# Weed Control in Peanut Grown in a High-Residue Conservation-Tillage System

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## ABSTRACT

Information is needed on the role of cover crops as a weed control alternative due to the increase in adoption of conservation-tillage in peanut production. Field experiments were conducted from autumn 1994 through autumn 1997 in Alabama to evaluate three winter cereal cover crops in a high-residue conservation-tillage peanut production system. Black oat (*Avena strigosa* Schreb.), rye (*Secale cereale* L.), and wheat (*Triticum aestivum* L.) were evaluated for their weed-suppressive characteristics compared to a winter fallow system. Three herbicide systems were utilized: no herbicide, preemergence (PRE) herbicides followed by (fb) postemergence (POST) herbicides, and PRE fb sequential POST herbicides. The PRE fb POST herbicide input system consisted of pendimethalin at 1.12 kg ai/ha fb an additional early POST application of paraquat at 0.14 kg ai/ha plus bentazon at 0.56 kg ai/ha. The PRE fb sequential POST herbicide input system contained the aforementioned herbicides fb 2,4-DB at 0.22 kg ai/ha plus chlorimuron at 0.14 kg ai/ha applied late POST. No cover crop was effective in controlling weeds without a herbicide program. However, when black oat or rye was utilized with PRE fb POST herbicides, weed control was similar to the high input system in two out of three years. Yield increased in 14 of 27 comparisons following conservation-tilled peanut using the Brazilian cover crop management system, compared to a winter fallow system. Yields never decreased following a winter cover crop compared to winter fallow. The winter fallow, high herbicide input system yielded between 7 and 26% less peanut compared to the highest yielding system that included a winter cover crop. The Brazilian system using black oat or rye cover crop has potential to increase peanut productivity and reduce herbicide inputs for peanuts grown in the Southeast.

Key Words: Allelopathic cover crops, cover crop, herbicide, peanut.

Conservation-tillage systems are primarily used to address concerns about soil erosion, soil quality, and water availability (Blevins *et al.*, 1971; Reeves, 1994; Reeves, 1997; Kaspar *et al.*, 2001). Peanut (*Arachis hypogaea* L.) hectarage in conservation-tillage systems is estimated to be 45, 30, 25, 20, 10% respectively, in Alabama, Florida, Georgia, North Carolina, and Virginia (personal communications, Dallas Hartsog, Barry Brecke, Eric Prostco, David Jordan, and Joel Faircloth). Approximately 98% of peanut grown in Alabama, Florida, Georgia, North Carolina and Texas in 2004 received herbicides (Anonymous 2005). Practical alternatives to the intensive use of herbicides for peanut weed control offers economical as well as environmental benefits.

The use of cover crops in conservation tillage has advantages, one of which is weed suppression through physical and chemical allelopathic effects (Nagabhushana *et al.* 2001; Phatak 1998). Cereal rye and soft red winter wheat are common winter cover crops recommended for peanut production in the U.S. (Wright *et al.*, 2002). These cover crops contain allelopathic compounds that inhibit weed growth (Akemo *et al.*, 2000; Chase *et al.*, 1991; Perez and Ormeno-Nunez, 1991; Yenish *et al.*, 1996).

In southern Brazil, black oat is the predominate cover crop on millions of hectares of conservation-tilled soybean [*Glycine max* (L.) Merr.] due in part to its weed suppressive capabilities (Derpsch *et al.*, 1991). Black oat has recently been introduced in the southeastern U.S. through a joint release between Auburn University and The Institute of Agronomy of Paraná, Brazil, and is currently marketed as "SoilSaver black oat" (Bauer and Reeves, 1999). In a greenhouse study, allelopathic compounds released from black oat inhibited cotton root elongation 16% compared to rye when residue was mixed with soil (Bauer and Reeves, 1999). However, in a field study where residue remained on the soil surface, cotton stand establishment was

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not affected by black oat, rye, or wheat winter cover crops and cotton lint yield was higher in plots containing black oat residue compared to rye (Bauer and Reeves, 1999). No other published research has been conducted evaluating black oat as a winter cover crop preceding row crop establishment in the U.S.

Typically, cooperative extension service recommendations in the southeastern U.S. encourage growers to terminate cereal winter cover crops relatively early prior to row crop production, citing concerns for excessive residue interfering with planting operations or excessive moisture depletion (Jost et al., 2006). Cooperative extension service recommend waiting approximately 2 wk after desiccating cereal winter cover crops before cash crop planting to avoid allelopathic effects on the following crop (Reeves, 1994).

