EFFECTS OF SEED TREATMENT NEMATICIDES WITH AND WITHOUT FOLIAR APPLICATIONS OF VYDATE-CLV ON THE GROWTH AND DEVELOPMENT OF *GOSSYPIUM HIRSUTUM* GROWN IN *ROTYLENCHULU RENIFORMIS* INFESTED SOILS

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Abstract

Reniform nematode (*Rotylenchulus reniformis* Linford and Oliveira) infests 36% of the Mississippi cotton acres causing $130 million loss annually. *R. reniformis,* was controlled using at-planting treatments of Temik 15G or soil fumigants. With Temik 15G being removed from the market and fumigant expense there was need to focus on Nematicide Seed Treatment (NST) with and without foliar applications of Vydate-CLV®. In greenhouse and field studies at Mississippi State University and Belle Mina, Alabama, effects of *R. reniformis* upon growth and development of Phy 375 WRF were assessed. All NSTs improved root and shoot biomass. Aeris® + Votivo® produced greater biomass in inoculated populations (*Pi*) up to 5,000 reniform nematodes/500 cc of soil comparable to Temik 15G. Temik 15 G did continue providing growth at higher *R. reniformis* populations. Aeris was reduced in bimoss earlier than other treatments at 2,500 reniform nematodes/500 cc. In-field plant mapping indicated node of first fruiting branch (NFFB) reduced with all nematicides while plant height and height to node ratios (HNR) were greater with Vydate-CLV®. At the final mapping evaluation, Vydate-CLV® improved retention at position two and greater.

Introduction

G. hirsutum remains a significant Mississippi agronomic crop accounting for 1.1 million hectares (MS Agricultural Statistical Service, 2013). Since the 1990s, several changes have occurred in the cotton industry (USDA-Agricultural Marketing Service, 2007) allowing for address of other problems like plant parasitic nematodes.

A predominant plant parasitic nematode that is most damaging pathogen to cotton is reniform nematode (*Rotylenchulus reniformis* Linford and Oliveira). *R. reniformis*, (Linford and Oliveira, 1940) has become widely distributed through the United States cotton producing region (Kinloch and Sprenkel, 1994; Lawrence and McLean, 1996; Star, 1998; and Koenning. et al., 1999). Because of rapid in-field development, production plant symptoms uniformly across fields making identification difficult while reducing yield (Lawrence and McClean, 2001), boll size and lint percent (Jones et al., 1959). In addition, *G. hirsutum* responds poorly to normal agronomic management practices (Birchfield and Jones, 1961) in presence of *R. reniformis* and provides portals for secondary infection (Palmateer et al., 2004). Since 1960, *R. reniformis* has spread through much of the eastern half of the *G. hirsutum* producing region (Heald and Robinson, 1990) and as far north as Lubbock, Texas and the Missouri bootheel (Held and Thames, 1982; Wrather et al., 1992). Today, *R. reniformis* has been associated with *G. hirsutum* yield loss in all cotton producing states it is found (Koenning. et al., 1999) accounting for 11.7% yield loss in 2014 totaling nearly $70.0 million economic loss (Lawrence et al., 2015). In Mississippi, *R. reniformis* caused yield loss of 235,398, 252,023, 56,378 and 58,000 bales in 2004, 2005, 2011 and 2014 respectively (Blasingame, 2004; 2005; 2011; Lawrence et al., 2015). Lawrence, et al. (2002) reported more than 32% of Mississippi *G. hirsutum* acres were infested with *R. reniformis*. Gazaway and Mclean (2003) further reported *R. reniformis* infested 36% of the Alabama *G. hirsutum* acres. Primary reasons for *R. reniformis* successful spread is due to its ability to reduce egg hatching of root knot (*Meloidogyne incognita)* (Diez et al., 2003), ability to reproduce in many soil types (Gazaway and McLean, 2003; Moore and Lawrence, 2013), ability to survive and promote yield loss under low water conditions (Herring et al., 2010), survive in fallow fields (Koenning et al., 1996), complete spread across a field in one season, ability to be moved by equipment and irrigation (Moore et al., 2010;*)* and ability to survive deep in soil profile (Moore et al., 2010; Robinson, 2005).

Nematicides continue to be an integral part of cotton management allowing production in infested soils. This becomes important because label loss of Temik 15G has generated reliance upon Nematicide Seed Treatments (NSTs). Padgett et al (2004) reported that some NSTs were as effective as Temik 15G at labeled rate but did not improve maturity or yield. Kirkpatrick and Monfort (2004) reported that NST did not differ from Temik 15G from 14 to 35 days after planting. Monfort et al. (2004) reported root knot nematode numbers and gall numbers were reduced using NSTs similar to Temik 15G. To further extend *R. reniformis* management of NST treatments beyond 35 days after planting, foliar applied Vydate-CLV® has been shown to be a viable tool as observed with older nematicides (Lawrence; Lawrence and McLean, 2000; 2002; 2003). Vydate-CLV® with nematicide/insecticide properties remains a viable tool in managing nematodes in *G. hirsutum* because of foliar application ease and phloem transmission to the root system (Hsu and Kleier, 1996). This tool becomes crucial since *R. reniformis* obtains maximum population densities when cotton is in its peak reproductive phase (Lawrence and McLean, 1995; 1996; 1997).

Understanding *G. hirusutum* growth and development is critical in implementing management to maximize yields, profits and understanding stress effects. *G. hirusutum* possesses a unique fruiting pattern making *G. hirsutum* different in growth from other row crops. This growth mechanism makes *G. hirusutum* an ideal plant in which to evaluate and quantify stresses due to nematodes and environment (Jenkins and McCarty, 1995; Kerby et al., 1987; Smith et al., 1996; 1998). Gutherie and Kerby (1993) reported *G. hirsutum* growth maintains a record of its response to environment and management inputs that can be traced by monitoring fruiting architecture via quantifiable plant mapping. Importance of plant mapping has been well documented (Jenkins and McCarty, 1995; McCarty et al., 1994, Albers, 1993). Smith and McCarty (1996) used in-season plant mapping to demonstrate the effectiveness of Temik 15G applied at-planting and as a side-dress in *G. hirusutum* growing in *R. reniformis* infested soils. From this methodology, Smith and McCarty (1996) were able to capture fruiting pattern differences, growth differences, maturity and yield. Turnage and Smith (1998) further used in-season plant mapping to demonstrate how Temik 15G performed compared to Acephate 15G under heavy thrips pressure across 15 *G. hirusutum* varieties based on growth parameters and yield in *R. reniformis* infested soils. Lawrence et al. (1998; 2001; 2002) and Lawrence and McLean (2002) further demonstrated influence of nematicide treatments on *G. hirusutum* in *R. reniformis* infested soils via plant mapping processes.

