Compatibility of Acephate with Herbicides Applied Postemergence in Peanut

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ABSTRACT

Numerous agrochemicals can be applied in peanut to control pests. Field and laboratory experiments were conducted in North Carolina during 2009 and 2010 to determine peanut response to paraquat and tobacco thrips (*Frankliniella fusca* Hinds.) when acephate was applied in combination with chloroacetamide and contact herbicides. Experiments were also conducted during 2011 to determine peanut response to acephate applied alone or with paraquat when peanut was planted either without aldicarb or when aldicarb was applied in the seed furrow at planting. Visible peanut damage caused by tobacco thrips feeding was greater when chloroacetamide herbicides were applied without acephate compared with application with acephate regardless of paraquat treatment. Visible injury caused by paraquat was higher when chloroacetamide herbicides were included compared with paraquat alone in one of two years. Visible injury by paraquat was lower when applied with acephate compared to paraquat alone in one of two years. Acephate applied to peanut foliage and aldicarb applied in the seed furrow at planting protected peanut similarly from damage associated with tobacco thrips feeding. Acephate alone or with chloroacetamide herbicides changed solution pH from slightly acidic to highly acidic. Several combinations of pesticides formed either transient or permanent precipitates.

Key Words: Agrochemicals, paraquat, precipitates, solution pH, tobacco thrips.

Peanut (*Arachis hypogaea* L.) is an important crop in North Carolina (Brown, 2011). Several biotic and abiotic stresses occur during the peanut growing season and timing of their occurrence can overlap. Peanut growers utilize a wide range of agrochemicals to manage these stresses (Gascho and Davis, 1995; Lynch and Mack, 1995; Sherwood *et al*., 1995; Wilcut *et al*., 1995). Among different agrochemicals used in peanut, insecticides are often applied in the seed furrow at planting to control tobacco thrips and include organophosphate and carbamate groups (Brandenburg, 2011; Minton and Morgan, 1974; Riley *et al*., 1997). Tobacco thrips can affect peanut growth and subsequent yield in North Carolina if insecticides are not used (Carley *et al*., 2009; Drake *et al*., 2009; Herbert *et al*., 2007). Acephate, aldicarb, and phorate can be used to control tobacco thrips in peanut when applied in the seed furrow at planting (Brandenburg, 2011). Acephate can also be applied to peanut foliage to control tobacco thrips (Brandenburg, 2011).

Paraquat can be applied within 28 days after peanut emergence to control small annual broadleaf weeds, grasses, and sedges (Wilcut *et al*., 1995). Bentazon applied with paraquat reduces injury caused by paraquat and in some cases can either increase or decrease weed control (Wilcut *et al*., 1995). Injury caused by paraquat generally does not reduce peanut yield under weed-free conditions (Blenk *et al*., 1991; Carley *et al*., 2009; Drake *et al*., 2009).

Removal of aldicarb from the commercial market required growers to rely on postemergence applications of insecticides to control tobacco thrips. Although phorate controls tobacco thrips adequately in most instances, control is often less consistent than control by aldicarb (Herbert *et al*., 2007). Importance of paraquat in a comprehensive weed management program has increased due to prevalence of herbicide-resistant weeds (Jordan *et al*., 2007). Applying chloroacetamide herbicides with paraquat can increase weed control (Askew *et al*., 1999; Bailey *et al*., 1999; Grey *et al*., 2002; Grichar and Colburn, 1996) although peanut injury often increases (Jordan *et al*., 2003). However, interactions of acephate, chloroacetamide herbicides, and paraquat are not well defined.

Although interactions of paraquat and acephate have been evaluated in some instances with respect to weed control and peanut injury, compatibility of these pesticides in spray solution prior to application has not been documented. Lack of information on physical compatibility of different agrochemicals in the spray tank can lead to the formation of precipitates or suspended solids which may adversely affect application and consequently affect pest control (Houghton, 1982).

Defining interactions of paraquat and acephate with respect to visible injury caused by paraquat and damage from tobacco thrips feeding will be of

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value for growers formulating pest management strategies in peanut. These findings will be especially important if greater use of paraquat occurs due to herbicide-resistant weeds and if acephate is applied more frequently in absence of aldicarb availability. Therefore, objectives of this research were to define interactions of acephate and paraquat applied alone or in combination with chloroacetamide herbicides with respect to tobacco thrips damage and peanut injury and to determine changes in spray solution characteristics when these pesticides are co-applied.

