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Editor: Linda Chalker-Scott

Hawbaker, I.[1], Seipel, T.[3], Mills, S.[2]

[1]Daniels County MSU Extension Agent, Montana State University Extension, Scobey, Montana, 59263
[2]Assistant Research Professor, Extension Cropland Weed Specialist, Montana State University Extension, Bozeman, Montana, 59717-3120
[3]Valley County MSU Extension Agent, Montana State University Extension, Glasgow, Montana, 59230

Effectiveness of Chemical and Mechanical Management on Perennial Baby's Breath in Conservation Reserve Program, Rangeland, Pasture, and Hayland

Abstract

Our understanding of the invasive potential of *Gypsophila paniculata* L. (baby's breath) and the ecological and economic consequences has progressed in recent years. However, there is a lack of information concerning management of the invasive species using chemical control in Conservation Reserve Program (CRP), rangeland, pasture, and hayland. This study investigated the herbicide and mowing options in perennial ecosystems in northeastern Montana using a split plot randomized complete replicate design with three replicates. Three different herbicides applied in the fall, spring, or fall and spring, and a non-sprayed control were applied for a total of 10 treatments. The herbicide active ingredients (a.i.) evaluated included imazethapyr, dicamba, and metsulfuron-methyl. The split plot included (non)-mowed to simulate dryland haying operations utilized by producers in the region. Herbicide treatments containing the a.i. metsulfuron-methyl significantly reduced the density of baby's breath at the end of the three-year study, strongly indicating that active ingredient is more important than timing. Mowing had no effect on density of baby's breath (P=0.3930) and did not interact with

herbicide treatment (P=0.3067). Perennial grass cover was not affected by herbicide treatment over the three-years (P=0.6101). Metsulfuron-methyl treatments applied in the spring were the most effective in reducing the density of baby's breath. Mowing or haying should not be used as standalone treatments for baby's breath, as mowing does not affect the density of baby's breath. Furthermore, if admissible for the site, mowing or haying operations should take place before the flowering stage to effectively inhibit seed production.

Introduction

Baby's breath (*Gypsophila paniculata* L.) is a highly adaptive, herbaceous perennial that was introduced to North America from Eurasia for ornamental purposes as early as 1887 (Darwent, 1975). While still used extensively in the floral industry, baby's breath is considered a naturalized garden escape, has high reproductive and dispersal potential, and is listed as a noxious weed in some states and Canadian provinces (Darwent, 1975; Darwent and Coupland, 1966; DiTomaso et al., 2013). Although baby's breath is not listed as a state noxious weed in Montana, the species has been listed as a county noxious weed in 14 of 56 counties (Montana State University Extension, 2015). Because of its ability to grow in coarse-textured soils, the invasive species thrives across the semi-arid landscape of northeastern Montana. Baby's breath has been associated with shifts in plant community composition, structure, and displacement of desirable native and forage species disrupting ecosystem function (Baskett et al., 2011; Brusati, 2016; Darwent and Coupland, 1966;). Baby's breath poses a significant problem for land managers and producers in the region, where it has invaded thousands of hectares of Conservation Reserve Program land (CRP), rangeland, pasture, and hayland (Figure 1). CRP is a land conservation program administered by Farm Service Agency (FSA) that encourages eligible producers to remove environmentally sensitive land from crop production and convert it to valuable land cover (Daniels County Long Range Plan, 2019). Implementing control methods such as mowing or herbicide applications on invaded CRP hectares may be contingent on the primary bird nesting period, thus limiting their feasibility as management tools (USDA NRCS, 2023).

Baby's breath infestations are often found in habitats where heavy, continual grazing, or regular, intense cultivation are not practiced (Darwent et al., 1967). The tumbling dispersal behavior of baby's breath results in infestations along roadsides, ditches, and fence lines (Figure 2). Baby's breath has been known to tolerate shallow tillage, but frequent, deep tillage can stave off establishment and survival of plants (Darwent et al., 1967; DiTomaso et al., 2013). But tillage has implications for soil erosion, soil health, and habitat provided by rangeland and CRP (Seitz et al., 2019).

Figure 1: Baby's breath (*Gypsophila paniculata*) infestation in Conservation Reserve Program hectares in Daniels County, Montana. Photos: Inga Hawbaker.

