PERFORMANCE OF ROOT-KNOT AND RENIFORM NEMATODE RESISTANT COTTON CULTIVARS IN ALABAMA

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Abstract

Root-knot nematode (*Meloidogyne incognita*) and reniform nematode (*Rotylenchulus reniformis*) account for an estimated 7% of the cotton yield lost in Alabama in 2021. Integrated management practices such as nematode resistant cotton cultivars and nematicides are considered the most effective management strategies for reducing both nematodes. New nematode resistant cotton cultivars and new nematicides are becoming available to help manage nematode yield reductions. The objectives of this study were: 1) to determine the yield potential of the new root-knot resistance variety PHY 360 W3FE and the reniform resistant variety PHY 332 W3FE in nematode infested fields and 2) to determine the additional benefit of adding the new nematicide fluazaindolizine, with Vydate® C-LV (oxamyl), and the seed treatment TRiO™ with genetic resistance to further enhance yields. TRiO™ is an on-seed application of products including fungicides, insecticides, and biological nematicides. In 2020, four field trials were established in nematode infested fields and arranged as a RCBD with five replications. A Vydate® C-LV and fluazaindolizine mixture was applied at planting as an in-furrow spray across two resistant cultivars, PHY 360 W3FE and PHY 332 W3FE, and a susceptible cultivar, PHY 340 W3FE to further reduce nematode population levels. Field trials indicated that both root-knot and reniform eggs per gram of root were significantly ($P > 0.05$) lower on the resistant cotton cultivars, PHY 360 W3FE and PHY 332 W3FE, at 45 days after planting compared to the control PHY 340 W3FE without nematicides. Root-knot population levels were 84% lower on PHY 360 W3FE compared to PHY 340 W3FE and reniform populations were 78% lower on the PHY 332 W3FE variety compared to PHY 340 W3FE. Nematode eggs per gram of root were further reduced after addition of Vydate® C-LV and fluazaindolizine to both susceptible and resistant varieties. In the root-knot tests, PHY 360 W3FE with TRiO™ + Vydate® C-LV + fluazaindolizine at the high nematicide rate supported the greatest lint yield (1571 kg/ha), which was increased by 419 kg/ha over the lowest yielding treatment, PHY 340 W3FE + TRiO™ (1152 kg/ha). The addition of the nematicides improved yield by 34 and 15 kg/ha for PHY 340 W3FE and PHY 360 W3FE, respectively. In the reniform tests, PHY 332 W3FE with TRiO™ + Vydate® C-LV + fluazaindolizine at the medium nematicide rate, supported the greatest yields (2137 kg/ha) which was increased by 1288 kg/ha over the lowest yielding treatment, PHY 340 W3FE. The addition of the nematicides improved yield by 572 and 293 kg/ha for PHY 340 W3FE and PHY 332 W3FE, respectively. Overall, the use of the resistant varieties significantly increase yield while limiting nematode population density; the addition of the nematicides also further enhanced yields of the PHY 360 W3FE and PHY 332 W3FE, nematode resistant varieties.

Introduction

Upland cotton, *Gossypium hirsutum*, is one of the most prominent crops grown in the Mid-South region of the United States. In 2021, an estimated 725,800 bales of cotton in the U.S Cotton Belt were lost to plant-parasitic nematodes (Lawrence et al., 2022). Two important examples that cause consistent yield losses are the southern root-knot nematode (*Meloidogyne incognita*), and the reniform nematode (*Rotylenchulus reniformis*). Southern root-knot nematode and reniform nematode were responsible for 71% and 23%, respectively, of total bales lost to nematodes in 2021 (Lawrence et al., 2022). In Alabama, root-knot nematode and reniform nematode accounted for an estimated cotton yield loss of 7% in 2021(Lawrence et al., 2022). Recent studies show that *M. incognita* and *R. reniformis* cause the greatest damage to upland cotton production (Khanal et al., 2018). Both nematodes have a worldwide distribution throughout most sub-tropic and tropic geographic regions. However, root-knot nematode prefers soil percentages with a high sand content, and reniform nematode favors soils with a high content of clay and silt. Symptoms of these nematodes feeding on cotton plants include stunting and wilting of the plant, a reduction of feeder roots, and interveinal chlorosis on the foliage. Traditionally, nematode management consists of combined practices of crop rotation, nematicide applications, and resistant cultivars when available. For root-knot nematodes, there are several cotton cultivars commercially available with resistance such as PHY 360 W3FE, but there are limited reniform

resistant cotton cultivars with PHY 332 W3FE being one of them. Currently, chemical nematicides are the most common form of nematode management. Therefore, two trials were conducted for this study. The first evaluated three rates of the nematicides Vydate® C-LV and Reklemel™ along with a nematode susceptible cotton cultivar, PHY 340 W3FE, with a nematode resistant cotton cultivar, PHY 360 W3FE, for their efficacy in root-knot nematode management, and the second evaluated three rates of the nematicides Vydate® C-LV and Reklemel™ along with a nematode susceptible cotton cultivar, PHY 340 W3FE, with a nematode resistant cotton cultivar, PHY 332 W3FE, for their efficacy in reniform nematode management.

