Herbicide and Rye Cover Crop Residue Integration Affect Weed Control and Yield in Strip-Tillage Peanut

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ABSTRACT

Reduced-tillage peanut production is increasing due to reduced production costs and increased environmental and economic benefits compared to conventional systems. Experiments were conducted in Alabama and Georgia between 2005 and 2007 to evaluate a strip-tillage system utilizing a high-residue cereal rye cover crop, in comparison to a conventional tillage system. Six weed management schemes were evaluated including a preemergence (PRE) application of pendimethalin alone at 1.12 kg ai/ha or in combination with *S*-metolachlor at 1.36 kg ai/ha. Both PRE applications were applied alone or followed by (fb) a postemergence (POST) application consisting of a mixture of paraquat at 0.140 kg ai/ha plus bentazon at 0.56 kg ai/ha plus 2,4-DB at 0.224 kg ae/ha. The remaining two treatments consisted of a no-herbicide control and aforementioned POST-only application. In 2005 at the Alabama location, pendimethalin plus metolachlor with or without a POST application controlled all weeds >91% in the strip tillage treatment and controlled tall morningglory, yellow nutsedge, and common bermudagrass >83% in the conventional tillage system. Pendimethalin fb a POST application controlled all weeds > 97%, except large crabgrass (75%) and common bermudagrass (≤ 58%) regardless of tillage system. In 2007, pendimethalin and pendimethalin plus S-metolachlor followed by (fb) a POST application controlled smooth pigweed, tall morningglory, large crabgrass, Florida beggarweed, and sicklepod 70 to 99%, across tillage systems. In 2005 at the Georgia location, large crabgrass control was consistently reduced in strip-tillage compared to conventional tillage regardless of herbicide treatment. In 2006, pendimethalin plus S-metolachlor fb POST controlled common bermudagrass and yellow nutsedge 74 to 99%. Herbicide treatment effect on peanut yield varied with environment. Peanut yield was equivalent or greater by 25% or more in 3 of 4 site years utilizing strip-tillage indicating a yield advantage compared to conventional tillage. Peanut market grade was not affected by any herbicide treatments or tillage methods evaluated. Results show that producers can maintain weed control, equivalent grade and yield in reduced-tillage systems when utilizing a high-residue conservation agriculture system integrated with a PRE plus POST herbicide system.

Key Words: Agrochemicals, bentazon, paraquat, pendimethalin, *S*-metolachlor, 2,4-DB, conservation agriculture, peanut grade, peanut yield, rye residue, weed control.

Peanut (*Arachis hypogaea* L.) production in the southeastern United States has traditionally been a tillage intensive enterprise utilizing both primary and secondary tillage to create residue-free raised or flat seedbeds. Peanut production typically includes preplant incorporated (PPI) and/or PRE herbicides in conventional tillage systems. However, concerns of soil and environmental quality, coupled with rising expenses associated with management and fuel costs, have led to the adoption of conservation tillage systems in peanut production. The most commonly used conservation tillage system in peanut production is strip-tillage, which is used to alleviate soil compaction commonly encountered in the southeastern US soils (Busscher and Bauer 2003; Truman *et al.* 2003). Benefits of strip-tillage include those of both conservation tillage and conventional systems. Strip-tillage utilizes coulters and rolling baskets that create a residue-free, smooth seedbed to facilitate seed soil contact, increased soil temperature at planting and PRE herbicide activation. Previous peanut research in the U.S. indicated higher or equivalent yields with strip-tillage compared to conventional tillage systems (Faircloth *et al.* 2012; Johnson *et al.* 2001; Tubbs and Gallaher 2005; Wilcut *et al.* 1987) while others report lower yields (Drake *et al.* 2010; Jordan *et al.* 2001). Finally, conservation tillage systems reduce input costs and can offer economic advantages over conventional tillage practices after several years of their successful adoption (Bowman *et al.* 1998).

