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ARTICLE

Winter covers, planting dates and cultivar influence on diseases and nematode pests of peanut in a rainfed production system

A.K. Hagan[1*]; K.L. Bowen[1]; H.L. Campbell[1]; A. Strayer-Scherer[1]; C. Parker[2]

[1]First, second, third, and fourth author are Emeritus Professor, Professor, Retired Research Associate, Associate Professor, Department of Entomology and Plant Pathology, Auburn University, Auburn, AL 36849

[2]Fifth author is an Associate Superintendent, Wiregrass Research and Extension Center, Headland, AL 36345

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Corresponding Author:
A.K. Hagan
haganak@auburn.edu

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ABSTRACT

Peanuts (*Arachis hypogaea* L.) are a valuable crop in Alabama that is vulnerable to tomato spotted wilt (TSW), stem rot (SR), and the peanut root-knot nematode (PRKN, *Meloidogyne arenaria* Race 1). Winter covers are widely employed in Alabama strip or no-till peanuts to suppress erosion and runoff as well as enhance moisture retention and carbon sequestration. Adjusting planting dates for disease avoidance along with disease and nematode resistant cultivars help maximize yield and reduce input costs. Here, the influence of the cereal winter covers (oat, rye, and wheat) along with a weed fallow was evaluated on the above diseases and nematode pest, as well as yield components, in the following peanut crop on a rainfed site with resident *M. arenaria* and *Agroathelia* (*Sclerotium*) *rolfsii* (SR) populations. The impact of April or May planting dates along with the PRKN-resistant Tifguard and susceptible Georgia-09B cultivars, both of which are partially resistant to TSW, and any interactions were assessed annually from 2014 to 2018. Superior yields were often obtained for peanut cropped behind a rye or weed fallow compared with oats and wheat. Except for oats in 2017 and 2018, pod grades did not significantly differ by winter cover. In addition, winter cover had limited effects on TSW and SR indices, root and pod galling (RKDam) and *M. arenaria* juvenile populations (RKPop) in the following peanut crop. While yield was greater for April than May peanut plantings for the 2017 and 2018 study period, May plantings had superior yields in 2016 with similar yield reported for both plantings in 2014 and 2015. Higher grades were noted for May than April plantings in only one of five years with similar grades for both plantings recorded for the remaining four years. Planting date had limited impact on TSW and SR indices along with RKDam and RKPop. Georgia-09B often suffered greater SR than Tifguard. In addition, the resistant cultivar Tifguard had significantly less RKDam along with lower final PRKN juvenile populations compared with the susceptible Georgia-09B. Because of reduced SR, RKDam, and RKpop, Tifguard produced significantly greater yield than Georgia-09B. Except for 2015, Tifguard and Georgia-09B had similar grades. Therefore, the PRKN-resistant Tifguard consistently produced significantly greater yield often with less damage attributed to SR along with PRKN in a rainfed production system compared with the susceptible Georgia-09B with a rye or weed fallow being the preferred winter cover for optimizing yield of strip-till peanuts.

INTRODUCTION

Behind corn (105,218 ha), cotton (159,851 ha), and soybean (141,640 ha), peanuts (*Arachis hypogaea* L.), planted on 76,081 ha and valued at $564 million in 2024, are the fourth widely produced row crop in Alabama (USDA NASS, 2025). While peanuts are produced in 33 of 67 counties in Alabama, the bulk of the acreage is in counties adjacent to the Florida Panhandle. Due to extended periods of dry late summer and early fall weather in 2024, average yield for Alabama declined to 3363 kg / ha compared with 4200 and 4560 kg / ha for 2023 and 2022, respectively (USDA NASS, 2024). In addition, approximately 90% of peanut acreage in Alabama (USDA NASS, 2024) is rainfed compared with approximately 50% in Georgia (Porter, 2022).

Production practices that intensify diseases and nematode pests and potential yield loss include cropping patterns such as a peanut monoculture or one year out rotation with corn or cotton (Johnson *et al.*, 1998; Rodríguez-Kábana *et al.*, 1991), irrigation (Fulmer *et al.*, 2019), cultivar selection (Woodward *et al.*, 2008), planting date (Fulmer *et al.*, 2019; Hagan *et al.*, 2001; Jordan *et al.*, 2019) and seeding rate (Hagan *et al.*, 2015). Occurrence of tomato spotted wilt (TSW), which is caused by the thrips-transmitted tomato spotted wilt virus (TSWV), genus *Orthotospovirus*; family *Bunyaviridae*, has sharply intensified in Alabama in recent years (Hagan *et al.*, 2023) and is best controlled with a combination of TSWV resistance, mid-May or later planting, twin row planting pattern, strip or no till, and recommended seeding rates (Brown *et al.*, 2005; Hagan *et al.*, 2015; Johnson *et al.*, 2001; Monfort *et al.*, 2004; Srinivasan *et al.*, 2017). Following a century of peanut production in Alabama, Florida, and Georgia, stem rot (SR, *Agroathelia rolfsii* Redhead & S-T. Mullineux (anamorph *Sclerotium rolfsii* Sacc.)) and the peanut root-knot nematode (PRKN, *Meloidogyne arenaria* race 1 (Neal) Chitwood) are widely distributed and often damaging pests of peanuts (Bowen *et al.*, 1996; Timper *et al.*, 2018). Wet/dry and hot late summer weather patterns favor SR development (Bowen, 2003), while moist soil moisture conditions for an extended time period favor PRKN reproduction (Hagan *et al.*, 2025). Cropping a non-host crop such as corn and/or cotton for a minimum of two years in between peanuts is a sustainable and cost-effective method for minimizing PRKN-incited yield loss, particularly when compared with nematicides (Bowen *et al.*, 1996; Hagan *et al.*, 2025; Rodríguez-Kábana and Touchton, 1984). Additionally, establishment of PRKN-resistant cultivars, with resistance introgressed from *A. cardenasii* (Starr et al. 2002), is an effective but often underutilized method of avoiding significant yield loss (Brenneman *et al.*, 2017; Hagan *et al.*, 2025). However, concerns about yield potential and grade compared with commercial standard cultivars, especially in fields where *M. arenaria* populations are low or absent, have limited the adoption of PRKN resistant cultivars (Grabau *et al.*, 2020; Starr *et al.*, 2002).