Material and Methods

Interactions of Acephate, Paraquat, and Chloroacetamide Herbicides

Experiments were conducted in North Carolina during 2009 and 2010 at the Peanut Belt Research Station near Lewiston-Woodville on a Norfolk sandy loam soil (fine-loamy, kaolinitic, thermic Typic Kandiudults). The peanut cultivar Phillips (Isleib *et al.*, 2006) was planted in rows spaced 91 cm apart in conventionally prepared seed beds with a final in-row population of 13 plants/m. Plot size was one row by 3.5 m long with a non-treated row separating each plot. Peanut was not irrigated.

Treatments included two levels of acephate (Orthene97®, Amvac Chemical Corp., Los Angeles, CA 90023) (0 and 1.1 kg ai/ha); three levels of contact herbicides including no contact herbicide, paraquat (Gramoxone Inteon Herbicide, Syngenta Crop Protection, Inc. Greensboro, NC 27419) at 0.14 kg ai/ha, and paraquat plus bentazon (Basagran Herbicide, BASF Corp., Research Triangle Park, NC 27709) at 0.14 kg/ha + 0.28 kg ai/ha; and four levels of chloroacetamide herbicides including no chloroacetamide herbicide, alachlor (Intrro Preemergence Herbicide, Monsanto Co., St. Louis, MO 63167) at 3.4 kg ai/ha, dimethenamid-*P* (Outlook Herbicide, BASF Corp., Research Triangle Park, NC 27709) at 0.84 kg ai/ha, and *S*-metolachlor (Dual Magnum Herbicide, Syngenta Crop Protection, Inc. Greensboro, NC 27419) at 1.1 kg ai/ha. Treatments were applied 7 to 10 days after peanut emergence. Nonionic surfactant (Induce®, Helena Chemical Corp., Collierville, TN 38017) at 0.125% (v/v) was applied with all treatments containing paraquat. No insecticide was applied in the seed furrow at planting to promote tobacco thrips feeding in peanut. Treatments were applied in 140 L/ha aqueous solution using a CO_2-pressurized backpack sprayer with flat-fan nozzles (TeeJet TP8002 flat-fan spray nozzles, Spraying Systems Co., Wheaton, IL 60189) at 275 kPa.

The experimental design was a randomized complete block with four replications. An ordinal scale of 0 to 5 where 0 = no damage, 1 = noticeable feeding but no stunting, 2 = noticeable feeding and 25% stunting, 3 = noticeable feeding with blackened terminals and 50% stunting, 4 = severe feeding and 75% stunting, and 5 = severe feeding and 90% stunting was used to visibly assess damage from tobacco thrips feeding 10 days after postemergence treatment (DAT). Visible estimates of percent injury relative to symptoms associated with paraquat (Senseman, 2007) were recorded 10 DAT using a scale of 0 to 100% where 0 = no foliar necrosis and 100 = plant death. Peanut was not harvested.

Tobacco Thrips Control with Aldicarb and Foliar Pesticide Treatments

Experiments were conducted in North Carolina during 2011 at the Peanut Belt Research Station near Lewiston-Woodville and the Upper Coastal Plain Research Station located near Rocky Mount in two separate fields at each location. Soils were a Norfolk sandy loam described previously at Lewiston-Woodville and an Adcock fine sandy loam soil (fine-loamy, siliceous, subactive, thermic Aquic Paleudults) at Rocky Mount. The peanut cultivar Phillips was planted as described previously in plots with two rows spaced 91 cm apart by 9 m in length. Peanut was not irrigated.

Treatments included no aldicarb or aldicarb (Temik 15G insecticide, Bayer CropScience, Research Triangle Park, NC 27709) at 1.1 kg ai/ha applied alone in the seed furrow at planting following seed drop but before slit closure. These treatments also received acephate postemergence, paraquat postemergence, acephate plus paraquat postemergence, or no additional pesticides to establish a 2 by 4 factorial treatment structure. Acephate and paraquat were applied at the rates described previously. Nonionic surfactant at 0.125% (v/v) was applied with all treatments containing paraquat.

The experimental design was a randomized complete block with four replications. Visible estimates of tobacco thrips damage from feeding were determined 10 and 14 DAT using the ordinal scale described previously. Visible estimates of percent injury relative to symptoms associated with paraquat were recorded 10 and 14 DAT using the injury scale described previously. The number of days from peanut emergence to canopy closure was determined, and peanut was dug and vines inverted when approximately 65% of pods were in the brown and black category based on pod mesocarp color for the treatment of aldicarb with no other postemergence treatment (Williams and Drexler, 1981).

