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ARTICLE

Impact of Variety, Planting Date and At-plant Insecticide on Thrips and Tomato Spotted Wilt Virus Management in Alabama Peanuts

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ABSTRACT

Peanuts grown in Alabama are at risk of thrips injury and tomato spotted wilt virus (TSWV) infection, which could result in reduced yield and seed quality at harvest. Feeding from thrips can cause severe seedling injury and potential stand loss, but the primary concern is transmission of TSWV. To control this disease, management practices such as planting date, varietal selection, and insecticides use are utilized. The objective of this experiment was to evaluate how three planting dates of varying thrips infestation risk, three varieties of varying susceptibility to TSWV, and the use of Thimet insecticide impacts thrips injury, TSWV incidence, and yield. A field study was done in 2022 and 2023 at the Wiregrass REC in Headland, AL, where the research plots were grown near other fields of row crops such as cotton, corn, soybeans, and peanuts. Treatments included three varieties (GA-06G, GA-12Y and AU-NPL 17) planted at high (April), low (May) and mid (June) TSWV risk planting dates with and without Thimet in-furrow insecticide. Overall, planting date was the driving factor for thrips injury, TSWV incidence and yield. Peanuts planted in April tended to have higher injury and TSWV with lower yields. While it did not significantly impact TSWV incidence, peanuts treated with Thimet had significantly lower injury ratings and higher yields than those not treated, when averaged across planting dates and varieties. Based on these data, peanut growers in Alabama should focus on avoiding April planting dates to reduce their risk of TSWV infection and maintain yield potential.

INTRODUCTION

Peanuts thrive in the warm, humid climate of the southeastern United States, particularly in states like Georgia, Florida, and Alabama and are a valuable cash crop with a variety of uses, including human consumption, animal feed, and oils (Wrenshall 1949; Dixon 2009; National Peanut Board 2023). Different peanut types, such as runner, Virginia, Spanish, and Valencia, contribute to the diverse peanut market. In Alabama, runner peanuts make up the majority of production acreage and are primarily roasted or made into peanut butter (National Peanut Board 2023). Approximately 175,000 acres of peanuts are grown in Alabama, producing 480.5 million pounds in yield with a value of 119 million dollars per year (U.S. National Agricultural Statistics Service North American Spine Society 2023).

Peanuts are susceptible to thrips feeding and subsequent injury during the seedling stage (Strayer-Scherer and Graham 2021; Hollis 2023). There are four thrips species known to occur on peanuts in Alabama; *Frankliniella fusca* (tobacco thrips), *F. occidentalis* (western flower thrips), *F. bispinosa* (Florida flower thrips), and *F. triciti* (eastern flower thrips). Of these four species, *F. fusca* and *F. occidentalis* are of greatest concern due to their higher abundance, with *F. bispinosa* and *F. triciti* occurring in lower numbers (Strayer-Scherer and Graham 2021). In addition to foliar injury and potential stand loss, thrips can also transmit Tomato spotted wilt virus (TSWV) (Hollis 2023). Of the four aforementioned species, two are known to transmit TSWV (*F. fusca* and *F. occidentali*) to peanuts (Strayer-Scherer and Graham 2021). This virus causes a wide range of symptoms, including stunted growth, pod malformation, chlorotic rings on the leaves, reddening of seed coats, and reduced yield (Strayer-Scherer and Graham 2021; Culbreath *et al.* 2003; Sundaraj *et al.* 2014). TSWV is exclusively transmitted to peanuts by thrips, which acquire the virus in the larval stage by feeding on an infected plant. Infected thrips can then transmit TSWV in the adult stage to a non-infected plant upon dispersal (Wijkamp and Peters 1993). TSWV has an extremely broad host range, extending to over 900 species of weeds, cash crops, and ornamentals, and is difficult to control with conventional methods, like crop rotation or tillage (Business Queensland 2023). Once plants are infected with TSWV, it is not possible to cure (Groves *et al.* 2001; Srinivasan *et al.* 2014; Cabrera 2020). Thus, management methods for TSWV are entirely based on prevention, either by selecting field resistant varieties that are less susceptible to TSWV, selecting planting dates outside of expected thrips flight windows, or by using insecticides targeted to reduce thrips populations (Cabrera 2020).

