Weed Management in Evenly-Spaced 38- vs. 76-cm Row Peanut (*Arachis hypogaea*)

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ABSTRACT

Research was conducted in Florida in 2005 through 2008 to evaluate weed management systems in narrow (38-cm)- and wide (76-cm)-row peanut. Benghal dayflower control increased when peanut row spacing was narrowed. Paraquat plus bentazon early-postemergence (EPOST) followed by (fb) imazapic or imazethapyr mid-postemergence (MPOST) or chlorimuron late-postmergence (LPOST) controlled Benghal dayflower at least 90%. Imazapic EPOST with or without 2,4-DB MPOST controlled Benghal dayflower 98 to 100%. Diclosulam or flumioxazin preemergence (PRE) fb paraquat plus bentazon EPOST fb 2,4-DB MPOST or either PRE herbicide fb 2,4-DB MPOST did not increase Benghal dayflower control compared with imazapic-containing treatments. Browntop millet control was 98 to 100% for treatments with imazapic or imazethapyr EPOST and control was greater in narrow-row compared to wide-row peanut. All herbicide treatments controlled pitted morningglory at least 90% and peanut row spacing did not influence control. Only treatments with imazapic EPOST as a component controlled sicklepod at least 90%. No difference between peanut row spacing was observed for sicklepod control. Peanut planted in narrow-rows yielded greater than wide-row peanut. Few differences in peanut yield were observed among herbicide treatments, but all herbicide treatments resulted in yields greater than the nontreated control. Data indicates that seeding peanut in narrow-rows will improve Benghal dayflower and browntop millet control and will increase peanut yield compared to wide-row peanut.

Key Words: *Arachis hypogaea* L., narrow-row, row spacing, cultural weed management.

Weeds in peanut (*Arachis hypogaea* L.) are a major obstacle for profitable production and herbicides are an important tool for their control (Brecke and Colvin, 1991). Total annual losses from weeds in peanut were estimated to be $11.2, $6.4, and $47.5 million in Alabama, Florida, and Georgia, respectively (Webster, 2001). Yield loss from weeds in peanut is of great concern since there are only 10 herbicide active ingredients registered for in-crop use (Ferrell *et al.,* 2009a). Price and Wilcut (2002) reported that herbicide programs that included a preemergence (PRE) followed by (fb) early-postemergence (EPOST) fb postemergence (POST) applications were needed for season-long control of annual morningglories (*Ipomoea* spp.), common ragweed (*Ambrosia artemisiifolia* L.), eclipta (*Eclipta prostrata* L.), prickly sida (*Sida spinosa* L.), and yellow nutsedge (*Cyperus esculentus* L.). Due to the continued losses caused by weeds and the need for multiple herbicide applications for weed management in peanut, systems that integrate cultural and chemical weed control need to be assessed.

The potential for utilizing cultural practices to enhance weed management in peanut have been researched (Cardina *et al.,* 1987; Johnson and Mullinix, 2000; Johnson et. al. 2005; Wehtje *et al.,* 1984). Reducing the distance between rows can improve weed control by increasing crop competitiveness and reducing light transmittance to the soil (Tharp and Kells, 2001). Johnson *et al.* (2005) noted that total weed densities were less and peanut yield increased by 300 kg/ha for peanut rows spaced 30-cm apart compared to 91-cm. Florida beggarweed [*Desmodium tortuosum* (Sw.) DC] and sicklepod (*Senna obtusifolia* L.) late-season green weights were reduced 28 and 18%, respectively, when peanut was seeded in 41-cm rows compared to 81-cm(Buchanan and Hauser, 1980). Additionally, peanut yield was 10 to 30% greater for 41-cm peanut rows compared to 81-cm peanut, respectively.

