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ARTICLE

Peanut Cultivar Tolerance and Weed Control with Fluridone

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ABSTRACT

Increasing challenges associated with herbicide resistance in weeds necessitates the exploration of herbicides with underutilized modes of action. Currently, fluridone is labeled in cotton for preemergence (PRE) control of small-seeded broadleaf weeds and annual grasses. But, no information is available evaluating current peanut cultivar response to fluridone and its utility in a peanut weed control system. Thus, three unique field experiments were conducted and replicated in time from 2019 through 2022 to determine the response of seven peanut cultivars to PRE applications of fluridone and to determine the efficacy of fluridone at multiple rates and tank-mixtures (acetochlor, diclosulam, dimethenamid-*P*, pendimethalin, *S*-metolachlor, and trifludimoxazin) for weed management. At rates ≥ 168 g ai/ha, fluridone caused significant peanut injury in the form of leaf bleaching and necrosis under extreme moisture and temperature conditions. In this scenario, fluridone at 336 and 673 g ai/ha caused 18% and 54% yield losses. Under ideal environmental conditions only 673 g ai/ha of fluridone resulted in significant peanut yield loss (6%). Fluridone rates ≤ 252 g ai/ha did not reduce peanut yield in any experiment. Although peanut cultivar differences were not common across experiments, GA-16HO exhibited increased leaf bleaching and necrosis when compared to GA-18RU. In the weed control experiment, PRE fluridone tank-mixtures were less injurious to peanut when compared to the current standard flumioxazin system at 2 weeks after application (WAA). Palmer amaranth control with fluridone based systems was ≥ 86%, wild radish control was ≥ 92%, and annual grass control was ≥ 94%, which was similar to the standard flumioxazin based systems. Collectively these data support the use of fluridone at a maximum rate of 168 g ai/ha in a total peanut weed control system. In 2023, fluridone received a federal label for use in peanut at rates ranging from 126 to 168 g ai/ha.

INTRODUCTION

In 2023, the U.S. harvested approximately 35 million ha of field corn (*Zea mays* L.), 33 million ha of soybeans (*Glycine max* L.), 2.9 million ha of cotton (*Gossypium hirsutum* L.), 15 million ha of wheat (*Triticum aestivum* L.), and only 637,247 ha of peanut (*Arachis hypogaea* L.) (USDA-NASS 2024). Georgia, the nation's top peanut-producing state, harvested 311,741 ha or 49% of the total U.S. peanut hectarage. Despite peanut being a valuable commodity for Georgia and the U.S., agrichemicals are rarely developed for peanut production in contrast to the major agronomic crops.

Field crops, such as field corn and soybean, offer a competitive advantage to competing weeds due to their ability to quickly close the crop canopy and ability to shade the soil beneath (Ethridge *et al.,* 2022; Jha *et al.,* 2017). Because the growth habit and structure of peanut is low growing and is slow to shade the soil often allowing multiple flushes of weeds, peanut is considered a poor early-season competitor (Burke *et al.*, 2007, Everman *et al.*, 2008, Wilcut *et al.,* 1994). Herbicides can be valuable tools maximizing peanut growth while minimizing the competitiveness of yield-limiting broadleaf and grass weeds such as Palmer amaranth (*Amaranthus palmeri* S. Wats.), Texas millet [*Urochloa texana* (Buckl.)], goosegrass (*Eleusine indica* L.), crabgrass spp. (*Digitaria* spp.), crowfootgrass (*Dactyloctenium aegyptium* L.), wild radish (*Raphanus raphanistrum*), Florida beggarweed [*Desmodium tortuosum* (Sw.) DC.], common cocklebur (*Xanthium strumarium* L.), Benghal dayflower (*Commelina benghalensis* L.), common ragweed (*Ambrosia artemisiifolia* L.), and sicklepod (*Senna obtusifolia* L.) (Buchanan *et al.*, 1976; Burke *et al.*, 2004; Burke *et al.*, 2007; Cardina and Brecke, 1991; Everman *et al.*, 2008; Grichar *et al.*, 2004; Hauser *et al.*, 1975; Norsworthy *et al.*, 2010; Prostko *et al.*, 2001).

Herbicide-resistant Palmer amaranth is the most prolific and second most difficult weed to manage in Georgia peanut production (Wychen, 2019). This finding was prior to Randell-Singleton *et al.*, (2024) who documented a population of Palmer amaranth in Georgia with resistance to residual (soil) applications of WSSA Group 14 protoporphyrinogen oxidase (PPO) herbicides. This new resistance confirmation is additional to previous discoveries of resistance to WSSA/HRAC Group 9 (glyphosate), Group 2 (acetolactate synthase [ALS] inhibitors), and/or Group 5 (triazine) herbicides (Heap, 2024).

