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Macartney Rose (*Rosa bracteata*) Response to Herbicide and Mowing Treatments

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Macartney rose is an aggressive thorny shrub that displaces forage species and hinders cattle grazing in rangelands and pastures of the southern United States. Historically, Macartney rose has proven to be extremely difficult to control even with high rates of soil residual herbicides such as picloram. Recent advances in herbicide chemistry warrant testing on this troublesome species. We compared mowing and late summer broadcast applications of thirteen herbicide treatments that included combinations of aminopyralid, fluroxypyr, metsulfuron, picloram, triclopyr, and 2,4-D. Treatments were applied to the same rose clumps for 2 consecutive yr. An additional mowing was done to one half of the rose clumps in each treatment 6 mo after the second herbicide treatment. At 11 mo after initial treatment (MAIT), mowing and all herbicide treatments performed very poorly and provided 35% control or less. At 12 mo after retreatment (24 MAIT), picloram + 2,4-D and aminopyralid + metsulfuron, both followed by mowing, were the most effective treatments, providing 72 to 91% control. All other treatments provided less than 70% control. However, complete clump mortality was very low across all treatments, ranging from 3 to 32%. These results indicate that Macartney rose suppression is possible with certain new herbicides, but complete clump kill is still lacking.

Nomenclature: Aminopyralid; fluroxypyr; metsulfuron; picloram; triclopyr; 2,4-D; Macartney rose, *Rosa bracteata* J. C. Wendl. ROSBC.

Key words: Invasive roses, mechanical control, pasture weed control.

Macartney rose (*Rosa bracteata* J. C. Wendl.) is a thorny clump-forming or trailing shrub native to China and Taiwan. It was introduced into the southern United States in the early 1800s as a hedge plant (Hume 1943). Macartney rose has rapidly expanded over the last 50 yr and is now a serious problem across coastal praire, blackland prairie, and western portions of the post oak (*Quercus stellata* Wangenh.) savannah of Texas where it is estimated to currently infest over 200,000 ha (494,000 ac) (Meyer and Bovey 1990). Macartney rose has been reported in virtually every southern state but appears to be most problematic in Texas and the Blackland Prairie region of Alabama and Mississippi. These prairie soils are often characterized by dark, smectitic, poorly drained clay soils that can be acid or alkaline (Mitchell 2008). In Alabama, Macartney rose is often misidentified as Cherokee rose (*Rosa laevigata* Michx.). Both species have large white, solitary flowers but can readily be distinguished by leaflet, stipule, and hip characteristics (Radford et al. 1968).

Macartney rose spreads via seed dispersal attributed to many animals, including wildlife, birds, and cattle that consume rose hips (Hume 1943; McCully 1951; Taylor 1949). McCully (1951) found high seed viability following passage of Macartney rose through cattle. Vegetative spread also occurs from shallow lateral roots and canes rooting at the nodes. If left unmanaged, individual clumps eventually coalesce to form large, impenetrable thickets (Scifres 1975a).

In Texas rangelands, grazing losses within and around these thickets have been reported to be as high as 75% (Scifres 1975b). Losses appear to be two-fold, because Macartney rose both shades out forage grasses and discourages cattle from grazing available forage nearby. No other estimates of forage losses have been published in the Southeast. However, in Alabama, it is common to observe a clear pattern of ungrazed forage within and around Macartney rose clumps and sprawling canes (S. F. Enloe, personal observation).

Macartney rose control was intensively studied in Texas where it was the focus of numerous studies from the 1960s

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Management Implications

Macartney rose is one of the most difficult-to-control thorny shrubs in pastures across the Southeast. We evaluated a suite of newer pasture herbicides that included several combinations of 2,4-D, aminopyralid, fluroxypyr, metsulfuron, picloram, and triclopyr. Broadcast treatments were applied for 2 consecutive yr in August over the same individual rose clumps and mowing was done 6 mo after the second application. We found that none of the herbicides and rates tested effectively killed entire clumps but that Macartney rose was suppressed best with picloram + 2,4-D treatments. Triclopyr was ineffective when applied alone or when tank-mixed with aminopyralid + 2,4-D or aminopyralid + metsulfuron. Metsulfuron was also ineffective and did not improve control when applied with aminopyralid alone or in combination with 2,4-D. These results indicate that typical annual broadcast applications currently utilized for broadleaf pasture weed control will not effectively eliminate the invasive shrub Macartney rose and more integrated methods need to be evaluated.

