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PH98M-3196: THE PERFORMANCE OF A NEW HIGH YIELDING, EARLY MATURITY, ROOT-KNOT NEMATODE RESISTANT COTTON LINE UNDER DIFFERING NEMATICIDE TREATMENTS

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Abstract

Cotton (*Gossypium hirsutum* L.) production in the United States has been plagued for many years by root-knot nematodes (*Meloidogyne incognita acrita)* and the root-knot/fusarium wilt (*Fusarium oxysporum*) complex. In 1999, the estimated loss from nematodes was approximately 625,200 bales (3.53%) and from Fusarium wilt approximately 87,137 bales (0.45%) (Blasingame &Patel, 1999). A PhytoGen experimental cotton line, PH98M-3196, was derived from a cross with Stoneville LA 887 and it has the same level of root-knot resistance. PH98M-3196 is an early to medium maturity, semi-smooth leaf variety that has demonstrated good fiber quality and yielding abilities throughout the South. To fully understand the value of this level of root-knot resistance, 4 in-house trials were conducted in root-knot infested fields in different areas of the South where root-knot nematodes are considered to be a problem. These trials evaluated different nematicide treatments on PH98M-3196 and a root-knot susceptible check, PSC 355. For the Phytogen in-house trials, the main plot, nematicide, treatments were not significantly different at any location for lint yield, lint percentage or fiber quality traits; however, there were numeric differences for main plot effects at all locations for lint yield. As nematicide levels increased, lint yields increased. In Dumas only one sampling date was significant for main plot effect. In both locations however, the last 2 sampling dates were significant for split plot treatment, variety. PH98M-3196 had dramatically lower live root-knot nematodes larva counts than PSC 355. Under conditions where nematode populations reduce stand counts and suppress plant growth, planting of varieties with resistance to root-knot nematodes may allow for lower rates of nematicide to be applied. The ability of PH98M-3196 to suppress nematode populations seen in the present study may make it possible for growers to plant susceptible crops the following year since the initial root-knot levels the following year should be at a reduced level. Even a moderate level of resistance has demonstrated its ability to give some economic benefits to growers in allowing lower levels of nematicides to be used. Also, this level of resistance will provide growers with more crop rotation options that can further enhance profitability.

Introduction

Cotton (*Gossypium hirsutum* L.) production in the United States has been plagued for many years by root-knot nematodes (*Meloidogyne incognita acrita)* and the root-knot/fusarium wilt (*Fusarium oxysporum*) complex. In 1999, the estimated loss from nematodes was approximately 625,200 bales (3.53%) and from Fusarium wilt approximately 87,137 bales (0.45%) (Blasingame &Patel, 1999). So far in cotton production history, nematicides have been the method of choice to combat the effects of root-knot nematodes. Unlike other nematode species, root-knot has a very broad spectrum of host plants, which makes crop rotation almost impossible other than to peanuts or root-knot resistant soybeans (Colyer, 2000). In many areas, neither of these crops are acceptable alternatives to cotton production. Also, the use of crop rotation to reduce Fusarium wilt is of limited value because this pathogen has the ability to survive in soils for several years on roots of non-host plants (Colyer, Kirpatrick, Caldwell, & Vernon, 1996). There have been very few root-knot nematode resistant cotton cultivars available for cotton producers. The only root-knot nematode resistant cotton varieties in the Mid-South and Southeast have been Stoneville LA 887 (Jones and Dickson, 1991) and its sister line Paymaster 1560. Unfortunately, these varieties never made much of an impact due to late maturity and leaf pubescence.

A PhytoGen experimental cotton line, PH98M-3196, was derived from a cross with Stoneville LA 887 and it has the same level of root-knot resistance (unpublished data). PH98M-3196 is an early to medium maturity, semi-smooth leaf variety that has demonstrated good fiber quality and yielding abilities throughout the South. To fully understand the value of this level of root-knot resistance, 4 in-house trials were conducted in root-knot infested fields in different areas of the South where root-knot nematodes are considered to be a problem. These trials evaluated different nematicide treatments on PH98M-3196 and a root-knot susceptible check, PSC 355. The nematicide treatments included Telone (*dichloroproene*), a soil fumigant produced by Dow AgroSciences, and Temik (*aldicarb*), a systemic insecticide with nematicidal properties. In 2001 and 2002, PH98M-3196 was also entered into the various university testing programs and the Fusarium Wilt Nursery in Tallassee, AL.

