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Seasonal Variation in Macartney Rose (*Rosa bracteata*) Response to Herbicide Treatment

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Macartney rose is an aggressive, thorny shrub that suppresses forage production and strongly hinders cattle grazing in southern pastures. Previous studies have found this weed to be extremely difficult to control with most pasture herbicides. We conducted two studies in central Alabama to assess several new herbicide chemistries applied at spring, early fall, and late fall timings. In the first study, we compared aminocyclopyrachlor, tank mixed with either 2,4-D, triclopyr, metsulfuron, or chlorsulfuron, with the commercial standard, picloram + 2,4-D. In the second study, we compared aminopyralid, tank mixed with either 2,4-D or metsulfuron and triclopyr + fluroxypyr, to the commercial standard, picloram + 2,4-D. Aminocyclopyrachlor + chlorsulfuron or metsulfuron and aminopyralid + 2,4-D or metsulfuron provided acceptable control and were comparable to picloram + 2,4-D at the early fall timing. Macartney rose control with treatments applied at the late fall timing tended to be less than commercially acceptable levels. We found that no herbicide treatment controlled Macartney rose at the spring timing. In addition, triclopyr + fluroxypyr did not control Macartney rose at any application timing. These results indicate that the early fall timing was optimal and that both aminocyclopyrachlor and aminopyralid can provide good Macartney rose control when mixed with certain other herbicides, including metsulfuron.

Nomenclature: 2,4-D; aminocyclopyrachlor; aminopyralid; chlorsulfuron; fluroxypyr; metsulfuron; picloram; triclopyr; Macartney rose, *Rosa bracteata* J.C. Wendl ROSBC.
Key words: Herbicide application timing, invasive rose, mixed grass pasture.

Rosa bracteata es un arbusto espinoso agresivo que suprime la producción de forrajes e inhibe fuertemente el pastoreo del ganado en pastizales del sur. Estudios previos han encontrado que esta maleza es extremadamente difícil de controlar con la mayoría de los herbicidas para pastos. Nosotros realizamos dos estudios en el centro de Alabama para evaluar varios herbicidas químicos nuevos, aplicados en la primavera, temprano en el otoño, y tarde en el otoño. En el primer estudio, comparamos con el estándar comercial, picloram + 2,4-D aplicaciones de aminocyclopyrachlor, mezclado ya fuese con 2,4-D, triclopyr, metsulfuron, o chlorsulfuron. En el segundo estudio, comparamos aminopyralid, mezclado en tanque con ya fuese 2,4-D o metsulfuron y triclopyr + fluroxypyr, con el estándar comercial, picloram + 2,4-D. Aminocyclopyrachlor + chlorsulfuron o metsulfuron y aminopyralid + 2,4-D o metsulfuron brindaron un control aceptable y fueron comparables con picloram + 2,4-D para aplicaciones temprano en el otoño. El control de *R. bracteata* con tratamientos aplicados tarde en el otoño tendió a ser inferior a los niveles comercialmente aceptables. Encontramos que ningún tratamiento con aplicaciones de herbicidas en la primavera controló *R. bracteata*. Adicionalmente, triclopyr + fluroxypyr no controló *R. bracteata* en ningún momento de aplicación. Estos resultados indican que temprano en el otoño fue el momento de aplicación óptimo y que tanto aminocyclopyrachlor como aminopyralid pueden brindar buen control de *R. bracteata* cuando se mezclan con otros herbicidas incluyendo metsulfuron.

Macartney rose is a thorny, thicket-forming shrub that is native to China and Taiwan. Introduced into the United States as a hedge plant almost 200 yr ago (Hume 1943), Macartney rose quickly escaped and has invaded hundreds of thousands of hectares in the southern United States. It is one of the worst weeds of improved Blackland Prairie pastures of Alabama and Mississippi and occurs on > 200,000 ha of coastal prairie in Texas (Meyer and Bovey 1990).

The successful spread of Macartney rose in pastures is largely attributed to its thorny growth form, prolific seed production, and effective dispersal by numerous species of birds, wildlife, and cattle (McCully 1951; Taylor 1949). In addition to seed, Macartney rose also aggressively sprouts from the root crown and shallow lateral roots after fire (Gordon et al. 1982), mowing (Haas et al. 1970), and many herbicide treatments (Meyer

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and Bovey 1984, 1980, 1973). The impacts of Macartney rose have been well documented in Texas, where, if left unchecked, grazing losses have been reported to be as high as 75% (Scifres 1975).