Flumioxazin, a WSSA/HRAC Group 14 PPO herbicide, is a key preemergence (PRE) herbicide that has been utilized in peanut production since 2001 and remains a critical component of a peanut weed management system (Basinger *et al.*, 2021; Grichar *et al.*, 2004; Wilcut *et al.*, 2001). Flumioxazin is used on more than 60% of the U.S. peanut crop (USDA-NASS, 2024). Typically, growers do not experience yield loss associated with PRE applications of flumioxazin as peanut cultivars have excellent crop tolerance (Basinger *et al.*, 2021; Grichar *et al.*, 2004; Main *et al.*, 2003; Wilcut *et al.*, 2001). However, injury or stunting can occur early in the season under wet conditions, but research has shown this injury to be transient without impacting yields (Basinger *et al.* 2021; Wilcut *et al.* 2001). The recent discovery of PPO resistance to the residual activity of flumioxazin in Georgia has become a major concern for its future use in peanut especially when considering a single Palmer amaranth plant/row meter of peanut can reduce yields by 28% (Burke *et al.*, 2007).

Weed management in peanut requires a dynamic systems approach utilizing a combination of herbicides (PRE + POST), and cultural production methods that promote vigorous crop growth reducing the competitiveness of problematic weeds (Buchanan *et al.* 1982; Burke *et al.*, 2007; Everman *et al.* 2008). It is vital to evaluate herbicides, developed for use in other crops, for their potential use in peanut as herbicide-resistance and the lack of new herbicide chemistries are concerning.

Fluridone, formerly ELI-171, was originally developed for the aquatic weed control market and was introduced into the U.S. in 1986 under the trade name of Sonar® (Shaner 2014). Fluridone + fomesafen and fluridone + fluometuron pre-mixtures were registered for use in cotton in 2016 under the trade names of Brake® F16 and Brake® FX. Fluridone alone was labeled for use in cotton in 2017 under the trade name of Brake® (K. Briscoe, pers. commun.). Fluridone applied at rates above 450 g ai/ha has been documented to control pigweed spp. (*Amaranthus hybridus* L.), common purslane (*Portulaca oleracea* L.), Texas millet, junglerice [*Echinochloa colonum* (L.) Link] and seedling johnsongrass (*Sorghum halepense* L.) on Miller clay soils for up to 60 days after application (Banks and Merkle 1979). Fluridone, a WSSA Group 12 herbicide, inhibits phytoene desaturase and this inhibition that occurs in susceptible plants leads to bleaching, chlorosis, necrosis, and plant death (Waldrep and Taylor 1976). Fluridone, with its underutilized mode of action in agronomic crops, could be an important tool in a peanut weed-resistance management program if acceptable crop tolerance exists (Cahoon *et al.*, 2015). Prior research indicates differential peanut cultivar response to other herbicides highlighting the need for research focusing on peanut cultivar response to fluridone (Jordan *et al.*,1998; McLean *et al.*, 1994; Richburg *et al.* 1995; Wilcut *et al.* 2001). Additionally, little is understood regarding how fluridone would perform in a peanut weed management system.

Therefore, the objectives of this research were 1) to determine the effects of fluridone applied PRE on the growth and development of seven commercially available peanut cultivars and 2) to determine the effectiveness of fluridone as part of a peanut weed management system.

MATERIALS AND METHODS

Peanut Cultivar Experiment 1

A field experiment was conducted each year from 2019 through 2021 (3 site-years) at the University of Georgia Ponder Research Farm in Ty Ty, Georgia (31.507654° N, -83.658395° W) to determine the effects of fluridone applied PRE on three peanut cultivars. The soil type was a Tifton sand with 92-94% sand, 4-6% silt, 2% clay, 0.62-0.93% organic matter, and a pH of 6.0. Treatments were arranged in a split-plot design with main-plots consisting of the cultivars [Georgia-06G (Branch 2007), Georgia-16HO (Branch 2017), and Georgia-18RU (Branch 2019)] and sub-plots consisting of four rates of fluridone including 0, 168, 336, or 673 g ai/ha, with all twelve treatments replicated four times.

Peanut cultivars were planted into conventionally tilled seedbeds using a vacuum planter (Monosem Precision Planters, 1001 Blake St., Edwardsville, KS) calibrated to deliver 18 peanut seed/m at a depth of 5 cm. Peanuts were planted in twin rows spaced 23 cm apart on a 91 cm center. Plots were 1.8 m (two sets of twin rows) wide and 7.6 m in length. Herbicide treatments were applied 1 day after planting (DAP) using a CO_2-pressurized backpack sprayer calibrated to deliver 140 L/ha at 5.3 km/hr. Immediately following herbicide applications, treatments were activated with 1.3 cm of overhead irrigation. Plots, including the non-treated control, were maintained weed-free throughout the season by applying pendimethalin [1066 g ai/ha] plus diclosulam [26 g ai/ha] over the entire experimental area PRE followed by hand-weeding when necessary. Production, irrigation, and pest management practices other than specific treatments were held constant over the entire experiment to optimize peanut growth and development (Monfort 2022).

