

Chapter

Weed Control in Peanut (*Arachis hypogaea* L.) Using Carfentrazone Plus Pyroxasulfone Herbicide Systems

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Abstract

Field studies were conducted during the 2017 through 2019 growing seasons in Texas and Oklahoma to determine weed control when using herbicide systems containing the pre-mixture of carfentrazone plus pyroxasulfone (C + P) applied pre-emergence (PRE), early postemergence-peanut cracking (EPOST), or postemergence (POST). When pendimethalin was not used as a base PRE herbicide treatment, C + P applied PRE controlled Texas millet [*Urochloa texana* (Buckl.)] $\leq 75\%$; however, the addition of pendimethalin to C + P applied PRE increased control to $>85\%$. Palmer amaranth (*Amaranthus palmeri* S. Wats.) control was $>70\%$ with most C + P systems while smellmelon (*Cucumis melo* L. var. *Dudaim* Naud.) control was never $<97\%$ with any C + P system. Pitted morningglory (*Ipomoea lacunose* L.) control in systems with C + P applied either PRE or POST was never $<79\%$ while ivyleaf morningglory (*Ipomoea hederacea* Jacq.) control with C + P systems applied PRE varied from 73 to 90%, applied EPOST from 53 to 95%, and POST from 84 to 98%. The use of the premix of C + P provided excellent season—long residual control of several broadleaf weeds including Palmer amaranth, smellmelon, and morningglory spp. This herbicide mixture offers peanut growers another option to control ALS- and glyphosate-resistant Palmer amaranth, which is becoming a major problem in many areas of Texas and Oklahoma.

Keywords: annual grasses, broadleaf weeds, glyphosate resistance, groundnut, preemergence applications, early-postemergence applications, herbicide systems, palmer amaranth (*Amaranthus palmeri* S. Wats.), postemergence applications, smellmelon (*Cucumis melo* L.), Texas millet [*Urochloa texana* (Buckl.) R. Webster]

1. Introduction

Weeds associated with peanut production are predominantly comprised of annual herbaceous species that are propagated by seeds. Because of the disturbance of soil in land preparation and the use of conventional and reduced tillage before planting, not only small-seeded weed species {e.g., pigweed (*Amaranthus* spp.), eclipta (*Eclipta prostrata* L.), goosegrass [*Eleusine indica* (L.) Gaertn.], crabgrass (*Digitaria* spp.)},

but also large seeded species {e.g., sicklepod [*Senna obtusifolia* (L.) H.S. Irwin & Barneby], Benghal dayflower (*Commelina benghalensis* L.), morningglories (*Ipomoea* spp.) and common ragweed (*Ambrosia artemisiifolia* L.)} can successfully emerge from deeper in the soil. Most of these weed species have temperature and soil moisture germination requirements similar to peanut and this favors their emergence and establishment before peanut canopy closure [1, 2]. Perennial weed species are fairly common in peanut fields and those that are successful frequently produce vegetative propagules such as tubers and rhizomes {e.g., bermudagrass (*Cynodon dactylon* L.), nutsedge (*Cyperus* spp.) and johnsongrass [*Sorghum halepense* (L.) Pers.]}, which can be greatly reduced with the use of tillage and cultivation [3, 4].

Weed management in peanut is challenging because of the prostrate growth habit of the peanut plant, which allows weeds to become established if weed control practices are not properly implemented [5, 6]. Weed control can be influenced by the ability of peanut to compete with weeds, cultural practices that minimize the soil seed bank and weed infestation, mechanical practices such as primary tillage prior to planting, cultivation during the growing season, and also by efficacy of herbicides. Weeds interfere with peanut through direct competition for light, water, nutrients, essential gases, and space [5, 6]. Weeds also can interfere with peanut growth through allelopathy [7–9].

The process of digging and inverting the vines and pods prior to mechanical harvest makes the need for effective season-long weed control a necessity. The tight fibrous root system of annual grasses such as Texas millet [*Urochloa texana* (Buckl.) R. Webster] and southern crabgrass (*Digitaria ciliaris* L.) and broadleaf weeds such as morningglory spp. (*Ipomoea* spp.) and pigweed spp. (*Amaranthus* spp.) becomes intertwined with the peanut plant, causing peanut pods to be stripped from the vine during digging and can also slow down the drying process. Peanuts that become detached from the plant remain unharvested in or on the soil surface [5, 6].

In most instances, fungicides are applied multiple times to peanut fields to control various diseases including stem rot (caused by *Sclerotium rolfsii* Sacc.), early leaf spot [caused by *Passalora arachidicola* previously known as *Cercospora arachidicola* (Hori)] and late leaf spot [caused by *Nothopassalora personata* previously known as *Cercosporidium personatum* (Berk. & M.A. Curtis) Deighton]. Herbicides are often applied in combination with fungicides to control both weeds and diseases [10–12]. Weeds can also interfere with uniform deposition of fungicides reducing disease control [13].

There are many weeds found in Texas and Oklahoma peanut production areas (Table 1); however, some of the most common include Texas millet, horse purslane (*Trianthema portulacastrum* L.), smellmelon (*Cucumis melo* L.), morningglory spp., and Palmer amaranth (*Amaranthus palmeri* S. Wats.). Texas millet is a large seeded, vigorous, fast growing annual grass commonly found in peanut fields in parts of Florida, South Carolina, Oklahoma, and Texas [14]. It is listed as one of the most troublesome weeds in all peanut growing states except Alabama and Georgia [15].

Horse purslane occurs in tropical and subtropical areas throughout the world [16] and has cylindrical green leaves. The seeds germinate at 20–45 C [17] and have essentially no dormancy and can germinate soon after they mature [16]. Although common purslane (*Portulaca oleracea* L.) was rated as one of the ten most common weeds found in Texas peanut fields as early as 1989 [18], horse purslane only recently has become a problem in certain peanut growing areas of south Texas (author's personal observation). Horse purslane can be a stronger competitor with peanut early in