When peanut is seeded in twin-rows (sets of two 18-cm rows separated by 91-cm centers), late-season control of Florida beggarweed, sicklepod, and Texas millet [*Urochloa texana* (Buckl.) R. Webster] was greater compared to single-row peanut (91-cm rows) (Colvin *et al.,* 1985). When averaged over herbicide programs, twin-row peanut yielded 400 kg/ha more that single-row peanut (Colvin *et al.,* 1985). Brecke and Stephenson (2006) observed greater late-season control of common cocklebur (*Xanthium strumarium* L.), Florida beggarweed, and sicklepod with twin-row compared to

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single-row peanut in conventional- and conservation-tillage. However, twin-row peanut provided a consistent yield increase only in conservation-tillage peanut (Brecke and Stephenson, 2006). Lanier *et al.* (2004) reported that twin-row peanut yielded 300 to 500 kg/ha more than single-row peanut in the absence of weed interference. A twin-row row spacing improved Benghal dayflower (*Commelina benghalensis* L.) control by 8% when averaged over several herbicide combinations (Ferrell *et al.,* 2009b). Additionally, tomato spotted wilt tospovirus (TSWV) infection and incidence in peanut is decreased by multiple factors including narrow peanut row spacing (Mossler and Aerts, 2007; Wright *et al.,* 2009). Johnson *et al.* (2005) stated that 30-cm peanut may reduce TSWV incidence compared to 91-cm peanut.

Seeding crops in narrow rows is a cultural weed management tool (Anderson, 1996). Numerous researchers have observed greater weed control and yields when soybean was seeded in narrow (19 to 51-cm) rows compared to wide (76-cm) rows (De Bruin and Pederson, 2008; Ethridge *et al.,* 1989; Hock *et al.,* 2006; Knezevic *et al.,* 2003), indicating an advantage of seeding soybean in narrow rows. Rogers *et al.* (1976) stated that the weed-free period to maximize cotton yield was 4 to 8 wk less for 53-cm row cotton compared to 79 and 106-cm rows. Ultra narrow row cotton (19 to 25-cm rows) provides the benefits of narrow rows in cotton, but erratic stands due to seeding with a grain drill and fiber quality issues related to finger-stripper harvesting (McAllister and Rogers, 2005; Vories *et al.,* 2001) have decreased use of this method by producers.

Recently, a harvester capable of spindle-picking cotton planted in 38-cm rows has been commercialized (Karnei, 2005) that facilitates the harvesting of narrow-row cotton without the issues associated with finger stripper cotton harvesters. Additionally, vacuum-unit seeding equipment is available to seed cotton and other crops in 38-cm rows eliminating the requirement of seeding with a grain drill (Waitrak *et al.,* 1998). Unfortunately, adoption of 38-cm cotton row spacing by producers may be reduced due to the cost of cotton seeding and harvesting equipment. Cotton and peanut are common rotational crops in the Southeast US (Lamb *et al.,* 2007); therefore adoption of narrow row spacing may be increased if producers could utilize a single implement to seed both cotton and peanut in 38-cm rows. Others have shown that seeding peanut in narrow-rows, specifically twin-rows, aids in management of TSWV, enhances weed management, and increases yields (Brecke and Stephenson, 2006; Wright *et al.,* 2009).

Information is not available concerning the utility of peanut grown in 38-cm rows. Therefore the objectives of this study were to determine whether growing peanut in 38-cm rows offered weed control and/or yield advantages over peanut grown in 76-cm rows.

Materials and Methods

Experiments were conducted in 2005 through 2008 at the West Florida Research and Education Center near Jay. Soil was a Red Bay fine sandy loam with 69% sand, 15% silt, and 16% clay, with pH 5.8–6.0 and 1.5–2% organic matter. A randomized complete block arranged in a split-plot experimental design with four replications was used. Main plots consisted of two peanut row spacings: single rows evenly spaced 38-cm apart (narrow rows) or single rows spaced 76-cm apart (wide rows). Sub-plots consisted of 13 herbicide treatments applied PRE, EPOST 2 wk after planting (WAP), mid-postemergence (MPOST) 5 WAP, or late-postemergence (LPOST) 7 WAP. Sub-plot herbicide treatments, rates, and timings of application are listed in Table 1. A nonionic surfactant at 0.25% volume-to-volume was added to all postemergence treatments. The entire test area was treated with pendimethalin PRE at 840 g/ha for early-season control of annual grasses and some small-seeded broadleaf weeds. Herbicides were applied with a tractor-mounted compressed-air sprayer calibrated to deliver 187 L/ha at 145 kPa using TeeJet 11004, flat-fan nozzles.

