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A Survey of Weeds and Herbicides in Georgia Pecan

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A survey was conducted in 2012 in Georgia to determine the most troublesome weeds in pecan orchards and document common herbicide weed control practices. Weed control practices and infestations in pecan were divided between winter and summer seasons. The most troublesome pecan winter weed species were wild radish and Italian ryegrass, whereas the most troublesome summer season weeds were Palmer amaranth and bermudagrass. Other weeds included crabgrass species, bahiagrass, Florida pusley, purslane species, morningglory species, curly dock, and cutleaf evening-primrose. The most widely used POST herbicide in both the winter and summer season was glyphosate. The most commonly used year-round herbicides with soil persistence were pendimethalin, diuron, flumioxazin, halosulfuron, simazine, indaziflam, and oryzalin. Use of multiple herbicides, PRE- and POST-contact and soil-persistent, with various herbicide mechanisms of action, have benefited pecan producers by providing year-round weed control, despite herbicide-resistant weeds being widely established in this region.

Nomenclature: 2,4-D; clethodim; diruron; flumioxazin; glyphosate; glufosinate; halosulfuron; indaziflam; paraquat; sethoxydim; simazine; bahiagrass, *Paspalum notatum* Flueggé; bermudagrass, *Cynodon dactylon* (L.) Pers.; crabgrass species, *Digitaria* spp; curly dock, *Rumex crispus* L.; cutleaf evening primrose, *Oenothera laciniata* Hill; Florida pusley, *Richardia scabra* L.; Italian ryegrass, *Lolium perenne* L. ssp. *multiforum* (Lam.) Husnot; morningglory species, *Ipomoea* spp.; Palmer amaranth, *Amaranthus palmeri* S. Wats.; purslane species, *Portulaca* spp.; wild radish, *Raphanus raphanistrum* L.; pecan, *Carya illinoinensis* (Wangenh.) K. Koch

Key words: Postemergence, preemergence, soil residual herbicides, weed management.

Se realizó una encuesta en 2012 en Georgia para determinar los malezas más problemáticas en plantaciones de pacana y documentar prácticas comunes de control de malezas con herbicidas. Las prácticas de control de malezas y las infestaciones en pacana fueron divididas entre las temporadas de invierno y verano. Las malezas de invierno más problemáticas en pacana fueron *Raphanus raphanistrum* y *Lolium perenne* ssp. *multiflorum*, mientras que las malezas de verano más problemáticas fueron *Amaranthus palmeri* y *Cynodon dactylon*. Otras malezas incluyeron *Digitaria* spp., *Paspalum notatum*, *Richardia scabra*, *Portulaca* spp., *Ipomoea* spp., *Rumex crispus*, y *Oenothera laciniata*. El herbicida POST más ampliamente usado en ambas temporadas fue glyphosate. Los herbicidas con persistencia en el suelo más comúnmente usados a lo largo de todo el año fueron pendimethalin, diuron, flumioxazin, halosulfuron, simazine, indaziflam, y oryzalin. El uso de múltiples herbicidas, ambos PRE y POST de contacto y persistentes en el suelo, con varios mecanismos de acción, ha beneficiado a los productores de pacana al brindar control de malezas durante todo el año, a pesar de que malezas resistentes a herbicidas se están estableciendo ampliamente en esta región.

Pecan production is increasing in the United States because exports to foreign markets have stimulated pecan value and spurred planting of new orchards. Valued for their nutritional benefit, pecan nuts provide multiple flavonoid and antioxidant properties and have been widely researched and reviewed (Bhagwat et al. 2011; Villarreal-Lozoya et al. 2007). Between 2009 and 2012, U.S. in-shell pecan production increased from 113,271 to 139,970 metric tons (MT), with values increasing from $382 million to $656 million between 2009 and 2011 (NASS 2012). In the United States, the state of Georgia ranks number one in pecan production, generating 46,266 MT on 60,300 ha, a value of $265 million (Figure 1) in 2011 (Wolfe and Shepherd 2012). Currently, there are approximately 1,000 pecan farms in Georgia with greater than 6 ha of production (Anonymous 2007), of which 65% have 6 to 20 ha, 17% have 20 to 40 ha,

