

Influence of Planting Date and Insecticide on Injury Caused by Tobacco Thrips and Peanut Yield in North Carolina

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ABSTRACT

Planting date can affect pest incidence and severity in peanut. Research was conducted from 2013 to 2016 in North Carolina to determine tobacco thrips [*Frankliniella fusca* (Hinds)] injury and pod yield when peanut was planted in early, mid-, and late-May when phorate was applied in the seed furrow at planting, acephate was applied to emerged peanut 3 wk after planting, or when both insecticides were applied. Differences in visible injury to peanut caused by tobacco thrips feeding were observed across yr, planting dates, and insecticide treatments. Applying either phorate or acephate was often as effective as the combination of both insecticides in preventing injury caused by tobacco thrips although in some instances applying both insecticides was more effective than a single insecticide. Visible injury caused by tobacco thrips was often greater when peanut was planted in early May compared with later plantings. Peanut yield was protected equally from tobacco thrips injury by phorate, acephate, and the combination of both insecticides. Planting date and insecticides affected peanut yield independently suggesting that strategies for managing tobacco thrips will not differ across planting dates in North Carolina. Peanut yield was greater in 2 of 4 yr when planted in mid-May compared with planting in early or late-May.

Key Words: acephate; cultivar Bailey; cultural practices; integrated pest management; phorate; systemic insecticide; Virginia market type.

Tobacco thrips, *Frankliniella fusca* (Hinds), is an important pest in peanut and if not adequately controlled may limit vegetative growth, delay pod maturation, and reduce yields caused by injury from direct feeding during early stage peanut growth (Drake *et al.*, 2009; Herbert *et al.*, 2007; Marasigan *et al.*, 2016). In addition to direct injury,

thrips (*Frankliniella* spp.) are a vector for tomato spotted wilt virus (family *Bunyaviridae*, genus *Tospovirus*). Tomato spotted wilt (TSW) reduces pod quality, impedes plant vigor, and may be yield limiting if incidence is severe (Culbreath *et al.*, 2003; Culbreath and Srinivasan 2011; Lassiter *et al.*, 2016). Cultural practices to suppress thrips populations and minimize incidence of TSW include increased plant populations, planting in twin rows, utilizing resistant cultivars, planting to avoid peak thrips flight, using conservation tillage, and applying phorate in the seed furrow at planting (Culbreath *et al.*, 2003).

In North Carolina peanut can be planted the entire month of May, but growers are cautioned for late-May plantings as weather conditions during the season or at harvesting may reduce yields (Drake *et al.*, 2014). Altering planting dates has been shown to affect peanut yield and thrips injury in peanut (Carley *et al.*, 2008; Drake *et al.*, 2014; Hurt *et al.*, 2005). In a three year study, Carley *et al.* (2008) reported greater peanut yields for those planted in mid-May compared to early or late-May in two out of the three yr. In the third year, no significant differences in yield were noted among planting dates. In a four year study, Drake *et al.* (2014) reported greater yields from late-May plantings compared to early May plantings in two out of four yr. Hurt *et al.* (2005) reported approximately 20% less thrips injury when peanut was planted in late-May compared with those planted in early May. While the effect of planting date on yield, pod maturity, or TSW has been investigated, research defining the relationship of planting date and thrips control with insecticidal treatments is limited in North Carolina (Carley *et al.*, 2008; Culbreath *et al.*, 2008; Culbreath *et al.*, 2010; Drake *et al.*, 2014; Hurt *et al.*, 2005).

While employing cultural control methods to minimize impact of thrips on peanut is important for farm managers, insecticides are typically applied to suppress thrips and protect peanut yield in North Carolina (Brandenburg, 2017). Phorate applied in the seed furrow at planting or acephate applied postemergence (POST) to peanut foliage are used to control thrips (Herbert *et al.*, 2007; Marasigan *et al.*, 2016; Rhodes *et al.*, 2008; Tubbs *et al.*, 2013; Whalen *et al.*, 2014). Whalen *et al.* (2014) reported less thrips injury and greater yield when phorate was applied in the seed furrow at

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planting compared with non-treated peanut. Tubbs *et al.* (2013) measured 50% fewer adult thrips 14 and 21 days after planting (DAP) and 75% fewer immature thrips 28 DAP when phorate was applied in the seed furrow at planting compared with the non-treated control. Less injury from thrips resulted in 15% increase in yield over non-treated peanut. Marasigan *et al.* (2016) reported that phorate applied in-furrow reduced thrips injury similar to aldicarb, cyantraniliprole, neonicotinoid insecticides, and spinetoram. Herbert *et al.* (2007) evaluated aldicarb and phorate in-furrow with acephate applied up to four times after planting. Thrips control by aldicarb and phorate applied alone in the seed furrow was similar with less injury compared with non-treated peanut. Acephate further reduced injury and increased yield above the non-treated control or either insecticide but there was no advantage to multiple applications of acephate (Herbert *et al.*, 2007).

