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Evaluation of fumigant and non-fumigant nematicides for management of *Rotylenchulus reniformis* on sweetpotato

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Abstract

Reniform nematode (*Rotylenchulus reniformis*) is a major pest of sweetpotato in many production regions in Southern United States. Applying soil fumigants and non-fumigant nematicides are the primary management strategies available to growers. This study compared the relative efficacy of nematicides (1,3-dichloropropene, fluopyram, oxamyl, fluazaindolizine, aldicarb, Majestene, and fluensulfone) for management of reniform nematode on sweetpotato. Fumigating soil with 1,3-dichloropropene consistently reduced soil population densities of reniform nematode at the time of planting in both trial years (31 – 36% reduction relative to the untreated control); however, the duration of suppression varied greatly by growing season. A similar trend was observed with fluopyram (56 – 67% reduction) and aldicarb (63 – 65% reduction), which provided season-long suppression of reniform nematode population development in 2021 but had no impact in 2022. In 2021, nematicide application had no impact on yield; however, in 2022, oxamyl and aldicarb increased the yield of U.S.#1 grade sweetpotato. Overall, soil fumigation with 1,3-dichloropropene and in-furrow application of fluopyram and aldicarb provided the most consistent suppression of reniform nematode on sweetpotato.

Keywords

sweetpotato, *Ipomoea batatas*, reniform nematode, *Rotylenchulus reniformis*, management, non-fumigant nematicides

Sweetpotato, *Ipomoea batatas*, are an important vegetable crop produced in the United States, with over 133,000 acres planted in 2022 (USDA-NASS, 2023). Louisiana has a long history in sweetpotato production and development, with the first commercial operation dating back to the early 1900s (LaBonte and Smith, 2012). While acreage has decreased in recent years, Louisiana still ranks fourth in production in the U.S. with 7,300 acres planted in 2021 and a farmgate value of $47 million (Smith, 2022). Common production constraints in the region include accumulation of viruses in vegetatively propagated planting material (Clark et al., 2012), postharvest fungal and bacterial diseases (Clark et al., 2009), insect pests (Hammond and Smith, 2013), and plant-parasitic nematodes (Overstreet, 2013a).

Although most research on plant-parasitic nematodes in sweetpotato has centered on the management of root-knot nematode (*Meloidogyne* spp.) (Ploeg et al., 2019; Liu and Grabau, 2022; Watson, 2022), other nematode genera can also negatively impact production (Overstreet 2013a).

In some areas of the United States, including Louisiana, Mississippi, and Arkansas, the reniform nematode (*Rotylenchulus reniformis*) is often more widespread and damaging than the southern root-knot nematode (*Meloidogyne incognita*), likely due to the history of cotton acreage in this region (Baker et al., 1985). In sweetpotato, reniform nematode damage often goes unnoticed until harvest as there are few if any aboveground symptoms associated with infection (Overstreet, 2013b). Belowground, reniform nematode feeding reduces storage root size (Abel et al., 2007) and quality (Clark et al., 1980; Clark and Wright, 1983; Gapasin and Valdez, 1979), leading to reduced marketable yield (Birchfield and Martin, 1965). Yield reductions and cracking of storage roots have been observed when initial reniform nematode soil population densities are moderate to high (1,500 – 10,000 nematodes per 500 ml) (Clark and Wright, 1983). Yield loss estimates for Louisiana are 5 – 10 %; however, these estimates may be slightly inflated because they included fields infested with both reniform nematode and southern root-knot nematode (Koenning et al., 1999). During a survey conducted from 2019 – 2021 of 97 sweetpotato fields in Louisiana, the reniform nematode was detected in over 87% of the fields (Watson unpublished data), and often at soil population densities well above the damage threshold (10,000 nematodes per 500 ml) (Clark and Wright, 1983).