Materials and Methods

In-field nematicide study: Studies were conducted at two locations, Tennessee Valley Research and Extension Center (TVREC) of Auburn University in Belle Mina, Ala. and the R. R. Foil Plant Science Research Center of Mississippi State University (MSU) in Starkville, Miss. Treatments consisted of two NSTs (Aeris® @ 0.075 mg ai/seed rate and Aeris® + Votivo® @ 0.075 + 0.1424 mg ai/seed rate) (Bayer Crop Science-Raleigh, North Carolina) compared to Temik 15G. Additional treatments included the previously mentioned treatments with a post-plant foliar broadcast application of Vydate-CLV® (Dupont USA-Wilmington, Delaware) at 8.50 oz/Ac applied at the sixth true leaf growth stage. A second application of Vydate-CLV® was applied ten days later. NSTs without Vydate-CLV® were treated with the insecticide Orthene (acephate) 90S® at 0.75 lb ai/Ac. Continued insect management was conducted similarly across all plots on an as needed basis. Vydate-CLV® and Orthene 90S® treatments were applied using a CO_2 back-pack sprayer calibrated to deliver 15 gallons of water/Ac (Table 1.0). Cotton variety Phy 375 WRF (Dow AgroScience- Indianapolis, IN) was used since it possesses low *R. reniformis* tolerance. Planting was conducted on May 1, 2012 and May 15, 2012 at TVREC and MSU respectively. Soil tests were conducted prior to planting and analyzed at Mississippi State University Extension Soil Testing Lab (Mississippi State, Miss.). Soil texture at TVREC was a clay-loam soil of high Cation Exchange Capacity (CEC) nature (CEC 17) while MSU location was a silt-loam soil of lower CEC (CEC 13). Both locations had irrigation capability with MSU location having furrow irrigation and TVREC having center pivot irrigation. Due to dry weather, TVREC location was the only location irrigated.

Experimental design and trial establishment: Trial design used at both locations was a randomized complete block (RCB) consisting of five replications at MSU and four at TVREC. Data was analyzed using Analysis of Variance (ANOVA) for a RCB (ARM 8 statistical software-Gylling Data Management; Brookings, South Dakota). Means were separated using Least Significant Difference (LSD) at 0.05 probability level. Individual plot length consisted of two-row plots of 12.16 meters at MSU and 7.6 meters at TVREC with 3.04 m alleys. Row spacing consisted of a solid planting pattern at both locations being planted on 15.75 cm at TVREC and 14.96 cm at MSU with a seeding rate of 13.15 seed per row meter using a cone planter and pre-counted seed.

R. reniformis sampling and processing: R. reniformis collection included nematode soil samples collected prior to planting from each plot with further monitoring during square, bloom and open boll. Samples were acquired at six samples per plot simultaneously using a fluted probe designed to collect multiple samples per plot. Probe dimensions were 8.75 cm at the top and tapering to 1.91 cm at the bottom facilitating multiple samples without loss of soil. Length of sample device was 27.94 cm to guarantee the acquisition of 500 cc of soil. Samples were acquired from row side at a distance of 15.24 cm in a zig-zag method allowing samples to be obtained at three samples per row. Depth of sample was conducted at an approximate depth of 10.16 cm. Samples were bagged in plastic bags and kept cold until extraction using semi-automatic elutriator and centrifugal flotation. The resulting nematodes were enumerated using a stero-microscope.

Evaluation of vigor, plant population and hypocotyl lengths: Visual plant vigor and plant population were evaluated at 14 days following emergence. Vigor was established using two processes; 1. Visual assessment on a scale of one to five where one had greatest vigor and five the lowest vigor and, 2: hypocotyl measurement. Hypocotyl measurement involved a measurement of length from the seed embryo axis to the cotyledonary node. The hypocotyl distance is a direct measurement of seedling vigor and provides a quantifiable method to analyze vigor. Plant population was determined by counting every plant in all plots to determine plants per hectare.

Evaluation during mid-square: Evaluation criteria monitored included: plant height (PH), node of first fruiting branch (NFFB), total nodes (TN), height to ratio (HNR), retention by position along the sympodial branch and average plant height by node measurements. Average plant height by node measurements were conducted by measuring each internode length separately from cotyledons to terminal leaf that was 2.54 cm wide in a manner where overall length cumulated to obtain a final height (Kerby, et al., 2003). Six consecutive plants possessing a normal terminal were sampled destructively per plot providing a total of 30 plants sampled at MSU and 24 plants at TVREC. Evaluation time was two weeks following initial square initiation.

Evaluation during bloom: Growth parameters on six consecutive plants per plot included the following: PH, TN, HNR, nodes above white flower (NAWF), node of white flower (NOWF), retention by position and average plant height by node measurements conducted at TVREC but not from MSU location. In addition, digital caliper readings were taken at cotyledonary node to obtain basal stalk diameter and from unopened first position bolls at node 9 and 12 from the terminal. Evaluation time occurred during mid to late bloom.

Evaluation during open boll: Evaluation parameters included the following criteria on six consecutive plants: PH, TN, cumulative plant height, node above cracked boll (NACB), fruit retention by position and percent open boll. The monitoring phase began when cotton bolls of the earliest treatment within the study was approximately 30% open collectively.

Machine harvest: Defoliation was conducted based on visual assessments of 60% open boll with harvest aids applied using high clearance ground equipment. Harvest was conducted using a John Deere 9965 (Moline, Illinois) harvester equipped with a Rice Lake 9201i weighing system (Rice Lake Weighing Systems-Rice Lake, WI) to measure seed cotton of individual plots. Seed cotton weights were converted to lint pounds per acre using historical lint percentages established via University Official Variety Trials at Mississippi State University.

Trial establishment and experimental design: Two separate greenhouse studies were established using cotton variety Phy 375 WRF planted at two seeds per 4.0" clay pot into a sterile Free Stone fine sandy loam amended with 50% sand in a 1:1 ratio by volume. All pots were brought to a 500 cc level. Planting depth for all seed was 0.5 inch. Upon emergence, one plant was removed to leave one plant per container. Treatments included Temik 15G at an equivalent rate of 5.0 lbs/Ac, Aeries, Aeries + Votivo at above cited rates and an UTC (Table 2.0). Nematode populations were applied to soil in a liquid solution using a graduated pipette and included *Pi* of 0, 2,500, 5,000, 10,000 *R. reniformis* per 500 cc of soil (Table 2.0). Each study was conducted for 90 days. Experimental design was established as a RCB using four replications. Data was analyzed using an ANOVA for a RCB (ARM 8 statistical software-Gylling Data Management- Brookings, South Dakota). Means were separated using the Least Significant Difference (LSD) at the 0.05 level of probability.

Evaluation criteria: Before harvest parameters gathered included TN, PH, NFFB, HNR and basal stalk diameter. At harvest evaluations included root and shoot biomass and nematode extraction (eggs and juveniles). At harvest, shoot was removed from root by cutting shoot at ground level using hand pruners. Shoot was weighed and recorded. Roots were extracted from soil in a bucket and soil-free roots soaked in a 10% Chlorox solution for three minutes and then weighed. The remaining solution was poured through a 200 over 500 mesh screen. The remaining soil was processed through a 60 over 325 mesh screen and centrifuged for six minutes. Excess water was next removed and mixed with a sucrose mixture (454 g sucrose per 1,000 ml of water) followed by a one minute centrifuge process. The liquid was next poured through a 500 mesh screen and sample refrigerated in a 250 ml beaker until counted. Nematode numbers were surveyed via sterio-scope for *R. reniformis* juveniles and eggs by pipetting 20 mls of liquid into a quadrated petri dish.

Results and Discussion

In-the-field evaluation of R. reniformis populations across time: Populations of *R. reniformis* at MSU (Table 3) were low in totals compared to TVREC (Table 4). At MSU population May began moderately high but fell and remained low during June but showed sharp increases in July and September. At TVREC, the *R. reniformis* population was much higher at planting then declined during June but began sharp increases during July and September. At both locations all nematicides treated with Vydate-CLV® had higher populations of *R. reniformis* at end of season relating to a well-developed root system where reproduction could occur.

