Interactions of Clethodim and Sethoxydim with Other Pesticides

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ABSTRACT

A wide range of agrochemicals are applied in peanut to manage biotic and abiotic stresses. Experiments were conducted to evaluate the efficacy of clethodim and sethoxydim applied alone or with dimethenamid-*P*, pyraclostrobin, *S*-metolachlor, and 2,4-DB. When applied in combination with clethodim, pyraclostrobin often reduced goosegrass and large crabgrass control compared with clethodim only. Pyraclostrobin did not impact efficacy of sethoxydim in most instances. Dimethenamid-*P* and *S*-metolachlor did not negatively affect efficacy of clethodim and sethoxydim. The impact of 2,4-DB on efficacy of clethodim and sethoxydim was inconsistent. The magnitude of adverse impact on graminicides (clethodim and sethoxydim) performance did not exceed 19% and was caused primarily by pyraclostrobin. Conversely, increased efficacy of graminicides caused by chloroacetamide herbicides did not exceed 14%. Graminicides and chloroacetamide herbicides changed solution pH from slightly acidic to highly acidic. Several combinations of clethodim and sethoxydim produced temporary precipitates but no permanent precipitates. Results from these experiments suggest that applying tank mixtures containing up to four chemical components will not dramatically reduce control of emerged annual grasses in peanut.

Key Words: compatibility, precipitates, solution pH.

Annual grasses are often present in peanut (*Arachis hypogaea* L.) in North Carolina and can reduce yield through interference and reduced harvest efficiency (Jordan, 2011; Wilcut *et al*., 1995). The relatively poor competitive ability of peanut and the requirement of digging and inversion for crop harvest require season-long weed control to optimize yield (Wilcut *et al*., 1995). In addition to monocotyledonous weeds, including annual and perennial grasses and sedges, dicotyledonous weeds are also prevalent in peanut grown in the United States (Webster, 2009; Wilcut *et al*., 1995). Comprehensive herbicide programs, in combination with appropriate cultural practices, are employed to manage weeds and minimize interference and subsequent yield loss (Wilcut *et al*., 1995). Large crabgrass [*Digitaria sanguinalis* (L.) Scop.] and goosegrass (*Eleusine indica* L.) are among the most common weeds found in peanut grown in North Carolina (Webster, 2009). The requirement of digging and inversion as part of the peanut harvesting procedure necessitates effective season-long control of weeds, especially grasses, to optimize peanut yield (Wilcut *et al*., 1995). Chloroacetamide herbicides are applied primarily at planting to control annual grasses, small-seeded broadleaf weeds and sedges (Wilcut *et al*., 1995). These herbicides can also be applied later in the season to minimize late-season emergence of annual grasses (Jordan, 2011).

Diseases, caused by viruses, bacteria, or fungi, can reduce peanut yield when not controlled. Fungicides are applied routinely to peanut to control foliar diseases including early leaf spot (caused by *Cercospora arachidicola* Hori), late leaf spot (caused by *Cercosporidium personatum* Berk. and Curtis), and web blotch (caused by *Phoma arachidicola* Marasas, Pauer, and Boerema) (Brenneman *et al*., 1994; Culbreath *et al*., 2008). Fungicides are also applied to control the soil-borne diseases stem rot (caused by *Sclerotium rolfsii* Sacc.) and Sclerotinia blight (caused by *Sclerotinia minor* Jagger) (Smith *et al*., 1992). Although variation is noted among geographical regions, years, and environmental conditions, during a typical growing season fungicides are applied either singly or in combination beginning approximately 45 days after peanut emergence and continuing throughout the remainder of the growing season up to several weeks prior to digging and vine inversion (Sherwood *et al*., 1995; Shew, 2011; Smith and Littrell, 1980).