Physical Compatibility of Insecticides with Other Agrochemicals

Laboratory experiments were conducted to compare physical compatibility of acephate combinations used in the field experiments during 2009 and 2010. Unlike experiments in the field where a municipal water source was used, deionized water at pH 6.27 was used in the laboratory experiments. Pesticides were mixed in the following order: dry flowables (acephate), emulsifiable concentrates (alachlor and *S*-metolachlor), and soluble liquids (bentazon, dimethenamid-*P*, nonionic surfactant, and paraquat). Solutions were prepared in a final volume of 80 ml in sterilized plastic specimen cups (Specimen cup120 ml-53 ST ORG CAP, Fisher Scientific, Fairlawn NJ 07410) of 120 ml capacity at ratios reflecting spray volume and pesticide ratios used in the field. After mixing, solution was vortexed (Vortex Genie 2™, Fisher Scientific, Fairlawn, NJ 07410) immediately and evaluated visually for precipitates followed by determining pH using a portable pH meter (Oakton portable pH meter, Fisher Scientific, Fairlawn, NJ 07410). Solutions were allowed to sit for 6 h after mixing, evaluated for precipitates, vortexed, and re-evaluated for precipitates followed by pH determination. Similarly, mixtures were allowed to sit for 24 and 72 h after the initial solution preparation and subjected to the same procedure and observations. Presence or absence of precipitates were determined visually and described as Yes or No, respectively. Visible deposition on the bottom of the specimen cup or presence of suspended solids in the solution was considered precipitates. Temporary precipitates went back into solution on vortexing while permanent precipitates did not go into solution after vortexing. Experiments were conducted as a completely randomized design with two replications and the experiment was repeated.

Statistical Analysis

Data for peanut damage, visible peanut injury, and solution pH from field and physical compatibility studies were subjected to ANOVA using the PROC MIXED procedure of SAS (Statistical Analysis Systems®, version 9.2, SAS Institute Inc., Cary, NC 27513) appropriate for the factorial arrangement of treatments using expected mean squares to test fixed and random effects. Pesticide treatments were considered as fixed effects while experiments and replications were considered as random effects. Data for peanut damage from thrips feeding and peanut injury from paraquat were log and arcsine transformed, respectively, using Box-Cox procedure. However, transformation of data did not change data interpretation, hence, data were presented without transformation (Box *et al.*, 1978). Means for significant main effects and interactions were separated using Tukey's pair-wise comparison test at $P \leq 0.05$.

Table 1. Peanut damage 10 d after application when acephate was applied alone or in combination with chloroacetamide herbicides during 2009 and 2010.[a,b]

Chloroacetamide herbicide	Acephate	
	No	Yes
	scale 0–5	
None	1.8 bc	1.3 cd
Alachlor	2.8 a	1.3 cd
Dimethenamid-*P*	2.3 abc	0.8 d
S-metolachlor	2.5 ab	1.3 cd

[a]Means followed by the same letter are not significantly different according to Tukey's test at $P \leq 0.05$. Data are pooled over contact herbicides and years.

[b]Acephate, alachlor, dimethenamid-*P*, and *S*-metolachlor applied at 1.1, 3.4, 0.84 and 1.1 kg/ha, respectively.

Results and Discussion

Interactions of Acephate, Paraquat, and Chloroacetamide Herbicides

Damage from tobacco thrips feeding 10 DAT was affected by interaction of acephate X chloroacetamide herbicide ($p = 0.0028$). When pooled over contact herbicides and years, damage from tobacco thrips feeding was no more than 1.3 on a scale of 0 to 5 when acephate was applied irrespective of chloroacetamide herbicide (Table 1). In absence of acephate, more damage from tobacco thrips feeding was noted when alachlor was applied compared with no chloroacetamide herbicide. Damage was similar for all chloroacetamide herbicides in absence of acephate. When acephate was included there was no difference in damage from tobacco thrips when comparing among chloroacetamide herbicides.