Materials and Methods

The four sites chosen were: 1) the Kevin Blagge Farm in Dumas, AR, 2) the Steve Jackson Farm in Cardwell, MO, 3) the Seiger Brothers Farm in Shorter, AL and 4) the Sam Story Farm in Waynesboro, GA. These locations were chosen because of their history of problems with root-knot nematodes. All locations were set up in a split plot design, with nematicide treatments as the main plots and varieties, PH98M-3196 and PSC 355, as the split plots. All of the main plot and split plot treatments ran the length of the field, whatever that may have been. Throughout the season, soil samples were pulled from within the root zone in the 2 center rows of each plot then bulked together to form 1 sample per plot. Those samples were then sent to Mississippi State University, Plant Pathology Laboratory for soil analysis. All nematicide rates are listed as product quantities and not as active ingredient.

The Dumas, AR location was planted on May 16, 2002 and was non-irrigated during the season. This location was a 3-replication test with 3 main plot treatments. The 3 treatments were: 1) 3.5 lbs. Temik per acre at planting, 2) 5 lbs. Temik per acre at planting, and 3) 5 lbs. Temik per acre at planting plus 5 lbs. Temik per acre side dressed at match head square stage. The side dress application was applied on July 2, 2002. Soil samples were pulled every 100-ft through the field for 600 ft of the 2 center rows of the 4 row plots per treatment. Soil samples were pulled on May 16, July 29, August 30 and October 15, 2002. The trial was machine harvested on October 15, 2002 and plots were weighed using a weigh buggy. Sub-samples of the plots on replications 1 and 2 were taken and ginned for gin turnout and HVI fiber analysis.

The Cardwell, MO location was planted on May 23, 2002 and was furrow irrigated as needed. This location was a 2-replication test with 4 main plot treatments. The 4 treatments were: 1) 3.5 lbs. Temik per acre at planting, 2) 5 lbs. Temik per acre at planting, 3) 3 gal Telone per acre pre-plant plus 3.5 lbs. Temik per acre at planting, and 4) 3 gal Telone per acre pre-plant plus 5 lbs. Temik per acre at planting. Soil samples were pulled every 50-ft. through the field for 300 ft of the 2 center rows of the 6 row plots per treatment. Soil samples were pulled on May 23, July 1, August 14, and October 14. The trial was machine harvested on October 14, 2002 and plots were weighed using a weigh buggy. Sub-samples of the plots on replications 1 and 2 were taken and ginned for gin turnout and HVI fiber analysis.

The Shorter location was planted on May 21, 2002 and was over-head irrigated as needed. This location was a 3-replication test with 3 main plot treatments. The 3 treatments were: 1) 3.5 lbs. Temik per acre at planting, 2) 5 lbs. Temik per acre at planting and 3) 3 gal Telone per acre pre-plant and 3.5 lbs. Temik per acre at planting. Soil samples were pulled every 100-ft through the field for 600 ft of the 2 center rows of the 4 row plots per treatment. Soil samples were pulled on May 21, July 9, August 29, and December 8, 2002. The trial was machine harvested on December 8, 2002 and plots were weighed using a weigh buggy. Sub-samples of the plots on replications 1 and 2 were taken and ginned for gin turnout and fiber analysis.

The Waynesboro location was lost due to a shift in the nematode population from root-knot to reniform, and the late rains that they received destroyed that trial. No data will be reported on this location.

The sub-samples were ginned on the Phytogen micro-gin at Leland, Mississippi. All statistical analyses were done with the use of Agrobase 99, from Agronomix Software, Inc.

Results

Breeders typical enter advanced breeding lines in the Fusarium Wilt Nursery in Tallassee, AL. After receiving the results back from the 2001 nursery, Table 1, we were interested in seeking to further measure the value of this level of resistance and the studies presented in this report were initiated. To confirm these results of the 2001 trial, PH98M-3196 was entered at Tallassee again in 2002, Table 2, and the level of resistance previously measured was confirmed. As measured by the percent of wilted plants, PH98M-3196 was equal in resistance to the highly resistant check, M-315, and had 50-60% less wilted plants than the susceptible check, Rowden, (Glass, Gazaway, & Santen, 2001 & 2002).

For the Phytogen in-house trials, the main plot, nematicide, treatments were not significantly different at any location for lint yield, lint percentage or fiber quality traits; however, there were numeric differences for main plot effects at all locations for lint yield, Table 3. As nematicide levels increased, lint yields increased. This indicated that the nematicides were effective in controlling root-knot nematodes. Significant split plot effects were observed at Dumas and Shorter at prob $f<0.01$, Table 3. In Dumas, PH98M-3196, significantly out yielded PSC 355. However in Shorter, PSC 355 out yielded PH98M-3196. In Dumas, the plots received a lot more drought stress than did in Shorter, which magnified the affects of the root-knot nematodes. The main plot by split plot interaction effects for lint yield was not significant at any location. There were no significant interactions between the main plot and split plot effect for all variables. In all locations, split plot affects for fiber quality were significant, but will not be discussed since this was anticipated.