The experimental area was disk-harrowed and para-tilled (Bigham Brothers, Lubbock, TX) to a depth of 30-cm 2-4 wk prior to planting. Peanut cv. C99R (2005), GA-02C (2006 and 2007), and Florida 07 (2008) was planted in late-May or early-June with a vacuum planter (Deere & Company, Moline, IL) equipped with planter units spaced 38-cm apart. The 76-cm row spacing was achieved by placing seed only in alternate planter units. Peanut were seeded 5-cm deep at a density of 13 seed/m in narrow rows and 26 seed/m in wide rows resulting in the same seed/ha for both row spacings. Excluding weed management, pest and crop management practices were held constant over the experiments and were based on Florida Cooperative Extension Service recommendations (Mossler and Aerts, 2007; Wright *et al.,* 2009). Irrigation was provided as needed.

Control of Benghal dayflower, browntop millet [*Urochloa ramosa* (L.) Nguyen], pitted morningglory (*Ipomoea lacunosa* L.), and sicklepod were evaluated. Benghal dayflower and sicklepod were

Table 1. Herbicide treatments evaluated over a 4-yr period (2005–2008).[a]

Herbicide treatment	Rate	Timing
	g/ha	
Paraquat + bentazon fb 2,4-DB	140 + 560 fb 280	EPOST fb MPOST
Paraquat + bentazon fb imazethapyr	140 + 560 fb 71	EPOST fb MPOST
Paraquat + bentazon fb imazapic	140 + 560 fb 71	EPOST fb MPOST
Paraquat + bentazon fb chlorimuron	140 + 560 fb 10	EPOST fb LPOST
Imazapic	71	EPOST
Imazapic fb 2,4-DB	71 fb 280	EPOST fb MPOST
Flumioxazin fb paraquat + bentazon	105 fb 140 + 560	PRE fb EPOST
Diclosulam fb paraquat + bentazon	27 fb 140 + 560	PRE fb EPOST
Flumioxazin fb 2,4-DB	105 fb 280	PRE fb MPOST
Diclosulam fb 2,4-DB	27 fb 280	PRE fb MPOST
Flumioxazin fb paraquat + bentazon fb 2,4-DB	105 fb 140 + 560 fb 280	PRE fb EPOST fb MPOST
Diclosulam fb paraquat + bentazon fb 2,4-DB	27 fb 140 + 560 fb 280	PRE fb EPOST fb MPOST

[a]Abbreviations: EPOST, early-postemergence; fb, followed by; LPOST, late-postemergence; MPOST, mid-postemergence; PRE, preemergence, +, indicates a tank mixture prepared by research at time of application.

present in 3 and 4 yr of the study, respectively. Pitted morningglory and browntop millet were present in 2 yr of the study. Densities of all evaluated weeds were 3 to 10 plants/m^2. At the time of EPOST, MPOST, and LPOST herbicide application, weeds were 3 to 8-cm, 13 to 18-cm, and 20 to 42-cm tall, respectively. Weed control and peanut injury were visually evaluated 9 and 15 WAP using a scale of 0 (no injury symptoms or weed control) to 100 (death of all plants). Only the late-season (15 WAP) data are presented.

Johnson *et al.,* (2005) observed that a peanut digger/inverter with conventional (107-cm) length blades did not adequately dig peanut seeded in narrow rows, resulting in unacceptable yield losses. As a result they retrofitted a digger/inverter with 119-cm length blades to improve harvesting efficiency. In our research, peanut yields were measured in late-October or early-November by digging and inverting peanut from the center 4 and 2 rows of the narrow and wide row spacings, respectively, using a KMC (Kelly Manufacturing Co., Tifton, GA) digger/inverter retrofitted with 119-cm length blades. Following 3d of peanut air-curing, peanut was harvested with a commercial peanut combine. Yields were adjusted to 10% moisture before analysis.