Previous early research on chemical control of Macartney rose found that high rates of picloram or tebuthiuron were required for long-term control (Bovey et al. 1972; Haas et al. 1970; Meyer 1982; Meyer and Bovey 1984, 1980, 1973). Enloe et al. (2013) found repeated, August applications of aminopyralid + metsulfuron and picloram + 2,4-D combined with mowing provided > 80% control at 24 mo after initial treatment. However, all treatments provided poor control approximately 1 yr after treatment. The August timing in that study was based on a desire to protect spring and summer clover (*Trifolium* spp.) growth and to allow clover seed production before treatment. However, it was clear that other timings should be evaluated, given the relatively poor performance of most treatments.

Aminocyclopyrachlor has recently been tested for use on several perennial weeds in southern pastures, including dogfennel [*Eupatorium capillifolium* (Lam.) Small], tropical soda apple (*Solanum viarum* Dunal) and ragweed parthenium (*Parthenium hysterophorus* L.) (Abe et al. 2016), horsenettle (*Solanum carolinense* L.) and tall ironweed [*Vernonia gigantea* (Walt.) Trel.] (Phillips et al. 2015), largeleaf lantana (*Lantana camara* L.) (Ferrell et al 2012), and silverleaf nightshade (*Solanum elaeagnifolium* Cav.) and Brazil vervain (*Verbena brasiliensis* Vell.) (Matocha et al. 2014). Aminocyclopyrachlor has, in almost all cases, provided excellent control of very troublesome weed species at various application timings, including spring, summer, and fall. However, there are no reports of aminocyclopyrachlor efficacy on Macartney rose. Aminopyralid is also widely used for pasture weed control and is frequently comparable in efficacy to aminocyclopyrachlor and picloram on many species. Aminopyralid and picloram also exhibit enough soil residual activity to provide season long control of many perennial weeds and are the foundations of many pasture weed-control programs. Aminocyclopyrachlor is not currently labeled for use in pastures but is labeled for use in noncrop settings (Anonymous 2014) and is persistent in soils. with a half-life ranging from 114 to 433 d (Shaner 2014).

As a semievergreen to evergreen shrub, Macartney rose often retains green leaves into late fall or early winter. Very late fall or winter herbicide treatments of other semievergreen and evergreen species, including Chinese privet (*Ligustrum sinense* Lour.) (Harrington and Miller 2005), hen's eyes (*Ardisia crenata* Sims) (Hutchinson et al. 2011), and garlic mustard [*Alliaria petiolata* (Bieb.) Cavara & Grande] (Frey et al. 2007), have been very effective. Late fall or winter treatments also reduce nontarget damage when other species have entered into winter dormancy. Therefore, our objective was to evaluate spring, early fall, and late fall herbicide treatment timings for Macartney rose control with aminocyclopyrachlor and aminopyralid tank mixes, compared with the commercial standard, which is picloram + 2,4-D.

Materials and Methods

Studies were conducted at two pasture locations in central Alabama near Letohatchee and Sawyerville. The Letohatchee, AL, site was a mixed-grass pasture primarily, composed of tall fescue [*Lolium arundinaceum* (Schreb.) S.J. Darbyshire] and bahiagrass (*Paspalum notatum* Fluegg). Soils were an Oktibbeha clay (very-fine, smectitic, thermic Chromic Dystruderts). The Sawyerville site was also a mixed tall fescue and bahiagrass pasture. Soils were a Kipling clay loam (fine, smectitic, thermic Vertic Paleudalfs). Both sites had interspersed clumps of Macartney rose spread throughout each pasture. Two separate studies were conducted in adjacent areas of each pasture. For the first study (study 1), 60 plots, each 9 by 9 m, were established. For the second study (study 2), 52 plots of similar dimensions were established. Both pastures were grazed for the duration of each study, and neither had been mowed or sprayed in recent years. Herbicide treatments in studies 1 and 2 are shown in Table 1.