to the mid 1980s. Most studies focused on chemical control using various herbicides such as 2,4-D, 2,4,5-T, dicamba, hexazinone, picloram, and tebuthiuron (Bovey et al. 1972; Haas et al. 1970; Meyer 1982; Meyer and Bovey 1973, 1980, 1984). These were often integrated with mowing (Haas et al. 1970) or burning (Gordon et al. 1982) to remove the thorny persistent skeletons which were as problematic to grazing as live plants. These studies commonly found that Macartney rose was exceedingly difficult to control, even with picloram rates as high as 2.24 to 3.36 kg ha^{-1} (2.0 to 3.0 lb ac^{-1}) (Meyer et al. 1976). The most recent published study on Macartney rose chemical control was conducted by Meyer and Bovey (1990) in Texas, who found chlorsulfuron, metsulfuron, or sulfometuron applied at 1.12 kg ha^{-1} to be either ineffective or only marginally effective.

In Alabama, mowing is widely used in infested pastures to suppress Macartney rose. This typically results in mixed populations of low-growing plants (< 1.5 m [5.0 ft] in height) that can range in diameter from < 1 m to > 4 m (S. F. Enloe, personal observation). Additionally, mowing is used following herbicide treatment to allow cattle to graze previously infested areas. However, there has been some concern regarding the timing of mowing following herbicide treatment because mowing too soon could possibly reduce herbicide translocation, but mowing too late would eliminate any forage benefit due to the persistent thorny rose skeletons.

Over the last few years, there have been several new herbicides labeled for use in range and pasture, including aminopyralid (alone and with metsulfuron or 2,4-D) and picloram plus fluroxypyr. These herbicides are very effective for controlling many range and pasture weeds. However, no published studies have evaluated their effectiveness for Macartney rose control. From the literature, it is evident that single applications of any herbicide does not generally provide long-term control and multiple treatments are necessary. Therefore, our objectives were to (1) evaluate several new herbicides for Macartney rose control, (2) determine if control is improved by repeated annual herbicide application, (3) determine if individual rose clump size influences herbicide efficacy, and (4) determine if mowing following herbicide treatment influences control.

Material and Methods

Two research sites were established in 2009 near Eutaw, AL in mixed bahiagrass (*Paspalum notatum* Flueggé) and bermudagrass [*Cynodon dactylon* (L.) Pers.] pastures infested with Macartney rose. Other forage species present in the pastures included dallisgrass (*Paspalum dilatatum* Poir.), carpetgrass [*Axonopus fissifolius* (Raddi) Kuhlm.] and white clover (*Trifolium repens* L.).

Soils in Pasture 1 were predominantly Eutaw clay (Very-fine, smectitic, thermic Chromic Dystraquerts) with a minor component of Vaiden silty clay (Very-fine, montmorillonitic, thermic Vertic Hapludalfs). Soils in Pasture 2 were predominantly Angie fine sandy loam (Clayey, mixed, thermic Aquic Paleudults) with a minor inclusion of Vaiden silty clay.

Both pastures were mowed 3 yr prior to the initiation of the study. Due to the clumping but widespread nature of Macartney rose, individual clumps served as experimental units and treatments were assigned to rose clumps in a completely random fashion. In Pasture 1, 15 treatments were randomly assigned to 15 rose clumps each for a total of 225 experimental units. In Pasture 2, the same 15 treatments were assigned to 10 individual rose clumps each for 150 total experimental units. To account for variation in the size of individual rose clumps, each was classified according to diameter: small (< 1 m), medium (1 to 2 m), large (2 to 3 m), and very large (3 to 4 m). Clump height in both pastures was not individually measured before treatment but ranged from 0.5 to 1 m. Herbicide treatments included metsulfuron (0.02 kg ha^{-1}) (Escort®, Dupont); aminopyralid (0.12 kg ha^{-1}) (Milestone®, Dow AgroSciences); aminopyralid + metsulfuron (0.09 + 0.016 kg ha^{-1} and 0.12 + 0.02 kg ha^{-1}) (Chaparral®, Dow AgroSciences); aminopyralid + 2,4-D (0.12 + 0.97 kg ha^{-1}) (GrazonNext®, Dow AgroSciences); picloram + 2,4-D (0.3 + 1.12 and 0.6 + 2.24 kg ha^{-1}) (Grazon P+D®, Dow AgroSciences); picloram + fluroxypyr (0.28 + 0.28 kg ha^{-1} and 0.38 + 0.38 kg ha^{-1}) (Surmount®, Dow AgroSciences); triclopyr (0.56 and 1.12 kg ha^{-1}) (Remedy®, Dow AgroSciences); aminopyralid + 2,4-D + triclopyr (0.12 + 0.98 + 0.56 kg ha^{-1}); and aminopyralid + metsulfuron + triclopyr (0.09 + 0.016 + 0.56 kg ha^{-1}) (Table 1). A nonionic surfactant at 0.25% v/v was

