪144 cotton genotypes (including modern cultivars, advanced breeding lines, and plant introductions from the national germplasm collection) were grown in greenhouse conditions (University of Missouri, Columbia, MO) during 2008 and 2009. Dry matter and leaf area of cotyledons and individual leaves, as well as stem dry weight were determined at 34 days after planting (Figure 1).

▪48 cotton genotypes were selected based on different seedling vigor characteristics (from greenhouse studies). Plants were grown in field conditions (Delta Research and Extension Center, Portageville, MO) during 2009. Five plants from each genotype were sampled 17, 27, 35, and 48 days after planting from each of four replications (Figure 2).

▪Four cotton genotypes of low, medium, and high seedling vigor (determined by screening in field and greenhouse environments) were greenhouse-grown (5L, 75cm long pots) and frequently harvested from 7 to 65 days after planting. Individual cotyledon and leaf photosynthetic rates (LiCor 6400), relative chlorophyll content, and leaf area were determined, and tissues were collected and freeze-dried for future dry weight measurements and carbohydrate analyses (Figure 3).

Genotypic Variation of Seedling Vigor

Greenhouse Studies:

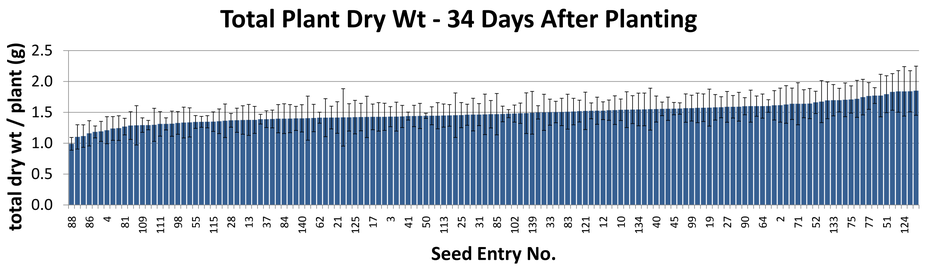

Figure 1. Shoot dry weight per plant of 144 cotton genotypes, including modern cultivars, advanced breeding lines, and plant introductions. Plants were grown in greenhouse conditions and harvested 34 days after planting. Values are means ± SE, n=4.

Field Studies:

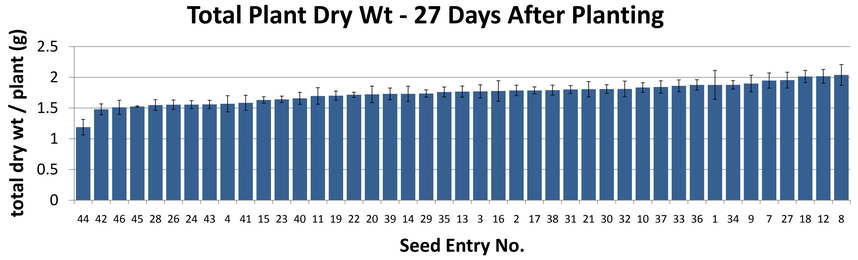

Figure 2. Shoot dry weight per plant of 48 cotton genotypes, including modern cultivars, advanced breeding lines, and plant introductions. Plants were grown in field conditions and harvested 27 days after planting. Values are means ± SE, n=4.

Results and Conclusions: **Greater than 1.75X differences in total plant dry weight in greenhouse conditions (Figure 1) and greater than 1.5X differences in field conditions (Figure 2) were found between genotypes. As measured by dry weight (Figures 1 and 2) and leaf area (data not shown), significant genotypic variation in cotton seedling vigor was identified in both field and greenhouse conditions.**