Interactions of acephate by contact herbicide by chloroacetamide herbicide ($p = 0.0075$) and acephate by contact herbicide ($p = 0.0011$) were significant for peanut injury associated with paraquat symptomology during 2009 and 2010, respectively. In the absence of acephate, co-application of paraquat with alachlor, dimethenamid-*P*, and *S*-metolachlor increased injury compared to peanut treated with paraquat alone during 2009 (Table 2). Peanut injury associated with paraquat did not differ when bentazon was included in absence of acephate or when acephate was applied irrespective of chloroacetamide herbicide treatment (Table 2). Jordan *et al.* (2003) reported that the chloroacetamide herbicides *S*-metolachlor applied with paraquat

Table 2. Peanut injury 10 d after application associated with paraquat symptomology when acephate was applied alone or in combination with chloroacetamide and contact herbicides for the control of tobacco thrips in 2009.[a,b]

	Acephate					
	No			Yes		
	Contact herbicide			Contact herbicide		
Chloroacetamide herbicide	None	Paraquat	Paraquat plus bentazon	None	Paraquat	Paraquat plus bentazon
	%					
None	0 e	10 de	14 cd	0 e	18 bcd	16 bcd
Alachlor	0 e	39 a	23 bcd	0 e	16 bcd	14 cd
Dimethenamid-*P*	0 e	25 bc	19 bcd	0 e	14 cd	14 cd
S-metolachlor	0 e	29 ab	23 bcd	0 e	14 cd	13 cde

[a]Means followed by the same letter are not significantly different according to Tukey's test at $P \leq 0.05$.

[b]Acephate, alachlor, bentazon, dimethenamid-*P*, paraquat and *S*-metolachlor applied at 1.1, 3.4, 0.28, 0.84, 0.14, and 1.1 kg/ha, respectively. Paraquat was applied with nonionic surfactant at 0.125% (v/v).

increased peanut injury compared with paraquat alone. The mechanism of increased injury when paraquat was applied with chloroacetamide herbicides compared with paraquat alone is not known. However, it is speculated that emulsifiers in the formulated product containing *S*-metolachlor may increase injury from paraquat through increased absorption of paraquat in peanut. Although chloroacetamide herbicides did not affect injury in 2010, less injury from paraquat was noted when acephate was applied with paraquat compared with paraquat alone (Table 3). However, when bentazon was included with paraquat, acephate did not reduce injury. When acephate was not included, our results were similar to previous research (Wehtje *et al.*, 1986, 1992; Wilcut *et al.*, 1989) indicating that bentazon reduces peanut injury by paraquat compared with paraquat alone. In contrast, benefits of bentazon in reducing injury by paraquat were reduced or eliminated when acephate was included in the mixture. These results are not substantiated or refuted in the peer-reviewed literature.

Table 3. Peanut injury 10 d after application associated with paraquat symptomology when acephate was applied alone or in combination with contact herbicides for the control of tobacco thrips at Lewiston-Woodville in 2010.[a,b]

	Acephate	
Contact herbicides	No	Yes
	%	
None	0 c	0 c
Paraquat	22 a	7 bc
Paraquat plus bentazon	11 b	4 bc

[a]Means followed by the same letter are not significantly different according to Tukey's test at $P \leq 0.05$. Data are pooled over chloroacetamide herbicides.

[b]Acephate, bentazon, and paraquat applied at 1.1, 0.28, and 0.14 kg/ha, respectively. Paraquat was applied with nonionic surfactant at 0.125% (v/v).

Tobacco Thrips Control with Aldicarb and Foliar Pesticide Treatments

Results from the experiment with acephate, chloroacetamide herbicides, and paraquat were unclear with respect to whether or not reduction in paraquat injury by acephate was associated with interactions in the spray solution, physiological response on the leaf surface, or the plant's ability to compensate for injury through more expansive growth in absence of tobacco thrips feeding. Therefore, the experiment comparing paraquat injury and tobacco thrips damage was conducted to address this question. In theory, applying combinations of acephate, bentazon, and paraquat in presence and absence of tobacco thrips feeding could allow a greater distinction among peanut response to these interactions.

Peanut damage caused by tobacco thrips at 10 and 14 DAT was affected by the interaction of aldicarb (no aldicarb or aldicarb) X foliar pesticide (no pesticide, acephate, paraquat, or acephate plus paraquat) ($p = 0.0379$ at 10 DAT; $p \leq 0.0001$ at 14 DAT). Damage from tobacco thrips feeding did not exceed a value of 1.0 at 10 DAT regardless of foliar pesticide treatment but ranged from 0 to 4.0 by 14 DAT (Table 4). Surprisingly, less visible damage from tobacco thrips feeding was noted when paraquat was applied alone compared with the no-insecticide control 10 and 14 DAT. Acephate and aldicarb were both equally effective in preventing visible damage from tobacco thrips 10 and 14 DAT (Table 4). Previous research (Drake *et al.*, 2009; Funderburk *et al.*, 1998) indicates that peanut damage by tobacco thrips decreases when aldicarb is applied in the seed furrow at planting or