With the limited availability of aldicarb, understanding how to best utilize existing insecticides and cultural strategies for thrips management in peanut production is important for practitioners. Farmers often plant during the entire month of May in North Carolina depending on crop mix, the number of ha devoted to peanut, and weather conditions. Determining if farmers need to adjust pest management practices, in this case systemic insecticides to control thrips, is important in implementing economical practices without sacrificing yield. Therefore, the objective of this study was to determine if management strategies for thrips differ in North Carolina across the traditional planting window. More specifically, the objective was to define interactions of planting date, phorate, and acephate applications on thrips control and peanut yield.

Materials and Methods

Experiments were conducted in North Carolina from 2013 through 2016 in different fields at the Peanut Belt Research Station located near Lewiston–Woodville (36.07 N, –77.11W) on a Norfolk sandy loam (fine loamy, siliceous, thermic, Aquic Paleudults) with organic matter ranging from 0.5 to 1.2% and pH 5.9 to 6.1. The Virginia market type peanut cultivar ‘Bailey’ (Isleib *et al.*, 2011) was planted at a seeding rate designed to achieve a final in-row population of 12 to 15 plants/m of row. Two yr of corn (*Zea mays* L.) and one year of cotton (*Gossypium hirsutum* L.) preceded peanut.

Treatments consisted of a factorial arrangement of 3 levels of planting date (May 2-4, May 16-18,

and May 28), 2 levels of phorate applied in the seed furrow at planting (with or without phorate), and 2 levels of acephate (with or without acephate) applied 3 wk after planting (WAP). Phorate (Thimet 20 G; AMVAC Chemical Corporation, Los Angeles, CA) was applied in the seed furrow at 1.12 kg ai/ha and acephate (Orthene 97; AMVAC Chemical Corporation, Los Angeles, CA) was applied 3 WAP at 0.4 kg ai/ha. Acephate was applied using a CO₂-pressurized backpack sprayer calibrated to deliver 140 L/ha at a pressure of 275 kPa. Peanut was planted into conventionally-prepared, raised seedbeds. Plot size was 2 rows spaced 91-cm by 9 m. Production and pest management practices other than those associated with thrips control were held constant across the entire test area and were based on Cooperative Extension Service recommendations for North Carolina (Jordan *et al.*, 2017).

Injury from thrips feeding was recorded 2 wk after acephate was applied using an ordinal scale of 0 to 5, where 0 = no damage, 1 = noticeable feeding but no stunting, 2 = noticeable feeding and 25% stunting, 3 = feeding with blackened terminals and 50% stunting, 4 = severe feeding and 75% stunting, 5 = severe feeding and 90% stunting (Carley *et al.*, 2008; Drake *et al.*, 2009). Peanut pods were dug and vines inverted based on pod mesocarp color (Williams and Drexler, 1981). Final pod yield was adjusted to 8% moisture.

The experimental design was a split plot with planting date serving as whole plot units and combinations of phorate and acephate serving as sub-plot units. Treatments were replicated 4 times. Data for thrips injury and pod yield were subjected to ANOVA using the PROC MIXED procedure in SAS 9.4 (SAS Institute Inc., Cary, NC) appropriate for the factorial treatment arrangement. Planting date, acephate, and phorate treatments were considered fixed effects with year and replication considered random effects. Means of significant main effects and interactions were separated using Fisher’s Protected LSD test at $P \leq 0.10$.

Results and Discussion

The interaction of experimental year \times planting date \times phorate \times acephate was significant for injury caused by tobacco thrips (Table 1). However, the interaction of planting date, phorate, and acephate pooled over yr is presented because of a larger F statistic and clarity of discussion. When insecticide was not applied, delaying planting from early May through the end of May resulted in less injury from thrips feeding (Table 2). Regardless of planting

Table 1. F-statistic and $P > F$ for thrips injury and peanut yield as effected by main effects and interactions of year, planting date, phorate, and acephate applications.

