Effects of Peanut Stand Uniformity and Herbicide Regime on Weed Management and Yield

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ABSTRACT

Crop stand directly affects ability of any crop to compete with weeds. To capture this form of cultural weed control, final crop stands need to be uniform. Peanut stands are frequently non-uniform, despite the use of precision vacuum planters. Trials were conducted from 2009 through 2011 in Tifton, GA to determine the effect of non-uniform peanut stands on weed control, grade, and marketable peanut yield. Non-uniform peanut stands were established by modifying vacuum planter discs that created skips 18 cm wide and 36 cm wide at regular intervals and compared with peanut at a uniform stand. The weed control regimes chosen reflected differing degrees of residual weed control provided by flumioxazin or imazapic and addressed the need for residual weed control when peanut stands are non-uniform. Postemergence (POST) herbicides bentazon, paraquat, and 2,4-DB were chosen to test the theory that properly timed applications of non-residual herbicides will control weeds in skips without the need for preemergence (PRE) herbicides. There was no significant interaction between peanut stand uniformity and weed control regime for any parameter. Weed response to peanut stand was variable among species and inconsistent. Weed densities tended to be lower when the residual herbicides flumioxazin and/or imazapic were part of the herbicide regime. Peanut yields and percent total sound mature kernels were not affected by narrow (18 cm) skips, but were reduced two years out of three by wide (36 cm) skips. Peanut yields and grade were similar among weed control regimes that used PRE herbicides and POST herbicides with no residual weed control properties. These results indicate that weed control considerations are not a factor when peanut skips are <18 cm. The herbicide choices evaluated are capable of controlling weeds allowing peanut to compensate for non-uniform stands and not have yield reduction when skips are <18 cm.

Key Words: Crop stand, cultural weed control.

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Cultural weed control is the ability of a crop to suppress weeds and minimize losses. Three of the most effective forms of cultural weed control are seeding rate, row pattern, and uniformity of crop stand. In areas where intense weed competition is anticipated, increased seeding rates in rice (*Oryza sativa* L.) reduces losses from weeds by enhancing crop competition that lowers weed biomass (Chauhan 2011, Chauhan *et al*. 2011). Narrow row spacing and increased corn (*Zea mays* L.) seeding rate reduced weed biomass and seed production (Fahad *et al*. 2014), which is an additional goal in the integrated management of weeds. In locations where herbicide resistant weeds are problematic, crop seeding rate and other forms of cultural weed control lessen herbicide selection pressure on weed populations and were shown to be of value in the management of wild oat (*Avena fatua* L.) in barley (*Hordeum vulgare* L.) (O'Donovan *et al*. 2013). Similarly, weed management in wheat (*Triticum aestivum* L.) was improved by higher seeding rate and uniform stands (Olsen *et al*. 2005; Weiner *et al*. 2001).

In peanut (*Arachis hypogaea* L.) production, there have been numerous research trials and reports on optimum peanut seeding rates and row patterns. Sturkie and Buchanan (1973) summarized the early research trials and concluded that optimum row patterns and seeding rates depended on growth characteristics (bunch- vs. runner-type) of the cultivar. With early weed control technologies that relied heavily on postemergence (POST) herbicides with no residual weed control properties, peanut seeded in narrow row patterns yielded more than peanut seeded in wide rows due to improved weed suppression (Buchanan and Hauser 1980). Trials continued into the 21st century using modern cultivars and herbicides. Using herbicides with superior residual weed control (diclosulam, flumioxazin, imazapic, sulfentrazone), narrow row patterns did not improve weed control over wide rows. However, peanut yields in narrow rows were still greater compared to wide rows (Johnson *et al*. 2005).