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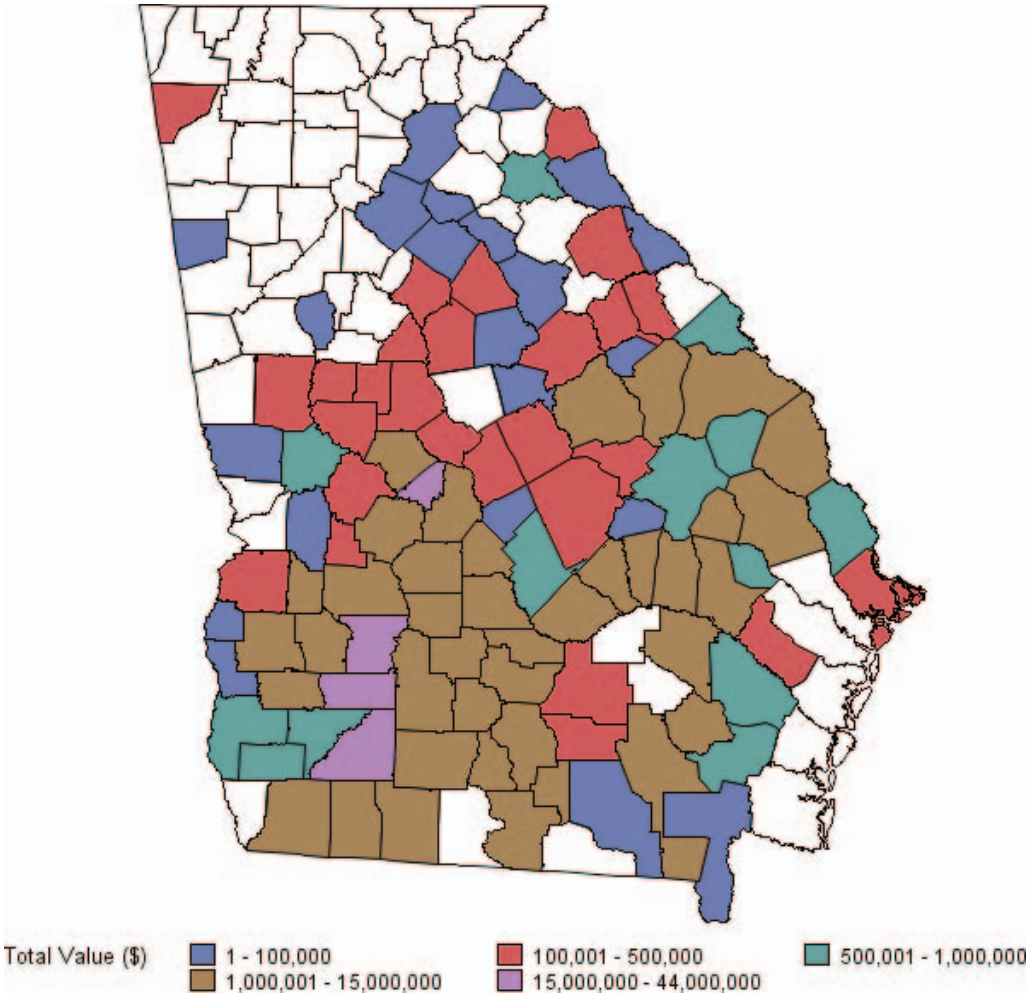

Figure 1. Value of Georgia pecan by county, 2011.

12% have 40 to 200 ha, and 5% have greater than 200 ha. In addition to large-scale production, an additional 2,000 Georgia pecan growers have production on < 6 ha (Anonymous 2007). The wide-scale production value of pecan to Georgia growers is demonstrated by Figure 1, with over 67% of the counties reporting revenues from nut sales (Wolfe and Shepherd 2012).