Presence of the biotic and abiotic stresses mentioned previously often occurs simultaneously during the peanut growing season, and timing of

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application for many agrochemicals overlap (Brandenburg, 2011; Jordan, 2011; Shew, 2011). Therefore, many growers apply herbicides and fungicides simultaneously in peanut production systems. This approach is preferable because of convenience, savings in time, reduced application costs, and freeing labor for other operations. In spite of above mentioned benefits, incompatibility can be associated with some of these mixtures of agrochemicals. Co-applying pesticides can negatively influence agrochemical efficacy and increase crop phytotoxicity (Green, 1989; Hatzios and Penner, 1985). Identifying interactions of agrochemicals is important when considering applying agrochemicals simultaneously (Green, 1989; Hatzios and Penner, 1985; Nash, 1981).

Incompatibility can occur through physicochemical interactions in the spray tank, while biological incompatibility occurs on plant surfaces or by affecting physiological processes associated with absorption, translocation, and metabolism (Houghton, 1982; Johanson and Kaldon, 1972). Various types of interactions can occur in the spray tank, on the plant surface, and/or inside the plant when agrochemicals are applied simultaneously. These interactions may occur either due to change in solution pH or due to differential absorption, translocation, or metabolism of agrochemicals in target pests (Burke and Wilcut, 2003; Culpepper *et al.*, 1999b; Hatzios and Penner, 1985; Nalewaja *et al.*, 1994; Rhodes and Coble, 1984). To overcome these adverse interactions, more efficacious formulations or spray adjuvants can be used (Hazen, 2000; Jordan, 1995; McMullan, 2000; Stock and Briggs, 2000). However, in some instances, these interactions can increase crop phytotoxicity and decrease pest control (Byrd and York, 1988; Franzen *et al.*, 2003; Jordan *et al.*, 2003; Pankey *et al.*, 2004). Research has been conducted to define interactions of herbicides (Askew *et al.*, 1999; Burke *et al.*, 2004; Culpepper *et al.*, 1998; Culpepper *et al.*, 1999a, 1999b; Flint and Barrett, 1989; Jordan and York, 1989; Wehtje *et al.*, 1992) and herbicides and fungicides (Jordan *et al.*, 2003; Lancaster *et al.*, 2005a, 2005b, 2008).

Clethodim and sethoxydim, referred to as graminicides, can be applied postemergence to control annual grasses in peanut throughout the majority of the growing season (Jordan, 2011). Efficacy of clethodim or sethoxydim has been evaluated when applied with azoxystrobin, chlorothalonil, pyraclostrobin, tebuconazole, and other standard fungicides (Jordan *et al.*, 2003; Lancaster *et al.*, 2005b). Previous research indicates that annual grass control may be reduced when these graminicides are applied with other pesticides (Byrd and York, 1988; Grichar *et al.*, 2002; Holshouser and Coble, 1990; Jordan *et al.*, 2003). Most of these studies were focused only on the biological compatibility of graminicides with other pesticides in two- or three-way mixtures (Lancaster *et al.*, 2005b). Studies showing biological and physicochemical responses of graminicides in four or five-way mixtures are limited.

Defining interactions among agrochemicals is important in assisting growers and their advisors as they make decisions on co-application of these products. Therefore, the objectives of this research were to compare grass control by clethodim or sethoxydim when applied alone or with combinations of dimethenamid-*P*, *S*-metolachlor, 2,4-DB, and pyraclostrobin and to define changes in spray solution characteristics with these combinations.

Materials and Methods

Large crabgrass and goosegrass control with graminicides applied with other pesticides. Research was conducted in North Carolina from 2007 through 2010 at the Central Crops Research Station located near Clayton and the Upper Coastal Plain Research Station located near Rocky Mount. Soils were a Johns sandy loam (fine-loamy over sandy, siliceous, semiactive, thermic Aquic Hapludults) at Clayton and a Goldsboro fine sandy loam (fine-loamy, siliceous, subactive, thermic Aquic Paleudults) at Rocky Mount. Efficacy of graminicides was evaluated in separate experiments in non-crop areas. Plot size was 2.4 by 5.0 m.