Treatments were applied with a 3-m boom sprayer mounted on an all-terrain vehicle. Pressure was supplied by a compressed air system and set at 345 kPa. Treatment application volume was 187 L ha^{-1}. For both studies, treatment timings included October 21–30, 2013, December 18, 2013, and May 6–13, 2014. These timings corresponded to (1) when many woody, perennial plants allocate photosynthates to the roots for winter storage and are effectively controlled with herbicides; (2) when Macartney rose leaves were still green and assumed to be photosynthetically active but when most warm season and deciduous woody shrubs have already entered dormancy; and (3) at spring flowering, when many perennials have depleted winter storage reserves and are more susceptible to herbicide treatment. The experimental design was a randomized complete block for each study with four replicate plots for each treatment and timing combination.

Baseline Macartney rose cover data were collected by establishing two fixed transects diagonally from each corner across the plot. Transects were point sampled at 30-cm intervals for a total of 84 or 85 points per transect. At each sample point, a wire pin flag was dropped, and every point that touched live green Macartney rose leaves or stems was recorded as a hit. Hits were converted to percentage of cover based on the number of positive hits out of the total number sampled for each transect. Posttreatment data were collected at 12 mo after each application timing by sampling the same transects in an identical manner. This allowed true comparisons of seasonal treatment efficacy by giving Macartney rose 1 full yr to recover after each treatment timing before sampling. This was strongly recommended from previous Macartney rose control studies (Meyer and Bovey 1984).

Statistical Analysis. A statistical analysis was performed on the proportion of points out of total sampled points that hit live Macartney rose within each field plot. The number of rose hits per plot was considered a binomial random variable, and the analysis was performed as a generalized linear mixed model using a logit link function with PROC GLIMMIX (SAS Institute Inc., 100 SAS Campus Drive, Cary, NC 27513-2414) (Littell et al. 2006). Study location and blocks within location were considered random effects. Fixed effects were treatment, which consisted of the herbicide formulation and application-date combinations as well as the untreated check and the two evaluation times (initial and final). Contrasts were performed to partition treatment effects in terms of the main effects of application month and herbicide formulation to exclude the untreated check in these effects.

The response variable of interest here is the difference between initial and final Macartney rose

Table 1. Herbicides, amounts, and suppliers used in studies 1 and 2 on control of Macartney rose.

Common name	Trade name	Rate	Supplier	
			Company name, City, State	Web site
		kg ai ha^{-1}		
Study 1				
Aminocyclopyrachlor + 2,4-D		0.12 + 0.89	E. I. DuPont de Nemours and Co., Wilmington, DE	http://www.dupont.com/
Aminocyclopyrachlor + triclopyr		0.14 + 0.28	E. I. DuPont de Nemours and Co., Wilmington, DE	http://www.dupont.com/
Aminocyclopyrachlor + metsulfuron		0.11 + 0.04	E. I. DuPont de Nemours and Co., Wilmington, DE	http://www.dupont.com/
Aminocyclopyrachlor + chlorsulfuron		0.12 + 0.05	E. I. DuPont de Nemours and Co., Wilmington, DE	http://www.dupont.com/
Picloram + 2,4-D	Grazon P+D	0.6 + 2.24	Dow AgroSciences LLC, Indianapolis, IN	http://www.dowagro.com/en-US
Study 2				
Aminopyralid + 2,4-D	GrazonNext	0.12 + 0.97	Dow AgroSciences LLC, Indianapolis, IN	http://www.dowagro.com/en-US
Aminopyralid + metsulfuron	Chaparral	0.12 + 0.02	Dow AgroSciences LLC, Indianapolis, IN	http://www.dowagro.com/en-US
Triclopyr + fluroxypyr	PastureGard	0.84 + 0.28	Dow AgroSciences LLC, Indianapolis, IN	http://www.dowagro.com/en-US
Picloram + 2,4-D	Grazon P+D	0.6 + 2.24	Dow AgroSciences LLC, Indianapolis, IN	http://www.dowagro.com/en-US
Both studies				
NIS[a,b]	Induce	0.25% v/v	Helena Chemical Company, Collierville, TN	http://www.helenachemical.com/

[a] Abbreviation: NIS, nonionic surfactant.

[b] NIS was included with each herbicide treatment in each study.