Another important component of a strip-tillage peanut production system in the southeastern

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United States is the use of cover crops. Cover crop benefits include an increase in soil organic matter, water and soil conservation, and enhanced nutrient cycling (Blevins *et al.* 1971; Kaspar *et al.* 2001; Sainju and Singh 1997; Schwab *et al.* 2002). Cover crop residue conserves water by preventing evaporative and runoff losses and aids in soil conservation by reducing wind and water erosion (Dabney *et al.* 2001; Snapp *et al.* 2005). The presence of residue around the seedbed also reduces seedling peanut damage due to sandblasting (Wright *et al.* 2002). The most commonly used cover crops in peanut production are cereal grain crops such as rye (*Secale cereale* L.), wheat (*Triticum aestivum* L.) and black oat (*Avena strigosa* L.) because they are easy to establish and provide relatively high amounts of biomass (Price *et al.* 2007; Wright *et al.* 2002). Cover crop residue can also aid in early-season weed control through allelopathy and direct physical suppression (Creamer *et al.* 1997; Price *et al.* 2006; Teasdale and Abdul-Baki 1998; Yenish *et al.* 1996). Cover crops have been shown to reduce tomato spotted wilt incidence over bare ground, conventional systems (Marois and Wright 2003).

The major crop management challenge in conservation tillage systems is the loss of weed control provided by seedbed preparation and cultivation in conventional tillage systems, as well as potentially reduced weed control due to interception of PRE herbicides by cover crop residues (Banks and Robinson 1986; Isensee and Sadeghi 1994; Teasdale *et al.* 2005). In conservation tillage, it is common to have an increase in the weed seed bank present near the soil surface leading to germination of these seeds over a longer period of time (Kells and Meggitt 1985), requiring additional herbicide inputs. Additionally, with the adoption of conservation tillage systems, weed communities may shift over time from easy to control annual species to harder to control perennials (Barberi 2002; Cardina *et al.* 2002). Therefore, weed management in strip-tillage management of peanut may require more intensive herbicide inputs compared to conventional tillage systems (Wilcut *et al.* 1987). Weed interference is a very important factor determining profitability in peanut production. Webster (2001) reported total annual losses from weeds in Alabama and Georgia to be $11.2 and $47.5 million, respectively.

Because of the above mentioned concerns and increased adoption of conservation tillage systems utilizing high-residue cover crops by growers, further research is needed to evaluate weed control and yield under different tillage systems and herbicide intensities. Currently, high residue agriculture system literature is limited, especially in peanut. Therefore, the objectives of this study were to compare weed control provided by a high-residue rye cover crop in conventional tillage and strip-tillage systems and its effect on weed control, peanut yield and peanut grade in Alabama and Georgia.

Materials and Methods

Field experiments were conducted at sites in Alabama (2004/05 and 2006/07) and Georgia (2004/05 and 2005/06), each replicated in time for two crop years. The Alabama site was located on a Dothan sandy loam (fine-loamy, siliceous, thermic, Plinthic Paleudult) at the Alabama Agricultural Experiment Station's Wiregrass Research and Extension Center (31°24′N, 85°15′W), located near Headland, AL. The Georgia site was located on a Red Bay loamy sand (Fine-loamy, kaolinitic, thermic Rhodic Kandiudult) at the USDA-ARS National Peanut Research Laboratory field research site near Dawson, GA (31°45′N, 84°26′W).

The experiment was conducted as a randomized complete block design with four replicates at both sites. A cereal rye (cv. Elbon) cover crop was seeded (100 kg/ha) in early November every year with a no-till drill. Regardless of tillage system, the cover crop was terminated in early May (Feekes' soft dough growth stage 11.2) of each year approximately 2 weeks prior to planting peanut each year with an application of glyphosate at 1.12 kg/ha utilizing a compressed CO_2 backpack sprayer delivering 140 L/ha at 147 kPa. For preparation of strip-tillage plots, the cover crop was then rolled once with a mechanical roller-crimper to flatten residue on the soil surface resulting in a uniform residue mat. Conventional tillage plots were prepared with three passes of a disk followed by a seedbed conditioner. All plots were then strip-tilled using a subsoiler equipped with coulters, rolling baskets, and drag chains to eliminate confounding deep tillage affects. An area approximately 30 cm wide was tilled over each row with this implement. Plots were 12 feet wide by 25 feet in length.