Management of reniform nematode on sweetpotato has primarily focused on the utilization of nematicides (Overstreet, 2013b); however, rotation to non-host crops such as corn can also be used. Unlike the southern root-knot nematode, there are no commercially available sweetpotato varieties with resistance to reniform nematode (Robinson, 2002; Smith et al., 2017). Application of soil fumigants, carbamate nematicides, and organophosphate nematicides have shown potential to reduce reniform nematode population development and associated yield loss on sweetpotato (Abel et al., 2007; Adams et al., 2011; Clark and Wright, 1983). Environmental, human health, and product availability concerns associated with soil fumigants and older nematicide chemistries are driving grower interest in next generation nematicides. In recent years, new nematicides with safer toxicology profiles and new mechanisms of action have entered the market (Desaeger et al., 2020), some of which are registered for use on sweetpotato. The efficacy of these new products for reniform nematode management on sweetpotato is largely unknown; however, preliminary field trials conducted at a commercial sweetpotato farm in Evangeline Parish in 2021 have demonstrated successful suppression of reniform nematode through in-furrow application of fluopyram (Watson, 2022). In contrast, recent trials conducted with fluopyram applied in-furrow on cotton have shown inconsistent efficacy towards *R. reniformis* (Grabau et al., 2021).

Given the widespread distribution of reniform nematode in many southern sweetpotato production regions in the United States, a lack of effective non-chemical management tactics, and unknown efficacy of new nematicide chemistries, there is a considerable need to evaluate the utility of nematicides for reniform nematode management on sweetpotato. Using a combination of field and greenhouse trials, this study compared the relative efficacy of new and existing nematicides for management of reniform nematode on sweetpotato.

Materials and Methods

Field experiments

Studies were conducted at the LSU AgCenter Northeast Research Station (NERS) in St. Joseph, Louisiana, United States, in a field with a history of moderate reniform nematode infestation. Soil at the site is a Bruin silt loam (31% sand; 58% silt; 11% clay; 1.1% organic matter; 6.0 pH; 5.5 meq/100g cation exchange capacity). The field was planted with cotton prior to establishing the sweetpotato field in both trial years. Small-plot field trials were conducted in 2021 and 2022 to evaluate the efficacy of various nematicide formulations for management of reniform nematode on sweetpotato. For both years, the experimental design was a randomized complete block consisting of four replicate plots of eight soil treatments; Table 1: (1) no nematicide (control); (2) 1,3-dichloropropene (Telone® II (Salt Lake Holding LLC., Midland, MI); (3) fluopyram (Velum® (Bayer CropScience LP, St. Louis, MO)); (4) oxamyl (Vydate® L (DuPont Crop Protection, Wilmington, DE)); (5) fluazaindolizine (Salibro™ (Corteva Agriscience, Indianapolis, IN)); (6) aldicarb (AgLogic 15GG (AgLogic Chemical LLC, Chapel Hill, NC)); (7) Majestene® (heat-killed *Burkholderia* spp. strain A396 (Marrone Bio Innovations, Davis, CA)); and (8) fluensulfone (Nimitz (ADAMA, Raleigh, NC). Beds were fumigated with a single shank 21 days before planting (DBP). For all non-fumigant nematicides, prior to treatment application rows were opened with a plow. Aldicarb was applied in-furrow as granules 2 DBP. All other nematicides were applied as in-furrow sprays with a 187 L/ha carrier volume using a CO_2-powered backpack sprayer 2 DBP. The rows were then immediately reshaped

Table 1. Nematicide active ingredients, application rates, application methods, and application timing for the sweetpotatoes field experiments conducted at LSU AgCenter Northeast Research Station in 2021 and 2022. DBP refers to days before planting.