Winter cover crops are an integral component in Southern crop production systems, primarily for producers employing strip or no-till practices. Strip or no-till with a winter cover, accelerated with the introduction of USDA NRCS conservation farm plans, is designed to suppress soil and wind erosion (Johnson *et al.*, 2006; Wallander *et al.*, 2021), enhance soil quality and health by enhancing microbial flora and fauna diversity (Lehman *et al.*, 2015), improve water infiltration and moisture retention (Hawkins *et al.*, 2016), and nutrient recycling (Bender and van der Heijden, 2015) while reducing fuel and labor inputs and CO_2 emissions (Godsey *et al.*, 2011; Sørensen and Nielsen, 2005). Additionally, enhanced carbon sequestration to increase percent (%) organic soil carbon is observed in strip and particularly no-till as compared with a conventional till production system (Veum *et al.*, 2002). However, weed management issues have slowed the adoption of strip till practices for peanuts (Monfort and Tubbs, 2022). Presently, approximately 60% of the acreage cropped to peanuts in Alabama is strip or no-tilled (Balkcom, *Personal Communication*).

Tillage affects the occurrence of diseases and nematode pests of peanuts Johnson *et al.* (2001) and Monfort *et al.* (2004) observed a significant reduction in TSW incidence in strip and/or no-till systems compared with conventionally till peanuts. While greater SR has been recorded for strip than no- or conventionally till peanuts (Grichar, 1998), others have noted that tillage did not influence SR incidence (Godsey *et al.*, 2011; Hartzog and Adams, 1989; Minton *et al.*, 1991; and Sorensen *et al.*, 2010). The impact of strip-till on PRKN juvenile population dynamics has not been assessed. Overall, most field trials addressing the influence of tillage practices on the occurrence of diseases and nematode pests have been conducted primarily on irrigated and not rainfed peanuts (Godsey *et al.*, 2011; Grichar, 1998; Johnson *et al.*, 1998; Johnson *et al.*, 2001; Minton *et al.*, 1991; Monfort *et al.*, 2004; Sorensen *et al.*, 2010).

In Alabama, rye and to a lesser extent wheat and oats are employed as a winter cover crop preceding peanuts, typically with limited supplemental fall and layby fertilization. However, most overwintering fields going into reduced till peanuts the following spring are not planted to a winter cereal but are maintained in a weed fallow. In Georgia, common winter weeds on fallowed fields after peanut or cotton, in no particular order, include wild radish (*Raphanus raphanistrum* L.), cutleaf evening primrose (*Oenothera laciniata* Hill), henbit (*Lamium amplexicaule* L.), Italian ryegrass (*Lolium multiflorum* Lam.), common and mouse-ear chickweed (*Stellaria media* L. and *Cerastium fontanum* Baumg., respectively), Carolina geranium (*Geranium carolinianum* L.), swinecress (*Lepidum coronopus* L.), and red sorrel (*Rumex acetosella* L.) (Prostko, *Personal Communication*).

Limited information is available concerning the impact of winter cover crops on diseases and, to a lesser extent, nematode pests in peanuts. In Alabama, Campbell *et al.* (2002) reported that the incidence of TSW and SR in peanuts did not significantly differ following wheat, rye, oats, ryegrass, or weed fallow. When weed fallow and rye were compared in Georgia, populations of PRKN and *Belonolaimus longicaudatus* Rau (sting nematode) on the following irrigated peanuts were similar, though a reduction in root and pod galling was noted in two of seven years in peanut after the former winter cover (Johnson *et al.*, 1998). Similar populations of PRKN were also noted for peanut following weed fallow and rye (Rodríguez-Kábana and Ivey, 1986). Wang *et al.* (2004) also did not report any reductions in PRKN populations on irrigated peanuts cropped behind wheat, rye, oats, lupine (*Lupus augustifolius*

L.), hairy vetch (*Vicia villosa* Roth), or crimson clover (*Trifolium incarnatum* L.).

The objective of the study was to compare the influence of selected cereals (oats, rye, and wheat) along with a weed fallow on the occurrence of TSW, SR, juvenile populations and damage associated with PRKN, along with yield and grade of the following peanut crop in a rainfed strip-till production system. In addition, the influence of planting date along with that of selected commercial PRKN-resistant and susceptible cultivars on the above variables was assessed.

MATERIALS AND METHODS

The study site, which has a resident population of the peanut root-knot nematode (PRKN) and the causal fungus of stem rot [syn white mold], is located at the Wiregrass Research and Extension Center (WGREC; 31° 22" 34' N 85° 18" 54' W) in Headland, AL. In mid- to late-November, the winter cover crops Wrens Abruzzi rye (*Secale cereale* L.), Florida 501 oats (*Avena sativa* L.), and Jamestown wheat (*Triticum aestivum* L.) were sown with a no-till drill on 18 cm centers at 67 kg seed / ha following cotton (*Gossypium hirsutum* L.) in a Dothan fine sandy loam [fine-loamy, kaolintic, themic plinthic kandiudults; 0-2% slope; < 1% organic matter]. While rye, oats, and weed fallow were included in all studies conducted between 2014 and 2018, wheat was grown only in 2014, 2015, and 2016. A weed fallow treatment was included where the dominant weeds were henbit, common chickweed, Italian ryegrass, and wild radish, none of which are known hosts of *M. arenaria* (Rich *et al.*, 2008). Individual cover crop plots, which were arranged in four complete blocks, were 14.6 m wide by 15.2 m long. In each year, adjustments in soil fertility and pH were according to the results of a soil fertility assay done by the Auburn University Soil, Forage & Water Testing Laboratory. No pre- or post-plant supplemental nitrogen or pesticide applications were made to the above winter covers. Winter covers and weeds were terminated with a mid-March application of glyphosate at 1.12 kg / ha (Roundup PowerMAX®, Bayer CropScience, St. Louis MO).