Row patterns and seeding rates also affects peanut response to other pests. Tomato spotted wilt (tomato spotted wilt tospovirus) in peanut became epidemic in the southeastern U. S. region during the early 1990's and seeding rates to produce a final stand of >13 plants/m of row were recommended to reduce losses due to the disease (Culbreath *et al.* 2003, 2013; Tillman *et al.* 2006; Tubbs *et al.* 2011). The premise was that dense peanut growth was less attractive to thrips vectors and compensated for early-season stand losses due to the disease. Managing tomato spotted wilt requires a broad-based integrated management approach and final peanut stand is one of several factors that reduce losses from disease epidemics (Culbreath *et al.* 2003).

Despite yield and broad-spectrum pest management advantages of narrow row patterns and dense seeding rates, peanut seed are costly. Peanut is a large-seeded legume and seed are among the most costly inputs the production budget, with seed costs estimated at $233/ha (Smith and Smith 2015). This projection is based on peanut seeded at a rate of 151 kg/ha using runner market-type peanut cultivars. In 2014, the most common runner-type peanut cultivar planted in the southeastern U. S. was GA-06G, a large-seed runner cultivar, which has a seed count of approximately 1660 seed/kg (Branch 2007). Optimum seed spacing is directly related to row pattern, with single rows having >13 seed/m and paired row patterns having >6 seed/m, with the final seeding rate (kg/ha) being the same between the two row patterns.

Regardless of row pattern, the desired seed spacing is assumed to be uniform, although uniformity has not been a treatment factor in any of the earlier research trials. Uniformity of peanut plant spacing was correlated with optimized vegetative growth and yield, including cultivars that had aggressive growth habit to facilitate canopy closure (Gardner and Auma 1989). In practice, uniform peanut stands are often difficult to achieve. Chhinnan *et al.* (1975) determined that plate-type planters (an old design concept) metered peanut seed erratically at high ground speeds and seed size affected uniformity of seed placement with large peanut seed having more skips than small peanut seed. In the early 1990's, vacuum planters became common in the peanut producing region and offered improved precision in seed placement over plate-type planters. Despite the improved precision in seed metering and placement by vacuum planters, this technological improvement did not eliminate the risk of poor or erratic peanut stands (Wehtje *et al.* 1994). Regardless of planter type and performance, risk factors that affect peanut stand are poor seed quality that results in lower germination, environmental conditions that slow germination, and pests of emerging seedlings. Thus, non-uniform peanut stands remain problematic.

Stand uniformity and weed control have been correlated in other crops. It is hypothesized that similar relationships exist in peanut and residual weed control from commonly used peanut herbicides would help compensate for non-uniform peanut stands. Therefore, trials were initiated in 2009 to determine the effect of peanut stand uniformity on weed management.

Materials and Methods

Irrigated field trials were conducted at the University of Georgia Ponder Research Farm near Ty Ty, GA (31.510551°, –83.642605°) for three seasons from 2009 through 2011. The soil was a Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) with 88% sand, 8% silt, and 4% clay and 1.0% organic matter. The soil at this location is representative of soils in the southeastern U. S. peanut producing region and naturally infested with weeds that are common pests of crops.

The experimental design was a split-plot with four replications. Main plots were three levels of peanut stand uniformity, with skips in the stand intentionally created at recurring intervals; narrow skip with a skip 18 cm in length followed by 54 cm of uniform stand of seed spaced 6 cm apart creating a final density of 11 seed/m, wide skip with a skip 36 cm in length followed by 36 cm of uniform stand of seed spaced 6 cm apart creating a final density of 8 seed/m, and uniform stand with peanut seed uniformly 6 cm apart with final density of 16 seed/m. Skips were created by filling holes in vacuum planter (Monosem, Inc., 1001 Blake St., Edwardsville, KS 66111) seed discs with a two-part epoxy adhesive (J-B Weld®, P.O. Box 483, Sulphur Springs, TX 75483) that prevented seed from being drawn and held to the rotating disc by the vacuum suction. That process created a skip by simply not having a seed on that portion of the rotating disc to place in the furrow. Vacuum planter discs chosen were typical for those used for peanut and had 36 holes evenly spaced around the circumference of the disc, with each hole 6.5 mm in diameter. To create the narrow skip, three adjacent holes were filled with epoxy and followed by nine holes not filled, with the pattern repeated a total of three times around the disc. The wide skip pattern was created by filling six adjacent holes with epoxy, followed by six holes not filled, with that pattern repeated a total of three times around the disc. The uniform density had all holes on the disc open. This

Table 1. Weed control regimes used to evaluate effect on non-uniform peanut stand on weed control.