All data were subjected to analysis of variance using PROC MIXED (SAS 2009) with year and replication (nested within year) as a random effect. Peanut row spacing and herbicide treatment were considered fixed effects. Considering year and replication an environmental or random effect permits inferences about treatments to be made over a range of environments (Carmer *et al.,* 1989). Peanut row spacing was compared using pre-planned orthogonal contrasts at the 0.05 level of probability. Least square means were calculated and mean separation ($P \leq 0.05$) was produced for herbicide treatment using PDMIX800 in SAS, which is a macro for converting means separation output to letter groupings (Saxton 1998). This statistical approach has been used successfully in previous research (Bond *et al.,* 2009; Bond *et al.,* 2008; Bond *et al.,* 2007; Etheredge *et al.,* 2009; Leon *et al.,* 2008; Levy *et al.,* 2006; Stephenson *et al.,* 2010; Walker *et al.,* 2008; Webster *et al.,* 2007).

Results and Discussion

Peanut injury was 5% or less regardless of row spacing or herbicide treatment (data not shown). Analysis indicated a significant row spacing effect for Benghal dayflower and browntop millet control and peanut yield (Tables 2) Greater Benghal dayflower control was observed when peanut was seeded in 38-cm rows compared to 76-cm rows regardless of herbicide treatment 15 WAP (Table 3), indicating that a narrow-row spacing for peanut may reduce competition from Benghal dayflower. Similarly, Ferrell *et al.* (2009b) found that twin-row row peanut increased Benghal dayflower control by 8%.

Averaged across all herbicide treatments, 38-cm peanut provided 93% control of browntop millet compared with only 79% control in 76-cm peanut 15 WAP (Table 3). Similar to our findings, others have reported control of Texas millet, another annual grass species, was increased 6% when peanut was seeded in twin-rows compared to single-rows regardless of herbicide treatment (Colvin *et al.,* 1985). Peanut row spacing did not influence pitted morningglory control (Table 3). Similarly, Brecke and Stephenson (2006) reported

Table 2. Significance of the main effects of row spacing (RS), herbicide treatment (HT), and the interactions of the main effects combined across environments.[a]

Weed	RS	HT	PP × HT
	p-value		
Benghal dayflower	0.0032	0.0261	0.8344
Browntop millet	0.0001	0.0001	0.0504
Pitted morningglory	0.3857	0.0403	0.0703
Sicklepod	0.4799	0.0001	0.6489
Peanut yield	0.0038	0.0012	0.9430

[a]Main effects and interaction are considered significant for type III error if $P < 0.05$. All data were analyzed using PROC MIXED with year and replication (nested within year) as a random effect. Peanut row spacing and herbicide treatment were considered fixed effects.

that twin-row peanut did not provide an increase in control of ivyleaf morningglory (*Ipomoea hederacea* Jacq.).

Regardless of herbicide treatment, peanut row spacing did not influence sicklepod control (73% control in narrow rows and 79% control in wide rows) (Table 3). However, Johnson *et al.,* (2005) observed a reduction in mid-season sicklepod density in peanut seeded in 30-cm compared to 91-cm. Additionally, sicklepod control was increased when peanut was seeded in twin-rows in both conventional- and strip-tillage (Brecke and Stephenson, 2006). Peanut seeded in a 38-cm row spacing yielded greater than 76-cm spacing (3,500 kg/ha vs. 3,200 kg/ha). In other research, Johnson *et al.* (2005) and Brecke and Stephenson (2006) observed greater yields from peanut seeded in 30-cm and twin-rows compared to wide-row peanut.