Mowing can be used to decrease annual seed set and to increase the availability of resources for desirable plants. Research indicates that baby's breath seeds continue to ripen when discarded in cut floral bouquets, suggesting mowing or haying operations should take place before flowering to inhibit seed production (DiTomaso et al., 2013; Sheley et al., 2017; Washington State Noxious Weed, 2021). Prior research indicates that mowing does not have a noticeable effect on the vigor or abundance of existing baby's breath plants (DiTomaso et al., 2013).

Herbicides with varying modes of action have been used to manage baby's breath. Post-emergent herbicides used in perennial landscapes include 2,4-D, dicamba, glyphosate, chlorsulfuron, imazapic, and metsulfuron-methyl (DiTomaso et al., 2013). All herbicides are recommended as post emergent treatments when plants are rosettes or are bolting (DiTomaso, 2013; Prather and Peachey, 2022). Peer reviewed research is limited regarding effectiveness or results of these treatments. The herbicide a.i. selected as treatments in this project included imazethapyr, metsulfuron-methyl, and dicamba.

The objective of this study was to improve baby's breath management by addressing the following: 1) identify a treatment regime that provided effective control of baby's breath; 2) determine whether herbicide application timing, or mowing as a treatment, lends value to an herbicide management program; and 3) identify a treatment regime with minimal injury to desirable vegetation, specifically perennial grasses. Perennial grass species include but are not limited to crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.), smooth brome (*Bromus inermis* Leyss.), blue grama (*Bouteloua gracilis* Willd), western wheatgrass (*Elymus smithii* Rydb) and needle and thread grass (*Stipa comata* Trin. & Rupr.).

Figure 2: Baby's breath (*Gypsophila paniculata*) (a) mature plant late in the season (b) broken plants caught in fence along roadside. Photos: Inga Hawbaker.

Materials and Methods

A field trial was conducted from fall of 2020 to summer of 2023 on a formerly renovated CRP field in Daniels County, Montana. The experiment was conducted on sandy-loam soil in the frigid Typic Argiustolls class. Average annual precipitation for the area is 320 mm with the majority falling in May, June, and July (Western Regional Climate Center, 2023). The field trial used a split-plot randomized complete replicate design with three replicates measuring 3 m by 9m each. Each replicate was divided in half and one side was determined at random to receive a mowing treatment (split-plot).

Three different herbicides applied in the fall, spring, or fall and spring, and a non-sprayed control were applied for a total of 10 treatments (Table 1). The split plot included (non)-mowed to simulate dryland haying operations. Herbicide applications were made using a handheld CO_2 pressurized backpack sprayer and a 4-nozzle hand boom with 19-inch spacing. Standard Teejet® flat fan nozzles were used at 60 psi to deliver 16 gallon per acre (GPA) spray volume. The herbicides selected as treatments in this project included imazethapyr (Pursuit®, BASF Corporation, Research Triangle Park, NC), metsulfuron-methyl (Omni® Brand MSM 60 DF, Helena Chemical Company, LLC, Collierville, TN), and dicamba (Opti-DGA™, Helena Agri-Enterprises, LLC, Collierville, TN). All herbicides were applied with non-ionic surfactant alkyl aryl polyoxlkane ethers (Induce®, Helena Agri-Enterprises, LLC, Collierville, TN) at 0.25% v/v herbicide solution. Fall herbicide treatments were applied on 16 September 2020, 16 September 2021, and 29 September 2022. Spring herbicide treatments were applied on 15 May 2021, 2 June 2022, and 17 June 2023. Split-plots were mowed to 8 cm with a brush mower (18hp DR®, DR Power Equipment, Vergennes, Vermont) on 5 August 2020, 13 August 2021, and 31 August 2022.

Data collection occurred on 28 July 2021, 17 August 2022, and 28 August 2023. To limit subjectivity, field teams consisted of two experienced persons that made measurements, and two recorders. Data collected included: the number of individuals, plant height, number of stems, diameter of plants, and flower stage. Canopy cover was evaluated based on the following functional groups: perennial forbs, perennial grasses, annual forbs, annual grasses, litter, and bare ground. A 20 cm x 50 cm Daubenmire (1959) frame was used to estimate cover; three frames were randomly placed in the center of each split-plot and cover to the nearest 1% of each functional group was recorded. A 0.61-m buffer between adjacent plots within replicates was excluded to avoid edge effects.

All statistical analyses and graphics were performed and produced using R, version 4.3.2 (2023-10-31 ucrt). Differences between all explanatory and response variables for the models were analyzed at the $P < 0.05$ level.

