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Genetics of the ovule fiberless and foliar glabrous traits in *Gossypium arboreum* germplasm line PI 529740

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ABSTRACT

Accession PI 529740 from the Gossypium arboreum germplasm collection and characterized by fiberless seeds and glabrous leaves and stems was crossed with two G. arboreum accessions, PI 417890 or PI 529729, to develop F_2 populations for genetic analysis. Segregation data indicated that these traits were all conferred by a single recessive gene. More than 800 F_2 plants were evaluated across the two populations and no recombinants were observed; thus, it is unknown whether a single gene or tightly linked genes conferred the fiberless and glabrous phenotypes. The fiberless and glabrous traits also segregated independently of corolla color, petal spot, and stem color.

Keywords: cotton, fiber, germplasm, pubescence, trichome

INTRODUCTION

*Gossypiumarboreum*L.(Asiatic cotton) is an important source of genetic diversity for cotton improvement, including drought tolerance [6], and insect [11], nematode [16], and disease resistance[15]. Typically, *G. arboreum* cultivars are grown in less productive regions; thus, cultivar improvement in *G. arboreum* is focused on enhancing stress tolerance. Transferring desirable genes from the diploid species *G. arboreum* to allotetraploid upland cotton (*G. hirsutum* L.)requires specialized breeding approaches [3, 8, 13]. Information on the inheritance of specific traits is needed to increase the efficiency of introgression of these traits from *G. arboretum* into *G. hirsutum* cultivars. Additionally, evaluating the genetics and physiological aspects of these traits is simplified in diploid species compared to tetraploid species.

Cotton fibers (ovular trichomes) originate from the epidermal layer of ovules and grow as single cells up to 3 cm in length [1]. Two types of fiber occur on the ovule [12]. The long lint fibers are the economically important fibers; whereas, fuzz fibers are short fibers that adhere to the seed coat. The fiberless trait is characterized by a lack of lint and fuzz development. The trait has been reported in the diploid species *G. arboreum* and *G. herbaceum* L. with recessive genes conferring the fiberless trait[4, 9].

Leaf and stem pubescence (non-glandular foliar trichomes) have diverse functions. In the United States, cultivars with few leaf trichomes are more desirable, because the amount of trash in the seed cotton is reduced during mechanical harvesting [14].The glabrous trait is characterized as a lack of pubescence on leaves and stems, and has been reported in *G. arboretum* germ plasm [2, 4] and several D genome diploid species including *G. armourianum* Kearney, *G. raimondii* Ulbr., and *G. anomalum* Wawra and Peyritsch[5, 7, 10].

One accession, PI 529740, from the United States Department of Agriculture (USDA), National Plant Germplasm System (NPGS) *G. arboreum* collection, was identified as lacking lint development on the ovules and having glabrous leaves and stems. To determine the genetics of the ovule fiberless and foliar glabrous traits, PI 529740 was crossed with two *G. arboreum* accessions having ovule fibers and foliar pubescence. Segregation of these traits was evaluated in F_2 populations derived from these crosses. The parental germplasm lines also showed variation in stem color, corolla color, and the presence or absence of petal spots and these traits were evaluated in the populations to determine whether the fiberless and glabrous traits were linked with these traits.

MATERIALS AND METHODS

PI 529740 (A_2-113) was the only accession that showed no lint development or foliar pubescence from 1,506 accessions evaluated from the NPGS *G. arboreum* collection maintained in College Station, TX and was selected for genetic characterization. PI 529740 was crossed with two *G. arboreum* accessions, PI 417890 (A_2-82) and PI 529729 (A_2-101), that exhibited lint development and variation for density and length of foliar pubescence. These accessions differed from PI 529740 for several other traits. Accession PI 417890 has red colored stems, okra shaped leaves that are slightly larger than PI 529740, and flowers that are more open at maturity than PI 529740 with yellow colored corolla and red petal spots. Accession PI 529729 has red colored stems, okra shaped leaves that are deeply lobed and larger than PI 529740, and flowers that are open at maturity with white colored corolla and red petal spots. In comparison, accession PI 529740 has green colored stems, okra shaped leaves that are smaller and more broadly shaped, and flowers that do not fully open at maturity with white colored corolla and no petal spots. Accessions PI 529740 is also shorter in plant height and has a tendency to produce more branches than accessions PI 417890 and PI 529729. The crosses PI 529740 x PI 417890 and PI 529729 x PI 529740 were made to evaluate the genetics of the fiberless and glabrous traits plus stem color, corolla color, and petal spot presence. TheF_1 plants from the crosses were evaluated for these traits and self-pollinated to produce F_2 seed for genetic characterization.