Analysis indicated a significant herbicide treatment effect for all weeds and yield (Tables 2). All herbicide treatments, except flumioxazin PRE fb paraquat plus bentazon EPOST, provided 86% or greater control of Benghal dayflower 15 WAP (Table 4). Paraquat plus bentazon EPOST fb either imazethapyr or imazapic MPOST or chlorimuron LPOST provided 90 to 100% Benghal dayflower control; however, imazapic EPOST alone or imazapic EPOST fb 2,4-DB MPOST provided 98 to 100% control 15 WAP (Table 4). All treatments with diclosulam PRE controlled Benghal dayflower 87 to 93% (Table 4). Applications of 2,4-DB MPOST were needed to provide 90% or greater control of Benghal dayflower when flumioxazin was applied PRE. Others have reported that chlorimuron, diclosulam, imazapic, and 2,4-DB effectively control 5- to 8-cm Benghal dayflower (Ferrell *et al.,* 2009b). Additionally, Prostko *et al.* (2005) stated that paraquat and imazethapyr provide good control of 5 lf Benghal dayflower. The findings of past research support the observations of our research for Benghal dayflower control.

Browntop millet control was 99% or greater when peanut was treated with paraquat plus bentazon EPOST fb imazethapyr MPOST 15 WAP (Table 4). All treatments that had imazapic EPOST or MPOST as a component provided 98 to 100% browntop millet control (Table 4). In previous research imazapic at 70 g/ha controlled 15 to 30-cm goosegrass [*Eleusine indica* (L.) Gaertn.] 37–62%, fall panicum (*Panicum dichotomiflorum* Michx.) 82%, and large crabgrass [*Digitaria sanguinalis* (L.) Scop.] 76 to 95% (Burke *et al.,* 2004); however, Tubbs and Gallaher (2005) observed excellent control of fall panicum, large crabgrass, and Texas millet with imazapic POST. The addition of diclosulam or flumioxazin PRE to paraquat plus bentazon EPOST fb 2,4-DB MPOST did not increase browntop millet control compared to paraquat plus bentazon EPOST fb 2,4-DB (Table 4). In other research, however, Grichar *et al.* (2004) reported diclosulam PRE provided 80% control of Texas millet.

Table 3. Benghal dayflower, browntop millet, pitted morningglory, and sicklepod control and peanut yield as influenced by row spacing 15 wk after planting.[a]

Row spacing	Benghal dayflower	Browntop millet	Pitted morningglory	Sicklepod	Peanut yield
	%				kg/ha
38-cm estimate	95	93	97	73	3500
76-cm estimate	87	79	94	79	3200

[a]Data pooled across herbicide treatment. Main effects are considered significant for type III error if $P < 0.05$. All data were analyzed using PROC MIXED with year and replication (nested within year) as a random effect. Peanut row spacing and herbicide treatment were considered fixed effects.

Table 4. Benghal dayflower, browntop millet, pitted morningglory, and sicklepod control and peanut yield as influenced by herbicide treatment and row spacing 15 wk after planting.[a,b]

Herbicide treatment	Benghal dayflower		Browntop millet		Pitted morningglory		Sicklepod		Peanut yield	
	%								kg/ha	
Paraquat + bentazon fb 2,4-DB	86	bc	78	de	96	ab	74	b	3500	ab
Paraquat + bentazon fb imazethapyr	92	ab	99	a	95	ab	73	bc	3200	b
Paraquat + bentazon fb imazapic	100	a	100	a	100	a	95	a	3600	ab
Paraquat + bentazon fb chlorimuron	90	abc	60	f	95	ab	68	bc	3200	b
Imazapic	98	ab	98	ab	99	a	91	a	3700	ab
Imazapic fb 2,4-DB	100	a	99	a	100	a	93	a	3800	a
Flumioxazin fb paraquat + bentazon	78	c	79	cde	90	b	60	c	3400	ab
Diclosulam fb paraquat + bentazon	93	ab	78	de	94	ab	63	bc	3300	ab
Flumioxazin fb 2,4-DB	91	ab	72	ef	96	ab	73	bc	3500	ab
Diclosulam fb 2,4-DB	87	bc	84	bcde	96	ab	70	bc	3300	ab
Flumioxazin fb paraquat + bentazon fb 2,4-DB	88	abc	93	abc	96	ab	72	bc	3400	ab
Diclosulam fb paraquat + bentazon fb 2,4-DB	90	abc	91	abcd	92	b	75	b	3200	b
UTC	0		0		0		0		2300	c

[a]Data pooled across peanut row spacing. Means within each weed species and peanut yield following the same letter are not significantly different at $P \leq 0.05$. All data were analyzed using PROC MIXED with year and replication (nested within year) as a random effect. Peanut row spacing and herbicide treatment were considered fixed effects.