Data collected included peanut density (stand) at 27 to 34 DAP, visual estimates of peanut injury (bleaching, necrosis, and stunting), plant height/width, and yield. Peanut plant density was obtained by counting the number of emerged plants from 1-row m of twin rows. Visual estimates of crop injury were obtained from 1, 3, 4, 5, 6, 8, and 10 weeks after application (WAA) using a subjective scale of 0 to 100 (0=no injury;

100=plant death). Plant height (cm) and width (cm) data were collected at 8 WAA by measuring 5 plants/plot. Plant heights/widths were recorded at 5 random but representative locations from each plot. Heights were measured from individual plants from the soil line to the top of the terminal leaflet, and plant width measurements were recorded from measurements of the lateral branches from the twin-row. Peanut yield data were obtained using commercial harvesting equipment with yields adjusted to 10% moisture. A complete summary of planting, inversion, and harvesting dates can be found in Table 1. Weather conditions, irrigation, and rainfall for the first 30 DAP are presented in Table 2.

Table 1. Planting, inversion, and harvest dates of fluridone peanut trials in Ty Ty, Georgia, 2019-2022.

Year	Planting	Inversion	Harvest
Cultivar Experiment 1:			
2019	May 1	Sep 19	Sep 25
2020	Apr 28	Sep 21	Sep 24
2021	May 7	Sep 23	Sep 28
Cultivar Experiment 2:			
2021	Apr 29	Sep 23	Sep 27
2022	May 4	Sep 16	Sep 20
Weed Control Experiment[a]:			
2020[b]	May 12	Sep 30	Oct 9
2021[c]	May 10	Sep 24	Sep 29
2022[d]	Apr 27	Sep 15	Sep 19

[a] GA-16HO planted in all years.

[b] 2020 Herbicide application dates: preemergence (PRE) - May 13; postemergence (POST) - Jun 4.

[c] 2021 Herbicide application dates: PRE May 11; POST Jun 4.

[d] 2022 Herbicide application dates: PRE Apr 28; POST May 24.

Table 2. Weather comparison for fluridone cultivar experiment one during the first 30 days after planting (DAP) in Ty Ty, Georgia, 2019-2021.

	2019	2020	2021
Daily Avg. Max Air Temp (C)	32	28	30
Daily Avg. Min Air Temp (C)	19	16	16
Average 5cm Soil Temp (C)	30	26	28
Total Rainfall (mm)	51	111	73
Total Irrigation (mm)	41	34	61
Total Rainfall/Irrigation – 14 DAP	76 mm of 92 mm	57 mm of 145 mm	37 mm of 134 mm

Data for all parameters were analysed as a split-plot design and subjected to ANOVA using PROC GLIMMIX in SAS, version 9.4 (SAS Institute, Cary, NC). Peanut cultivar and fluridone rate were set as fixed effects. Replications within years and cultivars by replications within years were set as random effects. Peanut density, injury, plant height/width, and yield were set as the response variables. A fluridone rate-by-year interaction for 2019 prevented the pooling of data across all years. Thus, all data for 2019 were separated from that acquired during 2020 and 2021. Lack of year interactions allowed data to be pooled over the 2020 and 2021 experiments. All P-values for tests of differences between least-square means were compared and separated using the Tukey-Kramer method at $P < 0.10$.

Peanut Cultivar Experiment 2

A second field experiment was conducted to further determine the effects of fluridone PRE on four additional cultivars. Production practices, location, soil type, pest management, and data collection were identical to that noted in the first cultivar experiment. The split-plot design main-plots consisted of four different peanut cultivars [AUNPL-17 (Chen *et al.*, 2017), FloRun 331 (Tillman 2021), Georgia-20VHO (Branch 2021), and TifNV High O/L (Holbrook *et al.*, 2017)] and three sub-plots of fluridone rates including 0, 126, or 252 g ai/ha, with all twelve treatments replicated three times. Fluridone rates were reduced as a result of observations documented during the first cultivar experiment. A complete summary of peanut planting, inversion, and harvesting dates can be found in Table 1. The statistical analysis was identical to that noted with cultivar experiment one with the exception that no year interactions were observed allowing data to be pooled across years.

Weed Control Experiment

Cultural production practices, location, and soil type for the weed control experiment were identical to those provided for the cultivar experiments. However, only one peanut cultivar [GA-16HO (Branch 2017)] was planted. Planting, herbicide application, inversion, and harvest dates are presented in Table 1.