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Table 1. Arrangement of 15 treatments with respect to formulation, rates, and tank mixes with triclopyr.

Formulation	Low rate	High or only rate	Triclopyr tank mix
	kg ha^{-1}		
Triclopyr	0.56	1.12	—
Aminopyralid	—	0.12	—
Metsulfuron	—	0.02	—
Aminopyralid + metsulfuron	0.09 + 0.016	0.12 + 0.02	Low rate + 0.56
Aminopyralid + 2,4-D	—	0.12 + 0.97	Only rate + 0.56
Picloram + 2,4-D	0.3 + 1.12	0.6 + 2.24	—
Picloram + fluroxypyr	0.28 + 0.28	0.38 + 0.38	—
Mow	—	—	—
Untreated check	—	—	—

included with all treatments. Two additional treatments were mowing (without herbicide) at the time of herbicide treatment and an untreated control. First-year herbicide treatments were broadcast-applied across individual rose clumps on August 21, 2009 with a custom-built, 3-m side-mounted ATV boom sprayer. The application volume was 327 liters ha^{-1} and used a compressed air system at a pressure of 290 kPa (42 psi). The mowing treatment was done with a tractor mounted bush hog at a cutting height of approximately 10 cm. Second-year herbicide treatments and the mowing treatment were applied to the same experimental units in a similar manner on August 21, 2010. The August application timing was selected because many cattlemen in the Blackbelt prairie frequently delay pasture herbicide treatments until summer to allow clovers to fully produce seed in the spring (J. Gladney, personal communication).

In February 2011, approximately one-half of the rose clumps (experimental units) from every treatment in both pastures were randomly selected and mowed in a similar manner as previously described. For Pasture 1, which had 15 experimental units for each treatment, seven were randomly selected for this mowing. For Pasture 2, which had 10 experimental units per treatment, five were randomly selected for this mowing. The timing of this mowing was 6 mo after the final herbicide treatment but prior to the onset of new spring growth. The timing of this mowing was set to allow the maximum possible time after herbicide treatment before initiation of new growth the following spring.

Meyer and Bovey (1984) found Macartney rose control evaluations approximately 1 yr after treatment to be most useful for quantifying maximum canopy reduction and death of plants. Therefore, data was collected 11 mo after initial treatment (MAIT) and 12 mo after retreatment (MART). Visual percent control of treated rose plants, where zero equals no control and 100 equals complete control, was estimated by comparing each treated plant to the untreated control plants. In 2011, visual control estimates compared treated plants to appropriate mowed or unmowed plants from the untreated controls. Additionally, height of all rose clumps was measured at the end of the study to quantify regrowth.

Statistical Analysis. Treatments were compared in terms of visual percent control at 11 and 24 mo (after initial treatment), percent mortality at 24 mo, and clump height at 24 mo. A combined analysis was performed using the Mixed procedure (SAS Institute Inc., Cary, NC) with pasture treated as a random block effect. Treatments within a pasture were considered a completely random assignment for percent control and height data. The analysis of mortality used average percent mortality for each treatment within a pasture. The arcsin–squareroot transformation was used to stabilize variance of the residuals for percent control and percent mortality (Mendenhall 1968). Untransformed means and confidence intervals are reported for ease of interpretation.

Clumps were classified into four diameter classes: $<$ 1 m, 1 to 2 m, 2 to 3 m, and 3 to 4 m in diameter. Clump size was not initially accounted for, and depended on what was available at the time of treatment assignment. Clump size was tested as a covariate to examine its effect on percent control using the midpoint value for each clump diameter class. The relationship between clump size and percent control could vary by treatment, so both a test of treatment interaction with the covariate and test of a common slope for the covariate were performed. There was no significant interaction between treatment and clump size for percent control at either 11 ($P = 0.81$) or 24 mo ($P = 0.53$). Percent control was not found to be related to clump size when clump size was added as a common covariate to the analysis of 11-mo percent control ($P = 0.36$) or 24-mo percent control ($P = 0.43$). Therefore, clump size was ignored in the remaining analysis due to lack of evidence of a relationship with percent control.