[b]Abbreviations: fb, followed by; +, indicates a tank mixture prepared by research at time of application. Refer to Table 1 for more detail on herbicide rate and timing.

All herbicide treatments provided 90% or greater pitted morningglory control 15 WAP (Table 4). Treatments containing imazapic EPOST or MPOST provided 99 to 100% control 15 WAP, and provided better pitted morningglory control than flumioxazin PRE fb paraquat plus bentazon EPOST or diclosulam PRE fb paraquat plus bentazon EPOST fb 2,4-DB MPOST (Table 4). Brecke and Stephenson (2006) observed excellent late-season control of ivyleaf morningglory with diclosulam, flumioxazin, or imazethapyr PRE fb paraquat plus bentazon EPOST fb imazapic or 2,4-DB POST. Diclosulam PRE fb paraquat plus bentazon EPOST fb imazapic MPOST controlled entireleaf morningglory, ivyleaf morningglory, and pitted morningglory 100% in North Carolina (Price and Wilcut, 2002).

Herbicide treatments containing imazapic controlled sicklepod 91 to 95% 15 WAP (Table 4). In other research, paraquat plus bentazon EPOST fb imazapic MPOST controlled sicklepod 93 to 100%, regardless of tillage system or peanut row spacing (Brecke and Stephenson, 2006). All other treatments in our study provided 75% or less control. The addition of diclosulam or flumioxazin PRE did not increase sicklepod control compared to paraquat plus bentazon EPOST fb 2,4-DB MPOST (Table 4). Brecke and Stephenson (2006) previously reported diclosulam and flumioxazin PRE fb various POST herbicides provided 70 to 100% sicklepod control.

Peanut yield ranged from 3,200 to 3,600 kg/ha for all herbicide treatments and all herbicide treatments yielded greater than the nontreated control (2,300 kg/ha) (Table 3). Peanut treated with imazapic EPOST fb 2,4-DB MPOST yielded 3,800 kg/ha which was greater than peanut treated with paraquat plus bentazon EPOST fb chlorimuron LPOST or diclosulam PRE fb paraquat plus bentazon EPOST fb 2,4-DB MPOST (both 3,200 kg/ha), but did not differ from any other herbicide treatment (Table 4).

Summary and Conclusions

Regardless of herbicide treatment, seeding peanut in 38-cm rows provided an increase in Benghal dayflower and browntop millet control, but did not influence control of pitted morningglory or sicklepod. Others observed increased control of common cocklebur, Florida beggarweed, and sicklepod when peanut was seeded in twin-rows (Brecke and Stephenson 2006; Colvin *et al.,* 1985), which is not a direct comparison to our data due to different row spacings in our research. Peanut yield increased when peanut was seeded in 38-cm rows, indicating a yield advantage of seeding peanut in narrow rows.

Averaged across peanut row spacing, applications of imazapic EPOST or MPOST with or without paraquat plus bentazon EPOST or 2,4-DB MPOST provided excellent control of Benghal dayflower, browntop millet, pitted morningglory, and sicklepod. Although few differences were observed among herbicide treatments for peanut yield, yields were maximized with treatments containing imazapic.

The benefits of narrow row crop production have been highlighted by this research and the research of others. Due to the advantages for control of Benghal dayflower and browntop millet and increased yields by seeding peanut in 38-cm rows, seeding peanut in narrow rows is advantageous even though a peanut digger/inverter would require slight modification. In addition, with the commercialization of narrow-row spindle-picking cotton harvesters, the ability to harvest cotton seeded in 38-cm rows is possible without the issues of increased foreign matter and decreased fiber quality. The primary issue is the cost of a planter able to seed both cotton and peanut in 38-cm rows, but this cost may become practical by sharing the cost in both production systems.

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