Treatments included all possible combinations of clethodim (Select 2EC herbicide, Valent U.S.A. Corporation, Walnut Creek, CA 94596) or sethoxydim (Poast herbicide, BASF Corporation Agricultural Products, Research Triangle Park, NC 27709) with no chloroacetamide herbicide, dimethenamid-*P* (Outlook, BASF Corporation, Research Triangle Park, NC 27709); or *S*-metolachlor (Dual Magnum, Syngenta Crop Protection, Inc., Greensboro, NC 27419); with or without 2,4-DB (Butyrac 200, Albaugh Inc., Ankeny, IA 50021); and with or without pyraclostrobin (Headline, BASF Corporation, Research Triangle Park, NC 27709). Clethodim, dimethenamid-*P*, pyraclostrobin, sethoxydim, *S*-metolachlor, and 2,4-DB were applied at 0.14, 0.84, 0.17, 0.21, 1.1, and 0.28 kg ai ha^{-1}, respectively. Crop oil concentrate (Agri-Dex nonionic spray adjuvant, Helena Chemical Company, Collierville, TN 38137) at 1.0% (v/v) was included in all treatments. Treatments were applied in 140 L ha^{-1} aqueous solution from a municipal water source using CO_2-pressurized backpack sprayer with flat-fan nozzles (TeeJet TP8002 flat-fan spray nozzles, Spraying Systems Co., Wheaton, IL 60189) at 275 kPa.

Large crabgrass control was evaluated during 2007, 2008, and 2009 while goosegrass control was evaluated during 2009 and 2010. Goosegrass and large crabgrass were 15 to 20 cm in height at the time of application. Visual estimates of percent weed control were recorded 21 d after treatment using a scale of 0 to 100% where 0 = no weed control and 100 = complete weed control (Frans *et al.*, 1986). Foliar chlorosis, necrosis, and plant stunting were considered when making the visual estimates.

Physicochemical compatibility of graminicides with other pesticides. Laboratory experiments were conducted to compare physicochemical compatibility of the graminicide combinations at rates and spray volumes used in field experiments. Deionized water at pH 6.3 was used in the laboratory experiments. Agrochemicals were mixed in the following order: emulsifiable concentrates (clethodim, pyraclostrobin, sethoxydim, *S*-metolachlor, and 2,4-DB), and soluble liquids (crop oil concentrate and dimethenamid-*P*). Graminicides solutions were prepared in a final volume of 80 ml in sterilized plastic specimen cups (Specimen cup120ml-53 ST ORG CAP, Fisher Scientific, NJ 07410) of 120 ml capacity. After mixing different agrochemicals, solution was vortexed (Vortex Genie 2, Fisher Scientific, Fairlawn, NJ 07410) immediately and examined for precipitates followed by determining pH using a portable pH meter (Oakton portable pH meter, Fisher Scientific, Fairlawn, NJ 07410). Solutions were allowed to settle for 6 h after the time of mixing, examined for precipitates, vortexed, and re-examined for precipitates followed by pH determination. Similarly, mixtures were allowed to settle for 24 h after the initial solution preparation using the same procedure. Presence or absence of precipitates were determined visually and described as Yes or No, respectively. Any visual depositions on the bottom of the specimen cup or the presence of suspended solids in the solution were considered as precipitates. Two types of precipitates, temporary and permanent, were noticed when herbicides were mixed with other agrochemicals. Temporary precipitates went back into solution upon vortexing while permanent precipitates did not go into solution after vortexing.

Statistical analysis. The experimental design in the field was a randomized complete block and treatments were replicated four times. In the laboratory, the experimental design was a completely randomized design and the experiment was repeated with two replicates in each experiment. Data for visual estimates of percent grass control and solution pH were subjected to ANOVA using the PROC MIXED procedure of SAS (Statistical Analysis Systems version 9.2, SAS Institute Inc., Cary, NC 27513) with year and sampling intervals as random variables for field and laboratory studies, respectively. Data for visual estimates of percent weed control were transformed to the arcsine square root prior to analysis. However, non-transformed means are presented because transformation did not affect data interpretation. Means of significant main effects and interactions were separated using Tukey's pair-wise comparison tests at P = 0.05.

