Population development, selection, and evaluation for lint yield, fiber quality, and disease resistance
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Objectives: To improve cotton germplasm with potential heat stress tolerance, better fiber quality, lint yield and pest resistance, broadening the genetic base of cotton.

Justification and Problem Statement
To improve cultivar performance above current yield, fiber quality, and disease resistance baselines, it is essential that new genetic variability be introduced into elite cotton germplasm pools used by breeding programs. In terms of the maintenance of elite genes/traits, very high constraints are placed on today’s cotton breeders. There is strong pressure for the use of exotic germplasm sources in breeding, but large blocks of genes that are also introgressed during recombination between two parental lines (linkage drag) has limited the use of such germplasm. An apparent plateau in breeding progress has been observed over the last 35 years in Upland cotton. Narrow genetic variability or diversity has been suggested as a contributor to this plateau (May and Taylor, 1998; Meredith, 1992; Ulloa, 2006). In addition, the vulnerability of cotton production in California to race 4 Fusarium wilt [Fusarium oxysporum f. sp. vasinfectum Atk. Sny & Hans (FOV)] highlights the need for comprehensive research to protect the future of the cotton industry in the San Joaquin Valley. This strain of Fusarium has proven especially damaging to most varieties of Pima cotton (Hutmacher et al., 2005). Development of host-plant resistance is currently the most economic and effective strategy for managing FOV (Ulloa et al., 2006a). Growth and competitiveness of the cotton industry are dependent upon continuing improvements in yield, fiber quality, and disease resistance.

Since the re-establishment of a cotton breeding effort within the USDA-ARS, Western Integrated Cropping Systems Research Unit, we have focused on increasing genetic diversity through acquisition of novel germplasm. We have been introducing germplasm from multiple sources including non-commercial landraces and species of wild cottons. Currently, we continue to make progress on germplasm development for heat stress tolerance, lint yield, better fiber quality, and disease resistance.

Summary
For the last six years, potential heat tolerant breeding lines were evaluated in Florence, SC, Tifton, GA, Baton Rouge, LA, Maricopa, AZ, and Shafter, CA. These breeding lines were developed from a cooperative project that initiated in 2003. The goal of this project was to develop adapted elite cotton germplasm with improved fiber quality and heat tolerance. From this research, four cotton germplasm lines SJ-U86 (Reg. no. GP-868; PI 642414) (Ulloa et al., 2006), AGC85 (Reg. no. GP-860; PI 641928), AGC208 (Reg. no. GP-861; PI 641929), and AGC375 (Reg. no. GP-862; PI 641930) (Percy et al., 2005) were released by USDA-ARS and Cotton Incorporated in 2005. Also SJ-U86 was jointly released with the University of California in 2006 (Ulloa et al., 2006b). Germplasm lines originated from the cross of commercial cultivars FiberMax 958 and Sure Grow 248 (PVP 9700092). These upland cotton germplasm lines
possessed superior lint, fiber length, and competitive fiber strength under heat stress environments that are found in the Western U.S.

In 2006, 70 breeding lines were tested in non-replicated progeny tests, and 16 selected from the 70 lines were tested in replicated testing across five locations in 2007 and 2008, including California. The 16 lines exhibited superior fiber characteristics, with lint percentages ranging from 36.0 % to 42.0 %. In 2009, one line (CRB 252) was selected for release from the 16. The release of CRB 252, an upland (Gossypium hirsutum L.) cotton germplasm line possessing superior fiber quality traits, is in review. CRB 252 derives from a “double cross” involving the cultivars Sure Grow 248, Phytojen 72 (PVP 200100115), Stoneville 474 (PVP 9400152), and Acala Maxxa (PVP 9000168). This line provides public and private breeders with a broadly adapted resource for the improvement of fiber quality. The CRB 252 line will be jointly released by The Agricultural Research Service, United States Department of Agriculture, Louisiana Agricultural Experiment Station, Georgia Agricultural Experiment Station and Cotton Incorporated (Percy et al., 2009). CRB 252 can be used as a broadly adapted resource for the improvement of fiber quality by public and private breeders. Currently, we are testing additional selected breeding lines that originated from the same cross-pool to validate improved heat tolerance, yield, and fiber quality properties in California for future release. We hope that by this coming fall or early next year we will release additional improved germplasm from this project.