Source of variation	df	Thrips injury		Peanut yield	
		F-statistic	P > F	F-statistic	P > F
Planting date (Plant)	2	2.4	0.1727	1.6	0.2841
Phorate	1	48.9	0.0060	4.5	0.1253
Plant × Phorate	2	0.8	0.5028	0.4	0.7056
Acephate	1	31.3	0.0113	1.3	0.3309
Plant × Acephate	2	6.2	0.0352	1.1	0.3894
Phorate × Acephate	1	384.3	0.0003	5.7	0.0963
Plant × Phorate × Acephate	2	7.5	0.0234	1.6	0.2790
Year	3	5.2	0.2576	2.2	0.1707
Year × Plant	6	0.6	0.6988	10.1	< 0.0001
Year × Phorate	3	0.7	0.5691	4.0	0.1703
Year × Acephate	3	3.3	0.1610	3.0	0.1507
Year × Plant × Phorate	6	19.2	0.0011	1.6	0.2888
Year × Plant × Acephate	6	3.6	0.0719	2.9	0.1075
Year × Phorate × Acephate	3	0.2	0.8709	0.8	0.5293
Year × Plant × Phorate × Acephate	6	2.2	0.0423	0.5	0.7958
Coefficient of variation, %	-	-	28.8	-	9.5

date, applying phorate in the seed furrow at planting, applying acephate to peanut foliage, or the combination of both insecticides resulted in less injury from thrips feeding than non-treated peanut. The combination of insecticides was more effective in protecting peanut from thrips than either insecticide alone during the early and mid-May planting dates but not when peanut was planted in late May. More injury caused by thrips was noted for acephate alone than phorate alone or phorate

followed by acephate when peanut was planted in early or late May.

Table 2. Thrips injury as affected by the interaction of planting date by phorate by acephate application.^{a,b}

Treatment	Planting date		
	Early May	Mid May	Late May
	—scale 5 (SE)—		
None	3.1 a (0.1)	2.3 b (0.1)	1.8 c (0.2)
Phorate	0.7 f (0.1)	1.0 e (0.1)	0.3 g (0.1)
Acephate	1.2 d (0.1)	1.0 e (0.1)	1.1 de (0.2)
Phorate fb acephate	0.3 g (0.1)	0.4 g (0.0)	0.2 g (0.0)

^aMeans within a year followed by the same letter are not significantly different according to Fisher's Protected LSD test at $P \leq 0.10$. Data are pooled over yr. Standard error (SE) of the mean is included to illustrate deviation around the population mean. Phorate applied in the seed furrow at planting and acephate applied POST 3 WAP at 1.12 kg/ha and 0.4 kg/ha, respectively.

^bInjury from thrips feeding was recorded 2 wk after acephate was applied using an ordinal scale of 0 to 5, where 0 = no damage, 1 = noticeable feeding but no stunting, 2 = noticeable feeding and 25% stunting, 3 = feeding with blackened terminals and 50% stunting, 4 = severe feeding and 75% stunting, 5 = severe feeding and 90% stunting.

Peanut planted in North Carolina in late-May often experience less thrips injury than peanut planted in early May (Brandenburg *et al.*, 2017; Drake *et al.*, 2009; Hurt *et al.* 2005). Morsello *et al.* (2008) trapped tobacco thrips from 1997 to 2001 in North Carolina and Virginia at 12 and 9 sites, respectively, and observed peak dispersal in early-to mid-May. Herbert *et al.* (2007) reported that phorate applied in the seed furrow at planting followed by acephate POST reduced thrips larvae compared to phorate in-furrow alone and no treatment. It has been well documented that phorate reduces thrips injury compared to non-treated peanut (Herbert *et al.* 2007; Hurt *et al.* 2005; Marasigan *et al.* 2016; Tubbs *et al.* 2013). Additionally, phorate in-furrow provides similar or increased control of thrips compared to POST application of systemic insecticide. Mulder and Seus (2002) performed adult and larval thrips counts over three dates following insecticide applications, including phorate in-furrow and acephate applied POST. Populations of both adult and larval thrips were similar in peanut treated with phorate in-furrow only compared to those receiving acephate only. Marasigan *et al.* (2015) measured thrips injury and populations in peanut following various in-furrow and insecticide applications over three field seasons. In all studies, phorate in-furrow provided similar or increased protection from thrips compared with insecticides applied to emerged peanut. Peanut not receiving in-furrow insecticide are not protected from thrips

Table 3. Peanut yield as affected by planting date within year.^a

Planting date	Peanut yield			
	2013	2014	2015	2016
	kg/ha (SE)			
Early May	5520 b (110)	5780 a (80)	5400 b (110)	4310 c (140)
Mid-May	6870 a (110)	5090 b (80)	7100 a (120)	5620 a (120)
Late-May	7120 a (180)	4370 c (180)	5160 b (100)	5020 b (140)

^aMeans within a year followed by the same letter are not significantly different according to Fisher's Protected LSD test at $P \leq 0.0001$. Standard error (SE) of the mean is included to illustrate deviation around the population mean. Data are pooled over phorate and acephate treatments.

feeding from emergence until systemic insecticide is applied and distributed throughout the peanut plant. In our study peanut was exposed to thrips feeding for 2 wks prior to acephate application.