Since the soil sampling data is incomplete for the Shorter location, it will not be discussed at this time. In all locations, as nematicide rates increased, root-knot larva levels decreased, Tables 4 & 5. In Dumas only one sampling date was significant for main plot effect, Table 4. In both locations however, the last 2 sampling dates were significant for split plot treatment, variety. PH98M-3196 had dramatically lower live root-knot nematodes larva counts than PSC 355, Tables 4 & 5. Figures 1 through 4 and Tables 4 &5 clearly demonstrate the ability of PH98M-3196 to decrease or hold root-knot nematodes at stable levels through out the year.

PH98M-3196 was tested in the strains test in 2001 and in 2002, it was entered into some of official variety trials and remained in the strains test of others. The data present in Table 6 is a head to head analysis over the 2 year period. The state strains and variety trials demonstrated the ability of PH98M-3196 to yield well across the belt, along with a having a good fiber quality package.

Conclusions

The Dumas location received more water stress than any of the other locations, which lead to the better performance of PH98M-3196. Also, there was some Fusarium wilt that visibly showed up in the seedling stages after planting and again in mid-July. Nematodes can significantly suppress the growth and development of seedling cotton (Kirkpatrick, 1996). This resulted in a thinner plant stand in the PSC 355 than in the PH98M-3196. Wilt rating were not taken mainly because about the time the leaf symptoms started showing well enough to be rated, rain was received and leaf symptoms faded out. The Cardwell location never received any drought stress and Fusarium wilt never developed to a level that was visibly detectable.

In the present study, there was no significant yield difference in any of the treatments. This is not entirely unexpected, given the know ability of the cotton plant to compensate depending on environmental conditions and length of growing season. However, there were consistently lower populations of root-knot nematodes in the PH98M-3196 plots. The level of resistance of PH98M-3196 to Fusarium wilt was also confirmed. Under conditions where nematode populations reduce stand counts and suppress plant growth, planting of varieties with resistance to root-knot nematodes may allow for lower rates of nematicide to be applied. Certainly this was the case in this study, Figures 1 – 4. The ability of PH98M-3196 to suppress nematode populations seen in the present study may make it possible for growers to plant susceptible crops the following year since the initial root-knot levels the following year should be at a reduced level. Near immunity to root-knot nematodes is available, but it is still in the developmental stages. Even a moderate level of resistance has demonstrated its ability to give some economic benefits to growers in allowing lower levels of nematicides to be used. Also, this level of resistance will provide growers with more crop rotation options that can further enhance profitability.

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Table 1. Percent wilted plants by rep in 2001 Fusarium Wilt Test, Plant Breeding Unit, EVSRC, Tallassee, AL.

Entry	Rep 1	Rep 2	Rep 3	Rep 4	Average
PH98M-3196	1	6	0	10	4
Rowden	69	87	75	38	67
M-315	4	8	1	6	5

Table 2. Percent wilted plants by rep in 2002 Fusarium Wilt Test, Plant Breeding Unit, EVSRC, Tallassee, AL.

Entry	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Average**
PH98M-3196	0	2	0	0	1
Rowden	84	63	63	14	56
M-315	2	0	3	3	2

Table 3. Mean lint yield in Shorter, AL and Dumas, AR.

Shorter, AL		**Dumas, AR**	
Main Plot	**Mean**	**Main Plot**	**Mean**
3.5 lbs. Temik	398	3.5 lbs. Temik	502
5 lbs. Temik	411	5 lbs. Temik	464
Telone + 3.5 lbs Temik	422	5 lbs. + 5 lbs Temik	560
Prob f<0.01	NS	Prob f<0.01	NS
Split Plot	**Mean**	**Split Plot**	**Mean**
PSC 355	430	PSC 355	434
PH98M-3196	391	PH98M-3196	583
Prob f<0.01	***	Prob f<0.01	***
R-square	90.3%	R-Square	93.3%
C.V.%	5.18%	C.V.%	9.73%

NS= not significant
*= Significant @0.10%
**= Significant @0.05%
***= Significant @ 0.01%

Table 4. Means table for root-knot nematode development level over time in Dumas AR.