Effect of nematicides on vigor, plant population and hypocotyl length: UTC had greater number of plants per acre than nematicide treatments with Aeris® having greater plant population of nematicide treatments at MSU (Table 5). However, no difference in plant population occurred at TVREC (Table 5). Visual vigor at both locations increased with all nematicide treatments compared to UTC. Temik 15G provided the greatest vigor level at MSU while Temik 15G and Aeries® + Votivo® provided greater vigor at TVREC. This was further manifested in hypocotyl lengths where all nematicide treatments were greater than the UTC.

Effect of nematicides on NFFB during square: NFFB at both locations was reduced by all nematicide treatments compared to UTC indicating improved early fruiting. Of the nematicide treatments Aeris® + Votivo® and Aeris® were greater in NFFB compared to Temik 15G (Table 6) indicating delayed harvest maturity with the Aeris treatments.

Effect of nematicides on plant height ("): Plant height during square was reduced at TVREC (Table 8) due to thrips and cold temperatures following emergence. However, after application of Vydate-CLV®, plant height became greater than UTC and Vydate-CLV® increased plant height of NSTs as observed with findings by Lawrence and McClean (2000; 2002; 2003). Throughout the remainder of the studies addition of Vydate-CLV® improved plant height of NST making them comparable to Temik 15G. Of the nematicides without Vydate-CLV® across both locations, Temik 15G and Aeris® + Votivo® resulted in greater plant heights than Aeris® alone (Table 7 & 8). NST plant height measured at open boll greatly benefited from applications of Vydate-CLV®.

Effect of nematicides on average plant height by node: Evaluation of plant height by node facilitates a method where stress effect can be quantified via internode elongation (Kerby et al., 2003). Average plant height by node at MSU (Table 9) indicated no differences among nematicides until node 13 during square. Temik 15G with foliar applications of Vydate-CLV® at node 13 and 15 had greater (two inches) internode elongation than UTC but did not differ from Temik 15G alone or NSTs. Internode growth at TVREC (Table 10) under higher *R. reniformis* populations was strikingly different from MSU during square (Table 10). At this location, differences in internode elongation began at node one, but Aeris® + Vydate-CLV® did not increase elongation compared to nematicide without Vydate-CLV® or UTC. However, application of Vydate-CLV® did improve internode elongation in plants treated with Temik 15G and Aeris® + Votivo®. Aeris + Votivo® + Vydate-CLV® did not differ from Temik 15G alone indicating NSTs were made comparable to Temik 15G alone through node 15 during square (Table 10). NSTs without Vydate-CLV® did not differ from Temik 15G alone at nodes one to five. From node seven to node 11, Temik 15G and Aeris + Votivo did not differ from each other and at nodes 13 and 15 Temik 15G was different from the NSTs. During bloom at TVREC (Table 11), effects of Vydate-CLV® added to nematicides increased plant height above UTC and NSTs alone.

At node one through five all nematicide treatments had greater internode length than UTC which continued through node 21. At node seven separation in plant height occurred with Aeris® + Votivo® + Vydate-CLV® being taller compared to nematicides without Vydate-CLV®. It was not until node nine that Aeris® + Vydate-CLV® became taller than Aeris alone. Therefore, by node nine Vydate-CLV® treatments began to increase plant height over non-Vydate-CLV® treatments. By node 15, Aeris® + Votivo® + Vydate-CLV® effect on plant height began to decline but remained taller than NSTs. Temik 15G and Temik 15G + Vydate-CLV® treatments had greater plant heights than other treatments from nodes 15 to 21. It was not until node 17 that Aeris® + Vydate-CLV® and Temik 15G did not differ from or were comparable to Aeris® + Votivo® + Vydate-CLV® and Temik 15G + Vydate-CLV®. Internode elongation began to slow at node 17 for Aeris® + Votivo® alone, node 16 for Aeris®, node 19 for Temik 15G, node 18 Aeris®+ Votivo® + Vydate-CLV®, node 17 for Aeris® + Vydate-CLV® and node 20 for Temik 15G + Vydate-CLV®. All nematicide treatments improved internode elongation and plant height in *R. reniformis* infested soils compared to UTC. Vydate-CLV® treatments applied to NSTs improved final plant height and internode distances but had less effect on Aeris®. Application of Vydate-CLV® enhanced NST effect compared to NST with no Vydate-CLV® making them comparable to or better than Temik 15G.

Effect of nematicides on total node number: Node number at square and bloom increased across all nematicide treatments with Vydate-CLV® (Table 8) during square making NST comparable to or better than Temik 15G alone. This further validates value of Vydate-CLV ® in *R. reniformis* management as observed in findings by Lawrence and McClean (2000; 2002; 2003). Nematicide treatments at both locations without Vydate-CLV® also increased total node count initially compared to UTC but basically remained lower than treatments containing Vydate-CLV®. In final evaluation across both locations (Table 7 & 8), UTC had greater node number compared to NSTs resulting from continued growth due to lower fruit retention. NSTs and Temik 15G treatments at MSU possessed greater node number than treatments containing Vydate-CLV® except for Aeris® indicating Vydate-CLV® hastens maturity.

Effect of nematicides on Height to Node Ratio: Height to node ratios (HNR) across treatments were improved at final evaluation compared to UTC. Vydate-CLV® made NST performance comparable to Temik 15G alone which was greater at MSU. During bloom no treatment differences occurred but HNR was greater than the UTC at MSU (Table 7). At TVREC (Table 8), all treatments had a greater HNR than UTC with all NSTs being improved with addition of Vydate-CLV® which did not differ from Temik 15G alone (Lawrence and McClean, 2000; 2002; 2003).

Percent retention across sympodial fruiting positions as affected by nematicides: Percent retention during square revealed few differences compared to UTC at fruiting position one. At fruiting position two all treatments had improved retention compared to UTC, but there was slight benefits at this fruiting position at MSU (Table 12) with Vydate-CLV®. Under higher *R. reniformis* population at TVREC (Table 13), Vydate-CLV® did improve retention. Fruiting position >2 did not exist at TVREC during square due to high levels of *R. reniformis*, thrips and cold weather, but later planted MSU location did have retention at position >2. At MSU, all treatments had fruit retention greater than UTC and Vydate-CLV® treatment improved retention for all NSTs at positions > 2. During bloom, percent retention with all nematicide treatments was greater than the UTC at fruiting position one at MSU (Table 12). Nematicide treatments were improved in retention with applications of Vydate-CLV® with exception of Aeris®. Each NST had improved retention at position one compared to UTC at TVREC (Table 13) and did not differ from each other. Retention at position two was improved above UTC and at both locations NSTs had improved retention with Vydate-CLV®. NSTs alone had a lower retention than Temik 15G at either location for this fruiting position which indicates NSTs alone were not as long-lived in the plant. Percent retention at position >2 with nematicides were all greater than UTC at both locations; however, NSTs without Vydate-CLV® at MSU had higher retention than Temik 15G alone or nematicide treatments treated with Vydate-CLV® indicating a harvest maturity delay. Percent retention during the final evaluation at MSU (Table 12) indicated positive treatment effects resulting in improved retention at fruiting position one compared to UTC facilitating yield improvement. However under higher *R. reniformis* populations of TVREC (Table 13), position one retention with NSTs without Vydate-CLV® did not differ from UTC and had lower retention compared to Temik 15G. At both locations, NSTs were improved by application of Vydate-CLV® which improved retention at a level equivalent to Temik 15G. Percent retention at position two was greater across all nematicide treatments compared to UTC at MSU and TVREC retention was improved in all treatments compared to UTC with exception of Aeris® + Votivo®. At both locations, presence of Vydate-CLV® in the management strategy improved retention of position two fruiting sites across all nematicides. Final evaluation at fruiting position >2 at MSU (Table 12) showed retention was lower across most treatments receiving Vydate-CLV® indicating normal termination. Aeris®, Aeris® + Votivo® and Aeris® + Vydate-CLV® treatments possessed greater retention indicating delayed maturity. Vydate-CLV® treatments at TVREC increased retention at this fruiting position for all nematicide treatments and all nematicide treatments had greater retention than UTC. Improvements in retention with nematicide treatments occurred at positions one and two when compared to UTC. However, use of Vydate-CLV® enhanced performance of NSTs, especially under high *R. reniformis* populations and early season stress.