Table 4. Peanut damage from tobacco thrips feeding and injury from paraquat in presence or absence of tobacco thrips damage due to in-furrow application of aldicarb in 2011.[a,b,c]

	Damage from tobacco thrips feeding				Visible injury from paraquat				
	10 DAT		14 DAT			14 DAT			
	Aldicarb		Aldicarb			Aldicarb			
Foliar treatment	No	Yes	No	Yes	10 DAT	No	Yes	Canopy closure after emergence	Pod yield
	scale 0–5				% necrosis			days	kg/ha
None	1.0 a	0 c	4.0 a	0 c	0 b	0 d	0 d	80 a	5350 b
Acephate	0 c	0 c	0 c	0 c	0 b	0 d	0 d	76 b	5890 a
Paraquat	0.6 b	0.3 bc	1.0 b	0 c	30 b	35 a	25 b	82 a	5520 ab
Acephate plus paraquat	0 c	0 c	0 c	0 c	40 a	16 c	16 c	80 a	5660 ab

[a]Means within a rating interval (DAT) and for days to canopy closure and pod yield followed by the same letter are not significantly different according to Tukey's test at $P \leq 0.05$. Data are pooled over four experiments for tobacco thrips damage and visible injury from paraquat 14 DAT. Data for visibly injury from paraquat 10 DAT, canopy closure, and pod yield are pooled over four experiments and aldicarb treatments.

[b]Acephate, aldicarb, and paraquat applied at 1.1, 1.1, and 0.14 kg/ha, respectively. Paraquat was applied with nonionic surfactant at 0.125% (v/v).

[c]Aldicarb was applied in the seed furrow.

when acephate is applied to peanut foliage (Brandenburg, 2011; Herbert *et al.*, 2007).

Main effect of aldicarb and foliar pesticide treatment were significant ($p \leq 0.0001$) 10 DAT for peanut injury reflecting paraquat symptoms. The interaction of aldicarb X foliar pesticide treatment was also significant ($p \leq 0.0001$) 14 DAT. When pooled over foliar pesticide treatments at 10 DAT, paraquat injury was 16% (data not presented in tables). When pooled over aldicarb treatments and experiments, injury by acephate plus paraquat exceeded that of paraquat alone at 10 DAT (Table 4). However, by 14 DAT, less injury from paraquat was noted when paraquat was applied either with acephate or following aldicarb applied to the seed furrow compared with paraquat alone (Table 4). The reason for increased injury when paraquat and acephate were co-applied is not clear. Adverse interactions of carbamate insecticides and herbicides have been reported previously (Hatzios and Penner, 1985) but not with this particular combination. Fewer symptoms associated with paraquat by 14 DAT may have been associated with more rapid growth of foliage in absence of tobacco thrips feeding and less total foliar necrosis on a percentage basis than would have been observed with paraquat symptoms on plants with less growth during the 5-day period after the first visible rating was recorded.

Main effects aldicarb and foliar pesticide treatment were significant for the number of days from peanut emergence to row closure ($p \leq 0.0001$ for both main effects) and pod yield ($p = 0.0033$ and 0.0169 for these respective main effects). When

Table 5. Solution pH determined when acephate was applied alone or in combination with chloroacetamide and contact herbicides.[a,b]

	Acephate					
	No			Yes		
	Contact herbicide			Contact herbicide		
Chloroacetamide herbicide	None	Paraquat	Paraquat plus bentazon	None	Paraquat	Paraquat plus bentazon
	pH					
None	6.27 a	5.32 de	5.89 c	3.64 klm	3.71 jkl	4.33 hi
Alachlor	4.88 g	4.93 fg	6.23 a	3.73 jk	3.75 j	5.39 de
Dimethenamid-*P*	3.57 m	3.56 m	5.30 e	3.34 n	3.35 n	5.00 f
S-metolachlor	4.28 i	4.42 h	6.10 b	3.67 j-m	3.61 lm	5.42 d

[a]Means followed by the same letter are not significantly different according to Tukey's test at $P \leq 0.05$. Pooled over sampling times.