	Means			
Main Plot	**May 16**	**July 29**	**Aug 30**	**Oct 15**
3.5 lbs. Temik	455	434	1091	680
5 lbs. Temik	436	165	571	438
5 lbs. + 5 lbs. Temik	665	176	310	570
Prob f<0.01	NS	**	NS	NS
Split Plot	**May 16**	**July 29**	**Aug 30**	**Oct 15**
PSC 355	485	372	1091	1037
PH98M-3196	552	145	223	88
Prob f<0.01	NS	NS	**	***
R-Square	43.2%	62.8%	75.9%	97.3%
C.V.%	121%	107%	121%	30.2

NS= not significant
*= Significant @0.10%
**= Significant @0.05%
***= Significant @ 0.01%

Table 5. Means table for root-knot nematode development level over time in Cardwell MO.

	Means			
Main Plot	**May 23**	**July 1**	**Aug 14**	**Oct 14**
3.5 lbs. Temik	363	310	960	993
5 lbs. Temik	363	202	945	565
Telone + 3.5 lbs. Temik	63	109	201	243
Telone + 5 lbs. Temik	118	0	310	449
Prob f<0.01	NS	NS	NS	NS
Split Plot	**May 23**	**July 1**	**Aug 14**	**Oct 14**
PSC 355	227	217	929	931
PH98M-3196	225	93	279	194
Prob f<0.01	NS	NS	**	**
R-Square	10.5%	64.0%	91.1%	85.2%
C.V.%	225%	196%	70.8%	80.3%

NS= not significant
*= Significant @0.10%
**= Significant @0.05%
***= Significant @ 0.01%

Table 6. Means from head-to head analysis for 2001 and 2002. "Note-2002 data set is incomplete and does not comprise all states actually entered into."

Entry	Lint Yield (lbs./acre)	Prob F	Mic (inches)	Length (grams/tex)	Strength (%)	Uniformity
PSC 355	1277	***	4.7	1.13	30.8	84.2
PH98M-2983	1255	***	4.5	1.11	29.5	83.7
SG 215 B/R	1244	*	4.6	1.08	28.2	84.0
SG 747	1244	**	4.6	1.14	28.7	84.2
DP X99X35	1239	***	4.6	1.12	29.1	83.7
PM 1218 B/R	1238	**	4.9	1.08	28.2	83.9
SG 501 B/R	1231	NS	4.7	1.08	30.1	83.7
FM 966	1222	NS	4.5	1.14	33.6	84.5
FM 958	1186	NS	4.5	1.15	30.9	83.9
DP 444 B/R	1184	NS	3.8	1.12	31.6	82.8
FM958 B	1166	NS	4.3	1.14	32.9	84.1
PH98M-3196	**1139**		**4.3**	**1.13**	**29.9**	**83.7**
DP 451 B/R	1117	NS	4.4	1.13	28.5	84.3
SG 521R	1117	NS	4.6	1.10	28.7	83.2
ST 4892 B/R	1116	NS	4.8	1.08	29.5	83.2
DP 491	1103	NS	4.4	1.20	32.0	84.4
ST 457	1103	NS	4.4	1.13	30.6	83.7
SG 105	1101	NS	4.6	1.15	30.1	84.9
DP 555 B/R	1100	NS	4.4	1.13	29.7	82.7
FM 966 B	1098	NS	4.3	1.14	33.4	84.5
DP 436 R	1078	--	4.4	1.12	28.9	84.6
ST 4793 R	1078	NS	4.8	1.09	29.5	84.0
PM 1199 R	1050	--	4.7	1.12	30.3	84.4

NS= not significant
*= Significant @0.10% better than control
**= Significant @0.05% better than control
***= Significant @ 0.01% better than control
-= Significant @0.10%
--= Significant @0.05%
---= Significant @0.01%
States tested in 2001: SC, NC, TN, AL, AR, & MO
States tested in 2002: LA, AR, MO, TN, MS, AL, GA, SC, & NC

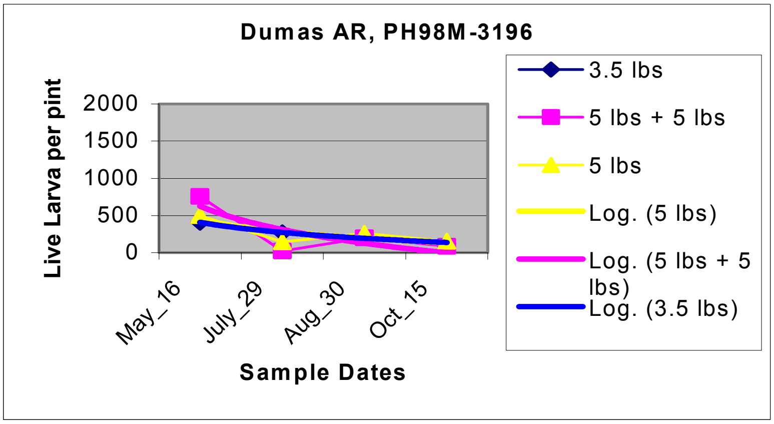

Figure 1. Live root-knot nematode larva counts in Dumas, AR over time.