The peanut cultivar 'Georgia Green' was planted with a four-row planter each year at both locations at a rate of 28 seed per meter of row. State Cooperative Extension System recommendations were used for insect and disease control and nutrient management at each experimental site. Peanut yield was determined by machine-digging followed by (fb) harvesting the middle two rows of each 4-row plot.

Six herbicide weed management schemes were evaluated. The first and second included a PRE application of pendimethalin at 1.12 kg ai/ha either alone or in combination with *S*-metolachlor at 1.36 kg ai/ha. Both PRE treatments were applied alone or in conjunction with a POST application consisting of a tank mixture of paraquat at 0.140 kg ai/ha plus bentazon at 0.56 kg ai/ha plus 2,4-DB at 0.224 kg ae/ha applied 21 days after emergence. The remaining two treatments consisted of a no-herbicide control and the aforementioned POST-only application. These herbicide treatment schemes were applied as a factorial with the two tillage systems yielding 12 treatment combinations replicated four times. The effectiveness of herbicide programs was determined by visual assessment of weed control on a 0 to100 scale was used where 0 and 100 indicate no control and complete control, respectively.

Mixed model analysis of variance procedures (PROC GLIMMIX) in SAS® (SAS version 9.3, SAS Institute Inc, Cary, NC) were used to analyze weed control, yield and grade data. Weed control data were analyzed separately for each environment due to an interaction revealed by ANOVA (experiment location x year). Herbicide treatment, tillage system and their interactions were considered fixed effects, whereas replication and their interaction with herbicide treatment and tillage system were considered random effects. Percent weed control data were subjected to the arcsine transformation to account for non-normality of residuals and heterogeneity of variances. Back-transformed means for appropriate main effects and interactions are presented with contrasts based on the transformed data. Significance of the means was tested by performing two types of comparisons. Effect of all herbicide treatments vs. most effective herbicide treatment containing pendimethalin and S-metolachlor PRE fb tank mixture of paraquat plus bentazon plus 2,4-DB within each tillage system was accomplished by using Dunnett's test option in least square means statement of PROC GLIMMIX. Significance of the tillage system effect on performance of each herbicide regimen was tested using pdiff option in LSmeans statement of PROC GLIMMIX. Both tests utilized $P=0.01$, a common standard utilized in field data sets.

Results and Discussion

Weed Control

A total of nine weed species were evaluated for weed control but none of the species were present in all environments. Weed species at Headland, AL included: common bermudagrass [*Cynodon dactylon* (L.) Pers.], Florida beggarweed [*Desmodium tortuosum* (Sw.) DC.], large crabgrass [*Digitaria sanguinalis* (L.) Scop.], sicklepod [*Senna obtusifolia* (L.) Irwin & Barneby], smooth pigweed (*Amaranthus hybridus* L.), tall morningglory [*Ipomoea purpurea* (L.) Roth], and yellow nutsedge (*Cyperus esculentus* L.). At the Dawson, GA site, weed species evaluated included: common bermudagrass, crowfootgrass [*Dactyloctenium aegyptium* (L.) Willd.], and yellow nutsedge. Since the objective of this experiment was to compare the efficacy of the chosen herbicide treatments in strip and conventional tillage systems, results for each weed species are discussed at the factorial treatment interaction level (herbicide treatment x tillage system).

Headland, AL.

