GENETIC DIVERSITY STUDIES AT VARIOUS LEVELS OF EXOTIC GERMPLASM INTROGRESSION

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Abstract

Upland cotton (*Gossypium hirsutum* L.) is an economically important fiber crop. Despite severe competition from the synthetic fiber industry in recent years, cotton is still holding its commercial value as an important natural fiber crop in the textile industry. In the process of developing high yielding lines and cultivars with better fiber properties, little importance has been given to broadening the genetic base of cotton germplasm. As a result, the genetic base of present day upland cotton is very narrow, prompting interest in expanding the genetic base of the modern cotton cultivars to avoid future risks of pest and disease outbreak. Our research is focused on the objective of determining the effect of exotic germplasm introgression on agronomic and fiber properties of adapted cotton germplasm. For this we studied eight populations derived by crossing two exotic parents (TX 245 and TX 1419) with four adapted cultivars (FM 966, PM 1218, Deltapearl and SG 747). In each population we generated five combinations with 0, 25, 50, 75 and 100 percent exotic germplasm. Results indicated that most traits showed a decreasing trend with increase in exotic percentage. Across populations not much reduction was observed with respect to agronomic traits whereas, all fiber properties except fiber elongation were lowered with an increase in exotic percentage. Within populations, some lines were observed at 25 and 50 percent exotic with improved agronomic and fiber properties but very few lines with 75 percent exotic showed any trait improvement. Populations with 75 percent exotic germplasm showed more variability among all combinations. Results indicate that the use of PI germplasm did not enhance fiber properties overall but there are some improved lines observed within each population therefore there exists the possibility for improvement with introgression of exotic germplasm.

Introduction

Upland cotton (*Gossypium hirsutum* L.) is an economically important fiber crop. Despite severe competition from the synthetic fiber industry in recent years, cotton is still holding its commercial value as an important natural fiber crop in the textile industry. Upland cotton with an annual production of around 100 million bales is facing risk associated with a narrow genetic base (May et al., 1995; McCarty, 2007). In the process of developing high yielding lines and cultivars with better fiber properties, little importance has been given to broadening the genetic base of cotton germplasm. Earlier studies revealed that only a fraction of the available genetic base has been utilized in cotton cultivar development and the large number of reselections in the pedigrees of modern upland cotton cultivars suggests reduced genetic variability and could be a potential cause for genetic vulnerability (Bowman et al., 1996). Yield, along with fiber properties, has actually declined since 1990 (Lewis, 2000). It has been speculated that the decline in yield and fiber properties is a result of a narrow genetic base in elite cotton germplasm (Bowman et al., 1996). Genetic uniformity predisposes crops to various abiotic and biotic stresses, which has already been observed in the U.S. corn (*Zea mays* L.) crop in 1970 (Ullstrup, 1972). Cotton cultivars with a wider genetic base should be developed which can offer plasticity to stressful environments and help in trait improvement. Increasing genetic diversity can help in alleviating the genetic vulnerability and may also increase transgressive segregates for yield (Rodgers et al., 1983; Cowen and Frey, 1987). The importance of genetic diversity in reducing crop vulnerability was widely acknowledged by Duvick (1984) and Cox et al. (1986). It has been shown that primitive upland cotton accessions contain useful genetic variability for cotton development (Meredith, 1990). Early studies on using PIs in soybean breeding indicated that PIs improved the genetic variability for seed yield (Thorne and Fehr, 1970). Plant introductions (PIs) are used as sources of pest resistance in back crossing programs but not as sources for yield improvement (Schoener and Fehr, 1979). Plant introductions (PIs) may offer some solution for the genetic uniformity problem and may be used to broaden the genetic base. The major problem with the use of genetically diverse parents is that they tend to be from different regions so adaptation is a problem and may also break favorable linkage groups leading to loss of favorable allele combinations. A greater effort to introgress diverse germplasm into locally adapted cultivars without much yield penalty can offer greater rewards in cotton improvement and reduce genetic vulnerability (Van Esbroeck et al., 1998).

Materials and Methods

This is a preliminary study carried out at the Plant Breeding Unit, E. V. Smith Research center, Tallassee, AL during summer 2008. Eight populations derived by crossing two exotic parents (TX 245 and TX 1419) with four adapted cultivars (FM 966, PM 1218, Deltapearl and SG 747) were used in this study. These exotic parents were selected based on previous observations that they offer moderate resistance to reniform nematode, an observation that later proved to be false. The locally adapted cultivars were selected as parents based on their performance and represent elite cotton germplasm for the mid-South and Southeastern production regions.