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The analysis of 11-mo percent control compared 15 treatments (13 herbicide treatments, mowing only, and an untreated check). The analysis of 24-mo percent control, percent mortality, and clump height compared these 15 treatments with and without subsequent 18-mo mowing. A repeated measures analysis was performed to determine if retreatment improved control using only the 15 treatments without mowing because mowing was not a factor for the 11 mo evaluation. The repeated measures analysis used a heterogeneous compound symmetry covariance structure (Littell et al. 2006) to model covariance between measurements (variance was greater at 24 mo).

Field studies are often limited in the number of treatment combinations included due to space constraints. This experiment did not include all combinations but did arrange sets of treatments in a factorial-like structure (Table 1) that allows specific comparisons to be made in a planned fashion. Contrast statements were used in SAS Proc Mixed to test the appropriate sub-main effects and interaction, where applicable, for each of these factorial-like structures. This provided a powerful test of an effect, such as rate, and was used to group treatments based on nonsignificant effects as would be done with a simple factorial design. The use of high vs. low rates could be tested for four herbicide formulations (triclopyr, aminopyralid + metsulfuron, picloram + 2,4-D, and picloram + fluroxypyr). The use of triclopyr tank mixed with aminopyralid + metsulfuron and aminopyralid + 2,4-D could be compared to these treatments without triclopyr. The aminopyralid, metsulfuron, high-rate aminopyralid + metsulfuron, and check treatments form a 2 by 2 structure to test herbicide effects and interaction for these treatments. Interactions of these effects and the 18-mo mowing factor were also tested for the 24-mo evaluations.

At 24 mo there are a total of 30 treatment combinations (treatments and 18-mo mow combinations) to summarize in a concise fashion. The methods used here were to list the 15 treatment means in a table for 11-mo percent control along with their 95% confidence intervals. Specific statistical tests performed are noted in the text. The 24-mo summaries (which include the additional mowing factor to all treatments) for percent control and percent mortality group treatments based on significant effects and interactions using a significance level of 0.10 to avoid obfuscation of trends. This grouping of treatment means is indicative of significant effects and condenses results using planned comparisons. The 95% confidence interval can be used to compare group means. Note that the confidence interval depends on the number of treatment combinations in a group. The same approach is used for 24-mo clump height but means are kept separate for levels of the 18-mo mow treatment because mowing directly affects height. This presentation method groups treatments based on statistical tests, ranks these groups in terms of efficacy, and provides a confidence interval on expected results.

Results and Discussion

At 11 mo after the initial treatment timing, mowing did not control Macartney rose ($P = 0.91$) and rose clumps had new growth similar to or greater than the unmowed clumps as indicated by percent control evaluations (Table 2). Macartney rose is a vigorous sprouter following mowing, with new growth emerging from the root crowns and lateral roots. Additionally, mowing did not control many prostrate stems growing along the ground. Herbicide efficacy was very poor across all treatments and the best treatment (picloram + 2,4-D) provided only 35% control of Macartney rose (Table 2). In general, new growth was noted from older canes that were not completely killed, as well as from the root crown and creeping roots.

Contrasts designed to compare low and high rates of specific herbicides at 11 MAIT did not elucidate any differences for triclopyr at 0.56 vs. 1.12 kg ha^{-1} ($P = 0.74$), picloram + 2,4-D at 0.3 + 1.12 vs. 0.6 + 2.24 kg ha^{-1} ($P = 0.29$), picloram + fluroxypyr at 0.28 + 0.28 vs. 0.38 + 0.38 kg ha^{-1} ($P = 0.25$), or aminopyralid + metsulfuron at 0.09 + 0.016 vs. 0.12 + 0.2 kg ha^{-1} ($P = 0.12$). Additionally, tank mixing triclopyr (0.56 kg ha^{-1}) with aminopyralid + 2,4-D (0.12 + 0.97 kg ha^{-1}) did not improve control ($P = 0.35$) with control of 27% for aminopyralid +2,4-D compared to 18% for the combination with triclopyr. Adding triclopyr (0.56 kg ha^{-1}) to aminopyralid + metsulfuron (0.09 + 0.016 kg ha^{-1}) did not improve control ($P = 0.43$). Finally, the combination of aminopyralid + metsulfuron (0.12 + 0.02 kg ha^{-1}) was not significantly better than aminopyralid (0.12 kg ha^{-1}) alone (Table 2), as indicated by a significant treatment interaction ($P = 0.03$).

