ADDITIONAL FERTILIZER AND NEMATICIDE COMBINATIONS APPLIED ON UPLAND COTTON IN *ROTYLENCHULUS RENIFORMIS* AND *MELOIDOGYNE INCOGNITA* INFESTED FIELDS.

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Abstract

The reniform (*Rotylenchulus reniformis)* and root-knot (*Meloidogyne incognita)* nematodes can cause major yield loss on upland cotton in the Southern United States. A management strategy is crucial for nematode infested fields to reduce populations and mitigate damage. The objective of this study was to apply fertilizer and nematicide combinations at specific plant growth stages in addition to current management practices to reduce plant stress and promote yield. Field trials were conducted with the variety DP 1646 B2XF. The nematicides COPeO Prime (Fluopyram) was applied at planting and Vydate (Oxamyl) applied at pinhead square (PHS) were applied to select treatments. Fertilizers $(NH_4)_2SO_4$, 28-0-0-5, and Max-In Sulfur (0-0-19-21) were applied at pinhead square (PHS) and/or repeated at first bloom (FB) in 12 various combinations. For both reniform and root-knot fields, nematode eggs/g of root populations were similar between initial nematicide applications at planting. In the reniform field, after PHS chemical application, the populations of eggs/g of root remained consistent among all treatments. Root fresh weights also remained unaffected among treatments. In the root-knot field, the combination of COPeO Prime + $(NH_4)_2SO_4$ + Max-In Sulfur + Vydate at PHS significantly ($P \leq 0.05$) reduced eggs/g of root when compared to the combinations COPeO Prime + $(NH_4)_2SO_4$ at PHS and COPeO Prime + 28-0-0-5 at PHS & FB. The combination of COPeO Prime + 28-0-0-5 + Vydate at PHS supported a ($P \leq 0.05$) larger root fresh weight when compared to the combination of COPeO Prime + 28-0-0-5 + Max-In Sulfur + Vydate at PHS & FB. An application of 28-0-0-5 + Max-In Sulfur + COPeO Prime + Vydate at PHS & FB had a significantly ($P \leq 0.05$) increased lint yield when compared to treatments that did not have a nematicide. Overall, there were greater lint yields in treatments that used a combination of COPeO Prime and Vydate at either PHS or PHS & FB.

Introduction

The reniform (*Rotylenchulus reniformis*) and root-knot (*Meloidogyne incognita*) nematodes are common pathogens in the Southern United States and can cause significant damage to upland cotton varieties (Lawrence et al., 2020). Both nematodes are commonly found in tropical and subtropical regions across the United States. Common symptoms associated with reniform and root-knot nematodes include stunted growth, reduced yield, chlorosis and nutrient deficiencies (Blasingame et al., 2002). The reniform nematode will often limit root development, causing a wave-like pattern across the canopy (Lawrence and McLean, 2001). The root-knot nematode will cause spindle-shaped or rounded galls on the root system (Moens et al., 2009). Current management strategies focus on crop rotation, nematicides and resistant varieties. Applications of nitrogen play a vital role in cotton production by increasing efficiency and profitability but also reduces the impact of environmental stressors (Duncan and Raper, 2019). Combinations of fertilizers and nematicides have the potential to reduce nematode populations while limiting abiotic stressors and increasing yield (Khan et al., 2017). The objective of this study was to find a cost-efficient management strategy utilizing fertilizer and nematicide combinations to reduce reniform and root-knot population density while supporting plant health to combat nematode induced yield losses.

Materials and Methods

Reniform field trials were conducted at the Tennessee Valley Research and Extension Center in Belle Mina, AL where the soil type is a Decatur silt loam (24% sand, 49% silt and 28% clay). The field was inoculated and is continuously supplemented to maintain a level at 5000 vermiform reniform/100 cm^3 of soil. Root-knot field trials were conducted at the Plant Breeding Unit in Tallassee, AL where the soil type is a Kalmia sandy loam (80% sand, 10% silt and 10% clay). The field is naturally infested with root-knot nematodes. All test plots were arranged in a RCBD with five replications and the entire test was repeated twice at each location. Plots consisted of 2 rows that were 25ft long with

