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Influence of Cropping Sequence and Tillage System on Plant-Parasitic Nematodes and Peanut (*Arachis hypogaea*) Response to Fluopyram Applied at Planting

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Abstract: Crop sequence and tillage can affect the yield of peanut (*Arachis hypogaea* L.) and other crops. Research was conducted from 2006 through 2022 to determine the response of peanut to previous crop sequences including corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.) planted in continuous conventional tillage (e.g., disking, field cultivating, and bedding with in-row sub-soiling) or strip tillage (e.g., tilling a 45 cm section on rows spaced 91 cm apart using fluted coulters, rolling baskets, and in-row sub-soiling). In 2013, 2019, and 2022, the entire test area was planted with peanut. In 2019 and 2022, peanut was planted without or with fluopyram applied in the seed furrow at planting. Decreasing the number of years between peanut planting resulted in lower peanut yields compared with fewer years of peanut planting in the rotation sequence. Continuous conventional tillage and strip tillage resulted in similar peanut yields at one location, while the yield was lower at a second location when peanut was planted in continuous strip tillage. Fluopyram did not affect peanut yield regardless of previous crop rotation sequence, the number of years separating peanut plantings, or the tillage system. However, minor differences in the populations of plant-parasitic nematodes in soil were noted when comparing fluopyram treatment. The results from these experiments indicate that while fluopyram can reduce the populations of some plant-parasitic nematodes in soil, the magnitude of reduction does not translate into increases in peanut yield.

Keywords: conventional tillage; integrated pest management; nematicide; strip tillage

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1. Introduction

Crop rotation is an important component of integrated pest management and the maintenance of yield for many crops including peanut [1,2]. The sequence of crops in a rotation can affect disease incidence and populations of plant-parasitic nematodes in soil [3–8]. Increasing the number of crops other than peanut between peanut plantings often reduces the negative impact of diseases and plant-parasitic nematodes on peanut yield [7,8]. Peanut and other leguminous crops contribute to soil fertility for succeeding crops including corn and cotton [9–13].

Conservation tillage contributes positively to cropping systems through the protection of soil from erosion, aggregate formation in soil that minimizes crusting, increasing water-holding capacity, contributions to weed management, increased crop yield, and lower input costs [14–31]. In North Carolina, conservation tillage for peanut increased from 10% of peanut acreage in 1998 to 23% and 41% in 2004 and 2009, respectively [32]. However, conservation tillage for peanut decreased to 20% in 2014 but increased to 30% in 2019 [32]. Concern over efficient digging and vine inversion and pod loss exists when peanut is grown on finer-textured soils in conservation tillage compared with peanut grown on coarser-textured soils [32,33].

Interactions of crop sequences and tillage systems have been reported in the peer-reviewed literature for several agronomic crops [34–40]. However, research comparing peanut response to interactions of tillage systems and cropping sequence is limited. The majority of research on peanut has focused on its response to tillage at multiple locations or over several years but generally for a single season, without information on the residual effects of tillage on succeeding crops [41–44]. Grichar [45] evaluated peanut response to tillage over a 10-year period, but in continuous peanut planting. Jordan et al. [35] reported that interactions of cropping sequence and tillage systems were not observed in experiments established in 1999 or 2000 through 2006 when conservation tillage in the form of strip tillage was compared with conventional tillage including disking and bedding in the same plots over this period of time. In those experiments, the yield of corn, cotton, and peanut were affected in some years by cropping sequence and tillage, but the plants' response was independent for these variables.

In North Carolina, the predominant parasitic nematodes that affect peanut are northern root-knot (*Meloidogyne hapla* Chitwood), peanut root-knot (*M. arenaria* race 1 Neal), sting (*Belonolaimus longicaudatus* Rau), lesion (*Pratylenchus brachyurus* Filipjev & Schuurmans-Stekhoven), and ring (*Mesocriconema ornatum* Raski) nematodes [32]. Current management practices include rotation to a non-suitable host, detection or diagnosis of nematode damage and species, and chemical control [32]. In Alabama and Florida, the application of fluopyram has been shown to increase peanut yield and decrease root galling in the presence of plant-parasitic nematodes compared to non-treated peanut [46–48]. Information on nematode suppression in peanut plants with fluopyram is limited in North Carolina.

The experiments initiated by Jordan et al. [35] have been maintained since 2006, with peanut planted following all previous cropping sequences and tillage systems in 2013 and with modifications to the rotation sequence through 2022. The objective of this research study is to compare peanut yield, visual estimates of canopy health, and populations of plant-parasitic nematodes in soil when fluopyram was applied in the seed furrow at planting after cropping sequences that included corn and cotton at various intervals relative to peanut in continuous conventional and strip tillage systems.

2. Materials and Methods

The experiment was conducted in North Carolina at the Peanut Belt Research Station located near Lewiston-Woodville (36.07 N, −77.11 W) on a Norfolk loamy sand soil (fine-loamy, kaolinitic, thermic typic Kandiudults) and at the Upper Coastal Plain Research Station near Rocky Mount on a mix of a Norfolk loamy sand soil (fine-loamy, siliceous, semiactive, thermic typic Paleaquults) and Goldsboro loamy sand soil (fine-loamy, siliceous, sub-active, thermic Aquic Paleudults). Crop sequences and tillage systems from 1999 (Lewiston-Woodville) and 2000 (Rocky Mount) through 2022 at both locations are presented in Tables 1 and 2. The peanut cultivar NC 12C [49] was planted in 2006 at Lewiston-Woodville, while the cultivar VA 98R [50] was planted at Rocky Mount during 2006. The cultivar Bailey [51] was planted at both locations in 2013, while the cultivar Bailey II [52] was planted at both locations in 2019 and 2022. The cultivars Bailey and Bailey II express resistance to several economically important diseases [51,52]. However, these peanut cultivars, including NC 12C and VA 98R, do not express resistance to root-knot nematodes [49,50]. The plot size was 12 rows wide (91 cm spacing) by 15 m at Lewiston-Woodville and 8 rows (91 cm spacing) by 25 m at Rocky Mount.

Table 1. Crop sequences from 1999–2022 for both conventional and strip tillage at Lewiston-Woodville, North Carolina [a].