To mitigate the economic impact of TSWV, breeding efforts have focused on developing field resistant varieties. Currently, GA-06G and GA-12Y are popular TSWV field resistant varieties across the southeastern US, with GA-06G being widely used for its large seeds and high yield (Monfort 2020). The recently released AU-NPL 17 is another resistant variety that was developed by the peanut breeding program at Auburn University. AU-NPL 17 is a high yielding, medium maturity cultivar bred for southeastern US conditions (Hollis 2023). While not as high yielding as GA-06G or AU-NPL 17, GA-12Y boasts a higher field resistance to TSWV according to the Peanut Rx guide (Peanut RX, UGA) (Monfort 2020). A study by Sundaraj *et al.* (2014) aimed to determine the mechanism of resistance to TSWV in peanut varieties across several field resistant and susceptible species, including Tifguard, Georgia Green and Georgia-06G. This study found that, while field resistant varieties had little to no effect of mechanical inoculation rates or virus attributes such as nucleocapsid gene copies or positive selection, there was a difference in the thrips (Sundaraj *et al.* 2014). Choice and no-choice tests showed that field resistant varieties had lower feeding incidences and lower thrips survival compared to susceptible (Sundaraj *et al.* 2014). This results in a lower percentage of virus infection in field resistant peanuts, as well as reduced viral accumulation in thrips populations (Sundaraj *et al.* 2014).

Thrips follow consistent annual migratory patterns, making planting dates crucial for minimizing damage. Tobacco thrips peak migration occurs in late April, while flower thrips peak in early June in Alabama (Brown et al 2005; Frank *et al.* 2020). A study by Todd *et al.* (1995) in Georgia found that planting in May or June reduces tobacco thrips populations in peanuts. Planting date recommendations for TSWV risk mitigation are provided by the Peanut Rx guide, currently suggesting May 11th to May 31st for optimal protection. Weather conditions, especially warm winters and springs, can influence thrips migrations, impacting their lifecycle and potentially leading to earlier infestations (North Carolina State Climate Office 2021). Producers can monitor weather patterns for thrips flights and adjusting planting dates to mitigate TSWV by utilizing resources such as the North Carolina State Tobacco Thrips Flight and TSWV Intensity Predictor (North Carolina State Climate Office 2021).

Insecticides like aldicarb, acephate, imidacloprid, and phorate are used for thrips management (Greene *et al.* 2021). Imidacloprid is popular among farmers due to its economic value, but studies indicate potential negative effects in preventing tomato spotted wilt (Kichler 2022). Research suggests imidacloprid may increase thrips feeding and TSWV transmission risk (Kichler 2022). In contrast, phorate is believed to trigger plant defense responses, potentially reducing TSWV severity (Cabrera 2020). Motta *et al.* (1998) found that peanuts treated with 5 lb/acre of phorate showed reduced TSWV incidence and severity compared to untreated peanuts. In addition to mitigating virus severity, phorate is also comparable to imidacloprid in reducing thrips injury (Anco *et al.* 2023). However, imidacloprid may still be an option for peanuts planted outside of the high-risk window for TSWV incidence, or for growers without the ability to use granular in-furrow insecticides. Graham and Balkcom (2023) found that imidacloprid alone provided similar thrips injury protection and yield as Thimet when peanuts were planted in early May. This would provide growers with an option for insecticide resistance management and a more economical option in the lower risk window.

The goal of this study was to evaluate the impacts of planting date, variety and Thimet usage on thrips injury, TSWV incidence and yield. Based on the Peanut Rx Guide, three planting dates were selected (late April, mid-May, and mid-June), as well as three peanut varieties (GA-12Y, GA-06G, and AU-NPL 17). In addition to this, peanuts were also treated with Thimet or did not receive an at-plant insecticide.