40 in row spacing and a 20 ft. wide alley separated blocks. Irrigation through a center point irrigation system was applied as needed to all plots. The reniform trial was planted on May 4th and harvested on October 22nd 2020. The root-knot trial was planted May 7 and harvested October 7 2020. All trials were planted with the cotton variety DP 1646 B2XF. COPeO Prime seed treatment was applied at planting to select treatments at a rate of 8.1 oz/cwt. The granular fertilizer $(NH_4)_2S0_4$ was applied by hand, directly to the plant base at a rate of 150 lb/A. The liquid fertilizer 28-0-0-5 was knifed into the soil 2 in beside and 2 in below the plant at a rate of 128oz/a. Max-In Sulfur and Vydate were applied as foliar sprays at rates of 32 oz/A and 17 oz/A. All chemicals were applied at different plant growth stages; pinhead square (PHS) and/or first bloom (FB). Treatments in the reniform field applied at PHS were administered 41 days after planting (DAP), treatments applied at FB were administered 69 DAP. Treatments in the root-knot field applied at PHS were administered 39 DAP; treatments at FB were administered 70 DAP. Plant samples were collected by digging 4 randomly selected plants from each plot to record plant parameters and nematode egg data. Plant sampling occurred at 41 DAP and 69 DAP in the reniform field and 39 DAP and 70 DAP in the root-knot field. Reniform and root-knot population density was recorded as the ratio of number of eggs per gram of root fresh weight. Data on plant height, root fresh weight, eggs/g of root, seed cotton yield, and lint weight were analyzed with SAS 9.4 using PROC GLIMMIX. LS-means were compared using the Tukey-Kramer method with a significance value of $P \leq 0.05$. Revenue was determined using the upland cotton price of 60 cents/lb. Profit was calculated by subtracting chemical input costs from revenue.

Results and Discussion

The combination of COPeO + $(NH_4)_2SO_4$ at PHS & FB had significantly reduced reniform eggs/g of root when compared to almost all other treatments (Table 1). In the reniform field, average lint yield was increased by 91 lbs/A (6%) with the application of COPeO Prime. Average lint yields were increased by 100 lbs/A (7%) with a single application of Vydate at PHS and by 38 lbs/A with an application of Vydate at PHS + FB (Table 1). The most cost efficient strategy in the reniform field was the combination of COPeO + $(NH_4)_2SO_4$ + Vydate at PHS. This treatment yielded 1836 lbs/A of lint and required $59.07, giving it the largest overall profit of $1042.53 (Table 3). This combination provided the greatest profit of $122.88 when compared to a base fertilizer application of $(NH_4)_2SO_4$ at PHS (Table 4). The combination of COPeO + 28-0-0-5 + Vydate + Max-In Sulfur at PHS had numerically the lowest root-knot eggs/g of root (Table 2). In the root-knot field, average lint yield was increased by 157 lbs/A (20%) with the application of COPeO Prime. Average lint yields were increased 98 lbs/A (12%) with a single application of Vydate at PHS and by 120 lbs/A (13%) with an application of Vydate at PHS & FB (Table 2). The most cost efficient strategy in the root-knot field was the combination of COPeO + 28-0-0-5 + Vydate + Max-In Sulfur at PHS & FB. This treatment yielded 1122 lbs/A of lint and required $83.44, giving it the largest overall profit of $589.76 (Table 3). This combination provided the greatest profit of $151.34 when compared to a base fertilizer application of 28-0-0-5 at PHS (Table 4).

Table 1. Reniform eggs/g of fresh root weight per treatment and lint yield in Belle Mina, AL 2020.

No	Treatments	Reniform Eggs/g Root[z]	Lint Yield (LB/A) 168 DAP
1	$(NH_4)_2SO_4$ - PHS	7014 a[z]	1567 ab[z]
2	28-0-0-5 - PHS	8292 a	1441 b
3	COPeO + $(NH_4)_2SO_4$ - PHS	5293 a	1590 ab
4	COPeO + 28-0-0-5 - PHS	5890 a	1584 ab
5	COPeO + $(NH_4)_2SO_4$ – PHS + FB	2429 b	1657 ab
6	COPeO + 28-0-0-5 – PHS + FB	4610 a	1324 b
7	COPeO + $(NH_4)_2SO_4$ + Vydate - PHS	5046 ab	1836 ab
8	COPeO + 28-0-0-5 + Vydate - PHS	5999 a	1552 ab
9	COPeO + $(NH_4)_2SO_4$ + Vydate + Max-In-Sulfur - PHS	7535 a	1654 ab
10	COPeO + 28-0-0-5 + Vydate + Max-In-Sulfur - PHS	4297 a	1501 b
11	COPeO + $(NH_4)_2SO_4$ + Vydate + Max-In-Sulfur – PHS + FB	4377 a	1582 a
12	COPeO + 28-0-0-5 + Vydate + Max-In-Sulfur – PHS + FB	6623 a	1636 ab

[z] Values followed by the same letter are not significantly different at $P \leq 0.05$ as determined by the Tukey Kramer method.

Table 2. Root-knot eggs/g of fresh root weight per treatment and lint yield in Tallassee, AL 2020.