With increased demand, new orchard planting exhausted nursery supplies of pecan tree seedlings in 2011, 2012, and 2013 with continued high seedling demand projected until at least 2014. Over 3,240 ha of pecan trees seedlings were planted in 2012 in Georgia (Wells 2013). Pecan production in Georgia currently ranks sixth in the state's overall commodity value (Wolfe and Shepherd 2012). While pecan production in Georgia continues to increase in value and demand, there is limited weed control information and herbicide usage data with respect to grower practices.

Weed competition can reduce growth in new pecan orchards by more than 50%, and has the capability to out-compete new trees for sunlight, moisture, and nutrients (Smith 2011). In established orchards, weeds also serve as an inoculum for diseases and alternate hosts for insects (Lee 1994). Establishing weed-free strips by applying herbicides between pecan trees increases survival, water use efficiency, and growth. This reduces the time required for pecan trees to begin bearing nuts and producing the first commercially viable yield (Smith 2011). Vegetative areas are maintained between tree rows and are generally planted to perennial and annual legumes and grass species. Herbicide programs used in established and nonestablished orchards have provided effective weed control,

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increased tree growth, and improved yield and quality (Faircloth et al. 2007). Typical pecan weed management programs include PRE herbicides applied to control weeds in the winter and prior to harvest, and then summer POST applications as needed (Faircloth et al. 2007; Mitchem and Parker 2005). However, herbicide-resistant weeds have been reported in pecan orchards in New Mexico (Mohseni-Moghadam et al. 2013) and it is likely that herbicide-resistant (Sosnoskie et al. 2011; Wise et al. 2009) and herbicide-tolerant (Webster et al. 2005) weeds also infest Georgia pecan orchards, because they are widespread in this region.

The objective of the survey was to characterize the most troublesome weed species and the most commonly used PRE and POST herbicides in Georgia pecan. The survey was conducted during the spring 2012 Pecan Extension Production Meetings in Georgia. The purpose of the survey was to identify research and extension opportunities that will further support producers in providing a safe and economically sustainable pecan industry.

Materials and Methods

In 2012, a survey of Georgia pecan producers was developed to identify the most troublesome weeds, and characterized weed-control practices in pecan orchards. The survey was reviewed and edited by an anonymous panel prior to administering. Growers were given a list of weeds and registered herbicides common to Georgia. The survey was conducted at 17 Georgia pecan production meetings between February and April 2012 using a questionnaire. Because the number of pecan extension grower meetings is limited and not all counties participate each year, growers from adjacent counties often attend the closest meeting to them, resulting in growers from several counties attending one meeting. For the survey, growers were asked to identify the county in which their orchards were located and to participate only once.

The survey was divided into two sections; the first section was concerned with the most difficult-to-control weeds, and the second section detailed weed control practices in their orchards. The weeds presented in the survey included plant descriptions and picture samples of weeds for ease of identification (Table 1). These weeds were selected based on weeds previously identified as difficult to control in orchard crops in Georgia and surrounding states (Webster et al. 2010).

Growers were then asked questions related to their herbicide use in pecan. The herbicides included in the survey were listed in the 2012 Georgia Pest Handbook for pecan, which includes the University of Georgia-recommended grower practices (Mitchem and Culpepper 2012). Questions as to when herbicides were applied in pecan over a 12-mo production regime for winter/spring (December 21 to June 21) and summer/autumn (June 22 to December 20) were included. Growers were asked what herbicides they used, when they were applied, how frequently they were applied during the year, and satisfaction about control.

Data were compiled by the factors evaluated: county, weed identity, herbicides, PRE or POST applications, and time of year herbicides were applied. Data were then analyzed using the frequency (PROC FREQ) procedure in SAS (SAS 1999) to obtain a county-by-county breakdown. Analysis of data by PROC FREQ in SAS provides an analysis by computing statistics across as well as within strata. Strata included counties, herbicides, and weed species. These data were then used to identify the most prevalent weed species, commonly used herbicides, and grower satisfaction based on a method used previously to describe crop production in Georgia (Webster and MacDonald 2001; Webster and Nichols 2012). As outlined by Webster and MacDonald (2001) and Webster and Nichols (2012), the weed species prevalence is weighted to reflect its rank in the survey and the number of hectares affected by county. Although this system is biased and weights weeds prevalent in counties with large pecan production areas more heavily, it does achieve the purpose of determining the most troublesome weeds for pecan in Georgia. There were 44 Georgia counties represented and 200 participants for the survey. Respondents were from counties representing 82% of the state's pecan hectares.

