COMPARATIVE PERFORMANCE OF RENIFORM NEMATODE RESISTANT GERMPLASM LINES

Roelof B. Sikkens
Department of Entomology and Plant Pathology
Auburn University, Alabama
David B. Weaver
Department of Crop, Soil and Environmental Sciences
Auburn University, Alabama
Kathy S. Lawrence
Department of Entomology and Plant Pathology
Auburn University, Alabama
Robert L. Nichols
Cotton Incorporated
Cary, North Carolina

Abstract

A decade long concerted effort to develop host plant resistance to reniform nematode in Upland Cotton has resulted in the release of several germplasm lines. During 2013, thirteen such lines were subjected to a comparative performance study, both in the field and in the greenhouse. Results show that lines belonging to the BARBREN and M713 germplasm groups, which share a common source of resistance, not only reduce nematode reproduction, but also offer good tolerance and good agronomic performance.

Background

Since 2007, several Upland Cotton (*Gossypium hirsutum*) germplasm lines with introgressed resistance to reniform nematode (*Rotylenchulus reniformis*) have been released for use by the cotton breeding community. At present, four groups of released germplasm lines can be differentiated based on their source of resistance and developmental background (see the Release Notices listed in the Reference section):
(a) the LONREN group, with reniform nematode (RN) resistance derived from *G. longicalyx*,
(b) the BARBREN group, with RN resistance derived from the wild accession GB-713 of *G. barbadense*,
(c) the M713 group, also with resistance derived from the GB-713 accession, but with a different developmental trajectory, and
(d) the MT2468 group, with reportedly moderate levels of RN resistance derived from the photoperiodic primitive race accession TX2468 of *G. hirsutum*.
In order to further appreciate the potential of each germplasm line, a comparative study was done in 2013. This study included three lines of the LONREN group, two lines of the BARBREN group, five lines of the M713 group and three lines of the MT2468 group, for a total of 13 RN resistant germplasm lines. Conventional cultivars FiberMax 966 (FM966) and SureGrow 747 (SG747) were included as RN susceptible controls.

Materials and Methods

Studies were done both in the field and under controlled environmental conditions in the greenhouse. Field performance evaluation was conducted during the 2013 growing season at the Tennessee Valley Research and Extension Center (TVREC) near Belle Mina, Alabama. The greenhouse experiment, consisting of an assay with inocula of different nematode densities, was conducted at the Plant Science Research Center located on the campus of Auburn University, Alabama.

Field Trial

Testing was conducted on two fields at TVREC. One field has an established population of reniform nematode. The other field, located some 200 meters to the west, is free from reniform nematode. The Soil on both fields is classified as a Decatur silt loam, with textural composition in the upper 0-6 inch horizon of 23% sand, 49% silt and 28% clay. Layout of the test on each field was a randomized complete block design, consisting of 5 replications of two 25-ft row plots for each entry. The two fields were independently randomized. The field with RN was planted on May 1, 2013; the field without RN was planted the next day. At 41 days after planting (DAP), four seedlings from each plot on the field with RN were dug out. Shoot height of each sampled seedling was measured, followed by the weighing

of the combined shoot and root fresh weights on a per plot basis. Nematode eggs were collected from the combined root mass of each plot by shaking the roots on a rotary shaker for four minutes in a 0.625% NaOCl solution. Thereafter, eggs were washed with water over nested 75 µm and 25 µm sieves, sucrose centrifuged, and enumerated at 40X with a Nikon TSX inverted microscope. On October 10, 25-boll samples were collected from each plot on both fields, from which turnout percentages were derived. Lint samples from each plot were submitted to the Product Evaluation Laboratory of Cotton Incorporated for HVI fiber quality assessment. The non-RN field was harvested on October 21, 172 Days after Planting (DAP), and the with-RN field on October 24 (176 DAP). Seed cotton weights from all plots were collected, on which basis yield potentials per acre were established.