Smooth pigweed. All herbicide treatments except pendimethalin alone controlled smooth pigweed 77 to 99% compared with no herbicide treatment irrespective of tillage system (Table 1). Pendimethalin alone produced variable response with 13 and 78% control in conventional and 61 and 69% control in strip-tillage system in 2005 and 2007, respectively. Improved control in the high-residue system may be attributed to weed suppression by the cereal rye mulch (Aulakh *et al.* 2012; Price *et al.* 2007). Pendimethalin plus *S*-metolachlor controlled smooth pigweed 77% and 81% in conventional tillage system and 98% and 84% in the strip-tillage system in 2005 and 2007, respectively. A Texas study reported less than 42% control of Palmer amaranth with pendimethalin applied PPI, and 95% control with pendimethalin PPI fb *S*-metolachlor PRE (Grichar 2008). Tredaway-Ducar *et al.* (2006) reported 73% control of smooth pigweed with *S*-metolachlor alone PRE. Wilcut *et al.* (1994), however, reported good control of *Amaranthus* spp. with dinitroaniline herbicides such as pendimethalin and less consistent control with *S*-metolachlor. In our study, the tank mixture of the two herbicides applied PRE improved yellow nutsedge, common bermudagrass, and large crabgrass control in comparison to pendimethalin applied alone. These results indicate both herbicides applied as a tank mixture or sequentially can maintain the control of *Amaranthus* spp. A POST application following pendimethalin or pendimethalin plus *S*-metolachlor improved control ($\geq$ 98%). However, the POST-only treatment was also sufficient in controlling smooth pigweed in both tillage systems in 2005 with 99% control. In 2007, the POST-only treatment controlled 85% of smooth pigweed under the conventional tillage system and 81% under the strip-tillage system.

Table 1. Smooth pigweed and tall morningglory control as influenced by herbicide and tillage treatments at Headland, AL in 2005 and 2007.

Herbicide treatment		Smooth pigweed 2005		Smooth pigweed 2007		Tall morningglory 2005		Tall morningglory 2007	
PRE[a]	POST[b]	Conventional tillage	Strip tillage	Conventional tillage	Strip tillage	Conventional tillage	Strip tillage	Conventional tillage	Strip tillage
		% control							
Pendi + *S*-met	Yes	99	99	99	99	99	99	96	88
Pendi	Yes	99	99	98	99	99	99	98	99
Pendi + *S*-met	No	77*	98†	81*	84*	83*	94†	56*	67*
Pendi	No	13*	61*†	78*	69*	0*	68*†	0*	53*†
No	Yes	99	99	85*	81*	96	99	63*	76*
No	No	0*	64*†	0*	52*†	0*	49*†	0*	69*†

[a]Preemergence treatments included pendimethalin (Pendi) at 1.12 kg/ha alone or mixed with *S*-metolachlor (*S*-met) at 1.36 kg/ha.

[b]Postemergence tank mixture of paraquat applied at 0.140 kg /ha, bentazon applied at 0.56 kg/ha and 2,4-DB applied at 0.224 kg/ha.

*Indicates significant differences (P < 0.10) based on Dunnett test comparing least square means of herbicide treatments with the pendimethalin + S-metolachlor applied preemergence followed by a postemergence tank mixture of paraquat + bentazon + 2,4-DB.

†Indicates significant difference (P < 0.10) in efficacy of herbicide regimen between tillage treatments within individual weed species based on single degree of freedom contrasts.

Tall morningglory. Pendimethalin alone did not effectively control tall morningglory (<68%) in either conventional or strip-tillage during two years of the study (Table 1). Grey and Wehtje (2005) also reported lack of tall morningglory control with pendimethalin alone. Addition of *S*-metolachlor to pendimethalin improved the control across both tillage systems in 2005. Residual PRE treatments fb a POST application controlled tall morningglory 99% in 2005 and ≥ 88% in 2007 regardless of tillage system. The POST-only treatment also provided ≥ 96% control in both conventional tillage and strip-tillage in 2005. However in 2007, the same treatment did not control tall morningglory greater than 76% in either tillage system.

Yellow nutsedge. Strip tillage without any herbicide treatment was ineffective (<31%) in controlling yellow nutsedge (Table 2). Pendimethalin alone did not adequately control yellow nutsedge (≤ 63%). Grichar *et al.* (1992) also observed lack of yellow nutsedge control with dinitroaniline herbicides. Addition of *S*-metolachlor to pendimethalin improved control to >89 in 2005. However in 2007, the same treatment failed to control yellow nutsedge in either tillage system due to lack of rainfall to move the herbicide into the zone of tuber germination. Both residual PRE treatments fb a POST application controlled yellow nutsedge ≥ 97% irrespective of tillage system in 2005. In 2007, only the pendimethalin plus S-metolachlor fb a POST application provided ≥ 90% control of yellow nutsedge. The POST-only treatment was not adequate in controlling yellow nutsedge in either tillage system. Overall in 2007, none of the herbicide treatments adequately controlled yellow nutsedge in the strip-tillage system.