Table 1. Herbicide treatments applied to baby's breath (*Gypsophila paniculata)* in Daniels County, MT.

Herbicide Chemical Name	Herbicide Trade Name	Rate	Spray Season	Spray Year
Control	-	-	-	-
Imazethapyr	Pursuit®	210.2 g ha^{-1} + NIS	Fall	2020, 2021, 2022
Metsulfuron-methyl	Omni® Brand MSM 60 DF	46.9 g ha^{-1} + NIS	Fall	2020, 2021, 2022
Dicamba	Opti-DGA™	280.2 g ha^{-1} + NIS	Fall	2020, 2021, 2022
Imazethapyr	Pursuit®	210.2 g ha^{-1} + NIS	Spring	2021, 2022, 2023
Metsulfuron-methyl	Omni® Brand MSM 60 DF	46.9 g ha^{-1} + NIS	Spring	2021, 2022, 2023
Dicamba	Opti-DGA™	280.2 g ha^{-1} + NIS	Spring	2021, 2022, 2023
Imazethapyr	Pursuit®	210.2 g ha^{-1} + NIS	Fall	2020, 2021, 2022
		210.2 g ha^{-1} + NIS	Spring	2021, 2022, 2023
Metsulfuron-methyl	Omni® Brand MSM 60 DF	46.9 g ha^{-1} + NIS	Fall	2020, 2021, 2022
		46.9 g ha^{-1} + NIS	Spring	2021, 2022, 2023
Dicamba	Opti-DGA™	280.2 g ha^{-1} + NIS	Fall	2020, 2021, 2022
		280.2 g ha^{-1} + NIS	Spring	2021, 2022, 2023

*NIS = Non-ionic surfactant at 0.25% v/v herbicide solution *g ha^{-1} = grams per hectare

Changes in plant density and perennial grass cover were assessed annually over a three-year period following herbicide treatments. Density of baby's breath was analyzed using a linear mixed effects model ('lmer' in R package 'lme4'; Bates et al., 2015). The random effect was plot identity, which was used to account for repeated measures of the same plots over the three-year period. To assess the impact of herbicide treatment and mowing, backwards model selection was used starting with the full model and removing the interactive terms first. The full model had fixed effects of mowing, year, and herbicide, the 3-way interaction between the 3 effects, and the 2-way comparisons of the effects. To simplify models a criterion of alpha=0.05 derived from an F-test ratio was used to justify removal of terms, and type-III analysis of variance (ANOVA) using the Satterthwaite's method was used to estimate degrees of freedom. Using the most parsimonious model, estimated marginal means of baby's breath was calculated and compared using the Tukey *post-hoc* ('emmeans' in R package 'emmeans'; Lenth, 2021). Perennial grass cover was also analyzed using the same backward analysis of variance (ANOVA) procedure. All statistical analyses and graphics were performed and produced using R, version 4.3.2 (2023-10-31 ucrt). Differences between all explanatory and response variables for the models were analyzed at the $P < 0.05$ level.

Results

Density of baby's breath

The density was significantly affected by herbicide treatments (P=0.001; Table 2), and year (P=0.0043), but not by mowing (P=0.3930). The interaction of mowing and herbicide was not significant (P=0.3067). Mowing did not affect density in the non-sprayed control (P=0.3930). Year significantly affected density (P=0.0043). The interaction of herbicide and year was not significant (P=0.4018).

Table 2: Analysis of variance (ANOVA) for a linear mixed effects model of baby's breath relative density in response to herbicide treatment (Herbic); mowing treatment (Mow); over years (Year), and their 2- and 3-way interactions. Significant P-values are in bold type ($\alpha = 0.05$).

Predictor	Sum Sq.	Mean Sq.	NumDF	DenDF	F-value	Pr(>F)
Herbic	192.5	21.4	9	165	65.3	**<0.001**
Mow	0.2	0.2	1	164	0.7	0.3930
Year	3.7	1.8	2	165	5.6	**0.0043**
Herbic: Mow	3.5	0.4	9	155	1.2	0.3067
Herbic: Year	6.1	0.3	18	137	1.1	0.4018
Mow: Year	0.2	0.1	2	135	0.2	0.7965
Herbic: Mow: Year	3.8	0.2	18	117	0.6	0.8786

Metsulfuron-methyl treatments resulted in the lowest density after three years (Figure 3). All herbicides reduced density compared to the non-sprayed control (4.8 plants/13.5 m^2). Spring-only application and combined spring and fall treatments of imazethapyr (3.5 plants/13.5 m^2; 3.6 plants/13.5 m^2) and dicamba (3.3 plants/13.5 m^2; 3.4 plants/13.5 m^2) resulted in higher densities than treatments that contained metsulfuron-methyl. Timing of metsulfuron-methyl treatments affected density, with combined spring and fall application (0.1 plants/13.5 m^2) and spring-only application (1.4 plants/13.5 m^2) being significantly lower than the fall-only application (2.7 plants/13.5 m^2). Timing of dicamba and imazethapyr treatments was not significant.