Inoculation Assay

All 13 germplasm lines included in the field trial, as well as both controls, were entered into the various inocula test. Inoculum levels were 0, 1000, 5000, 10,000 and 50,000 juveniles and vermiform adults per cone-tainer of 150 cm^3 (Ray-Leach Cone-tainers™, 2.5 cm diameter and 20 cm deep). The cone-tainers were filled with a sandy-loam soil mixture of 83% sand, 2% silt and 15% clay, with 1.1% organic matter and a pH of 6.4. The soil was sterilized by autoclaving. At planting, Osmocote Pro 8-9M 19-5-8 fertilizer (Everris) was mechanically mixed into the soil at a rate of 2.9g/dm^3. Cone-tainers were grouped together according to inoculum levels, fully randomized, and placed on racks. To limit the possibility of cross-contamination between nematode inoculum levels, racks with similar inoculum levels were placed at different locations in the same greenhouse zone, and were rotated on a weekly basis to minimize location effects. Each entry was replicated 10 times at each inoculum level, for a total of 750 cone-tainers. Because of its large size, the test was performed in two sets of 5 replications per genotype and per inoculum level each. Planting of the first set was done on August 7; the second set followed eight days later on August 15, 2013. All cone-tainers were double planted (2 seed/cone), with, in the general case of double germination, one seedling removed one day prior to inoculation. Cones were inoculated seven days after planting; the first set on August 14, and the second set on August 23, 2013. Cones were watered as needed, with a weekly application of Peter's 20-10-20 water-soluble fertilizer (Buddies Plant Food) after the 2nd true leaf stage. Seedlings were removed from the cones at 60 days after inoculation (DAI), when shoot height, and shoot and root fresh weights were measured. All roots were photographed; thereafter eggs were collected and counted as described above.

Results and Discussion

Field trial

Earlier season observations from the field with the established population of reniform nematode at TVREC are summarized in Table 1. No early season data were collected on the field free of reniform nematode. At 41 DAP, seedlings of the BARBREN and M713 groups outperformed those of the other 3 groups. Mean nematode eggs counts per gram of fresh root weight were also lowest for lines of the BARBREN and M713 groups. The counts were highest for the control and LONREN groups. For the latter these results are surprising and could indicate a loss of resistance. Such a result could be due to rossing due to previous exposure of the lines to other cotton genotypes in the field, possible segregation of the original material, or reversion of the introgressed material. Figure 1 presents an image of three lineson the reniform nematode infested field on July 30, 2013 (90 DAP). Germplasm line BAR 41 is demonstratively better performing than control entry FM966 to its left, while plants on the LONREN 21-4 plot to the right are severely stunted by exposure to high in-field nematode populations that may have increased their susceptibility to soil pathogens as well. Observed lint yields are summarized in Table 2. Yields on the non-RN field ranged from 1177 lbs/acre for the MT2468 Ren1 line to a high of 1748 lbs/acre for LONREN-1. Yield variations on the with-RN field were larger, with the highest yield of 1617 lbs/acre observed for the BAR 41 line; LONREN 21-4 was the lowest yielding line here with a mere 102 lbs/acre. All germplasm lines yielded lower on the with-RN field than on the RN-free field, with yield reductions varying from 2% for M713 Ren3 to 92% for LONREN 21-4. The most dramatic yield reductions were observed in the LONREN and MT2468 groups: on the average 83% and 57%, respectively. Both controls also registered considerable yield losses: 64% in the case of SG747 and 67% for FM966. For all entries, except SG747, lint turnout percentages were higher from the with-RN field than from the no-RN field (Table 2). Although not statistically comparable, lint quality between the with- and without RN fields was very similar (Table 3). Quality characteristics of the RN resistant germplasm lines were largely at par with those of the control cultivars. Longest fiber lengths were obtained for BAR 41, M713 Ren3 and M713 Ren1, resulting in higher than average Q1 quality scores for these lines (see also: Bourland *et al*., 2010). Little variation between lines for fiber strength was observed, resulting in rather flat Q2 scores. Line M713 Ren1 had the highest Q2 score (79.2); MT2468 Ren2 the lowest (55.2).

Table 1. Means of early season observations of the field trial at TVREC: shoot heights, shoot and root fresh weights, and nematode egg counts per gram of root fresh weight. Also included are the mean post-harvest reniform nematode counts.