Common bermudagrass. Common bermudagrass infestation occurred only in 2005. Pendimethalin plus *S*-metolachlor PRE provided effective control (≥ 92%) with or without a POST application regardless of tillage system (Table 2). Other herbicide treatments resulted in poor control regardless of tillage. Although pendimethalin or POST-only treatments were not effective (≤ 58%) for common bermudagrass control, strip-tillage outperformed conventional tillage, suggesting weed suppression by the high-residue rye cover.

Large crabgrass. Large crabgrass infestation occurred only in 2007. Without herbicides, control was 41% in strip-tillage system (Table 2). In the strip-tillage system, treatments containing pendimethalin alone or fb a POST application provided 75 and 78% control, respectively. Pendimethalin plus *S*-metolachlor controlled large crabgrass ≥ 91% with or without a POST application. Previous research reported satisfactory annual grass weed control in peanut with the use of pendimethalin (Grey and Wehtje 2005; Teasdale *et al.* 2005; Wilcut *et al.* 1995). The POST-only treatment did not effectively control (≤ 33%) large crabgrass in either tillage systems.

Sicklepod. Pendimethalin alone was not effective (≤ 55%) in controlling sicklepod in either tillage system (Table 3). However, pendimethalin plus *S*-metolachlor PRE in strip-tillage resulted in 92% control that was 29% higher than in conventional

Table 2. Yellow nutsedge, common bermudagrass, and large crabgrass control as influenced by herbicide and tillage treatments at Headland, AL in 2005 and 2007.

Herbicide treatment		Yellow nutsedge 2005		Yellow nutsedge 2007		Common bermudagrass 2005		Large crabgrass 2007	
PRE[a]	POST[b]	Conventional tillage	Strip tillage	Conventional tillage	Strip tillage	Conventional tillage	Strip tillage	Conventional tillage	Strip tillage
		% control							
Pendi + *S*-met	Yes	99	99	90	62†	97	99	93	95
Pendi	Yes	97	97	29*	61†	36*	58*†	75	78
Pendi + *S*-met	No	89*	91*	54*	72	92*	97	61	91†
Pendi	No	0*	63*†	0*	25*†	0*	31*†	77	62
No	Yes	4*	41*†	13*	46*	20*	39*†	33*	23*
No	No	0*	31*†	0*	28	0*	48*†	0*	41*†

[a]Preemergence treatments included pendimethalin (Pendi) at 1.12 kg/ha alone or mixed with *S*-metolachlor (*S*-met) at 1.36 kg/ha.

[b]Postemergence tank mixture of paraquat applied at 0.140 kg /ha, bentazon applied at 0.56 kg/ha and 2,4-DB applied at 0.224 kg/ha.

*Indicates significant differences ($P < 0.10$) based on Dunnett test comparing least square means of herbicide treatments with the pendimethalin + S-metolachlor applied preemergence followed by a postemergence tank mixture of paraquat + bentazon + 2,4-DB.

†Indicates significant difference ($P < 0.10$) in efficacy of herbicide regimen between tillage treatments within individual weed species based on single degree of freedom contrasts.

tillage in 2005. In 2007, sicklepod control ranged from 31 to 48% with the same treatment regardless of tillage system. Control was higher (≥ 96%) in 2005, regardless of tillage system, when a POST application occurred with or without residual PRE herbicides. Brecke and Stephenson (2006) also reported > 90% control with paraquat and bentazon applied early postemergence fb imazapic. In 2007, control was higher (80%) in the strip-tillage system than in conventional tillage (39%) with the POST-only treatment.

Florida beggarweed. Control was inadequate (≤53%) without an herbicide application in either tillage system for 2007 (Table 3). Addition of *S*-metolachlor to pendimethalin did not improve control over pendimethalin alone irrespective of tillage system. Pendimethalin fb a POST application controlled Florida beggarweed ≥ 87% in both tillage systems. Pendimethalin plus *S*-metolachlor fb a POST herbicide application controlled Florida beggarweed 79 and 95% in strip- and conventional-tillage systems, respectively. A POST application for effective control of Florida beggarweed was suggested by Webster and Cardina (2004) owing to the irregular germination of this weed species. Brecke and Stephenson (2006) also reported greater than 90% control of Florida beggarweed with treatments including either diclosulam or flumioxazin PRE fb either paraquat plus bentazon or paraquat plus bentazon fb 2,4-DB. However, in our study the

Table 3. Sicklepod and Florida beggarweed control as influenced by herbicide and tillage treatments at Headland, AL in 2005 and 2007.

