Effect of Thiamethoxam Seed Treatment on Injury from Tobacco Thrips, Incidence of Spotted Wilt Disease, and Peanut Yield

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Abstract

Tobacco thrips (*Frankliniella fusca* Hinds) and tomato spotted wilt orthotospovirus (TSWV)- (family Tospoviridae, genus Orthotospovirus) can reduce peanut (*Arachis hypogaea* L.) yield. Systemic insecticides are applied in the seed furrow at planting and to peanut foliage to reduce injury from tobacco thrips and decrease incidence of TSWV. Research was conducted in Georgia, North Carolina, South Carolina, and Virginia in 2013 and 2014 to compare the effect of the following treatments on tobacco thrips feeding injury and expression of tomato spotted wilt virus (TSWV) in peanut: thiamethoxam seed treatment, thiamethoxam seed treatment followed by acephate 3 weeks after planting, phorate applied in the seed furrow at planting, and a non-treated check. Tobacco thrips feeding injury and TSW incidence were significantly higher in thiamethoxam and thiamethoxam followed by acephate treated peanut than peanut treated with phorate. Thiamethoxan seed treatment followed by acephate resulted in significantly lower tobacco thrips feeding injury compared to thiamethoxam seed treatment alone. Peanut yield was not affected by insecticide treatment for runner market type cultivars (Georgia 06G and Georgia 12Y). In contrast, treating seed with thiamethoxam resulted in peanut yield greater than non-treated peanut for Virginia market type cultivars (Bailey, CHAMPS, and Sugg).

Introduction

Tobacco thrips, *Frankliniella fusca* Hinds, can reduce peanut (*Arachis hypogaea* L.) yield directly by feeding on plants early in the growing cycle and indirectly by transmitting tomato spotted wilt orthotospovirus (TSWV) (family *Tospoviridae*, genus *Orthotospovirus*) in the process (Culbreath et al., 2003; Culbreath and Srinivasan 2011; Marasigan et al., 2016). Systemic insecticides applied in the seed furrow at planting suppress thrips, protect yield, and in the case of phorate, reduce the risk of TSWV infection (Srinivasan et al., 2017). When no insecticide is applied at planting or when at-plant insecticides do not adequately control thrips, growers often apply acephate directly to peanut foliage to suppress thrips and minimize peanut injury (Brandenburg et al., 2019). Insecticides applied at planting, in particular aldicarb and phorate, are highly toxic to humans, and developing reduced risk alternatives with less potential negative impact on the environment and human health is a priority. Though not without environmental risks of their own, the neonicotinoid insecticides represent a reduced-risk option for thrips management compared to carbamate and organophosphate insecticides. Thiamethoxam is a neonicotinoid insecticide that suppresses thrips in cotton (*Gossypium* *hirsutum* L.) and has gained widespread acceptance (Lahiri et al., 2018; Knight et al., 2015; North et al., 2017). Faircloth et al. (2013) reported that thiamethoxam applied to seed reduced injury caused by thrips compared with non-treated peanut and was as effective as phorate applied in the seed furrow at planting in protecting yield. However, efficacy of thiamethoxam against thrips in peanut is not well established in the peer-reviewed literature when applied as a seed treatment. The objective of this research was to compare the effect of thiamethoxam seed treatment alone and in combination with a foliar acephate application on injury caused by tobacco thrips, incidence of tomato spotted wilt, and yield of runner and Virginia market type peanut cultivars with a commercial standard (phorate applied in the seed furrow at planting) and a non-treated control.

Locations and Treatments

Research was conducted in Georgia, North Carolina, South Carolina, and Virginia in separate experiments with runner and Virginia market type cultivars. Runner market type cultivars included Georgia 06G (Branch, 2007) and Georgia 12Y (Branch, 2013). Virginia market type cultivars included Bailey (Isleib et al., 2011), CHAMPS (Mozingo et al., 2006), and Sugg (Isleib et al., 2014) (Table 1). Twenty-five trials were conducted in 2013 and 2014 for runner market type cultivars (12 site years) and Virginia market type cultivars (13 site years). Peanut was seeded at an in-row rate to obtain 6 seed/foot and 5 seed/foot for Runner and Virginia market types respectively. Seed were planted in a single row pattern in conventionally-tilled, raised seedbeds with rows spaced 36 inches apart. All seed for each cultivar were obtained from a single seed lot and were treated with azoxystrobin, fludioxonil, and mefenoxam either as the commercial seed treatment Dynasty PD (Syngenta Crop Protection, Greensboro, NC) or as