Year	Crop Rotation Sequence			
1999	Cotton	Corn	Cotton	Cotton
2000	Peanut	Peanut	Cotton	Cotton
2001	Cotton	Corn	Cotton	Corn
2002	Peanut	Peanut	Peanut	Peanut
2003	Cotton	Corn	Cotton	Cotton
2004	Peanut	Peanut	Cotton	Cotton
2005	Cotton	Corn	Cotton	Corn
2006	Peanut	Peanut	Peanut	Peanut
2007	Cotton	Cotton	Cotton	Cotton
2008	Cotton	Cotton	Cotton	Cotton
2009	Corn	Corn	Corn	Corn
2010	Peanut	Peanut	Cotton	Cotton
2011	Corn	Corn	Corn	Corn
2012	Cotton	Cotton	Cotton	Cotton
2013	Peanut	Peanut	Peanut	Peanut
2014	Cotton	Corn	Cotton	Corn
2015	Cotton	Corn	Cotton	Corn
2016	Peanut	Peanut	Cotton	Corn
2017	Cotton	Corn	Cotton	Corn
2018	Cotton	Corn	Cotton	Corn
2019	Peanut	Peanut	Peanut	Peanut
2020	Corn	Corn	Corn	Corn
2021	Corn	Corn	Corn	Corn
2022	Peanut	Peanut	Peanut	Peanut

[a] Conventional tillage consisted of two passes with a disk harrow, one pass with a field cultivator, and bedding with in-row sub-soiling at a depth of 25 cm. Strip tillage consisted of fluted coulters, two rolling baskets, and in-row sub-soiling on a 45 cm band on 91 cm rows.

Table 2. Crop sequences from 2000–2022 for both conventional and strip tillage at Rocky Mount, North Carolina [a].

Year	Crop Rotation Sequence	
2000	Cotton	Peanut
2001	Cotton	Cotton
2002	Peanut	Peanut
2003	Cotton	Cotton
2004	Peanut	Peanut
2005	Cotton	Cotton
2006	Peanut	Peanut
2007	Cotton	Cotton
2008	Cotton	Cotton
2009	Corn	Corn
2010	Cotton	Peanut
2011	Corn	Corn
2012	Cotton	Cotton
2013	Peanut	Peanut
2014	Corn	Corn
2015	Cotton	Cotton
2016	Cotton	Peanut
2017	Corn	Corn
2018	Cotton	Cotton
2019	Peanut	Peanut

Table 2. *Cont.*

Year	Crop Rotation Sequence	
2020	Corn	Corn
2021	Corn	Corn
2022	Peanut	Peanut

[a] Conventional tillage consisted of two passes with a disk harrow, one pass with a field cultivator, and bedding with in-row sub-soiling at a depth of 25 cm. Strip tillage consisted of fluted coulters, two rolling baskets, and in-row sub-soiling on a 45 cm band on 91 cm rows.

Continuous conventional tillage and reduced tillage systems were compared within each crop sequence, with the same tillage system maintained in the same plot area each year. Disking twice, field cultivating once, and sub-soiling and bedding were included in the conventional tillage system. In the reduced tillage system, a 45 cm wide band on 91 cm rows was prepared prior to planting using a strip tillage implement consisting of two sets of coulters and basket attachments followed by in-row sub-soiling (KMC Manufacturing Corp., Tifton, GA, USA). The depth of sub-soiling was 25 to 30 cm, with crops planted within one week following reduced tillage. Existing winter vegetation and emerging summer weeds were controlled using sequential applications of glyphosate at 2 to 3 weeks prior to planting and glyphosate or paraquat applied prior to crop emergence after planting so that seedbeds were weed free at the time of crop emergence.

Production and pest management practices other than tillage for each crop were implemented to optimize the yield of each crop and were administered uniformly across all cropping sequences and tillage systems based on Cooperative Extension Service recommendations for the region [32]. Fungicides were applied bi-weekly to suppress late leaf spot disease [caused by *Nothopassalora personata* (Berk. & M.A. Curtis) U. Braun, C. Nakash., Videira & Crous] and southern stem rot (caused by *Athelia rolfsii* Sacc.). Although Sclerotinia blight (caused by *Sclerotinia minor* Jagger) is present at these locations, this disease was not present in fields where the experiment was conducted.

In 2019 and 2022, four rows of each plot (e.g., a combination of crop rotation sequence and tillage system) were planted with imidacloprid (Admire Pro, Bayer CropScience, Research Triangle Park, NC, USA) at 0.43 kg ai/ha or with imidacloprid plus fluopyram (Velum, Bayer CropScience, Research Triangle Park, NC, USA) at 0.25 kg ai/ha in the seed furrow at planting. This third treatment factor completed a balance of a 4 (crop rotation sequence including length of rotation relative to peanut of previous crop in the rotation) × 2 (tillage system) × 2 (fluopyram) factorial arrangement of treatments. Pesticides were applied in a 30 L/ha aqueous solution immediately after seed drop but prior to slit closure.

Visual estimates of plant health were recorded within one week prior to digging pods and inverting vines using an ordinal scale from 0 to 5, where 0 = yellow peanut canopy and 5 = deep-green peanut canopy. Peanut pods were dug and vines were inverted in late September based on pod mesocarp color [53]. The populations of plant-parasitic nematodes in soil were determined in peanut during 2013, 2019, and 2022 by removing 10 soil cores from each plot at a depth from 1 to 10 cm within two weeks prior to digging and vine inversion. A 500 cm^3 sub-sample of soil from each plot was submitted to the North Carolina Department of Agriculture and Consumer Services Nematology division (Raleigh, NC, USA) for nematode extraction, identification, and quantification using standard procedures [54,55]. Plant-parasitic nematodes present in 2013, 2019, and 2022 are listed in Supplemental Table S1.