Product	Active Ingredient	Product Application Rate	Application Rate (a.i.)	Application Method	Application Timing
Telone II	1,3-dichloropropene	74.8 L/ha	84.9 kg/ha	Shank	21 DBP
Velum	Fluopyram	500 ml/ha	238 g/ha	In-furrow	2 DBP
Vydate	Oxamyl	18.7 L/ha	4.28 kg/ha	In-furrow	2 DBP
Salibro	Fluazaindolizine	2.24 L/ha	1.12 kg/ha	In-furrow	2 DBP
AgLogic	Aldicarb	16.8 kg/ha	2.52 kg/ha	In-furrow	2 DBP
Majestene	Bacterial metabolites	18.7 L/ha	-	In-furrow	2 DBP
Nimitz	Fluensulfone	8.18 L/ha	3.92 kg/ha	In-furrow	2 DBP

with a plow that incorporated the treatments while injecting 853 ml/ha of Belay Insecticide (Clothianidin; Valent USA Corporation, San Ramon, CA). Rows were then rolled with a cone roller to prepare for transplanting. Prior to transplanting, a herbicide application of 219 ml/ha of Valor SX (Flumioxazin; Valent USA Corporation, San Ramon, CA) and 3.11 L/ha of Command 3ME (Clomazone; FMC Corporation, Philadelphia, PA) was applied. Plots were 9.14 m long by 2 rows wide on 1.02-m row spacing with a 1-row planted buffer between adjacent plots across the rows, and 3.05 m of planted buffer between plots along a row. The trial was planted using the 'Orleans' sweetpotato cultivar (cv.) with slips being obtained from generation 1 seedbeds. Slips were transplanted to a depth of 3 nodes deep on a 30-cm-in-row plant spacing on July 28, 2021 (year 1) and June 8, 2022 (year 2), utilizing separate but adjacent portions of the same field for each year of the field study. Throughout the growing season, plots were treated with a combination of group 3, 4, and 28 insecticides following standard best management practices to insure low insect damage.

Reniform nematode soil population densities were monitored in plots on four sampling dates: prior to fumigating (21 DBP), at plant (2 DBP), mid-season (56 days after planting (DAP)), and at harvest (104 DAP). On each sampling date, ten soil cores (20 to 25 cm in length, 2.5 cm in diameter) were collected at random from both rows of each plot, thoroughly mixed in a plastic bucket, then placed in a labelled plastic bag. Soil samples were stored at 10 °C for a maximum of 14 days prior to subsequent processing. Nematodes were extracted from a 250 ml subsample of soil from each plot using a NC elutriator followed by a sucrose centrifugation technique (Baker et al., 1985). After collecting the nematodes over a 25-µm sieve, the nematode samples were transferred in water into plastic vials and stored at 4 °C for a maximum of two weeks prior to counting. The abundance of plant-parasitic nematode species was determined using an inverted compound microscope. Data are presented as the number of nematodes per 500 ml of soil.

Yield data was collected from a single row of each plot using a 1-row mechanical digger on November 9, 2021 (year 1) and September 20, 2022 (year 2). Sweetpotato from each plot were sorted using modified U.S. grades and weighed. Grades consisted of U.S.#1 (5.1 – 8.9 cm diameter and 7.6 – 22.9 cm length), canner (2.5 – 5.1 cm diameter and 5.1 – 17.8 cm length), jumbo (larger than U.S.#1), and total marketable yield (the total of U.S.#1, canner, and jumbo). Data are presented as the weight of each grade per hectare after culls (rotted storage roots or roots smaller than canner grade) were removed. From each plot, a total of 10 US#1 storage roots (or as many storage roots as available for plots with fewer than 10 of them) were inspected for cracking and the percent occurrence of cracking within the 10-root subsample from each plot was recorded.