MATERIALS AND METHODS

Experimental Design

A field trial was conducted at the Wiregrass Research and Extension Center in Headland, AL during the 2022 and 2023 growing seasons. The experiment was planted in a split-split plot design within a randomized complete block with four replications. Main plots consisted of 24 rows and contained three planting dates: late April (high risk to thrips infestation), mid-May (low risk), and mid-June (moderate risk). These risk levels were determined by the Georgia Peanut Rx guide (Kemerait *et al.* 2004). The sub-plot consisted of eight rows and contained three varieties selected based on the Peanut Rx guidelines determined by the spotted wilt index rating: GA-12Y (field resistant to TSWV; '5' rating on PeanutRx), GA-06G (moderately field resistant, but historically high yielding; '10' rating on PeanutRx), and AU-NPL 17 (moderately field resistant; '10' rating on PeanutRx) (Kemerait *et al.* 2024). Lastly, the sub-sub plot was four rows, either treated or not treated with an in-furrow application of Thimet according to the product label (20 g of phorate, 5 lbs/acre). Plots were 9.1 m long and spaced 0.9 m apart and planted at a seeding rate of 20 seed per row meter. Peanuts were grown under dryland conditions in the 2022 season and were irrigated in the 2023 season. All plots were managed for high yield with regards to insect, weed and disease management according to recommendations from the Alabama Cooperative Extension System.

Data Collection

In both years, the percentage stand was evaluated by randomly sampling the number of plants per 9 meters of row in the center two rows of each plot at 14 days after planting (DAP). Whole plot vigor and thrips injury ratings were made at 14, 21, and 28 DAP. Vigor was rated on a 0 to 10 scale, with 0 being no vigor and 10 being maximum vigor, and is based on the overall health, growth, and fullness of the plants in the plot. Thrips injury was rated on a 0 to 5 scale, with 0 being no injury and 5 being complete absence of leaf tissue, measured based on the severity of thrips damage symptoms (silvery speckling, leaf crinkling, etc., scale shown in Figure 1) seen in the plot. Due to *F. fusca* and *F. occidentalis* being the primary thrips pests of peanuts in Alabama, both species being vectors for TSWV, and both species exhibiting similar foliar feeding patterns, thrips injury ratings were deemed an appropriate measure for determining infestation levels in this trial.