[b]Acephate, alachlor, bentazon, dimethenamid-*P*, paraquat and *S*-metolachlor applied at 1.1, 3.4, 0.28, 0.84, 0.14, and 1.1 kg/ha, respectively. Paraquat was applied with nonionic surfactant at 0.125% (v/v).

pooled over foliar pesticide treatments, fewer days from emergence to row closure were required when aldicarb was applied (77 vs. 82 days, data not shown in tables), and pod yield was higher following aldicarb (5760 kg/ha vs. 5430 kg/ha, data not shown in tables). These differences most likely reflect a reduction in tobacco thrips feeding resulting in more rapid and sustained peanut growth when aldicarb was applied. Peanut yield is often higher when aldicarb is applied and tobacco thrips damage is minimized (Carley *et al.*, 2009; Drake *et al.*, 2009; Funderburk *et al.*, 1998; Herbert *et al.*, 2007). When pooled over aldicarb treatments, peanut treated with acephate took fewer days to close the canopy when paraquat was not included (Table 4). However, no difference in days to row closure were noted when paraquat was applied alone or with acephate compared with the no-foliar pesticide control. Pod yield following acephate exceeded that of the no-pesticide control while yield following paraquat alone or with acephate was intermediate between these treatments (Table 4). Consistent with research by Herbert *et al.* (2007), these data indicate that both aldicarb and acephate contribute to yield increases over peanut not treated with insecticide in presence of tobacco thrips and the damage they cause. Drake *et al.* (2009) reported that paraquat injury generally does not affect pod yield unless paraquat is applied when significant damage from tobacco thrips feeding is present. Also, manufacturers of paraquat indicate that paraquat should not be applied if tobacco thrips damage is severe (Anonymous, 2011). In contrast, peanut yield reductions caused by damage from tobacco thrips in absence of insecticide are not affected by paraquat treatment (Carley *et al.*, 2009; Drake *et al.*, 2009).

Physical Compatibility of Insecticides with Other Agrochemicals

The interaction of acephate by contact herbicide by chloroacetamide herbicide was significant for solution pH ($p = \leq 0.0001$). When compared to carrier pH (6.27), all combinations reduced solution pH except the combination of alachlor with paraquat plus bentazon. When compared with mixtures without acephate, solution pH decreased when acephate was included irrespective of chloroacetamide or contact herbicides. Regardless of chloroacetamide herbicide in solution, paraquat plus bentazon decreased solution pH to approximately 5.0. When compared with solutions containing paraquat with or without acephate, including bentazon increased solution pH.

In most of instances, solutions either with or without acephate combinations formed temporary precipitates at 0, 6, 24, and 72 h sampling times (data not shown in tables). Combinations of acephate with dimethenamid-*P* formed temporary precipitates, however, in the absence of acephate this combination did not produce precipitates across sampling intervals (data not shown in tables). Solutions containing alachlor with acephate formed permanent precipitates across sampling times but the addition of paraquat or paraquat plus bentazon to these combinations changed the permanent precipitates to temporary precipitates (data not shown in tables).

Practical application of these physical observations is currently unknown. However, very little information on changes in pH and observations on precipitate formation are found in the peer-reviewed literature. These results may at some point contribute to a greater understanding of issues related to agrochemical compatibility.

Collectively, results in the field during 2009 and 2010 demonstrated that chloroacetamide herbicides were more injurious when acephate was not applied and damage from tobacco thrips was present compared with co-application with acephate. Acephate and aldicarb contributed to tobacco thrips control independently and protected pod yield, although the benefit from acephate was marginalized when paraquat was included. Co-application of paraquat with alachlor and *S*-metolachlor increased injury in the absence of acephate compared with co-application with acephate. Paraquat injury was lower when paraquat was applied with bentazon in absence of acephate compared with paraquat alone. When acephate was applied, there was no difference in injury with paraquat alone or paraquat plus bentazon. The combination of paraquat without acephate was more injurious than this paraquat applied with acephate. However, the value of acephate in reducing paraquat injury most likely was associated with ability of peanut to grow more rapidly in presence of acephate, and less damage from tobacco thrips most likely was associated with the use of a visible scale for evaluation. Bentazon reduces injury from paraquat by affecting physiological process associated with electron transport in treated leaves (Wehtje *et al.*, 1992). Bentazon was not included in the second experiment where pesticides were applied to foliage in presence or absence of damage from tobacco thrips feeding created by aldicarb treatment. While these results provide some insight into possible interactions of acephate and paraquat and subsequent injury and damage when co-applied, the replacement of bentazon with acephate as a "safener" is not established in this research. These data suggest that reductions in tobacco thrips feeding by acephate contribute to a perception of less injury from paraquat, and recommendations of using bentazon to minimize peanut injury from paraquat should not be changed. Paraquat and chloroacetamide herbicides did not adversely affect tobacco thrips control by acephate suggesting that these pesticides can be co-applied to maximize weed control without adversely affecting tobacco thrips control.

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