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Table 2. Macartney rose control 12 mo after treatment by herbicide treatment and application timing for study 1. Data are pooled across location.

Treatment	Rate	% control[a,b]		
		October timing	December timing	April timing
	kg ha^{-1}	%		
Aminocyclopyrachlor + 2,4-D	0.12 + 0.89	59* bcx	35 ax	27 ax
Aminocyclopyrachlor + triclopyr	0.14 + 0.28	31 cx	32 ax	15 ax
Aminocyclopyrachlor + metsulfuron	0.11 + 0.04	84* abx	62* ax	44 ax
Aminocyclopyrachlor + chlorsulfuron	0.12 + 0.05	88* ax	77* axy	32 ay
Picloram + 2,4-D	0.6 + 2.24	89* ax	65* axy	42 ay

[a] Percentage of control for the nontreated check averaged −28% and was not significantly different. Asterisks (*) indicate the percentage of control was significantly different from zero.

[b] Herbicide treatment means for a given application timing followed by the same letter (a-c) and application timing means for a given herbicide treatment followed by the same letter (x–z) do not differ using a Fisher's protected LSD test at P = 0.05.

cover. Tests of main effects and mean comparisons were performed on these estimated differences. There was also a test for a significant response for each treatment that tested whether the percentage of control differed from zero (to test that final cover differs from initial cover). Statistical tests were performed on logits of proportion, but the summary converts those responses into the more easily interpreted variable of percentage of control. Percentage of control averages were calculated using treatment-average proportions as 100 × (*Initial* − *Final*)/*Initial*. A Fisher's protected LSD test was used to compare means, using a 5% level of significance. Percentage of control means differed among formulations for an application month only if the overall test of differences among formulations for that month was significant at P = 0.05. This Fisher's protected LSD approach was also used for comparing application-month means for each formulation.

Results and Discussion

For study 1, there was a significant herbicide by application timing interaction (P = 0.004). This interaction was largely driven by two herbicide treatments, aminocyclopyrachlor + chlorsulfuron and picloram + 2,4-D. Both treatments provided good Macartney rose control with the October-application timing and very poor control with the May-application timing (Table 2). The December application timing resulted in intermediate control for both treatments. Aminocyclopyrachlor tank mixed with 2,4-D, triclopyr, or metsulfuron did not significantly vary among application timings.

Macartney rose control was also compared among herbicides within each application timing. For the October application timing, aminocyclopyrachlor + metsulfuron, aminocyclopyrachlor + chlorsulfuron, and picloram + 2,4-D all provided 84 to 89% control of Macartney rose at 12 mo after treatment and were not different. Aminocyclopyrachlor + 2,4-D resulted in less control (59%) and was not different from aminocyclopyrachlor + metsulfuron. All four of these treatments significantly reduced final cover from initial cover. Aminocyclopyrachlor + triclopyr did not reduce final Macartney rose cover when compared with initial cover.

There were also no differences among herbicide treatments for the December timing, and control ranged from 32 to 77%. However, the within-herbicide test indicated that aminocyclopyrachlor + metsulfuron, aminocyclopyrachlor + chlorsulfuron, and picloram + 2,4-D all differed significantly from zero. This indicated that these treatments did significantly reduce final cover from initial cover. This was not the case for aminocyclopyrachlor + 2,4-D or aminocyclopyrachlor + triclopyr because neither of those treatments significantly reduced final cover when compared with initial cover.

For the May timing, there were no significant differences among any herbicide treatment, and the percentage of control ranged from 15 to 44%. Additionally, no herbicide treatment significantly varied from zero, indicating no treatment reduced final cover when compared with initial cover.

For study 2, there was, again, a significant herbicide by application timing interaction (P =

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Table 3. Macartney rose control 12 mo after treatment by herbicide treatment and application timing for study 2. Data are pooled across location.

Treatment	Rate	% control[a,b]		
		October timing	December timing	April timing
	kg ha^{-1}	%		
Aminopyralid + 2,4-D	0.12 + 0.97	70* ax	44 axy	−3 ay
Aminopyralid + metsulfuron	0.12 + 0.02	80* ax	72* ax	−8 ay
Triclopyr + fluroxypyr	0.84 + 0.28	4 bx	24 ax	−9 ax
Picloram + 2,4-D	0.6 + 2.24	86* ax	61* axy	46 ay

[a] Percentage of control for the nontreated check averaged −10% and was not different (initial vs. final cover). Asterisks (*) indicate the percentage of control was significantly different from zero.

