Western cotton (Acala, Upland, and Pima) germplasm enhancement for agronomic, fiber traits, and pest resistance

Project 36 is located fields 20, 23, and S40.

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Summary:
Growth and competitiveness of the cotton industry are dependent upon continuing improvements in yield, fiber quality, and pest resistance. Over the last 30 years the cotton germplasm base used in plant breeding has narrowed. This relatively narrow genetic diversity, which has been suggested as a contributor to an apparent plateau in breeding progress, may also represent an impediment to efforts to sustain high yields (May and Taylor, 1998; Meredith, 1992; Ulloa, 2006a). To improve cultivar performance above current yield and fiber quality baselines, it is essential that new genetic variability be introduced into elite germplasm pools used by breeding programs. 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 from multiple sources including non-commercial landraces and species of wild cottons.

Recently, UC Davis scientists identified a race 4 isolate of Fusarium wilt [*Fusarium oxysporum* f.sp. *vasinfectum* Atk. Sny & Hans] in California cotton (Kim et al., 2005). Before 2003, Fusarium wilt in California was thought to be primarily caused by race 1. Race 1 is typically found in sandy soils and also damages cotton through an interaction with root-knot nematodes (Bell, 1984; Veech, 1984). Fusarium wilt race 4, first identified in India on Asiatic cottons, had not previously been identified as a problem in the U.S. Recent field investigations (Kim et al., 2005; Ulloa et al., 2006b) found Fusarium wilt race 4 in clay loam and loam soils, in which root knot nematode populations and root damage symptoms were largely absent. Disease symptoms of the race 4 isolate have been most severe in Pima varieties. However, this pathogen also infects Acala and Upland cottons. The current genetic base for Fusarium resistance within commercial Pima varieties in California is limited (Hutmacher et al., 2005; Ulloa et al., 2006b). This disease could exert a significant impact on cotton production, and when established in a field, may cause persistent problems as the causal fungus has resting stages with great longevity. In addition, a new virulent isolate of Fusarium wilt has recently been identified in Australian cotton fields (Kochman et al., 2002; Wang et al., 2004). To date, the Australian isolate(s) of Fusarium wilt has not been confirmed in U.S. cotton. The vulnerability of cotton in California and other US production regions to introduced pathogens, such as race 4 and the Australian races of FOV, highlights the need for additional comprehensive research to protect our cotton industry.

Development of host-plant resistance is currently the most economic and effective strategy for managing Fusarium wilt. Our research has been key in supporting this effort. Later this year (2007), the Agricultural Research Service and the University of California will announce the release of four Pima (*Gossypium barbadense* L.) germplasm lines, SJ-07P-FR01,

SJ-07P-FR02, SJ-07P-FR03, and SJ-07P-FR04, that possess good levels of resistance to Fusarium wilt race 4, moderate lint yield, and good to superior fiber length and strength. Given the seriousness of the Fusarium wilt problem in California, cotton breeders need these sources of resistance to improve Fusarium wilt race 4 resistance in commercial Pima varieties and to broaden the genetic base available to breeders, which is critical to the future of the pima cotton industry in the San Joaquin Valley (SJV).

SJ-07P-FR01, SJ-07P-FR02, and SJ-07P-FR03 lines originated from the cross of germplasm lines 8810 and NMSI 1601. Line 8810 possesses superior fiber strength and yields well under the high temperatures of the far west. Line 8810 was developed from a cross between P 73 x P 72. The P 73 parent of 8810 was developed from the cross P 53 x PS 6. NMSI 1601 possesses excellent fiber length and fineness and originated from the New Mexico State University Pima Breeding Program from a Sea Island cotton germplasm line. SJ-07P-FR01, SJ-07P-FR02, and SJ-07P-FR03 lines were each developed from a single F_2 plant, and were advanced from F_2 to F_3 by single plant selection. Subsequent generations were advanced as individual families or populations. SJ-07P-FR04 is a population originating from re-selection within P73. Two recurrent selections were applied for uniformity, yield and fiber properties.