The experimental design in 2013 was a randomized complete block with combinations of crop sequence and tillage systems replicated 4 times. In 2019 and 2022, the experimental design was a split-plot design with each combination of crop sequence and tillage system serving as whole plot units and fluopyram treatment serving as sub-plot treatments. Each combination of crop sequence, tillage system, and fluopyram treatment were replicated four times. Data for crop yield, plant condition rating in 2019 and 2022, and populations of plant-parasitic nematodes in soil at each location were subjected to ANOVA using the GLIMMIX procedure in SAS (SAS Institute, Cary, NC, USA) by year, considering the factorial arrangement of treatments. Combinations of crop sequence, tillage system, and fluopyram treatment were considered fixed effects. Replication was considered a random effect. Data for each plant-parasitic nematode taxon were transformed to the natural log of nematode population for each species prior to analysis. For experimental units without a measurable population for a nematode species, the value was changed from 0 to 1 prior to statistical analysis. Fisher's protected LSD test at $p \leq 0.05$ was used to separate means for significant main effects and interactions.

3. Results and Discussion

3.1. Peanut Yield and Plant-Parasitic Nematode Population in Soil in 2013

The interaction of crop sequence and tillage system was not significant for peanut yield in 2013 at either location (Supplemental Tables S2 and S3). However, the main effect of the tillage system was significant at both locations. When pooled over the rotation sequence, peanut yield was lower in strip tillage compared to conventional tillage at both locations (Table 3). The results for Rocky Mount in 2013 were consistent with previous findings that peanut yield in reduced tillage can be lower than the yield in conventional tillage systems on finer-textured soils [35]. Lower peanut yield can also occur on coarse-textured soils in reduced tillage compared with conventional tillage [35]. However, the likelihood of peanut yield being similar in reduced tillage and conventional tillage is greater when peanut is grown on coarser-textured soil [35]. The population of stunt nematodes was greater in strip tillage compared with conventional tillage at Rocky Mount (Table 3). However, it is unlikely that this population of nematodes in soil was the primary reason for the lower yield in strip tillage compared with conventional tillage. It is postulated that digging peanut in reduced tillage on finer-textured soils where soils are relatively flat compared with conventional tillage on these soils with raised seedbeds results in greater pod loss at digging [35].

Table 3. Influence of tillage system on peanut yield at Lewiston-Woodville and Rocky Mount and population of stunt nematodes at harvest at Rocky Mount in 2013.

Tillage System (2007–2013) [a]	Peanut Yield		Stunt Nematode Population
	Lewiston-Woodville	Rocky Mount	
	kg/ha		No./500 cm^3
Conventional tillage	6250	6070	11
Strip tillage	5620	4920	55
P > F	*	*	*

* Indicates significance at $p \leq 0.05$. Data are pooled over levels of crop rotation sequence. [a] Conventional tillage consisted of two passes with a disk harrow, one pass with a field cultivator, and bedding with in-row sub-soiling at a depth of 25 cm. Strip tillage consisted of fluted coulters, two rolling baskets, and in-row sub-soiling on a 45 cm band on 91 cm rows.

The peanut yield at Lewiston-Woodville in 2013 was lower when peanut was planted in two of seven years compared with the yield when peanut followed six years of cotton and corn (Table 4). The lower yield with the additional year of peanut in the crop sequence may have been a result of injury from root-knot nematodes. A significantly higher population of root-knot nematodes was observed when the rotation had one more year of peanut (Table 4). The lack of a response to crop sequence at Rocky Mount may have been a result of overall lower populations of dagger and ring nematodes (Table 5). Additionally, the dagger nematode population in soil was higher when peanut was only planted in 2013. This result is unexpected because corn is a host of dagger nematodes, while cotton and peanut are not and each rotation sequence had the same number of years of corn [35]. In contrast, the population of ring nematodes was lower when peanut was planted in one year compared to two years. This is expected given peanut is a host for ring nematodes [35].

Table 4. Influence of rotation sequence on peanut yield and population of root-knot nematode at harvest at Lewiston-Woodville in 2013.

Rotation Sequence (2007–2013) [a]								
2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Peanut Yield**	**Root-Knot Nematode Population**
							kg/ha	**No./500 cm^3**
CT	CT	CT	PN	CN	CT	PN	5430	1766
CT	CT	CT	CT	CN	CT	PN	6440	10
P > F							*	*

* Indicates significance at $p \leq 0.05$. Data are pooled over levels of tillage system. [a] Abbreviations: CN, corn; CT, cotton; PN, peanut.

Table 5. Influence of rotation sequence on population of dagger and ring nematodes at harvest at Rocky Mount in 2013.

Rotation Sequence (2007–2013) [a]							Plant-Parasitic Nematode Population	
2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Dagger**	**Ring**
							No./500 cm^3	
CT	CT	CT	PN	CN	CT	PN	3	65
CT	CT	CT	CT	CN	CT	PN	12	11
P > F							*	*

* Indicates significance at $p \leq 0.05$. [a] Abbreviations: CN, corn; CT, cotton; PN, peanut.

3.2. Peanut Yield and Plant-Parasitic Nematode Population in Soil in 2019 and 2022

The interaction of the tillage system, the length of rotation relative to peanut, previous crops, and nematicide was not significant for peanut yield at either location during either year (Supplemental Tables S3 and S4). Two-way and three-way interactions were also not significant for peanut yield. Rotation length was significant for peanut yield at Lewiston-Woodville in 2019 and 2022. No other main effects were significant for peanut yield. In 2019, peanut yield was greater when cotton or corn were the only crops in the rotation between peanut in 2013 and 2019 (Table 6). This difference in peanut yield due to crop sequence was also noted in 2022 after two years of corn was planted in all plots during 2020 and 2021.

Table 6. Influence of rotation on peanut yield in 2019 and 2022 at Lewiston-Woodville.

Rotation Sequence (2013–2018) [a]						Peanut Yield	
2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2022**
						kg/ha	
PN	CN or CT	CN or CT	PN	CN or CT	CN or CT	5600	3840
PN	CN or CT	CN or CT	CN or CT	CN or CT	CN or CT	6240	4400
P > F						*	*

* Indicates significance at $p \leq 0.05$. The data are pooled over levels of previous crops in the rotation, the tillage system, and nematicide treatment. [a] Abbreviations: CN, corn; CT, cotton; PN, peanut.

Plant condition, a reflection of plant health, was affected by the interaction of rotation length, previous crops, and the tillage system in 2019 at Lewiston-Woodville. When pooled over nematicide treatments, the plant-condition rating was higher when peanut was strip-tilled compared with conventional tillage and when fewer years of cotton separated peanut plantings (Table 7). No difference in plant condition was noted between conventional and strip tillage systems for the other combinations of rotation length and previous crops. In 2022, at this location, plant condition was rated higher when peanut was strip-tilled (4.2 on a scale of 0–5) compared with conventional tillage (3.9).