Effect of nematicides on cotton maturity (NAWF, NACB and % open boll): NAWF, NACB and % open boll showed that NSTs without Vydate-CLV® were comparable to UTC in maturity (Table 14 & 15) indicating delayed harvest maturity. Maturity was hastened with Vydate-CLV® (Mauney and Stewart, 1986) resulting from better fruit retention. Maturity at TVREC was delayed because of the early season stress but showed benefits from Vydate-CLV®.

Effect of nematicide treatments on basal stalk and boll diameter: All nematicide treatments increased basal stalk diameter compared to the UTC at MSU but Vydate-CLV® did not improve basal stalk diameter in Aeris treatment. At TVREC, Vydate-CLV® did not improve basal stalk diameter (Tables 16 & 17). Boll diameter taken at node nine and 12 below the terminal revealed responses in boll development due to nematicides and Vydate-CLV® (Tables 16 and 17). Boll diameter at MSU (Table 16) was consistently larger in size than TVREC (Table 17). At both locations, Vydate-CLV® applications improved boll size of NSTs except for Aeris. In addition, all nematicide treatments increased boll size at node nine compared to UTC at TVREC. Temik 15G alone resulted in larger bolls at node nine compared to NSTs alone at MSU (Table 16) but at TVREC (Table 17), Aeris® + Votivo® nor Aeris differed from Temik 15G. Across both locations, with exception of Aeris® + Vydate® at MSU, NSTs + Vydate- CLV® were comparable to Temik 15G treatments. Node nine boll diameters at TVREC were larger in Temik 15G + Vydate-CLV® treatments than NSTs treated with Vydate-CLV®. Due to early stress at TVREC, boll development and size were delayed but were improved in size when using the NSTs or Temik compared to UTC. At 12 nodes below terminal, boll diameter at MSU (Table 22) was greatest using Aeris + Votivo + Vydate-CLV® compared to the UTC. There was no difference between remaining treatments and UTC. At this fruiting site, enough time lapsed allowing treatment effect on maturity to even out. Aeris® + Votivo® + Vydate-CLV® had larger boll diameter than. At TVREC (Table 17) location did show differences where NSTs increased boll diameter at Node 12 with application of Vydate-CLV® with the exception of Aeris + Vydate. Temik 15G + Vydate-CLV® had greater boll diameter when compared to the other nematicide treatments. At TVREC, all nematicide treatments improved boll diameter at fruiting position 12, with exception of Aeris®.

Effect of nematicides on cotton yield grown in R. reniformis infested soils: Treatment effects upon yield at both locations indicated benefits of Vydate-CLV® above NSTs alone and UTC (Table 18). Under lower *R. reniformis* populations at MSU, Aeris® + Votivo® + Vydate-CLV® was greater than Aeris® + Vydate- CLV®. The NSTs + Vydate-CLV® treatments were comparable or greater than Temik 15 G without Vydate-CLV®. At TVREC, Aeris® + Votivo® + Vydate-CLV® produced higher yields than Temik 15G but did not differ from Temik 15G + Vydate-CLV® as observed at MSU. Aeris® + Vydate-CLV® was yielded lower than Temik 15G at this location indicating weakness under high *R. reniformis* populations. However, Aeris® + Votivo® at this location was greater in yield than Aeris alone. Conclusively, Vydate-CLV® applications improved yield when compared to NSTs alone and NSTs alone were higher in yield than the UTC. Definitely, under high *R. reniformis* populations, NSTs require additional assistance as with the Vydate-CLV® applications as has been observed in findings by Lawrence and McClean (2000; 2002; 2003).

Effect of R. reniformis on root biomass development: In all treatments, as *R. reniformis* population (juvenile and eggs) increased, root mass decreased correlating to reduced shoot biomass (Table 19). Under initial population *(Pi,), R. reniformis* population of 2,500, Aeris® had lower root biomass than Temik 15 G, but greater root biomass than UTC. Addition of Votivo to Aeris did improve root biomass over Aeris alone. Treatment effects at *Pi* 5,000 and 7,500, indicated all nematicide treatments had greater root biomass than UTC. However, Temik 15G had greater root biomass development than NSTs. NSTs did not differ from each other at *Pi* 5,000 but Aeris ® + Votivo® did improve root biomass development at *Pi* 7.500. As *R. reniformis* numbers increased, root biomass development declined in Aeris® and Aeris® + Votivo® treatments with little decline in Temik 15G treatment. Aeris® + Votivo® provided better management at higher *R. reniformis* populations than Aeris. Root biomass declined less as nematode populations increased when using Temik 15G than with NSTs; however, all treatments improved nematode management and root biomass over UTC.

Effect of R. reniformis on shoot biomass development: At *Pi* 2,500 *R. reniformis* population, all nematicide treatments had greater shoot biomass than UTC with Aeris® + Votivo® and Temik 15G having greater shoot biomass than Aeris®. Temik 15G at *Pi* 5,000 *R. reniformis* improved shoot biomass development compared to NSTs which did not differ from each other. However, these treatments were greater than UTC. At *Pi* 7,500 Temik 15G and Aeris® + Votivo® did not differ in shoot biomass production, but all treatments were greater than UTC. Temik 15G and Aeris® + Votivo® provided greater shoot biomass development than Aeris® treatment (Table 19).

Egg and juvenile R. reniformis populations across nematicide treatments: Juvenile *R. reniformis* populations were higher in all NSTs compared to UTC except at *Pi* 7,500 (Table 19). Aeris® + Votivo® had higher *R. reniformis* numbers than Aeris® at the *Pi* of 2,500 to 7,500. Nematode population can be associated to root volume where there is direct relation between root growth and nematode population. Evidence indicates Aeris® + Votivo® facilitated higher level of root biomass development which supported a higher population of *R. reniformis* and provided suitable reproduction sites as was also observed in egg production. Therefore, a healthy root system resulting from benefits of nematicide treatment not only enhanced yield but increased *R. reniformis*. Temik 15G, reduced *R. reniformis* population in greenhouse environments and prevented normal reproduction. Of NSTs, Aeris® + Votivo® provided greater root mass development at *Pi* 7,500 than Aeris but neither of NSTs were as effective in managing *R. reniformis* as Temik 15G . Egg production within Temik 15 G treatment was closely aligned to results found in juvenile comparisons (Table 19). Temik 15G prevented reproduction but populations of *R. reniformis* increased as treated *Pi* increased indicating some control may be lost under greater nematode pressure. Across NSTs, egg production of *R. reniformis* decreased at *Pi* 2,500 populations compared to UTC but did not differ at higher populations.