In each year, a factorial set of treatments were arranged in a split-split plot design with winter cover as the whole plot, planting date as the split plot, and peanut cultivar as the split-split plot. Individual subplots, which consisted of four 15.2 m rows on 0.9 m centers, were randomized in four complete blocks. Prior to planting, rows in the terminated winter cover were laid off with a KMC strip till implement with rolling baskets. A conventional tillage treatment for peanut was not included in the study design. In all years, the PRKN-susceptible cultivar, Georgia-09B [listed as GA09B in tables] (Branch, 2010), and the PRKN resistant cultivar, Tifguard (Holbrook *et al.*, 2008), were sown at 13 seed / m row and were cropped behind one year of cotton. Both are obsolete runner, high-oleic market-type cultivars that display partial TSW resistance (Branch, 2010; Holbrook *et al.*, 2008). Planting dates are listed in Table 1. Disease and weed control recommendations of the Alabama Cooperative Extension System were followed (Majumdar *et al.*, 2025). Thrips control was obtained with an in-furrow application of 1.12 kg / ha phorate (Thimet 20G, AMVAC Chemical Corporation, Newport Beach, CA). Soil fertility and pH adjustments were according to the results of a soil fertility assay done by the Auburn University Soil, Forage & Water Testing Laboratory. The study area was not irrigated.

Table 1. Dates for the early and late plantings, along with TSW incidence assessment, plot inversion, and nematode soil assay collection for each planting.

Year	Planting		TSW incidence		Plot inversion [z]		Nematode soil assay [y]	
	Early	Late	Early	Late	Early	Late	Early	Late
2014	28 Apr	29 May	5 Aug	19 Aug	19 Sep	13 Oct	30 Sep	10 Oct
2015	24 Apr	22 May	2 Sep	5 Oct	8 Sep	9 Oct	26 Aug	
2016	20 Apr	17 May	30 Aug	22 Sep	2 Sep	3 Oct	26 Aug	30 Sep
2017	18 Apr	17 May	28 Aug	20 Sep	5 Sep	29 Sep	23 Aug	19 Sep
2018	22 Apr	4 Jun	27 Aug	9 Oct	2 Sep	18 Oct	16 Aug	28 Sep

[z] Stem rot (SR) incidence along with the level of root and pod damage (RKDam) attributed to M. arenaria was rated immediately after plot inversion.

[y] Prior to plot inversion at each planting date, soil samples for a nematode assay were randomly collected from the root zone of the plants in the center two 'yield' rows and consisted to ten subsamples of 2.5 cm diameter cores taken to a depth of 10 cm. In 2015, both plantings were sampled on 26 Aug.

Rating dates for TSW are listed in Table 1. Loci counts for TSW (1 locus was defined as < 30.5 cm consecutive row of disease-damaged plants per row) were made on the two harvest rows in each plot (Branch et al., 2021; Culbreath et al., 2010; Hagan et al., 2023). Prior to plot inversion for each planting date (Table 1), soil samples consisting of ten subsamples of 2.5 cm diameter cores collected to a 10 cm depth, were randomly taken from the root zone of plants in the center two rows of each plot. Soil subsamples were stored in a cooler at 3°C until processed, then thoroughly mixed, and 100 cm^3 of soil was processed using the centrifugal-flotation method for determining juvenile root-knot nematode densities (Jenkins, 1964). Nematode populations are presented as number of root-knot juveniles per 100 cm^3 of soil (RKpop). Stem rot incidence (SR), presented as the number of loci (< 30.5 cm of consecutive symptomatic plants in row) in each of two center rows, was recorded immediately following plot inversion (Table 1). In addition, damage to the roots and pods attributed to the peanut root-knot nematode (RKDam), which was rated on a 1 to 5 scale where 1 = no visible damage to 5 = 75 to 100% of roots or pods damaged over the yield rows, was recorded immediately after plot inversion. Inversion dates listed in Table 1 were determined using the hull scrape method as described by Williams and Drexler (1981). Plots were mechanically harvested four to seven d following inversion. Heated forced air (35%) was employed to reduce kernel moisture to approximately 7-8% prior to collecting weights for yield. Farmer stock grade for a 500 g sample of the above in-shell peanuts from each plot was determined using USDA grading procedures (USDA, 2019).

Data analysis.

Data for TSW, SR, RKDam, RKpop, and yield, were analyzed with a generalized linear mixed model approach (PROC GLIMMIX: SAS 9.4 with ddfm=satterthwaite option). Year, winter cover crop, cultivar, and the four-way interaction of year × winter cover crop × planting date × cultivar were treated as fixed factors; random effects were block and block within year. Statistical analyses were conducted on rank transformations of data for TSW, SR, RKDam, and RKpop to normalize variances, which were back transformed for presentation. Means separation was according to Fisher's protected least significant difference (LSD) test ($P = 0.05$). Since the winter cover treatments differed, data analysis for the 2014 to 2016 and 2017 to 2018 trials were separated.

Daily maximum and minimum temperatures along with rainfall were recorded by and collected from the AL Mesonet station at WGREC each year. Plots were located within 2 km of the weather station. The evenness or regularity with which rain events occurred was calculated using the Shannon Diversity-Evenness Index (SDI) (Bronikowski and Webb, 1996). As SDI approaches 1.0, rainfall regularity increases, e.g., rain events would consistently occur every other day of the period being monitored.

RESULTS

Influence of Production Inputs on Tomato Spotted Wilt and Stem Rot

The incidence of TSW was significantly affected by year, cultivar, and a year × cultivar interaction ($P = 0.0001$) but not winter cover ($P = 0.3187$) or planting date ($P = 0.060$) (Table 2). Overall TSW incidence was low with disease indices ranging from a non-significant 0.1% to 1% of symptomatic plants in 2014 and 2016, respectively. The percentage of symptomatic plants were similarly low for Tifguard, while those for Georgia-09B differed significantly by year with significant stepwise increases in TSW incidence observed in each year between 2014 to 2016 (Fig. 1).

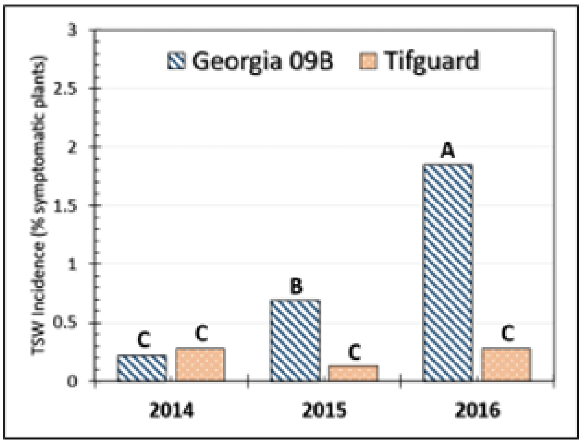

Figure 1. TSW incidence in peanuts influenced by an interaction of year × cultivar. Means with the same letter are not significantly different according to Fisher's least significant difference (LSD) test ($P < 0.05$).