Table 7. The plant-condition rating as influenced by the interaction of crop rotation length relative to peanut, cotton, or corn as the previous crop, and tillage system at Lewiston-Woodville in 2019 [a].

Rotation Sequence (2013–2018) [b]							
2013	**2014**	**2015**	**2016**	**2017**	**2018**	**Tillage System** [c]	**Plant Condition** [d] **Scale 0–5**
PN	CT	CT	PN	CT	CT	Conventional	4.2 b
PN	CT	CT	PN	CT	CT	Strip	4.5 a
PN	CN	CN	PN	CN	CN	Conventional	4.2 b
PN	CN	CN	PN	CN	CN	Strip	4.2 b
PN	CT	CT	CT	CT	CT	Conventional	4.6 a
PN	CT	CT	CT	CT	CT	Strip	4.4 ab
PN	CN	CN	CN	CN	CN	Conventional	4.4 ab
PN	CN	CN	CN	CN	CN	Strip	4.6 a

[a] Means followed by the same letter are not significant at $p \leq 0.05$. [b] Abbreviations: CN, corn; CT, cotton; PN, peanut. [c] Conventional tillage consisted of two passes with a disk harrow, one pass with a field cultivator, and bedding with in-row sub-soiling at a depth of 25 cm. Strip tillage consisted of fluted coulters, two rolling baskets, and in-row sub-soiling on a 45 cm band on 91 cm rows. [d] Ordinal scale of 0 to 5 where 0 = yellow peanut canopy and 5 = deep green peanut canopy.

At Rocky Mount, peanut yield was affected by the main effect of the tillage system during both years but not by crop sequence. When pooled over crop sequence and nematicide treatment, peanut yield was 810 kg/ha and 770 kg/ha higher in 2019 and 2022, respectively, when peanut was planted in conventional tillage compared with strip tillage. In 2019, plant condition was lower when peanut was planted into the strip tillage system compared with conventional tillage and when peanut was planted in fewer years. No difference in plant condition was noted between tillage systems when peanut was planted one more year in the crop sequence (Table 8). However, plant condition was lower in strip tillage when peanut was not planted from 2014–2018. Plant condition did not differ when comparing rotation length relative to peanut within a tillage system.

Table 8. Influence of rotation sequence and tillage system on plant condition at Rocky Mount in 2019 [a].

Rotation Sequence (2013–2018) [b]						Plant Condition	
2013	**2014**	**2015**	**2016**	**2017**	**2018**	**Conventional Tillage**	**Strip Tillage**
						Scale 0–5	
PN	CN	CT	PN	CN	CT	4.5 ab	4.3 bc
PN	CN	CN	CT	CN	CT	4.6 a	4.2 c

[a] Means followed by the same letter are not significant at $p \leq 0.05$. The data for the plant-condition rating are pooled over nematicide treatment. [b] Abbreviations: CN, corn; CT, cotton; PN, peanut.

The population of dagger nematodes was 5 individuals/500 cm^3 when comparing response to crop rotation length and previous crops at Lewiston-Woodville in 2019 (Table 9). While differences in the population of this nematode were noted when comparing rotations, these differences are likely not biologically significant. The highest population of lesion nematodes in soil was noted when peanut was planted for fewer years and when corn was the previous rotation crop (Table 9).

The interaction of rotation sequence, strip tillage, and nematicide was significant for spiral nematode populations in soil (Table 10). Although spiral nematode populations were relatively low, the interaction was caused primarily by differences in the population when fluopyram was applied due to the tillage system and when peanut was planted in the shorter rotation relative to peanut. In the longer rotation, no difference in spiral populations in soil was noted when comparing combinations of rotation, tillage, and fluopyram. The cause of the change in response to fluopyram as a result of tillage in the shorter rotation is not known. The lack of difference in fluopyram treatment in the longer rotation was expected because fewer years of peanut would likely result in lower populations of this nematode in soil and there is a greater chance that no response to fluopyram would be observed.

Table 9. The population of dagger and lesion nematodes in soil at the harvest of peanut as affected by the interaction of crop rotation length relative to peanut and cotton or corn as the previous crop at Lewiston-Woodville in 2019 [a].

Rotation Sequence (2013–2018) [b]						Population of Plant-Parasitic Nematodes in Soil	
						Dagger	Lesion
2013	2014	2015	2016	2017	2018	No./500 cm^3	
PN	CN	CN	PN	CN	CV	5 a	101 a
PN	CT	CT	PN	CT	CT	0 b	23 b
PN	CN	CN	CN	CN	CN	2 ab	11 b
PN	CT	CT	CT	CT	CT	0 b	21 b

[a] Means within a column followed by the same letter are not significant at $p \leq 0.05$. The data are pooled over levels of the tillage system and nematicide treatment. [b] Abbreviations: CN, corn; CT, cotton; PN, peanut.

Table 10. The population of spiral nematodes at the harvest of peanut as affected by the interaction of crop rotation length relative to peanut, the tillage system, and nematicide treatment at Lewiston-Woodville in 2019 [a].

Rotation Sequence (2013–2018) [b]							Spiral Nematode Population	
							Nematicide Treatment [d]	
2013	2014	2015	2016	2017	2018	Tillage System [c]	No Fluopyram	Fluopyram
							No./500 cm^3	
PN	CN or CT	CN or CT	PN	CN or CT	CN or CT	Conventional	0 b	16 a
PN	CN or CT	CN or CT	PN	CN or CT	CN or CT	Strip	16 a	0 b
PN	CN or CT	CN or CT	CN or CT	CN or CT	CN or CT	Conventional	11 ab	6 ab
PN	CN or CT	CN or CT	CN or CT	CN or CT	CN or CT	Strip	0 b	0 b

[a] Means followed by the same letter are not significant at $p \leq 0.05$. The data are pooled over levels of the previous crop. [b] Abbreviations: CN, corn; CT, cotton; PN, peanut. [c] Conventional tillage consisted of two passes with a disk harrow, one pass with a field cultivator, and bedding with in-row sub-soiling at a depth of 25 cm. Strip tillage consisted of fluted coulters, two rolling baskets, and in-row sub-soiling on a 45 cm band on 91 cm rows. [d] Fluopyram applied at 0.25 kg/ha in the seed furrow at planting.