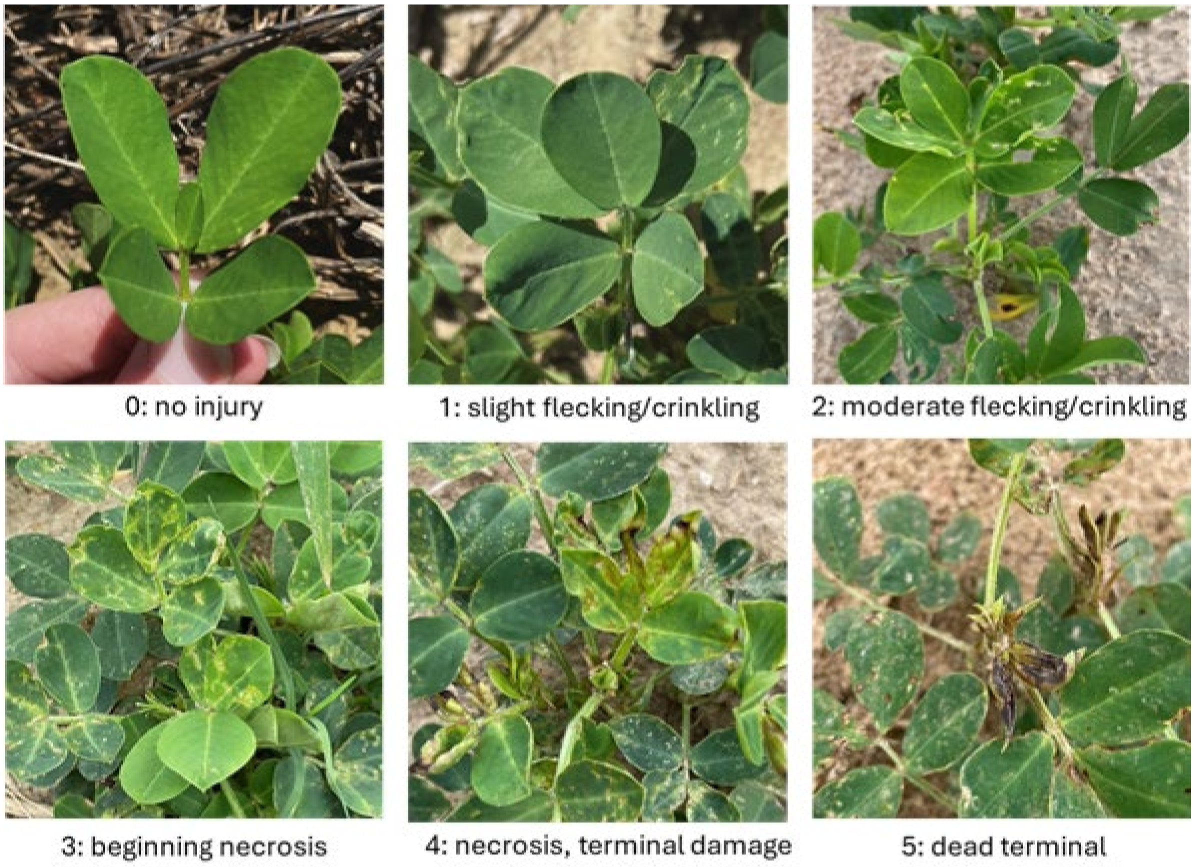

Figure 1. Levels of thrips injury to peanut plants, rated on a 0 (no injury) to 5 (dead terminal) scale.

Fractional green canopy cover (FGCC) and virus incidence was recorded at 42, 49, and 56 DAP. FGCC was recorded with the Canopeo application on iPhone in the center two rows of each plot to assess for growth stunting and general lack of vitality. The Canopeo app was developed at Oklahoma State University App Centre and works by analyzing R/G and B/G ratios and the excess green index to produce a binary image, wherein white pixels represent green matter and black pixels represent all other colors (Patrignani and Ochsner 2015). Canopeo then quantifies the FGCC as a percentage, which is then used to estimate canopy coverage. This method has been found to be a fast, reliable, and nondestructive way to accurately assess plant health in small-plot cotton and peanut trials (Graham *et al.* 2019; Yash *et al.* 2022). Percent virus incidence was recorded by dividing the number of row meters that contained plants which exhibited symptoms of TSWV (stunted growth, leaf chlorosis) by the total number of row meters (18.3 m) in the center two rows of each plot. Finally, the center two rows of each plot were harvested and yield was taken at approximately 150 DAP.

Statistical Analysis

Combined percent stand counts, seedling vigor, thrips injury ratings, Canopeo ratings, TSWV incidence and yield data were analyzed with a mixed model of variance (PROC GLIMMIX, SAS 9.4, SAS Institute Inc. Cary, NC). Planting date, variety, insecticide and their interactions were considered fixed effects in the model. Replication, replication by planting date and plant date nested in replication by year were considered random effects. Degrees of freedom were estimated using the Kenward Rogers Method. Means and standard errors were calculated with PROC MEANS. Means were separated using LSMEANS and were considered significant at α=0.05. Unless indicated, two- and three-way interactions were not significant and are not discussed.

RESULTS AND DISCUSSION

Early Season Results

Variety (F = 7.37; df = 2, 18; P = 0.005) and planting date (F = 34.56; df = 2, 6; P < 0.001) significantly impacted percent stand. Varieties GA-12Y and GA-06G had significantly higher stands than AU-NPL17 (Table 1). Peanuts planted at early (April) and mid (May) planting dates had significantly higher stand than peanuts planted at the late (June) plant date (Table 1). No significant difference was observed for insecticide (F = 0.49; df = 1, 99; P = 0.485) (Table 1).

Table 1. Average mean (± SEM) percent stand, seedling vigor, and thrips injury for three varieties of peanuts planted across three planting dates with and without an at-plant insecticide in Headland, AL (2022-23).

