MANAGEMENT OF ROOT-KNOT NEMATODE WITH PARTIALLY RESISTANT VARIETIES

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Abstract

Small plot variety trials were conducted in six locations to determine root-knot nematode (RKN) reproduction on varieties. Yield was obtained at three of the sites. In general, the susceptible varieties Fibermax (FM) 1944GLB2, FM 2484B2F, and Phytogen (PHY) 499WRF had greater RKN densities than the partially resistant (PR) varieties Stoneville (ST) 4946GLB2, ST 5458B2F, and PHY 367WRF. FM 2011GT was being evaluated as partially resistant, but whether or not it has RNR resistance is still hard to determine. The new varieties PHY 417WRF, PHY 427WRF, and Deltapine (DP) 1454NRB2RF had lower densities of RKN than the susceptible and partially resistant varieties. However, nematode reproduction was more variable on DP 1454NRB2RF than PHY 417WRF and PHY 427WRF. Yields were greater on partially resistant varieties than the susceptible varieties, particularly as RKN pressure at sites increased. Yields of the more resistant PHY 417WRF and PHY 427WRF were often intermediate, though not significantly lower than the PR varieties. Yield of DP 1454NRB2RF was quite low at both sites, but growing conditions did not allow a full season variety to mature out.

Introduction

Root-knot nematode (*Meloidogyne incognita*) (RKN), which parasitizes cotton (Koenning et al., 2004), infests at least 40% of cotton acreage in the Southern High Plains of Texas (Starr et al., 1993; Wheeler et al., 2000). In the absence of any control, RKN causes an average of 26% yield loss in this region (Orr and Robinson, 1984).

Host resistance can be one of the most cost-effective management tools for RKN (Starr et al., 2007). Germplasm with genes for resistance to RKN have been available for over 40 years (Shepherd, 1974). There is a positive association between resistance to RKN in cotton and cotton yields (Davis and May, 2003; Davis and May, 2005; Wheeler et al., 2014). Commercial varieties that have been available with the Roundup Ready Flex gene and RKN resistance appear to have only partial suppression of RKN reproduction (Wheeler et al., 2014). The RKN genes from the original Auburn 623RNR release of Shepherd (1974) appear to have a two-gene system (Gutierrez et al., 2010; He et al., 2014).

The objective of this research is to evaluate new varieties that were commercially available in 2014 as well as previously available RKN partially resistant (PR) varieties for RKN reproduction and yield performance in fields in the Southern High Plains of Texas.

Materials and Methods

Variety trials designed specifically with the above objectives were conducted at two sites, a short-season northern site in Whiteface, TX and a longer season site in Brownfield, TX. The plots were four rows wide, 36 feet in length (40-inch centers), and varieties were arranged in a randomized complete block design with six replications. The varieties planted at each of these sites were: Fibermax (FM) 1944GLB2, Phytogen (PHY) 499WRF, FM 2011GT, Stoneville (ST) 4946GLB2, PHY 367WRF, ST 5458B2F, Deltapine (DP) 1454NRB2RF, PHY 417WRF, and PHY 427WRF. Seed which contained an insecticide/nematicide seed treatment (Aeris for Fibermax and Stoneville varieties; Avicta + Gaucho for Phytogen and Deltapine varieties) was planted (4 seed/foot of row) with a cone planter. Brownfield was planted on 15 May and Whiteface was planted on 20 May. Plots were sampled for RKN population density late in the season (13 and 12 August for Brownfield and Whiteface, respectively). Soil samples to a depth of 12 inches were taken that consisted of 10 cores of soil + roots taken from the outside plot rows and combined in a composite sample. Nematode assay procedures will be described below. Tests were harvested on 29 October and 2 December for Brownfield and Whiteface, respectively. Both sites had hail damage during the growing season, but the damage at Brownfield resulted in skippy stands and a significant delay in plant development. The plots at Brownfield contained a high percentage of green bolls at harvest. Skips were measured in the plots and yields were adjusted for the actual number of feet in each row. Plots with > 20 feet missing (out of 72 feet total) were deleted from the analysis. The entire first replication of the Brownfield site was deleted due to water erosion and hail damage. Plots were harvested with a two-row cotton stripper that weighed the stripped contents of the entire plot (lint, seed, burrs, branches, etc.) with load cells. A 1,000 g sample was taken of the harvested cotton and ginned to determine lint percentage for each variety.