Table 1. Parents and populations

POP 1	Fibermax 966 × TX 245
POP 2	PM 1218 ×TX 245
POP 3	Delta Pearl × TX 245
POP 4	SG 747 × TX 245
POP 5	Fibermax 966 × TX 1419
POP 6	PM 1218 × TX 1419
POP 7	Delta Pearl × TX 1419
POP 8	SG 747 × TX 1419

In each population five combinations were generated with 0, 25, 50, 75 and 100 percent exotic introgression. Parents represented the 0 and 100 percent exotic; for 50 percent exotic $F_{2:3}$ lines were used and 25 and 75 percent exotic were represented by $BC_1F_{1:2}$ lines. Six lines were used for each population/percent exotic combination except for the 0 and 100 % combinations. Plots were single rows 3m long with 1m spacing between rows. No specific design was followed as the lines were not replicated; lines within each population/exotic level combination were considered replicates. These populations will be further studied over locations and years in 2009 and 2010. Agronomic traits (days to first flowering, bolls per plant, boll mass, seed cotton yield, seeds per boll, lint percent, lint mass per seed and lint yield) were recorded. Fiber properties (fiber length, fiber strength, fiber fineness, fiber elongation, short fiber content and uniformity index) were determined by HVI analysis at Cotton Incorporated, Cary, NC. Data were analyzed using SAS® PROC GLIMMIX with population and percent exotic as class variables. The effect of exotic germplasm percentage was studied by taking each trait as a response variable.

Results and Discussion

Across populations, for most traits an increase in exotic germplasm resulted in decreased mean line performance (Table 2). Days to first flowering did not differ much from 0 to 50 percent exotic whereas there was significant difference observed in 75 percent exotic over the 0 percent exotic parent. Bolls per plant showed a significant increase at 50 percent exotic over 0 percent exotic parent, whereas boll mass, lint mass per seed, lint percent and lint yield decreased with an increase in exotic percentage. Other traits showed a decrease with increasing exotic percentage. There was a nonsignificant increase in the number of seeds per boll with 25 percent exotic germplasm but started declining with further increase in exotic percentage. Seed cotton yield increased with the increase in exotic percentage up to 50 percent exotic and decreased in 75 percent exotic and in the 100 percent exotic parent.

Table 2: Agronomic traits across populations

Exotic percent	DTFF	Bolls per plant	Boll Mass(g)	Lint mass/seed (mg)	Lint percent	Seeds/ boll	SCY (g/plot)	Lint yield (lbs/A)
0%	54.75	10.05	4.55	7.82	43.21	24.96	1383.5	1916.2
25%	54.16	9.90	4.31	6.85	39.63	25.12	1449.4	1832.9
50%	54.41	12.62	3.65	6.17	35.89	21.67	1435.0	1648.5
75%	56.10	8.69	3.59	5.88	34.12	21.47	1003.6	1117.1
100%	59.50	15.87	3.24	5.40	31.93	19.91	818.0	840.9
SE*	0.98	1.28	0.24	0.42	2.0	1.03	129.2	210.0

* The standard error given in table represents the standard error for 25, 50, and 75 percent exotic only

Almost all fiber properties were lowered with increased exotic percentage except elongation percentage which increased almost linearly with increased exotic percentage (Table 3).

Table 3: HVI fiber properties across populations

Exotic percent	Fiber length (inches)	Fiber strength (g/tex)	Fiber Fineness (mic)	Fiber Elongation	SFC	UI
0%	1.12	29.48	4.56	4.98	7.93	83.45
25%	1.04	28.03	4.90	5.91	7.92	83.36
50%	1.01	27.60	4.65	5.85	8.53	82.57
75%	0.98	27.07	4.91	6.24	8.31	82.31
100%	0.93	27.75	5.72	6.75	9.05	81.95
SE	0.03	0.40	0.20	0.29	0.21	0.29

* The standard error given in table represents the standard error for 25, 50, 75 percent exotic only

In population 1, 2, 5 and 6 there was a significant increase in lint yield at 25 percent exotic and in 50 percent exotic for populations 1 and 5 (Table 4). In the remaining populations there is a decrease in lint yield with increased exotic percentage. Lint percent decreased with increased exotic percentage in all populations except in population 7.

Table 4: Effect of exotic germplasm on agronomic traits within populations.