Herbicide treatment		Sicklepod 2005		Sicklepod 2007		Florida beggerweed 2007	
PRE[a]	POST[b]	Conventional tillage	Strip tillage	Conventional tillage	Strip tillage	Conventional tillage	Strip tillage
		% control					
Pendi + *S*-met	Yes	99	99	80	70	95	79
Pendi	Yes	99	99	76	92*	87	88
Pendi + *S*-met	No	63*	92*†	48	31*	45*	53*
Pendi	No	20*	55*†	36*	45*	31*	76†
No	Yes	96	99	39*	80†	31*	8*
No	No	0*	62*†	0*	26*	0*	53*†

[a]Preemergence treatments included pendimethalin (Pendi) at 1.12 kg/ha alone or mixed with *S*-metolachlor (*S*-met) at 1.36 kg/ha.

[b]Postemergence tank mixture of paraquat applied at 0.140 kg /ha, bentazon applied at 0.56 kg/ha and 2,4-DB applied at 0.224 kg/ha.

*Indicates significant differences ($P < 0.10$) based on Dunnett test comparing least square means of herbicide treatments with the pendimethalin + S-metolachlor applied preemergence followed by a postemergence tank mixture of paraquat + bentazon + 2,4-DB.

†Indicates significant difference ($P < 0.10$) in efficacy of herbicide regimen between tillage treatments within individual weed species based on single degree of freedom contrasts.

Table 4. Large crabgrass, yellow nutsedge, crowfoot grass, and common bermudagrass control as influenced by herbicide and tillage treatments at Dawson, GA in 2005 and 2006.

Herbicide treatment		Large crabgrass 2005		Yellow nutsedge 2006		Crowfootgrass 2006		Common bermudagrass 2006	
PRE[a]	POST[b]	Conventional tillage	Strip tillage	Conventional tillage	Strip tillage	Conventional tillage	Strip tillage	Conventional tillage	Strip tillage
		% control							
Pendi + *S*-met	Yes	89	69†	96	99	57	74	95	94
Pendi	Yes	99	71†	93	99	59	42	5*	49*†
Pendi + *S*-met	No	93	65†	99	98	54	52	91	90
Pendi	No	96	72†	0*	4*	55	60	0*	33*†
No	Yes	14*	26*†	89	96†	38*	47	32*	51*†
No	No	0*	10*†	0*	5*	0*	16†	0*	38*†

[a]Preemergence treatments included pendimethalin (Pendi) at 1.12 kg/ha alone or mixed with *S*-metolachlor (*S*-met) at 1.36 kg/ha.

[b]Postemergence tank mixture of paraquat applied at 0.140 kg /ha, bentazon applied at 0.56 kg/ha and 2,4-DB applied at 0.224 kg/ha.

*Indicates significant differences ($P < 0.10$) based on Dunnett test comparing least square means of herbicide treatments with the pendimethalin + S-metolachlor applied preemergence followed by a postemergence tank mixture of paraquat + bentazon + 2,4-DB.

†Indicates significant difference ($P < 0.10$) in efficacy of herbicide regimen between tillage treatments within individual weed species.

POST-only treatment provided ≤ 31% control. Wilcut *et al.* (1995) also reported variable control of Florida beggarweed with bentazon plus paraquat or paraquat alone due to the lack of residual activity of these herbicides.

PRE herbicides provided equivalent or greater weed control in strip-tillage compared with conventional tillage in 2005 likely due to additional weed suppression provided by cover crop residue. This finding is supported by increased control of most weed species observed in no-herbicide plots under strip-tillage system compared to conventional tillage system.