Effect of nematicide treatments on cotton growth at varying R. reniformis populations under greenhouse environments: Initiation of fruiting (NFFB) was earlier in nematicide treatments at Pi 5,000 and 7,500 compared to UTC (Table 20). Greatest differences in NFFB occurred at *Pi* 2,500 where Temik 15G facilitated fruit initiation similar to conditions of no *R. reniformis*. NSTs at this population did not differ from UTC and initiated fruiting one node higher than Temik 15G. Within *Pi* 5,000 and 7,500, all nematicide treatments fruited at nodes lower than UTC, but at these populations did initiate fruiting one node higher than genetically governed NFFB. Initiation of fruiting began two nodes higher in *Pi* of 5,000 and 7,500 compared to UTC in absence of *R. reniformis*. In presence of nematicide treatments, *R. reniformis* at higher *Pi* experience fruit initiation delays, however, NFFB remained one node earlier than UTC.

Plant height increased across all nematode populations with nematicide treatments compared to UTC (Table 20). The greatest height reduction occurred in UTC at *Pi* 5,000 and 7,500. At *Pi* 2,500 treatment, all nematicide treatments resulted in taller plants than UTC with no differences among nematicide treatments. In *Pi* 5,000 treatment, all nematicide treatments improved plant height over UTC, however, at this population Temik 15G and Aeris® + Votivo® showed no differences between each other in plant height while Aeris® plants were shorter. All treatments were taller at *P*i 7,500 population than UTC with, Temik 15G treated plants having greater plant height than NSTs. Temik 15G offered greater management of *R. reniformis* across a wider initial nematode population range than NSTs. This indicates there may be need for assistance, *i.e.* Vydate-CLV®, to maintain *G. hirsutum* growth under high populations of *R. reniformis* when using NSTs. Despite the nematicide treatments, plant growth was reduced as *Pi* increased above *Pi* 2,500 but varied by degree of effect among treatments.

Effect on TN increased as *Pi* increased influencing HNR (Table 20). All nematicide treatments increased TN across all *R. reniformis* populations. In presence of *R. reniformis,* effect among nematicides became apparent. *Pi* 2,500 treatments, showed all nematicides increased HNR over UTC with Temik 15G and Aeris® producing greater HNR compared to Aeris® + Votivo®. Treatment effects at *Pi* 5,000 indicated Temik 15G allowed *G. hirsutum* to produce a greater HNR than Aeris + Votivo® or Aeris®. Temik 15G also produced a greater HNR under *Pi* 7,500 nematode population. HNR at *Pi* 7,500, indicated plants treated with Aeris® + Votivo® continued to produce more nodes than Aeris® with a greater HNR. Temik 15G and Aeris® produced greater HNR compared to Aeris® + Votivo® and the UTC. At *Pi* 7,500, Temik 15 G had a greater HNR than treatment of Aeris® + Votivo® or Aeris®. While Temik 15G plants had fewer nodes, HNR was greater under increasing *R. reniformis* populations than Aeris or Aeris® + Votivo®.

Conclusion

Effects of *R. reniformis* upon *G. hirsutum* under greenhouse environments indicated that as nematode population increases, the NST need additional assistance to improve growth and development. This assistance can be obtained, as observed in field studies, with the use of Vydate-CLV®. Foliar applications of Vydate-CLV® improved growth of

G. hirsutum as well as improved fruit retention and yield of the NSTs making them comparable to Temik 15G. In addition use of plant mapping facilitates acquisition of data that show-cases the performance of *G. hirsutum* in presence of *R. reniformis* when treated with a nematicide.

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Table 1. In the field treatment list for seed applied nematicides (Aeris and Aeris + Votivo), at-planting hopper box treatment (Temik 15G) and in-season foliar application (Vydate-CLV) applied with CO_2 back-pack sprayer

Treatment	Rate	Mode of Application
Aeris + Orthene 90 S	.075 mg ai/seed rate + 0.75 Lbs ai/Ac	Seed treatment followed by foliar applications at 6 leaf and 10 leaf
Aeris + Votivo + Orthene 90 S	0.424 mg ai/seed rate+ 0.75 Lbs ai/Ac	Seed treatment followed by foliar applications at 6 leaf and 10 leaf
Temik 15G + Orthene 90 S	5.0 Lbs/ac+ 0.75 Lbs ai/Ac	At-planting followed by foliar applications at 6 leaf and 10 leaf
Aeris +Vydate-CLV + Vydate-CLV	.075 mg ai/seed rate; + 8.0 Oz/ac; + 8.0 Oz/ac	Seed Treatment followed by foliar applications at 6 leaf and 10 leaf
Aeris + Votivo + Vydate-CLV + Vydate-CLV	.075 mg ai/seed rate; + 0.424 mg ai/seed rate; + 8.0 Oz/ac; + 8.0 Oz/ac	Seed Treatment followed by foliar applications at 6 leaf and 10 leaf
Temik 15G + Vydate-CLV + Vydate-CLV	5.0 Lbs/ac; + 8.0 Oz/ac; +8.0 Oz/ac	At-Planting followed by foliar applications at 6 leaf and 10 leaf
UTC	-	-

Table 2. Treatment list for greenhouse nematicide study under varying *R. reniformis* populations

Treatment	Rate	Mode of Application	Reniform inoculum rates
Aeris	.075 mg ai/seed rate	Seed Treatment	0
Aeris + Votivo	.075 mg ai/seed rate + 0.l424 mg ai/seed rate	Seed Treatment	2,500
			5,000
Temik 15G	5.0 Lbs/ac	At-Planting	7,500
UTC	-	-	

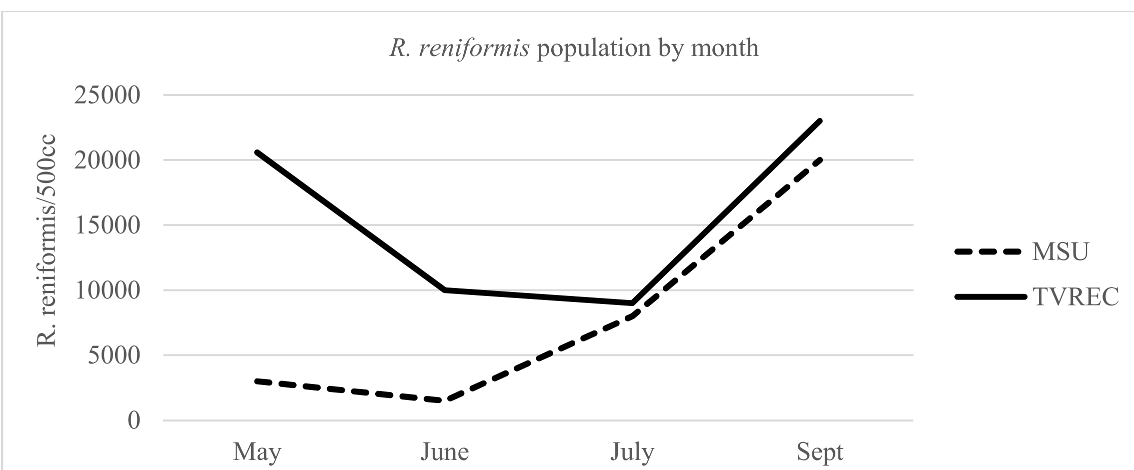

Figure 1. Seasonal progression of *R. reniformis* sampled at six samples per plot during four growth stages at MSU and TVREC.