Variety	Planting Date	Insecticide	% Stand		Vigor (0-10)		Thrips Injury* (0-5)	
GA-12Y			68.7 (2.3)	a	7.8 (0.1)	a	1.3 (0.1)	b
GA-06G			67.9 (2.2)	a	7.7 (0.1)	a	1.2 (0.1)	b
AU NPL17			59.2 (2.5)	b	7.3 (0.1)	b	1.6 (0.1)	a
P>F			<0.01		<0.01		<0.01	
	Early (April)		73.9(1.27)	a	7.7 (0.1)	a	2.1 (0.04)	a
	Mid (May)		79.6 (2.0)	a	7.4 (0.1)	b	1.3 (0.1)	b
	Late (June)		52.4 (2.3)	b	7.7 (0.1)	a	0.7 (0.1)	c
P>F			<0.01		0.02		<0.01	
-		Non-Treated	66.1	a	7.6	a	1.5 (0.1)	a
-		Thimet[1]	64.5	a	7.6	a	1.2 (0.1)	b
P>F			0.485		0.24		<0.01	

Means within a column followed by a common letter are not significantly different (FPLSD P=0.05).
[1]11.68 kg ai/ha (phorate).
***Indicates significant interactions**

Similarly, variety (F = 18.15; df = 2, 18; P <0.001) and planting date (F = 7.65; df = 2, 6; P <0.001) significantly impacted seedling vigor. GA-12Y and GA-06G again significantly outperformed AU-NPL17 (Table 1). However, the early (April) and late (June) planted peanuts both averaged ≈0.3 vigor points higher than peanuts planted at the Mid (May) date (Table 1). No significance was found for insecticide treatment (F = 0.24; df = 1, 99; P = 0.624) for seedling vigor.

A significant two-way interaction of variety by planting date was observed for thrips injury (F = 6.27; df = 2, 99; P = 0.003). In general, Early (April) planted peanuts had higher thrips ratings than Mid (May) or Late (June) planted peanuts. However, at both the Mid (May) and Late (June) planting dates AU-NPL17 had more thrips injury than either GA-12Y or GA-06G (Table 2). There was also a significant interaction of insecticide by planting date (F = 6.27; df = 2, 99; P = 0.003) for thrips injury. While Thimet significantly reduced injury in the early (April) and mid (May) planting dates, there was no reduction in injury for Thimet in the late (June) planting date (Table 3).

Table 2. Average (Mean ± SEM) thrips injury ratings for three peanut varieties planted across three planting dates in Headland, AL (2022-23).

Variety	Planting Date	Thrips Injury (0-5)	
GA-12Y	Early (April)	2.1 (0.1)	a
GA-12Y	Mid (May)	1.2 (0.1)	c
GA-12Y	Late (June)	0.5 (01)	d
GA-06G	Early (April)	2.0 (0.1)	a
GA-06G	Mid (May)	1.2 (0.1)	c
GA-06G	Late (June)	0.5 (0.04)	d
AU NPL17	Early (April)	2.2 (0.1)	a
AU NPL17	Mid (May)	1.4 (0.1)	b
AU NPL17	Late (June)	1.1 (0.1)	c
P>F		0.047	

Means within a column followed by a common letter are not significantly different (FPLSD P=0.05).

Table 3. Average (Mean ± SEM) thrips injury ratings for peanuts planted with and without an at-plant insecticide across three planting dates in Headland, AL (2022-23).

Planting Date	Insecticide	Thrips Injury (0-5)	
Early (April)	Thimet[1]	2.0 (0.1)	b
Mid (May)	Thimet[1]	1.0 (0.1)	d
Late (June)	Thimet[1]	0.7 (0.1)	e
Early (April)	Non-Treated	2.2 (0.1)	a
Mid (May)	Non-Treated	1.5 (0.1)	c
Late (June)	Non-Treated	0.7 (0.1)	e
P>F		<0.01	

Means within a column followed by a common letter are not significantly different (FPLSD P=0.05).
[1]11.68 kg ai/ha (phorate).

Late Season Results

There was no impact of variety (F =1.41; df = 2, 18; P = 0.270) or insecticide (F = 0.40; df = 1, 96; P = 0.527) on Canopeo ratings. However, there was an effect of planting date (F = 59.71; df = 2, 6; P = <0.001), where late planted peanuts had the highest Canopeo ratings, followed by mid and early planted peanuts (Table 4).

Table 4. Impact of peanut variety, planting date and at-plant insecticide on fractional green canopy closure (FGCC) (Mean ± SEM), percent tomato spotted wilt virus (TSWV) incidence, and yield (kg/ha) for peanuts planted in Headland, AL (2022-23).