Results and Discussion

Large crabgrass and goosegrass control with graminicides applied with other pesticides. Interactions of graminicide by 2,4-DB by pyraclostrobin and graminicide by chloroacetamide herbicide by pyraclostrobin were significant for goosegrass control. Large crabgrass control was affected by the interaction of graminicide by pyraclostrobin by 2,4-DB. Significant interaction of chloroacetamide herbicide by 2,4-DB was noted for both goosegrass and large crabgrass.

When pooled over years and chloroacetamide herbicide treatments, goosegrass control with clethodim was greater than control with sethoxydim when pyraclostrobin or 2,4-DB was not included in the mixture (Table 1). Clethodim plus pyraclostrobin controlled goosegrass less than clethodim alone when 2,4-DB was not included in the mixture. Regardless of pyraclostrobin, control by clethodim applied with 2,4-DB was similar to that by clethodim alone. Goosegrass control with sethoxydim was not negatively affected by pyraclostrobin but only when applied with 2,4-DB; in absence of 2,4-DB, pyraclostrobin did not affect goosegrass control with sethoxydim (Table 1).

When pooled over years and 2,4-DB treatment, clethodim plus pyraclostrobin controlled goosegrass less than clethodim alone when dimethenamid-*P* or *S*-metolachlor was not included in this mixture (Table 2). When compared with clethodim alone, chloroacetamide herbicides did not affect goosegrass control irrespective of pyraclostrobin treatment. In the absence of chloroacetamide herbicides, control of goosegrass with sethoxydim plus pyraclostrobin was similar to sethoxydim alone. When dimethenamid-*P* or *S*-metolachlor was applied with sethoxydim, goosegrass control was similar regardless of pyraclostrobin treatment when comparing within a chloroacetamide herbicide or with sethoxydim alone.

Table 1. Goosegrass control 21 d after application when clethodim and sethoxydim were applied alone or with 2,4-DB and pyraclostrobin.[a,b]

	Clethodim		Sethoxydim	
	Pyraclostrobin		Pyraclostrobin	
2,4-DB	0	0.17 kg ha^{-1}	0	0.17 kg ha^{-1}
kg ha^{-1}	%			
0	86 a	67 bcd	69 bcd	65 cd
0.28	80 a	76 ab	73 abc	59 d

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

[b]Clethodim and sethoxydim applied at 0.14 and 0.21 kg ha^{-1}, respectively. Crop oil concentrate at 1.0% (v/v) was applied with all treatments.

Table 3. Goosegrass and large crabgrass control 21 d after application when clethodim and sethoxydim were applied alone or with chloroacetamide herbicides and 2,4-DB.[a,b]

	Goosegrass control		Large crabgrass control	
	2,4-DB		2,4-DB	
Chloroacetamide herbicide	0	0.28 kg ha^{-1}	0	0.28 kg ha^{-1}
	%			
None	61 b	71 a	68 b	73 ab
Dimethenamid-*P*	75 a	73 a	75 a	75 a
S-metolachlor	75 a	73 a	75 a	72 ab

[a]Means within a weed species followed by the same letter are not significantly different according to Tukey's test at P = 0.05. Data are pooled over years, graminicides and pyraclostrobin.

[b]Dimethenamid-*P* and *S*-metolachlor were applied at 0.84 and 1.1 kg ha^{-1}, respectively. Crop oil concentrate at 1.0% (v/v) was applied with all treatments.

Combinations of graminicides with dimethenamid-*P* or *S*-metolachlor controlled goosegrass more effectively than graminicides alone irrespective of 2,4-DB (Table 3). On the other hand, addition of 2,4-DB to graminicides plus *S*-metolachlor provided similar control of large crabgrass as compared to graminicides alone. However, the control of large crabgrass with graminicides plus chloroacetamide herbicides was greater than graminicides alone.