For 2017 and 2018, TSW incidence significantly differed by year ($P = 0.0433$) but not winter cover ($P = 0.8551$), planting date ($P = 0.2568$), cultivar ($P = 0.1139$), or any interactions between two or more of the above variables (Table 3). While overall TSW incidence here was similar to levels recorded in the previous three years, the percentage of symptomatic plants was significantly greater at 0.25% in 2017 than at 0.06% in 2018.

For 2014 to 2016, SR incidence differed by year × planting date according to a significant year × planting date interaction ($P = 0.0076$) but not by winter cover ($P = 0.8259$) or cultivar ($P = 0.9188$) (Table 2). Planting date affected SR incidence in 2015 with significantly greater disease indices recorded for April than May planting dates (Fig. 2A). In 2014 and 2016, similar disease levels occurred at both planting dates.

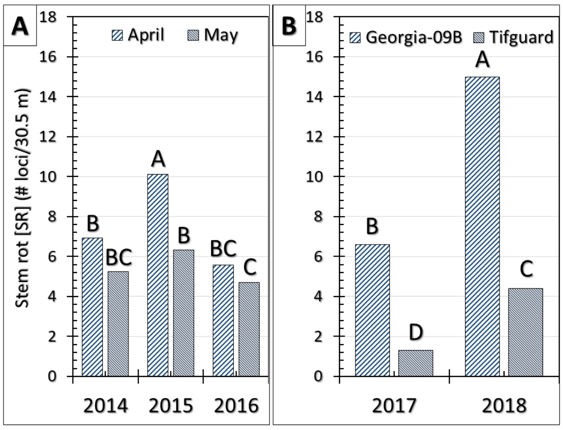

Figure 2. Incidence of stem rot in peanuts as influenced by a significant year × planting date interaction in 2014 to 2016 and significant year × cultivar interaction in 2017 and 2018. Means in each figure with the same letter are not significantly different according to Fisher's least significant difference (LSD) test ($P < 0.05$).

In 2017 and 2018, a significant year × cultivar interaction (P = 0.0291) showed that SR incidence differed by year and cultivar but not planting date (P = 0.7138), weed cover (P = 0.8836), or interactions of the latter variables (Table 3). For both years, SR incidence was greater for Georgia-09B than Tifguard with higher disease ratings noted for both cultivars in 2018 compared with 2017 (Fig. 2B). Similar stem rot indices were noted for April and May plantings with 7.0 and 6.6 loci / 30.5 m of row recorded, respectively. With SR indices ranging from 6.4 to 7.2 loci / 30.5 m of row, statistically similar disease ratings were recorded for rye, wheat, and weed fallow.

Table 2. F values for generalized linear models for effects of year, winter cover crops, planting date, and cultivar on TSW and SR incidence, root and pod damage (RKDam), peanut root knot juvenile counts (RKpop), pod yield, and grade (TSMK), 2014 to 2016.

	F value					
Source	TSW	SR	RKDam	RKpop	Yield	Grade
Year (YR)	16.20*** z	8.92***	0.90	27.56***	53.30***	114.50***
Cover Crop (CC)	1.18	0.30	11.32***	2.64	11.30***	1.42
YR × CC	0.73	1.72	0.47	2.92*	1.91	1.69
Planting Date (PD)	3.43	6.18*	10.48**	37.02***	13.18***	9.48**
YR × PD	0.20	5.04**	4.09*	12.79***	6.95**	36.04***
CC × PD	0.61	2.17	0.58	1.92	0.83	0.93
YR × CC × PD	0.73	1.22	1.55	2.75*	0.75	0.60
Cultivar (CV)	30.90***	0.01	174.66***	50.93***	46.44***	0.44
YR x CV	14.64***	0.73	14.42***	21.86***	1.14	4.21*
CC × CV	1.45	0.74	8.61***	2.25	1.80	1.40
YR × CC × CV	0.40	0.40	0.33	2.95**	0.39	0.16
PD × CV	0.26	1.67	0.29	20.68***	2.62	0.23
YR × PD × CV	1.79	1.88	6.67**	12.33***	1.08	1.54
CC × PD × CV	0.50	0.91	0.29	1.63	0.45	0.04
YR × CC × PD × CV	0.56	0.33	0.78	2.81*	0.78	0.82

z Significance at the 0.05, 0.01, and 0.001 levels is indicated by *, **, and ***, respectively.

Table 3. F values for generalized linear models for effects of year, winter cover crop, planting date, and cultivar on TSW and SR incidence, root and pod damage (RKDam), peanut root knot juvenile counts (RKpop), pod yield, and grade, 2017 and 2018.

	F Values					
Source	TSW	SR	RKDam	RKpop	Yield	Grade
Year (YR)	4.23* z	23.25***	0.64	22.05***	23.51***	9.84**
Cover Crop (CC)	1.31	0.14	1.00	0.01	5.60**	14.05***
YR × CC	0.05	0.00	0.16	2.25	8.73***	24.73***
Planting Date (PD)	0.16	0.12	1.91	1.23	7.07**	0.25
YR × PD	0.16	1.95	1.61	1.28	1.81	3.44*
CC × PD	0.37	0.07	0.91	0.72	0.33	0.34
YR × CC × PD	0.37	0.86	0.60	0.98	1.81	0.34
Cultivar (CV)	2.56	44.17***	25.08***	20.34***	43.37***	1.69
YR x CV	1.31	4.96*	0.64	9.92**	1.01	0.47
CC × CV	0.47	0.00	1.00	0.05	3.64	0.47
YR × CC × CV	1.31	0.93	0.16	2.25	0.34	1.69
PD × CV	0.37	0.11	1.91	0.28	1.69	4.37*
YR × PD × CV	0.99	0.62	1.61	0.26	0.80	0.43
CC × PD × CV	0.16	0.13	0.91	0.12	0.19	0.09
YR × CC × PD × CV	0.37	1.49	0.60	0.34	0.98	0.13

z Significance at the 0.05, 0.01, and 0.001 levels is indicated by *, **, and ***, respectively.