Twelve herbicide treatments were arranged in a randomized complete block design with 3 to 4 replications. Fluridone at 126, 147, 168, 252, 294, and 336 g ai/ha was tank-mixed with pendimethalin at 1066 g ai/ha and applied PRE. Additionally, fluridone at 147 g ai/ha was applied with tank-mixtures of diclosulam, *S*-metolachlor, acetochlor, and/or dimethenamid-*P*. Fluridone treatments were directly compared to a standard recommended peanut PRE-tank-mix of flumioxazin + pendimethalin + diclosulam (1066 + 91 + 13 g ai/ha). All PRE-herbicide treatments were applied 1 DAP using a CO_2-pressurized backpack sprayer calibrated to deliver 140 L/ha at 5.3 km/hr. Immediately following herbicide applications, treatments were activated with 1.3 cm of overhead irrigation. All PRE treatments were followed with POST applications (27-31 DAP) of imazapic + 2,4-DB and either *S*-metolachlor, dimethenamid-*P*, or acetochlor. Two nontreated checks were also included for comparison. A complete list of treatment rates and combinations are presented in Table 3.

Data collection included visual estimates of peanut injury (stunting and bleaching), visual estimations of weed control, and yield. Visual estimates of crop injury were obtained from 2, 3, 5, 6, and 8 WAA using a subjective scale of 0 to 100 (0=no injury; 100=plant death). Weed control ratings were collected using a scale of 0 to 100 (0=no weed control; 100=weed free). Weed control ratings were collected on the same dates as injury evaluations with additional evaluations also occurring 9, 11, and 13 WAA. Peanut yield data were obtained using commercial harvesting equipment with yields adjusted to 10% moisture.

Data were subjected to ANOVA using PROC GLIMMIX in SAS, version 9.4 (SAS Institute, Cary, NC). Peanut injury, weed control, and yield were set as the response variables with replication within year included in the model as random factors. There was not a year-by-treatment interaction, thus data were pooled over years. All P-values for tests of differences between least-square means were compared and separated using the Tukey-Kramer method ($P<0.1$).

RESULTS AND DISCUSSION

Peanut Cultivar Experiment 1

Visual estimates of leaf bleaching and necrosis evaluations for 2019, presented in Table 4, were obtained at 3 WAA. A significant interaction between cultivar and fluridone rate was observed for bleaching ($P=0.0005$) and necrosis ($P=0.0472$). Foliar bleaching of 23 to 56% was observed with fluridone ranging from 168 to 673 g ai/ha with some cultivar differences. For example, GA-16HO exhibited more foliar bleaching than GA-06G and GA-18RU when fluridone was applied at 168 g ai/ha. For necrosis, the only difference observed between cultivars within comparable rates was with GA-16HO which exhibited greater foliar necrosis than GA-18RU at the 673 g ai/ha rate. In 2019, peanut cultivar stunting followed similar trends as noted with bleaching and chlorosis as GA-16HO was stunted more than GA-18RU when pooled over rates (Table 5). Fluridone at 168, 336, and 673 g ai/ha when averaged across cultivars, resulted in significant stunting of 11, 28, and 57%, respectively.

In 2020/2021, bleaching and necrosis data were obtained at 3 WAA, and stunting injury was obtained at 6 WAA (Table 5). Cultivar ($P=0.0917$) and fluridone rate ($P<0.0001$) main effects were significant. The cultivar GA-16HO exhibited greater foliar bleaching than GA-18RU when averaged across all fluridone rates (20% vs. 14%). Fluridone at 168, 336, and 673 g ai/ha, when averaged across cultivars, resulted in bleaching of 8%, 18%, and 39%, respectively, with each rate resulting in significantly more bleaching. Foliar necrosis was impacted by fluridone rate ($P<0.0001$) when averaged across cultivars. Fluridone rates at 336 and 673 g ai/ha resulted in 5 to 8% leaf necrosis and 6 to 22% stunting.

In comparison, 2020/2021 had optimal daily average air and soil temperatures during the first 30 DAP (Table 2). Despite rainfall and irrigation totals being greater in 2020/2021 for the first 30 DAP, emerging peanuts only received 39% and 28% of those totals during the first 2 weeks after planting, respectively (Table 2). These conditions could contribute to optimal fluridone metabolism, resulting in significantly less stand loss from the two highest rates of PRE-applied fluridone when comparing differences between years. While stand loss was significant for the highest rate of fluridone across all years, there was only a 13% reduction in density at the highest rate in 2020/2021, whereas in 2019, a 65% reduction in peanut density was observed with fluridone at 673 g ai/ha.

Table 3. Weed control programs, rates, and application timing for weed control experiment with fluridone in Ty Ty, Georgia, 2020-2022.