CruserMaxx Peanuts (Syngenta Crop Protection, Greensboro, NC). Insecticide treatments consisted of: 1) no insecticide; 2) thiamethoxam (CruiserMaxx Peanuts) applied to seed prior to planting (0.25 lbs/100 lbs seed); 3) thiamethoxam followed by acephate (Orthene 97 S, AMVAC Chemical Co., Los Angeles, CA) at 0.5 lb ai/acre; and 4) phorate (Thimet, AMVAC Chemical Company, Los Angeles, CA) at 0.75 lbs ai/acre applied in the seed furrow at planting. All trials were managed according to Extension recommendations for peanut production in each state.

Data Collected

Visual estimates of peanut injury caused by tobacco thrips were recorded on an ordinal scale of 0 to 10 where: 0 = no injury, 1 = 10% leaves injured, 2 = 20% leaves injured, 3 = 30% leaves injured, 4 = 40% leaves injured, 5 = >50% of leaves injured and < 5% terminals injured, 6 = > >50% of leaves injured and < 25% terminals injured, 7 = >50% of leaves injured and < 50% terminals injured, 8 = >50% of leaves injured and < 75% terminals injured, 9 = >50% of leaves injured and < 90% terminals injured, and 10 = dead plants. Injury ratings were taken 10 to 18 days after acephate was applied (20 to 30 days after planting) depending on the trial. The percentage of plants expressing visible symptoms of tomato spotted wilt was recorded between late July and mid-September depending on the trial. Peanut pods were dug and vines inverted at optimum maturity based on pod mesocarp color (Williams and Drexler, 1982). Final pod yield was adjusted to 7% moisture.

Experimental Design and Statistical Analyses

The experiment was arranged in a randomized complete block design with 4 or 5 replications. Data for visual estimates of peanut injury caused by tobacco thrips, the percentage of plants expressing visible symptoms of tomato spotted wilt, and pod yield were subjected to ANOVA using the GLIMMIX Procedure in SAS (SAS) considering main effects of cultivar and insecticide treatments and the interaction of these factors. Data for the percentage of plants expressing visible symptoms of tomato spotted wilt were subjects to the arcsine square root prior to analysis. Data were grouped based on market type cultivar (runner or Virginia). Trial and replication within a trial were considered random effects. Cultivar and insecticide treatment were considered fixed effects. Means of significant main effects and interactions were separated using Fisher's LSD test at $\alpha = 0.05$.

Peanut Response to Tobacco Thrips Feeding

The interaction of cultivar and insecticide treatment was not significant for peanut injury caused by tobacco thrips, incidence of tomato spotted wilt, or peanut pod yield for either market type (Table 2). The main effect of cultivar was significant for incidence of tomato spotted wilt and pod yield for runner market type; cultivar did not affect injury caused by tobacco thrips. Less tomato spotted wilt was observed for Georgia 12Y than Georgia 06G. However, the difference was only 3% and the biological significance considered minor. When pooled over insecticide treatments, pod yield was 710 lbs/acre higher for Georgia 12Y compared with Georgia 06G (Table 3). Cultivar affected injury caused by thrips, incidence of tomato spotted wilt, and yield in the Virginia market type group (Table 2). Injury caused by thrips was higher for the cultivar CHAMPS compared with Bailey; peanut injury for Sugg was intermediate and did not differ from the other two cultivars. Tomato spotted wilt incidence differed significantly between all three cultivars: CHAMPS > Sugg > Bailey. Likewise, pod yield differed significantly for all three cultivars: Bailey > Sugg > CHAMPS.

Similar to our results, Sidu et al. (2019) reported greater yields for Georgia 12Y than Georgia 06G. Although Balota and Phipps (2013) reported no difference in yield for Bailey, CHAMPS, and Sugg, Drake et al. (2013) observed less disease and reported greater yield for the cultivar Bailey compared with CHAMPS. Lack of a response to injury from tobacco thrips associated with cultivar was not unexpected for these runner market type cultivars. Even though a statistically significant difference in injury caused by thrips was observed among Virginia market type cultivars, the difference observed is likely of minor biological significance. Bailey and Sugg are considered to be less susceptible to tomato spotted wilt than CHAMPS (Isleib et al., 2011 2014; Mozingo et al., 2006). Our data show a difference in susceptibility of Bailey and Sugg to tomato spotted wilt, although the difference was relatively minor.