Treatment[a]	Abbreviation	Respective rate (kg ai/ha)	Respective time of application[b]
Flumioxazin, imazapic[c], 2,4-DB	PRE 1X/POST 2X	0.107, 0.071, 0.28	PRE, 2wk, 6wk
Flumioxazin, paraquat + bentazon[c] (twice), 2,4-DB	PRE 1X/POST 3X	0.107, 0.14 + 0.56, 0.28	PRE, VE, 2wk, 6wk
Imazapic, 2,4-DB	POST 2X	0.107, 0.28	2wk, 6wk
Paraquat + bentazon (2X), 2,4-DB	POST 3X	0.14 + 0.56, 0.28	VE, 2wk, 6wk
Handweeded check			—
Weedy check			—

[a]All plots were treated with pendimethalin (1.1 kg ai/ha) preplant incorporated.

[b]Abbreviations for times of application: 2wk, postemergence application made 2-wk after crop emergence; 6wk, postemergence application made 6-wk after crop emergence; PRE, preemergence application made before crop and weed emergence; VE, application made at vegetative emergence of crop.

[c]Non-ionic surfactant adjuvant included with paraquat + bentazon applications (0.13% by vol.) and imazapic (0.25% by vol.).

technique of non-uniform stand establishment was developed and used to establish a repeatable pattern of skips in the peanut stand in a non-disruptive manner eliminating the potentially confounding factor of excessive soil disturbance caused by hand-thinning.

Sub-plots were six weed control regimes using combinations of preemergence (PRE) and POST herbicides tailored to the weed history of the research site. The weed control regimes were based on herbicides with varying degrees of residual weed control, differing times of application, and are commonly used in the region. Specific details for each weed control regime are listed in Table 1. Paraphrased, weed control regimes were (1.) one PRE with two POST applications (PRE 1X/POST 2X), (2.) one PRE with three POST applications (PRE 1X/POST 3X), (3.) no residual herbicides with two POST applications (POST 2X), (4.) no residual herbicides with three POST applications (POST 3X), (5.) a weed-free handweed control, and (6.) a weedy nontreated control. The herbicide combinations chosen reflect differing degrees of residual weed control provided by flumioxazin and/or imazapic and whether residual weed control is needed when peanut stands are non-uniform. Additionally, non-residual POST herbicides bentazon, paraquat, and 2,4-DB (POST 3X) were chosen to test the theory that properly timed applications will control weeds in skips without the need for residual weed control. The value of imazapic (PRE 1X/POST 2X; POST 2X), which provides both postemergence and residual weed control, would also be determined if peanut stands are non-uniform.

Individual plots were 1.8 m wide and 6.1 m in length. The entire experimental area was treated with pendimethalin (1.1 kg ai/ha) and soil incorporated with a power tiller before planting. 'Georgia-06G' peanut (Branch 2007) were seeded mid-May each year in rows spaced 91 cm apart, to a depth of 6.4 cm. Other than weed control, peanut production and pest management practices were consistent with those recommended by the Georgia Extension Service (Beasley *et al.* 1997).

Weed densities were determined mid-season of each year. Weeds were counted in two 0.5 m^2 quadrats (dimensions - 0.5 m by 1.0 m) in each plot, centered over the peanut row. Peanut yields were obtained by pre-harvest mowing to cut tops of tall weeds, digging, inverting, air-curing, and combining peanut from the entire plot using commercial two-row equipment. Yield samples were mechanically cleaned to remove foreign material, particularly weed biomass, with yields reported as cleaned farmer stock peanut. A 500 g sub-sample was used to measure peanut grade according to established industry standards (Davidson *et al.* 1982), expressed as percent total sound mature kernels (TSMK).