Variety	Planting Date	Insecticide	% FGCC		% TSWV Incidence		Yield* (kg/ha)	
GA-12Y			66.6	a	7.5 (0.6)	b	4803.3	a
GA-06G			63.7	a	12.9 (0.9)	a	4606.3	a
AU NPL17			64.5	a	10.7 (1.1)	a	4983.9	a
P>F			0.270		<0.01		0.07	
	Early (April)		47.5 (1.2)	c	13.4 (1.3)	a	4455.3 (157.3)	b
	Mid (May)		67.1 (1.7)	b	7.7 (0.6)	b	5124.2 (93.8)	a
	Late (June)		80.1 (0.9)	a	10.0 (0.6)	b	4813.9 (94.6)	ab
P>F			<0.01		<0.01		0.04	
		Non-Treated	64.4	a	11.0	a	4622.6 (106.7)	b
		Thimet[1]	65.4	a	9.7	a	4973.0 (92.4)	a
P>F			0.527		0.180		0.01	

Means within a column followed by a common letter are not significantly different (FPLSD P=0.05).

[1]11.68 kg ai/ha (phorate).

*Indicates significant interactions.

Significant differences for variety (F = 10.85; df = 2, 18; P = 0.001) and planting date (F = 11.95; df = 2, 6; P = 0.008) were found for TSWV incidence. The highest TSWV incidence was found in GA-06G, with GA-12Y and AU-NPL17 showing similar and lower TSWV incidence (Table 4). Planting date (F = 1.83; df = 1, 96; P = 0.180) also had a significant effect on TSWV incidence, where peanuts planted at the early (April) plant date had significantly higher TSWV incidence than those planted at the mid (May) or late (June) planting dates (Table 4). No significant effect of insecticide treatments (F = 1.83; df = 1, 96; P = 0.180) was observed for TSWV incidence.

A significant difference was found for yield in insecticide (F = 7.9; df = 1, 114.2; P = 0.006) and variety (F = 3.03; df = 2, 18; P = 0.073) treatments. Plots that received Thimet had significantly higher yield than plots without Thimet treatment (Table 4). Mid-planted peanuts had significantly higher yield than early-planted peanuts, with the Late-planted date falling between the other two dates.

In our study, AU-NPL17 had significantly lower stands than GA-12Y and GA-06G. These results are similar to those found by Faske *et al.* (2020) who observed AU-NPL17 to have lower stands than GA-12Y and GA-06G. We also found that percent stand counts were reduced at the late (June) planting date. Zurweller *et al.* (2023) also reported lower stand in later planted peanuts (May 30). In that study, the authors suggested lower stands could have been due to warmer soils and less moisture. In our study, we did not monitor soil temperatures, but we did have adequate moisture for germination.

AU-NPL 17 had significantly lower average vigor than GA-12Y and GA-06G, which could be attributed to lower stands observed with this variety, which could suggest less seedling vigor. Peanuts at the mid (May) planting date had significantly lower vigor than planting dates, however the differences were minor (0.3 points on 0-10 scale) and statistical differences may be a result of the trial design.

Two interactions were observed for thrips injury. In the first, variety by planting date, the mid and late-planted GA12-Y and GA-06G had significantly less thrips injury than AU-NPL 17 at these planting dates. This may again be attributed to the low stand in AU-NPL 17. Lower plant populations are known to correlate with higher incidences of TSWV (Tillman *et al.* 2015; Strayer-Scherer and Graham 2021). AU-NPL 17 likely had more thrips injury at the mid and late planting dates due to the reduced stands at these dates, which has been seen previously (Zurweller *et al.* 2023). Peanut stands with fewer plants down the row are thought to result in higher thrips populations on individual plants, resulting in higher injury (Brown *et al.* 2005). In the second interaction, insecticide by planting date, Thimet usage correlated with significant reductions in thrips injury at the early and mid-planting dates, but not at the late planting date. Despite Peanut Rx guidelines suggesting the late plant date is at moderate risk compared to the mid plant date (low risk), late planted peanuts were observed to have the least amount of thrips injury in both years of this study (University of Georgia 2021). Based on thrips injury trends for planting date over the two years assessed, Thimet correlated with a significant reduction in feeding injury when thrips pressure was high but did not result in reduced damage when pressure was low.

