UPDATE ON THE PERFORMANCE OF TRANSGENIC COTTON OVER-EXPRESSING SUCROSE PHOSPHATE SYNTHASE

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Abstract

We set out to use genetic engineering to enhance the probability of obtaining mature cotton fibers even under adverse environmental conditions such as cool nights. Background biochemical work in the Haigler and Holaday labs implicated sucrose phosphate synthase (SPS) as a likely candidate for beneficial change. Analogously to other transgenic plants, we predicted that increased SPS activity might result in export of more sucrose from source leaves to support fiber development. From our experiments, we hypothesized that SPS also had a specific metabolic role within the fiber itself by promoting the synthesis of sucrose, which is thought to be a required substrate for cellulose synthesis. A family of transgenic plants was produced with spinach SPS up-regulated under a constitutive promoter. Previously we reported that, in a growth chamber test under 30/15°C day/night temperatures, these transgenic plants showed improved fiber and seed weight and improved fiber properties compared to their parent (*Gossypium hirsutum* cv. Coker 312) (Haigler et al., 2000 a). These improvements were explained, in part, by the deposition of more cellulose in fiber secondary cell walls as directly demonstrated through image analysis of fiber cross-sections and chemical analysis (Haigler et al., 2000 b).

Here we report results from field plots within an irrigated breeding nursery and a water-limited production field in Lubbock, Texas in 1999. In both cases, transgenic plants grew similarly to controls. Twelve representatives of nine independent transgenic lines were grown at the T2 or T3 generations in the irrigated breeding nursery along with their parent and an adapted cultivar (*G. hirsutum* cv. Paymaster HS200). In 6 randomly selected plants of each line, we observed that the transgenic lines compared to their parent had increased seedcotton yield (up to 49% increase, $p = 0.072$) and increased open boll number (up to 59% increase, $p = 0.015$). (Harvest was terminated at the top of the plant on 11/16/99). Seedcotton yield and open boll number showed a linear correlation ($R^2 = 0.59$), and number of seeds per boll was similar in the transgenic lines compared to the parent. The seven independent transgenic lines with yield equal or better than their parent also had equal or better fiber quality, showing that there was no negative correlation between yield and fiber quality in these transgenic plants. Among the seven transgenic lines with yield equal or better than their parent, two to five transgenic lines had increased maturity ratio (0.943 maximum value; $p = 0.001$), bundle strength (31.5 g/tex maximum; $p = 0.003$), UHM length (1.27 inches maximum; $p < 0.001$), Short Fiber Content (n by AFIS, 28.1 % minimum; $p < 0.001$), and Uniformity Index (85.6 % maximum; $p < 0.001$). The parental Coker 312 had comparative fiber quality values of 0.918, 29.2 g/tex, 1.13 in, 36.0 %, and 83.8 %, respectively.

For the yield and fiber quality parameters except length, Paymaster HS200 performed within but at the upper end of the improved range established by the transgenic lines. However, this adapted cultivar has low leaf and fiber SPS activity like the Coker 312 parent, whereas the transgenic lines have elevated SPS activity in both tissues. Crossing experiments are in progress to determine if the SPS transgenic trait can further improve the performance of adapted cotton cultivars.

The best-yielding transgenic line in the irrigated breeding nursery also had among the highest fiber quality in all parameters tested. Comparing three cases where this line has been grown along with its parent (the Duke University Phytotron, the irrigated breeding nursery, and the water-limited production field), we noted that fiber quality in parental Coker 312 responded to the environment, with its best fiber quality observed in the irrigated breeding nursery. However, the transgenic line attained very near its apparent genetic potential for fiber quality under all three growing conditions. Therefore, we hypothesize that the SPS transgenic trait may stabilize or enhance fiber quality across diverse growing conditions.

The increased yield and fiber quality in SPS transgenic plants could be explained by positive effects of up-regulated SPS at both the source leaf and the fiber sink. Work is in progress to explore the physiological changes correlated with this transgenic trait.

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