Common name	Latin name	Bayer code
Barnyardgrass/Junglerice	<i>Echinochloa crus-galli</i> (L.) Beauv.	ECHCG
Broadleaf signalgrass	<i>Brachiaria platyphylla</i> (Griseb.) Nash.	BRAPP
Carolina horsenettle	<i>Solanum carolinense</i> L.	SOLCA
Carpetweed	<i>Mollugo verticillata</i> L.	MOLVE
Coffee senna	<i>Cassia occidentalis</i> L.	CASOC
Common bermudagrass	<i>Cynodon dactylon</i> (L.) Pers.	CYNDA
Common cocklebur	<i>Xanthium strumarium</i> L.	XANST
Common purslane	<i>Portulaca oleracea</i> L.	POROL
Common sunflower	<i>Helianthus annuus</i> L.	HELAN
Devil's-claw	<i>Proboscidea louisianica</i>	PROLO
Eclipta	<i>Eclipta alba</i> L.	ECLAL
Fall panicum	<i>Panicum dichotomiflorum</i> Mich.	PAQIN
Golden crownbeard	<i>Verbesina encelioides</i> (Cav.) Benth. & Hook. f. ex A. Gray	VEREN
Hophornbean copperleaf	<i>Acalypha ostryifolia</i> Riddell	ACCOS
Horse purslane	<i>Trianthema portulacastrum</i> L.	TRIPO
Ivyleaf morningglory	<i>Ipomoea hederacea</i> (L.) Jacq.	IPOHE
Johnsongrass	<i>Sorghum halepense</i> (L.) Pers.	SORHA
Kochia	<i>Bassia scoparia</i> (L.) A. J. Scott	BASSC
Large crabgrass	<i>Digitaria sanguinalis</i> (L.) Scop.	DIGSA
Palmer amaranth	<i>Amaranthus palmeri</i> S. Wats	AMAPA
Pitted morningglory	<i>Ipomoea lacunose</i> L.	IPOLA
Prairie/Maximillian sunflower	<i>Helianthus maximiliani</i> Schrad.	HELMA
Prickly sida	<i>Sida spinose</i> L.	SIDSP
Prostrate pigweed	<i>Amaranthus blitoides</i> S. Watson	AMABL
Purple nutsedge	<i>Cyperus rotundus</i> L.	CYPES
Red morningglory	<i>Ipomoea coccinea</i> L.	IPOCO
Russian-thistle	<i>Salsola tragus</i> L.	SALTR
Sandbur	<i>Cenchrus</i> spp.	CENZZ
Sicklepod	<i>Senna obtusifolia</i> (L.) Irwin & Barneby	CASOB
Silverleaf nightshade	<i>Solanum elaeagnifolium</i> Cav.	SOLEL
Southern crabgrass	<i>Digitaria ciliaris</i> (Retz.) Koel.	DIGSP
Texas millet	<i>Urochloa texana</i> (Buckl.) R. Webster	UROTE
Tropic croton	<i>Croton glandulosus</i> Muell. Arg.	CVNGS
Tumble pigweed	<i>Amaranthus albus</i> L.	AMAAL
Wild poinsettia	<i>Euphorbia heterophyll</i> L.	EPHHL
Yellow nutsedge	<i>Cyperus esculentus</i> L.	CYPRES

Table 1.
 Weeds found in Texas and Oklahoma peanut growing areas.

the growing season than common purslane due to a more upright growth habit [19]. For example, in competition studies with mung bean [*Vigna radiate* (L.) R. Wilczk.], horse purslane reduced yield 50–60% when left untreated [20]. In earlier work on peanut, Grichar [19] reported a yield increase when controlling horse purslane with postemergence (POST) herbicides.

Hand-hoeing is a common practice for horse purslane control in mung bean in India [16]. Fomesafen {5-[2-chloro-4-(trifluoromethyl) phenoxy]-N-(methylsulfonyl)-2-nitrobenzamide} controlled horse purslane 57–87% in mung bean [20]. Grichar [19] reported that acifluorfen, lactofen, and 2,4-DB controlled horse purslane at least 78% in peanut. He also reported that tank-mixing these herbicides with other broadleaf herbicides did not improve horse purslane control over acifluorfen, lactofen, or 2,4-DB alone.

Smellmelon is becoming more of a problem in south Texas peanut production fields and has become a problem in several crops along the Texas Gulf Coast [21]. The range of smellmelon stretches from Georgia to the southern part of California and as far north as Arkansas [22]. Smellmelon can be a problem at peanut harvest as the melon can become broken apart during mechanical harvest, increasing drying time because of the high moisture content of the melon [23]. Thompson et al. [24] reported that imazapic at 0.07 and 0.14 kg ai ha⁻¹ applied preemergence (PRE), early postemergence (EPOST), or late postemergence (LPOST) in corn (*Zea mays* L.) controlled smellmelon greater than 90%. Tingle and Chandler [25] reported that smellmelon control was at least 93% with various herbicide systems in a corn-cotton (*Gossypium hirsutum* L.)-corn rotation. Glyphosate and glufosinate systems have provided effective smellmelon control [26, 27] in cotton. Tingle et al. [28] reported when smellmelon was allowed to compete with cotton for at least 6 wks, yield was reduced 7% compared to the weed free check, but when smellmelon was allowed to compete for 10–12 wks, cotton yield was reduced 22 and 27%.

Palmer amaranth is ranked as a major weed in several crops in the U.S. and is a common weed in many major crops around the world [14, 15, 21, 29]. Pigweed is listed as one of the 10 most common weeds in most all major peanut-growing states in the U.S., with Palmer amaranth among the 10 most common weeds in Alabama, Arkansas, Florida, Georgia, Mississippi, North Carolina, Oklahoma, South Carolina, and Texas [14, 15]. Palmer amaranth is listed as the most troublesome weed in peanut in 8 peanut producing states [14]. Most of the current distribution of Palmer amaranth is in the southern half of the U.S.; however, it has now been found in 28 states and as far north as Minnesota [30]. In Texas, Palmer amaranth can be found in all areas of the state [31] as well as in Oklahoma (author's personal observation). It is a severe problem in most fields when not properly controlled [32].

Morningglory spp. (*Ipomoea* spp.) are found throughout the peanut growing regions of Texas and Oklahoma and are some of the most common and troublesome weeds to control [33]. The two most common species are ivyleaf [*Ipomoea hederacea* (L.) Jacq.] and pitted morningglory (*Ipomoea lacunose* L.). Morningglories are typically a late-season issue and help to reduce crop yield [34]; however, the main issue in peanut is that they make digging and harvesting difficult because the vines can become intertwined in the digging and harvesting equipment [35]. Barbour and Bridges [36] concluded from field studies that shading from weed escapes leads to reduced peanut yield. Crop shading leads to irreversible adaptations in the photosynthetic processes such as altered partitioning of photosynthetic assimilates and this results in fewer pods set [37].