Greenhouse experiments

In 2022, complimentary greenhouse nematicide efficacy trials were conducted using soil collected from the field site, NERS, as well as soil collected from the LSU AgCenter Macon Ridge Research Station (MRRS) in Winnsboro, Louisiana, United States, from a field with a moderate reniform nematode infestation. Soil at the MRRS site was a Gigger silt loam (35% sand; 48% silt; 17% clay; 1.3% organic matter; 6.7 pH; 6.3 meq/100g cation exchange capacity) that

was planted with cotton in 2022. Soil (~150 L) was collected from NERS on June 8, 2022, for experiment 1 and June 22, 2022, for experiment 2 as well as from MRRS on June 15, 2022, for experiment 1 and June 29, 2022, for experiment 2. The soil was placed in sealed plastic buckets and transported to the LSU AgCenter Plant Material Center in Baton Rouge, Louisiana, United States, where it was thoroughly mixed prior to subsequent use in the greenhouse experiments. Nematodes were extracted from a 250-ml subsample of soil from each field site, as described above, to determine the initial reniform nematode soil population density for each field soil during each experimental repetition. For each field site, approximately 2.5 L of soil was placed in a 19.1-cm diameter pot and planted with a single 20-cm-long 'Orleans' cv. sweetpotato slip prior to nematicide application. The experimental design for each field soil examined was a randomized complete block consisting of six replications of eight soil treatments: (1) no nematicide (control); (2) steam pasteurized soil (80 °C for two hours on two consecutive days); (3) fluopyram (Velum® at 1.4 µL/pot); (4) oxamyl (Vydate® L at 53.0 µL/pot); (5) fluazaindolizine (Salibro™ 6.4 µL/pot); (6) aldicarb (AgLogic 15G 47.6 mg/pot); (7) Majestene® at 53.0 µL/pot); and (8) fluensulfone (Nimitz® at 23.2 µL/pot). All liquid nematicide formulations were applied at an equivalent label rate (Table 1) according to the calculated pot soil surface area as a 25-ml drench application. Aldicarb was applied immediately prior to planting the sweetpotato slip by mixing the granules with the field soil. After 10 weeks in a temperature-controlled greenhouse, the experiment was terminated. Plants were carefully uprooted, rinsed clean of soil under tap water, and the fresh weights of adventitious roots (>5 mm in diameter) was recorded as storage root weights. Soil from each pot was mixed thoroughly and nematodes were extracted from a 250-ml subsample, as described above, to determine the final reniform nematode soil population density in soil. The entire experiment was repeated once for each field soil examined.

Statistical analysis

For the field trials, data from each year were subjected to a one-way ANOVA in the SAS Studio (SAS University Edition; version 3.3; SAS Institute Inc., Cary, NC, USA) using the PROC GLM procedure. The experimental model was a randomized complete block with four blocks and eight nematicide treatments. Differences between treatment means were examined using Tukey's HSD test ($P < 0.05$). For the greenhouse trials, data from each field soil examined were subjected to a two-way ANOVA in the SAS Studio using the PROC GLM procedure. The experimental model was a randomized complete block with six blocks, eight soil treatments, and two experimental repetitions. When there was no interaction between main factors, treatment means were pooled across both experiments and data were resubjected to a one-way ANOVA.

Results

Nematicide efficacy at managing reniform nematode

Reniform nematode was the predominant plant-parasitic nematode found in soil samples in both growing seasons. In 2021, reniform nematode soil population densities in the field averaged 3,500 nematodes per 500 ml of soil prior to applying the soil fumigant to select plots. In 2022, initial reniform nematode soil population densities averaged 1,319 nematodes per 500 ml of soil. In 2021, southern root-knot nematode was detected from select plots during the harvest sampling date (data not shown); however, soil population densities were low (<13 juveniles per 500 ml of soil) and inconsistent among replicate plots within a treatment. Southern root-knot nematode was not detected in any sample collected during the 2022 growing season. The stunt nematode (*Tylenchorhynchus* sp.) was also detected from select plots during both growing seasons; however, soil population densities were similarly low, and the presence of this nematode was inconsistent among replicate plots.