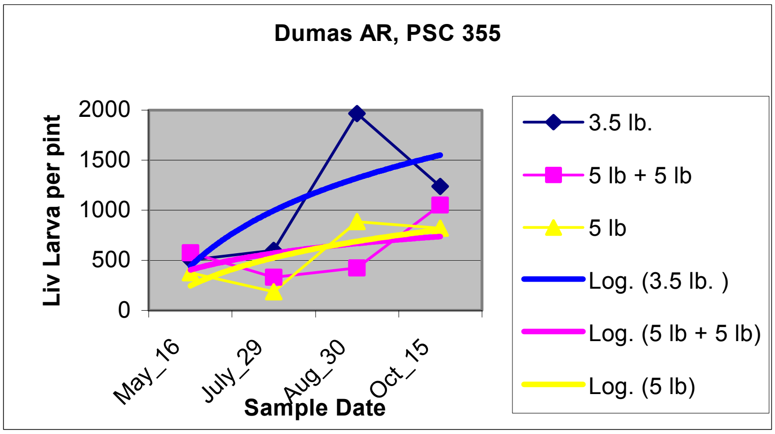

Figure 2. Live root-knot nematode larva counts in Dumas, AR over time.

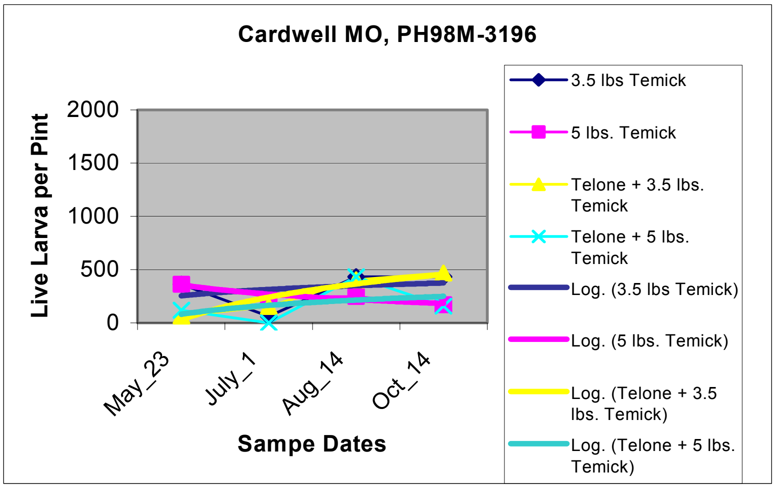

Figure 3. Live root-knot nematode larva counts in Cardwell, MO over time.

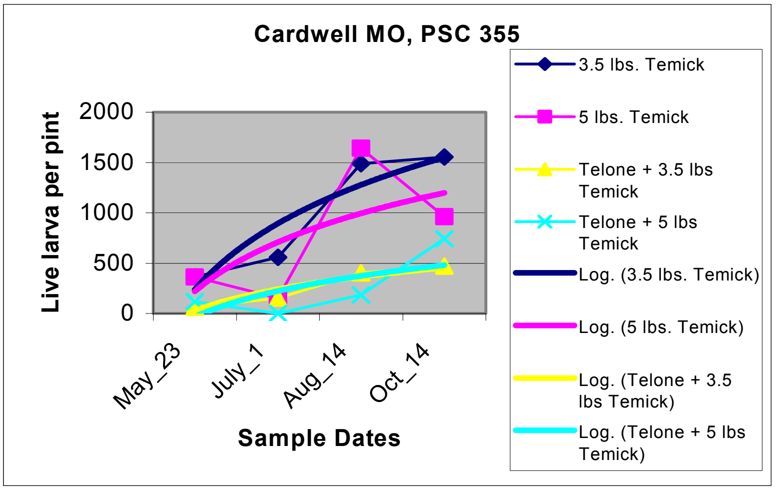

Figure 4. Live root-knot nematode larva counts in Cardwell, MO over time.