Results for large crabgrass control by clethodim and sethoxydim were surprising in that pyraclostrobin reduced control by clethodim but not sethoxydim when 2,4-DB was not included (Table 4). Control of large crabgrass was greater with clethodim than with sethoxydim. In contrast, applying 2,4-DB with graminicides alone or in mixture with pyraclostrobin resulted in similar control.

Previous research indicates that clethodim was more effective in controlling broadleaf signalgrass [*Brachiaria platyphylla* (Griseb.) Nash] and large crabgrass than sethoxydim (Jordan *et al.*, 1993; Lancaster *et al.*, 2005a). As noted for goosegrass control by clethodim, co-application of clethodim with pyraclostrobin reduced large crabgrass control compared with clethodim alone. Lancaster *et al.* (2005a) reported that large crabgrass control was reduced in three of four experiments when sethoxydim was applied with pyraclostrobin.

Table 2. Goosegrass control 21 d after application when clethodim and sethoxydim were applied alone or with chloroacetamide herbicides and pyraclostrobin.[a,b]

	Clethodim		Sethoxydim	
	Pyraclostrobin		Pyraclostrobin	
Chloroacetamide	0	0.17 kg ha^{-1}	0	0.17 kg ha^{-1}
	%			
None	80 a	63 cde	63 cde	58 e
Dimethenamid-*P*	83 a	75 a-d	73 a-d	62 de
S-metolachlor	78 ab	77 abc	77 abc	66 b-e

[a]Means followed by the same letter are not significantly different according to Tukey's test at P = 0.05. Data are pooled over years and 2,4-DB treatments.

[b]Clethodim, dimethenamid-*P*, sethoxydim, and *S*-metolachlor were applied at 0.14, 0.84, 0.21, and 1.1 kg ha^{-1}, respectively. Crop oil concentrate at 1.0% (v/v) was applied with all treatments.

Results suggesting that chloroacetamide herbicides can mitigate adverse interactions of graminicides with other pesticides or increase control over the graminicide alone were surprising. Data in the peer-reviewed literature are limited with respect to defining interactions of graminicides and chloroacetamide herbicides. The inconsistent impact of 2,4-DB on interactions of graminicides with pyraclostrobin also was surprising. In previous research (Chahal *et al.*, 2012d), pyraclostrobin and 2,4-DB influenced efficacy of graminicides independently.

Although interactions were noted in these experiments among pesticide combinations, the magnitude of negative impact did not exceed 19% when comparing within a graminicide (Tables 1, 2, and 4). Also, the improved control in presence of chloroacetamide herbicides did not exceed 14% (Table 3). The biological significance of these interactions is difficult to quantify. None-the-less, these data do indicate that in some instances control by clethodim and sethoxydim can be negatively or positively impacted by pesticide combinations included in this study but at a relatively low level.

Physicochemical compatibility of graminicides with other pesticides. The interaction of graminicide by chloroacetamide herbicide by 2,4-DB by

Table 4. Large crabgrass control 21 d after application when clethodim and sethoxydim were applied alone or with 2,4-DB and pyraclostrobin.[a,b]

	Clethodim		Sethoxydim	
	Pyraclostrobin		Pyraclostrobin	
2,4-DB	0	0.17 kg ha^{-1}	0	0.17 kg ha^{-1}
kg ha^{-1}	%			
0	81 a	71 b	70 bc	69 bc
0.28	80 a	76 ab	75 ab	63 c

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

[b]Clethodim and sethoxydim applied at 0.14 and 0.21 kg ha^{-1}, respectively. Crop oil concentrate at 1.0% (v/v) was applied with all treatments.

pyraclostrobin was significant for solution pH determined for graminicide combinations. Solution with clethodim or sethoxydim alone had pH 4.24 or 4.11, respectively, over the sampling intervals (Table 5). In the absence of 2,4-DB and pyraclostrobin, addition of dimethenamid-*P* and *S*-metolachlor to clethodim or sethoxydim solutions slightly decreased solution pH compared with solution containing clethodim or sethoxydim alone. Regardless of chloroacetamide herbicides, fungicide, and graminicides, 2,4-DB added to graminicide solution increased pH greater than 6.0. Regardless of graminicides, fungicide, and 2,4-DB, solutions containing dimethenamid-*P* had pH lower than solutions with *S*-metolachlor (Table 5).