Insecticide treatment affected both injury caused by thrips and incidence of tomato spotted wilt but not yield in the runner market type grouping (Table 4). In the Virginia market type grouping, insecticide affected all three parameters. Differences among insecticide treatments for peanut injury caused by thrips feeding demonstrated a similar trend for both market types. When pooled over cultivars, all insecticide treatments reduced injury caused by thrips compared to the non-treated. The thiamethoxam seed treatment was the least effective treatment. Including a foliar application of acephate decreased injury caused by thrips compared to the seed treatment alone but was not as effective as phorate applied in the seed furrow at planting. Incidence of tomato spotted wilt was relatively low when comparing cultivars and insecticide treatments for both market types, and the biological significance is likely minor. In the runner market type grouping was higher when the seed treatment only was applied or when acephate followed this treatment compared with phorate applied in the seed furrow (Table 4). There was no difference in incidence of tomato spotted wilt when comparing non-treated peanut with peanut receiving phorate. Minor differences in tomato spotted wilt incidence were noted among treatments receiving thiamethoxam alone or with a follow up application of acephate and non-treated peanut. Less tomato spotted wilt was observed when phorate was applied compared with all other treatments. Peanut yield for Virginia market types was greater when either thiamethoxam was applied to seed and followed up with acephate applied to peanut foliage or phorate was applied in the seed furrow at planting compared with non-treated peanut or thiamethoxam only. Yield was higher when thiamethoxam was applied to seed than non-treated peanut.

Data are limited on the comparison of thiamethoxam only versus a follow up application of acephate, although less injury caused by thrips would be expected from suppression of thrips from the seed treatment and the systemic insecticide applied after peanut emerged compared with the seed treatment alone. Lack of a yield response for the runner market type cultivars but a significant response of yield among Virginia market types was surprising. In an additional analysis of the data, the market types were grouped into the southern region of peanut production (Georgia and South Carolina) and the northern region of peanut production (North Carolina and Virginia) for each market type. In this analysis, main effects of cultivar and insecticide treatment and their interactions mirrored closely the results when trials were grouped by market type only irrespective of geography or these parameters. These results suggest that while visible estimates of injury caused by tobacco thrips feeding may be similar, differences in yield response for cultivars may vary market type. However, market types were not included in the same experiment in our study and limit broad conclusions for comparing response of market types.

Summary

Results from this study over twenty-five site-year combinations indicate that thiamethoxam is less effective in suppressing tobacco thrips compared with the commercial standard insecticide phorate. These results are in contrast to those reported by Faircloth et al. (2013) demonstrating that thiamethoxam applied to seed at planting controlled thrips and protected yield similar to phorate. Thiamethoxam resulted in less injury than non-treated peanut and a follow up application of acephate resulted in less injury from tobacco thrips. Tomato spotted wilt incidence was lower when phorate was applied compared with other insecticide treatments in most instances. Regardless of the level of injury caused by tobacco thrips or incidence of tomato spotted wilt, yield was similar across insecticide treatments for runner market types. Insecticide treatment was important in protecting yield of Virginia market types. Thiamethoxam has been used effectively as a seed treatment in cotton across the states represented in this study (Anders et al., 2017). However, the consistency of control has decreased in cotton and has been attributed in part to possible evolved resistance in tobacco thrips (Anders et al., 2017). While this could be the case with thiamethoxam in peanut, the amount of insecticide delivered through seed treatments in cotton versus peanut varies and could contribute to what appears to be limited effectiveness of thiamethoxam.

Acknowledgements

This research was supported financially by the Georgia Peanut Commission, the North Carolina Peanut Growers Association, the National Peanut Board, the South Carolina Peanut Growers Association, and the Virginia Peanut Growers Association. Appreciation is expressed to staff and the Border Belt Tobacco Research Station, the Peanut Belt Research Station, the Upper Coastal Plain Research Station, and the Tidewater Agricultural Research and Extension Center for assistance with this research.

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Table 1. Year, state, location, and planting date for trials comparing peanut injury caused by thrips, tomato spotted wilt of peanut, and pod yield with combinations of cultivars and insecticide treatments.