Table 3. Seasonal progression of *R. reniformis* sampled at six samples per plot during four growth stages at Mississippi State University

Treatment	Reniform Nematode Numbers/500 cc			
	May (Pre Plant)	June (Square)	July (Bloom)	September (Open boll)
UTC	4726.4a	2760.6a	4982.6d	8973.6c
Temik 15G	4540.8a	928.0d	9306.2a	16092.8b
Aeris	5308.4a	1821.0b	5828.6cd	15263.6b
Aeris + Votivo	4107.4a	1550.5bc	6181.0cd	16622.8b
Temik + Vydate	-	577.80e	9490.6a	23026.6a
Aeris + Vydate	-	1418.4c	7922.8ab	22704.0a
Aeris + Votivo + Vydate	-	1030.8d	7236.6bc	18105.4b
LSD (0.05)	3381.2	307.6	1297.4	2990.9

^{z} Means followed by same letter are not different according to Least Significant Difference means separation test $P\alpha$=0.05.

Table 4. Seasonal progression of *R. reniformis* sampled sampled at six samples per plot during four growth stages at TVREC

Treatment	Reniform Nematode Numbers/500 cc			
	May (Pre Plant)	June (Square)	July (Bloom)	September (Open boll)
UTC	22252.5b	21901.3a	5848.0c	7625.3d
Temik 15G	27755.9a	6536.0cd	9030.0bc	16015.1bc
Aeris	21376.4b	11008.0b	8428.0bc	11829.5c
Aeris + Votivo	20981.9b	11180.0b	8886.7bcc	13416.0c
Temik + Vydate	-	5188.8d	13588.0a	24710.7a
Aeris + Vydate	-	9508.3bc	9173.3bc	16301.7bc
Aeris + Votivo + Vydate	-	7138.0cd	12040.0b	20668.7b
LSD (0.05)	1549.1	2628.5	2898.4	67.8

^{z} Means followed by same letter are not different according to Least Significant Difference means separation test $P\alpha$=0.05.

Table 5. Plants/Ha (in 1000's), visual vigor and hypocotyl lengths acquired during square at Mississippi State University and TVREC

Treatment	MSU			TVREC		
	Plnts/Ha (1000's)	Vigor (1-5)	Hypocotyl (mm)	Plnts/Ha (1000's)	Vigor (1-5)	Hypocotyl (mm)
UTC	113.8a	2.1a	9.6b	66.1a	3.33a	6.7d
Aeris	108.1b	1.5b	10.4a	59.3ab	2.35b	7.2bc
Aeris + Votivo	100.4c	1.5b	10.8a	54.5b	1.5c	7.5b
Temik 15G	99.8c	1.0c	10.8a	59.8ab	1.85c	7.1c
LSD (0.05)	2.2125	0.41	0.31	2.2731	0.302	0.13

^{z} Means followed by same letter are not different according to Least Significant Difference means separation test Pα=0.05.

Table 6. Node of first fruiting branch (NFFB) acquired during square at Mississippi State University and TVREC

Treatment	NFFB	
	MSU	TVREC
UTC	7.0a	7.5a
Temik 15G	5.75c	6.56b
Aeris	6.33b	7.2ab
Aeris + Votivo	6.33b	6.92b
LSD (0.05)	0.46	0.71

[z] Means followed by same letter are not different according to Least Significant Difference means separation test Pα=0.05.

Table 7. Cotton growth parameters, plant height, total nodes and height to node ratio, at square, bloom and open boll stages in *R. reniformis* infested soils at Mississippi State University

Treatment	Square			Bloom			Open Boll		
	PH (inches)	TN	HNR (inches)	PH (inches)	TN	HNR (inches)	PH (inches)	TN	HNR (inches)
UTC	12.8dc	12.16d	1.2c	31.3b	17.9d	1.7a	37.4f	23.2a	1.6c
Temik 15G	15.1abc	12.8bc	1.0d	33.1a	18.5c	1.8a	39.0d	21.3bc	1.8b
Aeris	14.7c	12.4d	1.1c	31.8b	18.3c	1.8a	38.1e	21.2bc	1.8b
Aeris + Votivo	14.9bc	12.7c	1.3a	32.5ab	18.5c	1.8a	38.9d	21.6b	1.8b
Temik + Vydate	15.8a	13.3a	1.2b	34.3a	18.8bc	1.8a	40.9a	20.5c	1.99a
Aeris + Vydate	15.5ab	13.4a	1.1c	33.1a	19.1b	1.7a	39.5c	21.9b	1.8b
Aeris + Votivo + Vydate	15.8a	13.2a	1.2b	33.3a	19.5a	1.8a	40.2b	20.6c	1.93a
LSD (0.05)	0.69	0.341	0.05	1.6	0.48	0.1	0.58	0.82	0.07

[z] Means followed by same letter are not different according to Least Significant Difference means separation test Pα=0.05.

Table 8. Cotton growth parameters, plant height ("), total nodes and height to node ratio, at square, bloom and open boll stages in *R. reniformis* infested soils across time at TVREC

Treatment	Square			Bloom			Open Boll		
	PH (inches)	TN	HNR (inches)	PH (inches)	TN	HNR (inches)	PH (inches)	TN	HNR (inches)
UTC	5.5d	11.3b	0.5d	15.8d	18.0d	0.87e	23.4d	25.8a	0.9d
Temik 15G	8.7b	12.8a	0.69b	23.4b	19.4bc	1.2b	28.5bc	24.0c	1.2bc
Aeris	5.7d	11.0b	0.52d	20.4c	18.9c	1.0cd	27.5c	24.2c	1.1c
Aeris + Votivo	7.1c	11.8b	0.60c	20.5c	19.3bc	1.0d	28.0bc	23.9c	1.2bc
Temik + Vydate	9.9a	12.3a	0.80a	26.6a	20.3a	1.3a	29.8b	24.5c	1.2b
Aeris + Vydate	8.4b	11.3b	0.74b	22.0bc	19.4bc	1.1bc	32.7a	25.0b	1.3a
Aeris + Votivo + Vydate	8.9b	12.6a	0.71b	23.2b	19.8ab	1.2b	28.8b	24.9b	1.2bc
LSD (0.05)	0.59	0.67	0.07	1.7	0.65	0.88	1.6	0.7	0.06

[z] Means followed by same letter are not different according to Least Significant Difference means separation test Pα=0.05.