In studies in two infested fields (inoculum levels were unknown and varied from year to year) in 2003 and 2004 in the San Joaquin Valley (SJV), and three greenhouse evaluations in 2004 and 2005 at two different sites (the University of California, Davis and the Kearney Research and Extension Center), the SJ-07P-FR series exhibited moderate to high levels of resistance for foliar damage and root vascular staining. Individual plants were rated for disease severity based on a 1 to 5 scale, where 0 = no foliar damage or vascular staining and 5 = dead plant. Across years and test sites, average ratings for foliar damage and vascular staining did not differ significantly among the SJ-07P-FR lines (SJ-07P-FR01, 0.69 and 0.68; SJ-07P-FR02, 0.83 and 0.79; SJ-07P-FR03, 0.59 and 0.67; and SJ-07P-FR04, 0.60 and 0.56, foliar damage and root vascular staining, respectively), or between the SJ-07P-FR lines and the resistant Phytogen 800 check (0.43 and 0.35, foliar damage and root vascular staining, respectively). However, significant differences (LSD, foliar damage=0.53, vascular staining=0.56) were observed between ratings for the SJ-07P-FR lines and those of the susceptible checks (NMSI 1601, 3.26 and 3.25; PS 7, 3.43 and 3.04; and DP744 3.88 and 3.25, foliar damage and root vascular staining, respectively). Under infested field conditions, seed germination was difficult to determine with certainty. However, based upon post-emergence survival rates, the race 4 Fusarium wilt pathogen was able to infect and kill susceptible cotton seedlings at high rates in the six weeks following emergence.

The purpose of releasing the SJ-07P-FR lines at this time is to provide to other breeders germplasm with good levels of resistance to Fusarium wilt race 4. However, users of these lines should not assume the presence of complete resistance against Fusarium wilt race 4. Furthermore, the agronomic and fiber traits of these lines are not yet known with precision, and such data are not complete for the whole series.

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Population development, selection, and evaluation for heat stress

Project 67 is located field 20 and 23.
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Summary:

The primary objective of this research is to develop broadly adapted Acala and Upland cotton germplasm with potential heat stress tolerance, better fiber quality, and improved lint yield, while broadening the genetic base of cotton. When above normal temperatures in the San Joaquin Valley occur during the critical stage of peak flowering, yield losses may occur in response to the heat sensitivity of currently grown varieties. Among the cotton varieties grown commercially in California, the number exhibiting useful levels of heat tolerance is not well known. However, it is well documented that Acala varieties Maxxa and Phytogen 72 yield poorly in the heat stress environment of Maricopa, AZ.

Recently, the first Upland germplasm line from the USDA-ARS, WICSRU breeding program was released (SJ-U86; Ulloa et al., 2006). The Unit has also participated in the release of three additional Upland lines (AGC85, AGC208, and AGC375) (Percy et al., 2006). These new Upland cotton germplasm lines possess superior fiber length and competitive fiber strength under high-heat stress environments found in the Western U.S. Heat-stress tolerance of these lines was selected on the bases of agronomic performance and fiber quality under three different environments (CA, AZ, and GA).

The creation of a germplasm pool to facilitate breeding for heat tolerance and fiber quality improvement was initiated in 2002 utilizing four double cross populations which involved cultivars SG 474, Phytogen 72, Maxxa, DP565, and NM67 as parents in different cross-combinations. A breeding scheme was developed with potential heat tolerant progenies evaluated at Florence, SC, Tifton, GA, Baton Rouge, LA, Maricopa, AZ, and Shafter CA. In 2006, non-replicated tests of 70 progeny lines were conducted at these five locations with the check cultivars SG747, DP393, FM958, and PHY72. The goal was to identify candidate lines for replicated testing in a randomized complete block design in 2007. The cooperative project continued this year with the goal of providing parental materials for the improvement of heat tolerance of Acala/Upland cottons. Based upon the results of 2006 progeny evaluations, 16 progeny lines were selected for replicated testing across the five locations in 2007. These 16 lines exhibit superior fiber characteristics and lint percentages ranging from 36.0 % to 42.0 % upper half mean fiber lengths ranging from 1.20 to 1.29 inches, and strengths ranging from 23.0 to 26.0 grams/tex. We hope that by the end of the 2007 season we will have identified breeding lines for future release. Demonstration plots will be available at the September 18th, 2007, field day at the REC Shafter, CA 93263.

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