In 2021, reniform nematode soil population densities in plots were not significantly different among treatments prior to applying the soil fumigant (Table 2), with soil population densities ranging from 1,625 – 5,500 nematodes per 500 ml of soil. Immediately prior to planting, reniform nematode soil population densities in plots fumigated with 1,3-dichloropropene were reduced by 84% relative to that of the untreated control. By the mid-season sampling date, many of the nematicide treatments had reduced reniform nematode soil population densities relative to that of the untreated control, including 1,3-dichloropropene (94% reduction), fluopyram (67% reduction), oxamyl (84% reduction), and aldicarb (65% reduction). By the harvest sampling date, the only nematicide treatments to maintain lower reniform nematode soil population densities relative to that of the untreated control were 1,3-dichloropropene (67% reduction), fluopyram (56% reduction), and aldicarb (63% reduction).

In 2022, reniform nematode soil population densities ranged from 975 – 1,650 nematodes per 500 ml of soil prior to applying the soil fumigant (Table 3). At planting, reniform nematode soil population densities in plots fumigated with 1,3-dichloropropene were reduced by 80% relative to that of the untreated control. By the mid-season sampling date, no soil treatment was successful in reducing reniform nematode soil population densities relative to that of the untreated control; however, the 1,3-dichloropropene treatment reduced reniform nematode abundance by 66% relative to that of the Majestene treatment. Similarly, no differences in reniform nematode soil population densities were observed during the harvest sampling date.

Nematicide efficacy on storage root yield and cracking

In 2021, nematicide treatments did not significantly increase the yield of U.S.#1, Canner, Jumbo, or the total marketable weight of sweetpotato relative to that of the untreated control (Table 4); however, the

Table 2. 2021 effect of soil treatment on the abundance of reniform nematode (*Rotylenchulus reniformis*) in soil planted with sweetpotato at the LSU AgCenter Northeast Research Station in 2021. Soil treatments sharing the same letter within a column do not differ significantly ($P > 0.05$), according to Tukey's HSD test.

	Rotylenchulus reniformis per 500 ml soil						
Soil Treatment	Pre-Fum	At Plant		Mid-Season		Harvest	
Control	4,125	1,188	a	5,575	a	5,875	a
1,3-dichloropropene	3,000	188	b	350	b	1,963	b
Fluopyram	4,625	1,750	a	1,825	b	2,575	b
Oxamyl	1,000	1,438	a	888	b	3,148	ab
Fluazaindolizine	4,625	1,500	a	3,170	ab	3,395	ab
Aldicarb	5,500	1,063	a	1,950	b	2,200	b
Majestene	1,625	1,250	a	2,468	ab	2,968	ab
Fluensulfone	3,500	1,625	a	3,188	ab	3,438	ab
P-value	0.193	0.014		<0.001		0.004	

Table 3. 2022 effect of soil treatment on the abundance of reniform nematode (*Rotylenchulus reniformis*) in soil planted with sweetpotato at the LSU AgCenter Northeast Research Station in 2022. Soil treatments sharing the same letter within a column do not differ significantly ($P > 0.05$), according to Tukey's HSD test.

	Rotylenchulus reniformis per 500 ml soil					
Soil Treatment	Pre-Fum	At Plant		Mid-Season		Harvest
Control	1,425	1,500	a	3,000	ab	5,300
1,3-dichloropropene	1,000	300	b	1,175	b	3,015
Fluopyram	1,650	1,250	a	1,500	ab	3,800
Oxamyl	1,275	1,425	a	2,600	ab	4,775
Fluazaindolizine	975	925	ab	3,150	ab	4,050
Aldicarb	1,675	1,275	a	1,525	ab	2,375
Majestene	1,400	1,125	a	3,500	a	4,325
Fluensulfone	1,150	975	ab	2,025	ab	4,400
P-value	0.432	0.029		0.008		0.529

1,3-dichloropropene and Majestene treatments resulted in significantly greater yield of US#1 sweetpotato than plots treated with oxamyl or aldicarb. Cracking of U.S.#1 sweetpotato was low (<2%) and inconsistent among replicate plots within a treatment (data not shown).

