LONREN × FM966 PROGENY EVALUATION IN A FIELD INFESTED WITH RENIFORM NEMATODE

D. B. Weaver
R. B. Sikkens
R. R. Sharpe
Department of Agronomy & Soils
Auburn University, AL
S. R. Moore
K. S. Lawrence
Department of Entomology and Plant Pathology
Auburn University, AL

Abstract

Rotylenchulus reniformis (reniform nematode) can be a yield-limiting factor for upland cotton (*Gossypium hirsutum* L.). Resistance was discovered in a wild cotton relative, transferred to an upland background and released as the germplasm LONREN. We tested $F_{2:4}$ lines from the cross LONREN-1 × Fibermax 966 in two fields, one infested with reniform nematode and one not infested. Twenty resistant lines and 20 susceptible lines were tested, with the objective of determining the effect of the LONREN resistance gene on yield, agronomic traits, and fiber quality in a nematode-infested and nematode-free environment. Lines with the LONREN resistance gene were stunted during early season growth and yielded less than their susceptible counterparts in the nematode-infested field. Nematode populations were reduced in plots where lines carrying the LONREN resistance gene were planted. There were no yield differences in the nematode-free field. Fiber quality was largely unaffected by the LONREN resistance gene, except that lines carrying the gene tended to have greater fiber strength.

Introduction

Upland cotton is susceptible to a number of plant-parasitic nematodes, including the reniform nematode. Reniform nematode was first identified as a pest of cotton many years ago, (Smith, 1940) with subsequent studies showing significant distribution of the pest and its effects on cotton yield and quality (Birchfield and Jones, 1961; Jones et al., 1959). Losses to reniform nematode in U.S.-produced cotton have been estimated at approximately 204,000 bales with AL, LA and MS being the states with the highest losses in terms of percent of total crop (Blasingame et al., 2010). Management options are limited. Many studies have reported varying levels of genetic resistance to reniform nematode in cultivated cotton and its relatives (Robinson and Percival, 1997; Robinson et al., 2004; Weaver et al., 2007; Yik and Birchfield, 1984). In 2007 resistance from the an accession of the diploid *G. longicalyx* was introgressed into a *G. hirsutum* genetic background through a series of "bridge" crosses due to genome incompatibility issues between the two species (Robinson, et al., 2007) and released as germplasm lines LONREN-1 and LONREN-2. The gene for resistance was mapped to chromosome 11 (A genome). It was determined to be linked to the microsatellite marker BNL3279_114 and given the gene symbol REN^{lon} (Dighe, et al., 2009). REN^{lon} is also linked to a morphological marker, green seed fuzz, with gene symbol Fzg^{lon}. There have been reports of some stunting and plant development issues among lines carrying the REN^{lon} gene in fields where reniform nematode is present (Nichols et al., 2010). The objective of our research was to determine the effect of the LONREN resistance gene (REN^{lon}) on yield, agronomic traits, and fiber quality in a nematode-infested and nematode-free environment.

Materials and Methods

In 2007, 100 $F_{2:3}$ lines from the cross LONREN-1 × Fibermax 966 were evaluated for reaction to reniform nematode in greenhouse tests. Twenty-one lines were found to be homogeneous for resistance, and were thought to be descended from F_2 plants homozygous for the LONREN resistance gene. Another 20 lines were identified as highly susceptible and homogeneous for susceptibility, and were thought to be descended from F_2 plants that were homozygous null for the LONREN gene. These observations were confirmed by testing for presence (resistant lines) or absence (susceptible lines) of the SSR marker BNL 1066. Resistant lines were mostly also homogeneous for green seed coat fuzz, and susceptible lines did not have green seed coat fuzz. Some variability for these traits was noted in the 10 to 15% range. Lines were advanced in the field to the $F_{2:4}$ generation in 2009 to increase seed. In 2010 20 resistant and 20 susceptible lines along with checks LONREN-1, LONREN-2, Fibermax 966 and Deltapine 393 were planted in a field with a history of reniform nematode infestation near Belle Mina, AL at the

Tennessee Valley Research and Extension Center. Separated by a field road, one field has been repeatedly inoculated in previous years with reniform nematodes, and populations were confirmed by sampling previous to planting. The other field was nematode-free, confirmed by sampling. Single-row plots 25 feet long were planted in five replications on April 30, 2010 at a population density of 4 seed/foot. Identical randomizations in a randomized complete block design were used in both fields. Plant height was measured approximately every four weeks beginning 34 days after planting (DAP). Nematode counts were made on a plot basis at 25 and 60 DAP and again six days after harvest. Plots were harvested on September 30 (non-nematode field) and October 1 (nematode-infested field), 2010, following collection of boll samples for fiber quality analysis. Fields were sampled on an individual plot basis 25 DAP and 6 days after harvest. All data were analyzed by SAS (SAS, 2010)

Results and Discussion

Plant height was reduced in resistant lines in the nematode-infested field, but not in the nematode-free field (Table 1).