Seeds for the two F_2 populations were planted in the field at the USDA in Stoneville, MS on 27 April 2012. Each population was spaced planted in a single 150 m row with approximately 0.3 m spacing between plants within a row. At flowering, individual plants were tagged in each row and corolla color, presence or absence of petal spots, and stem color were recorded for each plant. Leaf and stem pubescence were visually rated at maturity as the presence or absence of non-glandular trichomes. Five to ten bolls from individual plants were harvested at maturity and visually rated for the presence or absence of ovule lint fibers. Segregation ratios for the traits were tested using the Chi-square test of significance (Statistix 9, Analytical Software, Tallahassee, FL).

RESULTS AND DISCUSSION

The F_1 plants from the crosses PI 529740 x PI 417890 and PI 529729 x PI 529740 showed pubescence on leaves and stems, and ovules had lint indicating the fiberless and glabrous traits were recessive. The dominant traits yellow corolla color, presence of petal spots, and red stem color were observed for PI 529740 x PI 417890 F_1 plants. The PI 529729 x PI 529740 F_1 plants showed the dominant phenotypes for the presence of petal spots and red stem color. Both parents for this cross had white colored corolla and all F_1 plants had flowers with white colored corolla. Plants from both crosses showed the upright growth habit characteristic of the PI 417890 and PI 529729 parents.

The F_2segregation data for the PI 529740 x PI 417890 population are presented in Table 1 and in Table 2 for the PI 529729 x PI 529740 population. In both populations, the fiberless and glabrous traits fit a single recessive gene model. More than 800 plants were evaluated across the two F_2 populations and all plants rated as fiberless were also glabrous; thus, it is unknown whether the two traits are conferred by a single gene or two closely linked genes. Hutchinson and Gadkari [4] reported the fiberless (lintless) and glabrous phenotypes were conferred by a single recessive gene. They evaluated three glabrous fiberless*G. arboreum* germplasm lines and identified two independent, complementary loci for the traits referred to as h_a and h_b. The lines Dharwar glabrous lintless and Mollisoni glabrous lintless, which have the same gene (h_a) for the traits, have a phenotype similar to PI 529740 where the seeds were slightly fuzzy. In comparison, seeds of the Punjad glabrous lintless germplasm line with the h_b gene were devoid of fuzz.

Table 1. Phenotypic segregation data for 438 F_2 plants derived from the *Gossypiumarboreum* cross PI 529740 x PI 417890

Trait	Phenotype	Number of Plants	χ^2 (3:1 segregation ratio)	P-value
Seed Fiber	Fibered Fiberless	339 99	1.34	0.2466
Leaf/Stem Trichomes	Pubescence Glabrous	339 99	1.34	0.2466
Stem Color	Red Green	343 95	2.56	0.1096
Corolla Color	Yellow White	329 109	<0.01	0.9560
Petal Spot	Present Absent	331 107	0.08	0.7826

Table 2. Phenotypic segregation data for 375 F_2 plants derived from the *Gossypiumarboreum* cross PI 529729 x PI 529740.

Trait	Phenotype	Number of Plants	χ^2 (3:1 segregation ratio)	P-value
Seed Fiber	Fibered Fiberless	282 93	0.01	0.9287
Leaf/Stem Trichomes	Pubescence Glabrous	282 93	0.01	0.9287
Stem Color	Red Green	280 95	0.02	0.8815
Petal Spot	Present Absent	287 88	0.47	0.4929

The present study confirms the results of Rong *etal*.[9] and Desai *etal*.[2]. They reported a single recessive gene conferred the fiberless trait [9] that cosegregated with the glabrous leaf trait[2]. Significantly larger populations were evaluated in the present study and intraspecific crosses were conducted to preserve normal chromosome pairing. Whereas, Rong *etal*. [9] and Desai *etal*. [2] evaluated 176 F_2 plants from an interspecific cross. Two diverse *G. arboreum* germplasm lines were used as parents with PI 529740 to develop the populations in the present study and both populations fit the single recessive gene model with no recombinants observed for the fiberless and glabrous traits. Rong *etal*. [9] reported that the loci for these traits were located near the centromere in a region of reduced recombination. Thus, it was presumed the traits were conferred by two closely linked loci.

Yellow colored corolla, presence of petal spots, and red stem color fit the expected single dominant gene model and showed no linkage to the fiberless or glabrous traits. In the PI 529740 x PI 417890 F_2 population, plants with red colored stems were more frequent than expected for plants having fibered ovules; whereas, the frequency of plants with red stems was as expected for plants showing the fiberless trait. For the PI 529729 x PI 529740 population, green colored stems were more frequently observed for the fiberless F_2 plants with the expected frequency observed for plants having fibered ovules. Hutchinson and Gadkari [4] report that the fiberless and glabrous traits were independent of corolla color, anthocyanin pigmentation, leaf shape, lint color, and leaf nectaries.

Recombinant inbred populations are being developed from the F_2 plants to further characterize the fiberless and glabrous traits. Using these populations, genotype by sequencing will be evaluated for the identification of single nucleotide polymorphic (SNP) markers associated with the traits.

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