Data were analyzed using a mixed-model analysis. Degrees of freedom were partitioned to test singularly and in combination the effects of peanut stand uniformity and weed control regime on weed densities, percent TSMK, and marketable peanut yield. Means were separated using Fisher's LSD ($P<0.05$).

Results and Discussion

Data were analyzed by year due to differences in weed species diversity and growing conditions among years. There were no significant interactions between peanut stand uniformity and weed control regime for any of the parameters. Therefore all data are presented as main effects, by year.

Weed control. When considered across all species and years, weed densities were not consistently affected by uniformity of peanut stand. Yellow nutsedge was present in 2009 and 2011, and

Table 2. Main effects of peanut stand uniformity and weed management regime on weed density, 2009 to 2011.

Main effect	Yellow nutsedge[a] 2009	Yellow nutsedge[a] 2011	Smallflower morningglory[a] 2009	Smallflower morningglory[a] 2010	Smallflower morningglory[a] 2011	Pitted morningglory[a] 2010	Sicklepod[a] 2011
	(no./m^2)						
Uniform stand[b]	6.8 a	3.0 a	0.7 b	0.1 b	3.2 a	2.7 ab	1.4 a
Narrow skip[b]	11.0 a	5.2 a	1.2 ab	1.3 a	3.8 a	0.6 b	0.4 ab
Wide skip[b]	12.7 a	4.8 a	1.8 a	0.8 a	2.5 a	4.5 a	0.0 b
PRE 1X/POST 2X[c,d]	1.3 b	0.7 c	0.0 c	0.1 c	1.0 c	0.9 c	0.1 b
PRE 1X/POST 3X[c,e]	3.7 b	4.6 bc	0.7 bc	0.3 bc	1.1 c	1.4 c	1.3 a
POST 2X[c,f]	1.3 b	1.4 c	0.0 c	0.2 c	1.4 c	2.1 bc	0.1 b
POST 3X[c,g]	1.5 b	10.9 a	1.5 b	1.5 a	1.5 c	4.3 ab	0.8 ab
Handweeded check[c]	0.2 b	2.2 bc	0.2 bc	1.0 ab	4.4 b	2.5 abc	0.6 ab
Weedy check[c]	52.8 a	6.1 b	5.0 a	1.5 a	9.6 a	4.6 a	0.8 ab

[a]Within each main effect, means in a column followed by the same letter do not differ according to Fisher's Protected LSD (0.05).

[b]Uniform stand, overall density of 16 seed/m, uniformly spaced 6 cm apart; narrow skip, overall density of 11 seed/m, 18 cm skip followed by 4 cm of uniformly spaced seed; wide skip, overall density of 8 seed/m, with 36 cm skip followed by 36 cm of uniformly spaced seed. All peanut stand uniformity treatments were established in a recurring pattern.

[c]All plots were treated with pendimethalin (1.1 kg/ha) preplant incorporated to control annual grasses.

[d]Flumioxazin PRE (0.107 kg/ha), imazapic 2wk (0.071 kg/ha), 2,4-DB 6wk (0.28 kg/ha).

[e]Flumioxazin PRE, paraquat (0.14 kg/ha) + bentazon (0.56 kg/ha) VE and 2wk, 2,4-DB 6wk.

[f]Imazapic 2wk, 2,4-DB 6wk.

[g]Paraquat + bentazon VE and 2wk, 2,4-DB 6wk.

densities were not significantly affected by peanut stand uniformity (Table 2). Cotton (*Gossypium hirsutum* L.) and corn suppress growth of yellow nutsedge by shading (Keeley and Thullen 1978; Stoller *et al*. 1979), which can be capitalized as a form of cultural weed control. These crops are more upright in growth than peanut, presumably offering more intense shading than peanut which has a prostrate growth pattern. These results show that a non-uniform peanut stand does not outright increase the likelihood of yellow nutsedge infestations in peanut over what would be expected in a uniform peanut stand.

