

## BREEDING AND GENETICS

### Atypical Ligon Lintless-2 Phenotype in Cotton

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#### ABSTRACT

**Ligon Lintless-2 ( $Li_2$ ) is a dominant single-gene mutant in cotton and plants typically have fuzzy seed with short lint fibers. Most  $Li_2 Li_2$  plants express this typical phenotype. However, three plants were observed that expressed two seed-cotton phenotypes on the same plant. Bolls on one branch on each of these plants expressed normal seed phenotype of fuzzy seed with normal length lint fibers; whereas, bolls on all other branches on these plants expressed the mutant phenotype of fuzzy seed with short lint fibers. Bolls from both branch types of these three plants were harvested by seed-cotton phenotype and seed were planted the following year. Plants from seed with short lint fiber and plants from seed with long lint fiber each produced short fiber plants, normal fiber plants, and plants with both fiber types on the same plant. Plants with two phenotypes on the same plant were stubbed below the branch with the normal bolls and transferred to the greenhouse and the regrowth continued to produce two phenotypes on the same plant. We propose that plants with two boll types on the same plant may be due to incomplete penetrance or lack of consistent expressivity of the dominant gene  $Li_2$  phenotype; however, the reoccurrence of the two phenotypes on the regrowth of stubbed plants in the greenhouse suggests that a more fundamental mechanism might be at work. This suggests a need for a deeper understanding of the  $Li_2$  allele on the expression and physiology of cotton fiber.**

A cotton plant, *Gossypium hirsutum* L., with abnormally short lint fibers was discovered in 1984 by Dr. G. A. Niles in a breeding nursery of the Texas Agricultural Experiment Station. The trait is

controlled by one completely dominant gene named *Ligon lintless 2* ( $Li_2$ ) (Narbutth and Kohel, 1990). This mutant has short lint fibers (< 10mm) and fuzzy seed. This gene is located on chromosome 18 (Kohel et al., 2002). We report herein atypical or chimeric phenotypes observed in a Mississippi greenhouse and field grown  $Li_2 Li_2$  plants in two different years (An, 2008).

#### MATERIALS AND METHODS

Homozygous  $Li_2 Li_2$  seed were obtained from R. J. Kohel and planted in the greenhouse in 2005 at Mississippi State, MS. Plants were self-pollinated and crossed as male to 'FiberMax 966' (FM966), PVP200100209 (Bayer Crop Science; Research Triangle Park, NC). Homozygous  $Li_2 Li_2$  seed were planted in 2006 at the Plant Science Research Center (33.4° N 88.8° W Mississippi State, MS) in a Marietta loam (fine-loamy, siliceous, active, Fluvaquentic Eutrudepts) soil. At harvest, three plants were observed with two seed-lint phenotypes on the same plant. Most branches on these three plants produced bolls with short lint but each plant also produced one branch with bolls with normal length lint. All bolls on a fruiting branch expressed the same seed-lint phenotype. All bolls on a fourth plant produced only normal length lint. Seeds from each type of boll on the three plants were harvested by lint phenotype. Bolls were harvested also from the one plant that only had normal length lint fiber bolls on all branches. All seed harvested were from open-pollinated bolls. Seeds of these four plants, self-pollinated seed from plants of the  $Li_2 Li_2$  genotype, and  $F_1$  seed from the FM966 x  $Li_2 Li_2$  cross were planted in the field in 2007.

#### RESULTS AND DISCUSSION

Figure 1 shows the typical phenotype of FM966 and fuzzy-lint  $Li_2 Li_2$ . Figure 2 shows a typical boll from FM966 and one from  $Li_2 Li_2$ . Figure 3 shows an atypical plant with both types of lint on the same plant in the field and a regrowth plant with two phenotypes after being stubbed and transplanted to the greenhouse.

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Figure 1. Normal lint phenotype of cultivar FM 966 (above) and fuzzy-short lint  $Li_2$  (below).



Figure 2. Cotton boll, normal lint phenotype of cultivar FM 966 (above) and fuzzy-short lint  $Li_2$  (below).



Figure 3. Two phenotypes, fuzzy-short lint and fuzzy-normal length lint fibers, observed on the same field plant (above) and a greenhouse plant that arose from a stubbed field plant transferred to the greenhouse that continued to exhibit the two phenotypes (below).

Phenotypes of plants from seed from the three two-lint phenotype plants, the one long lint plant, and the  $F_1$  are shown in Table 1. Progeny of the four atypical plants produced plants with all bolls showing short lint, plants with both short lint and normal length lint bolls on the same plant, and plants with only normal length lint (Table 1). Thus, the lint phenotype did not breed true in the next generation in 2007. We also stubbed several  $Li_2Li_2$  plants with

two phenotypes and transferred them to the greenhouse. These plants were stubbed below the branch with the normal length lint. In the greenhouse these plants continued to produce bolls with short lint on most fruiting branches and one branch with normal length lint bolls on the same plant. This suggests variable expressivity or incomplete penetrance of the  $Li_2Li_2$  genotype.