Herbicide		Rate	
PRE	POST	PRE	POST
		--------------g ai/ha--------------	
Pendimethalin + Flumioxazin + Diclosulam	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 91 + 13	71 + 1069 + 281
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 126	71 + 1069 + 281
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 147	71 + 1069 + 281
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 168	71 + 1069 + 281
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 252	71 + 1069 + 281
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 294	71 + 1069 + 281
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 336	71 + 1069 + 281
Pendimethalin + Fluridone + Diclosulam	Imazapic + S-metolachlor + 2,4-DB	1066 + 126 + 13	71 + 1069 + 281
S-metolachlor + Fluridone + Diclosulam	Imazapic + *S*-metolachlor + 2,4-DB	1069 + 126 +13.2	71 + 1069 + 281
Acetochlor + Fluridone + Diclosulam	Imazapic + Acetochlor + 2,4-DB+ NIS[a]	1262 + 126 +13	71 + 1262+ 281 + 0.25 % v/v
Dimethenamid-*P* + Fluridone + Diclosulam	Imazapic + Dimethenamid-*P* + 2,4-DB	552 + 126 + 13	71 + 552 + 281
Pendimethalin + Fluridone + Trifludimoxazin	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 126 + 38	71 + 1069 + 281

[a] NIS= non-ionic surfactant (Induce®, Helena Chemical Company, Collierville, TN 38017).

In 2019, there was no interaction between cultivar and fluridone for peanut density. (P=0.3568). However, the main effect of fluridone rate was significant (Table 5.) (P<0.0001). Peanut density was reduced across all cultivars when treated with 336 and 673 g ai/ha of fluridone. In 2020/2021 peanut density was influenced by cultivar and fluridone rate (Table 5). Peanut density main effects for cultivar were observed as follows: GA-16HO>GA-06G>GA-18RU, most likely due to seed quality (splits) issues. Differences in cultivar emergence can also be attributed to variations in management, harvesting, and storage/handling for each cultivar (W.S. Monfort, pers. commun. 2023). When averaged across cultivars, fluridone at 673 g ai/ha reduced final peanut density by 2 plants/1-row m (13%).

Stand loss differences in 2019 from the two highest rates of fluridone when compared to 2020/2021 can likely be attributed to environmental factors noted in Table 2. In 2019, on average over the course of 30 DAP, the metabolism of fluridone in peanut was decreased due to the extreme air and soil temperatures along with the increase of fluridone in an aqueous solution in the soil. Data reported by Ketring (1984) suggest air temperatures between 25 and 30 C are optimal for photosynthesis, vegetative growth, and development, whereas the temperature of 32C and 35C had significantly reduced leaf area, dry weight, and shortened stem length at 63 and 91 DAP in Spanish peanut cultivars. Temperature is directly proportional to vegetative and reproductive development in peanut, and increased temperatures can lead to reduced plant growth and metabolism (Boote 1982; Ketring 1984). Another contributing factor in 2019, could be that peanuts received 83% of total irrigation and rainfall within 14 DAP, allowing for increased root uptake of fluridone.

Table 4. Peanut cultivar and fluridone rate interaction effects on peanut injury (bleaching and necrosis), cultivar experiment 1, Ty Ty, Georgia, 2019.

Cultivar	Rate	Peanut Injury[a]	
		Bleaching	Necrosis
	-g ai/ha-	----------------%----------------	
GA-06G	0	0e[b]	0g
	168	33cd	14efg
	336	45abc	34cd
	673	56a	56ab
GA-18RU	0	0e	0g
	168	23d	3fg
	336	43bc	28de
	673	56a	48bc
GA-16HO	0	0e	0g
	168	48ab	19def
	336	50ab	34cd
	673	51ab	73a

[a] Visual estimates of peanut injury based on subjective scale of 0 = no injury and 100 = complete crop death. Ratings obtained 3 weeks after application.

[b] Means in the same column with the same letters are not significantly different according to the Tukey-Kramer method (P<0.10).

Plant heights or widths were not recorded in 2019. Plant height and width measurements from 2020/2021 are presented in Table 5. Peanut canopy height was influenced by herbicide rate (P=0.0001). Peanut canopy width was influenced by cultivar (P=0.0660) and herbicide rate (P<0.0001). Peanut plant height and width were reduced by 15% when subjected to the 673 g ai/ha rate, when averaged across cultivars. GA-16HO plant canopies were wider than GA-06G canopies at 10 WAA.

Peanut yield was reduced 18 and 54% by fluridone at 336 and 673 g ai/ha, respectively, during 2019 when pooled over cultivars (Table 5). When comparing cultivars, averaged over herbicide rates, no differences were observed. During 2020/2021, yield was influenced by both cultivar (P=0.0242) and fluridone rate (P=0.0149), but there was not a cultivar-by-herbicide interaction (Table 5). Following observations with injury and growth, fluridone influence on crop yield was less during the 2020/2021 seasons when compared to 2019 with only the highest rate of fluridone reducing yield (6%). Additionally, GA-18RU had higher yields than GA-06G and GA-16HO when averaged across all rates of fluridone. The yield loss associated with fluridone rates of 336 and 673 g ai/ha in this experiment, set the limitations on application rates for the second cultivar experiment.