Dawson GA

Large crabgrass. Tillage systems alone were not effective for large crabgrass control with only 10% control in strip-tillage in 2005 (Table 4). Control was higher in conventional tillage (≥93%) than in strip tillage (≤ 72%) with pendimethalin alone or pendimethalin plus *S*-metolachlor PRE with or without a POST application. Johnson *et al.* (2010) documented 87% large crabgrass control with pendimethalin alone applied PRE in strip tillage peanut production system. The POST-only treatment controlled large crabgrass < 26%, regardless of tillage treatment. Similarly, Faircloth *et al.*

Table 5. Smallflower morningglory control as influenced by herbicide and tillage treatments at Dawson, GA in 2006.

Herbicide treatment		Smallflower morningglory 2006	
PRE[a]	POST[b]	Conventional tillage	Strip tillage
		% control	
Pendi + *S*-met	Yes	82	86
Pendi	Yes	80	74
Pendi + *S*-met	No	94	92
Pendi	No	0*	24*†
No	Yes	81	95†
No	No	0*	20*†

[a]Preemergence treatments included pendimethalin (Pendi) at 1.12 kg/ha alone or mixed with *S*-metolachlor (*S*-met) at 1.36 kg/ha.

[b]Postemergence tank mixture of paraquat applied at 0.140 kg /ha, bentazon applied at 0.56 kg/ha and 2,4-DB applied at 0.224 kg/ha.

*Indicates significant differences ($P < 0.10$) based on Dunnett test comparing least square means of herbicide treatments with the pendimethalin + S-metolachlor applied preemergence followed by a postemergence tank mixture of paraquat + bentazon + 2,4-DB.

†Indicates significant difference ($P < 0.10$) in efficacy of herbicide regimen between tillage treatments within individual weed species based on single degree of freedom contrasts.

(2008) observed no large crabgrass control in POST-only systems because of the lack of a residual herbicide.

Yellow nutsedge. Strip tillage, without herbicides, did not improve yellow nutsedge control compared with conventional tillage (Table 4). Control improved significantly (≥ 96%) with addition of *S*-metolachlor to pendimethalin with or without a POST application irrespective of tillage system. Clewis *et al.* (2007) observed 70% control of yellow nutsedge with *S*-metolachlor alone applied PRE. In addition, the POST-only treatment was also adequate with 89 and 96% control in conventional and strip-tillage systems, respectively. The PRE application of pendimethalin alone was not adequate for yellow nutsedge control.

Crowfootgrass. No herbicide treatment effectively controlled crowfootgrass (<74) regardless of tillage system (Table 4). While a PRE application of pendimethalin or pendimethalin plus *S*-metolachlor (< 59%) improved control over a POST-only application (38%) in the conventional tillage system, no herbicide application had greater control in the strip tillage treatment. Earlier research has shown that effective crowfootgrass control can be achieved with pendimethalin applications when adequate rainfall occurs following application to ensure movement of the herbicide into the soil (Prostko *et al.* 2001). Lack of rainfall after PRE applications may have resulted in reduced control of crowfootgrass in this study.

Common bermudagrass. When no herbicide was applied, strip-tillage controlled bermudagrass 38% compared with no control in the conventional tillage system. Control was adequate (≥ 90%) only when pendimethalin plus *S*-metolachlor were applied with or without a POST application regardless of tillage system (Table 4). Faircloth *et al.* (2008) obtained only 60% common bermudagrass control with pendimethalin PRE fb paraquat plus bentazon fb imazapic. The POST-only treatment provided 32% control in conventional tillage system and 51% control in strip-tillage system.