Results and Discussion

Weed Species Relevance. Growers indicated similar weed problems for both the tree rows and vegetative areas between tree paths in orchards (Table 2). Summer species dominated the survey, with 7 of the 10 weeds. However, two of the top

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Table 1. Scientific and common names of weeds for the 2012 Georgia pecan survey.

Scientific name	Common name
Amaranthus palmeri S. Wats.	Palmer amaranth
Chenopodium album L.	common lambsquarters
Commelina benghalensis L.	Benghal dayflower
Cynodon dactylon (L.) Pers.	bermudagrass
Digitaria spp.	crabgrass spp.
Ipomoea spp.[a]	morningglory spp.
Lactuca serriola L.	prickly lettuce
Lolium perenne L. ssp. *multiforum* (Lam.) Husnot	Italian ryegrass
Oenothera laciniata Hill	cutleaf evening-primrose
Paspalum dilatatum Poir.	dallisgrass
Paspalum notatum Flueggé	bahiagrass
Plantago spp.	plantain spp.
Portulaca spp.	purslane spp.
Raphanus raphanistrum L.	wild radish
Richardia scabra L.	Florida pusley
Rumex crispus L.	curly dock
Sida spp.	sida spp.
Xanthium strumarium L.	common cocklebur

[a] The generic morningglory species includes *Ipomoea* spp. and *Jacquemontia tamnifolia* (L.) Griseb.

three most-dominant weed issues were with the winter species, wild radish and Italian ryegrass.

Winter/Spring Weed Control. Wild radish was considered the most troublesome weed in the orchard by 34% of respondents (Table 2). Pecan growers believed that wild radish was challenging to control both between and within tree rows (42 and 46%, respectively). Wild radish was reported as a problem in 67% of newly planted (< 5 yr old) and established orchards, with respondents from 36 of the 44 counties participating (data not presented). As a winter annual species, wild radish predominately emerges in the autumn and becomes problematic in the winter and spring seasons, but it can germinate and establish throughout the year in the southeast (Malik et al. 2010; Norsworthy et al. 2010). Herbicide resistance to several mechanisms of action has been reported in *Raphanus* species, including acetolactate synthase (ALS), photosystem II (PS II), and synthetic auxins (Heap 2013), but no herbicide resistance has been reported in Georgia. The successful spread of wild radish into pecan orchards can be attributed to the fecundity of mature plants, which can produce over 10,000 seed (Norsworthy et al. 2010). As a pest, wild radish also serves as a host for many insect pests, including pecan weevil (*Cryptorhynchus woodruffi* Sleeper) (Bloem et al. 2002) and southern green stink bug (*Nezara viridula* L.) (Todd 1989), which can negatively impact pecan nut yield and quality.

Italian ryegrass was the second most troublesome winter weed (third overall) in pecan orchards (Table 2). Italian ryegrass is one of the most common winter weeds in small grains in Georgia (Webster and MacDonald 2001; Webster and Nichols 2012). There are confirmed reports of Italian ryegrass populations exhibiting single and multiple resis-

Table 2. 2012 Survey of the most troublesome weeds as identified by 200 Georgia pecan producers.[a]

Rank	Weed species	Life cycle	Troublesome to control[b]	Tree row	Vegetative area between tree row
			% of growers[c]		
1	Wild radish	Winter annual	34	46	42
2	Palmer amaranth[d]	Summer annual	32	41	35
3	Italian ryegrass	Winter annual	19	34	37
4	Bermudagrass	Summer perennial	22	40	47
5	Crabgrass spp.	Summer annual	10	35	33
6	Bahiagrass	Summer perennial	14	28	38
7	Florida pusley	Summer annual	10	24	14
8	Purslane spp.	Summer annual	11	20	13
9	Morningglory spp.[e]	Summer annual	14	25	18
10	Curly dock	Winter perennial	7	10	11

[a] Weed species prevalence was weighted to reflect its rank in the survey and the number of hectares infested by county (see Figure 1).