Table 1. Yield and plant height least squares estimates for resistant and susceptible lines.

	Group means			
	Reniform present		Reniform absent	
	Yield ± SE (lbs lint/acre)	Height ± SE (cm)	Yield ± SE (lbs lint/acre)	Height ± SE (cm)
Resistant lines	834 ± 80	81 ± 2.4	1372 ± 52	98 ± 3.6
Susceptible lines	1071 ± 80	92 ± 2.4	1448 ± 52	97 ± 3.6
LONREN lines	845 ± 152	82 ± 4.8	1443 ± 89	106 ± 4.3
Susceptible checks	913 ± 152	90 ± 4.8	1405 ± 89	95 ± 4.3
	Group mean differences			
Resistant vs. susceptible	-237 ± 61*	-11 ± 1.9**	-76 ± 34	1 ± 1.1
Resistant vs. LONREN	-11 ± 143	0 ± 4.5	-61 ± 80	-8 ± 2.6*
Susceptible vs. susc. checks	158 ± 143	2 ± 4.5	43 ± 80	2 ± 2.6
LONREN vs. susc. checks	-68 ± 193	-8 ± 6.1	28 ± 108	11 ± 3.5*

*, ** indicate significant contrast differences at the 0.05 and 0.01 levels of probability respectively.

At harvest time resistant lines on average were 11 cm shorter in the nematode-infested field than susceptible lines, but were not different in the reniform-free field. Thus there were no inherent effects of the REN^{lon} gene on plant height in the absence of nematodes. Any height reduction caused by the REN^{lon} gene appeared to be a result of reaction to nematode feeding. The LONREN germplasm lines also tended to be shorter than the susceptible checks. Yield in the nematode-infested field was also significantly reduced in the resistant lines compared to the susceptible progenies. This result was somewhat surprising, as we expected the resistance in the lines carrying the REN^{lon} gene to result in higher yield. Susceptible lines yielded slightly higher than resistant lines in the nematode-free field (1448 vs. 1372 lbs. lint/acre) but the difference was not significant (P = 0.21). Fiber quality was largely unaffected by presence of the REN^{lon} gene (Table 2). There were no differences between lines carrying the REN^{lon} gene and

Table 2. Fiber quality traits for resistant and susceptible lines in nematode-infested field (+RN) and nematode-free field (-RN).

	Micronaire ---units---		UHM ----in.----		UR ---%---		Strength ---g/tex----		Elongation ----%----		SFC ----%----	
Group	+RN	-RN	+RN	-RN	+RN	-RN	+RN	-RN	+RN	-RN	+RN	-RN
R-lines[†]	5.1	5.0	1.06	1.07	83.7	83.5	31.7	31.4	4.9	4.7	7.4	7.5
S-lines	4.9	5.1	1.08	1.08	83.3	83.1	30.1	30.2	4.9	4.7	7.6	7.8
L-lines	4.8	5.0	1.05	1.06	83.2	83.3	29.8	29.8	5.3	4.5	8.0	7.9
Checks	4.8	4.7	1.11	1.12	83.9	83.3	31.4	31.1	5.1	4.9	7.3	8.1

Significant group mean difference

Trait	Group	Location	SE	Probability
Fiber strength	R-lines vs S-lines	Nematode infested	0.33	0.0071
		Nematode free	0.29	0.0013

[†]R-lines are resistant lines carrying the REN^{lon} gene, S-lines are susceptible lines, L-lines are LONREN-1 and LONREN-2.

those that did not except for one fiber quality trait: fiber strength. Lines that carried the *REN^lon^* gene had significantly greater fiber strength than those that did not, regardless of nematode environment. In fact, average fiber strength of the resistant lines was more than 5% greater than susceptible lines in the nematode-infested field, and equal to the checks in both fields, indicating that there may be some positive impact of the *REN^lon^* gene on fiber strength. All other group mean differences were not significant.

An important aspect of this research was to assess the effect of the *REN^lon^* gene on nematode populations, especially at the end of the season. At 25 DAP, there were no differences among the resistant, susceptible, LONREN and check genotypes in nematode population densities in the nematode-infested field (Figure 1).