Though corn, cotton, and peanut are non-hosts for soybean cyst nematodes [56,57], relatively low populations were found in the soil. Differences in soybean cyst nematode populations due to the tillage system in 2019 and 2022 were observed at Lewiston-Woodville. When pooled over levels of other treatment factors, the population of this nematode was lower in conventional tillage in 2019 but higher in this tillage system in 2022. The apparent change in response between the two years could not be explained. Rotation sequence and fluopyram did not affect the soybean cyst nematode population in 2019 but did affect this nematode in 2022. The rotation sequence with fewer years of peanut had lower populations of soybean cyst nematode compared to the short rotation relative to peanut. This is unexpected because corn and cotton are non-hosts of soybean cyst nematodes.

In 2019 at Lewiston-Woodville, the population of root-knot nematodes in soil was affected by the main effect of rotation. When pooled over previous crops, the tillage system, and fluopyram treatment, the population of this nematode in soil was higher when peanut was planted in three years from 2013 to 2019 (1091 nematodes/cm^3) compared with planting only in 2013 and 2019 (29 nematodes/500 cm^3). This response was expected because peanut is an effective host for this nematode [56]. Jordan et al. [35] reported higher populations of root-knot nematodes at these locations when peanut was present in the rotation more frequently compared with corn or cotton.

The stunt nematode population was affected by the interaction of the rotation sequence and the tillage system. When pooled over previous crops and fluopyram treatment, no difference in population was observed based on the rotation when peanut was planted in conventional tillage (30 to 40 nematodes/500 cm^3). However, in strip tillage, with the longer rotation relative to peanut, a higher population of this nematode was observed in comparison to the longer rotation in conventional tillage (65 vs. 40 nematodes/cm^3) or when comparing the long rotation with the shorter rotation within the strip tillage system (65 vs. 26 nematodes/500 cm^3). Cotton is not a host of stunt nematodes [57]; however, corn is [58]. This could explain the higher populations of this nematode in the longer rotation sequence.

In 2022, at Lewiston-Woodville, the root-knot nematode population was affected by the interaction of rotation length relative to peanut, the previous crop in the rotation, the tillage system, and fluopyram treatment (Table 11). No difference in the nematode population was observed in the shorter rotation relative to peanut in the absence of fluopyram, regardless of the previous crop in the rotation or the tillage system (Table 11). In the longer rotation sequence without fluopyram, a higher population of root-knot nematodes was observed when cotton was the previous crop in the rotation in conventional tillage compared with corn in strip tillage. When fluopyram was applied, fewer differences in population were observed as a result of the rotation sequence, the previous crop, and the tillage system. When comparing fluopyram treatments based on combinations of the rotation sequence, the previous crop, and the tillage system, fluopyram lowered the nematode population when the rotation sequence was short relative to peanut and when corn was the previous crop in continuous conventional tillage or when cotton was the previous crop in continuous strip tillage. It is important to note that these differences were observed when the population of nematodes was considerably higher in the no-fluopyram control compared with the populations in the absence of fluopyram for other rotation sequence, previous crop, and tillage system combinations.

Table 11. The population of root-knot nematodes at the harvest of peanut as affected by the interaction of crop rotation length relative to peanut, cotton, or corn as the previous crop, tillage system, or nematicide treatment at Lewiston-Woodville in 2022 [a].

Rotation Length and Crop Sequence (2013–2018) [b]							Root-Knot Nematode Population — Nematicide Treatment [d]	
2013	**2014**	**2015**	**2016**	**2017**	**2018**	**Tillage System** [c]	**No Fluopyram**	**Fluopyram**
							No./500 cm^3	
PN	CT	CT	PN	CT	CT	Conventional	788 ab	1075 ab
PN	CN	CN	PN	CN	CN	Conventional	4120 a	83 bc
PN	CT	CT	PN	CT	CT	Strip	3285 a	565 bc
PN	CN	CN	PN	CN	CN	Strip	2023 a	1748 ab
PN	CT	CT	CT	CT	CT	Conventional	823 ab	16 c
PN	CN	CN	CN	CN	CN	Conventional	406 bc	18 c
PN	CT	CT	CT	CT	CT	Strip	28 bc	11 c
PN	CN	CN	CN	CN	CN	Strip	3 c	15 c

[a] Means followed by the same letter are not significant at $p \leq 0.05$. [b] Abbreviations: CN, corn; CT, cotton; PN, peanut. [c] Conventional tillage consisted of two passes with a disk harrow, one pass with a field cultivator, and bedding with in-row sub-soiling at a depth of 25 cm. Strip tillage consisted of fluted coulters, two rolling baskets, and in-row sub-soiling on a 45 cm band on 91 cm rows. [d] Fluopyram applied at 0.25 kg/ha in the seed furrow at planting.

The populations of soybean cyst nematodes were lower when cotton was in the rotation rather than corn in 2019 (11 vs. 5 nematodes/500 cm^3) and 2020 (9 vs. 2 nematodes/500 cm^3) at Lewiston-Woodville. Similarly, in 2019, at this location, spiral and stunt nematode populations in soil were lower when cotton was planted compared with corn (11 vs.

2 nematodes/500 cm^3 and 57 vs. 24 nematodes/500 cm^3, respectively). This is probably due to the fact that cotton is not a host of stunt or spiral nematodes [59].