[b] This system is biased to reflect the response for the counties with large pecan production areas, but it also achieves the purpose of determining the most troublesome weeds for pecan in Georgia.

[c] Grower response data were analyzed using the frequency (PROC FREQ) procedure in SAS ($n = 200$).

[d] Palmer amaranth was not specified as herbicide-resistant or -susceptible in survey.

[e] The generic morningglory species includes *Ipomoea* spp. and *Jacquemontia tamnifolia* (L.) Griseb.

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tance to acetyl CoA carboxylase (ACCase) and ALS-inhibiting herbicides in Georgia (Heap 2013). One concern in southeastern pecan production is the potential spread of Italian ryegrass biotypes resistant to herbicides with other mechanisms of action. Currently, glyphosate-resistant Italian ryegrass has been reported in Mississippi, Arkansas, and North Carolina, and both glyphosate- and glufosinate-resistant Italian ryegrass have been reported in Oregon (Heap 2013). Despite identified cases of herbicide-resistant Italian ryegrass across the southeast, pecan growers have maintained control in orchards by utilizing various herbicides with different mechanisms of action that are still effective for ryegrass control (Table 3).

Curly dock was the only winter perennial weed species considered problematic by 7% of growers, ranking tenth overall (Table 2). Curly dock can produce up to 40,000 seeds plant^{-1} and can be difficult to control due to a long, spreading taproot (Monaco and Cumbo 1972). Curly dock can be controlled by glyphosate and auxinic herbicides (Dillehay and Curran 2010) in other crops, but no information about curly dock control in pecan was present in the literature.

Summer/Autumn Weed Control. Palmer amaranth was the most troublesome summer annual weed species (second overall) in Georgia pecan orchards (Table 2). Growers did not distinguish between herbicide-resistant and -susceptible *Amaranthus* species in the survey; therefore, both biotypes were combined for the purpose of this survey. Georgia has reported herbicide resistance in Palmer amaranth to glyphosate (Culpepper 2014; Culpepper et al. 2006), ALS (Wise et al. 2009), triazine (Vencill et al. 2013), and multiple herbicide resistance to ALS inhibitors and glyphosate (Sosnoskie et al. 2011). Although herbicides with these mechanisms of action are commonly used in pecan production, Palmer amaranth is effectively controlled in orchards due to the willingness of growers to incorporate multiple weed control tactics, including herbicides with soil persistence (Table 3), mowing, and hand weeding (personal observation). However, growers noted in the survey that too much reliance on single mechanisms of action, such as glyphosate, resulted in grower dissatisfaction with weed control.

The fourth and sixth most troublesome weed species in pecan orchards were perennials: bermudagrass and bahiagrass, respectively (Table 2). Bermudagrass and bahiagrass spread in orchards via rhizomes. Bermudagrass is known to affect growth and development of young pecan trees by competing for moisture and nutrients (Faircloth et al. 2007; Smith et al. 2001). There has been no reported research about the effect of bahiagrass on pecan in the literature.

Herbicides. The herbicides evaluated for this survey were registered for Georgia pecan orchards (Mitchem and Culpepper 2012). Because pecan is a perennial crop, herbicides can be applied in almost any month of the year. The Georgia Pesticide Handbook lists herbicides with ten different mechanisms of action for weed control in pecan (Table 3). Survey results determined that PRE herbicides were applied by 67% of growers and that each grower averaged 1.9 POST herbicide applications annually (data not presented). Multiple POST applications are not unusual in soybean [*Glycine max* (L.) Merr.], corn (*Zea mays* L.), cotton (*Gossipyium hirsutum* L.), and other crops (Young 2006).