Pyroxasulfone is in the class of herbicides called isoxaxolines [38]. Herbicides in this class are a site of action, Resistance Action Committee (HRAC) Group 15 herbicide, along with the chloroacetamide herbicides including acetochlor (Warrant®), S-metolachlor (Dual Magnum®), and dimethenamid (Outlook®) [38–41]. Such herbicides are shoot and root growth inhibitors and control susceptible germinating seedlings before or soon after they emerge from the soil by reducing the biosynthesis of very-long-chain fatty acids, which cause a buildup of fatty acid precursors [38–40]. Pyroxasulfone is registered in the U.S. for either preplant, preplant incorporated (PPI), PRE, or EPOST use in corn, cotton, soybean (*Glycine max* L.), and wheat (*Triticum aestivum* L.). Application timing is crop specific [41]. It controls many broadleaf weeds (*Amaranthus* spp., *Lolium* spp.) and annual grasses (*Urochloa* spp., goosegrass [*Eleusine indica* L.], crowfootgrass [*Dactyloctenium aegyptium* L.], and *Digitaria* spp. [42–47]. Although pyroxasulfone has a similar weed control spectrum as S-metolachlor and dimethenamid-P, it has a higher specific activity allowing for use rates approximately eight times lower than dimethenamid-P [40]. In previous research, pyroxasulfone has shown to have good peanut crop tolerance and provides control of problem weeds [23, 48–50]; however, pyroxasulfone applied PRE to peanut has been documented to cause early-season stunting but no yield loss [48].

Carfentrazone is an aryl triazolinone herbicide [51], and the mode of action is the inhibition of protoporphyrinogen oxidase (Protox) [52, 53] in the chlorophyll biosynthesis pathway that results in the accumulation of protoporphyrin IX (PPIX) in the cytosol (site of action Group 14) [54, 55]. PPIX is photoactive and involved in the light-dependent formation of singlet oxygen, which is responsible for plant death via membrane oxidation [56]. It is a rapid-acting contact herbicide with little or no residual activity [57], and susceptible weeds begin to desiccate within hours of treatment followed by necrosis and plant death within days.

Monoculture production systems and the repeated use of the same or similar herbicides have led to herbicide resistance in weeds [58–60]. *Amaranthus* species are very sensitive to ALS-inhibiting herbicides and possess characteristics that predispose them to have herbicide resistant biotypes such as high genetic variability, prolific seed production, and efficient pollen and seed distribution [61]. The use of soil-applied and POST herbicides with alternative sites of action is necessary to reduce the rate of development of herbicide-resistant weed populations [62].

The premix of carfentrazone + pyroxasulfone (C + P) was labeled for use on peanut in the U.S. as Anthem Flex® by the FMC Corporation [63] in time for the 2020 growing season. It is labeled in peanut for EPOST or POST use only. Pyroxasulfone systems have provided excellent season-long control of Palmer amaranth and smut/melon, which are broadleaf weeds that can cause peanut growers considerable problems and are hard-to-control with current herbicides [23, 49, 50]. This premix will control ALS- (HRAC Group 2 herbicide) and glyphosate- (HRAC Group 9 herbicide) resistant Palmer amaranth, which is becoming more widespread across southwestern peanut producing areas [64]. Control of annual grasses such as Texas millet is limited, and full-season control of this annual grass in peanut typically requires the postemergence use of clethodim® (WSSA Group 1 herbicide) or other graminicides [64]. Due to questions on weed efficacy of C + P systems on various weeds found in the southwestern U.S. peanut production area, research was undertaken to determine weed efficacy with C + P herbicide systems.

2. Materials and methods

2.1 Field studies

Studies were conducted in the 2017 through 2019 growing seasons to determine weed efficacy of C + P herbicide systems in the southwestern U.S. peanut growing areas. Locations in 2017 through 2019 included the Texas A&M AgriLife Research Site near Yoakum (29.1642°N, -97.1243°W) in south-central Texas, the Oklahoma State University Caddo Research Station near Ft. Cobb (35.0610°N, -98.2745°W) in southwestern Oklahoma, and in 2017 in the Texas High Plains at the Texas Tech Fiber and Biopolymer Research Institute (FBRI) near Lubbock (33.3527°N; -101.4657°W).

The test locations at Yoakum and Ft. Cobb were in the same general areas but different parts of the field in the 3 years. Other details of the test locations, peanut variety, and spray information are given in **Table 2**. The experimental design was a randomized complete block with three to four replications depending on location. An untreated check was included each year at all locations.

2.2 Plot size and weed populations

Each plot at Yoakum consisted of two rows spaced 97 cm apart and 7.6 m long, plots at Ft. Cobb were two rows spaced 91 cm apart and 9.1 m long, while plots at Lubbock were four rows spaced 102 cm apart and 9.5 m long. Plots were infested with naturally occurring weed populations at all locations. At the south Texas location, all field plots were naturally infested with populations of Texas millet, smellmelon, and Palmer amaranth with populations ranging from 6 to 14 plants/m². Pitted morningglory was only present in sufficient numbers (3–6 plants/m²) in 2017. At the Oklahoma locations, Texas millet, ivyleaf morningglory, and yellow nutsedge (*Cyperus esculentus* L.) populations (present in 2017) ranged from 9 to 45 plant/m² while Palmer amaranth populations in all 3 years were similar to those mentioned above. Wild poinsettia (*Euphorbia heterophylla* L.) populations in 2018 were 3 to 4 plants/m². At the Lubbock location in 2017, golden crownbeard [*Verbesnia encelioides* (Cav.) Benth. & Hook. F. ex A. Gray] populations ranged from 8 to 10 plants/m², devil's-claw [*Proboscidea louisianica* (Mill.) Thell] populations ranged from 1 to 2 plants/m², and Palmer amaranth populations ranged from 6 to 8 plants/m².

2.3 Herbicide treatments and application

In 2017 at Ft. Cobb and in 2018 and 2019 at both Yoakum and Ft. Cobb, pendimethalin at 1.06 kg ha⁻¹ was applied PRE to all treatments with the exception of the untreated check. The EPOST herbicide applications (also referred to as peanut cracking) were applied when the peanut plants had begun to emerge or were no bigger than saucer size (approximately 10–12 cm). In 2017, this was 21 days after planting (DAP) at Ft. Cobb. No EPOST treatments were applied at either Yoakum or Lubbock. In 2018, the EPOST treatments were applied 14 DAP at Yoakum and 22 DAP at Ft. Cobb while in 2019 EPOST treatments were applied 7 DAP at Yoakum and 27 DAP at Ft. Cobb. Postemergence (POST) treatments were applied 22–36 DAP at Yoakum, 35–41 DAP at Ft. Cobb, and 43 DAP at Lubbock. All EPOST and POST treatments included either a crop oil concentrate (Agridex®) at 1.25% v/v or a non-ionic surfactant (Induce®) at 0.25% v/v.