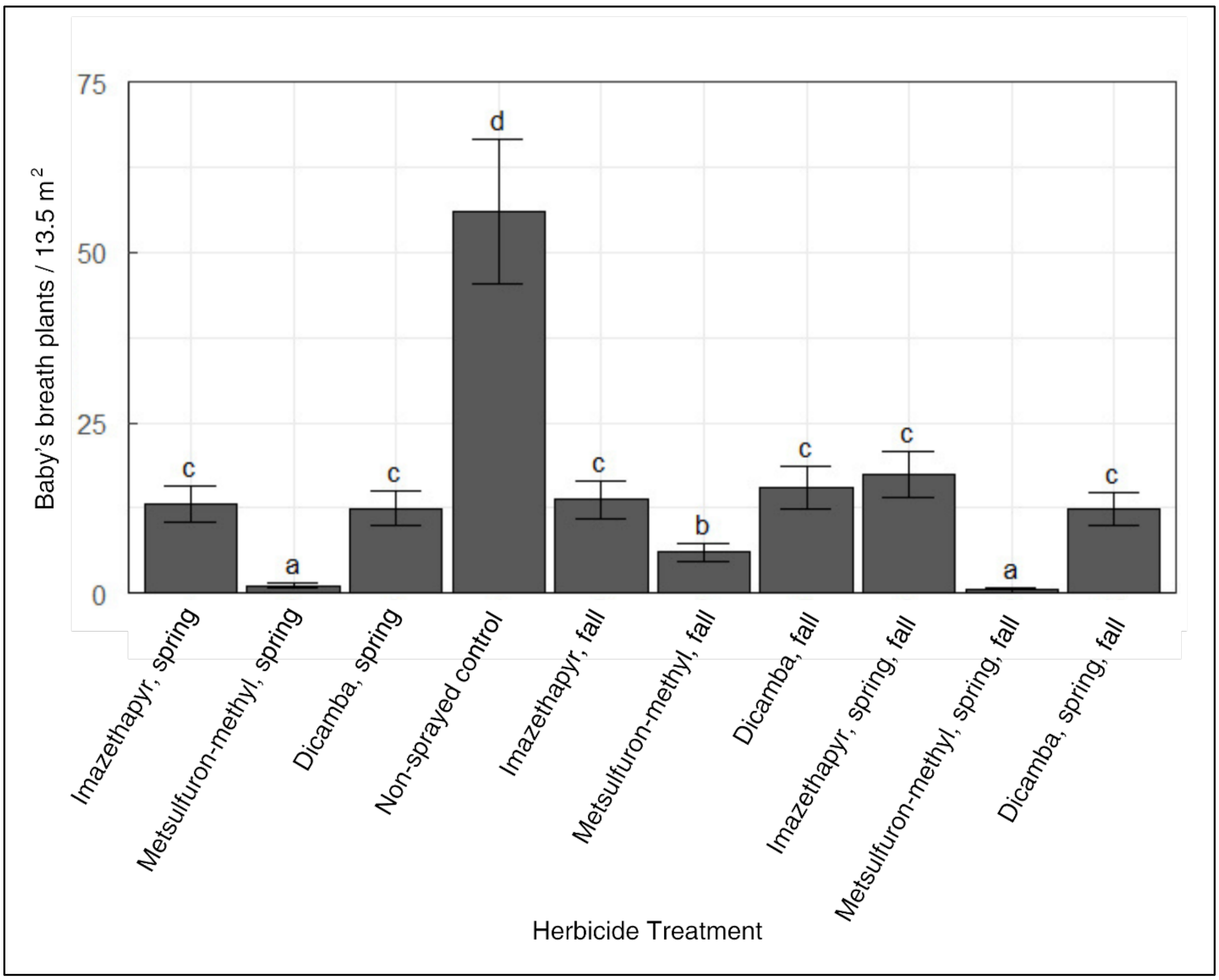

Figure 3: Effects of herbicide treatments on mean density of baby's breath (*Gypsophila paniculata)* per sample unit over a three-year period with 95% confidence intervals. Means for herbicide followed by the same letters are not significantly different (α = 0.05).