Reniform Nematode Resistance Group	Germplasm line	Shoot Height**	Shoot Fresh Weight*** (SFW)	Root Fresh Weight*** (RFW)	Nematode Eggs per gram of RFW	Vermiform R.Nematode in soil
		At 41 Days After Planting				At Harvest
		(cm)	(gram)	(gram)	(eggs/gRFW)	(RN/150cm3 soil)
BARBREN	BAR 41	9.4 bcd*	10.5 abc	1.0 bcd	1691 a	1885 a
	BARBREN 713	11.4 ab	13.4 a	1.3 ab	6205 ab	1947 a
LONREN	LONREN-1	9.5 bcd	8.7 a-d	0.9 bcd	13684 ab	4357 ab
	LONREN-2	8.5 cd	5.6 cd	0.6 cd	23705 b	3971 ab
	LONREN 21-4	7.6 d	4.4 d	0.5 d	16420 ab	1885 a
M713	M713 Ren1	10.5 abc	12.0 ab	1.3 ab	1105 a	3152 ab
	M713 Ren2	10.4 abc	10.5 abc	1.0 bcd	1989 a	1143 a
	M713 Ren3	12.1 a	13.6 a	1.5 a	814 a	2426 a
	M713 Ren4	10.1 a-d	11.2 ab	1.1 abc	1584 a	2457 a
	M713 Ren5	10.8 abc	11.2 ab	1.1 ab	1254 a	4790 ab
MT2468	MT2468 Ren1	9.7 bcd	8.6 a-d	0.9 bcd	5117 ab	4218 ab
	MT2468 Ren2	8.9 bcd	7.2 bcd	0.8 bcd	7347 ab	5871 ab
	MT2468 Ren3	8.9 bcd	7.5 bcd	0.8 bcd	3409 ab	2426 a
CONTROL	FM966	9.4 bcd	8.1 bcd	0.9 bcd	16477 ab	7694 b
	SG747	10.3 abc	9.0 a-d	1.0 bcd	18097 ab	3105 ab
	$LSD_{0.05}$	1.4	3.2	0.3	12198	2802

* Means in the same column followed by the same character do not differ significantly at the p=0.05 level (Newman-Keuls).

** Mean Shoot Height of 4 extracted seedlings per plot (n=20).

*** Combined Shoot or Root Fresh Weight of 4 extracted seedlings per plot (n=5).

Inoculation Assay

In the greenhouse, shoot heights measured at 60 DAI are summarized in Table 4. Only LONREN 21-4 saw a significant decrease in mean shoot height between the 0 and 50,000 inoculum levels: from 35.1 cm to 24.5 cm. The shoot heights of all other entries stayed more or less constant across the different inoculum levels, indicating a general lack of observable seedling stunting. In this context, it is worthwhile to compare shoot heights recorded in this year's various inoculum assays with heights obtained in a similar study conducted in 2010 (Sikkens *et al.*, 2011). In the 2010 study, the average shoot height across all inoculum levels was 8.4 cm at 63 DAI, compared to 39.3 cm at 60 DAI in this assay. Seasonal differences in growth are a probable cause of the some of the differences in the magnitude of the plant biomass parameters. The 2010 study was carried out during the spring and the 2013 study during the summer. However, based on our experience with other greenhouse tests, we suspect that the addition of the fertilizer to the soil mix had a more important effect on plant development, as it created a more conducive growing environment for the seedlings. Fertilization resulted in healthier seedlings that were less subject to stunting or other growth impediments due to the reniform nematode.

Table 5 contains the means of observed Shoot Fresh Weights (SFW) and Root Fresh Weights (RFW). As with the shoot heights, SFW values varied little among genotypes and inoculum levels. There is somewhat more differentiation in the RFWs: mean root weights at the 50,000 RN level are higher for all genotypes except for LONREN 21-4. In the case of FM966, RFW more than doubled between the 0 and 50,000 RN levels, and most other genotypes show a gradual increase of RFW at increased RN inoculum levels.

Figure1. Three plots of 2 rows each on the reniform nematode infested field on July 30, 2013 (90 DAP). On the left is the RN susceptible control FM966, in the center is RN resistant germplasm line BAR 41, and to the right is LONREN 21-4.

Table 2. Means of turnout percentages and cotton yields observed at the TVREC field trial.