Variables	Location						
	Yoakum			Ft. Cobb			Lubbock
	2017	2018	2019	2017	2018	2019	2017
Soil name	Tremona	Tremona	Tremona	Binger	Binger	Binger	Estacado
Soil type	Loamy fine sand	Loamy fine sand	Loamy fine sand	Fine sandy loam	Fine sandy loam	Fine sandy loam	Clay loam
Sand (%)	65	65	65	50	50	50	50
Silt (%)	35	35	35	30	30	30	25
Clay (%)	10	10	10	20	20	20	25
pH	7.4	7.5	7.5	7.0	7.0	7.0	8.2
OM (%)	0.7	0.7	0.7	0.5	0.5	0.5	1.1
CEC	31	30	30	25	25	25	15
Planting date	June 14	June 26	June 24	May 5	May 8	May 15	April 26
Application							
PRE	June 15	June 28	June 24	May 5	May 8	May 15	April 28
EPOST	—	July 10	July 1	May 26	May 30	June 11	June 7
POST	July 6	July 31	July 30	June 15	June 12	June 25	—
Weed ht. at EPOST (cm)							
AMAPA	8–15	10–15	10–15	1.5–7.5	1.5–8.0	1.5–8	6–8
CUMME	4–8	5–8	5–8	—	—	—	—
CYPES	—	2–6	—	5–20	—	—	—
EPPHL	—	—	—	—	1.5–15	—	—
IPOHE	—	—	—	1.5–15	1.5–15	—	—
IPOLA	4–8	—	—	—	—	—	—
PROLO	—	—	—	—	—	—	6–8
UROTE	12–16	10–15	10–15	1.5–5	1.5–6	—	—
VEEN	—	—	—	—	—	—	10–15
Weed ht. at POST (cm)							
AMAPA	15–25	30–36	18–35	1.5–10	1.5–8	1.5–30	12–20
CUMME	10–30	5–25	5–25	—	—	—	—
CYPES	—	10–16	20–30	5–20	2.5–20	—	—
EPPHL	—	—	—	—	1.5–20	—	—
IPOHE	—	—	—	1.5–20	1.5–15	—	—
IPOLA	10–20	—	—	—	—	—	—
PROLO	—	—	—	—	—	—	12–16
UROTE	15–20	18–20	18–20	6–10	1.5–41	—	—
VEEN	—	—	—	—	—	—	10–16
Sprayer	CO ₂ backpack						

Variables	Location						
	Yoakum			Ft. Cobb			Lubbock
	2017	2018	2019	2017	2018	2019	2017
Operating pressure (kPa)	207	207	207	161	165	165	220
Spray volume (L ha ⁻¹)	187	187	187	94	94	94	112
Spray nozzles	DG 11002	DG 11002	DG 11002	TT 110015	TTI 110015	TT 110015	TT1 10,015
Peanut variety	Georgia 09B	Georgia 13 M	Georgia 09B	Florida Fancy	Florida Fancy	Florida Fancy	Georgia 09B

^aAbbreviations: EPOST, early postemergence; POST, postemergence; PRE, preemergence.

^bBayer code for weeds: AMAPA, Palmer amaranth (*Amaranthus palmeri* L.); CUMME, smellmelon (*Cucumis melo* L.); CYPES, yellow nutsedge (*Cyperus esculentus* L.); EPHHL, wild poinsettia (*Euphorbia heterophylla* L.); IPOHE, ivyleaf morningglory [*Ipomoea hederacea* (L.) Jacq.]; IPOLA, pitted morningglory (*Ipomoea lacunose* L.); PROLO, devil's-claw [*Proboscidea louisianica* (Mill.) Thell]; UROTE, Texas millet [*Urochloa texana* (Buckl.)]; VEEEN, Golden crownbeard [*Verbesnia encelioides* (Cav.) Benth. & Hook. f. ex A. Gray] [22].

Table 2.

Variables associated with the study at each location.^{a, b}

Herbicide standards varied between locations and years. In 2017 at both the Yoakum and Lubbock locations, pendimethalin at 1.06 kg ai ha⁻¹ plus flumioxazin at 0.07 kg ai ha⁻¹ applied PRE followed by S-metolachlor at 1.07 kg ai ha⁻¹ applied POST was the standard comparison treatment. At Ft. Cobb in 2017, pendimethalin plus flumioxazin was applied PRE, and paraquat at 0.21 kg ai ha⁻¹ was added to S-metolachlor at 1.42 kg ai ha⁻¹ EPOST treatment. In 2018 and 2019 at both Yoakum and Ft. Cobb, flumioxazin at 0.11 kg ha⁻¹ applied PRE followed by lactofen at 0.22 kg ha⁻¹ plus S-metolachlor at 1.07 kg ha⁻¹ plus 2,4-DB at 0.25 kg ha⁻¹ applied POST was the standard.

2.4 Irrigation, weed control, and peanut harvest

Sprinkler irrigation was applied on a 2–3-wk schedule throughout the growing season as needed at all locations. Weed control and peanut leaf burn were visually estimated on a scale of 0–100 (0 indicating no control or plant death and 100 indicating complete control or plant death), relative to the untreated control [65]. Peanut yields were not obtained in any years due to the difficulty of digging plots with high weed pressure [23, 49, 50].

2.5 Data analysis

Weed control data were arcsine transformed prior to analysis of variance; however, because the transformation did not alter treatment means original data are presented. Means were compared with Fisher's protected LSD test at the 5% probability level. The untreated control was not included in the weed control analysis.

3. Results and discussion

Peanut injury (<15%) at all locations consisted of leaf burn, and this injury was visible for 7–21 days after a C + P application. Typically, the peanut leaf burn can be attributed to the carfentrazone in the premix. The peripheral leaves that were burned were replaced by new leaves that were void of any type of injury. This leaf burn has also been noted in another study with C + P [66].

Smellmelon data at Yoakum in 2018 and 2019 were combined over the 2 years because of a lack of treatment by year interaction. However, all other weed control data are presented separately by weed species, year, and location because there was a treatment by year and/or location interaction or herbicide treatments were different at the locations in some years.

3.1 Weed control

3.1.1 Palmer amaranth (AMAPA)

In 2017 at the Yoakum location when evaluated 16 weeks after planting (WAP), all herbicide systems that contained C + P at 0.007 kg ha^{-1} + at 0.11 kg ha^{-1} PRE controlled AMAPA at least 92% compared with the standard treatment of pendimethalin + flumioxazin PRE followed by S-metolachlor POST which provided 93% control (**Table 3**). Systems that included C + P at 0.005 kg ha^{-1} + 0.07 kg ha^{-1} PRE provided more variable AMAPA control which ranged from 76 to 100% while the system which included C + P POST provided 100% control. At the Lubbock location all C + P systems, with the exception of C + P at 0.005 kg ha^{-1} + 0.07 kg ha^{-1} PRE followed by imazapic POST, controlled AMAPA at least 90% compared with the standard treatment of pendimethalin + flumioxazin PRE followed by S-metolachlor POST which provided 67% control (**Table 4**). At the Ft. Cobb location, herbicide systems that included C + P EPOST controlled AMAPA 81–98% while systems that included S-metolachlor EPOST provided 81–96% control (**Table 5**).