Methods and Materials

Data collected for this research during the 2021 growing season included stand, nematode egg counts, and yield. The root-knot trial was planted April 27th, 2021 and harvested on October 21st, 2021 at the Plant Breeding Unit in Tallassee, AL. The field has a natural infestation of root-knot nematode, and the soil type is classified as a Kalmia loamy sand (80% sand, 10% silt, 10% clay). For the root-knot trial, two upland cotton cultivars PHY 340 W3FE and PHY 360 W3FE were evaluated for their performance in the presence of *M. incognita*. Vydate® C-LV (low, medium, and high) and Reklemel (low, medium, and high) were added as in-furrow treatments with three different rates for evaluation of the added yield benefit and ability to decrease root-knot egg population density. The reniform trial was planted May 7, 2021 and harvested November 8th, 2021 at the Tennessee Valley Research and Extension Center near Belle Mina, AL. The reniform field has a soil type classified as Decatur silt loam (24% sand, 49% silt, 28% clay). This field was originally inoculated in 1997 and has had supplemental inoculum added to maintain reniform nematode above detection levels. For the reniform trial, two upland cotton cultivars PHY 340 W3FE and PHY 332 W3FE were evaluated for their performance in the presence of *R. reniformis*. Vydate® C-LV (low, medium, and high) and Reklemel (low, medium, and high) were added as in-furrow treatments with three different rates for evaluation of the added yield benefit and ability to decrease reniform egg population density. Vydate® C-LV and Reklemel rates are labeled as low, medium, and high at Corteva AgriScience's specified terms. Lateral irrigation was used throughout the growing season at both field locations as needed to maintain water supply. Both tests were arranged in a Randomized Complete Block Design with five replications. Plots were set up with two, 25-foot-long rows with 36-inch row spacing. A 20-foot wide alley separated every replication. Four plants were randomly selected per plot for root-knot and reniform nematode egg numbers per gram of root at 42 days after planting (DAP) in the root-knot trial and 39 DAP in the reniform trial. Eggs per gram of root was calculated by taking the ratio of root fresh weight and the total eggs per four plants. Cotton was mechanically harvested at 181 DAP for the root-knot nematode trial and 182 DAP for the reniform nematode trial, with yield being reported as seed cotton. Data analysis occurred by ANOVA using PROC GLIMMIX via SAS 9.4 (SAS Institute, Inc., Cary, NC), and means were separated using Tukey Kramer's HSD test at the ± d 0.05 level.

Results and Discussion

Both root-knot and reniform nematode field trials produced positive yield returns for all treatments. The root-knot field trials showed the addition of the nematicides reduced root-knot nematode eggs/g of root 82 % for cultivar PHY 340 W3FE and 72 % for cultivar PHY 360 W3FE (Table 1). Stand was similar for all treatments except PHY 360 W3FE + Vydate® C-LV and Reklemel™ high + TRiO when compared to the control, PHY 340 W3FE. The highest yielding treatment was PHY 360 W3FE + Vydate® C-LV and Reklemel™ high + TRiO, with seed cotton yields increased by 1281 lb./A over the PHY 340 W3FE + TRiO lowest yielding treatment (Table 2). The control, PHY 340 W3FE, yielded 1299 lb./A compared to 2317 lb./A for PHY 360 W3FE. The addition of a nematicide improved seed cotton yield by 231 lb./A for PHY 340 W3FE and 81 lb./A for PHY 360 W3FE.

Reniform nematode disease pressure was moderate in 2021. Stand was significantly different between treatments with PHY 340 (1-8) and treatments with PHY 332 (9-16) (Table 3). Treatment PHY 332 W3FE + Vydate® C-LV and Reklemel™ med + TRiO was statistically the highest plant biomass when compared to the control. PHY 340 W3FE + TRiO had the highest reniform eggs/g of root. The addition of the nematicides reduced reniform nematode eggs/g of root 92 % for PHY 340 W3FE and 95 % for PHY 332 W3FE. The highest seed cotton yields in this test were recorded on PHY 332 W3FE + Vydate® C-LV and Reklemel™ med + TRiO, with yields increased by 2348 lb./A over the lowest yielding treatment, the control PHY 340 W3FE (Table 4). PHY 340 W3FE yielded 1479 lb./A compared to 2497 lb./A for PHY 332 W3FE. The addition of a nematicide improved seed cotton yield by 528 lb./A for PHY 340 W3FE and 923 lb./A for PHY 332 W3FE.