**Table 1. Segregation for lint phenotype in the OP<sub>1</sub> generation of three plants expressing atypical two lint phenotypes on the same plant, one plant with only atypical normal length lint phenotype, the S<sub>1</sub> generation of  $Li_2Li_2$  short lint phenotype plants, and F<sub>1</sub> plants from the cross of FM966 x  $Li_2Li_2$**

Genotype, plant no. and lint phenotype	Number of plants in next generation		
	Short lint	Two types on same plant	Normal length lint
$Li_2Li_2$ plant 1 SL <sup>z</sup>	11	15	13
$Li_2Li_2$ plant 1 NL <sup>y</sup>	13	7	14
$Li_2Li_2$ plant 2 SL	21	7	14
$Li_2Li_2$ plant 2 NL	6	2	3
$Li_2Li_2$ plant 3 SL	4	5	9
$Li_2Li_2$ plant 3 NL	5	5	7
$Li_2Li_2$ plant 4 NL	21	10	19
$Li_2Li_2$ SL	63	28	34
(FM966 x $Li_2Li_2$ ) F <sub>1</sub>	11	8	0

<sup>z</sup>SL short lint fibers

<sup>y</sup>NL normal length lint fibers

In 2007 we also grew 125 plants from selfed seed of homozygous  $Li_2Li_2$  plants with short lint phenotype. Because these plants were from self-pollinated seed, we expected all S<sub>1</sub> plants to have the same genotype and phenotype as the parental plant. However, the S<sub>1</sub> generation produced three plant phenotypes. We observed 63 plants with short lint only, 28 plants with both lint types on the same plant, and 34 plants with only normal length lint (Table 1). In these progeny from the self-pollinated seed, the 34 plants with long lint suggests that the parent  $Li_2$  plants we self pollinated were perhaps heterozygous. However, if the parental plants were heterozygous for  $Li_2$ , the S<sub>1</sub> generation should segregate 3 short lint : 1 normal lint. Our data showed three phenotypes: 63 short lint, 28 two types of lint on same plant, and 34 normal lint plants. The two lint types on the same plants in the progeny seem to negate heterozygous parental plants as the simple explanation.

The cross of FM966 x  $Li_2Li_2$  produced 11 short lint F<sub>1</sub> plants and 8 F<sub>1</sub> plants with both short and nor-

mal length lint on the same plant (Table 1). Because  $Li_2$  is a dominant mutant, we expected all plants to express the typical short lint phenotype.

We considered several scenarios to understand what is happening in the plants with two types of bolls on the same plant. Semigamy (Turcott and Feaster, 1963;1967) is one possible mechanism. In semigamy, haploid, and sometimes diploid, sectors are produced. Plants produced from the diploid sectors or plants produced from haploid sectors that are doubled with colchicines, breed true. The two lint type plants we report are diploid, but they do not breed true to lint type in the next generation. Dolan and Poethig (1988) produced chimeric plants for okra leaf that continued through the next generation to produce chimeric plants, as did our plants; however, they used female plants with the semigamy gene and their F<sub>1</sub> plants were heterozygous for okra leaf. Our  $Li_2$  plants did not, to our knowledge, carry the semigamy gene nor were they heterozygous for the  $Li_2$  allele, except for the F<sub>1</sub>. This would seem to negate semigamy as a cause of the atypical phenotypes we observed. Another possibility is spontaneous mutation as the branch is formed. With mutation we would expect that the bolls harvested from different branches would breed true to type. They did not. In unrelated research, we observed a plant with one branch mutated to white lint on a heterozygous brown lint plant (McCarty, unpublished data). In this case the next generation seed from the mutation to white lint bred true to type and seed from brown lint bolls segregated in a 1:2:1 ratio confirming that the original plant was heterozygous brown and the white lint branch was due to a simple mutation. The abnormal phenotype for  $Li_2$  did not behave like this brown to white lint mutant. Another possible cause could be that the plants with the atypical lint phenotypes are due to incomplete penetrance or lack of consistent expression of the dominant gene  $Li_2Li_2$ . We did not find any literature that reported variable expression of phenotype in  $Li_2Li_2$  plants. Because we observed the phenomenon in the field for two years and in stubbed plants transplanted into the greenhouse, we propose that plants with two boll types on the same plant might be due to incomplete penetrance or lack of consistent expressivity of the dominant gene  $Li_2$  phenotype. However, the reoccurrence of the two phenotypes in regrowth on the stubbed plants in the greenhouse suggest that a more fundamental mechanism might be at work. This strongly suggests the need for a deeper understanding of the  $Li_2$  allele on the expression and physiology of cotton fiber.

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## REFERENCES

- An, C. 2008. SNP characterization and genetic and molecular analysis of mutants affecting fiber development in cotton. PhD dis. Mississippi State University, Mississippi State, MS. Published on line at <http://sun.library.msstate.edu/ETD-db/theses/available/etd-03302008-191842/> (verified 23 January 2009).
- Dolan, L. and R.S. Poethig. 1988. The okra leaf shape mutation in cotton is active in all cell layers of the leaf. *American Journal of Botany* 85:322–327.
- Kohel, R.J., D.M. Stelly, and J. Yu. 2002. Tests of six cotton, *Gossypium hirsutum*, L mutants for association with aneuploids. *J.Hered.* 93:130–132.
- Narbuth, E.V., and R.J. Kohel. 1990. Inheritance and linkage analysis of a new fiber mutant in cotton. *J. Hered.* 81:131–133.
- Turcott, E.L. and C.V. Feaster. 1963. Haploids: high frequency production from single-embryo seeds in a line of Pima cotton. *Science* 140:1407–1408.
- Turcott, E.L. and C.V. Feaster. 1967. Semigamy in Pima cotton. *Heredity* 58:55–57.