Preemergence. The most commonly used PRE-applied herbicides included pendimethalin, oryzalin, diuron, and simazine, representing two different mechanisms of action (Table 3). When winter and summer herbicide applications were combined, pendimethalin and oryzlin were applied by 32 and 19% of growers, respectively. Pendimethalin has been registered for pecan since 1998 (Anonymous 1998) and provides residual control of many small-seeded broadleaf and grass weed species in the tree row. The PS II herbicides, diuron and simazine, were each applied by 25% of growers when winter and summer applications were combined. The remaining PRE herbicides applied by growers, flumioxizin (Protox inhibitor), indaziflam (cellulose biosynthesis inhibitor), and halosulfuron (ALS inhibitor), represented 13 and 9% of the total winter and summer applications, respectively. The PRE herbicides that growers were most satisfied with for weed control were pendimetalin, diruon, simazine, and oryzalin (data not shown).

Postemergence. One advantage pecan growers have when choosing a POST weed control management system within the tree row is the registration of herbicides with multiple mechanisms of action. Six of the most commonly used POST herbicides by growers represent five different Weed Science

Table 3. 2012 survey of herbicides used to control troublesome weeds in pecan as identified by Georgia producers. Herbicides identified by application timing, mechanism of action, and time of year applied.[a]

Herbicide	Timing	Mechanism of action	Winter application[b]	Summer application[b]
			% of growers	
Pendimethalin	PRE	Mitosis inhibitor	19	13
Oryzalin	PRE	Mitosis inhibitor	11	8
Diuron	PRE	PS II inhibitor[c]	15	10
Simazine	PRE	PS II inhibitor	11	14
Flumioxazin	PRE	Protox inhibitor	3	2
Indaziflam	PRE	Cellulose inhibitor	6	6
Halosulfuron	PRE	ALS inhibitor	4	1
Glyphosate	POST	EPSPS inhibitor	54	44
Paraquat	POST	PS I inhibitor	23	34
2,4-D	POST	Synthetic auxin	25	24
Glufosinate	POST	Glutamine synthetase inhibitor	5	2
Sethoxydim	POST	ACCase inhibitor	13	9
Clethodim	POST	ACCase inhibitor	6	5

[a] Grower response data were analyzed using the frequency (FREQ) procedure in SAS ($n = 200$).

[b] Seasonal timings defined by Gregorian calendar of December 21 to June 21 for winter/spring application; June 22 to December 20 for summer/autumn applications.

[c] Abbreviations: PS, photosystem; ALS, acetolactate synthase; EPSPS, 5-enolpyruvyl shikimate-3-phosphate synthase; ACCase, acetyl-coenzyme A carboxylase

Society of America (WSSA) groups (Table 3). However, there is a heavy reliance on glyphosate, with 54 and 44% of growers applying glyphosate as a winter and summer treatment, respectively. This reliance on glyphosate was reflected in the weed survey where Palmer amaranth was indicated as the most troublesome summer weed species and second overall (Table 2). Although the survey did not specify if growers were referring to glyphosate-susceptible or -resistant Palmer amaranth, by 2011 glyphosate resistance had been confirmed in 76 southern Georgia counties (Culpepper 2014). Paraquat was used by 23 and 34%, and 2,4-D by 25 and 24% of growers (Table 3), with respect to winter and summer applications, respectively. This is relevant in that many growers fear using paraquat and 2,4-D due to potential tree injury from drift. These herbicides are inexpensive and effectively control Palmer amaranth when applied in a timely fashion, and thus growers accept the potential of pecan tree injury caused by paraquat and 2,4-D. In contrast, glufosinate effectively controls Palmer amaranth, but costs more, and thus growers are less likely to use glufosinate as reflected by their responses of only 5 and 2% grower usage for winter and summer applications, respectively. For annual and perennial grass control within the tree row and where vegetative strips had established clovers, sethoxydim and clethodim were selected.