Table 1. Cultivar and nematicide effects on root-knot eggs per gram of root, stand counts, and plant biomass at Plant Breeding Unit in Tallassee, AL in 2021.

Treatments	Root-knot eggs/ g of root[z]	Stand[y]	Biomass[x]
PHY 340 W3FE	2991 ab[v]	85 a	30.2 a
PHY 340 W3FE + Vydate® C-LV + Reklemel low	903 abc	83 ab	36.9 abc
PHY 340 W3FE + Vydate® C-LV + Reklemel med	507 bc	85 a	40.80 abc
PHY 340 W3FE + Vydate® C-LV + Reklemel high	494 bc	83 ab	40 abc
PHY 340 W3FE + TRiO[w]	3394 a	85 a	31.5 a
PHY 340 W3FE + Vydate® C-LV + Reklemel low +TRiO	269 bc	85 a	43.2 abc
PHY 340 W3FE + Vydate® C-LV + Reklemel med + TRiO	771 abc	84 ab	42.8 abc
PHY 340 W3FE + Vydate® C-LV + Reklemel high+ TRiO	262 c	80 ab	49.1 bc
PHY 360 W3FE	590 bc	80 ab	31.4 a
PHY 360 W3FE + Vydate® C-LV + Reklemel low	211 c	82 ab	37.2 abc
PHY 360 W3FE + Vydate® C-LV + Reklemel med	132 c	83 ab	39.4 abc
PHY 360 W3FE + Vydate® C-LV + Reklemel high	66 c	80 ab	46.5 abc
PHY 360 W3FE + TRiO	735 abc	85 a	34.8 ab
PHY 360 W3FE + Vydate® C-LV + Reklemel low + TRiO	97 c	80 ab	52.4 c
PHY 360 W3FE + Vydate® C-LV + Reklemel med + TRiO	318 bc	84 ab	44.8 abc
PHY 360 W3FE + Vydate® C-LV + Reklemel high + TRiO	152 c	77 b	53.1 c

[z] Total number of eggs extracted from the roots of four plants.
[y] Stand was the number of seedlings in 25 feet of row.
[x] Total weight of plant measured in grams.
[w] TRiO is an addition seed treatment with a biological agent.
[v] Means followed by the same letter do not significantly differ by Tukey-Kramer s method (P d 0.05).

Table 2. Cultivar and nematicide effects on seed and lint cotton yields in the presence of root-knot at Plant Breeding Unit in Tallassee, AL in 2021.

Treatments	Seed Yield (lb./A)	Lint Yield (lb./A)
PHY 340 W3FE	1299 abc[z]	714 a
PHY 340 W3FE + Vydate® C-LV + Reklemel low	1676 abc	923 abc
PHY 340 W3FE + Vydate® C-LV + Reklemel med	1398 abc	991 abc
PHY 340 W3FE + Vydate® C-LV + Reklemel high	1441 abc	897 abc
PHY 340 W3FE + TRiO	1288 a	690 a
PHY 340 W3FE + Vydate® C-LV + Reklemel low +TRiO	1437 abc	849 abc
PHY 340 W3FE + Vydate® C-LV + Reklemel med + TRiO	1632 abc	806 ab
PHY 340 W3FE + Vydate® C-LV + Reklemel high+ TRiO	1841 bcd	974 abc
PHY 360 W3FE	2317 def	848 abc
PHY 360 W3FE + Vydate® C-LV + Reklemel low	2392 ef	1042 bc
PHY 360 W3FE + Vydate® C-LV + Reklemel med	1859 cde	940 abc
PHY 360 W3FE + Vydate® C-LV + Reklemel high	2468 f	883 abc
PHY 360 W3FE + TRiO	2340 def	999 abc
PHY 360 W3FE + Vydate® C-LV + Reklemel low + TRiO	2414 f	909 abc
PHY 360 W3FE + Vydate® C-LV + Reklemel med + TRiO	2742 f	1110 bc

PHY 360 W3FE + Vydate® C-LV + Reklemel high + TRiO	2569 f	1135 c

[z] Means followed by the same letter do not significantly differ by Tukey-Kramer s method (P d 0.05)

Table 3. Cultivar and nematicide effects on reniform eggs per gram of root, stand counts, and plant biomass at Tennessee Valley Research Extension Center in Belle Mina, AL in 2021.