Peanut Cultivar Experiment 2

Peanut density was not influenced by the interaction of cultivar and fluridone rate (P=0.4239). The main effect of fluridone rate did not influence final plant density (P=0.4660); however, the main effect of cultivar (P=0.0685) was significant (Table 6). FloRun331 density was reduced when compared to GA-20VHO but no other cultivar differences were observed (Table 7). Peanut emergence can be influenced by how seed is managed, stored, and handled prior to planting (W.S. Monfort, pers. commun. 2023).

Visual estimates of bleaching and stunting ratings for 2021/2022 are presented in Table 6. A significant interaction of herbicide rate was observed for both bleaching (P<0.0001) and stunting (P=0.0003). Fluridone at 252 g ai/ha resulted in 4% bleaching and stunting. No other visual injury was observed and the injury dissipated quickly as the season progressed.

Fluridone had no effect on peanut plant height. However, cultivar differences were observed with plant heights as follows: FloRun 331 = TifNV High O/L >AU NPL > GA-20VHO (Table 6). Plant width was not affected by either cultivar or fluridone rate (data not reported). This data supports peanut growth response to similar rates from cultivar experiment one.

Table 5. The influence of peanut cultivar and fluridone rate on peanut density, injury (bleaching, necrosis, stunting), and yield, cultivar experiment 1, Ty Ty, Georgia 2019-2021.

	Peanut Density[a]		Peanut Injury[b]				Peanut Canopy[c]		Yield	
					Stunting					
Cultivar or Rate	2019	2020-2021	Bleaching	Necrosis	2019	2020-2021	Height	Width	2019	2020-2021
	-plants/1-row m-		---------------------------%----------------------				----------cm---------		------- kg/ha -------	
Cultivar[d]										
GA-06G	14a[e]	16b	15ab	3a	23ab	7a	19a	69b	5745a	6475b
GA-16HO	12a	17a	20a	4a	30a	7a	19a	73a	5646a	6532b
GA-18RU	13a	13c	14b	4a	20b	7a	18a	71ab	6434a	6825a
Rate[f]										
0	17a	16a	0d	0c	0d	0c	20a	74ab	7487a	6784a
168	17a	17a	8c	1c	11c	1bc	20a	75a	6743ab	6724a
336	12b	16a	18b	5b	28b	6b	19a	72b	6111b	6578ab
673	6c	14b	39a	8a	57a	22a	17b	63c	3426c	6358b

[a] Peanut density data collected 27-34 days after planting.
[b] Peanut injury = Subjective visual estimates of peanut injury based on subjective scale of 0 = no injury and 100 = complete crop death. Bleaching/Necrosis = 3 weeks after application averaged over 2020/2021. Stunting = 6 weeks after application.
[c] Peanut canopy data collected 10 weeks after application, 5 plants/plot.
[d] Cultivar = averaged over fluridone rate.
[e] Means in the same column of either cultivar or rate with the same letter are not significantly different according to Tukey-Kramer method (P<0.10).
[f] Rate = averaged over cultivar.

Peanut yield in 2021/2022 was influenced by cultivar but not fluridone rate (Table 6). AU-NPL17 had 12 to 16% greater yields than the three other cultivars. In previous studies with older peanut cultivars, PRE applications of norflurazon, another WSSA Group 12 herbicide, did not influence yield (Mclean *et al.*, 1994).

Weed Control Experiment

Visual estimates of bleaching and stunting evaluations from 2020 through 2022, are presented in Table 7. Peanut stunting with the flumioxazin PRE treatment at 2 WAA was 20%. The highest level of stunting with any fluridone treatment was only 11%. In contrast, bleaching was greater with fluridone treatments as compared to the standard flumioxazin system. For example, fluridone applications at ≥168 g ai/ha resulted in foliar bleaching ranging from 10 to 28% at the same time interval. Stunting and bleaching were transient and dissipated as the season progressed.

Weed control evaluations were pooled over years and are reported at 2, 5, and 13 WAA (Table 7). The standard herbicide system for which all other PRE + POST herbicide combinations were compared to included pendimethalin + flumioxazin + diclosulam (PRE) followed by imazapic + *S*-metolachlor + 2,4-DB (POST).

Palmer Amaranth Control

Palmer amaranth was controlled by 99% up to 13 WAA with the standard system of pendimethalin + flumioxazin + diclosulam PRE followed by (FB) a timely post of imazapic + *S*-metolachlor + 2,4-DB. When comparing fluridone systems to the standard at 2 WAA, control was ≥ 97% with all herbicide treatment combinations. By 5 WAA, the systems including pendimethalin + fluridone at the two lowest rates of fluridone provided lower control than the standard program. In cotton, fluridone alone applied PRE did not provide greater Palmer amaranth control than either fluometuron or diuron (Hill *et al.*, 2016). By late-season, control from all fluridone systems provided control similar to the standard systems except for when pendimethalin was mixed with the lowest rate of fluridone PRE and FB imazapic + *S*-metolachlor + 2,4-DB POST. Control of Palmer amaranth with fluridone systems when applied at 147 g ai/ha or higher or by including diclosulam or trifludimoxazin in the PRE mixture were also very effective. However, increasing rates of fluridone could potentially increase peanut injury.