In 2018 at Yoakum when evaluated 16 WAP, all C + P systems with the exception of C + P at 0.004 kg ha^{-1} + 0.05 kg ha^{-1} PRE, controlled AMAPA 97–100% (**Table 6**). At Ft. Cobb, herbicide systems that included pendimethalin + (C + P) PRE followed by imazapic + S-metolachlor POST or pendimethalin + flumioxazin PRE followed by imazapic + (C + P) POST provided 83–92% control of Palmer amaranth (**Table 7**). The three-way combination of bentazon + acifluofen + S-metolachlor EPOST followed by imazapic + S-metolachlor POST provided 99% control while pendimethalin + flumioxazin PRE followed by imazapic + (C + P) POST controlled AMAPA 83–90%. No other herbicide systems provided better than 69% control.

In 2019 at Yoakum all herbicide systems provided almost perfect AMAPA control (**Table 6**). At Ft. Cobb, herbicide systems that included pendimethalin + flumioxazin PRE followed by imazapic + (C + P) POST controlled AMAPA 93–94%. Pendimethalin + flumioxazin PRE followed by imazapic + S-metolachlor POST provided 98% control and bentazon + acifluofen + pyroxasulfone EPOST followed by imazapic + pyroxasulfone POST provided 97% control (**Table 7**). In previous work, Grichar et al. [66] reported that C + P provided at least 90% Palmer amaranth control while herbicide systems that included either pendimethalin or flumioxazin controlled this weed 97–99%. Steele et al. [39] reported, in corn, that pyroxasulfone at $0.125\text{--}0.5 \text{ kg ha}^{-1}$

Treatments ^{a,b}	Rate	Appl timing ^c	AMAPA	CUMME	IPOLA	UROTE ^d
			Weeks after planting			
			16			
	kg ai ha ⁻¹			%		
Untreated	—	—	0	0	0	0
(C + P)	(0.005 + 0.07)	PRE	87	98	89	17
(C + P)	(0.007 + 0.11)	PRE	96	97	88	30
Flumioxazin + (C + P)	0.07 + (0.005 + 0.07)	PRE	100	100	79	27
Pendimethalin + (C + P)	1.06 + (0.005 + 0.07)	PRE	87	86	84	55
(C + P)	(0.005 + 0.07)	PRE	79	99	99	53
Imazapic	0.07	POST				
(C + P)	(0.007 + 0.11)	PRE	92	99	83	65
Imazapic	0.07	POST				
(C + P) + flumioxazin	(0.005 + 0.07) + 0.07	PRE	100	100	92	58
Imazapic	0.07	POST				
(C + P) + pendimethalin	(0.005 + 0.07) + 1.06	PRE	76	100	99	75
imazapic	0.07	POST				
Pendimethalin + flumioxazin	1.06 + 0.07	PRE	100	99	95	37
(C + P)	(0.007 + 0.11)	POST				
Pendimethalin + flumioxazin	1.06 + 0.07	PRE	93	88	82	70
S-metolachlor	1.07	POST				
LSD (0.05)			16	10	23	29

^aAll POST treatments included Induce at 0.25% v/v.

^bAbbreviations for herbicides: (C + P), premix of carfentrazone + pyroxasulfone.

^cApplication timing: PRE, preemergence; POST, postemergence.

^dBayer code for weeds: AMAPA, Palmer amaranth (*Amaranthus palmeri* S. Wats.); CUMME, smellmelon (*Cucumis melo* L.); IPOLA, pitted morningglory (*Ipomoea lacunose* L.); UROTE, Texasmillet [*Urochloa texana* (Buckl.)] [22].

^aAll POST treatments included Induce at 0.25% v/v.

^bAbbreviations for herbicides: (C + P), premix of carfentrazone + pyroxasulfone.

^cApplication timing: PRE, preemergence; POST, postemergence.

^dBayer code for weeds: AMAPA, Palmer amaranth (*Amaranthus palmeri* S. Wats.); CUMME, smellmelon (*Cucumis melo* L.); IPOLA, pitted morningglory (*Ipomoea lacunose* L.); UROTE, Texasmillet [*Urochloa texana* (Buckl.)] [22].

Table 3.

Late season weed control with carfentrazone + pyroxasulfone (C + P) during the 2017 growing season in south Texas (Yoakum).

provided comparable control of Palmer amaranth to S-metolachlor at rates of 1.1–4.3 kg ha⁻¹. Also, Knezevic et al. [44] found that pyroxasulfone at 0.16 kg ha⁻¹ provided 90% control of tall waterhemp [*Amaranthus tuberculatus* (Moq.)] 28 days after treatment (DAT) and a higher rate was required to obtain the same control at 45 (0.2 kg ha⁻¹) and 65 DAT (0.27 kg ha⁻¹). Jha et al. [67] reported that the addition of pendimethalin to pyroxasulfone improved control of several weeds including common lambsquarters (*Chenopodium album* L.), kochia [*Kochia scoparia* (L.) Schard], and wild buckwheat (*Polygonum convolvulus* L.) over pyroxasulfone alone.

3.1.2 Texas millet (UROTE)

In 2017 at Yoakum, no herbicide system provided better than 75% UROTE control (Table 3). Herbicide systems that included C + P but not imazapic controlled UROTE

Treatments ^{a,b}	Rate	Appl timing ^c	AMAPA	PROLO	VEEN
			Weeks after planting		
				13	
	kg ai ha ⁻¹			%	
Untreated	—	—	0	0	0
(C + P)	(0.005 + 0.07)	PRE	90	60	73
(C + P)	(0.007 + 0.11)	PRE	92	23	60
Flumioxazin + (C + P)	0.07 + (0.005 + 0.07)	PRE	100	63	62
Pendimethalin + (C + P)	1.06 (0.005 + 0.07)	PRE	100	17	67
(C + P) Imazapic	(0.005 + 0.07) 0.07	PRE POST	73	100	80
(C + P) Imazapic	(0.007 + 0.11) 0.07	PRE POST	92	100	85
(C + P) + flumioxazin Imazapic	(0.005 + 0.07) + 0.07 0.07	PRE POST	95	98	93
(C + P) + pendimethalin imazapic	(0.005 + 0.07) + 1.06 0.07	PRE POST	100	100	87
Pendimethalin + flumioxazin (C + P)	1.06 + 0.07 (0.007 + 0.11)	PRE POST	100	100	100
Pendimethalin + flumioxazin S-metolachlor	1.06 + 0.07 1.06	PRE POST	67	60	88
LSD (0.05)			32	54	20

^aAll POST treatments included Induce at 0.25% v/v.

^bAbbreviations for herbicides: (C + P), premix of carfentrazone + pyroxasulfone.