Other POST herbicides that were applied in the summer included combinations of glyphosate plus carfentrazone, carfentrazone, bentazon, and fluazifop. Some growers applied halosulfuron and rimsulfuron for both the POST and PRE activity. Although these herbicides were used in greater quantities in certain counties, this use was generally localized and not commonly used all across Georgia.

Based on the survey, pecan growers are applying herbicides with different mechanisms of action at various times of the calendar year, which is critical in preventing weed shifts and the establishment of herbicide-resistant populations. However, many pecan growers rely on only one POST herbicide option, namely glyphosate. Therefore, growers should attempt to incorporate more POST weed control options with alternate mechanisms of action to limit the development of resistance. Glufosinate is an alternative that is rarely used, although it is an excellent substitute to glyphosate for certain weed species, including glyphosate-resistant Palmer amaranth. If growers would include more PRE herbicides in their weed management program, then fewer POST applications would be required to manage weeds in pecan orchards. Additionally, this could reduce the number of required herbicide

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applications, thus reducing labor and fuel costs (Faircloth et al. 2007).

This survey defined the weeds in Georgia pecan orchards which were hardest to control to most troublesome. Problematic weeds need to be monitored as they spread throughout the state in order to prevent an epidemic problem, which seems to be occurring with wild radish, because 34% of growers ranked it most troublesome. This survey indicates that herbicides are being applied in all four seasons. Growers across the state need to adapt PRE and POST herbicides strategies that will improve their weed control programs. These management programs should include PRE herbicides applied in spring and autumn, followed by POST herbicides when weeds are less than 10 cm tall for optimum control. By adapting PRE and POST management systems, cost of labor and fuel could decrease due to fewer applications. Increasing the number of mechanisms of action used in weed management might also help reduce the intensity of selection for resistance to any one herbicide mechanism of action. Given that pecan weed management occurs year-round, the herbicides utilized need to be alternated in order to prevent overuse in any given year. Thus, some problematic weeds that are occurring in Georgia could be avoided.

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Literature Cited

Anonymous (1998) Prowl 3.3 EC Hercide Specimen Label. American Cyanamid Company. http://www.epa.gov/pesticides/chem_search/ppls/000241-00337-19980708.pdf. Accessed July 18, 2013

Anonymous (2007) Census of Agriculture, 2007. Georgia Pecan Farms—All. http://www.nass.usda.gov/Statistics_by_State/Georgia/Publications/State_Census_Summaries/GA07CensusPecanProfile1.pdf. Accessed May 7, 2013

Bhagwat S, Haytowitz DB, Holden JM (2011) USDA Database for the Flavonoid Content of Selected Foods. Release 3. Beltsville MD: USDA/ARS Beltsville Human Nutrition Research Center Nutrient Data Laboratory. 156 p

Bloem S, Mizell RF, O'Brien CW (2002) Old traps for new weevils: new records for curculionids, brentids, and anthribids from Jefferson Co., Florida. Fla Entomol 85:632–644

Culpepper AS (2014) Glyphosate-Resistant Palmer Amaranth Map—2011. http://www.gaweed.com/. Accessed February 5, 2014

Culpepper AS, Grey TL, Vencill WK, Kichler JM, Webster TM, Brown SM, York AC, Davis JW, Hanna WW (2006) Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) confirmed in Georgia. Weed Sci 54:620–626

Dillehay BL, Curran WS (2010) Comparison of herbicide programs for weed control in glyphosate-resistant alfalfa. Weed Technol 24:130–138

Faircloth WH, Patterson MG, Foshee WG, Nesbitt ML, Goff WD (2007) Comparison of preemergence and postemergence weed control systems in newly established pecan. Weed Technol 21:972–976

Heap I (2013) The International Survey of Herbicide-Resistant Weeds. www.weedscience.com. Accessed May 6, 2013

Lee RD (1994) Weed Management in Pecans. Cooperative Extension Service. Guide H-632. City, NM: New Mexico State University. Los Cruces, 6 p

Malik MS, Norsworthy JK, Riley MB, Bridges W, Jr (2010) Temperature and light requirements for wild radish germination over 12-month period following maturation. Weed Sci 58:136–140