Table 9. Average plant height (inches) at each node cumulating in total height (inches) of cotton measured during the square phase in *R. reniformis* infested soils at Mississippi State University

Treatment	Plant height at each node (inches) Node Number							
	1	3	5	7	9	11	13	15
UTC	1.5b	3.4b	6.3a	9.0a	11.7a	12.9a	13.2b	13.3b
Temik 15G	1.8a	4.3a	6.4a	9.0a	12.1a	14.0a	14.5ab	14.6ab
Aeris	1.6a	4.3a	6.2a	8.6a	11.5a	13.4a	14.0ab	14.0ab
Aeris + Votivo	1.6a	4.2a	6.2a	8.8a	11.7a	13.5a	14.1ab	14.2ab
Temik + Vydate	1.7a	4.5a	6.4a	9.5a	12.2a	14.5a	15.5a	15.5a
Aeris + Vydate	1.7a	4.6a	6.6a	9.2a	12.1a	13.7a	14.2ab	14.3ab
Aeris + Votivo + Vydate	1.8a	4.5a	6.4a	9.2a	12.3a	14.3a	14.9ab	15.0ab
LSD (0.050)	0.2	0.6	0.8	1.0	1.2	1.2	1.3	1.4

[z] Means followed by same letter are not different according to Least Significant Difference means separation test Pα=0.05.

Table 10. Average plant height (inches) at each node cumulating in total height (inches) of cotton measured during the square phase in *R. reniformis* infested soils at TVREC

Treatment	Plant height at each node (inches) Node Number							
	1	3	5	7	9	11	13	15
UTC	0.87cd	1.7c	2.6d	3.6e	4.8d	5.3e	5.4f	5.4f
Temik 15G	0.84cd	1.8c	2.8d	4.2d	5.1c	6.2d	6.8d	6.9d
Aeries	0.83cd	1.8c	2.7d	3.8e	4.8d	5.3e	5.4f	5.4f
Aeris + Votivo	0.77d	1.9c	2.6d	3.7e	5.2c	6.3d	6.5e	6.5e
Temik 15 G + Vydate	1.08a	2.9a	4.1a	5.7a	7.4a	8.9a	9.6a	9.7a
Aeris + Vydate	1.0b	2.4b	3.8b	5.4b	7.1b	8.2c	8.6c	8.6c
Aeris + Votivo + Vydate	1.02b	2.3b	3.4c	5.1c	7.5a	8.5b	8.8b	8.8b
LSD (0.05)	0.078	0.14	0.2	0.3	0.2	0.2	0.1	0.1

[z] Means followed by same letter are not different according to Least Significant Difference means separation test Pα=0.05.

Table 11. Average plant height (inches) at each node cumulating in total height (inches) of cotton measured during the bloom phase in *R. reniformis* infested soils at TVREC

Treatment	Plant height at each node (inches) Node Number										
	1	3	5	7	9	11	13	15	17	19	21
UTC	0.85b	1.7c	2.4d	3.6d	5.4e	8.5e	11.4e	14.3f	15.6f	16.4f	16.6f
Temik 15G	1.0a	2.5a	4.0a	5.3b	7.4b	11.1b	15.5b	20.9c	24.6b	26.4b	26.6b
Aeris	1.02a	2.3b	3.5c	4.6c	6.1d	8.6e	12.4d	16.8e	19.3f	20.0e	20.2e
Aeris + Votivo	1.03a	2.6a	3.7b	5.3b	7.2bc	9.1d	12.6d	17.1e	20.8e	22.7d	23.1d
Temik 15G + Vydate	1.04a	2.6a	3.7b	5.7a	8.3a	11.3ab	16.4a	22.7a	25.7a	27.2a	27.8a
Aeris + Vydate	1.06a	2.6a	3.7b	4.7c	6.9c	10.3c	14.8c	19.8d	22.5c	23.3c	23.3c
Aeris + Votivo + Vydate	1.08a	2.6a	3.8ab	5.7a	8.0a	11.5a	16.5a	21.6b	23.2c	23.7c	23.9c
LSD (0.05)	0.14	0.2	0.2	0.26	0.3	0.4	0.6	0.5	0.6	0.7	0.7

[z] Means followed by same letter are not different according to Least Significant Difference means separation test Pα=0.05.

Table 12. Percent (%) fruit retention of six sampled plants at sympodial positions 1, 2 and > 2 during square, bloom and open boll at Mississippi State University

Treatment	% Retention (Square)			% Retention (Bloom)			% Retention (Open Boll)		
	Pos[y] 1	Pos 2	Pos >2	Pos 1	Pos 2	Pos >2	Pos 1	Pos 2	Pos >2
UTC	99.2a	72.6d	26.2e	76.3d	36.1b	17.7b	49.4d	19.6d	3.9bc
Temik 15G	99.4a	75.1bc	50.1b	85.6c	52.4a	30.0b	66.3a	23.9c	2.9c
Aeris	100.0a	74.1bc	32.7d	83.3c	40.1b	43.6a	54.8c	24.4c	5.2b
Aeris + Votivo	99.4a	76.7ab	45.1c	86.6bc	37.4b	51.5a	59.8b	26.4c	7.4a
Temik 15G + Vydate	100.0a	79.2a	53.4a	94.4a	53.9a	25.4b	68.8a	33.8a	0.0d
Aeris + Vydate	99.0a	78.8ab	53.4a	84.3c	51.4a	25.7b	61.5b	29.9b	7.1a
Aeris + Votivo + Vydate	99.2a	76.1ab	50.4ab	89.2b	52.5a	25.1b	68.6a	30.4b	2.8c
LSD (0.05)	1.8	3.0	3.6	3.3	7.3	10.8	3.3	2.6	1.9

[z] Means followed by same letter are not different according to Least Significant Difference means separation test *P*α=0.05.

Table 13. Percent (%) fruit retention of six sampled plants at sympodial positions 1, 2 and > 2 during square, bloom and open boll at TVREC

Treatment	% Retention (Square)			% Retention (Bloom)			% Retention (Open Boll)		
	Pos 1	Pos 2	Pos >2	Pos 1	Pos 2	Pos >2	Pos 1	Pos 2	Pos >2
UTC	98.3a	13.5d	0.0a	70.5b	27.2d	1.4c	45.9c	16.8d	3.8c
Temik 15G	98.3a	50.9a	0.0a	95.9a	71.2a	65.5ab	51.3b	20.8c	7.9b
Aeris	98.6a	21.2cd	0.0a	95.2a	46.2c	35.2sbc	46.8c	22.2c	10.2b
Aeris + Votivo	100.0a	24.6c	0.0a	93.9a	58.0b	24.3bc	47.5c	17.4d	9.7b
Temik 15G + Vydate	100.0a	50.9a	0.0a	96.9a	70.6a	76.9a	53.8a	28.0a	14.1a
Aeris + Vydate	100.0a	33.5b	0.0a	94.1a	53.7b	36.2abc	53.2a	25.5b	15.3a
Aeris + Votivo + Vydate	97.5a	47.2a	0.0a	94.1a	65.9a	41.1abc	55.1a	29.2a	10.8b
LSD (0.05)	2.9	10.6	0.0	5.4	6.5	35.5	1.9	2.1	3.6

[z] Means followed by same letter are not different according to Least Significant Difference means separation test *P*α=0.05.