At Rocky Mount, in 2019, the population of dagger nematodes in soil was affected by the interaction of crop rotation and fluopyram treatment. When pooled over tillage systems, the population of this nematode was highest with the longer rotation when fluopyram was applied (11 nematodes/500 cm^3) compared with this rotation sequence in the absence of fluopyram (1 nematode/500 cm^3) or when one more year of peanut was included in the rotation irrespective of fluopyram treatment (2 nematodes/500 cm^3). These results could not be easily explained as a lower population of nematode in soil would be expected due to fluopyram treatment. A higher population of ring nematodes was noted when fewer years of peanut were present in the rotation (4723 vs. 2575 nematodes/500 cm^3). Similarly, a greater number of soybean cyst nematodes were noted when peanut was included more frequently in the rotation sequence (13 vs. 2 nematodes/500 cm^3). The stubby root nematode population was affected by the interaction of the tillage system and fluopyram treatment. When pooled over crop rotation, the population in soil was lower when fluopyram was applied in conventional tillage (1 nematode/500 cm^3) compared with no treatment of fluopyram (6 nematodes/500 cm^3) or with conventional tillage when fluopyram was applied (6 nematodes/500 cm^3) compared to strip tillage when fluopyram was applied (2 nematodes/500 cm^3). Fluopyram did not affect the population of this nematode in strip tillage.

4. Conclusions

The results from these experiments provide information on the response of peanut and plant-parasitic nematode populations in soil to rotation sequence, the previous crop in the rotation sequence, the tillage system, and fluopyram treatment. While variability in nematode populations was observed among different taxa with respect to cultural practices (e.g., the length of rotation relative to peanut, the previous crop in the rotation, and the tillage system) and nematicide treatment, interactions of these treatment factors did not translate directly into differences in peanut yield. These results suggest that fluopyram has limited utility in North Carolina under the edaphic and environmental conditions in these studies against populations of nematodes in these experiments. The results underscore the value of crop sequence in optimizing peanut yield and highlight the challenges of the adoption of reduced tillage systems for peanut, especially on finer-textured soils. The peanut yield was lower when grown on finer-textured soils in reduced tillage systems compared with conventional tillage, irrespective of cropping sequence or nematicide treatment. However, on coarser-textured soil, the peanut yield was similar in both tillage systems. These results also indicate that peanut yield responded independently to the tillage system and crop rotation sequence (e.g., a lack of an interaction of these treatment factors). This suggests that growers can transition to different crop rotation sequences and observe a similar response regardless of the tillage system. Likewise, the response to the transition to a different tillage system will not be affected by the crop rotation sequence.

Information gained from this research can be utilized in a number of ways. The presentation of the information through traditional Cooperative Extension Service platforms can be used by farmers and their advisors to optimize pest management and crop yield. The information can also be incorporated into decision tools that have been developed to manage risk. The findings from this research study will be incorporated into this risk management tool with respect to the impact of cropping sequence, tillage systems, and the use of fluopyram. Based on these results, the potential for nematodes in crops that follow peanut in a rotation can be estimated.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agronomy14040875/s1, Table S1: Plant-parasitic nematode taxa (including species name and authority where known), and the average and range of population densities across all treatments at harvest at Lewiston-Woodville and Rocky Mount in 2013, 2019, and 2022; Table S2: Analysis of variance for peanut yield and population of plant-parasitic nematodes in soil at Lewiston-

Woodville in 2013; Table S3: Analysis of variance for peanut yield and population of plant-parasitic nematodes at Rocky Mount in 2013; Table S4: Analysis of variance for peanut yield, plant condition rating, and populations of plant-parasitic nematodes at harvest at Lewiston-Woodville in 2019 and 2022; Table S5: Analysis of variance for peanut yield, plant condition rating, and populations of plant-parasitic nematodes at harvest at Rocky Mount in 2019 and 2022.

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References

1. Anderson, R.L.; Bailey, K.L.; Peairs, F.B. Guidelines for integrating ecological principles of pest management with rotation design. In *Dryland Agriculture*; Peterson, G.A., Unger, P.W., Payne, W.A., Eds.; Agronomy Monograph. 23; ASA and SSSA: Madison, WI, USA, 2006; pp. 195–225.
2. Lamb, M.C.; Davidson, J.I.; Butts, C.L. Peanut yield decline in the southeast and economically reasonable solutions. *Peanut Sci.* **1993**, *20*, 36–40. [CrossRef]
3. Barker, K.R.; Olthof, T.H.A. Relationships between nematode population densities and crop responses. *Annu. Rev. Phytopathol.* **1976**, *14*, 327–353. [CrossRef]
4. Culbreath, A.K.; Beute, M.K.; Shew, B.B.; Barker, K.R. Effects of *Meloidogyne hapla* and *M. arenaria* on black rot severity in new *Cylindrocladium*-resistant peanut genotypes. *Plant Dis.* **1992**, *76*, 352–357. [CrossRef]
5. Diomande, M.; Beute, M.K. Effects of *Meloidogyne hapla* and *Macroposthonia ornate* on Cylindrocladium Black Rot of Peanut. *Ecol. Epidemiol.* **1981**, *71*, 491–496.
6. Johnson, W.C., III; Brenneman, T.B.; Baker, S.H.; Johnson, A.W.; Sumner, D.R.; Mullinix, B.G., Jr. Tillage and pest management considerations in a peanut-cotton rotation in the southeastern Coastal Plain. *Agron. J.* **2001**, *93*, 570–576. [CrossRef]
7. Rodriguez-Kabana, R.; Ivey, H.; Backman, P.A. Peanut-cotton rotations for management of *Meloidogyne arenaria*. *J. Nematol.* **1987**, *19*, 484–487. [PubMed]
8. Rodriguez-Kabana, R.; Touchton, J.T. Corn and sorghum rotations for management of *Meloidogyne arenaria* in peanut. *Nematropica* **1984**, *14*, 26–36.
9. Hearn, A.B. Effect of preceding crop on the nitrogen requirements of irrigated cotton (*Gossypium hirsutum* L.) on a vertisol. *Field Crops Res.* **1986**, *13*, 159–175. [CrossRef]
10. Omay, A.B.; Rice, C.W.; Maddux, L.D.; Gordon, W.B. Corn yield and nitrogen uptake in monoculture and in rotation with soybean. *Soil Sci. Soc. Am. J.* **1998**, *62*, 1596–1603. [CrossRef]
11. Oyer, L.J.; Touchton, J.T. Utilizing legume cropping systems to reduce nitrogen fertilizer requirements for conservation-tilled corn. *Agron. J.* **1990**, *82*, 1123–1127. [CrossRef]
12. Rochester, I.J.; Peoples, M.B.; Hulugalle, N.R.; Gault, R.R.; Constable, G.A. Using legumes to enhance nitrogen fertility and improve soil condition in cotton cropping systems. *Field Crops Res.* **2001**, *70*, 27–41. [CrossRef]
13. Vetsch, J.A.; Randall, G.W.; Lamb, J.A. Corn and soybean production as affected by tillage systems. *Agron. J.* **2007**, *99*, 952–959. [CrossRef]
14. Baumhardt, R.L.; Lascano, R.J. Rain infiltration as affected by wheat residue amount and distribution in ridged tillage. *Soil Sci. Soc. Am. J.* **1996**, *60*, 1908–1913. [CrossRef]
15. Bruce, R.R.; Langdale, G.W.; West, L.T.; Miller, W.P. Soil surface modification by biomass inputs affecting rainfall infiltration. *Soil Sci. Soc. Am. J.* **1992**, *56*, 1614–1620. [CrossRef]
16. Hudson, B.D. Soil organic matter available water capacity. *J. Soil Water Conserv.* **1994**, *49*, 189–194.
17. Kemper, B.; Derpsch, R. Results of studies made in 1978 and to control erosion by cover crops and no-tillage techniques in Paraná, Brazil. *Soil Tillage Res.* **1981**, *1*, 253–267. [CrossRef]
18. Lithourgidis, A.S.; Dhima, K.V.; Damalas, C.S.; Vasilakoglou, I.B.; Eleftherohorinos, I.G. Tillage effects on wheat emergence and yield at varying seeding rates, and on labor and fuel consumption. *Crop Sci.* **2006**, *46*, 1187–1192. [CrossRef]