Variety trials were conducted at four additional sites that were infested with RKN. Three of these sites were planted for Verticillium wilt trials, and yield data will only be presented for those sites where RKN was the dominant pathogen affecting yield. The entries differed at each site and only a subset of each entry list will be presented, which include any entries with suspected RKN resistance and several susceptible checks, like FM 2484B2F, FM 1944GLB2, and PHY 499WRF. These sites (Ropesville, Slaton, Lamesa I, and Lamesa II) were planted on 15 May, 2 June, 3 May, and 20 May, respectively. The sites all consisted of two-row plots, with 20 to 32 varieties arranged in a randomized complete block design with four replications. Plot length was 36 foot long for all sites except Lamesa II. Soil samples were taken at five locations/plot on 25 and 29 August, for Lamesa II, Ropesville and 8, and 27 September for Slaton, and Lamesa I, respectively. Tests were harvested on 9 and 20 November for Slaton and Lamesa II with a two-row cotton stripper as described previously. Yield will not be presented for Ropesville and Lamesa I.

Juvenile RKNs were extracted from soil samples by a pie-pan method (Thistlethwayte, 1970). Root-knot nematode eggs were extracted by the following steps: 500 cm^3 of soil was placed in a bucket, which was then filled halfway with water and stirred thoroughly to form a suspension. After 15 seconds the suspension was poured through a 60-mesh sieve and the organic material was washed into a beaker. The contents of the beaker were stirred for 5 minutes with a 0.54% solution of sodium hypochlorite and then the contents were poured through a 60-mesh sieve stacked over a 500-mesh sieve. The eggs were washed from the 500-mesh sieve into a beaker and stained with acid fuchsin (Byrd et al., 1983). Juvenile RKN and eggs were counted using a stereoscopic microscope at ×30 magnification.

Data for RKN population density and yield were analyzed for each site using a mixed model (PROC MIXED, SAS version 9.3, SAS Institute, Cary, NC). RKN population density was transformed with LOG10(RKN + 1) to compare for differences between varieties, using the PDIFF option at P=0.10. In addition, the average densities and yields were analyzed across all sites using a mixed model analysis, where site and site × entry was used as the random factor.

Results and Discussion

At Whiteface, PHY 417WRF had a lower RKN density than both of the susceptible checks and three of the partially resistant (PR) varieties (Table 1). PHY 427WRF and ST 5458B2F had lower RKN densities than the susceptible check PHY 499WRF. At Ropesville, PHY 427WRF and PHY 417WRF had lower RKN densities than both of the susceptible checks (Table 1). PHY 367WRF had a lower RKN density than the susceptible check FM 2484B2F. PHY 417WRF had a lower RKN density than two of the PR varieties, while PHY 427WRF had a lower RKN density than three of the PR varieties. At Lamesa II, PHY 367WRF, DP 1454NRB2RF, and PHY 417WRF had lower RKN densities than both of the susceptible checks (Table 1). PHY 427WRF had a lower RKN density than the susceptible check FM 2484B2F. PHY 417WRF and DP 1454NRB2RF had lower RKN densities than two of the PR varieties. PHY 367WRF had a lower RKN density than the PR variety ST 4946GLB2. At Lamesa I, PHY 427WRF, PHY 417WRF, and the PR varieties FM 2011GT and PHY 367WRF had lower RKN densities than both of the susceptible checks (Table 1). PHY 427WRF also had a lower RKN density than DP 1454NRB2F. All PR varieties were not statistically different with respect to RKN density. At Slaton, PHY 417WRF had a lower RKN density than all other varieties (Table 1) – two susceptible checks and three PR varieties. At Brownfield, PHY 427WRF and PHY 417WRF had lower RKN densities than both of the susceptible checks. ST 4946GLB2 and ST 5458B2F had lower RKN densities than the susceptible check PHY 499WRF (Table 1). PHY 427WRF and PHY 417WRF also had lower RKN densities than DP1454NRB2RF. PHY 427WRF had a lower RKN density than three of the PR varieties, while PHY 417WRF had a lower RKN density than all four PR varieties. All PR varieties were not statistically different. The average RKN density of the susceptible and PR varieties was generally lower at Whiteface and Ropesville (average of 1,970 and 1,906 RKN/500 cm^3 soil) than at the other four sites (average of 3,313, 4,231, 6,105, and 4,107 RKN/500 cm^3 soil for Lamesa II, Lamesa, I, Slaton, and Brownfield, respectively.

