

SEGREGATION FOR FIBER QUALITY TRAITS IN SIX UPLAND COTTON POPULATIONS**David B. Weaver and Rachel S. Badger****Auburn University
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Progress in breeding for yield and fiber quality traits in upland cotton (*Gossypium hirsutum* L.) has been limited in recent years. It has been speculated that this is partly due to a narrow genetic base, resulting in reduced genetic variation for many traits of economic importance. We studied genetic variation and heritability for yield components and AFIS fiber quality traits in six populations of adapted \times adapted cotton germplasm in the F_2 and F_3 generations. Our objectives were to determine if sufficient genetic variability exists within adapted elite germplasm. Yield-related traits (lint percentage, lint weight boll⁻¹) were moderately to highly heritable in most of the populations and generations, while fiber quality-related traits were more population- and/or generation-dependent. Traits related to trash content were largely not heritable. It appears that selection for some AFIS fiber traits in early generations of cotton inbreeding will be effective but dependent on population.

Background

Fiber quality traits of upland cotton determine its usefulness by the industry and are largely under genetic control (Meredith, 1984). Progress in the improvement of upland cotton for traits related to yield and fiber properties has been limited in past years. Yield, along with fiber strength, has actually declined since 1990 (Lewis, 2000). It has been speculated that this is due in part to a narrow genetic base in elite cotton germplasm (Bowman, 1996). Improvements in yield and fiber quality remain as primary objectives in most cotton breeding programs.

Fiber traits of primary importance include fiber length, strength, maturity, and various fiber length uniformity indices, including short fiber content. Specific heritability estimates for fiber length measurements, including upper-half-mean length and 2.5% length are generally considered to be moderate, ranging from 0.54 to 0.88, averaging 59% (Al-Rawi and Kohel, 1970; Lewis, 1957; Miller, et al., 1958; May and Green, 1994), and indicate that improvements in fiber length can be made by selection. Interactions with environment are generally low. However, modern cotton breeding tends to emphasize a uniformity of fiber length, rather than improvements in length, because of changes in spinning technology that rely more on fiber uniformity than fiber length to produce quality yarn (Duessen, 1992). So, not only is an increase in fiber length still considered to be an important breeding objective, but care must be taken to reduce the overall short fiber content (May, 2002).

One of the major keys to success in any program of crop improvement is adequate genetic variation (Fehr, 1987), preferably within elite germplasm. Since a narrow genetic base has been implicated as a barrier to further genetic improvement of cotton yield and fiber quality, we decided to investigate genetic variability in early generations of cotton populations involving crosses among elite parents. Our objectives were to determine genetic variability among parents and their offspring in the F_2 and F_3 generations for yield-related and AFIS fiber quality traits, and determine heritability for these traits on a single plant basis.

Materials and Methods

Six F₂ cotton populations (Table 1) were grown in the field at the Plant Breeding Unit (PBU) in Tallassee, AL during 2002.

Table 1. Parents and populations

POP 1	Fibermax 966 (P ₁) × Deltapine 565 (P ₂)
POP 2	Arkcot A129 (P ₁) × Stoneville 580 (P ₂)
POP 3	PD 94042 (P ₁) × Delta Pearl (P ₂)
POP 4	Miscot 8004 (P ₁) × Fibermax 966 (P ₂)
POP 5	PD 94045 (P ₁) × Suregrow 821 (P ₂)
POP 6	Miscot 8001(P ₁) × Suregrow 747 (P ₂)

Parents were selected based on adaptation and performance, not necessarily for contrasting phenotypes for the traits of interest, and represent elite germplasm typical of a modern cotton improvement program. Also grown for each population were 20 parent plants, and from 1 to 27 F₁ plants, depending on population. F₂ population sizes ranged from 75 to 338 plants. Open-pollinated boll samples (five bolls plant⁻¹) were collected at harvest from parents, F₁'s and F₂'s. F₂ plants were also self-pollinated to produce F₃ seed. Lint percentage, lint weight seed⁻¹ and AFIS fiber quality traits were determined on an individual plant basis from boll samples. Phenotypic variance of parents and F₁ generation plants was used to estimate environmental variances, and subtracted from variance among F₂ plants to obtain an estimate of genetic variance. Broad sense heritability for traits among individual F₂ plants was calculated as the ratio of genetic to phenotypic variance.

In 2003 F_{2,3} rows were grown from self-pollinated seed of individual F₂ plants. Boll samples (five bolls) were collected from three F₃ plants within each row, and lint percentage, lint weight seed⁻¹ and AFIS fiber quality traits were determined on an individual F₃ plant basis. Parent-offspring regression was used to determine heritability of traits in the F₃ generation. Although all AFIS fiber quality traits were measured, data will only be reported on Upper Quartile Length (UQL), Fiber Length (upper 5%), Short Fiber Content, Fiber Fineness, and Neps gram⁻¹.

Results and Discussion

Parental, F₁ and F₂ phenotypes are given in Table 2. POP 4 was more diverse for most traits than any of the other populations. In the F₂ generation, traits related to yield (lint percentage and lint weight seed⁻¹) were generally heritable (Table 3). Lint percentage was heritable in the F₂ generation of all populations except POP 3. This was caused in part by one parent in POP 3 having greater variance than was present in the F₂ generation. A similar situation occurred for lint weight seed⁻¹, which was heritable in the F₂ of all populations except POP 2 and POP 4. In both these populations, at least one parent had greater variance

Table 2. Mean phenotypic values for AFIS fiber quality and yield-related traits for parents, F₁ and F₂ generations of six cotton populations.