The Brazilian conservation-tillage system is based on terminating cover crops during early reproductive growth, by treating with glyphosate and mechanically rolling the cover crop to form a dense mat of residue on the soil surface into which crop seeds are planted (Derpsch *et al.*, 1991; Reeves, 2003). Technological advancements in cover crop residue management are allowing producers to maximize cover crop biomass in conservation agriculture systems located where water utilization by winter cover crops is not usually a concern (Kornecki et al., 2005; Raper et al., 2004). In the southeastern U.S., winter cereal cover crops reach anthesis and can be terminated in a timely fashion prior to the recommended planting window for peanut. Ashford and Reeves (2003) evaluated a mechanical roller-crimper as an alternative method for termination of a black oat, rye, and wheat cover crop. Their results indicated that use of a roller-crimper in combination with glyphosate at 0.84 kg ae/ha at anthesis was as effective as using glyphosate at 1.68 kg ae/ha alone when treatments were applied at the same crop growth stage, for all cover crops evaluated. Few growers are currently utilizing roller-crimpers to manage cover crops; however, grower interest in this management technique exists due to the potential to reduce soil erosion and increase water infiltration and soil moisture storage (Truman *et al.*, 2002).

While research has evaluated weed-suppressive qualities of winter cover crops, few experiments have evaluated peanut response. Therefore, our objective was to evaluate weed control provided by black oat, rye, and wheat as winter cover crops within three herbicide input systems, compared to winter fallow, for conservation-tilled peanut using the Brazilian system of managing cover crops. Peanut yield was also evaluated for each cover crop and herbicide input system.

## Materials and Methods

Field experiments were conducted from autumn 1994 through autumn 1997 at the Alabama Agricultural Experiment Station's Wiregrass Research and Extension Center (31°24′N, 85°15′W), located near Headland, AL. The soil was a Dothan fine sandy loam (fine-loamy, siliceous, thermic Plinthic Paleudults). The experimental area had been in conservation tillage (strip-tillage) for the previous 8 y and had a high population of Palmer amaranth (*Amaranthus palmeri* S. Watts.).

The experimental was set up as a strip-plot design with a factorial arrangement of treatments with four replications. Horizontal strips consisted of black oat, rye, wheat, or fallow. The seeding rate for all cereal cover crops was 120 kg/ha and were established utilizing a Great Plains<sup>H</sup>[5] no-till drill[6] in early November of 1994, 1995, and 1996. Ammonium nitrate was applied at 56 kg/ha to the cover crops in fall of 1994 and 1995 after establishment. Ammonium nitrate was not applied in 1997 due to an oversight. Cover crops were terminated 3 wks prior to planting peanut in early May each year with an application of glyphosate at 1.12 kg ae/ha utilizing a compressed $CO_2$ backpack sprayer delivering 140 L/ha at 147 kPa. Biomass from black oat, rye, wheat, and fallow plots was measured immediately before glyphosate application in all years. The above-ground portion of each cover crop and weeds in the winter fallow plots was clipped from three randomly-selected 0.25-$m^2$ sections in each plot, dried at 60 C for 72 h, and weighed.

Within 3 d following glyphosate application, the cover crops were rolled with a mechanical roller-crimper as described by Ashford and Reeves (2003) to flatten all residues on the soil surface. The peanut variety GK 7 was planted each year at a rate of 28 seed per meter of row with a four-row John Deere MaxiMerge<sup>H</sup> planter[7] equipped with Martin® row cleaners[8] and ACRA-PLANT<sup>H</sup> retrofit seeding double-disk openers[9]. Plots were four 92 cm rows wide and 9.1 m long.

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[5]Mention of trade names or commercial products in this manuscript is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U. S. Department of Agriculture.

[6]Great Plains Mfg., Inc. 1560 East North Street, Salina, KS 67401.

[7]John Deere Seeding Group, 501 River Drive, Moline, IL 61265.

[8]Martin Industries LLC., 206 Elk Fork Rd., Elkton, KY 42220.

[9]ACRA-PLANT, 1285 Acraway, Garden City, KS 67846.

Vertical plots were herbicide input systems consisting of no herbicide, a low input system consisting of preemergence (PRE) followed by (fb) postemergence (POST) herbicides, or a high input system consisting of PRE fb sequential POST herbicides. The PRE fb POST herbicide low input system consisted of pendimethalin at 1.12 kg ai/ha fb an additional early POST application of paraquat at 0.14 kg ai/ha plus bentazon at 0.56 kg ai/ha. The PRE fb sequential POST herbicide high input system contained the aforementioned herbicides fb 2,4-DB at 0.22 kg ai/ha plus chlorimuron at 0.14 kg ai/ha applied late POST.