In 2022, oxamyl and aldicarb increased the yield of U.S.#1 sweetpotato relative to that of the untreated control and fluensulfone treatment (Table 5). Nematicide treatments did not significantly affect the yield of canners, jumbos, or the total marketable yield. As observed in 2021, cracking of US#1 sweetpotato in 2022 was low (<1%) and inconsistent among replicate plots within a treatment (data not shown).

Greenhouse nematicide efficacy trials

In the greenhouse experiment utilizing field soil from NERS, initial reniform nematode soil population densities averaged 1,680 nematodes per 500 ml of soil in experiment 1 and 1,980 nematodes per 500 ml of soil in experiment 2. Pasteurizing field soil resulted in significantly lower final reniform nematode soil population densities relative to all other soil treatments (Table 6). Application of fluopyram and fluazaindolizine reduced final reniform nematode soil population densities relative to the untreated control and aldicarb treatment. The weight of storage roots was significantly greater in the Majestene treated pots relative to that of the untreated control, fluopyram, oxamyl, fluazaindolizine, and fluensulfone treatments. The final reniform nematode population density in soil was higher in experiment 1 than in experiment 2.

In the greenhouse experiment utilizing field soil from MRRS, initial reniform nematode soil population densities averaged 1,540 nematodes per 500 ml of soil in experiment 1 and 2,200 nematodes per 500 ml of soil in experiment 2. Pasteurizing field soil resulted in significantly lower final reniform nematode soil population densities relative to all other soil treatments (Table 7). Application of aldicarb and fluensulfone reduced final reniform nematode soil population densities relative to the untreated control. There were no differences in final reniform nematode population density and storage root weight observed between the experimental repetitions.

Discussion

The use of soil fumigants is common in specialty crop production and these products are often efficacious toward nematodes; however, alternatives to soil fumigants are desired by the industry if they can provide similar levels of disease suppression and yield benefit. In this study, fumigating soil with 1,3-dichloropropene provided consistent suppression of reniform nematode soil population densities at the time of planting sweetpotato slips in both trial years. The duration of nematode population reduction varied greatly by trial year. 1,3-dichloropropene provided season-long reduction in reniform nematode soil population densities in 2021; however, in 2022, the

Table 4. 2021 effect of soil treatment on the yield of US#1, canner, and jumbo grade sweetpotato harvest at the LSU AgCenter Northeast Research Station. Soil treatments sharing the same letter within a column do not differ significantly ($P > 0.05$), according to Tukey's HSD test.

	Yield (Mg/ha)				
Soil Treatment	U.S.#1		Canner	Jumbo	Total Marketable Yield
Control	6.8	ab	7.4	0.1	14.2
1,3-dichloropropene	9.2	a	6.5	1.0	16.7
Fluopyram	8.9	ab	9.1	0.4	18.4
Oxamyl	5.5	b	7.9	0.8	14.3
Fluazaindolizine	6.2	ab	8.3	0.5	15.0
Aldicarb	5.5	b	8.0	1.9	15.4
Majestene	9.6	a	8.1	0.3	18.0
Fluensulfone	7.0	ab	8.4	0.6	15.9
P-value	0.017		0.892	0.493	0.425

Table 5. 2022 effect of soil treatment on the yield of US#1, canner, and jumbo grade sweetpotato harvest at the LSU AgCenter Northeast Research Station. Soil treatments sharing the same letter within a column do not differ significantly ($P > 0.05$), according to Tukey's HSD test.

Soil Treatment	Yield (Mg/ha)				
	U.S.#1		Canner	Jumbo	Total Marketable Yield
Control	7.4	b	3.4	1.8	12.6
1,3-dichloropropene	9.7	ab	4.4	3.0	17.1
Fluopyram	9.0	ab	3.7	1.0	13.6
Oxamyl	12.0	a	2.8	0.7	15.5
Fluazaindolizine	9.4	ab	3.6	3.5	16.5
Aldicarb	11.1	a	3.7	1.7	16.5
Majestene	9.2	ab	3.6	2.3	15.1
Fluensulfone	5.3	b	3.3	2.3	10.9
P-value	0.017		0.908	0.396	0.498

Table 6. Effect of soil treatment and experimental repetition on the final abundance of reniform nematode (*Rotylenchulus reniformis*) in soil and storage root weight of sweetpotato planted into potted field soil from the LSU AgCenter Northeast Research Station. Soil treatments sharing the same letter within a column do not differ significantly ($P > 0.05$), according to Tukey's HSD test.