The late plant date showed the highest canopy closure across treatments. This differs from previous research, which shows later planting dates correlate with decreased canopy closure (Bateman *et al.* 2020). While the decreased stand at the late plant date would lead to the assumption that it would also have decreased canopy closure, a study done by Plumblee *et al.* (2018) observed no correlation between seed density and canopy closure. Plumblee *et al.* (2018) also concluded that factors such as thrips population, flight patterns, feeding injury must be driving differences in canopy closure, which aligns with our observations of significantly lower thrips injury followed by significantly higher canopy closure, and vice versa. Another consideration for reduced canopy closure at the later planting date could be related to the increased risk of leaf spot diseases at later planting dates (Gonzales *et al.* 2023, Kermerait *et al.* 2024). However, this is unlikely because we did not observe leaf spot symptoms in this trial and all plots, regardless of planting date, were sprayed with fungicides on 14-day intervals to minimize impacts of fungal diseases, especially leaf spot.

The higher field resistant variety, GA-12Y, had significantly lower virus incidence than GA-06G or AU-NPL 17, reflective of Peanut Rx guidelines on TSWV resistant varieties. AU-NPL 17 and GA-06G did not significantly separate for virus incidence, but the highest incidence was found to be in GA-06G (12.9%) followed by AU-NPL 17 (10.7%). Though the Peanut Rx guide states GA-06G and AU-NPL 17 are of equal susceptibility to TSWV, other sources state that AU-NPL 17 may be more field resistant, especially given its high yield potential (Hollis 2017). While peanuts planted at the mid and late planting dates did not separate as they did for thrips injury and canopy closure, the early planting date was observed to have significantly higher TSWV incidence. The lack of separation between mid and late plant dates for TSWV incidence could be attributed to the less populous, but more efficient TSWV vectors, western flower thrips (*F. occidentalis*), have been found to migrate through Alabama at higher densities in late May to early June (Brown *et al.* 2005; Frank *et al.* 2020; Cook *et al.* 2003).

Insecticide treatment was found to have a significant impact on yield in this study. Plots that received an in-furrow application of Thimet yielded ≈350 kg/ha higher than plots without Thimet treatment (Table 4). The overall trend of peanuts treated with Thimet having higher yields than non-treated peanuts is similar to other studies (Zurweller *et al.* 2023; Brandenburg *et al.* 2021; Mahoney *et al.* 2018). This suggests that thrips injury can reduce yields, regardless of TSWV incidence in Alabama and thrips should be managed to maintain yields. Previous research has shown that using Thimet consistently results in higher yields than non-treated peanuts or peanuts with other treatments (Culbreath *et al.* 2008, Anco *et al.* 2020). This due to both controlling thrips and reducing TSWV incidence. The systemic activity of phorate may influence plant physiology and gene expression, potentially enhancing resistance to TSWV and improving overall yield. Systemic insecticides, like Thimet, are absorbed by plants and translocated throughout plant tissues influencing various physiological processes such as growth, development and defense mechanisms (Nauen and Bretschneider 2002, Thaler *et al.* 2002). These insecticides can induce changes in gene expression, particularly genes involved in plant defense responses, enhancing the ability of the plant to resist pathogens and pests (Nauen and Bretschneider 2002, Thaler *et al.* 2002).

Yield results also showed a significant interaction for planting date. Yield was significantly lower for early-planted peanuts than for any other treatment. This aligns with the literature which states TSWV causes significant yield loss (Strayer-Scherer and Graham 2021; Culbreath *et al.* 2003; Sundaraj *et al.* 2014). The reduced yield during the early plant date correlates with the significantly higher virus incidence observed at that date. The Mid-planted peanuts had the highest yield out of the three, which aligns with the Peanut Rx recommendations to plant in mid-May.

This study shows the importance of a systematic approach to TSWV management in peanuts to maximize yield. We found that planting date was the most important factor in thrips injury and TSWV incidence. Overall, the use of Thimet was important, but more so at the early planting date (April) when thrips injury and TSWV infection risk is the highest. These results demonstrate that farmers should plant high yielding cultivars in Mid-May with Thimet in areas with high TSWV incidence to reduce virus pressure and maintain yield potential.

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