In 1995, because the site had a well-developed hardpan, the experimental area was in-row subsoiled prior to planting with a KMC$^{H}$ narrow-shanked parabolic subsoiler[10], equipped with pneumatic tires to close the subsoil channel (Raper, 2005). In 1996 and 1997, the area was in-row subsoiled prior to planting with a bent-leg subsoiler (Paratill[11]) 2 wks prior to planting. In all years, residue disturbance was minimal and residue formed a thick (approximately 10 cm) mat over the soil surface with exception of the winter-fallow plot treatment. Weed control was determined by visual ratings a 0% = no control, 100% = complete control) early in the season [30 d after planting (DAP)] and late in the season (51–98 DAP). Only late season ratings are reported. All weed species present at both ratings were evaluated for control, as a reduction in total above ground biomass resulting from both reduced emergence and growth, and the combined average for each rating and treatment was calculated. Late season weed control ratings were averaged over all dominant weed species.

Alabama Cooperative Extension System recommendations were used for insect control and nutrient management. Peanut yield was determined by machine-digging the middle two rows of each plot and harvesting with a combine.

All data were subjected to analysis of variance (ANOVA) using the general linear models procedure in SAS (SAS, 1998) to evaluate the effect of a three (herbicide input level) by four (cover crops) factorial treatment arrangement. Herbicide input levels and winter cover crops were considered fixed effects while year effects were considered random variables. Non-transformed data for visual evaluations were presented because arcsine square root transformation did not affect data interpretation. Means for appropriate main effects and interactions were separated using Fisher's protected LSD test at $P \leq 0.10$ *a priori*. Where interactions occurred, data were presented separately and where interactions did not occur, data were combined.

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[11]Bigham Brothers Inc., 705 East Slaton Dr., Lubbock, TX 79404.

# Results and Discussion

**Cover Crop Biomass.**

Analysis revealed a year by treatment interaction; therefore, results are presented by year. In 1995, residue production was similar for all winter cereal cover crops, averaging 5,230 kg dry matter/ha (Table 1). Winter weeds produced 1,410 kg dry matter/ha in fallow plots. Dominant winter weeds in the fallow system in all three years were cutleaf evening primrose (*Oenothera laciniata* Hill) and chickweed [*Stellaria media* (L.) Vill.]. The severe winter of 1995–1996 resulted in differences in residue production between all cover crops. Dry matter averaged 6,550, 4,370, 1,320, and 870 kg/ha for rye, wheat, black oat, and winter fallow, respectively, in 1996. The minimum nighttime temperature from November 1$^{st}$ through March 31$^{st}$ was below 0 C for 56 nights in 1995–1996 (−13 C lowest temperature) compared to 33 nights in 1994–1995 (−8 C lowest temperature) and 26 nights in 1996–1997 (−10 C lowest temperature) (Alabama Mesonet weather data). In 1997, residue production was similar for rye (2,840 kg/ha) and black oat (2,770 kg/ha); however, wheat (1,600 kg/ha) and winter fallow (770 kg/ha) produced less biomass. Because nitrogen fertilizer was not applied to winter cover crops in 1997, dry matter production was less than prior years. Yenish *et al.* (1996) reported rye planted into a sandy loam soil resulted in biomass ranging from 4,540 to 5,140 kg/ha in an experiment conducted in North Carolina. Bauer and Reeves (1999) reported an average biomass of 5,300, 2,980, and 3,010 kg/ha for rye, black oat, and wheat, respectively, planted into a loamy sand soil in an experiment conducted in South Carolina. Ashford and Reeves (2003) reported higher biomass for rye, black oat, and wheat in experiments conducted in east-central Alabama

**Table 1. Cover crop biomass for three years at the Alabama Agricultural Experiment Station's Wiregrass Research and Extension Center in Headland, AL prior to termination.**

| Cover Crop | 1995[a] | 1996[b] | 1997[c] |
|---|---|---|---|
| | | kg/ha | |
| Black oat | 5,450 | 1,320 | 2,770 |
| Fallow | 1,410 | 870 | 770 |
| Rye | 5,130 | 6,550 | 2,840 |
| Wheat | 5,100 | 4,370 | 1,600 |
| $LSD_{(0.10)}$ | 960 | 595 | 584 |

when evaluating effectiveness of a roller-crimper for cover crop desiccation. Averaged over two years, dry biomass was 10,100, 9,700 and 9,100 kg/ha for rye, black oat, and wheat; respectively (Ashford and Reeves, 2003).