Physiological Mechanisms of Seedling Vigor

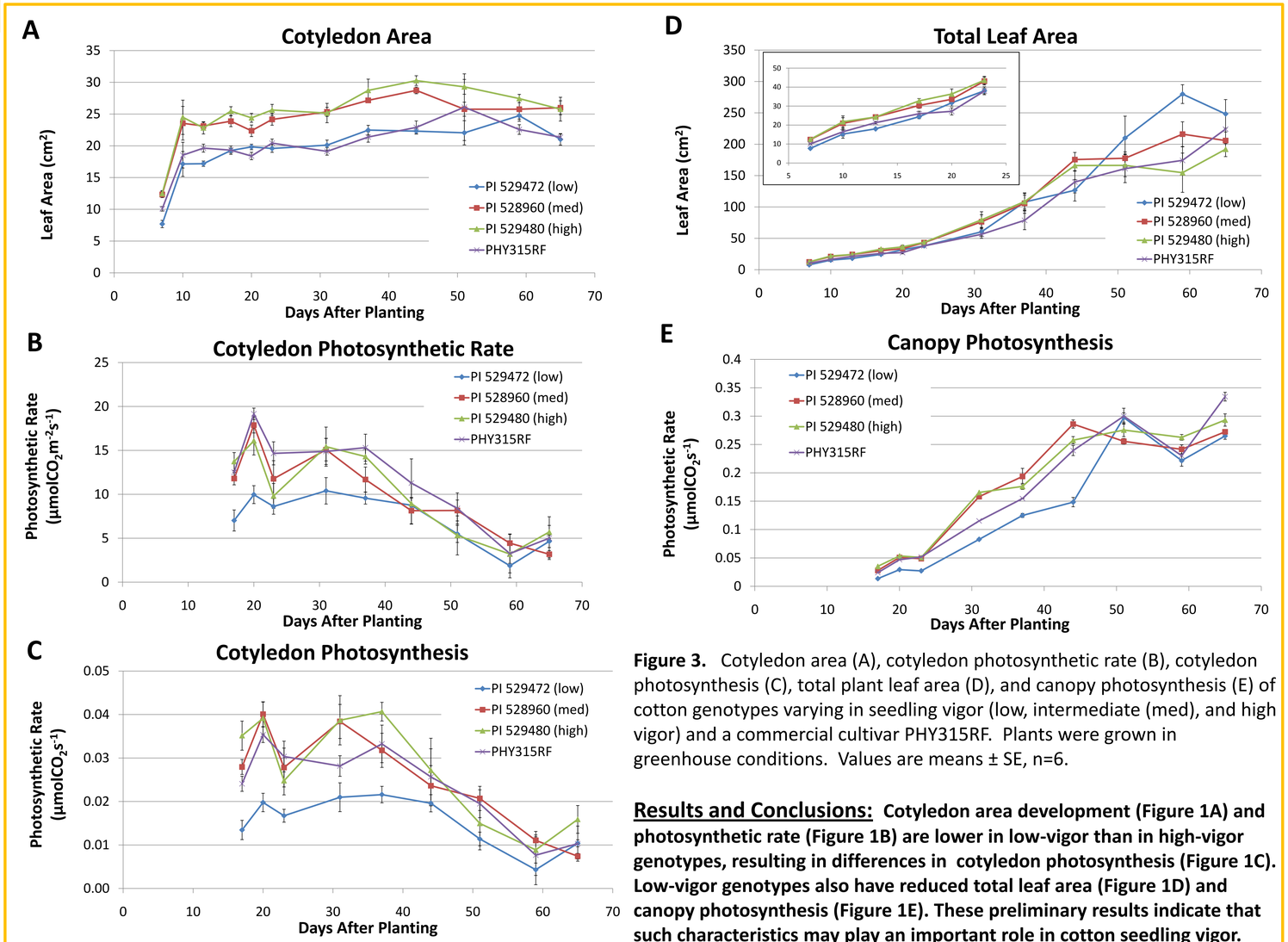

Figure 3. Cotyledon area (A), cotyledon photosynthetic rate (B), cotyledon photosynthesis (C), total plant leaf area (D), and canopy photosynthesis (E) of cotton genotypes varying in seedling vigor (low, intermediate (med), and high vigor) and a commercial cultivar PHY315RF. Plants were grown in greenhouse conditions. Values are means ± SE, n=6.

Results and Conclusions: **Cotyledon area development (Figure 1A) and photosynthetic rate (Figure 1B) are lower in low-vigor than in high-vigor genotypes, resulting in differences in cotyledon photosynthesis (Figure 1C). Low-vigor genotypes also have reduced total leaf area (Figure 1D) and canopy photosynthesis (Figure 1E). These preliminary results indicate that such characteristics may play an important role in cotton seedling vigor.**

Future Directions

▪ Current studies in both field and greenhouse conditions focus on early growth and development of cotton seedlings to determine physiological mechanisms involved in seedling vigor. Of special interest are carbon assimilation, partitioning, and allocation. Leaf development, leaf photosynthetic capacity, and carbohydrate dynamics are being measured.

▪ Further information about the physiological mechanisms underlying seedling vigor is needed to develop screening tools for germplasm improvement and breeding efforts.

▪The influence of seed characteristics on seedling vigor also need to be elucidated.

This project was funded by Cotton Inc. and the Missouri Cotton State Support Committee