Mitchem WE, Culpepper AS (2012) Commercial pecan weed control. Georgia Pest Control Handbook. Cooperative Extension Service, University of Georgia College of Agricultural and Environmental Sciences, Athens, GA. http://www.ent.uga.edu/pmh/. Accessed July 18, 2013

Mitchem WE, Parker ML (2005) Orchard-floor management in pecans. Horticulture Information Leaflets. Raleigh, NC: NC State University. 7 p

Mohseni-Moghadam M, Schroeder J, Heerema R, Ashigh J (2013) Resistance to glyphosate in Palmer amaranth (*Amaranthus palmeri*) populations from New Mexico pecan orchards. Weed Technol 27:85–91

Monaco TJ, Cumbo EL (1972) Growth and development of curly dock and broadleaf dock. Weed Sci 20:64–67

[NASS] National Agricultural Statistics Servicie (2012) United States Department of Agriculture. Crop Production ISSN:1936–3737 http://www.nass.usda.gov/Publications/Todays_Reports/reports/crop1012.pdf. Accessed July 18, 2013

Norsworthy JK, Malik MS, Riley MB, Bridges W, Jr (2010) Time of emergence affects survival and development of wild radish in South Carolina. Weed Sci 58:402–407

SAS (1999) SAS/STAT User's Guide. Version 8. Cary, NC: Statistical Analysis System Institute, Inc., 3,884 p

Sosnoskie, LM, Kichler JM, Wallace RD, Culpepper AS (2011) Multiple resistance in Palmer amaranth to glyphosate and pyrithiobac confirmed in Georgia. Weed Sci 59:321–325

Smith MW (2011) Pecan production increased by larger vegetation-free area surrounding the tree. Sci Hortic (Amst) 130:211–213

Smith MW, Cheary BS, Carroll BL (2001) Allelopathy of bermudagrass, tall fescue, redroot pigweed, and cutleaf evening primrose on pecan. HortScience 36:1047–1048

Todd JW (1989) Ecology and behavior of *Nezara viridula*. Annu Rev Entomol 34:273–292
Vencill WK, Li X, Grey TL (2013) Multiple mechanisms of Palmer amaranth resistance to ALS-inhibiting herbicides. Page 363 *in* Proceedings of the 2013 Weed Science Society of America. Lawrence, KS: Weed Science Society of America Villarreal-Lozoya JE, Lombardini L, Cisneros-Zevallos L (2007) Phytochemical constituents and antioxidant capacity of different pecan (*Carya illinoinensis*) cultivars. Food Chem 102:1241–1249
Webster TM, Burton MG, Culpepper AS, York AC, Prostko EP (2005) Tropical spiderwort (*Commelina benghalensis*): a tropical invader threatens agroecosystems of the southern United States. Weed Technol 19:501–508
Webster TM, MacDonald GE (2001) A survey of weeds in various crops in Georgia. Weed Technol 15:771–790
Webster TM, Nichols RL (2012) Changes in prevalence of weed species in the major agronomic crops of the southern United States: 1994/1995 to 2008/2009. Weed Sci 60:145–157
Webster TM, Patterson M, Culpepper AS, Mitchem W, MacRae A, Jennings K, Deer J (2010) Weed Survey—Southern States. Pages 252–253 *in* 2010 Proceedings, Southern Weed Science Society. Las Cruces, NM: Southern Weed Science Society
Wells ML (2013) Same old things won't work in a changing industry. Pecan South 45:4
Wise AM, Grey TL, Prostko EP, Vencill WK, Webster TM (2009) Establishing the geographic distribution level of acetolactate synthase resistance of Palmer amaranth accessions in Georgia. Weed Technol 23:214–220
Wolfe K, Shepherd T (2012) 2011 Georgia Farm Gate Value Report. AR-12-01. http://www.caes.uga.edu/center/caed/. Accessed May 2, 2013
Young BG (2006) Changes in herbicide use patterns and production practices resulting from glyphosate-resistant crops. Weed Technol 20:301–307

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