**Weed Control.**

Analysis revealed a year by treatment interaction; therefore, results are presented by year. Cover crop and herbicide input system main effects were significant for weed control. There were no interactions in 1995, 1996, or 1997 between cover crops and herbicide input systems for weed control. Grasses {primarily large crabgrass [*Digitaria sanguinalis* (L.) Scop.] and Texas panicum (*Panicum texanum* Buckl.)}, sedges [(*Cyperus esculentus* L.) and (*C. rotundus* L.)], sicklepod (*Cassia obtusifolia* L.), and Palmer amaranth were the dominant weed species present during peanut production all three years. No cover crop was adequate in controlling weeds without herbicide season long in all three years. In 1995, black oat and rye cover crops controlled the weed complex 70% and 61% respectively without herbicides, compared to wheat (43%) and winter fallow (24%) (Table 1). PRE fb POST herbicides increased control to 93% and greater when a winter cover crop was utilized. Additional sequential POST applications in the high input system did not result in increased weed control compared to the low input system. However, in 1996, sequential POST applications in the high input system result in increased weed control ranging from 5 (rye winter cover crop) to 18 percentage points (black oat winter cover crop) compared to the low input system. Without herbicide, rye gave similar visual control to black oat and wheat (25%); all cover crops provided superior weed control compared to winter fallow (15%). In 1997, the combination of low herbicide input system and rye provided 84% weed control compared to 69, 60, and 59% for black oat, winter fallow, or wheat systems, respectively. Similar to 1995, additional sequential POST applications in the high input system did not result in increased weed control compared to the low input system in 1997 regardless of winter cover crop.

In three years, rye cover crop; in one year, black oat; and in two years, wheat in combination with PRE fb POST herbicides provided similar weed control compared to the PRE fb sequential POST herbicides herbicide systems (Table 2). Yenish *et al.* (1996) reported increased short term weed control utilizing a non-rolled rye cover crop in no-till corn (*Zea mays* L.), but not season-long control. Reddy (2003) reported that rye reduced total weed density 27% in a no-till soybean [*Glycine max* (L.) Merr.] system 6 wks after planting. Black oat's popularity as a cover crop in Brazil is largely due to its ability to control both annual grasses and small-seeded broadleaf weeds (Derpsch, 1985; Derpsch, 1990). Weed control following black oat was similar to rye in 1995 and 1997 when biomass production between these two covers was similar (Table 1).

**Peanut Yield.**

Analysis revealed a year by treatment interaction; therefore, results are presented by year. Cover crop and herbicide input system main effects were significant for peanut yield. There were no interactions in 1995, 1996, or 1997 between cover crops and herbicide input systems for peanut yield. In 1995, yields in the low input systems were higher following any cover crop than yields following the high or low input winter fallow systems (4,280 kg/ha and 4,100 kg/ha respectively) with maximum yield following black oat (4,740 kg/ha) and rye (4,850 kg/ha). Additional sequential POST herbicides resulted in increased yield following wheat compared to the low input system.

In 1996, yields in the low input systems were highest following rye (4,250 kg/ha) compared to fallow (3,740 kg/ha), wheat (3,580 kg/ha) and black oat (2,740 kg/ha). Additional sequential POST herbicides resulted in increased yield following black oat (3,760 kg/ha) and fallow (4,290 kg/ha) compared to the low input system while yields following rye and wheat did not increase with additional POST herbicide applications.

In 1997, a relatively dry fall occurred during prior to digging, resulting in lower yields. The failure to apply N fertilizer to the cover crops in spring 1997 reduced cover crop biomass to only 2,840 kg/ha for rye, 2,780 kg/ha for black oat, and 1,610 kg/ha for wheat,. We speculate this negatively impacted peanut yield potential in this drought year. Without herbicide, yields were higher following black oat (770 kg/ha), rye (910 kg/ha), and wheat (730 kg/ha) compared to winter fallow (420 kg/ha). The low input herbicide system increased yield to 2,000 kg/ha following black oat, 1,150 kg/ha following fallow, 1,970 following rye, and 1,270 following wheat. In 1997, there was a yield benefit from the high herbicide system compared to the low input system following rye (2,430 kg/ha), wheat (1,610 kg/ha) and winter fallow (1,780 kg/ha).