Peanut Yield and Grade

No interaction between tillage system and herbicide treatment was observed for pod yield in any of the environments. Lower yields occurred at the Alabama location compared to the Georgia site. Impact of herbicide treatments on pod yield was significant at Headland, AL in 2005 and 2007 and at Dawson, GA in 2006 (Table 5). At Headland in 2005, the POST-only treatment produced the highest yield (3900 kg/ha) which was similar to the peanut yield produced by pendimethalin fb the POST application. Pendimethalin fb the POST application produced 30% more peanut yield than pendimethalin alone. Peanut yield in the no-herbicide treatment was 2240 kg/ha which was 20% lower than pendimethalin plus *S*-metolachlor fb the POST application. In 2007, pendimethalin plus *S*-metolachlor produced 39% higher yield than the pendimethalin plus *S*-metolachlor fb the POST application (2510 kg/ha). All other herbicide treatments produced significantly more yield than the nontreated control (1540 kg/ha). At Dawson, peanut yield ranged from 4710 to 5170 kg/ha in 2005, and 1930 to 3850 kg/ha in 2006 in various PRE and/or POST treatments. Johnson *et al.* (2010) obtained the highest pod yield when pendimethalin was applied PRE compared to the current producer standard for weed control programs that do not include pendimethalin (3480 vs. 3070 kg/ha).

Tillage systems affected the pod yield in all the environments except Dawson in 2006 (Table 5). Combined over herbicide treatments, strip-tillage peanuts yielded equivalent or higher than conventionally tilled peanuts in three of the four environments. However, at Dawson in 2005, conventional tillage peanuts yields (5090 kg/ha) were higher than the strip-tillage (4230 kg/ha) peanuts.

No interaction between years was observed for grade data. Peanut grade was not affected by any of the herbicide treatments or tillage systems (data not shown). Mean percentage of total sound mature kernels (TSMK) was 71% regardless of herbicide and tillage treatments.

In this study, the strip-tillage system provided, in some comparisons, slightly higher overall weed control. However, control of large crabgrass at Dawson, and Florida beggerweed and yellow nutsedge in 2007 at Headland, was reduced in the strip-tillage system. Several researchers reported lower weed density, higher weed control, equivalent or higher yields in reduced tillage systems compared to the conventional tillage systems; however, weed control and peanut yield is dependent on many factors such as reside levels attained and available soil moisture (Knavel and Herron 1986; NeSmith *et al.* 1994; Putnam *et al.* 1983; Rapp *et al.* 2004; Walters and Kindhart 2002; Weston 1990). Although strip-tillage provided moderate control in the absence of herbicides and adequate control in a few comparisons when only PRE herbicides were used, weed control levels varied by species, and overall weed control was not acceptable for commercial peanut production without additional POST herbicide inputs. Thus, results indicate that the PRE fb POST herbicide system was needed to provide maximum weed control and protect yield potential. Because of current herbicide resistance management concerns necessitating complete weed

Table 6. Effect of herbicide treatments and tillage system on peanut yield at Dawson, GA and Headland, AL.

Herbicide Treatment		Dawson, GA		Headland, AL	
PRE[a]	POST[b]	2005	2006	2005	2007
		Kg/ha			
Pendi + *S*-met	Yes	5170	3560	2820	2510
Pendi	Yes	4880	3240*	3340*	2790
Pendi + *S*-met	No	4970	3850*	3310*	3500*
Pendi	No	4890	3160*	2560	2600
No	Yes	4710	3150*	3900*	2390
No	No	3350	1930*	2240*	1540*
Tillage system					
Conventional Tillage		5090	3030	2580	2250
Strip Tillage		4230†	3260	3480†	2860†

[a]Preemergence treatments included pendimethalin (Pendi) at 1.12 kg/ha alone or mixed with *S*-metolachlor (*S*-met) at 1.36 kg/ha.
[b]Postemergence tank mixture of paraquat applied at 0.140 kg /ha, bentazon applied at 0.56 kg/ha and 2,4-DB applied at 0.224 kg/ha.
*Indicates significant differences ($P < 0.10$) based on Dunnett test comparing least square means of herbicide treatments with the pendimethalin + S-metolachlor applied preemergence followed by a postemergence tank mixture of paraquat + bentazon + 2,4-DB.
†Indicates significant difference ($P < 0.10$) in yield between tillage system within year and location.

control, reduction of herbicides use due to cover crop weed suppression is unlikely in most instances, depending on weed seedbank. As interest in high-residue conservation agriculture increases due to integrated weed management and economic advantages and agricultural policy (e.g. Natural Resource Conservation Service incentive payments), applied research evaluating these systems is helpful in understanding what cultural practices facilitate adequate weed control in conservation agriculture systems.

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