19. Le Bissonnais, Y. Experimental study and modeling of soil surface crusting processes. In *Soil Erosion, Experiments and Models*; Bryan, R.B., Ed.; Catena Supplement: Waganingen, The Netherlands, 1990; pp. 13–38.
20. Naderman, G.; Brock, B.; Reddy, G.B.; Raczkowski, C.W. Continuous conservation tillage: Effects on soil density, soil C and N in the prime rooting zone. In Proceedings of the 26th Conservation Tillage Conference for Sustainable Agriculture, Raleigh, NC, USA, 8–9 June 2004; Jordan, D., Caldwell, D., Eds.; North Carolina Agricultural Research Service Technical Bulletin TB-321: Raleigh, NC, USA, 2004; pp. 15–25.
21. Price, A.J.; Reeves, D.W.; Patterson, M.G. Evaluation of weed control provided by three winter cereals in conservation-tillage soybean. *Renew. Agric. Food Syst.* **2006**, *21*, 159–164. [CrossRef]
22. Price, A.J.; Reeves, D.W.; Patterson, M.G.; Gamble, B.E.; Balkcom, K.S.; Arriaga, F.J.; Monks, C.D. Weed control in peanut in a high residue conservation-tillage system. *Peanut Sci.* **2007**, *34*, 59–64. [CrossRef]
23. Raimbaunt, B.A.; Vyn, T.J. Crop rotation and tillage effects on corn growth and soil structural stability. *Agron. J.* **1991**, *83*, 979–985. [CrossRef]
24. Raper, R.L.; Reeves, D.W.; Burt, E.C.; Torbert, H.A. Conservation tillage and traffic effects on soil conditions. *Trans. Am. Soc. Agric. Eng.* **1994**, *37*, 763–768. [CrossRef]
25. Reeves, D.W. Cover crops and rotations. In *Crops Residue Management*; Hatfield, J.L., Stewart, B.A., Eds.; Advances in Soil Science; Lewis Publishers: Boca Raton, FL, USA, 1994; pp. 125–172.
26. Reeves, D.W. The role of soil organic matter in maintaining soil quality in continuous cropping systems. *Soil Tillage Res.* **1997**, *43*, 131–167. [CrossRef]
27. Riley, H.C.; Bleken, M.A.; Abrahamsen, S.; Bergjord, A.K.; Bakken, A.K. Effects of alternative tillage systems on soil quality and yield of spring cereals on silty clay loam and sandy loam soils in cool, wet climate of central Norway. *Soil Tillage Res.* **2005**, *80*, 79–93. [CrossRef]
28. Schwab, E.B.; Reeves, D.W.; Burmester, C.H.; Raper, R.L. Conservation tillage systems for cotton in the Tennessee Valley. *Soil Sci. Soc. Am. J.* **2002**, *66*, 569–577. [CrossRef]
29. Smart, J.R.; Bradford, J.M. Conservation tillage corn production for a semiarid, subtropical environment. *Agron. J.* **1999**, *91*, 116–121. [CrossRef]
30. Truman, C.C.; Reeves, D.W.; Shaw, J.N.; Motta, A.C.; Burmester, C.H.; Raper, R.L.; Schwab, E.B. Tillage impacts on soil property, runoff, and soil loss variations of a Rhodic Paleudult under simulated rainfall. *J. Soil Water Conserv.* **2003**, *58*, 258–267.
31. Truman, C.C.; Shaw, J.N.; Reeves, D.W. Tillage effects on rainfall partitioning and sediment yield from an Ultisol in central Alabama. *J. Soil Water Conserv.* **2005**, *60*, 89–98.
32. Jordan, D.L.; Auman, D.; Brandenburg, R.L.; Buol, G.; Collins, A.; Dunne, J.; Foote, E.; Gorny, A.; Lux, L.; Reisig, D.; et al. *Peanut Information 2024*; North Carolina Cooperative Extension Service Publication AG-331: Raleigh, NC, USA, 2024.
33. Jackson, J.L.; Beasley, J.P., Jr.; Tubbs, R.S.; Lee, R.D.; Grey, T.L. Fall-bedding for reduced digging losses and improved yield in strip-till peanut. *Peanut Sci.* **2011**, *38*, 31–40. [CrossRef]
34. Al-Kaisi, M.; Archontoulis, S.; Kwaw-Mensah, D.; Miguez, F. Tillage and crop rotation effects on corn agronomic response and economic return at seven Iowa locations. *Agron. J.* **2015**, *107*, 1411–1424. [CrossRef]
35. Jordan, D.L.; Barnes, J.S.; Corbett, T.; Bogle, C.R.; Johnson, P.D.; Shew, B.B.; Koenning, S.R.; Ye, W.; Brandenburg, R.L. Crop response to rotation and tillage in peanut-based cropping systems. *Agron. J.* **2008**, *100*, 1580–1586. [CrossRef]
36. Katsvario, T.W.; Cox, W.J. Tillage x rotation x management interactions in corn. *Agron. J.* **2000**, *92*, 493–500. [CrossRef]
37. Katvairo, T.W.; Wright, D.L.; Marios, J.J.; Hartzog, D.L.; Balkom, K.B.; Wiatrak, P.P.; Rich, J.R. Performance of peanut and cotton in a bahiagrass cropping system. *Agron. J.* **2007**, *99*, 1245–1251. [CrossRef]
38. Soon, Y.K.; Clayton, G.W. Eight years of crop rotation and tillage effects on crop production and N fertilizer use. *Can. J. Soil Sci.* **2002**, *82*, 165–172. [CrossRef]
39. Wilhelm, W.W.; Wortmann, C.S. Tillage and rotation interactions for corn and soybean grain yield as affected by precipitation and air temperature. *Agron. J.* **2004**, *96*, 425–432. [CrossRef]
40. Zuber, S.M.; Behnke, G.D.; Nafziger, E.D.; Villamil, M.B. Crop rotation and tillage effects on soil physical and chemical properties in Illinois. *Agron. J.* **2015**, *107*, 971–978. [CrossRef]
41. Colvin, D.L.; Brecke, B.J. Peanut cultivar response to tillage systems. *Peanut Sci.* **1988**, *15*, 21–24. [CrossRef]
42. Godsey, C.B.; Vitale, J.; Mulder, P.G.; Armstrong, J.Q.; Damicone, J.P.; Jackson, K.; Suehs, K. Reduced tillage practices for the southwestern US peanut production region. *Peanut Sci.* **2011**, *38*, 41–47. [CrossRef]
43. Marios, J.J.; Wright, D.L. Effect of tillage system, phorate, and cultivar on tomato spotted wilt of peanut. *Agron. J.* **2003**, *95*, 386–389. [CrossRef]
44. Zhao, D.; Wright, D.L.; Marios, J.J. Peanut yield and grade responses to timing of Bahiagrass termination and tillage in a sod-based crop rotation. *Peanut Sci.* **2009**, *36*, 196–203. [CrossRef]
45. Grichar, W.J. Long-term effects of three tillage systems on peanut grade, yield, and stem rot development. *Peanut Sci.* **1998**, *25*, 59–62. [CrossRef]
46. Grabau, Z.J.; Mauldin, M.D.; Habteweld, A.; Carter, E.T. Nematicide efficacy at managing *Meloidogyne arenaria* and non-target effects on free-living nematodes in peanut production. *J. Nematol.* **2020**, *52*, e2020–28. [CrossRef] [PubMed]
47. Hagan, A.K.; Bowen, K.L.; Strayer-Scherer, A.; Campbell, H.L.; Parker, C. Evaluation of fluopyram for disease and root knot nematode control along with yield response on peanut. *Crop Prot.* **2024**, *175*, 106459. [CrossRef]