The interaction of year \times planting date was significant for peanut yield (Table 1). In 2013, yield of peanut planted in mid-May and late-May exceeded that of peanut planted in early May (Table 3). In contrast, yield of peanut planted in early May was greater than yield of peanut planted in mid-May in 2014; yield for late-May planted peanut was the lowest. In 2015 and 2016, yield of peanut planted in mid-May was greater than yield of peanut planted in early May or late-May. Variation in yield response to planting date has been observed in North Carolina. For example, Carley *et al.* (2008) planted peanut at four dates from early-May to early-June and in two of the three yr in their study, mid-May planted peanut yielded the greatest and with yield similar to all other planting dates in the third year. Yield from early and late-May plantings was similar across yr. Drake *et al.* (2014) reported that peanut yield was greatest when planted in early May compared with planting in late-May in two of four yr with no difference among planting dates noted in the other two yr of the study.

Main effects of phorate and acephate and the interaction of phorate \times acephate affected peanut yield irrespective of year or planting date (Table 1). Phorate applied in the seed furrow at planting, acephate applied to peanut foliage 3 WAP, and the combination of both insecticides increased yield by 280 kg/ha, 210 kg/ha, and 330 kg/ha, respectively, over non-treated peanut (Table 4). Herbert *et al.* (2007) reported greater peanut yield when phorate was in-furrow alone compared to non-treated peanut yields in three studies from 2000-2002. The authors conducted five more field studies from 2003-2005 that included phorate in-furrow application with multiple applications of acephate to emerged peanut. Peanut yield in those studies also increased when insecticide was applied compared with non-treated peanut. Marasigan *et al.* (2005)

reported yield increases from phorate in-furrow alone were detected in one of three yr. Culbreath *et al.* (2008) conducted three field studies during 2006 and 2007 in Florida and Georgia with eight different peanut cultivars. In 2006, they reported a yield increase for two of the eight cultivars in one study when phorate was applied in the seed furrow at planting.

Visible expression of TSW was low in the experiment during all yr and was not assigned a numerical value. The cultivar Bailey has a high level of field resistance to TSW (Isleib *et al.*, 2011; Shew, 2017) and the seeding rate used in this experiment likely help minimize the impact of TSW (Brandenburg, 2017). During the period of time this experiment was conducted incidence of TSW was relatively low at this location and across North Carolina in general (Brandenburg, 2017; Shew, 2017). Although both TSW and thrips control can be affected by planting date and insecticide (Brandenburg, 2017; Culbreath *et al.*, 2003), the very low incidence of visible expression of TSW allowed evaluation of planting date and insecticide effects on yield without confounding effects of TSW.

Table 4. Peanut yield in 2013-2016 as affected by the interaction of phorate and acephate application.^{a,b}

Treatment	Peanut yield
	kg/ha (SE)
No insecticide	5410 b (120)
Phorate	5690 a (110)
Acephate	5620 a (120)
Phorate followed by acephate	5730 a (130)

^aMeans followed by the same letter are not significantly different according to Fisher's Protected LSD test at $P \leq 0.10$. Data are pooled over yr and planting dates. Standard error (SE) of the mean is included to illustrate deviation around the population mean.

^bPhorate applied in the seed furrow at planting and acephate applied POST 3 WAP at 1.12 kg/ha and 0.4 kg/ha, respectively.

Tobacco thrips are a major insect pest for peanut producers in North Carolina and injury caused by this insect can reduce peanut yield (Brandenburg, 2017). Planting peanut in mid- and late-May reduced injury from thrips compared with injury when peanut was planted in early May. Phorate in-furrow, acephate applied POST after peanut emergence, and phorate followed by acephate reduced thrips injury and protected yield equally compared with non-treated peanut. While insecticides did increase yield, these data suggest that peanut response to planting date is independent of insecticide treatment. Even though considerable differences in peanut yield were noted for the interaction of year and planting date (Table 3), lack of an interaction of planting date with either insecticide main effect or interaction of phorate and acephate strengthens the argument that recommendations on insecticide use for protection from thrips injury should not be adjusted based on planting date in North Carolina. The present work also supports the current recommendation of planting peanut in North Carolina in mid-May.

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