Table 1. Root-knot nematode (RKN) population density as affected by variety at six sites in 2014.

Variety[1]	Whiteface	Ropesville	Lamesa II	Lamesa I	Slaton	Brownfield
	Root-knot nematode/500 cm^3 soil					
FM 1944GLB2	997 ab[2]	1945 ab	-	-	-	7436 ab
FM 2484B2F	-	5270 a	5970 a	9825 a	9240 a	-
PHY 499WRF	2440 a	-	3590 ab	7030 a	6650 a	10,629 a
FM 2011GT	3017 ab	445 ab	3830 abc	1665 bc	7590 a	2268 ab
ST 4946GLB2	2693 ab	895 ab	3060 ab	1520 abc	2480 a	1029 bc
PHY 367WRF	4353 ab	975 bc	113 cd	1113 bc	4565 a	1737 ab
ST 5458B2F	290 bc	-	-	-	-	1544 b
DP 1454NRB2RF	393 abc	-	55 d	967 ab	-	2050 ab
PHY 427WRF	530 bc	300 d	360 bcd	40 c	-	312 cd
PHY 417WRF	60 c	240 cd	90 d	205 bc	200 b	176 d

[1]FM = Fibermax, DP = Deltapine, PHY = Phytogen, ST = Stoneville.
[2]Means with the same letter are not significantly different at *P*=0.10, when nematode densities were transformed with LOG10(RKN+1).

When RKN reproduction was analyzed across multiple sites, the PR varieties – except for FM 2011GT – had lower RKN densities than two of susceptible checks (Fig. 1). FM 2011GT had a lower RKN density than one susceptible check, FM 2484B2F. PHY 427WRF, PHY 417WRF, and DP 1454NRB2RF had lower RKN densities than all three susceptible checks. Also, PHY 417WRF had a lower RKN density than DP 1454NRB2RF and all four PR varieties, while PHY 427WRF had lower RKN density than three of the PR varieties. These two varieties, PHY 427WRF and PHY 417WRF, consistently had lower RKN densities than the susceptible and PR varieties. It is possible that these two varieties have the two-gene system described by Gutierrez et al, 2010 and He et al., 2014. DP 1454NRB2RF had lower RKN densities than two of the PR varieties in the overall analysis, but it did not have significantly lower RKN densities than the susceptible checks at Whiteface, Lamesa I, and , Brownfield (Table 1). It may have a 2-gene system as well, but it does not appear to be the same as those of PHY 417WRF and PHY 427WRF.