In a few instances, solution with graminicides combinations formed temporary precipitates at 0, 6, and 24 h sampling times (Table 6). For instance, a combination of clethodim plus crop oil concentrate plus pyraclostrobin with or without *S*-metolachlor formed temporary precipitates across sampling times but solution was reestablished after vortexing. In contrast, combination of sethoxydim plus crop oil concentrate plus pyraclostrobin did not form any precipitates regardless of sampling time.

The application of results from the pH component of this research is unknown. Although pH can impact herbicide efficacy, the impact of mixtures was relatively minor, either positively or negatively

Table 5. Solution pH when clethodim or sethoxydim were applied alone or with chloroacetamide herbicides, pyraclostrobin, and 2,4-DB at the time of solution preparation and 6 and 24 h after preparation.[a]

	Agrochemicals[b]			
Graminicides	Chloroacetamide herbicide	Fungicide	Synthetic auxin	Solution pH
Clethodim	None	None	None	4.24 jk
Clethodim	*S*-metolachlor	None	None	4.17 l
Clethodim	Dimethenamid-*P*	None	None	3.52 o
Clethodim	None	Pyraclostrobin	None	4.44 i
Clethodim	None	None	2,4-DB	6.07 h
Clethodim	*S*-metolachlor	Pyraclostrobin	None	4.28 j
Clethodim	Dimethenamid-*P*	Pyraclostrobin	None	3.56 o
Clethodim	*S*-metolachlor	None	2,4-DB	6.71 a
Clethodim	Dimethenamid-*P*	None	2,4-DB	6.55 d
Clethodim	None	Pyraclostrobin	2,4-DB	6.38 f
Clethodim	*S*-metolachlor	Pyraclostrobin	2,4-DB	6.72 a
Clethodim	Dimethenamid-*P*	Pyraclostrobin	2,4-DB	6.64 bc
Sethoxydim	None	None	None	4.11 m
Sethoxydim	*S*-metolachlor	None	None	4.00 n
Sethoxydim	Dimethenamid-*P*	None	None	3.40 p
Sethoxydim	None	Pyraclostrobin	None	4.21 kl
Sethoxydim	None	None	2,4-DB	6.20 g
Sethoxydim	*S*-metolachlor	Pyraclostrobin	None	4.06 m
Sethoxydim	Dimethenamid-*P*	Pyraclostrobin	None	3.44 p
Sethoxydim	*S*-metolachlor	None	2,4-DB	6.59 cd
Sethoxydim	Dimethenamid-*P*	None	2,4-DB	6.49 e
Sethoxydim	None	Pyraclostrobin	2,4-DB	6.39 f
Sethoxydim	*S*-metolachlor	Pyraclostrobin	2,4-DB	6.69 ab
Sethoxydim	Dimethenamid-*P*	Pyraclostrobin	2,4-DB	6.57 d

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

[b]Clethodim, dimethenamid-*P*, pyraclostrobin, sethoxydim, *S*-metolachlor, and 2,4-DB were applied at 0.14, 0.84, 0.17, 0.21, 1.1, and 0.28 kg ha^{-1}, respectively. Crop oil concentrate at 1.0% (v/v) was added with all treatments.

Table 6. Presence or absence of precipitates when clethodim or sethoxydim were mixed alone or with chloroacetamide herbicides, pyraclostrobin, and 2,4-DB at the time of solution preparation and 6 and 24 h after preparation.[a]