Population	P ₁	P ₂	F ₁	F ₂	P ₁	P ₂	F ₁	F ₂
	Lint percentage				Lint Weight seed ⁻¹ (grams × 10 ⁻²)			
POP 1	43.3	42.1	39.0	40.0	8.9	7.0	6.6	7.2
POP 2	34.5	41.4	36.3	37.2	10.0	6.0	6.0	9.0
POP 3	42.8	42.8	45.2	46.5	10.0	7.0	7.0	8.0
POP 4 [†]	48.4	43.3		43.8	8.0	8.9		8.0
POP 5	42.9	41.6	41.1	42.6	7.0	8.0	8.0	8.0
POP 6	39.9	45.1	40.8	40.9	10.0	8.0	7.0	7.0
	Fiber Length (upper 5%)				Upper Quartile Length			
POP 1	1.35	1.37	1.40	1.35	1.22	1.24	1.26	1.21
POP 2	1.37	1.34	1.38	1.35	1.24	1.21	1.24	1.21
POP 3	1.40	1.37	1.35	1.31	1.23	1.21	1.22	1.18
POP 4	1.16	1.35		1.19	1.04	1.22		1.07

POP 5	1.34	1.30	1.38	1.36	1.21	1.18	1.25	1.22
POP 6	1.34	1.31	1.31	1.34	1.21	1.19	1.19	1.21
	Neps gram ⁻¹				Short Fiber Content			
POP 1	120	125	180	181	11.8	5.8	4.8	5.3
POP 2	117	112	100	89	5.9	6.3	4.7	4.8
POP 3	110	123	132	113	6.9	6.1	6.8	7.1
POP 4	113	120		96	7.5	11.8		6.5
POP 5	136	102	103	111	7.0	5.3	4.4	4.6
POP 6	103	113	103	100	14.3	6.4	5.6	5.4
	Fiber Fineness							
POP 1	161	201	177	167				
POP 2	179	204	185	190				
POP 3	187	190	186	193				
POP 4	185	161		189				
POP 5	184	208	193	191				
POP 6	170	203	198	199				

[†]Only one F₁ plant was available for POP 4, therefore no phenotypic data are presented.

Table 3. Heritability estimates for AFIS fiber quality and yield-related traits for six cotton populations in F₂ and F₃ generations.

	POP 1	POP 2	POP 3	POP 4	POP 5	POP 6
	Lint Percentage					
h ² (F ₂ plants)	0.45	0.48	0.04	0.59	0.76	0.56
h ² (F ₃ plants)		0.44		0.95	0.15	0.06
	Lint Weight Seed ⁻¹					
h ² (F ₂ plants)	0.99		0.72		0.98	0.76
h ² (F ₃ plants)		0.13		0.35		
	Fiber Length (upper 5%)					
h ² (F ₂ plants)	0.30	0.43		0.65		0.58
h ² (F ₃ plants)	0.32		0.31	0.60		0.26
	Upper Quartile Length					
h ² (F ₂ plants)	0.46	0.49		0.72		
h ² (F ₃ plants)	0.25		0.29	0.60		0.57
	Neps gram ⁻¹					
h ² (F ₂ plants)	0.70	0.31	0.37	0.29	0.62	0.68
h ² (F ₃ plants)		0.22	0.36	0.63		0.30
	Short Fiber Content					
h ² (F ₂ plants)			0.10			
h ² (F ₃ plants)	0.17	0.36	0.27	0.43		0.26
	Fiber Fineness					
h ² (F ₂ plants)	0.01	0.21			0.08	
h ² (F ₃ plants)	0.16	0.21	0.34	0.43		0.18

than the F₂ generation. Lint percentage and lint weight seed⁻¹ were generally less heritable in the F₃ generation, and were more population-dependent.

AFIS traits measuring fiber length were also heritable. With little exception, upper 5% fiber length and Upper Quartile Length had very similar heritability estimates. Again, POP 3 and POP 5 had one parent with greater variance for fiber length traits than the F₂ generation. Neps gram⁻¹ was at least moderately heritable in the F₂ generation of all populations, but somewhat less heritable among the F₃ populations. Neps are caused by fiber immaturity and can result in problems in dyeing the resulting fabric. Short fiber content was not heritable in the F₂ generation, even though POP 1, POP 4 and POP 6 were relatively diverse for this trait. Heritability estimates for short fiber content in the F₃ were generally low, thus the outlook for genetic manipulation of this trait in early generation of cotton populations is not very

encouraging. Fiber fineness, a trait related to fiber maturity and known to be environmentally-influenced had very poor heritability in the F₂ generation, but was somewhat higher in the F₃.

We concluded that adequate genetic variation exists for yield-related traits, particularly among F₂ plants. Fiber length traits were also heritable, and should be amenable to selection. Neps gram⁻¹ was heritable, but response to selection for reduction of short fiber content, particularly in the F₂ generation, may be poor. Future work will focus on following these populations through later stages of inbreeding, determining the response to selection, and calculation of phenotypic and genetic correlations among traits.

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