Production Inputs Effect on Peanut Root-Knot

For 2014 through 2016, significant year × planting date × cultivar (P = 0.0017) and cover crop × cultivar (P < 0.0001) interactions for RKDam were recorded (Table 3). As expected, RKDam was consistently lower for Tifguard than Georgia-09B (Fig. 3). Reduced RKDam values for the May compared with April plantings were recorded for Georgia-09B in 2015 and Tifguard in 2016 (Table 4).

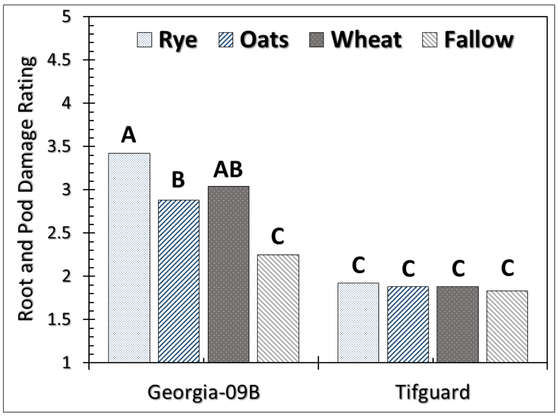

Figure 3. Peanut root-knot damage (RKDam) to the pods and roots as influenced by an interaction of winter cover × cultivar in 2014 through 2016. Means with the same letter are not significantly different according to Fisher's least significant difference (LSD) test (P < 0.05).

Table 4. Peanut root-knot pod and root damage (RKDam) as influenced by year × planting date × cultivar interaction in 2014, 2015. and 2016.

	Root-knot pod and root damage (RKDam) [z]					
	2014		2015		2016	
Planting date	GA09B	Tifguard	GA09B	Tifguard	GA09B	Tifguard
April	2.6 cd [y]	2.0 e	3.2 ab	2.0 e	3.3 a	1.9 e
May	2.7 bcd	2.1 e	2.4 d	2.0 e	3.1 abc	1.3 f

[z] Ratings of root-knot galling to the pods and roots (RKDam) were made on a 1 to 5 scale with 1 = no damage and 5 = severe galling on the roots, pegs, and pods, immediately after plot inversion.

[y] Means in all columns followed by the same letter are not significantly different according to Fisher's least significant difference (LSD) test (P < 0.05).

In 2017 and 2018, cultivar (P < 0.0001) but not year (P = 0.4256), planting date (P = 0.3199), or winter cover (P = 0.1549), or interactions among the latter variables significantly impacted RKDam (Table 3). As previously noted, RKDam values were significantly lower for Tifguard than Georgia-09B (data not shown).

As indicated by a significant interaction for 2014 through 2016, RKPop differed (P = 0.0218) by year, winter cover, planting date, and cultivar (Table 2). With few exceptions, RKPop values for all cover crops did not significantly differ across study years. In 2014 and 2016, RKPop values were often significantly lower for Tifguard than Georgia-09B regardless of the planting date (Table 5). In addition, Tifguard generally supported lower RKPop than Georgia-09B, except for the May 2015 planting, where similarly low PRKN juvenile counts were recorded for both cultivars.

For 2017 and 2018, RKPop significantly (P = 0.0024) differed by year and cultivar (Table 3). Lower RKPop values were noted in 2018 than 2017 on both cultivars with Tifguard supporting significantly lower PRKN juvenile populations than Georgia-09B (Fig. 4). Winter cover (P = 0.2992) and planting date (P = 0.9264) did not influence RKPop on either cultivar.

Table 5. Final peanut root-knot juvenile (J2) counts (RKpop) as influenced by a year × winter cover crop × planting date × cultivar interaction for 2014 to 2016.

		Final peanut root-knot juvenile (J2) counts (RKPop) [z]					
		2014		2015		2016	
Planting date[y]	Winter cover	GA09B	Tifguard	GA09B	Tifguard	GA09B	Tifguard
April	Rye	1367 a [x]	72 b-i	294 abc	53 d-k	249 a-d	27 e-o
	Oats	1602 a	39 h-n	28 h-o	111 d-m	196 a-d	18 h-o
	Wheat	1444 a	179 a-d	272 abc	64 c-h	95 c-g	139 c-m
	Weed Fallow	120 b-f	72 c-i	325 abc	114 bcd	161 a-d	28 h-m
May	Rye	324 ab	72 b-i	5 mno	10 j-o	202 b-e	22 h-o
	Oats	72 b-g	39 m-p	20 f-o	9 j-o	73 c-k	17 i-o
	Wheat	179 a-d	11 k-o	14 i-o	25 o	95 f-o	12 l-o
	Weed Fallow	193 abc	52 c-i	10 h-o	23 h-o	71 c-k	4 no

[z] Counts of peanut root-knot J2 juveniles per 100 cc soil.

[y] Planting dates for each study year are listed in Table 1.

[x] Means followed in all columns by the same letter are not significantly different according to Fisher's least significant difference (LSD) test (P < 0.05).

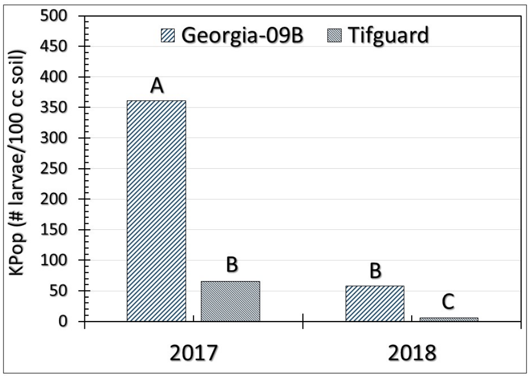

Figure 4. Peanut root-knot juvenile populations (RKPop) as influenced by a year × cultivar interaction in 2017 and 2018 with the cultivars Georgia-09B and Tifguard. Means with the same letter in each figure are not significantly different according to Fisher's least significant difference (LSD) test (P < 0.05).