Table 14. Cotton maturity (nodes above white flower, nodes above cracked boll, node of last harvestable boll and percent open boll) as affected by nematicides in *R. reniformis* infested soils at Mississippi State University

Treatment	NAWF (bloom)	NACB (open boll)	NLHB (open boll)	Open Boll (%)
UTC	8.1ab	8.2a	16.4a	22.2d
Temik 15G	7.6bc	8.4a	16.5a	24.2c
Aeries	8.1ab	8.3a	16.2a	23.9c
Aeris + Votivo	8.3a	8.5a	15.5a	21.1d
Temik + Vydate	7.4cd	7.4bc	16.4a	28.4a
Aeris + Vydate	7.0d	7.7b	16.2a	26.2b
Aeris + Votivo + Vydate	7.1cd	7.1c	16.0a	29.6a
LSD (0.05)	0.42	0.37	0.76	1.4

[z] Means followed by same letter are not different according to Least Significant Difference means separation test *P*α=0.05

Table 15. Cotton maturity (nodes above white flower, nodes above cracked boll, node of last harvestable boll and percent open boll) as affected by nematicides in *R. reniformis* infested soils TVREC

Treatment	NAWF	NACB	NLHB	% Open Boll
UTC	10.1ab	10.4a	19.0	9.6d
Temik 15G	10.1ab	9.3ab	18.3b	23.9b
Aeris	10.13ab	10.4a	18.3b	10.3d
Aeris + Votivo	10.3a	10.0a	17.2c	16.4c
Temik + Vydate	9.7abc	8.5b	17.3c	29.9a
Aeris + Vydate	10.1ab	9.7ab	17.7c	21.8b
Aeris + Votivo + Vydate	9.51c	9.7ab	17.5c	25.0b
LSD (0.05)	0.6	0.6	0.5	1.3

[z] Means followed by same letter are not different according to Least Significant Difference means separation test *P*α=0.05.

Table 16. Basal stalk and boll diameters taken at the ninth and twelfth node below terminal to showcase plant performance resulting from nematicide treatments in *R. reniformis* soils at Mississippi State University

Treatment	Basal Stalk Diameter (mm)	Boll Diameter (mm)		Boll Diameter Difference (mm)
		Node-9	Node-12	
UTC	5.9d	24.8d	32.9bc	8.2d
Temik 15G	9.0ab	29.5b	32.9bc	3.5a
Aeries	6.9c	27.8c	32.4bc	7c
Aeries + Votivo	8.4b	28.4c	32.8bc	5.9b
Temik 15G + Vydate	9.8a	31.0a	33.6b	2.6a
Aeries + Vydate	7.0c	25.5d	32.9bc	5.1b
Aeries + Votivo + Vydate	9.7a	30.5a	34.2a	2.3a
LSD (0.05)	0.9	1.1	0.6	1.1

[z] Means followed by same letter are not different according to Least Significant Difference means separation test *P*α=0.05.

Table 17. Basal stalk and boll diameters taken at ninth and twelfth node below terminal to showcase improved plant performance resulting from nematicide treatments in *R. reniformis* soils at TVREC

Treatment	Basal Stalk Diameter (mm)	Boll Diameter (mm)		Boll Diameter Difference (mm)
		Node-9	Node-12	
UTC	6.31b	9.22d	26.4d	17.2c
Temik 15G	8.63ab	15.3b	31.3b	15.9b
Aeris	7.5ab	15.5b	31.0b	15.5b
Aeris + Votivo	7.2ab	15.4b	31.1b	15.8b
Temik 15G + Vydate	9.4a	19.1a	32.1a	13.0a
Aeris + Vydate	8.0ab	13.4c	26.1d	13.9a
Aeris + Votivo + Vydate	8.0ab	15.3b	29.2c	12.7a
LSD (0.05)	1.9	0.4	1.7	1.8

[z] Means followed by same letter are not different according to Least Significant Difference means separation test *P*α=0.05.

Table 18. Yield of Phy 375 WRF in pounds (Lbs.) lint cotton per acre treated with nematicides grown in *R. reniformis* soils at Mississippi State University and TVREC

Treatment	Lbs Lint/Ac MSU	Lbs Lint/Ac TVREC
UTC	1417.60e	581.50f[z]
Temik 15G	1528.90bcd	1167.87c
Aeris	1474.20d	783.30e
Aeris + Votivo	1483.40d	886.98d
Temik 15G + Vydate	1754.87a	1330.53a
Aeris + Vydate	1556.70b	1245.70b
Aeris + Votivo + Vydate	1610.20a	1328.70a
LSD (0.05)	65.10	46.10

[z] Means followed by same letter are not different according to Least Significant Difference means separation test *P*α=0.05.

Table 19. Effect of nematicides on reproduction of *R. reniformis* and shoot and root biomass development of Phy 375 WRF under varying *R. reniformis* populations grown under greenhouse environments

Treatment	Nematode Population	Juvenile number/500 cc	Egg number/500 cc	Shoot Biomass (Grams)	Root Biomass (Grams)
UTC	0	0g	0d	47.70fgh	46.60d
Temik 15G	0	0g	0d	68.50ab	52.50b
Aeris	0	0g	0d	70.30a	55.60a
Aeris + Votivo	0	0g	0d	64.50bc	57.00a
UTC	2,500	1,596fg	1,122cd	46.90gh	35.00f
Temik 15G	2,500	901fg	437d	70.20a	51.60b
Aeris	2,500	7,892c	4,282ab	56.00d	46.70d
Aeris + Votivo	2,500	1,596fg	5,214a	60.90c	49.70c
UTC	5,000	3,901e	1,975cd	45.70h	34.50f
Temik 15G	5,000	1,086f	1,305cd	62.60c	51.40b
Aeris	5,000	5,021de	2,639bc	51.70ef	45.30d
Aeris + Votivo	5,000	9,750b	5,162a	53.30de	45.60d
UTC	7,500	5,994d	1,442cd	41.40i	25.10g
Temik 15G	7,500	1,575f	1,390cd	52.90de	51.40b
Aeris	7,500	4,171e	1,758cd	46.20h	39.80e
Aeris + Votivo	7,500	5,459d	2,819bc	50.60efg	44.60d
LSD (0.05)		1,236	2,196	4.10	2.70

[z] Means followed by same letter are not different according to Least Significant Difference means separation test *P*α=0.05.

Table 20. Effect of nematicides on growth of Phy 375 WRF grown under varying *R. reniformis* populations under greenhouse environments at 90 days following planting

Treatment	Nematode Population	NFFB (number)	Total Node (number)	Plant Height (inch)	HNR (inch)
UTC	0	6.00d	12.30c	21.43de	1.74bc
Temik 15G	0	6.50c	13.00b	22.73abc	1.74bc
Aeris	0	6.00d	13.00b	23.39ab	1.79ab
Aeris + Votivo	0	6.00d	14.00a	23.75a	1.69bcd
UTC	2,500	7.30b	11.00d	15.50g	1.40e
Temik 15G	2,500	6.00d	13.00b	23.37ab	1.79ab
Aeris	2,500	7.00b	12.30c	22.33bcd	1.79ab
Aeris + Votivo	2,500	7.00b	13.80a	23.20abc	1.68cd
UTC	5,000	8.00a	10.10d	14.00h	1.27f
Temik 15G	5,000	7.00b	12.00c	22.61abc	1.88a
Aeris	5,000	7.00b	12.30c	20.73e	1.68cd
Aeris + Votivo	5,000	7.00b	13.00b	22.00cd	1.69bcd
UTC	7,500	8.00b	10.00e	14.40gh	1.44e
Temik 15G	7,500	7.00b	12.00c	21.28de	1.77bc
Aeris	7,500	7.00b	13.30b	19.20f	1.60d
Aeris + Votivo	7,500	7.00b	12.00c	18.90f	1.42e
LSD (0.05)		0.03	0.40	1.20	0.10

[z] Means followed by same letter are not different according to Least Significant Difference means separation test $P\alpha$=0.05.