Reniform Nematode Resistance		Turnout		Lint yield		Yield Effect withRN
Group	Germplasm line	noRN**	withRN	noRN	withRN	vs. noRN
		(%)		(lbs/acre)		(%)
BARBREN	BAR 41	37.4 f*	39.0 d	1617 ab	1467 a	-9.3
	BARBREN 713	38.8 def	39.8 cd	1579 abc	1144 b	-27.5
LONREN	LONREN-1	41.5 a	43.8 a	1748 a	512 cd	-70.7
	LONREN-2	40.2 a-d	41.2 bcd	1640 ab	212 e	-87.1
	LONREN 21-4	38.4 ef	40.5 bcd	1418 abc	102 e	-92.8
M713	M713 Ren1	40.0 a-e	40.6 bcd	1261 bc	1231 ab	-2.4
	M713 Ren2	40.4 a-d	42.2 abc	1208 c	1122 b	-7.1
	M713 Ren3	41.7 a	42.7 ab	1260 bc	1234 ab	-2.0
	M713 Ren4	41.7 a	42.0 abc	1362 bc	1285 ab	-5.6
	M713 Ren5	37.2 f	38.8 d	1198 c	1094 b	-8.6
MT2468	MT2468 Ren1	38.2 ef	39.2 d	1177 c	590 cd	-49.8
	MT2468 Ren2	39.1 c-f	40.5 bcd	1318 bc	384 de	-70.9
	MT2468 Ren3	39.3 b-f	40.3 bcd	1506 abc	741 c	-50.8
CONTROL	FM966	40.8 abc	41.1 bcd	1631 ab	526 cd	-67.8
	SG747	41.0 ab	40.7 bcd	1390 abc	496 cd	-64.3
	$LSD_{0.05}$	1.2	1.5	235	202	

* Means in the same column followed by the same character do not differ significantly at the p=0.05 level (Newman-Keuls).

** noRN, withRN = Field without reniform nematode and field with reniform nematode, respectively.

Table 3. Fiber quality data from the field trial at TVREC.

Reniform Nematode Resistance		Fiber Length (UHM)		Micronaire (MIC)		Uniformity (UI)		Strength (STR)		Quality Scores**	
Group	Germplasm Line	noRN*	withRN	noRN	withRN	noRN	withRN	noRN	withRN	Q1	Q2
		(inch)				(%)		(g/tex)			
BARBREN	BAR 41	1.26	1.24	4.6	4.8	83.5	82.4	31.5	30.7	82.4	69.2
	BARBREN 713	1.11	1.12	4.3	4.5	82.9	82.7	29.9	30.6	51.7	62.8
LONREN	LONREN-1	1.12	1.12	4.4	4.6	83.4	83.2	29.2	29.3	52.6	65.1
	LONREN-2	1.15	1.14	4.2	4.5	84.1	83.1	32.7	31.1	59.6	68.5
	LONREN 21-4	1.16	1.16	4.2	4.4	84.5	82.8	31.3	30.5	64.6	69.7
M713	M713 Ren1	1.24	1.24	4.5	4.6	84.5	84.3	32.0	32.1	88.7	79.2
	M713 Ren2	1.19	1.22	4.5	4.9	83.6	84.0	31.2	31.1	72.5	71.7
	M713 Ren3	1.25	1.24	4.3	4.4	83.9	83.1	30.1	29.7	87.8	74.0
	M713 Ren4	1.18	1.19	4.3	4.3	84.3	83.3	31.4	30.9	73.3	72.5
	M713 Ren5	1.17	1.12	3.9	4.0	82.8	82.2	32.1	30.3	56.6	61.7
MT2468	MT2468 Ren1	1.16	1.13	4.5	4.5	84.7	84.2	30.0	30.7	62.5	74.0
	MT2468 Ren2	1.09	1.07	4.3	4.8	83.3	82.0	28.7	29.0	38.7	55.2
	MT2468 Ren3	1.10	1.05	4.4	4.5	84.1	82.1	29.3	28.7	43.0	62.4
CONTROL	FM966	1.18	1.18	4.1	4.2	84.0	83.9	32.0	32.5	71.8	73.3
	SG747	1.17	1.17	4.5	4.4	84.6	83.9	29.9	29.6	68.6	74.4
	$LSD_{0.05}$	0.03		0.3		1.1		1.3		7.9	7.6
Line by Field Interaction		NS*** (p = 0.19)		NS (p = 0.69)		NS (p = 0.22)		NS (p = 0.24)			

* noRN, with RN = field without reniform nematode and field with reniform nematode, respectively.

