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BREEDING & GENETICS

Ovule Fiber Cell Numbers in Modern Upland Cottons

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INTERPRETIVE SUMMARY

Concern over genetic gain for yield is an impetus for examining the components of yield, which are plants per unit area, bolls per plant, seeds per boll, fibers per seed, and weight per fiber. There is genetic variation for fibers per seed. This study examined genetic variation and combining ability of ovule fiber cell number in a full diallel of seven modern upland cotton cultivars: Deltapine 20, Deltapine 90, DES 119, Georgia King, KC 311, Stoneville 474, and Sure Grow 125. Ovule fiber cells were counted from 2-d post-anthesis bolls, and showed a 20% range for this trait among the seven parents. Years affected numbers significantly, but there was not a significant year–genotype interaction. Initial ovule fiber cell numbers were controlled primarily by additive gene effects. Georgia King and Sure Grow 125 exhibited positive combining ability for this trait, suggesting that they would make good parents in a breeding program to improve this trait.

ABSTRACT

Cotton yield is determined by the number of bolls per unit area, number of seeds per boll, number of fibers per seed, and average weight per fiber. Improvements in fiber number per seed may result in increased yields. The objective of this study was to determine the genetic variation and combining ability for initial ovule fiber cells in modern cotton cultivars. A seven-parent full diallel study was repeated for two years. Initial ovule fiber cell numbers were counted at 2-d post-anthesis. There was a 20% variation in ovule fiber cell numbers among the seven parents. There were significant year effects but no year–genotype interactions. This trait was controlled primarily by additive gene effects. Two cultivars, Georgia King and Sure Grow 125, contributed positively in hybrid combinations.

Cotton (*Gossypium hirsutum* L.) lint yield may be expressed as the function of the production of assimilates by photosynthesis (source), the translocation of assimilates to the developing fibers, and the utilization of assimilates by the fiber cells (sinks). For many crops, the partitioning of assimilates to the harvestable portion is enhanced by high endosperm cell number in developing seeds. Genotypic differences in seed growth rate and final seed weight for soybean [*Glycine max* (L.) Merr.] were associated with differences in the number of cells in the cotyledons (Guldan and Brun, 1985; Egli et al., 1989). In corn (*Zea mays* L.), wheat (*Triticum aestivum* L.), and barley (*Hordeum vulgare* L.), high seed growth rates were associated with a large number of endosperm cells (Herzog, 1982; Cochrane and Duffus, 1983; Reedy and Daynard, 1983). In soybean, however, environment, in addition to genetics, had a significant influence on the number of cells in the cotyledons. The number of endosperm cells was reduced by up to 50% when irradiance was low, pod numbers were high, and/or conditions were moisture-stressed (Egli et al., 1989).

Cotton differs from other crops in that the harvestable portion is not the seed but rather the lint fibers that are appendages of the seed. The lint fibers originate from fiber cells initiated on the developing ovules at the time of anthesis. Little is known about the number of fiber cells that initiate on the ovule. In theory, yields could be improved if a larger number of ovule fiber cells were initiated, thus increasing the number of harvestable fibers.

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Coyle and Smith (1997) reported a nearly 30% variation in mature fiber numbers per seed in a study of six diverse upland cottons. The authors reported on combining ability for this trait, as well as other within-boll yield components and fiber properties. In a separate paper (Smith and Coyle, 1997), the authors reported on the association of fibers per seed with other within-boll yield components and fiber quality. They reported that improvements in fiber length and strength in those six genotypes and their F1 progeny resulted in a decrease in number of fibers per seed. Thus, improvements in yield may have been sacrificed for improvements in lint quality.

A technique recently developed by Jack Van't Hof (1998) at Brookhaven National Laboratory now makes it possible to count the number of fiber cells initiated on an ovule. If the number of initial ovule fiber cells were under a high degree of genetic control, then this trait might be manipulated to improve lint yield. The objective of this research was to determine genetic variation and combining ability of initial ovule fiber cells in modern cotton cultivars.

METHODS

During August 1995 in a preliminary study, cotton squares were collected at 1- to 4-d post-anthesis from 65 cultivars at Clayton, NC, and the number of ovule fiber cells determined at Brookhaven National Laboratory. Sampling at 2-d post-anthesis produced the most reliable results with no genotype–sampling date interaction. This technique was published by Van't Hof (1998). During the winter of 1996-97 and summer 1997, crosses (including reciprocals) were made between seven modern cultivars. The cultivars were Deltapine 20, Deltapine 90, DES 119, Georgia King, KC 311, Stoneville 474, and Sure Grow 125. The full diallel of parents and F1 progeny were grown at Clayton, North Carolina, during the summers of 1997 and 1998 in a randomized, complete-block design with three replicates. Individual plots consisted of a single 3 m-long row containing about 10 plants. On sampling dates, 5 to 6 randomly selected flowers per plot were tagged on the day of anthesis. For each plot, young bolls were collected at 2-d-post-anthesis and placed in sealed plastic bags with moist paper towels and sent to Brookhaven National Laboratory overnight. Ovule fiber cells were counted on five randomly chosen ovules obtained from a minimum of three bolls (Van't Hof, 1998). All bolls from the same replicate were collected on the same day. In 1998, each of the three replicates was sampled on a different date; in 1997, all replicates were sampled on the same day.