				Market type	
Year	**State**	**Location**	**Planting date**	**Runner**	**Virginia**
2013	Georgia	Tifton	May 10	Yes	Yes
2013	Georgia	Tifton	May 2	Yes	Yes
2013	North Carolina	Lewiston-Woodville	May 3	Yes	Yes
2013	North Carolina	Rocky Mount	May 13	Yes	Yes
2013	North Carolina	Whiteville	May 9	Yes	Yes
2013	South Carolina	Edisto	May 10	Yes	Yes
2013	Virginia	Suffolk	May 13	Yes	Yes
2014	Georgia	Tifton	May 10	Yes	Yes
2014	Georgia	Tifton	May 9	Yes	Yes
2014	North Carolina	Lewiston-Woodville	May 8	No	Yes
2014	North Carolina	Rocky Mount	May 20	Yes	Yes
2014	South Carolina	Edisto	May 7	Yes	Yes
2014	Virginia	Suffolk	May 9	Yes	Yes

Table 2. Analysis of variance for injury caused by tobacco thrips, tomato spotted wilt of peanut, and peanut pod yield as influenced by peanut market type cultivar and insecticide treatment.[a]

Source of variation	Injury caused by tobacco thrips		Tomato spotted wilt of peanut		Peanut pod yield	
	F ratio	**P > F**	**F ratio**	**P > F**	**F ratio**	**P > F**
Runner market type cultivars						
Cultivar	0.1	0.7331	61.7	≤0.0001	79.0	≤0.0001
Insecticide	309.4	≤0.0001	3.6	0.0140	2.0	0.1205
Cultivar × Insecticide	0.2	0.8707	0.4	0.7883	1.1	0.3372
Virginia market type cultivars						
Cultivar	4.0	0.0184	103.1	≤0.0001	29.2	≤0.0001
Insecticide	546.0	≤0.0001	14.4	≤0.0001	15.0	≤0.0001
Cultivar × Insecticide	0.9	0.4927	1.0	0.3635	0.7	0.6380

[a]Data are pooled over 12 trials (runner market type cultivars) and 13 trials (Virginia market type cultivars) and cultivars within each market type in 2013 and 2014.

Table 3. Influence of cultivar on peanut injury caused by tobacco thrips, tomato spotted wilt of peanut, and peanut pod yield for runner and Virginia market type peanut.[a]

Cultivar[b]	**Injury caused by tobacco thrips**	**Incidence of tomato spotted wilt of peanut**	**Peanut pod yield**
	Scale 1-8	%	lbs/acre
Runner market type cultivars			
Georgia 06G	5.3 a	5 a	5080 b
Georgia 12Y	5.3 a	2 b	5790 a
Virginia market type cultivars			
Bailey	5.2 b	4 c	5240 a
CHAMPS	5.5 a	10 a	4750 c
Sugg	5.4 ab	8 b	4930 b

[a]Means within in a market type cultivar and column followed by the same letter are not significantly different at $\alpha = 0.05$. Data are pooled over 12 trials (runner market type cultivars) and 13 trials (Virginia market type cultivars) and insecticide treatments in 2013 and 2014.

Table 4. Influence of insecticide treatment on peanut injury caused by tobacco thrips, tomato spotted wilt of peanut, and peanut pod yield for runner and Virginia market type peanut.[a]

Insecticide treatment[b]	Injury caused by tobacco thrips		Incidence of tomato spotted wilt of peanut		Peanut pod yield	
	Scale 1-8		%		lbs/acre	
Runner market type cultivars						
No insecticide	7.2	a	4	a	5280	a
Thiamethoxam applied to seed	6.6	b	4	a	5420	a
Thiamethoxam applied to seed followed by acephate applied to foliage	4.2	c	4	a	5510	a
Phorate applied in the seed furrow at planting	3.1	d	3	b	5520	a
Virginia market type cultivars						
No insecticide	7.2	a	9	a	4720	c
Thiamethoxam applied to seed	6.7	b	9	a	4890	b
Thiamethoxam applied to seed followed by acephate applied to foliage	4.2	c	7	b	5140	a
Phorate applied in the seed furrow at planting	3.3	d	5	c	5140	a

[a]Means within in a market type cultivar and column followed by the same letter are not significantly different at $\alpha = 0.05$. Data are pooled over 12 trials (runner market type cultivars) and 13 trials (Virginia market type cultivars) and cultivars within each market type in 2013 and 2014.

[b]Thiamethoxam applied at 0.25 lb/100 lb seed prior to planting. All seed was treated with azoxystrobin, fludioxonil, and mefenoxam. Acephate was applied 3 weeks after planting at 0.5 lbs/acre.