^cApplication timing: PRE, preemergence; POST, postemergence.

^dBayer code for weeds: AMAPA, Palmer amaranth (*Amaranthus palmeri* S. Wats.); PROLO, devil's-claw [*Proboscidea louisianica* (Mill.) Thell]; VEEEN, Golden crownbeard [*Verbesnia encelioides* (Cav.) Benth. & Hook. f. ex A. Gray] [22].

Table 4.

Late season weed control with carfentrazone + pyroxasulfone (C + P) during the 2017 growing season at Lubbock in the High Plains of Texas.

17–55% while systems containing imazapic provided 53–75% control. The standard of pendimethalin + flumioxazin PRE followed by S-metolachlor POST provided 70% control. At Ft. Cobb all herbicide systems that included C + P without imazapic provided 44–56% control while all systems that included imazapic POST controlled UROTE 88–96% (**Table 5**). The standard of pendimethalin + flumioxazin PRE followed by paraquat + S-metolachlor EPOST provided 33% control.

In 2018 at Yoakum, all herbicide systems that included C + P without imazapic controlled UROTE 88–92% while systems that included imazapic controlled UROTE 96–100% (**Table 6**). At Ft. Cobb, only herbicide systems that included pendimethalin + (C + P) PRE at the two rates of either 0.004 kg ha⁻¹ + 0.05 kg ha⁻¹ or 0.005 kg ha⁻¹ + 0.07 kg ha⁻¹ followed by imazapic + S-metolachlor

Treatments ^{a,b}	Rate	Appl timing ^c	14 weeks after planting			
			AMAPA ^d	CYPES	IPOHE	UROTE
	kg ai ha ⁻¹			%		
Untreated	—	—	0	0	0	0
Paraquat + (C + P)	0.21 + (0.005 + 0.07)	EPOST	85	85	95	94
Imazapic	0.07	POST				
Paraquat + (C + P)	0.21 + (0.005 + 0.07)	EPOST	81	86	90	94
Imazapic + 2,4-DB	0.07 + 0.25	POST				
Paraquat + (C + P)	0.21 + (0.005 + 0.07)	EPOST	95	30	74	56
Lactofen + 2,4-DB	0.15 + 0.25	POST				
Paraquat + S-metolachlor	0.21 + 1.42	EPOST	86	84	89	95
Imazapic	0.07	POST				
Paraquat + S-metolachlor	0.21 + 1.42	EPOST	81	76	89	88
Imazapic + 2,4-DB	0.07 + 0.25	POST				
Paraquat + S-metolachlor	0.21 + 1.42	EPOST	94	28	43	33
Lactofen + 2,4-DB	0.22 + 0.25	POST				
Flumioxazin	0.07	PRE	85	85	90	90
Paraquat + (C + P)	0.21 + (0.005 + 0.07)	EPOST				
Imazapic	0.07	POST				
Flumioxazin	0.07	PRE	83	85	93	94
Paraquat + (C + P)	0.21 + (0.005 + 0.07)	EPOST				
Imazapic + 2,4-DB	0.07 + 0.25	POST				
Flumioxazin	0.07	PRE	98	30	53	44
Paraquat + (C + P)	0.25 + (0.005 + 0.07)	EPOST				
Lactofen + 2,4-DB	0.22 + 0.25	POST				
Flumioxazin	0.07	PRE	85	83	97	95
Paraquat + S-metolachlor	0.21 + 1.42	EPOST				
Imazapic	0.07	POST				
Flumioxazin	0.07	PRE	89	83	90	96
Paraquat + S-metolachlor	0.21 + 1.42	EPOST				
Imazapic + 2,4-DB	0.07 + 0.25	POST				
Flumioxazin	0.07	PRE	96	13	61	33
Paraquat + S-metolachlor	0.21 + 1.42	EPOST				
LSD (0.05)			7	13	18	16

^a All herbicide treatments, except the untreated check, included pendimethalin at 1.06 kg ha⁻¹ applied preemergence.

^b All POST carfentrazone + pyroxasulfone treatments included Induce at 0.25% v/v while all other POST herbicide treatments included Agridex at 1.25% v/v.

^c Abbreviations: (C + P), a premix of carfentrazone + pyroxasulfone; PRE, preemergence; EPOST, early postemergence (also referred to as peanut cracking); POST, postemergence.

^d Bayer code for weeds: AMAPA, Palmer amaranth (*Amaranthus palmeri* S. Wats.); CYPES, yellow nutsedge (*Cyperus esculentus* L.); IPOHE, ivyleaf morningglory [*Ipomoea hederacea* (L.) Jacq.]; UROTE, Texas millet [*Urochloa texana* (Buckl.)] [22].

Table 5.

Late season weed control with carfentrazone plus pyroxasulfone (C + P) during the 2017 growing season in Oklahoma (Ft. Cobb).

16 weeks after planting							
Treatments ^{a,b}	Rate	Appl timing	AMAPA ^d			UROTE	
			2018	2019	CUMME ^e	2018	2019
	kg ai ha ⁻¹				%		
Untreated	—	—	0	0	0	0	0
Flumioxazin Imazapic + S-metolachlor	0.11 0.07 + 1.07	PRE POST	97	99	98	99	94
(C + P) Imazapic + S-metolachlor	(0.004 + 0.05) 0.07 + 1.07	PRE POST	71	100	98	100	93
(C + P) Imazapic + S-metolachlor	(0.005 + 0.07) 0.07 + 1.07	PRE POST	99	99	99	97	90
Flumioxazin Imazapic + (C + P)	0.11 0.07 + (0.007 + 0.11)	PRE POST	100	99	100	99	86
Flumioxazin Imazapic + C + P	0.11 0.07 + (0.009 + 0.12)	PRE POST	99	100	99	96	83
Bentazon + acifluorfen + S-metolachlor Imazapic + S-metolachlor	0.37 + 0.19 + 1.07 0.07 + 1.07	EPOST POST	99	99	98	96	87
Bentazon + acifluorfen + (C + P) Imazapic + (C + P)	0.37 + 0.19 + (0.007 + 0.11) 0.07 + (0.007 + 0.11)	EPOST POST	99	100	95	99	91
Bentazon + acifluorfen + (C + P) Imazapic + (C + P)	0.37 + 0.19 + (0.008 + 0.13) 0.07 + (0.008 + 0.13)	EPOST POST	100	99	98	98	92
Bentazon + acifluorfen + pyroxasulfone Imazapic + pyroxasulfone	0.37 + 0.19 + 0.06 0.07 + 0.06	EPOST POST	100	100	99	98	92
Flumioxazin Lactofen + S-metolachlor + 2,4-DB	0.11 0.22 + 1.07 + 0.25	PRE POST	100	100	99	99	72
Flumioxazin Lactofen + (C + P) + 2,4-DB	0.11 0.22 + (0.009 + 0.12) + 0.25	PRE POST	99	100	99	92	66