Yield and Grade Response to Production Inputs

As indicated by a significant year × planting date interaction (P = 0.0123), yield differed significantly for 2014, 2015, and 2016 for the April and May plantings along with cultivar (P < 0.0001) and winter cover (P < 0.0001) (Table 2). At both planting dates, a significant stepwise increase in yield was noted from 2014 through 2016. In 2016 but not in previous years, a significantly greater yield of 5172 compared with 4593 kg / ha was recorded for May than April plantings, respectively. Averaged across study years, Tifguard produced significantly greater yield compared with Georgia-09B (Fig. 5A). At 4000 and 4274 kg / ha, peanuts cropped behind rye or weed fallow, respectively, when averaged over planting dates and years produced similarly greater yields than oat and wheat at 3585 and 3683 kg / ha, respectively (Fig. 5B).

For 2017 and 2018, yield was significantly impacted by year × winter cover interaction (P < 0.0001), planting date (P < 0.0001), and cultivar (P < 0.0001) (Table 3). In 2017, similarly greater yields were recorded for the weed fallow and rye than for wheat. For the following year, peanuts cropped behind rye but not wheat produced significantly greater yield compared to the weed fallow with similar yields for peanuts following the former two winter covers. The absence of a significant winter cover × cultivar interaction illustrates that the yield gains recorded for peanuts behind the rye cover were similar for both cultivars. In addition, yield was significantly greater when averaged across both cultivars for the May (3737 kg / ha) than April (3378 kg / ha) planting (Fig. 6A). Finally, Tifguard (4003 kg / ha) produced significantly greater average yield for 2017 and 2018 than Georgia-09B (3111 kg / ha) (Fig. 6B).

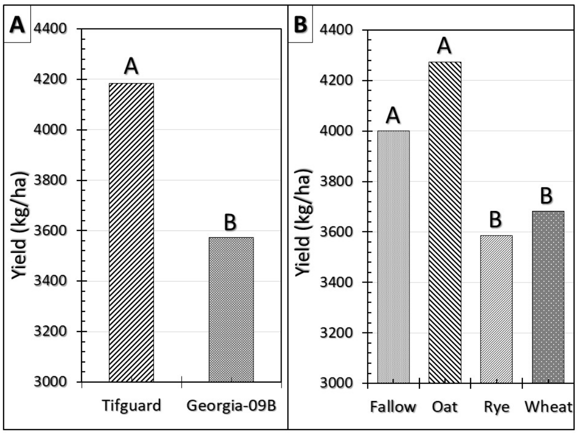

Figure 5. Peanut yield as impacted by A) cultivar and B) winter cover averaged over 2014, 2015 and 2016. All means with the same letter in each figure are not significantly different according to Fisher's least significant difference (LSD) test (P < 0.05).

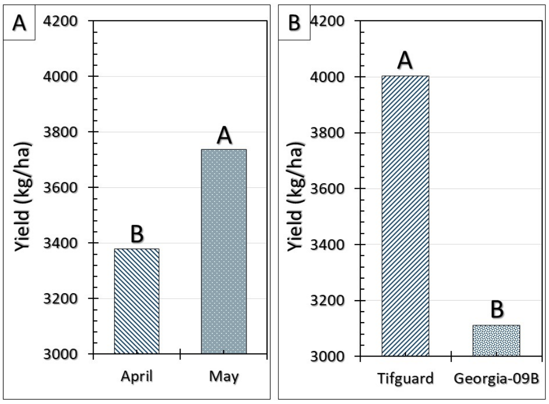

Figure 6. Yield as impacted by A) planting date and B) cultivar averaged across 2017 and 2018. All means with the same letter in each figure are not significantly different according to Fisher's least significant difference (LSD) test (P < 0.05).

Peanut grade as indicated by a significant year × planting date (P < 0.0001) and year × cultivar interaction (P = 0.0170) differed across the 2014 to 2016 study period by planting date as well as cultivar; however, winter cover did not significantly (P = 0.2414) affect this variable (Table 2). Equally greater grades were recorded in 2014 than 2015 and 2016, with similar intermediate values noted at both planting dates in the latter year (Fig. 7A). For 2015, but not other years, grades were significantly greater for April than May plantings. Both Georgia-09B and Tifguard had similarly greater grades in 2014 compared with 2015 and 2016 (Fig. 7B) with similarly higher values recorded in latter than the former year. While grades were poor in 2015, Tifguard had greater grades than Georgia-09B. Similar grades ranging from 66.1 to 67.2 were obtained for peanuts cropped behind all winter covers.

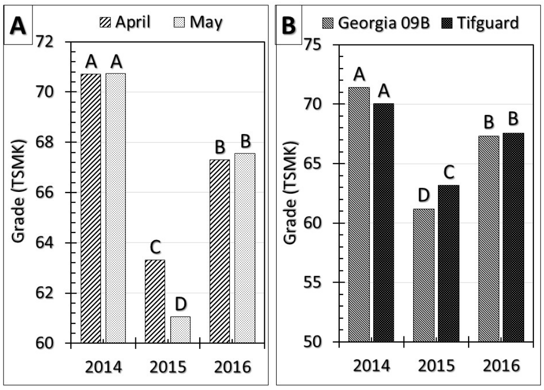

Figure 7. Peanut grade in 2014, 2015, and 2016 as influenced by A) significant year × winter cover and B) planting date × cultivar interactions. All means in each figure with the same letter are not significantly different according to Fisher's least significant difference (LSD) test (P < 0.05).

For the 2017 and 2018 study period, significant year × winter cover (P = 0.0373) and planting date × cultivar (P = 0.0162) interactions were recorded for grade (Table 3). In each of the above study years, no significant differences in grade were noted between the winter covers. In addition, grades for peanuts cropped behind oats were significantly greater in 2018 than 2017. For rye and weed fallow, similar grades for both cultivars in both years were recorded. While no significant differences in grade between cultivars were seen for each planting, higher values were recorded for the May than April planting of Tifguard but not Georgia-09B, which had similar grades for both plantings.