** see: Bourland et al., 2010. Score Q1 emphasizes Fiber Length, score Q2 emphasizes Fiber Strength.

*** NS = Not Significant.

Table 4. Least squares means of shoot heights observed at 60 Days After Inoculation (DAI) in the Various Inocula Assay.

Reniform Nematode Resistance		Shoot Height at 60 DAI (cm)				
		Reniform Nematode Inoculum Level (RN/150 dm^3)				
Group	Germplasm line	0	1000	5000	10,000	50,000
BARBREN	BAR 41	35.9	35.8	35.3	32.6	33.7
	BARBREN 713	40.3	38.4	40.2	35.4	36.6
LONREN	LONREN-1	36.5	36.6	40.4	35.5	30.5
	LONREN-2	38.9	42.6	41.0	34.7	38.2
	LONREN 21-4	35.1	30.1	36.4	34.2	24.5
M713	M713 Ren1	39.0	42.9	44.3	40.8	41.6
	M713 Ren2	37.3	38.4	44.3	41.0	40.4
	M713 Ren3	40.0	38.0	40.0	36.8	36.3
	M713 Ren4	43.8	39.9	47.6	40.6	41.3
	M713 Ren5	38.2	37.5	42.2	34.5	36.8
MT2468	MT2468 Ren1	41.6	45.3	47.5	43.2	43.2
	MT2468 Ren2	45.9	45.2	46.1	41.2	43.0
	MT2468 Ren3	43.1	42.2	43.6	42.2	40.8
CONTROL	FM966	37.4	36.5	41.7	36.7	38.1
	SG747	39.0	41.6	39.8	40.6	41.1

Table 5. Germplasm line by inoculums interaction least squares means for shoot and root fresh weights as observed at 60 DAI in the Various Inocula Assay.

Reniform Nematode Resistance		Shoot Fresh Weight (SFW) Inoculum level (RN/cone)					Root Fresh Weight (RFW) Inoculum level (RN/cone)				
Group	Germplasm line	0	1000	5000	10,000	50,000	0	1000	5000	10,000	50,000
				(gram)					(gram)		
BARBREN	BAR 41	7.74	8.22	8.14	6.92	8.29	3.13	4.46	3.51	4.25	4.55
	BARBREN 713	7.96	8.26	7.73	6.25	7.58	3.97	5.79	5.26	4.77	4.66
LONREN	LONREN-1	7.05	8.03	8.29	5.93	7.04	2.98	3.80	3.88	3.03	3.37
	LONREN-2	7.38	8.76	8.58	6.16	8.15	3.16	4.44	4.19	2.38	3.52
	LONREN 21-4	7.17	6.90	7.34	6.61	5.98	3.94	3.89	3.37	2.86	2.56
M713	M713 Ren1	7.38	9.31	7.49	6.83	8.46	3.38	5.43	4.02	4.15	5.34
	M713 Ren2	8.12	8.33	8.58	6.72	8.91	2.43	3.91	3.30	3.02	4.15
	M713 Ren3	7.67	7.93	7.67	6.99	7.48	3.90	4.63	4.77	4.29	4.35
	M713 Ren4	7.84	7.88	8.66	7.20	8.98	3.32	4.00	4.08	4.53	4.40
	M713 Ren5	7.84	8.04	7.31	6.84	7.80	3.41	5.13	4.03	3.50	4.01
MT2468	MT2468 Ren1	6.67	8.17	8.09	7.79	8.31	2.98	3.93	4.20	4.67	4.92
	MT2468 Ren2	7.69	7.79	8.21	6.77	8.53	3.35	4.25	3.95	4.16	4.67
	MT2468 Ren3	6.97	7.18	7.75	5.84	7.40	3.12	3.96	4.33	3.72	4.21
CONTROL	FM966	7.82	7.63	8.36	7.22	8.58	3.11	4.54	5.71	5.26	6.60
	SG747	8.11	8.46	7.95	6.84	8.17	3.13	4.90	5.25	4.68	5.57

These weight trends are captured in movements of the mean shoot-to-root fresh weight ratios (SFW/RFW), which are graphically presented on per-group basis in Figure 2. Progressively increasing RFWs combined with more stable SFWs result, in general, in decreasing SFW/RFW ratios at increasing RN inoculums levels. This is decrease is most noticeable in the control group of FM966 and SG747. The ratios of the BARBREN, M713 and MT2468 decreased more modestly. Ratios of the LONREN group showed a different trend, with a higher Shoot-to-Root ratio at the highest inoculums level than at the lowest level, indicating a loss of root mass. Similar trends in SFW/RFW ratios were found in an earlier various inoculum study (Sikkens et al., 2011).