Herbicide combinations that incorporate triclopyr and metsulfuron are commonly used for control of woody invaders and brambles such as *Rubus* spp. in pasture situations (Ferrell et al. 2009). However, these findings suggest that tank mix prescriptions of triclopyr with aminopyralid + 2,4-D or aminopyralid + metsulfuron might not improve Macartney rose control. It is also clear that Macartney rose did not respond in a meaningful fashion after one treatment to either triclopyr or metsulfuron alone or in combination with other herbicides (Table 2). Overall, percent control 11 MAIT indicated that none of these herbicide treatments provided meaningful Macartney rose control with a single late summer broadcast treatment. This is very noteworthy because these herbicide treatments encompass almost all of the commercial standards for broadleaf weed control in pastures.

The repeated measures analysis was limited to non-mowed retreatments. Retreatment often improved control, but control depended on the specific herbicide formulation with respect to comparing a herbicide formulation to the check or comparing a low vs. high herbicide rate. Percent control 24 mo after initial treatment (12 mo after

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Table 2. Macartney rose control 11 mo after initial treatment. CI, confidence intervals.

Treatment	Rate	% control	95% CI
	kg ha^{-1}		
Untreated	—	0	0–8
Mowing only	—	0	0–7
Triclopyr	1.12	7	0–26
Triclopyr	0.56	9	0–29
Aminopyralid + metsulfuron	0.09 + 0.016	16	2–38
Metsulfuron	0.02	16	2–39
Aminopyralid + 2,4-D + triclopyr	0.12 + 0.97 + 0.56	18	3–42
Picloram + fluroxypyr	0.28 + 0.28	22	5–47
Aminopyralid + metsulfuron + triclopyr	0.09 + 0.016 + 0.56	23	5–47
Picloram + 2,4-D	0.3 + 1.12	24	6–49
Aminopyralid + 2,4-D	0.12 + 0.97	27	8–52
Aminopyralid	0.12	28	9–54
Aminopyralid + metsulfuron	0.12 + 0.02	30	10–56
Picloram + fluroxypyr	0.38 + 0.38	34	12–60
Picloram + 2,4-D	0.6 + 2.24	35	13–60

retreatment) was improved ($P < 0.05$) for aminopyralid, metsulfuron, aminopyralid + metsulfuron, aminopyralid + 2,4-D, picloram + 2,4-D, and picloram + fluroxypyr (data not shown). However, differences between years were only additive for picloram + fluroxypyr and between rate and year for picloram + 2,4-D (data not shown). There were no significant interactions between year and triclopyr-only treatments (2 rates) but control decreased ($P = 0.03$) with retreatment (6% at 11 mo vs. 1% at 24 mo). The mow-only retreatment improved control from 0 to 15% ($P = 0.01$). This repeated measures analysis was useful to determine that control was often improved by retreatment but a separate 24-mo analysis might better characterize treatment differences dependent on specific combinations, including the additional 18-mo (6 mo after retreatment) mowing factor.

Twenty–four-mo percent control comparisons included the additional factor of 18-mo mowing for each treatment. Triclopyr did not control Macartney rose and control was not dependent on rate or the 18-mo mowing operation (Table 3). Other treatments did provide some level of control but 18-mo mowing did not improve control for the untreated check (data not shown), mowing alone, triclopyr alone, metsulfuron alone, aminopyralid alone, aminopyralid + 2,4-D, aminopyralid + 2,4-D + triclopyr, or picloram + fluroxypyr. The 18-mo mowing was important when used in combination with aminopyralid + metsulfuron, aminopyralid + metsulfuron + triclopyr, and picloram + 2,4-D. High and low herbicide rates did not differ for picloram + fluroxypyr or triclopyr alone. Twenty–four-mo percent control depended on the combination of rate and 18-mo mowing for aminopyralid + metsulfuron and picloram + 2,4-D. Percent control of 72 to 91% for the top four treatments was obtained by low or high rates of picloram + 2,4-D or aminopyralid + metsulfuron combined with 18-mo mowing (Table 3).