Trait	Exotic percent	Pop1	Pop2	Pop3	Pop4	Pop5	Pop6	Pop7	Pop8
Lint Yield(Lbs/A)	0%	1351	1445	1950	2918	1351	1445	1950	2918
	25%	1798*	2012*	1691	1737	1745*	2083*	1872	1721
	50%	2012*	1530	1640	1567	1986*	1335	1585	1530
	75%	832	1103	773	1172	1608*	1942*	626	878
	100%	655	655	655	655	1026	1026	1026	1026
	SE	192	127	128	113	182	125	116	104
Lint percent	0%	42.64	44.19	41.09	44.96	42.64	44.19	41.09	44.96
	25%	37.29	39.59	37.74	38.07	37.38	43.43	41.96	41.60
	50%	34.95	34.45	35.53	35.24	38.47	34.78	37.13	36.62
	75%	30.37	30.82	29.99	31.95	39.13	41.81	33.90	35.02
	100%	30.53	30.53	30.53	30.53	33.33	33.33	33.33	33.33
	SE	0.59	0.95	1.36	0.93	1.15	0.49	0.74	0.55
Fiber strength (g/tex)	0%	31.70	27.40	32.40	26.40	31.70	27.40	32.40	26.40
	25%	27.37	25.83	27.00	25.83	33.28*	27.40	28.23	29.28*
	50%	26.67	24.90	26.70	25.00	28.60	30.18*	29.97	28.78*
	75%	24.48	25.60	25.23	23.65	30.10	28.15	29.32	30.03*
	100%	24.40	24.40	24.40	24.40	31.10	31.10	31.10	31.10
	SE	0.72	0.57	0.82	0.53	0.70	0.89	0.54	0.81
Fiber length (inches)	0%	1.14	1.04	1.17	1.12	1.14	1.04	1.17	1.12
	25%	1.01	0.95	1.00	1.01	1.15*	1.02	1.09	1.09
	50%	0.99	0.91	1.00	0.95	1.04	1.07*	1.09	1.07
	75%	0.89	0.92	0.94	0.91	1.06	1.01	1.07	1.05
	100%	0.82	0.82	0.82	0.82	1.03	1.03	1.03	1.03
	SE	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02
Fiber fineness (Micronaire)	0%	4.41	4.82	3.89	5.11	4.41	4.82	3.89	5.11
	25%	4.53	5.12	5.08	4.91*	4.72	5.12	5.00	4.75*
	50%	4.77	5.03	4.36	4.42*	4.71	4.98	4.37	4.55*
	75%	4.66	4.88	4.75	4.81*	4.80	5.42	4.72	5.22
	100%	5.80	5.80	5.80	5.80	5.64	5.64	5.64	5.64
	SE	0.20	0.15	0.24	0.20	0.20	0.20	0.22	0.20

* Significant at $p \leq 0.05$ * only towards positive side

Fiber strength was reduced with increased exotic germplasm introgression in almost all populations whereas, there was a significant increase in fiber strength values in populations 5 and 8 at 25 percent exotic, populations 6 and 8 at 50 percent exotic and population 8 at 75 percent exotic introgression. Fiber length decreased with increased exotic germplasm in all populations except in population 5 at 25 percent exotic and in population 6 at 50 percent exotic. Fiber fineness too was lowered with increased exotic germplasm introgression in all populations except in population 4 at 25, 50, and 75 percent exotic and in population 8 at 25 and 50 percent exotic.

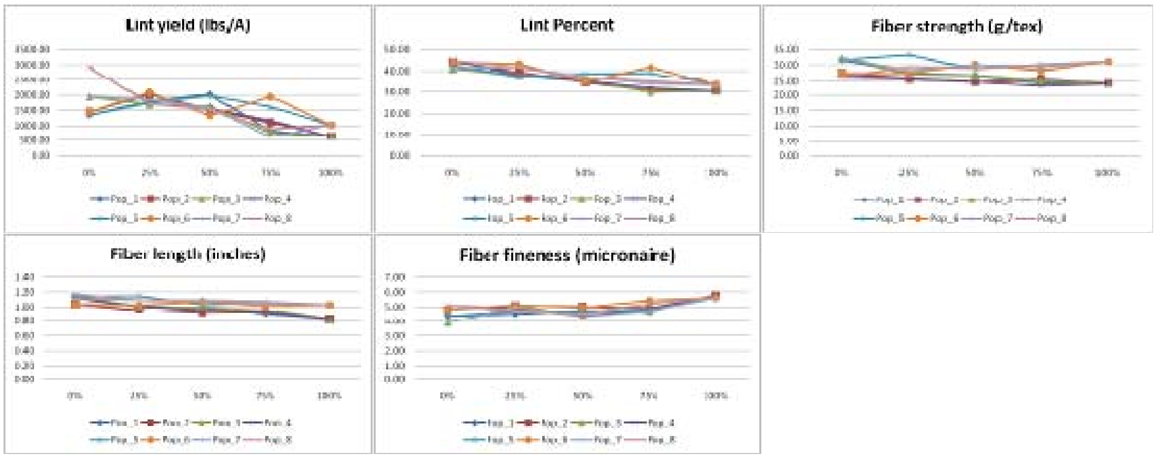

Fig.1: Graphs showing the trend of exotic germplasm effect on each trait across populations

Trend graphs plotted for some economically important traits showed that variability was high at 75 percent exotic compared to rest of the other combinations. From these preliminary study results we conclude that there was very limited improvement in agronomic and fiber properties with exotic germplasm introgression. We could not explain clearly how much PIs improved genetic variability because of the lack of replications in the parents, but future studies should help answer this question. Some improved lines were recorded within populations which could be promising material for future studies.

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