Smallflower morningglory response to peanut stand uniformity varied among years (Table 2). In 2009 and 2010, smallflower morningglory densities were lower when peanut stands were uniform compared to wide (36 cm) skips, with densities not differing between narrow (18 cm) skips and wide skips. However, there were no differences in smallflower morningglory density among peanut stands in 2011. With smallflower morningglory present all years of the study and significant response to peanut stands two years out of three, this species appears to be vulnerable to crop competition provided by uniform peanut stands under most conditions.

Unexplainable responses to peanut stand uniformity were seen with pitted morningglory, which was present only in 2010 (Table 2). Pitted morningglory densities were greater when peanut stands had wide 36 cm skips compared to stands that had narrow 18 cm skips, but pitted morningglory densities in wide skips did not differ from densities in the uniform peanut stand. Similarly, sicklepod densities were the lower when peanut had wide skips compared to peanut with a uniform stand. Overall, erratic broadleaf weed suppression by a uniform peanut stand suggests that response varies among weed species. Other than smallflower morningglory, uniform peanut growth was generally not essential for effective broadleaf weed management in these experiments provided that skips are $<$18 cm.

All weed control regimes were equally effective in controlling yellow nutsedge compared to the weedy check in 2009 (Table 2). In 2011, weed control regimes that used imazapic (PRE 1X/POST 2X, POST 2X) reduced yellow nutsedge densities equal to the handweeded check and densities were significantly lower than the weedy check. Weed control regimes that used the non-residual herbicides of two applications bentazon plus paraquat followed by 2,4-DB (POST 3X) controlled yellow nutsedge in 2009 similar to weed control regimes that used imazapic, but yellow nutsedge densities were greater in 2010 when non-residual POST herbicides alone were used for weed control compared to regimes that used imazapic.

In 2009, all weed control regimes reduced smallflower morningglory densities compared to the weedy check, with regimes that included

Table 3. Main effects of peanut stand uniformity and weed management on total sound mature kernels and peanut yield, 2009 to 2011.

Main effect	Total sound mature kernels[a]			Marketable peanut yield[a]		
	2009	2010	2011	2009	2010	2011
	(%)			(kg/ha)		
Uniform stand[b]	71.5 a	69.1 a	73.6 a	4090 a	2800 a	4670 a
Narrow skip[b]	70.7 ab	68.8 a	73.2 a	3660 a	2650 a	4540 a
Wide skip[b]	70.3 b	67.9 a	73.7 a	2840 b	2090 b	4260 a
PRE 1X/POST 2X[c,d]	70.6 a	68.8 a	73.8 a	4100 a	2630 a	5110 a
PRE 1X/POST 3X[c,e]	70.6 a	68.1 a	73.9 a	3720 a	2860 a	4860 ab
POST 2X[c,f]	70.4 a	69.0 a	74.1 a	3630 a	2790 a	5120 a
POST 3X[c,g]	71.9 a	69.2 a	74.1 a	3510 a	2430 ab	4530 ab
Handweeded check[c]	71.0 a	68.3 a	73.6 a	3780 a	2460 ab	4430 b
Weedy check[c]	70.5 a	68.1 a	71.4 b	2450 b	1930 b	2990 c

[a]Within each main effect, means in a column followed by the same letter do not differ according to Fisher's Protected LSD (0.05).

[b]Uniform stand, overall density of 16 seed/m, uniformly spaced 6 cm apart; narrow skip, overall density of 11 seed/m, 18 cm skip followed by 4 cm of uniformly spaced seed; wide skip, overall density of 8 seed/m, with 36 cm skip followed by 36 cm of uniformly spaced seed. All peanut stand uniformity treatments were established in a recurring pattern.

[c]All plots were treated with pendimethalin (1.1 kg/ha) preplant incorporated to control annual grasses.