In 1995, we observed an increase from 24 to 43% control, and in 1996, an increase from 15 to 24% in weed control in nontreated conservation-tilled peanut using the Brazilian cover crop management system; i.e., cover crops grown to produce large amounts (>4,480 kg/ha) of residue rolled to form a dense mat on the soil surface, compared to winter fallow (Derpsch *et al.*, 1991; Reeves, 2003). In two

**Table 2. Weed control[a] affected by cover crop and herbicide system for three years at the Alabama Agricultural Experiment Station's Wiregrass Research and Extension Center in Headland, AL 51 to 98 DAP.**

| | 1995[b] | | | 1996[c] | | | 1997[d] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Herbicide Input System | | | Herbicide Input System | | | Herbicide Input System | | |
| Cover Crop | High | Low | None | High | Low | None | High | Low | None |
| | weed control (%) | | | | | | | | |
| Black oat | 93 | 94 | 70 | 78 | 60 | 25 | 69 | 69 | 0 |
| Fallow | 91 | 88 | 24 | 82 | 72 | 15 | 61 | 60 | 0 |
| Rye | 94 | 93 | 61 | 83 | 78 | 25 | 81 | 84 | 0 |
| Wheat | 94 | 93 | 43 | 79 | 61 | 24 | 64 | 59 | 0 |

[a]Averaged over Palmer amaranth, sicklepod, annual grasses, and sedges.
[b]Herbicide input systems consisted of no herbicide, a low input system consisting of PRE fb POST herbicides, or a high input system consisting of PRE fb sequential POST herbicides.
[c]1995 $LSD_{(0.10)}$ for cover crop = 7; for herbicide level = 6; for cover crop within herbicide level interaction = ns; for herbicide level within cover crop interaction = ns.
[d]1996 $LSD_{(0.10)}$ for cover crop = 7; for herbicide level = 5; for cover crop within herbicide level interaction = ns; for herbicide level within cover crop interaction = ns.
[e]1997 $LSD_{(0.10)}$ for cover crop = 7; for herbicide level = 4; for cover crop within herbicide level interaction = ns; for herbicide level within cover crop interaction = ns.

of three years, black oat biomass was equivalent to rye and equivalent or greater than wheat. However, inferior cold tolerance of black oat compared to rye may limit its current zone of utilization and presents an opportunity for future germplasm research. Our results support literature that reports the allelopathic potential of black oat and rye is greater than wheat (Phatak, 1998). The maximum weed control gain provided by winter cover crops was an increase from 24 to 70% control when comparing black oat to winter fallow in non-treated plots in 1995. Systems that did not include herbicides were not effective at controlling weeds adequately the entire season and resulted in substantial yield losses. However, when winter cover crops were utilized along with PRE herbicides, similar weed control to the high input system was attained in eight out of twelve comparisons.

Results indicated yield increased in half the comparisons following conservation-tilled peanut using the Brazilian cover crop management system, compared to a winter fallow system. Yields never decreased following a winter cover crop compared to winter fallow. The winter fallow, high herbicide input system yielded less peanut two of three years, compared to the highest yielding system that included a winter cover crop. We attribute the observed increase in yield to many factors, including the observed decrease in weed competition, as well as other non-measured but known benefits

**Table 3. Peanut yields affected by cover crop and herbicide system for three years at the Alabama Agricultural Experiment Station's Wiregrass Research and Extension Center in Headland, AL.**

| | 1995[a] | | | 1996[b] | | | 1997[c] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Herbicide Input System | | | Herbicide Input System | | | Herbicide Input System | | |
| Cover Crop | High | Low | None | High | Low | None | High | Low | None |
| | peanut (kg/ha) | | | | | | | | |
| Black oat | 4,760 | 4,740 | 3,190 | 3,760 | 2,740 | 1,170 | 2,200 | 2,000 | 770 |
| Fallow | 4,280 | 4,100 | 2,030 | 4,290 | 3,740 | 1,090 | 1,780 | 1,150 | 420 |
| Rye | 4,690 | 4,850 | 3,460 | 4,640 | 4,250 | 2,020 | 2,430 | 1,970 | 910 |
| Wheat | 4,670 | 4,420 | 2,500 | 3,750 | 3,580 | 1,250 | 1,610 | 1,270 | 730 |

[a]Herbicide input systems consisted of no herbicide, a low input system consisting of PRE fb POST herbicides, or a high input system consisting of PRE fb sequential POST herbicides.
[b]1995 $LSD_{(0.10)}$ for cover crop = 303; for herbicide level = 161; for cover crop within herbicide level interaction = ns; for herbicide level within cover crop interaction = ns.
[c]1996 $LSD_{(0.10)}$ for cover crop = 536; for herbicide level = 493; for cover crop within herbicide level interaction = ns; for herbicide level within cover crop interaction = ns.
[d]1997 $LSD_{(0.10)}$ for cover crop = 504; for herbicide level = 224; for cover crop within herbicide level interaction = ns; for herbicide level within cover crop interaction = ns.

of conservation-tillage systems, including increased water infiltration, reduced water evaporation from the soil, and increased soil quality (Phillips *et al.*, 1980).

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