Some differences in weather parameters were noted between study years (Table 6). Except for 2016, maximum temperatures did not greatly differ from the 30-yr average, but minimum and average temperatures were consistently greater than the 30-yr average. Over the study period, rainfall totals for 2014 were well above the 30-yr average but were below to well below average for the remaining years. Surprisingly, low yields occurred in 2014 despite the highest yearly rainfall totals without an intensification of SR.

Table 6. Average maximum, minimum and average temperatures, total rain and rain days, and measure of rainfall uniformity from planting to inversion for each study year.

	Max Temp. (C)	Min Temp. (C)	Ave. Temp. (C)	Rain (cm)	Rain days (>0.25 cm)	SDI [z]
30-year average	30.8	19.4	25.1	64.2	--	--
2014	30.4	20.9	25.6	105.3	77	0.96
2015	31.9	20.3	26.1	40.5	47	0.66
2016	32.4	20.6	26.5	43.7	48	0.65
2017	30.1	19.8	25.0	52.9	51	0.73
2018	30.8	21.4	26.1	39.2	29	0.52

[z] SDI = Shannon's Diversity Index. Value reflects the uniformity of rain events, where approaching 1.0 reflects equal amounts of rain on a regular basis.

DISCUSSION

Winter covers, primarily rye, are widely used as winter grazing for feeder calves, for minimizing soil erosion (Johnson *et al.*, 2006; Wallander *et al.*, 2021), enhancing soil moisture retention (Hawkins et al., 2016), and nutrient recycling (Bender and van der Heijden, 2015). Here, peanut cropped behind rye, which already is the preferred cereal winter cover for Alabama peanut producers, consistently produced greater yields over the five-year study period compared with wheat and oats. Surprisingly, peanut following the winter weed fallow produced comparable yields as peanut cropped behind rye, except in 2018. Previously, few direct comparisons of the yield response of peanut to winter cereals have been made. When comparing rye and weed fallow, Johnson *et al.* (1998) noted that following irrigated peanuts yielded significantly greater following the former than latter winter cover in only one year between 1988 and 1994. In the two years that yield differences were reported by Campbell *et al.* (2002), yield rankings for peanuts following the above cereal covers did not always match those recorded here. In contrast to the study herein, the yield of peanuts cropped behind wheat and rye were similar in both years as compared with only one year for oats and weed fallow. In addition, yields were greater for strip till peanuts cropped behind black oats than oats, rye, triticale, or wheat in one of two years (Sorensen *et al.*, 2010).

Yield gains obtained following rye and weed fallow compared with wheat and oats are not closely linked to reductions in disease occurrence or PRKN suppression. While TSW has the potential to reduce peanut yield (Brown *et al.*, 2005), the low disease pressure noted over the study period, which matched that noted in a concurrent trial at the same location (Hagan *et al.*, 2023), was likely insufficient to cause a measurable decline in yield. As was noted here, Campbell *et al.* (2002) reported that winter covers, including a weed fallow, failed to influence TSW incidence in the following peanut crop. In contrast to TSW, SR indices and RKPop juvenile counts were sufficient to influence yield (Grichar, 1998; Hagan *et al.*, 2024; Minton *et al.*, 1991). For SR, however, similar loci counts were noted for peanuts cropped behind each of the winter covers, including the weed fallow, in all years. Previously in Alabama, oats, rye, and wheat, along with ryegrass and weed fallow failed to significantly impact SR incidence in the succeeding peanut crop (Campbell *et al.*, 2002). Sorensen *et al.* (2010) noted that yield gains observed for peanut behind black oats compared with other cereal covers were not associated with any reduction in the incidence of SR. Finally, the yield advantage for peanuts cropped behind rye and weed fallow was not reflected in a decline in RKDam values or RKPop juvenile counts when compared with those for oats and wheat. While Wang *et al.* (2004) reported lower *M. incognita* juvenile counts for rye and oats in September 2001 and April 2002, reduced juvenile populations were not compared with the yield of any summer crops. Overall, variations in disease incidence and PRKN juvenile counts cannot account for the yield gains observed for peanut cropped behind rye and the weed fallow compared with wheat and oats.

A plausible explanation for the differential yield response of peanut following oats, rye, wheat, and weed fallow is allelopathy, which occurs when leachates from straw of cereal or broadleaf covers influence germination, seedling emergence, and eventually yield of the following summer crop (Martinez-Feria *et al.*, 2016). Such phenomenon, which is usually suppressive but may be stimulatory, occurs in no-till when debris is near the target crops (Patrick *et al.* 1963). Overall, rye (Yenish *et al.*, 1996), oats (Guenzi *et al.*, 1967), and wheat (Wu *et al.*, 2001) residues have allelopathic activity with the former capable of providing significant weed suppression in the following peanut crop (Aulakh *et al.*, 2015). However, the potential suppressive and/or stimulatory activity of oats, rye, and wheat on seed germination, seedling growth, and yield of peanuts has not been established nor has the host status of oats, rye, and wheat to PRKN. Strip till peanuts, which often produces greater yield (Dowler *et al.*, 1999) or dollar value (Grichar and Boswell, 1987) compared with no-till, suggests that winter cover-related allelopathy may cause yield suppression. Here, greater yield for peanut following rye and weed fallow than oats and wheat suggests the former either maintains or enhances yield response or the latter two winter covers may suppress yield.

Yield gains for peanuts obtained with weed cover compared with oats and wheat are difficult to explain. As was noted for rye compared with oats or wheat, no reductions in SR indices or RKPop juvenile counts were associated with greater yields for peanut following the weed fallow. Henbit, which was the primary species in the weed fallow, along with chickweed and wild radish are hosts for *M. incognita* but not *M. arenaria* (Rich *et al.*, 2008). Among the plants identified in the weed fallow, only chickweed, which constituted only a small percentage (<1%) of total weed population, is a host for *A. rolfsii* (Hollowell and Shew, 2007). Given that winter soil temperatures were well below the optimum for SR (Punja, 1985) and PRKN (Dickson and Melouk, 1995) development along with the absence of a high susceptible host population, the weed fallow likely did not contribute to SR or PRKN development on the subsequent peanut crop. Of the common winter weeds, wild radish, henbit, and chickweed but not Italian ryegrass are hosts for TSWV (Parrella *et al.* 2003). Given the low TSW incidence during the study period, the former weed species likely had little if any effect on the occurrence of this disease in peanuts. Overall, the weeds in the fallowed plots likely did not increase inoculum density of virus, fungal, or nematode pests on peanuts, which may account for the similar yields for peanuts behind the weed fallow and rye. Overall, similarly higher yield for peanuts cropped behind winter weed fallow and rye compared with those for oats and wheat indicate that latter cover crops have a detrimental allelopathic effect on the yield of the following peanut crop.