Factor	Level	*Rotylenchulus reniformis* per 500 ml soil		Storage Root Weight (g)	
Soil Treatment	Untreated	31,060	a	15.5	b
	Pasteurized	3,515	c	19.0	ab
	Fluopyram	15,790	b	18.7	b
	Oxamyl	29,350	ab	17.6	b
	Fluazaindolizine	15,540	b	18.1	b
	Aldicarb	36,890	a	22.2	ab
	Majestene	29,110	ab	30.6	a
	Fluensulfone	29,400	ab	16.7	a
Experiment	1	18825	b	25.1	a
	2	35465	a	14.5	b
P-value	Soil Treatment	<0.001		0.005	
	Experiment	<0.001		<0.001	
	Interaction	0.122		0.073	

Table 7. Effect of soil treatment and experimental repetition on the final abundance of reniform nematode (*Rotylenchulus reniformis*) in soil and storage root weight of sweetpotato planted into potted field soil from the LSU AgCenter Macon Ridge Research Station. Soil treatments sharing the same letter within a column do not differ significantly ($P > 0.05$), according to Tukey's HSD test.

Factor	Level	*Rotylenchulus reniformis* per 500 ml soil		Storage Root Weight (g)
Soil Treatment	Untreated	13,790	a	29.8
	Pasteurized	2,155	c	32.1
	Fluopyram	10,560	ab	21.8
	Oxamyl	8,340	ab	30.5
	Fluazaindolizine	10,295	ab	36.0
	Aldicarb	6,575	b	31.1
	Majestene	11,055	ab	30.7
	Fluensulfone	6,890	b	28.4
Experiment	1	9,435		32.0
	2	8,025		28.0
P-value	Soil Treatment	0.045		0.530
	Experiment	0.136		0.188
	Interaction	0.749		0.701

suppressive effect of the soil fumigant was lost by the mid-season sampling date. This relatively short-term suppression of reniform nematode population development is consistent with another sweetpotato study conducted by Abel et al. (2007) in the Mississippi Delta, where plots treated with 1,3-dichloropropene showed reduced mid-season soil population densities of reniform nematode; however, by harvest this reduction was no longer detectable. Likewise, in a Florida sweetpotato field infested with southern root-knot nematode, 1,3-dichloropropene reduced mid-season soil population densities of infective juveniles; however, by harvest this reduction was no longer detected in both 2019 and 2020 (Liu and Grabau, 2022). The relatively short duration of nematode population reduction achieved with soil fumigants could be associated with the short half-life of these products (Desaeger et al., 2020) and the negative impact they have on soil suppressiveness (Watson et al., 2020; Watson et al., 2017), each of which are factors that would favor reinfestation of fumigated soil. Despite suppression of reniform nematode populations using 1,3-dichloropropene, the current study did not demonstrate a yield benefit of soil fumigation in either of the trial years. These results are in contrast with other studies with soil fumigants on sweetpotato, which have demonstrated yield benefits through application of 1,3-dichloropropene in a reniform nematode infested field in Mississippi (Abel et al., 2007) and in a southern root-knot nematode infested field in Florida (Liu and Grabau, 2022). Despite the apparent lack of yield response to soil fumigation observed in the current study, which may have been related to high variability in yield among treatments, applying 1,3-dichloropropene still resulted in a numerical increase of 36% more U.S.#1 sweetpotato per hectare relative to the untreated plots in 2021, and 31% more in 2022.