Perennial grass response

Perennial grass cover was not affected by the interaction between year and herbicide treatment ($P=0.9695$), by year ($P=0.1138$), nor was it affected over the three years by herbicide treatment ($P=0.6101$). Overt collateral damage to perennial grasses was not observed, despite cautionary statements on the metsulfuron-methyl and imazethapyr product labels stating that injury to perennial grasses may occur. Overt collateral damage to non-target perennial forbs and *Medicago sativa* was also not observed. Perennial forb cover data were convoluted as it included baby's breath, therefore was not statistically evaluated.

Discussion

Effects of herbicide treatments

The findings of this work demonstrate that certain herbicide treatments reduced baby's breath after initial treatment compared to the control and other herbicide treatments. Compared to non-sprayed control (4.8 plants/13.5 m^2), metsulfuron-methyl applied in the spring and fall were the most effective in reducing the density of baby's breath (0.1 plants/13.5 m^2), closely followed by the spring-only treatment of metsulfuron-methyl (1.4 plants/13.5 m^2). Both treatments were different from the fall-applied metsulfuron-methyl treatment (2.7 plants/13.5 m^2). However, the fall-applied metsulfuron-methyl treatment was more effective than the spring-applied imazethapyr and dicamba treatments. This strongly indicates that herbicide a.i. is more important than timing. It also suggests that the residual of fall-applied metsulfuron-methyl inhibits baby's breath spring growth. The results from the study highlight the effective control of the species provided by spring applications of metsulfuron-methyl, and align with previous work (DiTomaso, 2013; Montana State University Extension, 2015).

Imazethapyr and dicamba treatments had similar mean densities of baby's breath, and timing of both active ingredients was not significant. Even though they did not perform as well as metsulfuron methyl, they did reduce baby's breath compared to the non-sprayed control.

Effects of mowing

Mowing did not interact with the herbicide treatment, and it did not affect the density of baby's breath in the non-sprayed control which aligned with previous work (Agriculture Knowledge Centre, 2023; DiTomaso et al., 2013). The results suggest that mowing or haying during the tested period does not lend value to a management program as a stand-alone treatment, especially if applied when plants are beyond the early flowering stages. Proper timing of mowing is critical and should be tailored depending on the growth and flowering pattern of plants species. If properly timed, mowing plants will decrease reproductive potential and competitive abilities and favor desired plants (Flint, 2012; Sheley et al., 2017).

Over the three-year study, baby's breath was in the intermediate to late stages of flowering when mowing was applied, which was too late in the season to effectively inhibit seed production. Baby's breath seeds continue to ripen when discarded in floral arrangements, implying that baby's breath plants will do the same if mowed or harvested when plants are in full bloom or beyond (Darwent & Coupland, 1966; Washington State Noxious Weed, 2021). While mowing or haying operations may be regarded as reducing the number of seeds deposited on site, such activity may spread the species by blowing seeds from the site or transporting them on equipment (Hooks & Joseph, 2022).

Effects on perennial grass cover

Perennial grass cover was not affected by the interaction between year and herbicide treatment. Given the effectiveness of metsulfuron-methyl in reducing baby's breath density, the herbicide deserves further research to determine if it provides control of the species without sacrificing perennial forbs.

Conclusion

Overall, baby's breath invaded ecosystems pose a significant challenge for land managers and producers in northeastern Montana. This study presents results from nine different herbicide treatment regimens evaluated over a three-year period. Metsulfuron-methyl treatments applied in the spring were the most effective in reducing the density of baby's breath. Metsulfuron-methyl deserves further research to determine if the herbicide provides control of baby's breath without sacrificing perennial forbs. Mowing or haying should not be used as standalone treatments for baby's breath, as mowing does not affect the density of baby's breath. Furthermore, if admissible for the site, mowing or haying operations should take place before the flowering stage to effectively inhibit seed production. Perennial grass cover was not affected by herbicide treatment, and overt collateral damage to perennial grasses and perennial forbs were not observed. Prior research conducted regarding control of baby's breath in Montana is limited, therefore additional years of monitoring will occur to determine the long-term effects of the herbicide treatments to refine management decisions.

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