[d]Flumioxazin PRE (0.107 kg/ha), imazapic 2wk (0.071 kg/ha), 2,4-DB 6wk (0.28 kg/ha).

[e]Flumioxazin PRE, paraquat (0.14 kg/ha) + bentazon (0.56 kg/ha) VE and 2wk, 2,4-DB 6wk.

[f]Imazapic 2wk, 2,4-DB 6wk.

[g]Paraquat + bentazon VE and 2wk, 2,4-DB 6wk.

imazapic completely controlling the weed (Table 2). Smallflower morningglory densities were low in 2010, with weed control regimes that included imazapic having the lowest density of all herbicide-based programs compared to the weedy check. Smallflower morningglory was the dominant dicot species in 2011 and all weed control regimes were equally effective in controlling smallflower morningglory, significantly reducing densities compared to the weedy check.

Pitted morningglory was present only in 2010. Weed control regimes that used flumioxazin and/or imazapic (PRE 1X/POST 2X, PRE 1X/POST 3X, POST 2X) reduced pitted morningglory densities over the weedy check (Table 2). Weed control using non-residual POST herbicides (POST 3X) did not reduce pitted morningglory densities compared to the weedy check in 2010. Sicklepod was present only in 2011 and at low densities (Table 2). Weed control regimes that included imazapic (PRE 1X/POST 2X, POST 2X) had the lowest sicklepod density among all weed control regimes that used herbicides, but did not differ from the weedy check.

Total sound mature kernels. Shelled peanut kernel size, or grade, is expressed as percent TSMK. Peanut is a botanically indeterminate crop with continuous flowering and pod formation once initiated. Conceptually, skips in peanut stand may cause proportionally fewer mature pods due to numerous immature pods formed on laterally growing stems that are trying to fill voids in the stand which lowers grade. TSMK were lowest when peanut stands had wide skips in 2009, but there was no effect of peanut stand uniformity on TSMK in 2010 and 2011 (Table 3). These results suggest that under most conditions, vegetative growth of the peanut cultivar GA-06G fills voids $<$36 cm wide in the peanut stand before the onset of reproductive growth and thus percent TSMK is not affected by disproportionate numbers of immature pods on laterally growing stems.

There were no differences in percent total sound mature kernels among any of the weed control regimes in 2009 and 2010 (Table 3). In 2011, percent total sound mature kernels were lowest in the weedy check, but grades did not differ among the remaining weed control regimes.

Marketable peanut yield. Peanut yields were reduced two years out of three by wide (36 cm) skips in the final stand (Table 3). In 2009 and 2010, marketable peanut yields were lowest when peanut stands had wide skips compared to a uniform stand or stand with narrow (18 cm) skips. However, in 2011 yields were not affected by peanut stand uniformity. These results indicate that peanut with skips $<$18 cm have the ability to compensate for reduced stands and not have yields reduced. Final stands with skips $>$36 cm will likely have reduced yield.

Compared to any of the weed control regimes including the handweed check, 2009 peanut yields were lowest in the weedy check, with no difference in peanut yield among any of the systems that used herbicides. In 2010, compared to the weedy check, peanut yields were greatest where the residual herbicides flumioxazin and/or imazapic were part of the weed control regime. Peanut yields in 2010 using non-residual POST herbicides (POST 3X) for weed control, the handweed check, and weedy check did not differ. In 2011, peanut yields were lowest in the weedy check compared to yields from other weed control regimes, including the handweeded check. Peanut yields were greatest in 2011 where herbicides were used for weed control with no difference in peanut yield among any of the weed control regimes that used residual or contact herbicides.

The non-significant interaction for all parameters between the main effects of peanut stand uniformity and weed control regime indicates an interesting aspect of peanut weed management. There were no consistent effects of peanut stand uniformity treatments on weed densities among all species, with the exception of smallflower morningglory two years out of three. Additionally, there was no consistent effect of peanut stand uniformity on peanut yield and percent total sound mature kernels, provided skips in peanut stand were <18 cm. If skips in peanut stand were 36 cm wide, then peanut yields were reduced two years out of three. However, the lack of interaction between main effects indicates that the yield reduction due to wide skips was not due to compromised weed control. These results suggest that the commonly planted cultivar GA-06G has the ability to compensate for skips in peanut stand without compromising weed control and yield potential, provided that skips are no wider than 18 cm.