Diallel analyses were performed using the method advocated by Stuber (1970) for inbreds. General combining ability effects were calculated for each of the seven parents in the diallel. All effects were assumed fixed.

RESULTS AND DISCUSSION

Ovule fiber cell numbers ranged 20% (from 14,412 to 17,999) among the parents (Table 1). The seven genotypes selected for this study came from a pool of genotypes most likely to be used as parents in a contemporary breeding program; breeders are less likely to use obsolete cultivars or exotic germplasm in their crossing programs. There appears to be sufficient genetic variation for breeders to improve this trait.

Table 1. Number of ovule fiber cells for seven cotton cultivars.

Cultivar	No. ovule fiber cells†
Sure Grow 125	17 999 a
Georgia King	15 880 ab
Stoneville 474	15 613 b
DES 119	15 605 b
Deltapine 20	15 120 b
KC 311	14 942 b
Deltapine 90	14 412 b

† Means followed by the same letter are not different at $P < 0.05$.

Deltapine 90 had the lowest number of ovule fiber cells (Table 1). In the study by Coyle and Smith (1997), Deltapine 90 had the lowest number of mature lint fibers per seed.

Deltapine 90 is one of the parents of KC 311, and both cultivars have nearly identical low ovule fiber cell numbers. DES 119 is one of the parents of Stoneville 474, and both have similar ovule fiber cell numbers.

DES 119 is also a parent of Sure Grow 125 with a theoretical genetic contribution of 87.5%; however, Sure Grow 125 has a significantly higher number of ovule fiber cells. Deltapine 50, the other parent of Sure Grow 125, had significantly more ovule fiber cells per seed than DES 119 in the 1995 preliminary study.

Georgia King and KC 311 have a parent in common, McNair 235, but have significantly different numbers of ovule fiber cells.

Coyle and Smith (1997) reported a significant year effect for mature lint fibers per seed, which is similar to results on ovule fiber cell counts in this study. There was no year–genotype interaction for mature lint fibers per seed in either the study by Coyle and Smith (1997) or the present study for ovule fiber cell counts. Although the significant year effect would impact yield per se, the lack of an interaction is helpful to the breeder in making selections for higher lint fiber numbers.

Analyses of combining ability for ovule fiber cells is shown in Table 2. Significant levels of general combining ability across years for this trait indicate a preponderance of additive gene effects, suggesting breeders can make progress in improving this trait. Coyle and Smith (1997) also found significant levels of general combining ability for mature lint fibers per seed. Nonadditive gene effects were not contributing significantly to the inheritance of ovule fiber cells; this nonsignificant additivity also was found for mature lint fibers by Coyle and Smith (1997).

Table 2. Analysis of variance for 7 x 7 diallel of cotton cultivars for number of ovule fiber cells.

		Year	
Source	df	1996	1998
Rep	2	28.8**	232**
F1 hybrids	41	5.0*	5.2
GCA	6	17.9**	13.7*
SCA	14	3.2	3.6
Reciprocal	21	2.6	5.2
Error	82	2.8	5.4

*, ** = significant at $P = 0.05$ and 0.01 levels, respectively.

Reciprocal effects were not evident in either year for ovule fiber cells (Table 2). Thus breeders do not need to be concerned about which direction to make a cross with this trait in mind.

General combining ability effects for each of the seven parents in this study are reported in Table 3. Georgia King and Sure Grow 125 appeared to improve fiber cell counts while all others showed small but inconsistent or negative effects (Table 3). Deltapine 90 had the largest negative impact on ovule fiber cells. Coyle and Smith (1997) had reported similar findings for mature lint fibers per seed for Deltapine 90.

Predominance of additive gene effects should aid in improving ovule fiber cell count. Georgia King and Sure Grow 125, both high-yielding genotypes, should be good parents for improving ovule fiber cell numbers. To confirm the usefulness of this approach, counts of mature lint fibers per unit seed surface area would need to be determined and the two traits correlated. A strong positive correlation would suggest that either trait could be measured to make progress.

Table 3. General combining ability effects of seven cotton cultivars for ovule fiber cell numbers over years from a 7 x 7 diallel.

Cultivar	General combining ability
Georgia King	1163
Sure Grow 125	760
Deltapine 20	32
DES 119	-22
Stoneville 474	-318
KC 311	-375
Deltapine 90	-1230

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