Agrochemicals[b]				Hours after preparation[c]		
Graminicides	Chloroacetamide herbicide	Fungicide	Synthetic auxin	0	6	24
				precipitates		
Clethodim	None	None	None	N	N	N
Clethodim	*S*-metolachlor	None	None	N	N	N
Clethodim	Dimethenamid-*P*	None	None	N	N	N
Clethodim	None	Pyraclostrobin	None	Y*	Y*	Y*
Clethodim	None	None	2,4-DB	N	N	N
Clethodim	*S*-metolachlor	Pyraclostrobin	None	Y*	Y*	Y*
Clethodim	Dimethenamid-*P*	Pyraclostrobin	None	Y*	Y*	Y*
Clethodim	*S*-metolachlor	None	2,4-DB	N	N	N
Clethodim	Dimethenamid-*P*	None	2,4-DB	N	N	N
Clethodim	None	Pyraclostrobin	2,4-DB	N	N	N
Clethodim	*S*-metolachlor	Pyraclostrobin	2,4-DB	N	N	N
Clethodim	Dimethenamid-*P*	Pyraclostrobin	2,4-DB	Y*	Y*	Y*
Sethoxydim	None	None	None	N	N	N
Sethoxydim	*S*-metolachlor	None	None	N	N	N
Sethoxydim	Dimethenamid-*P*	None	None	N	N	N
Sethoxydim	None	Pyraclostrobin	None	N	N	N
Sethoxydim	None	None	2,4-DB	N	N	N
Sethoxydim	*S*-metolachlor	Pyraclostrobin	None	Y*	Y*	Y*
Sethoxydim	Dimethenamid-*P*	Pyraclostrobin	None	Y*	Y*	Y*
Sethoxydim	*S*-metolachlor	None	2,4-DB	N	N	N
Sethoxydim	Dimethenamid-*P*	None	2,4-DB	N	N	N
Sethoxydim	None	Pyraclostrobin	2,4-DB	N	N	N
Sethoxydim	*S*-metolachlor	Pyraclostrobin	2,4-DB	Y*	Y*	Y*
Sethoxydim	Dimethenamid-*P*	Pyraclostrobin	2,4-DB	Y*	Y*	Y*

[a]Data are pooled over experiments.

[b]Clethodim, dimethenamid-*P*, pyraclostrobin, sethoxydim, *S*-metolachlor, and 2,4-DB were applied at 0.14, 0.84, 0.17, 0.21, 1.1, and 0.28 kg ha^{-1}. Crop oil concentrate at 1.0% (v/v) was added with all treatments.

[c]Abbreviations: *Indicates temporary precipitates, ^Indicates permanent precipitates, 'Y' means presence of precipitates, and 'N' means no precipitates were observed.

on graminicide performance. Results from the precipitate observations suggest that these pesticides can be mixed with minimal concern of permanent precipitates forming which could cause major issues with application and sprayer cleanout.

Previous research (Chahal *et al.*, 2012a 2012b 2012c; Lancaster *et al.*, 2005a 2005b) with three or more components in tank mixtures often used in peanut have been evaluated but did not include chloroacetamide herbicides. Results from the current research suggest that the chloroacetamide herbicides dimethenamid-*P* and *S*-metolachlor will not adversely affect control by graminicides or the previously defined interactions of graminicides with 2,4-DB or pyraclostrobin. These experiments demonstrated that pyraclostrobin consistently reduced goosegrass and large crabgrass control by clethodim. When applied alone, clethodim controlled goosegrass and large crabgrass more effectively than sethoxydim. Lack of a consistent reduction of sethoxydim activity by pyraclostrobin may have been a reflection of relatively poor control by sethoxydim regardless of co-applied pesticides. Of the herbicides used in these experiments, 2,4-DB had the least effect on graminicides. Results of physicochemical compatibility indicated that addition of clethodim, sethoxydim, dimethenamid-*P*, *S*-metolachlor and 2,4-DB changed the carrier pH dramatically. Although several clethodim and sethoxydim combinations with chloroacetamide herbicides, 2,4-DB, and fungicide formed temporary precipitates at different time intervals, pesticides and crop oil concentrate could be brought back into solution after agitation. The impact of changes in pH on efficacy was not determined in this experiment. Future research measuring efficacy and pH affects with solutions used in the field would be more informative than results reported here. Lack of permanent precipitate formation from these mixtures is important in eliminating one possible negative impact of co-application of these pesticide combinations.

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