With the herbicides used in these weed control regimes and knowledge of the species diversity in these research sites, we were able to effectively control weeds even when stands were not optimal. Much of that can be attributed to correctly matching herbicides with endemic weed species and the excellent residual weed control provided by flumioxazin and/or imazapic that suppressed weed emergence until canopy closure. It is worth noting that one of the weed control regimes evaluated in these trials exclusively used non-residual POST herbicides; two applications of bentazon plus paraquat, followed by one application of 2,4-DB. This regime generally controlled weeds in the skips similar to regimes that used residual herbicides and protected peanut yields and grade. While the non-residual POST herbicide regime controlled weeds and protected peanut yields, residual weed control provided by regimes that used flumioxazin and/or imazapic lessened risk of weed control failure over non-residual POST herbicides that require careful timing to maximize control of emerged weeds. Additionally, imazapic controls both emerged and non-emerged weeds, and this versatility is an added value when trying to suppress weeds in peanut stand skips.

Conclusion

Uniform peanut stands are an important priority, particularly when the cost of seed is considered (Smith and Smith 2015) and a proven factor in reducing losses due to spotted wilt disease (Culbreath *et al.* 2003). Despite increased precision by using vacuum planters, peanut stands are still frequently non-uniform. These results indicate that weed control is not strongly affected by non-uniform peanut stands and present weed control programs are capable of adequately controlling weeds in the sparse stand. DeWerff *et al.* (2014) found that low populations of indeterminate soybean [*Glycine max* (L.) Merr.] did not necessarily result in yield losses from weeds and that was due to effectiveness of weed control programs. Our results with peanut, also an indeterminate crop, are similar. In situations where peanut stands are compromised, growers can be assured that weed control regimes that use residual herbicides like flumioxazin or imazapic are more versatile and slightly more effective on a diverse array of weed species than regimes that relied solely on non-residual POST herbicides. From an agronomic perspective, peanut seeded with an aggressive cultivar such as GA-06G will compensate for in the voids of the sparse stand without yield reduction, provided that skips are <18 cm.

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Literature Cited

Beasley, J.P., Jr, J.A. Baldwin, S.L. Brown, S.M. Brown, B. Padgett, M.J. Bader, and D. Shurley. 1997. Peanut production guide. Athens, GA: University of Georgia Cooperative Extension Service Bulletin Agron. 95-001.

Branch, W.D. 2007. Registration of ‘Georgia-06G’ peanut. J Plant Regist. 1:120.

Buchanan, G.A. and E.W. Hauser. 1980. Influence of row spacing on competitiveness and yield of peanuts (*Arachis hypogaea*). Weed Sci. 28:401–409.

Chauhan, B.S. 2011. Effect of tillage systems, seeding rates, and herbicides on weed growth and grain yield in dry-seeded rice systems in Philippines. Crop Prot. 54:244–250.

Chauhan, B.S., V.P. Singh, A. Kumar, and D.E. Johnson. 2011. Relations of rice seeding rates to crop and weed growth in aerobic rice. Field Crop Res. 121:105–115.

Chhinnan, M.S., J.H. Young, and R.P. Rohrbach. 1975. Accuracy of seed spacing in peanut planting. Transactions of the ASAE. 18:828–831.

Culbreath, A.K., J.W. Todd, and S.L. Brown. 2003. Epidemiology and management of tomato spotted wilt in peanut. Annu. Rev. Phytopathol. 41:53–75.