Table 6. The influence of peanut cultivar and fluridone rate on peanut density, injury (bleaching, stunting), canopy height, and yield, cultivar experiment 2, Ty Ty, Georgia 2021/2022.

		Peanut Injury[b]		Peanut Canopy[c]	
Cultivar or Rate	Peanut Density[a]	Bleaching	Stunting	Height	Yield
	plants/1-row m	----------------%----------------		cm	kg/ha
Cultivar[d]					
AU-NPL 17	17ab[e]	2a	3a	23b	6575a
FloRun 331	16b	1a	2a	26a	5812b
GA-20VHO	18a	1a	1a	21c	5516b
TifNV High O/L	17ab	2a	2a	26a	5770b
Rate[f]					
0	17a	0b	0b	24a	5913a
126	17a	1b	1b	24a	5944a
252	17a	4a	4a	23a	5898a

[a] Peanut density data collected 27-34 days after planting. Averaged over 2 site-years.

[b] Peanut Injury = Subjective visual estimates of peanut injury based on scale of 0 = no injury and 100 = complete crop death. Averaged over 2 site-years. Bleaching = 3 weeks after application and stunting = 6 weeks after application.

[c] Peanut canopy data collected 15 weeks after application, 5 plants/plot. Averaged over 2 site-years.

[d] Cultivar = averaged over fluridone rate.

[e] Means in the same column of either cultivar or rate with the same letter are not significantly different according to the Tukey-Kramer method (P<0.10).

[f] Rate = g ai/ha averaged over cultivar.

Table 7. Peanut injury, weed control, and yield in fluridone weed control experiment in Ty Ty, Georgia, 2020-2022.

Herbicide System		Rate		Peanut Injury[a]		Weed Control[bc]								
				Stunting	Bleaching	AMAPA	RAPRA	AGRASS	AMAPA	RAPRA	AGRASS	AMAPA	AGRASS	Yield
PRE	POST	PRE	POST	2 WAA[d]		----2 WAA-----			-----5 WAA-------			13 WAA		
		---g ai/ha---				-------------------------------%----------------------------								kg/ha
Pendimethalin + Flumioxazin + Diclosulam	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 91 + 13	71 + 1069 + 281	20a[e]	0f	99a	99a	99a	99a	99a	99a	99a	97ab	6328a
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 126	71 + 1069 + 281	4b	7def	97b	65d	88b	92b	92b	97ab	86b	98ab	6291a
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 147	71 + 1069 + 281	6b	6def	99a	71cd	87b	92b	93b	97ab	89ab	98ab	6364a
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 168	71 + 1069 + 281	6b	10de	99a	74bcd	89b	94ab	95ab	98ab	91ab	99a	6496a
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 252	71 + 1069 + 281	8b	19bc	98ab	84a-d	95ab	95ab	99a	97ab	90ab	99a	6255a
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 294	71 + 1069 + 281	10b	28a	99a	86a-d	95ab	98ab	99a	98ab	93ab	98ab	6268a
Pendimethalin + Fluridone	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 336	71 + 1069 + 281	8b	25ab	99a	83a-d	96ab	98ab	98a	99a	97a	99a	5871a
Pendimethalin + Fluridone + Diclosulam	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 126 + 13	71 + 1069 + 281	10b	5def	99a	86a-d	94ab	97ab	99a	98ab	97a	96ab	6101a
S-metolachlor + Fluridone + Diclosulam	Imazapic + *S*-metolachlor + 2,4-DB	1069 + 126 +13.2	71 + 1069 + 281	11b	8def	99a	95ab	94ab	99a	99a	96ab	97a	99a	6154a
Acetochlor + Fluridone + Diclosulam	Imazapic + Acetochlor + 2,4-DB+ NISf	1262 + 126 +13	71 + 1262+ 281 + 0.25 % v/v	8b	8def	99a	94ab	92ab	98ab	99a	95b	97a	94b	6478a
Dimethenamid-*P* + Fluridone + Diclosulam	Imazapic + Dimethenamid-*P* + 2,4-DB	552 + 126 + 13	71+ 552 + 281	9b	5def	99a	87a-d	95ab	99a	99a	98ab	99a	99a	6496a
Pendimethalin + Fluridone + Trifludimoxazin	Imazapic + *S*-metolachlor + 2,4-DB	1066 + 126 + 38	71 + 1069 + 281	5b	13cd	98ab	89abc	95ab	98ab	96ab	99a	97a	98ab	6193a

[a] Peanut Injury = Subjective visual estimates of peanut injury based upon a scale where 0= no crop injury and 100= complete crop death. Averaged over 3 site-years.