Treatments	Reniform eggs/ g of root[z]	Stand[y]	Biomass[x]
PHY 340 W3FE	591 b[v]	24 abc	7.3 a
PHY 340 W3FE + Vydate® C-LV + Reklemel low	23 b	31 cde	11.3 bcd
PHY 340 W3FE + Vydate® C-LV + Reklemel med	12 b	32 cde	12.4 bcd
PHY 340 W3FE + Vydate® C-LV + Reklemel high	134 b	28 bcd	11.3 bcd
PHY 340 W3FE + TRiO[w]	2241 a	25 bc	9.2 abc
PHY 340 W3FE + Vydate® C-LV + Reklemel low +TRiO	124 b	24 abc	12.6 bcde
PHY 340 W3FE + Vydate® C-LV + Reklemel med + TRiO	2 b	20 ab	12.6 bcde
PHY 340 W3FE + Vydate® C-LV + Reklemel high+ TRiO	5 b	15 a	11.8 bcd
PHY 332 W3FE	76 b	36 def	8.9 ab
PHY 332 W3FE + Vydate® C-LV + Reklemel low	4 b	48 g	11 abcd
PHY 332 W3FE + Vydate® C-LV + Reklemel med	8 b	37 ef	13.6 de
PHY 332 W3FE + Vydate® C-LV + Reklemel high	2 b	44 fg	13.4 de
PHY 332 W3FE + TRiO	340 b	40 efg	9.1 ab
PHY 332 W3FE + Vydate® C-LV + Reklemel low + TRiO	6 b	40 efg	14.7 de
PHY 332 W3FE + Vydate® C-LV + Reklemel med + TRiO	3 b	39 efg	16.2 e
PHY 332 W3FE + Vydate® C-LV + Reklemel high + TRiO	1 b	42 fg	12.9 de

[z] Total number of eggs extracted from the roots of four plants.
[y] Stand was the number of seedlings in 25 feet of row
[x] Total weight of plant measured in grams.
[w] TRiO is an addition seed treatment with a biological agent
[v] Means followed by the same letter do not significantly differ by Tukey-Kramer s method (P d 0.05).

Table 4. Cultivar and nematicide effects on seed and lint cotton yields in the presence of reniform at Tennessee Valley Research Extension Center in 2021.

Treatments	Seed Yield (lb./A)	Lint Yield (lb./A)
PHY 340 W3FE	1479 a[z]	671 ab
PHY 340 W3FE + Vydate® C-LV + Reklemel low	1807 ab	824 abc
PHY 340 W3FE + Vydate® C-LV + Reklemel med	2155 abc	977 abcd
PHY 340 W3FE + Vydate® C-LV + Reklemel high	2188 abc	992 bcd
PHY 340 W3FE + TRiO’	1367 a	614 a
PHY 340 W3FE + Vydate® C-LV + Reklemel low +TRiO	1882 ab	854 abc
PHY 340 W3FE + Vydate® C-LV + Reklemel med + TRiO	2178 abc	994 bcd
PHY 340 W3FE + Vydate® C-LV + Reklemel high+ TRiO	2476 abcd	1139 cde
PHY 332 W3FE	2497 abcd	1129 cde
PHY 332 W3FE + Vydate® C-LV + Reklemel low	3080 bcd	1414 efg
PHY 332 W3FE + Vydate® C-LV + Reklemel med	3572 cd	1622 fg
PHY 332 W3FE + Vydate® C-LV + Reklemel high	3469 cd	1587 fg
PHY 332 W3FE + TRiO	2950 bcd	1347 def
PHY 332 W3FE + Vydate® C-LV + Reklemel low + TRiO	3333 cd	1527 fg

PHY 332 W3FE + Vydate® C-LV + Reklemel med + TRiO	3827 d	1752 g
PHY 332 W3FE + Vydate® C-LV + Reklemel high + TRiO	3714 d	1699 fg

[z]Means followed by the same letter do not significantly differ by Tukey-Kramer s method (P d 0.05).

Summary

In summary, the addition of Vydate® C-LV and Reklemel™ significantly reduced root-knot and reniform nematode population density. The use of resistant cultivars PHY 360 and PHY 332 further reduced root-knot and reniform nematode population density an average of 84%. Lint yields improved with the resistant cultivars PHY 360 and PHY 332 by an average of 16% and 41% respectively. Even though it is apparent that cotton fields with heavily infested root-knot and reniform population density will never reach maximum yield potential, using nematode resistant cultivars, PHY 360 and PHY 332, and Reklemel and Vydate helped increase yields and minimize impact of root-knot and reniform nematodes.

References

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