Reniform Nematode eggs counts, reported on per gram of fresh root weight basis (eggs/gRFW), are presented in Table 6. There is an increase in counts as a response to increases in inoculum levels, but this increase is not proportional to inoculum increases. In fact, egg counts at all inoculum levels are of the same order of magnitude, with in several cases those at the 1,000 level higher than those of the intermediate inoculums levels. Overall, egg counts per root fresh weight unit were highest for the two susceptible controls. Germplasm lines of the BARBREN and M713 groups saw noticeably deceased numbers of eggs compared to the controls, while those of the MT2468 group were only slightly below the control entries. LONREN 21-4 was by far the most resistant germplasm line as measured by nematode reproduction, though it combined this feature with the decrease in average root fresh weights. The single most outstanding value in Table 6 is the very high egg count for LONREN-1 at the 50,000 inoculum level. This count was obtained from 10 seedlings, 8 of which proved to be highly susceptible with counts ranging from 21,000 to127,000 eggs/gFRW. The two remaining seedlings proved to be highly resistant (135 and 184 eggs/gRFW). Similar differences in resistance/susceptibility were found in other inoculum levels in both LONREN-1 and LONREN-2, though in these cases highly susceptible seedlings were found less frequently, thus limiting their impact on the mean counts.

Conclusions

Germplasm lines from the BARBREN and M713 groups of reniform nematode resistant lines derive this resistance from a common source: the wild accession GB-713 of *G. barbadense*. This commonality is reflected in the results