At 24 mo after initial treatment (12 mo after retreatment), percent clump morality was 32% or less (Table 4). The high rate of picloram + fluroxypyr with mowing, high rate of aminopyralid + metsulfuron with mowing, low rate of picloram+2,4-D with mowing, and aminopyralid + 2,4-D with or without mowing, had mortality rates of 15 to 17%. The high rate of picloram + 2,4-D with mowing averaged 32% mortality.

Because mortality was low, we also evaluated rose clump height 24 mo after initial treatment. Clump heights can provide some measure of vigor and sprouting ability following treatment. Mowing is expected to directly influence clump height, but to a greater extent if herbicide treatments suppressed regrowth. Treatments with the greatest reductions in clump height from regrowth were combinations of mowing with aminopyralid, aminopyralid + 2,4-D, aminopyralid + metsulfuron, and picloram + 2,4-D (Table 5).

These results indicate that the best possible Macartney rose control is still achieved with high rates of picloram + 2,4-D. Triclopyr did not control Macartney rose and might have been somewhat antagonistic with aminopyralid + 2,4-D and aminopyralid + metsulfuron. Metsulfuron alone performed poorly, and adding it to aminopyralid did not improve control. Surprisingly, picloram + fluroxypyr performed very poorly at the rates tested and resulted in only 0 to 4% clump mortality.

Some of these results are not surprising and are in agreement with previously published studies. Meyer and Bovey (1990) found sulfonylurea chemistries, including metsulfuron and chlorsulfuron, were largely ineffective in controlling Macartney rose at rates ranging from 0.28 to 1.12 kg ha^{-1}. They found metsulfuron at 0.28 kg ha^{-1}

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Table 3. Macartney rose control 24 MAIT based on significant effects.

Treatments in average[a]	N[b]	% Control[c]	95% CI
Triclopyr, low & high rates, no mow & mow	4	2	0–5
Mow alone, no mow & mow	2	14	6–24
Metsulfuron alone, no mow & mow	2	25	14–38
Aminopyralid + metsulfuron + triclopyr, mow	1	27	12–46
Aminopyralid + 2,4-D + triclopyr, no mow & mow	2	30	18–43
Aminopyralid + metsulfuron, low rate, no mow	1	33	16–52
Aminopyralid + metsulfuron + triclopyr, no mow	1	38	20–57
Picloram + fluroxypyr, low & high rates, no mow & mow	4	45	35–55
Picloram + 2,4-D, low rate, no mow	1	54	34–73
Aminopyralid + metsulfuron, high rate, no mow	1	60	40–78
Aminopyralid alone, no mow & mow	2	60	46–73
Aminopyralid + 2,4-D, only rate, no mow & mow	2	64	51–77
Picloram + 2,4-D, high rate, no mow	1	65	45–82
Picloram + 2,4-D, low rate, mow	1	72	53–87
Aminopyralid + metsulfuron, low rate, mow	1	75	56–89
Aminopyralid + metsulfuron, high rate, mow	1	81	63–93
Picloram + 2,4-D, high rate, mow	1	91	77–99

[a] Treatment averages combine herbicide rates and 18-mo mowing unless rate, mowing, or the interaction of herbicide rate and mowing were significant ($P < 0.10$).

[b] N is the number of rate and 18-mo mow combinations averaged.

[c] Treatment averages are ranked and can be compared using the 95% confidence interval (CI). Average differs from the check if the confidence interval does not include 0% control.

reduced canopy cover by 59 to 68% with only 10 to 20% kill of rose plants. Chlorsulfuron was less effective and provided only a 49% reduction when applied at 0.28 kg ha^{-1} with only 8% kill of rose plants. However, current herbicide labels restrict metsulfuron and chlorsulfuron use to much lower rates in range and pastures. In the present study, metsulfuron was applied at 0.02 kg ha^{-1}, a ten-fold decrease, compared to Meyer and Bovey's (1990) lowest rate.

Meyer and Bovey (1990) also found that triclopyr applied at 0.56 and 1.12 kg ha^{-1} resulted in a 22 to 32% reduction in canopy cover with no complete kill of rose plants. These results were comparable with our finding of no mortality with triclopyr at these rates.

Table 4. Macartney rose percent clump mortality 24 mo after initial treatment (MAIT), based on significant effects.

