MECHANISMS BY WHICH FIBER QUALITY AND FIBER AND SEED WEIGHT CAN BE IMPROVED IN TRANSGENIC COTTON GROWING UNDER COOL NIGHT TEMPERATURES

C. H. Haigler, L. K. Martin, J. Tummala, W. Cai,
K. Keating, R. Anconetani and A. S. Holaday
Texas Tech University
Lubbock, TX
G. J. Jividen
Cotton Incorporated
Raleigh, NC
J. G. Gannaway
Texas Agricultural Experiment Station
Lubbock, TX

<u>Abstract</u>

As described in the previous paper, transgenic cotton plants over-expressing spinach sucrose phosphate synthase (SPS) had improved seed and fiber weight and improved fiber quality when plants were grown under cool night temperatures. This paper describes mechanisms by which extra SPS activity can cause these effects, with possible contributions at both source (leaf) and sink (fiber) levels. In addition, this paper describes another positive effect on number of open bolls harvested leading to greatly increased seedcotton yield in an irrigated breeding nursery.

It has been previously demonstrated that SPS is a highly regulated enzyme with a key role in controlling sucrose synthesis in photosynthetic cells and some sugar-storing organs. Increased SPS activity is often correlated with reduced starch storage in leaves. Cotton tends to store starch in leaves during the day, degrading it at night to support synthesis of abundant sucrose for translocation to developing bolls. Developing fibers, which have cool-sensitive cellulose synthesis, use sucrose inefficiently during cool nights, resulting in sub-optimum fiber maturation. We hypothesized that up-regulation of SPS in cotton might cause less starch to be stored and more sucrose to be available for fiber maturation during warm days. Experiments to test this effect in leaves are in progress, but we have shown that SPS transgenic cotton plants store less starch in their lower stems. This may represent one source of extra carbohydrate that becomes available for fiber development.

Prior biochemical work in our lab also indicated a role for SPS in the cotton fiber itself. SPS activity increases in plant-grown fibers as high-rate cellulose synthesis for fiber maturation begins and continues. In highly cool-sensitive cotton cultivars (Acala SJ-1 and Coker 312), this developmental increase in SPS activity is inhibited by exposure to 15˚C as part of a 34/15˚C cycle. In a cotton cultivar with partial cool tolerance in fiber cellulose synthesis (Paymaster HS200), the developmental increase in fiber SPS activity is not inhibited by exposure to a 34/15˚C cycle. However, even in partially cool tolerant Paymaster HS200, metabolic flux to sucrose is still inhibited by 15˚C.

A role for SPS in cotton fiber maturation is consistent with a current model implicating sucrose as the preferred substrate for cellulose synthesis. In this model, the enzyme sucrose synthase degrades sucrose to yield fructose and UDP-glucose, and the UDP-glucose in then channeled to a closely coupled cellulose synthase as the direct substrate for cellulose synthesis. In the presence of SPS, the fructose released by sucrose synthase activity can be recycled into sucrose to support additional cellulose synthesis. Therefore, more SPS activity in the transgenic fibers could increase flux to sucrose and cellulose, which is supported by preliminary biochemical comparisons of transgenic plants and parental C312.

In an irrigated breeding nursery, we field-tested nine independent SPS transgenic lines in comparison to parental Coker 312 and Paymaster HS200. Seven of the transgenic lines showed increased number of open bolls harvested (14 – 59% increase) and increased seedcotton yield (16 – 48% increase) compared to parental Coker 312. Four transgenic lines also performed substantially better than the current adapted cultivar, Paymaster HS200, in these parameters. Fiber quality analysis from the irrigated breeding nursery is still in progress.

An important next step is to cross the SPS transgenic trait into adapted cotton cultivars. We have determined that a representative adapted cultivar, Paymaster HS200, has low levels of SPS activity in its leaves and fibers (like the parental Coker 312). By further work we expect to be able to increase SPS activity in adapted cotton cultivars, and we hope to stabilize and/or enhance their yield and fiber quality.

Acknowledgments: For funding this project, we thank Cotton Incorporated, Raleigh, NC, the Texas Advanced Technology and Advanced Research Programs, and the Texas Tech Institute for Plant Stress Research.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:483-484 (2000)
National Cotton Council, Memphis TN