[b] Weed control ratings are subjective visual estimates of weed control based on the percent of non-treated control (0=no weed control, 100= complete weed control). Averaged over 3 site-years.

[c] AMAPA= Palmer amaranth; RAPRA= Wild radish; AGRASS= Annual grasses (non-uniform mixture of Texas panicum, crabgrass spp., goosegrass, crowfootgrass).

[d] WAA= weeks after PRE-application.

[e] Means in the same column with the same letters are not significantly different according to the Tukey-Kramer method (P<0.10). The non-treated control was not included in the statistical analysis.

[f] NIS= non-ionic surfactant (Induce®, Helena Chemical Company, Collierville, TN 38017).

Wild Radish Control

Wild radish control is reported for only the 2 and 5 WAT observations as the weed had naturally senesced by 13 WAA. The standard PRE treatment of pendimethalin + flumioxazin + diclosulam resulted in 99% control of wild radish through 5 WAA. Pendimethalin + fluridone [1066 + (126, 147, and 168 g ai/ha)] provided 65 to 74% control of wild radish at 2 WAA. Pendimethalin is more effective at controlling grass species and small-seeded broadleaf weeds (Taylor-Lovell *et al.*, 2002); therefore, any control of wild radish is heavily influenced by fluridone. The addition of diclosulam at 13 g ai/ha or trifludimoxazin at 38 g ai/ha improved wild radish control ≥ 86% at 2 WAA. In previous studies, diclosulam reduced oilseed radish (*Raphanus sativus* var. Oleiferus) density and biomass by 68% and 89%, respectively (Roncatto *et al.*, 2022). Control of wild radish early-season is important, as it can be highly troublesome, competitive, and widespread (Eslami *et al.*, 2006; Hashem *et al.*, 2001). Wild radish control at 5 WAA was ≥ 92% after all POST treatments, which included imazapic + 2,4-DB, were applied. Imazapic applied POST is highly effective on wild radish (Prostko 2024)

Annual Grass Control

The standard PRE program consisting of pendimethalin + flumioxazin + diclosulam controlled annual grasses up to 99% through 2 WAA. Pendimethalin + fluridone at rates < 252 g ai/ha provided less control of annual grasses at 2 WAA when compared to the standard PRE program. At 13 WAA, annual grass control with pendimethalin + fluridone at rates ≥ 147 g ai/ha was similar to pendimethalin + flumioxazin + diclosulam. Acetochlor + fluridone + diclosulam based systems resulted in less annual grass control than flumioxazin based systems. At 13 WAA, all fluridone based systems provided grass control similar to the flumioxazin standard. It is important to note that the POST applications of imazapic in each system contributed to the overall grass control since imazapic has activity on annual grasses depending upon the species and stage of growth (Monks *et al.*, 1996; Wilcut *et al.* 1999; Jordan *et al.*, 2009).

Peanut yield for 2020/2022 was not influenced by herbicide system (P=0.2128). The non-treated controls are not included in the pairwise means comparison as those plots were unable to be mechanically harvested due to extreme weed pressure. Peanut weed control systems that include combinations of PRE + POST herbicide treatments provide the best opportunity for season-long weed control and yield protection (Daramola *et al.*, 2024; Seale *et al.*, 2020).

SUMMARY AND CONCLUSIONS

In 2019, peanut density was reduced 29% and 65% by 336 and 673 g ai/ha of fluridone resulting in an 18% and 54% reduction in yield. During 2020/2021, only fluridone at 673 g ai/ha resulted in a density reduction of 13% and a yield loss of 6%. Differing results by year were influenced by more stressful environmental conditions that occurred during 2019. Although cultivar response to fluridone was often similar, GA-16HO was consistently more sensitive to fluridone than GA-18RU. After concluding this first cultivar experiment, rates of fluridone were lowered for the second peanut cultivar experiment with a maximum fluridone rate of 252 g ai/ha. In the second cultivar experiment, the lack of foliar bleaching, necrosis, stunting, and effects on peanut yield supported the decision to consider the lower rates for potential labelling. For weed control, fluridone offers an alternative class of chemistry with a greater safety potential than current PRE chemistry. Additionally, when fluridone at 126 g ai/ha was applied in a PRE tank-mixture with acetochlor, diclosulam, dimethenamid-*P*, pendimethalin, *S*-metolachlor, and trifludimoxazin and followed with a timely standard POST herbicide program, control of Palmer amaranth, wild radish, and annual grasses were similar to current standard flumioxazin systems at seasons end. Other research has also shown that fluridone should not be a stand-alone treatment (Hill *et al.*, 2016). Results from these studies suggest that fluridone will provide peanut growers with another viable option to control problematic weeds. In 2023, fluridone received a label for peanut with use rates ranging from 126 to 168 g ai/ha (Anonymous 2024).

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