Treatments averaged[a]	N[b]	% Mortality[c]	95% CI
Triclopyr, low rate, mow	1	3	0–13
Aminopyralid alone, no mow & mow	2	4	1–11
Picloram + 2,4-D, high rate, no mow	1	11	2–26
Picloram + fluroxypyr, high rate, mow	1	15	4–31
Aminopyralid + metsulfuron, high rate, mow	1	16	5–32
Picloram + 2,4-D, low rate, mow	1	16	5–32
Aminopyralid + 2,4-D, no mow & mow	2	17	8–28
Picloram + 2,4-D, high rate, mow	1	32	16–51

[a] Treatment averages combine rates and 18-mo mowing unless rate, mowing, or the interaction of rate and mowing were significant ($P < 0.10$).

[b] N is the number of rate and 18-mo mow combinations averaged.

[c] Treatment averages are ranked and can be compared using the 95% confidence interval (CI). Only treatment averages with greater than 0% average mortality are shown.

Table 5. Summary of Macartney rose clump height (ht.) averages 24 mo after initial treatment (MAIT) based on significant effects.

Treatments averaged[a]	N[b]	Mow Signif.[c]	No mow Ht.	No mow 95% CI	Mow Ht.	Mow 95% CI
			cm			
Triclopyr, low & high rate	2	yes	61[d]	56–69	43	36–48
Untreated check	1	yes	56	48–64	41	33–51
Mow alone	1	no	43	36–53	38	30–48
Metsulfuron alone	1	no	46	36–53	36	28–43
Aminopyralid + 2,4-D + triclopyr	1	yes	56	48–66	33	25–43
Picloram + fluroxypyr, low & high rate	2	yes	51	43–56	30	23–36
Aminopyralid + metsulfuron + triclopyr	1	yes	46	38–56	30	23–36
Aminopyralid + metsulfuron, low rate	1	yes	56	46–64	28	18–36
Picloram + 2,4-D, low rate	1	yes	46	38–56	28	18–36
Aminopyralid alone	1	yes	48	38–56	25	15–33
Aminopyralid + metsulfuron, high rate	1	yes	46	36–53	20	13–30
Aminopyralid + 2,4-D, only rate	1	yes	43	36–53	20	10–28
Picloram + 2,4-D, high rate	1	yes	36	25–43	15	5–23

[a] Treatment averages combine rates unless rate or the interaction of rate and 18-mo mowing were significant ($P < 0.10$).

[b] N is the number of rates averaged.

[c] Significant differences ($P < 0.05$) due to 18-mo mowing are indicated by a "yes."

[d] Means can be compared between no-mow and mow as well as between treatments using the 95% confidence interval (CI).

Our results, however, were slightly better for picloram + 2,4-D. Meyer and Bovey (1990) found picloram + 2,4-D (0.56 + 2.2 kg ha^{-1}) resulted in a 28% reduction in canopy cover with no complete kill of rose plants, whereas we found approximately 20% mortality with the same treatment.

Earlier work by Meyer and Bovey (1984) found that rose control was lost between picloram rates of 4.5 and 2.2 kg ha^{-1} and that triclopyr at 4.5 kg ha^{-1} failed to control Macartney rose at 1 yr after treatment when applied in June or July. Meyer et al. (1976) found that picloram applied at 1.12 kg ha^{-1} resulted in a 21 to 69% Macartney rose canopy reduction and 0 to 38% plant death. Current maximum labeled use rates for picloram in range and pasture is 1.12 kg ha^{-1}, so repeated treatment over many years might be necessary for effective control of established stands.

In reviewing studies of herbicide efficacy on other invasive roses, it is clear that Macartney rose is much more difficult to control than multiflora rose (*Rosa multiflora* Thunb. ex. Murr.). Derr (1989) found that metsulfuron applied in the spring at 0.02 kg ha^{-1} provided greater than 95% control of multiflora rose clumps 320 d after treatment. Fall applications resulted in 55 to 96% control the following year. Other researchers have reported that both picloram + 2,4-D and triclopyr provided excellent multiflora rose control (Reed and Fitzgerald 1979; Sherrick and Holt 1977). There have been no published studies evaluating Cherokee rose control for pastures.

These results support the previously published work that combinations of picloram + 2,4-D provide the most effective control and are improved with additional control measures such as mowing. Newer herbicides combinations such as picloram + fluroxypyr, which generally provides excellent pasture weed control are not as effective on Macartney rose. Future research efforts should focus on understanding the mechanisms of herbicide tolerance exhibited by Macartney rose so better strategies can be developed.

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