Culbreath A.K., R.S. Tubbs, B.L. Tillman, J.P. Beasley, Jr., W.D. Branch, C.C. Holbrook, A.R. Smith, and N.B. Smith. 2013. Effects of seeding rate and cultivar on tomato spotted wilt of peanut. Crop Prot. 53:118–124.

Davidson, J.I., Jr., T.B. Whitaker, and J.W. Dickens. 1982. Grading, cleaning, storage, shelling, and marketing of peanuts in the United States. Pp. 571–623. In HE Pattee and CT Young (eds.) Peanut Science and Technology. American Peanut Research and Education Society, Yoakum, TX.

DeWerff. R.P., S.P. Conley, J.B. Colquhoun, and V.M. Davis. 2014. Can soybean seeding rate be used as an integrated component of herbicide resistance management? Weed Sci. 62:625–636.

Fahad, S., S. Hussain, S. Saud, S. Hassan, H. Muhammad, D. Shan, C. Chen, C. Wu, D. Xiong, S.B. Khan, A. Jan, K. Cui, and J. Huang. 2014. Consequences of narrow crop row spacing and delayed *Echinchloa colona* and *Trianthera portulacastrum* emergence from weed growth and crop yield loss in maize. Weed Res. 54:475–486.

Gardner, F.P. and E.O. Auma. 1989. Canopy structure, light interception, and yield and market quality of peanut genotypes as influenced by planting pattern and planting date. Field Crop Res. 20:13–29.

Johnson, W.C., III, E.P. Prostko, and B.G. Mullinix, Jr. 2005. Improving the management of dicot weeds in peanut with narrow row spacings and residual herbicides. Agron. J. 97:85–88.

Keeley, P.E. and R.J. Thullen. 1978. Light requirements of yellow nutsedge (*Cyperus esculentus*) and light interception by crops. Weed Sci. 26:10–16.

O'Donovan, J.T., K.N. Harker, T.K. Turkington, and G.W. Clayton. 2013. Combining cultural practices with herbicides reduces wild oat (*Avena fatua*) seed in the soil seed bank and improves barley yield. Weed Sci. 61:328–333.

Olsen, J., L. Kristensen, J. Weiner, and H.W. Griepentrog. 2005. Increased density and spatial uniformity increase weed suppression by spring wheat. Weed Res. 45:316–321.

Smith, N.B. and A. R. Smith. 2015. 2015 Peanut Update: 2015 Peanut Outlook and Cost Analysis. Prostko EP, ed. Athens, GA: The University of Georgia Cooperative Extension Service http://www.gapeanuts.com/growerinfo/2015_ugapeanutupdate.pdf . (Accessed 15 September 2016)

Stoller, E.W., L.M. Wax, and F.W. Slife. 1979. Yellow nutsedge (*Cyperus esculentus*) competition and control in corn (*Zea mays*). Weed Sci. 27:32–37.

Sturkie, D.G. and G.A. Buchanan. 1973. Cultural Practices. Pages 299–326 *in* Peanuts – Culture and Uses. Stillwater, OK. American Peanut Research and Education Society.

Tillman, B.L., D.W. Gorbet, A.K. Culbreath, and J.W. Todd. 2006. Response of peanut cultivars to seeding density and row patterns. Online Crop Manage. http://dx.doi.org/10.1094/CM-2006-0711-01-RS . (Accessed 15 September 2016)

Tubbs, R.S., J.P. Beasley, Jr., A.K. Culbreath, R.C. Kemerait, N.B. Smith, and A.R. Smith. 2011. Row pattern and seeding rate effects on agronomic, disease, and economic factors in large-seeded runner peanut. Peanut Sci. 38:93–100.

Weiner, J., H.W. Griepentrog, and L. Kristensen. 2001. Suppression of weeds by spring wheat (*Triticum aestivum*) increases with crop density and spatial uniformity. J. Appl. Ecol. 38:784–790.

Wehtje, G., R. Weeks, M. West, L. Wells, and P. Pace. 1994. Influence of planter type and seeding rate on yield and disease incidence in peanut. Peanut Sci. 21:16–19.