48. Kemerait, R.C.; Walls, J.T.; Brenneman, T.B.; Rucker, K.; Hunt, D. Assessment of fluopyram for management of the peanut root-knot nematode, *Meloidogyne arenaria* (Abstr.). *Proc. Am. Peanut Res. Educ. Soc.* **2013**, *45*, 22.
49. Isleib, T.G.; Rice, P.W.; Bailey, J.E.; Mozingo, R.W.; Pattee, H.E. Registration of 'NC 12C' peanut. *Crop Sci.* **1997**, *37*, 1976. [CrossRef]
50. Mozingo, R.W.; Coffelt, T.A.; Isleib, T.G. Registration of 'VA 98R' peanut. *Crop Sci.* **2000**, *40*, 1202–1203. [CrossRef]
51. Isleib, T.G.; Milla-Lewis, S.R.; Pattee, H.E.; Copeland, S.C.; Zuleta, M.C.; Shew, B.B.; Hollowell, J.E.; Sanders, T.H.; Dean, L.O.; Hendrix, K.W.; et al. Registration of "Bailey" peanut. *J. Plant Regist.* **2011**, *5*, 27–39. [CrossRef]
52. Anonymous. Peanut Varieties. North Carolina Crop Improvement Association. 2024. Available online: https://www.nccrop.com/varieties.php/6/Peanut (accessed on 15 April 2024).
53. Williams, E.J.; Drexler, J.S. A non-destructive method for determining peanut pod maturity, pericarp, mesocarp, color, morphology, and classification. *Peanut Sci.* **1981**, *8*, 134–141. [CrossRef]
54. Byrd, D.W., Jr.; Barker, K.R.; Ferris, H.; Nusbaum, C.J.; Griffin, W.E.; Small, R.H.; Stone, C.A. Two semi-automatic elutriators for extracting nematodes and certain fungi from soil. *J. Nematol.* **1976**, *8*, 206–212. [PubMed]
55. Jenkins, W.R. A rapid centrifugal-floatation technique for separating nematodes from soil. *Plant Dis. Rep.* **1964**, *48*, 692.
56. Ahumada, D.; Gorny, A. Disease Management in Cotton. In *Cotton Information 2024*; Edmisten, K.L., Ed.; AG-417; North Carolina Cooperative Extension Service Publication AG-417: Raleigh, NC, USA, 2024; pp. 65–75. Available online: https://content.ces.ncsu.edu/cotton-information (accessed on 15 April 2024).
57. Gorny, A.; Lux, L. *Soybean Cyst Nematode*; NC Extension Soybean Disease Information; North Carolina Cooperative Extension Service: Raleigh, NC, USA, 2023. Available online: https://content.ces.ncsu.edu/management-of-soybean-cyst-nematode (accessed on 15 April 2024).
58. Minton, N.A.; Baujard, P. Nematode parasites of peanut. In *Plant-Parasitic Nematodes in Subtropical Agriculture*; Luc, M., Sikora, R.A., Bridge, J., Eds.; CABI: Wallingford, UK, 1990; pp. 285–321.
59. Barker, K.R. Influence of geographic area and previous crop on occurrence and densities of plant-parasitic nematodes in North Carolina. *Plant Dis. Rep.* **1974**, *58*, 991–995.