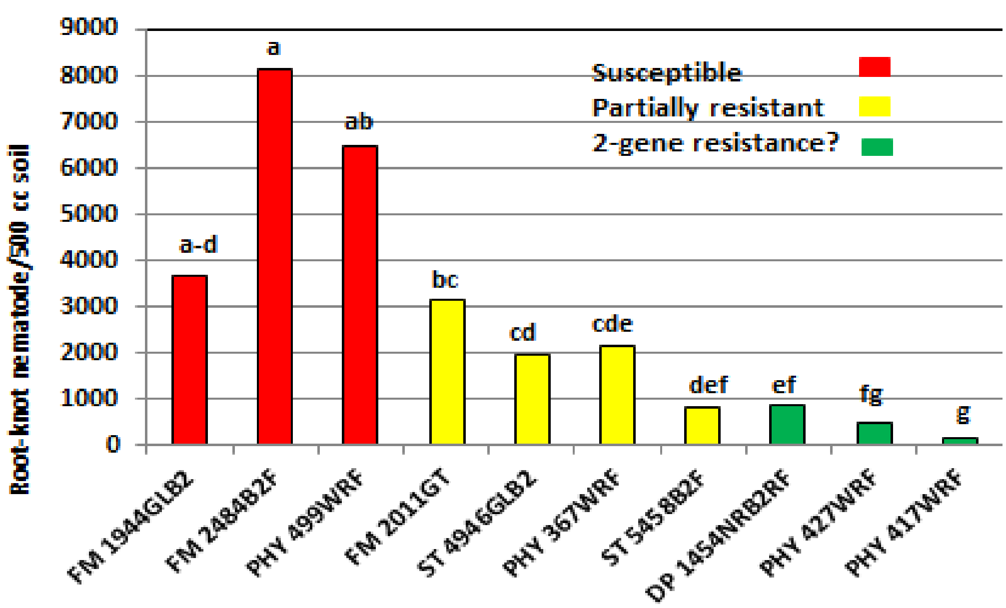

Figure 1. Reproduction of root-knot nematode averaged across six sites and 10 varieties. FM=Fibermax, PHY Phytogen, ST=Stoneville, and DP = Deltapine.

At the Whiteface site, ST 4946GLB2 and PHY 367WRF had better yields than FM 1944GLB2, but similar to PHY 499WRF (susceptible) (Table 2). DP 1454NRB2RF yield was lower than all varieties except FM 1944GLB2 and ST 5458B2F. At the Brownfield site, hail damage resulted in immature plants at harvest, especially DP 1454NRB2RF.

Most of the PR varieties had higher yields than both of the susceptible checks (Table 2). PHY 427WRF and PHY 417WRF had greater yields than both of the susceptible checks. DP 1454NRB2RF had lower yield than both of the susceptible checks, PHY 427WRF, PHY 417WRF, and all four PR varieties. The PR varieties ST 4946GLB2 and ST 5458B2F had greater yields than one of the other PR varieties, PHY 367WRF. At the Slaton site, FM 2011GT had a greater yield than both of the susceptible checks as well as PHY 417WRF (Table 2). FM 2011GT has both some resistance to Verticillium wilt and probably some to RKN, and so may have yielded better at the Slaton site where there is Verticillium wilt pressure.

Table 2. Effect of variety on cotton lint yields at three root-knot nematode infested sites in 2014.

Variety[1]	Whiteface	Slaton	Brownfield	Sites Combined
	Lint yield (lbs./acre)			
FM 1944GLB2	1061 cd[2]	-	881 d	1072 cd
FM 2484B2F	-	1514 bc	-	-
PHY 499WRF	1222 ab	1328 c	894 cd	1148 cd
FM 2011GT	1204 abc	1832 a	1180 ab	1405 a
ST 4946GLB2	1246 a	1637 ab	1384 a	1422 a
PHY 367WRF	1248 a	1475 bc	1132 bc	1285 abc
ST 5458B2F	1085 bcd	-	1415 a	1351 ab
DP 1454NRB2RF	971 d	-	607 e	890 d
PHY 427WRF	1141 abc	-	1238 ab	1291 abc
PHY 417WRF	1160 abc	1445 bc	1303 ab	1303 abc

[1]FM = Fibermax, DP = Deltapine, PHY = Phytogen, ST = Stoneville.
[2]Means with the same letter are not significantly different at *P*=0.10.

The analysis of yield across the three sites Whiteface, Brownfield, and Slaton shows that, with the exception of DP 1454NRB2RF, PR varieties had greater yields than both susceptible checks. PR varieties did not differ in their yield amongst each other.

Summary

FM 2011GT had greater RKN reproduction than only one susceptible check, and so it is still not clear whether it has real resistance to RKN. The PR varieties ST 4946GLB2, PHY 367WRF, AND ST 5458B2F overall demonstrated an intermediate level of resistance. The RKN reproduction averaged over multiple sites does support that PHY 427WRF and PHY 417WRF have the 2-gene resistance. DP 1454NRB2RF generally has a greater level of resistance than the partially resistant varieties tested but is not quite as consistent across sites as PHY 427WRF and PHY 417WRF. The partially RKN resistant varieties showed good tolerance to RKN and generally yielded as great or greater than those with a possible 2-gene level of RKN resistance. There was generally a greater yield advantage of the PR varieties over susceptible varieties as nematode population density increased.

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