No	Treatments	Root-knot Eggs/g Root[z]	Lint Yield (LB/A) 147 DAP
1	$(NH_4)_2SO_4$ - PHS	648 b[z]	843 bc[z]
2	28-0-0-5 - PHS	2451 a	747 c
3	COPeO + $(NH_4)_2SO_4$ - PHS	1108 ab	939 abc
4	COPeO + 28-0-0-5 - PHS	914 ab	753 c
5	COPeO + $(NH_4)_2SO_4$ – PHS + FB	680 ab	934 abc
6	COPeO + 28-0-0-5 – PHS + FB	1334 ab	978 ab
7	COPeO + $(NH_4)_2SO_4$ + Vydate - PHS	796 ab	985 ab
8	COPeO + 28-0-0-5 + Vydate - PHS	861 ab	897 bc
9	COPeO + $(NH_4)_2SO_4$ + Vydate + Max-In-Sulfur - PHS	664 b	1057 ab
10	COPeO + 28-0-0-5 + Vydate + Max-In-Sulfur - PHS	496 b	918 abc
11	COPeO + $(NH_4)_2SO_4$ + Vydate + Max-In-Sulfur – PHS + FB	1269 ab	940 abc
12	COPeO + 28-0-0-5 + Vydate + Max-In-Sulfur – PHS + FB	1962 ab	1122 a

[z] Values followed by the same letter are not significantly different at $P \leq 0.05$ as determined by the Tukey Kramer method.

Table 3. Treatment profit in a reniform and root-knot nematode field, 2020.

No	Treatments	Reniform Profit/ A	Root-knot Profit/A
1	$(NH_4)_2SO_4$ - PHS	$919.65	$485.41
2	28-0-0-5 - PHS	$855.12	$438.42
3	COPeO + $(NH_4)_2SO_4$ - PHS	$911.00	$520.69
4	COPeO + 28-0-0-5 - PHS	$918.53	$419.58
5	COPeO + $(NH_4)_2SO_4$ – PHS + FB	$930.52	$496.94
6	COPeO + 28-0-0-5 – PHS + FB	$752.57	$544.74
7	COPeO + $(NH_4)_2SO_4$ + Vydate - PHS	$1,042.52	$532.11
8	COPeO + 28-0-0-5 + Vydate - PHS	$882.83	$490.34
9	COPeO + $(NH_4)_2SO_4$ + Vydate + Max-In-Sulfur - PHS	$929.31	$570.86
10	COPeO + 28-0-0-5 + Vydate + Max-In-Sulfur - PHS	$847.69	$498.13
11	COPeO + $(NH_4)_2SO_4$ + Vydate + Max-In-Sulfur – PHS + FB	$844.66	$459.64
12	COPeO + 28-0-0-5 + Vydate + Max-In-Sulfur – PHS + FB	$898.20	$589.76

Revenue was determined using 60.00 cents/lb. Profit was calculated by subtracting input costs from lint yield revenue

Table 4. Profit over base fertilizer treatment in a reniform and root-knot nematode field, 2020

No	Treatments	Reniform Combination Profit/A	Root-knot Combination Profit/A
3	COPeO + $(NH_4)_2SO_4$ - PHS	$(8.65)	$35.28
4	COPeO + 28-0-0-5 - PHS	$63.41	$(18.84)
5	COPeO + $(NH_4)_2SO_4$ – PHS + FB	$10.87	$11.53
6	COPeO + 28-0-0-5 – PHS + FB	$(102.55)	$106.32
7	COPeO + $(NH_4)_2SO_4$ + Vydate - PHS	$122.88	$46.70
8	COPeO + 28-0-0-5 + Vydate - PHS	$27.71	$51.92
9	COPeO + $(NH_4)_2SO_4$ + Vydate + Max-In-Sulfur - PHS	$9.66	$85.45
10	COPeO + 28-0-0-5 + Vydate + Max-In-Sulfur - PHS	$(7.43)	$59.71
11	COPeO + $(NH_4)_2SO_4$ + Vydate + Max-In-Sulfur – PHS + FB	$(74.99)	$(25.77)
12	COPeO + 28-0-0-5 + Vydate + Max-In-Sulfur – PHS + FB	$43.08	$151.34

Treatment profit in a reniform field was subtracted from the corresponding base fertilizer profit of $(NH_4)_2SO_4$ at $919.65 or 28-0-0-5 at $855.12. Treatment profit in a root-knot field was subtracted from the corresponding base fertilizer profit of $(NH_4)_2SO_4$ at $485.41 or 28-0-0-5 at $438.42

Conclusions

In the reniform field, 3 out of 5 $(NH_4)_2SO_4$ combinations and 3 out of 5 28-0-0-5 combinations provided greater profit when compared to a single base fertilizer application. The combination of COPeO + $(NH_4)_2SO_4$ + Vydate at PHS was the most cost-efficient management strategy in a reniform field with the largest lint yield and profit. In the root-knot field, 4 out of 5 $(NH_4)_2SO_4$ combinations and 4 out of 5 28-0-0-5 provided greater profit when compared to a single base fertilizer application. The combination of COPeO + 28-0-0-5 + Vydate + Max-In Sulfur at PHS & FB was the most cost-efficient management strategy in a root-knot field with the largest lint and yield profit. In these trials, combinations that utilized multiple nematicides, benefits from increased yields and greater profits.

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