Identifying effective non-fumigant nematicides that provide season-long suppression of nematode feeding would be beneficial to the sweetpotato industry. Many new nematicides have become available to growers; however, there is minimal data available on efficacy of these products toward reniform nematode on sweetpotato. In this study, application of fluopyram and aldicarb provided season long reductions in reniform nematode soil population densities in the 2021 trial, whereas the level of population reduction achieved with oxamyl was short term and no longer detectable by harvest. The same trend was not observed during the 2022 growing season, where neither the nematicides nor the soil fumigant reduced reniform nematode soil population densities during the mid-season or harvest sampling

dates. The complimentary greenhouse nematicide efficacy trials showed similar patterns of inconsistent reductions in reniform nematode between the two soils examined, with fluopyram and fluazaindolizine reducing nematode population development in the NERS soil, whereas aldicarb and fluensulfone reduced population development in the MRRS soil. Similar results have been observed using aldicarb in a reniform nematode infested sweetpotato field in the Mississippi Delta, where mid-season reniform nematode soil population densities were reduced and the yield of US#1 grade sweetpotato increased (Abel. et al., 2007). In a Florida sweetpotato field infested with southern root-knot nematode, drench application of fluazaindolizine showed relatively consistent suppression of nematode populations, while suppression was more variable with oxamyl among trial years and not observed with fluopyram; however, the yield benefit of nematicide application was inconsistent and often unrelated to suppression of nematode population densities (Liu and Grabau, 2022). In a California sweetpotato field infested with southern root-knot nematode, pre-plant application of fluensulfone provided relatively consistent yield increase and supressed nematode egg production of sweetpotato; however, no differences were observed in soil population densities of infective juveniles (Ploeg et al., 2019). The inconsistent suppression of reniform nematode population development across trial years emphasizes the need for additional studies to understand how environmental conditions impact nematicide efficacy and how alteration of application methods may enhance the consistency of pest suppression. Similar to the soil fumigant, 1,3-dichloropropene, suppression of reniform nematode population development using a non-fumigant nematicide did not result in a consistent yield benefit. Nematicide treatments that improved yield did not always reduce reniform nematode population development during the growing season, as observed with Majestene in the 2022 field trial and the complimentary greenhouse experiment using NERS soil. This could be related to direct plant growth promotion through nematicide application, which has been observed with other nematicides like aldicarb but has not been documented with Majestene (Reddy et al., 1990). These results may also be related to early season suppression of reniform nematode during the critical stages of early storage root formation, which our sample timing would not have detected.

On sweetpotato, reniform nematode damage can manifest as reductions in storage root size (Abel et al., 2007) and quality (Gapasin and Valdez, 1979), with early studies documenting considerable cracking of storage roots when reniform nematode soil population densities were moderate to high (Clark and Wright, 1983). In the current study, very few storage roots showed cracking despite reniform nematode soil population densities being in the moderate range. This lack of cracking may be linked to the utilization of modern sweetpotato varieties, which may be less prone to cracking than earlier varieties that were developed (Clark and Wright, 1983).

These trials have demonstrated that applying non-fumigant nematicides can provide suppression of reniform nematode in sweetpotato production systems; however, akin to soil fumigants, efficacy varied by trial year. In 2022, the parish where this trial was conducted experienced a considerable drought period followed by excessive amounts of rain late in the season, which may have negatively influenced product efficacy and promoted late-season population development after the active ingredients had dissipated from the soil profile. With the exception of fluopyram and aldicarb, efficacy in the greenhouse nematicide trials did not necessarily correspond to successful suppression of reniform nematode in the field trials. Understanding the environmental factors and production practices that influence nematicide efficacy will be key to achieving more consistent suppression of plant-parasitic nematodes in sweetpotato production. Overall, our study suggests that soil fumigation with 1,3-dichloropropene and in-furrow application of fluopyram and aldicarb provides the most consistent and prolonged suppression of reniform nematode on sweetpotato under our conditions.

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