16 weeks after planting							
Treatments ^{a,b}	Rate	Appl timing	AMAPA ^d			UROTE	
			2018	2019	CUMME ^e	2018	2019
	kg ai ha ⁻¹				%		
Flumioxazin	0.11	PRE	100	100	99	88	83
Lactofen + (C + P)	0.22 + (0.007 + 0.11)	POST					
+ 2,4-DB	+ 0.25						
LSD (0.05)			9	2	4	6	18

^a All herbicide treatments, except the untreated check, included pendimethalin at 1.06 kg ha⁻¹ applied preemergence.
^b All POST treatments included Induce at 0.25% v/v.
^c Abbreviations: (C + P), a premix of carfentrazone + pyroxasulfone; PRE, preemergence; EPOST, early postemergence (also referred to as peanut cracking); POST, postemergence.
^d Bayer code for weeds: AMAPA, Palmer amaranth (*Amaranthus palmeri* S. Wats.); CUMME, smellmelon (*Cucumis melo* L.); UROTE, Texas millet [*Urochloa texana* (Buckl.)] [22].
^e Data combined over years because there was no treatment by year interaction.

Table 6.

Late season weed control with carfentrazone plus pyroxasulfone (C + P) during the 2018 and 2019 growing season in south Texas (Yoakum).

POST, pendimethalin + flumioxazin PRE followed by imazapic + (C + P) at 0.009 kg ha⁻¹ + 0.12 kg ha⁻¹ POST, or pendimethalin PRE followed by the 3-way mix of bentazon + acifluorfen + S-metolachlor EPOST followed by imazapic + S-metolachlor POST provided 90% or greater control (**Table 7**).

In 2019 at Yoakum, systems that did not include imazapic provided 66–83% UROTE control while systems that included imazapic controlled UROTE 83–94% (**Table 6**). Grichar et al. [66] reported that in 1 year at two locations, herbicide treatments that included either imazapic or imazethapyr provided 98% UROTE control while treatments that included the premix of C + P without imazapic controlled UROTE 88–98%. The herbicide systems that included the premix of C + P PRE and POST provided comparable control to those systems that included a POST application of imazapic. At another location, C + P PRE controlled UROTE 47–75%, EPOST provided 46–85% control, and POST provided 48–80% control while the herbicide standard of pendimethalin + S-metolachlor provided 66% control. Baughman et al. [50] and Grichar et al. [23] had previously reported that UROTE control with pyroxasulfone PPI or PRE was inconsistent when used alone; however, when used in a systems approach with either pendimethalin, S-metolachlor, or dimethenamid control was ≥90%.

3.1.3 Smellmelon (CUMME)

CUMME was only present at the Yoakum location. In 2017, all herbicide systems with the exception of pendimethalin + (C + P) at 0.005 kg ha⁻¹ + 0.07 kg ha⁻¹ PRE or the standard of pendimethalin + flumioxazin PRE followed by S-metolachlor POST controlled CUMME ≥97% (**Table 3**).

Data from 2018 and 2019 were combined since there was no treatment by year interaction. All herbicide systems provided ≥95% CUMME control (**Table 6**). Imazapic systems controlled CUMME 95–100% while systems containing lactofen provided 99% control. In earlier work, Grichar et al. [66] reported that C + P PRE and

Treatments ^{a,b,c}	Rate	Appl timing	16 weeks after planting				
			AMAPA ^d		EPPHL	UROTE	IPOHE
			2018	2019	2018	2018	2018
	kg ai ha ⁻¹		%				
Untreated	—	—	0	0	0	0	0
Flumioxazin	0.11	PRE	69	98	50	69	50
Imazapic + S-metolachlor	0.07 + 1.07	POST					
(C + P)	(0.004 + 0.05)	PRE	91	73	80	91	73
Imazapic + S-metolachlor	0.07 + 1.07	POST					
(C + P)	(0.005 + 0.07)	PRE	92	87	96	92	90
Imazapic + S-metolachlor	0.07 + 1.07	POST					
Flumioxazin	0.11	PRE	83	94	98	83	94
Imazapic + (C + P)	0.07 + (0.007 + 0.11)	POST					
Flumioxazin	0.11	PRE	90	93	85	90	84
Imazapic + (C + P)	0.07 + (0.009 + 0.12)	POST					
Bentazon + acifluorfen + S-metolachlor	0.37 + 0.19 + 1.07	EPOST	99	73	100	99	97
Imazapic + S-metolachlor	0.07 + 1.07	POST					
Bentazon + acifluorfen + (C + P)	0.37 + 0.19 + (0.007 + 0.11)	EPOST	62	82	68	62	89
Imazapic + (C + P)	0.07 + (0.007 + 0.11)	POST					
Bentazon + acifluorfen + (C + P)	0.37 + 0.19 + (0.008 + 0.13)	EPOST	58	87	71	58	96
Imazapic + (C + P)	0.07 + (0.008 + 0.13)	POST					
Bentazon + acifluorfen + pyroxasulfone	0.37 + 0.19 + 0.06	EPOST	56	97	35	56	76
Imazapic + pyroxasulfone	0.07 + 0.06	POST					
Flumioxazin	0.11	PRE	10	81	21	10	98
Lactofen + S-metolachlor + 2,4-DB	0.22 + 1.07 + 0.25	POST					
Flumioxazin	0.11	PRE	28	83	76	28	87
Lactofen + (C + P)	0.22 + (0.009 + 0.12)	POST					
+ 2,4-DB	+ 0.25						
Flumioxazin	0.11	PRE	25	81	79	25	98
Lactofen + (C + P)	0.22 + (0.007 + 0.11)	POST					
+ 2,4-DB	+ 0.25						

Treatments ^{a,b,c}	Rate	Appl timing	16 weeks after planting				
			AMAPA ^d		EPPHL	UROTE	IPOHE
			2018	2019	2018	2018	2018
	kg ai ha ⁻¹				%		
LSD (0.05)			24	12	25	24	18

^aAll herbicide treatments, except the untreated check, included pendimethalin at 1.06 kg ha⁻¹ applied preemergence.
^bAll POST treatments included Induce at 0.25% v/v.
^cAbbreviations: (C + P), a premix of carfentrazone + pyroxasulfone; PRE, preemergence; EPOST, early postemergence (also referred to as peanut cracking); POST, postemergence.
^dBayer code for weeds: AMAPA, Palmer amaranth (*Amaranthus palmeri* S. Wats.); EPPHL, wild poinsettia (*Euphorbia heterophylla* L.); IPOHE, ivyleaf morningglory [*Ipomoea hederacea* (L.) Jacq.]; UROTE, Texas millet [*Urochloa texana* (Buckl.) [22].