For the last three years, we developed progeny to conduct field and greenhouse evaluations for Fusarium wilt (FOV) resistance at the Research & Extension Center in Shafter, CA and at the Winter Nursery in Tecoman, Colima Mexico. These evaluations for resistance against FOV races 1 and 4, as well as root-knot nematodes (RKN), were possible with the support from our cooperators (University of California-Davis and UC-Riverside). More than 12,000 plants were assayed in multiple greenhouse and field evaluations. The assayed plants included germplasm from the USDA Cotton Collection, College Station, TX, breeding lines, and populations from developed progeny. We identified resistant or tolerant plants to FOV in the assayed germplasm and progeny. Studies to evaluate germplasm for response to races 1 and 4 of FOV, and RKN continued. In 2008, three fields infested with FOV race 4, one field infested with FOV race 1 and RKN, and one greenhouse FOV race 1 and 4 test were performed. We evaluated 460 cottons and checked for FOV symptoms in more than 2800 plants. Results revealed interactions in disease response between assayed cottons, FOV races (1 and 4), and evaluation sites (greenhouse and infested fields). These data are being further evaluated to investigate the inheritance and gene action of resistance to FOV races 1 and 4.

In 2008, the Agricultural Research Service, United States Department of Agriculture, University of California, and New Mexico State University registered four Pima cotton germplasm lines (SJ-07P-FR01, SJ-07P-FR02, SJ-07P-FR03, and SJ-07P-FR04) (Ulloa et al., 2009). SJ-07P-FR01 – FR03 lines originated from a cross of germplasm lines 8810 and NMSI 1601, and SJ-07P-FR04 is a population originating from re-selection within P 73. Based on the results of field and greenhouse studies from 2003 to 2006, these lines possess good, but not complete, levels of resistance to Fusarium wilt (FOV) race 4. In addition, these lines produced moderate yields of cotton lint with good to superior fiber length and strength. In 2008, we evaluated the SJ-07P-FR lines for FOV races 1 and 4, and RKN resistance (Figs. 1 and 2). In Figure 1, results revealed interactions in disease response between assayed cottons and FOV races (1 and 4). We observed that Pima S-7 and Phytogen 72 responded differently to the two races, being more susceptible to race 4 as compared to race 1 and RKN.
Figure 1. Mean values from field evaluations for vascular root staining or discoloration caused by *Fusarium oxysporum* f. sp. *vasinfectum* (FOV) Atk. Sny & Hans races 1 and 4, and root-knot nematode (RKN) on Upland and Pima cottons. Field sites: Shafter REC FOV race 1 and RKN (S40 FOV race 1 and RKN), Kern county site FOV race 4 (Kern FOV race R4), Fresno county site FOV race 4 (Fresno FOV race R4). Root staining was rated on a scale of 0 to 5, where 0 = no symptoms and 5 = vascular staining evident through cross-section of tap root.

Figure 2. Mean values of percentage of plants survival for evaluations from fields infested with *Fusarium oxysporum* f. sp. *vasinfectum* (FOV) Atk. Sny & Hans races 1 and 4, and root-knot nematode (RKN) on Upland and Pima cottons. Field sites: Shafter REC FOV race 1 and RKN (S40 FOV race 1 and RKN), Kern county site FOV race 4 (Kern FOV race R4), Fresno county site FOV race 4 (Fresno FOV race R4).
The SJ-07P-FR (1 – 4) germplasm lines were observed with good levels of resistance for the two FOV races, including RKN.

In Figure 2, the percentage of surviving plants was calculated by dividing the total number of plants surviving at the end of the study by the initial plant count at stand establishment and multiplying by 100. Similar results were observed for entries PhytoGen 72 and Pima S-7. These entries had a reduced number of plants by the end of the study for race 4. The SJ-07P-FR (1 – 4) germplasm lines were again observed to have good levels of resistance for the two FOV races and RKN, averaging 85% survival for race 1 and 75% for race 4.

Currently, we are gathering and analyzing data for an additional germplasm release with improved resistance to race 4 FOV, fiber quality, and yield. We are also advancing 20–25 Pima lines that were selected under FOV race 4 infested field conditions for the past two years. We hope that this improved Pima germplasm will contribute to the current germplasm resources available for development of future commercial cultivars grown in California.

References

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