[b] Herbicide treatment means for a given application timing followed by the same letter (a-c) and application timing means for a given herbicide treatment followed by the same letter (x–z) do not differ using a Fisher's protected LSD test at P = 0.05.

0.004). This interaction was explained by very good control at the October timing with aminopyralid + 2,4-D, aminopyralid + metsulfuron, and picloram + 2,4-D and poor control at the May timing for these three treatments (Table 3). Triclopyr + fluroxypyr performed poorly at all application timings.

Percentage of control was compared among herbicides for each application timing. For the October-application timing, aminopyralid + 2,4-D, aminopyralid + metsulfuron, and picloram + 2,4-D provided 70 to 86% control and were not different. All three treatments significantly reduced final cover when compared with initial cover. Triclopyr + fluroxypyr did not control Macartney rose at the October timing.

For the December timing, control ranged between 24 and 72% and was not different among treatments. However, aminopyralid + metsulfuron and picloram + 2,4-D significantly reduced final cover compared with initial cover, whereas aminopyralid + 2,4-D and triclopyr + fluroxypyr did not. For the May timing, percentage of control values ranged from −9 (which is indicative of a 9% increase) to 46% control. However, no herbicide treatment significantly changed Macartney rose cover when the initial cover was compared with the final cover.

These results indicate that Macartney rose control was often highly dependent on application timing for certain herbicides tested. May application was not effective for any herbicide treatment in either study. The October-application timing resulted in better control than the May timing did for aminocyclopyrachlor + chlorsulfuron and picloram + 2,4-D in study 1 and for aminopyralid + metsulfuron, aminopyralid + 2,4-D, and picloram + 2,4-D in study 2. For the December timing, herbicide treatments were almost always numerically intermediate in control between the October and May timings but were seldom statistically different from the other one. In both studies, all treatments containing triclopyr performed poorly. This is similar to the results from Enloe et al. (2013), who found triclopyr provided very poor control of Macartney rose with August applications. Meyer and Bovey (1990) also found triclopyr applied at 0.56 or 1.12 kg ha^{-1} resulted in only a 22 to 32% reduction in canopy cover and no mortality of rose plants.

These results are in contrast with research on the closely related species multiflora rose (*Rosa multiflora* Thunb. ex Murr.). Reed and Fitzgerald (1979) and Sherrick and Holt (1977) found that triclopyr provided excellent multiflora rose control. Additionally, Ferrell et al. (2009) found better control with fall applications than with spring applications of triclopyr on blackberry (*Rubus* spp.). Clearly, there is a large difference in susceptibility to triclopyr among these thorny species.

Based on this work and comparisons to previous work (Enloe et al. 2013), these results point to October as the optimal initial-treatment timing for Macartney rose control. Although not directly comparable, our results with the October timing were better for the commercial standard (picloram + 2,4-D) than those of Meyer and Bovey (1990), who found picloram + 2,4-D (0.56 + 2.2 kg ha^{-1}) resulted in only a 28% reduction in canopy cover after summer treatments. Unfortunately, however, the October timing is somewhat problematic for many pasture producers. Across much of the southern United States, pasture weed control is an annual undertaking, similar to agronomic weed control. Many producers who treat pastures allocate resources for spring and summer weed control and have little interest in fall treatment options (J Everest, personal communication). This issue has also arisen for horsenettle, which is often best controlled with late summer applications compared with spring applications (Phillips et al. 2015).

Despite this issue, these results demonstrate that aminocyclopyrachlor, when mixed with chlorsulfuron or metsulfuron, resulted in comparable weed control with picloram + 2,4-D at the October timing. Additionally, aminopyralid, when mixed with 2,4-D or metsulfuron, provided comparable control to picloram + 2,4-D at the October timing. The addition of these three treatments to the Macartney rose control toolbox is a promising step in the right direction. Future work is needed to continue to improve long-term control of this pernicious weed, including economic studies to test whether improved Macartney rose control with fall applications can benefit producers the following year.

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