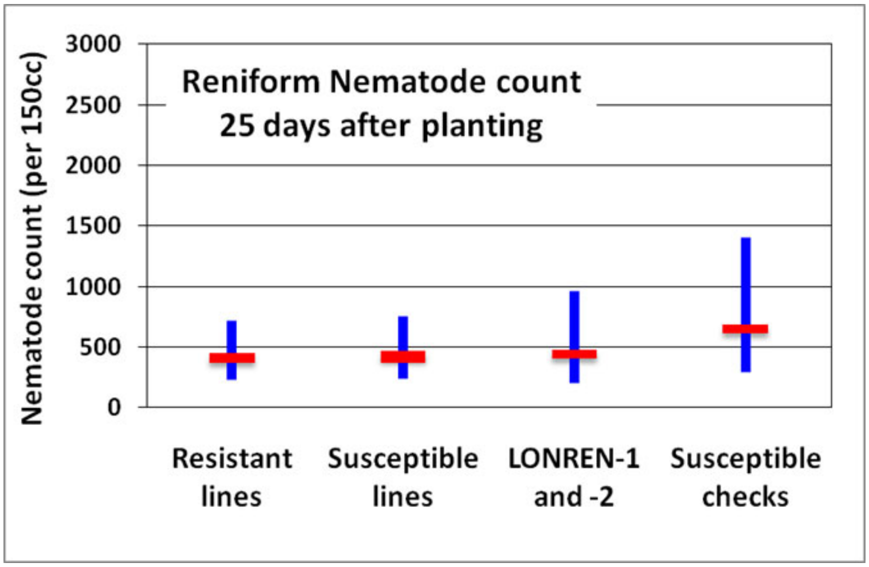

Figure 1.

At six days after harvest however, the differences were striking (Figure 2). Lines with the *REN^lon^* gene had

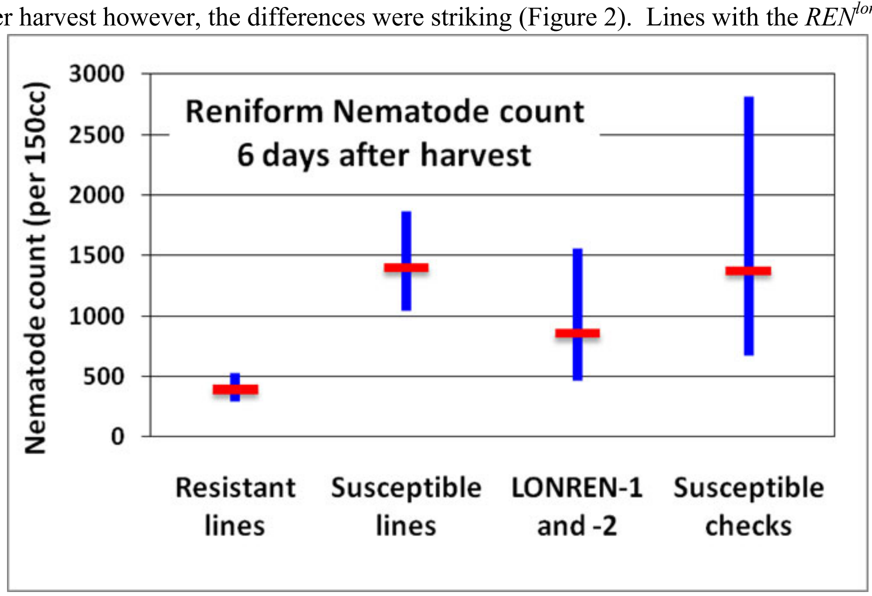

Figure 2.

far fewer reniform nematodes (392 per 150 cc of soil) than susceptible lines (1396 per 150 cc of soil). Susceptible checks and susceptible lines had essentially equal nematode numbers, with the two LONREN lines slightly, but not significantly, less. High nematode population variability and lack of observation numbers in the LONREN plots contributed to their high standard error. While the yield and height characteristics of the lines containing the *REN^lon^*

gene were not expected and somewhat disappointing, the *REN*^{lon} gene does appear to have some utility as a significant nematode management tool, by reducing populations. More research will have to be conducted to determine the longevity of the nematode population reduction and to determine a specific management system that can best utilize this positive aspect of the *REN*^{lon} gene.

Conclusions

In this experiment, lines carrying the *REN*^{lon} gene suffered significant reductions in growth rate, overall plant height, and yield in a field infested with reniform nematode. Performance of these lines was unaffected in a nematode-free field compared to their sister lines that did not carry the gene. Fiber quality traits were largely unaffected, except for fiber strength. Lines with the *REN*^{lon} gene had greater fiber strength than lines that did not carry the gene, indicating a contribution of the gene to improved fiber strength. The most positive aspect of the *REN*^{lon} gene appeared to be a reduction in nematode populations, a trait which could prove to have valuable utility in the overall management of this significant pest of cotton.

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