Winter cover influenced peanut grades for 2017 and 2018 but not for the 2014 to 2016 study. While peanuts behind rye and weed fallow had similarly high grades both years, those following oats had higher grades in 2018 than 2017. Greater yields obtained for peanut cropped behind rye and the weed fallow are not reflected in enhanced grades. Previously, Sorensen *et al.* (2010) reported that winter cover crops, including oats, rye, and wheat, did not have a significant effect on peanut grade.

Planting date often influences the occurrence of diseases in peanuts. While previous irrigated studies in Alabama, Florida, Georgia, and Texas, have shown that mid- to late April compared with later May plantings are prone to greater TSW and subsequent yield loss (Culbreath *et al.*, 2010; Hagan *et al.*, 2015; Mitchell *et al.*, 1991; Tillman *et al.*, 2007), which is likely linked with elevated thrips vector populations (Brown *et al.*, 2005; Srinivasan *et al.*, 2017; Todd *et al.*, 1995). Here, planting date, largely due to low disease pressure, had no impact on the occurrence of TSW in either cultivar. While the dryland production system may contribute to the reduced TSW pressure, disease activity in a concurrent irrigated nematicide study at the same location was also negligible (Hagan *et al.*, 2025). Incidence of SR differed by planting date only in 2015 with greater disease noted for the April than May planting, which matches the response previously reported by Bowen (2003) and Hagan *et al.* (2001). Otherwise, planting date, in the remaining four study years, failed to influence development of this disease, which was previously noted by Branch *et al.* (2021) and Hagan *et al.* (2015). Limited information is available concerning the impact of planting date on PRKN galling on roots and pods along with juvenile populations. Here, the effect of planting date on the level of PRKN galling to the roots, pegs, and pods differed by year and cultivar with greater damage noted for the April than May planting of Georgia-09B in 2015 and Tifguard in 2016. In a prior Alabama study, Hagan *et al.* (2001) noted that planting date generally did not significantly impact the level of pod and root damage on PRKN-susceptible cultivars. Planting date had little influence on final PRKN juvenile populations on both the susceptible Georgia-09B and resistant Tifguard. No prior studies have addressed the impact of planting date on PRKN population dynamics on a susceptible or resistant peanut cultivar.

Under minimal TSW pressure, the influence of planting date on yield here along with previous studies was mixed. In 2016, May compared with April plantings had greater mean yield, while superior mean yield for both cultivars was recorded for April than May plantings for the 2017 and 2018 study. In addition, yield did not significantly differ by planting date and cultivar in either the first or second study period. To reduce the risk of sizable yield losses due to intense TSW pressure, recommended planting dates were shifted from late April to mid- to late May (Brown *et al.,* 2005). Under light to moderate TSW pressure, McKinney and Tillman (2017) recorded similar yields for Florida-07 and Georgia Green along with two breeding lines at mid-April to mid-May planting dates. Concurrently, Hagan *et al.* (2015) noted a yield response to planting date in only one of three years with greater yield recorded for April than May plantings of Georgia Green, Georgia-06G, and Florida-07.

Due in large measure to superior resistance to SR and PRKN, Tifguard, which is a product of the COAN (Starr et al., 2002) PKRN resistance lineage along with TifNV-High O/L (Holbrook et al., 2017), TifNV-HG (Holbrook et al., 2023), Georgia-14N (Branch and Brenneman, 2015), and Georgia-22MPR (Branch and Brenneman, 2023) consistently produced significantly greater yield than Georgia-09B in a dryland production system. Concurrently, Hagan *et al.* (2025) recorded similar reductions in SR incidence, but similar yields for Tifguard compared with previous industry standard, Georgia-06G, with the PRKN-resistant TifNV-High O/L producing superior yields compared with the latter cultivar. In the absence of damaging PRKN populations but similar TSW and Total Disease (TSW + SR) indices, Branch *et al.* (2021) reported that Georgia-09B produced significantly greater yield than Tifguard in 30 irrigated and rainfed field trials conducted over a 3-yr period. Overall, this and the concurrent study (Hagan *et al.*, 2025) illustrate the value in terms of reduced SR and PRKN damage and resulting superior yields often associated with the use of resistant cultivars on irrigated and rainfed sites with potentially damaging resident *A. rolfsii* and *M. arenaria* Race 1 populations.

Similarly low yields to those noted in 2014 were also seen after the dry summer of 2018. As previously reported by Hagan *et al.* (2025), dry weather patterns in 2018 likely contributed to greatly reduced PRKN juvenile populations, particularly on the root-knot susceptible Georgia-09B, along with elevated SR indices (Bowen, 2003). Unlike the above study (Hagan *et al.*, 2025), yield gains associated with reduced PRKN juvenile populations did not occur due to the dry weather patterns in 2018, which likely suppressed nematode reproduction and their influence on yield (Wilcox-Lee and Loria 1987). In contrast, the elevated PRKN juvenile counts noted in 2014 were likely associated with the high rainfall, which was uniform across the production season as indicated by a high Shannon's Diversity Index value.

Despite having limited impact on diseases and nematodes, superior yields were noted in the following peanuts cropped after a rye compared to oats or wheat winter covers; weed fallow often giving greater yields than the latter cereal winter covers. While the response of disease and nematode activity along with yield over five years was muted in part due to the rainfed production system, the PRKN-resistant Tifguard, which also suffered less SR damage, greatly out yielded the PRKN-susceptible Georgia-09B in a one-year out rotation with cotton on a rainfed site with established *M. arenaria* Race 1 and *A. rolfsii* populations, a common situation across Alabama, Florida, and Georgia. Overall, the yield response of Tifguard was significantly better here, and in a concurrent study (Hagan *et al.,* 2025) than has been recorded in irrigated trials when PRKN and SR pressure was negligible (Branch 2021; Grabau *et al.*, 2020; Hagan *et al.*, 2023).

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