Table 7.

Late season weed control with carfentrazone plus pyroxasulfone during the 2018 and 2019 growing season in Oklahoma (Ft. Cobb).

POST controlled CUMME 95–100% while the combination of C + P PRE followed by imazapic + S-metolachlor POST failed to control CUMME (63%). However, other research indicated imazapic provides excellent control of smellmelon [21] similar to the results from these studies. While lactofen provided excellent control in this study, previous research by Grichar [21] stated that lactofen control of CUMME could be inconsistent.

3.1.4 Pitted morningglory (IPOLA)

IPOLA was present in sufficient numbers to evaluate only at Yoakum in 2017. Herbicide systems that included imazapic POST controlled IPOLA 83–99% while systems that included C + P, but not imazapic provided 79–95% control (Table 3). The herbicide standard of pendimethalin + flumioxazin PRE followed by S-metolachlor POST controlled IPOLA 82%. Imazapic has been reported to effectively control IPOLA in peanut [6, 68]. Jordan et al. [68] reported that imazapic alone or in combination with acifluofen, diclosulam, or 2,4-DB controlled IPOLA 89–97%.

3.1.5 Ivyleaf morningglory (IPOHE)

IPOHE was present only at the Ft. Cobb location in 2017 and 2018. In 2017, herbicide systems that included imazapic controlled IPOHE 89–97% while systems that included C + P but not imazapic provided 53–74% control. Herbicide systems that contained lactofen controlled this weed 43–74% (Table 5). In 2018 all systems, with the exception of either pendimethalin + flumioxazin or pendimethalin + (C + P) PRE followed by imazapic + S-metolachlor POST or pendimethalin PRE followed by bentazon + acifluofen + pyroxasulfone EPOST followed by imazapic + pyroxasulfone POST, controlled IPOHE ≥ 84% (Table 7).

Grichar et al. [66] reported in a two-year study that in 1 year of the study, systems that included C + P PRE provided 83–100% IPOHE control while the standard of flumioxazin plus S-metolachlor provided 80% control. In another year, all systems that included C + P alone PRE provided 30–46% control, C + P alone EPOST provided 29–43% control, and C + P alone POST controlled IPOHE 30–40%. No application timing of C + P improved IPOHE control.

3.1.6 Golden crownbeard (VEEEN)

VEEEN was present only in the High Plains of Texas (Lubbock) in 2017. Herbicide systems that did not include a POST treatment controlled VEEEN $\leq 73\%$ while systems which included imazapic POST provided 80–93% control (**Table 4**). Pendimethalin + flumioxazin PRE followed by C + P POST provided 100% control. Imazapic POST following ethalfluralin PPI has provided complete VEEEN control in a previous study [69]. Previously, Grichar and Sestak [70] reported imazapic provided inconsistent VEEEN control, and they attributed that to the amount and frequency of rainfall soon after application and taller weed size at the time of herbicide application.

3.1.7 Devil's-claw (PROLO)

PROLO was only present at the Lubbock location. Herbicide systems that included PRE treatments only or S-metolachlor POST provided 63% or less PROLO control while all POST treatments that included imazapic controlled PROLO at least 98% (**Table 4**). Pendimethalin + flumioxazin PRE followed by C + P POST also provided complete control.

3.1.8 Yellow nutsedge (CYPES)

CYPES was present only in sufficient populations to evaluate at Ft. Cobb in 2017. Herbicide systems that included imazapic provided 76–86% CYPES control while systems that did not include imazapic provided 30% or less control (**Table 5**). The standard of pendimethalin + flumioxazin applied PRE followed by paraquat + S-metolachlor applied EPOST controlled this weed only 13%. Imazapic typically provides excellent CYPES control [6, 71–74]. Grichar and Nester [71] found that imazapic at 0.05 and 0.07 kg ha⁻¹ controlled CYPES 88% in the early season but was inconsistent later in the season. Wilcut et al. [6] reported that imazapic controlled CYPES greater than 90% at rates as low as 0.04 kg ha⁻¹. Grichar and Sestak [72] also reported that imazapic provided at least 80% control of CYPES. Richburg et al. [73] found that applying imazapic below CYPES and purple (*Cyperus rotundus* L.) (CYPRO) tubers did not reduce CYPRO or CYPES shoot numbers, shoot dry weight, shoot regrowth dry weight, or root tuber dry weight. However, when applied above CYPRO tubers, shoot dry weight was reduced; and when applied above CYPES tubers, shoot dry weight and root dry weight were reduced. Imazapic applied 5 cm above + 5 cm below CYPRO tubers reduced shoot numbers, shoot dry weight, shoot regrowth weight, and root dry weight to 9, 4, 10, and 16% of the control, respectively, and with CYPES to 23, 16, 9, and 15% of the control, respectively.

3.1.9 Wild poinsettia (EPPHL)

EPPHL was present only at Ft. Cobb in 2018. Only pendimethalin + (C + P) PRE followed by imazapic + S-metolachlor POST, pendimethalin + flumioxazin PRE followed by imazapic + (C + P) POST, or pendimethalin PRE followed by bentazon + acifluofen + S-metolachlor EPOST followed by imazapic + S-metolachlor POST controlled EPPHL at least 96% (**Table 7**). Systems that included lactofen + (C + P) provided 76–79% control while systems that include imazapic but not C + P provided variable control which ranged from 35 to 100%.

4. Conclusion

When used in a peanut herbicide system, the premix of C + P (both are HRAC Group 9 herbicides) provided excellent season-long residual control of several broadleaf weeds including Palmer amaranth, smellmelon, and morningglory spp. This herbicide combination will control pigweed species including ALS- and glyphosate-resistant Palmer amaranth, which are becoming major problems in many areas of Texas and Oklahoma. It also can provide burndown activity on emerged broadleaf weeds. The premix of C + P does not effectively control large-seeded annual grasses such as Texas millet and requires the use of a graminicide such as fluazifop-P-butyl, clethodim, or sethoxydim (WSSA Group 1 herbicides) to provide season-long control. This premix of C + P offers growers another option to help provide season-long control of problem weeds commonly found in the southwestern U.S. peanut production areas.

The challenges offered by evolved resistance to herbicides used in peanut combined with the limited competitive ability of peanut with weeds create a potentially devastating scenario for high-input, mechanized production systems in the U.S. While continuing to use a diversity of herbicides with multiple mechanisms of action either sequentially or in tank-mixtures is critically important in managing evolved resistance to herbicides, developing effective crop rotations and managing herbicide resistance with emphasis on the soil seedbank in all crops in the rotation is also paramount. Deep tillage and the burial of weed seed enables more effective management when used in combination with other control practices including herbicides and cover cropping.

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