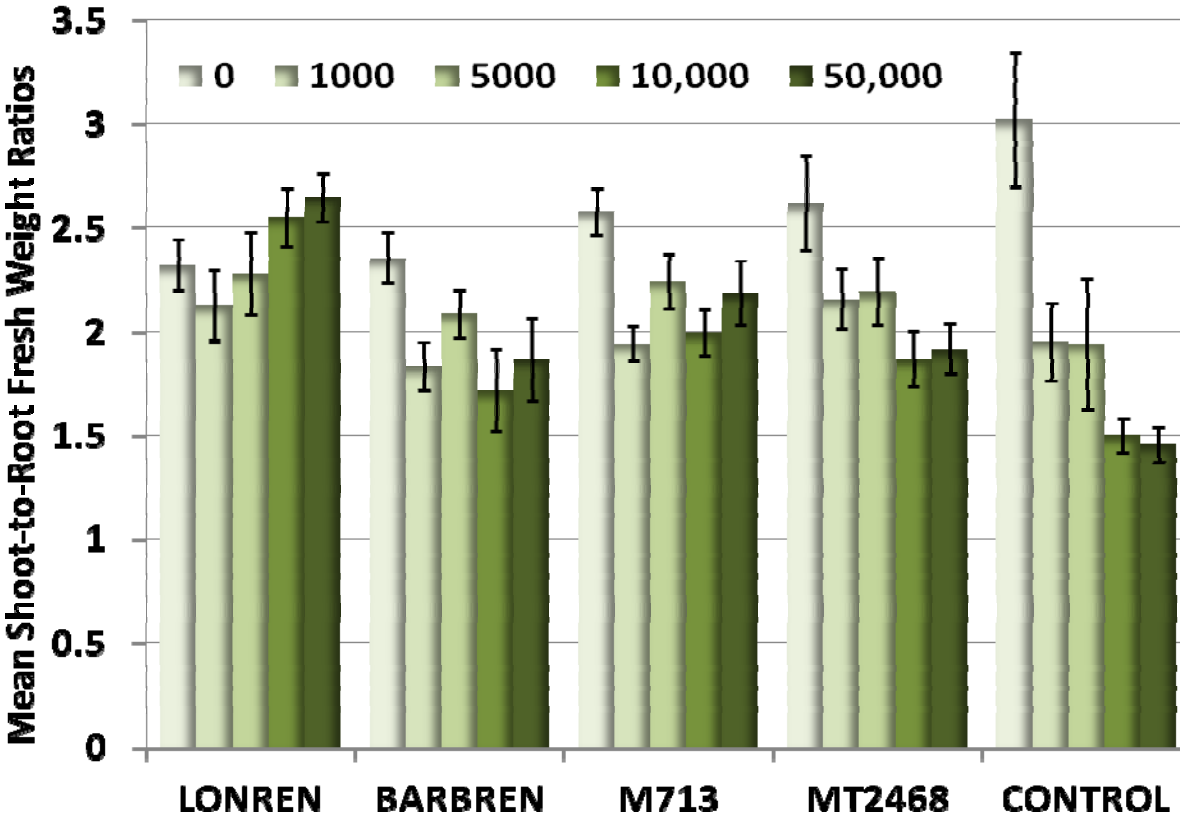

Figure 2. Mean Shoot-to-Root Fresh Weight ratios in the Various Inocula Assay, presented on per group basis. Vertical bars represent Standard Errors.

Table 6. Mean counts of Reniform Nematode eggs per gram of Root Fresh Weight at 60 DAI in the Various Inocula Assay.

Reniform Nematode Resistance		RN eggs per gram RFW			
		RN Inoculum level (RN/150cm3 soil)			
Group	Germplasm line	1,000	5,000	10,000	50,000
		(RNeggs/gRFW)			
BARBREN	BAR 41	6,565	6,123	8,549	11,291
	BARBREN 713	6,011	4,325	8,187	9,152
LONREN	LONREN-1	5,213	7,994	5,691	51,310
	LONREN-2	1,444	3,927	3,309	11,498
	LONREN 21-4	150	408	114	88
M713	M713 Ren1	1,747	3,621	3,832	3,347
	M713 Ren2	4,296	3,207	3,868	5,449
	M713 Ren3	3,955	4,559	4,755	7,223
	M713 Ren4	7,181	8,069	4,431	6,969
	M713 Ren5	5,637	5,661	6,705	8,097
MT2468	MT2468 Ren1	13,057	8,216	5,863	18,028
	MT2468 Ren2	10,027	10,679	13,092	25,039
	MT2468 Ren3	10,236	7,240	12,565	11,786
CONTROL	FM966	24,710	12,428	14,160	29,521
	SG747	28,671	11,420	19,317	28,383

of both the field trial and the greenhouse study, in which all lines performed comparatively well. All lines of these two groups yielded well under nematode free conditions, with BAR 41 matching FM966. Yield reductions due to exposure to reniform nematode were less than 10% for BAR 41 and the five M713 lines. BARBREN 713 still yielded 2 bales per acre on the RN infested field, though its yield penalty was a relatively high 27.5%. The three MT2468 lines did limit nematode reproduction, but suffered significant yield reductions of 50 to 70%, about equal to the yield losses of the two susceptible controls. Both high resistance and high susceptibility was found in LONREN-1 and LONREN-2, possibly due to contamination of our seed supply.

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Release Notices

For LONREN: USDA-ARS, Texas Agricultural Experiment Station and Cotton Incorporated. 2007. Notice of Release of two Upland Cotton Germplasm Lines resistant to Reniform Nematode.

For BARBREN: USDA-ARS, Mississippi Agricultural and Forestry Experiment Station and Cotton Incorporated (Undated). Notice of Release of an Upland Cotton Germplasm Line resistant to Reniform and Root-Knot Nematodes.

For M713: USDA-ARS and Mississippi Agricultural and Forestry Experiment Station. (Undated). Notice of Release of five Cotton Germplasm Lines with resistant to Reniform Nematode, *Rotylenchulus reniformis* Linford and Oliveira.

For MT2468: USDA-ARS and Mississippi Agricultural and Forestry Experiment Station. Undated. Notice of Release of MT2468 Ren1, MT2468 Ren2, MT2468 Ren3 three Upland Cotton *Gossypium hirsutum* L primitive derived day-neutral Germplasm Lines with moderate resistance to Reniform Nematode, *Rotylenchulus reniformis* Linford and Oliveira.