Native Grass and Forb Response to Pre-Emergent Application of Imazapic and Imazapyr

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ABSTRACT: Grassland restoration attempts to rehabilitate and/or re-create biologically diverse native plant communities using a variety of management techniques including seeding, burning, grazing, and most recently herbicides. Herbicides are an important tool for suppressing weed competition for initial seedling growth and removing exotic species in native plant communities. Little information is available on which species of native plants can endure a pre-emergent application of the imidazolinone herbicides. In spring 2006, we initiated a study testing responses of three native grasses and three native forbs to pre-emergent treatments of 0.035 kg ai/ha imazapic, 0.07 kg ai/ha imazapic, and 0.07 kg ai/ha imazapyr. Seedling establishment was monitored at 2.5, 5 and 14 months after treatment and weed cover was monitored at 5 and 14 months after treatment. There were no differences in the number of seedlings found in the untreated plots compared to all the herbicide-treated plots and there were no differences in seedling densities of green needlegrass (Nassella viridula) with the exception of the high imazapic treatment. Showy tick trefoil (Desmodium canadense) and Canada milk vetch (Astragalus crassicarpus) also appear to be able to tolerate applications of all herbicide treatments. There was less weed cover in the herbicide-treated plots when compared to the untreated control plots. This information provides managers options to include these species in initial seeding or restoration projects using these herbicides which may increase diversity and reduce restoration projects cost in the long term.

Index terms: herbicides, imidazolinone, native forb, native grass, restoration, wildflower

INTRODUCTION

Grasslands are among the most threatened terrestrial ecosystems on the globe. Less than 4% of the original 80 million ha of tallgrass prairie remains (Steinauer and Collins 1996). Managers have been recreating or restoring grasslands using a variety of management techniques including seeding, burning, grazing, and most recently using herbicides (Barnes 2007). Some of the restorations are more successful than others and success or failure often depends on how well weed competition is suppressed (Martin et al. 1982; Masters et al. 1996) – typically through the use of herbicides (Masters et al. 1996; Beran et al. 1999a; Barnes 2004). The imidazolinone herbicides have been shown to reduce weed competition and enhance native species stand establishment in the eastern United States (Washburn and Barnes 2000) and in the Great Plains (Masters et al. 1996; Beran et al. 1999a; Beran et al. 1999b; Beran et al. 2000; Washburn and Barnes 2000; Norcini et al. 2003), but the effects of imazapic on species found in the central and western United States is less documented (Bekedam 2005). Furthermore, there has been little work on which native plant species can grow after a pre-emergent application of imazapyr (Shaw et al. 2001).

Restoration projects in the western United States tend to concentrate on a few competitive native species to compete with introduced species such as cheatgrass (Bromus tectorum L.) (Cox and Anderson 2004) or knapweeds (Centaurea sp.) (Reever Morghan and Seastedt 1999). Eastern grassland restoration projects, on the other hand, often model restoration after local prairie remnants (Shramm 1990) and include a much more diverse assortment of native species to achieve more natural successional patterns (Betz 1986). By identifying native grass and forb species that respond favorably to pre-emergent herbicide application, more species could be included in initial restoration plantings, which may allow the community to better adapt to environmental change.
We selected three native grass and three native wildflower species that are commonly found in native grassland communities (Great Plains Flora Association 1986), with easily obtainable seed, and which we thought, based on previous observational information, would have some ability to withstand the herbicides. The species used in the experiment included green needlegrass [Nassella viridula (Trin. & Rupr.) Barkworth], slender wheatgrass [Elymus trachycaulus (Link) Gould ex Shinners], and roundhead lespedeza (Lespedeza capitata Michx.), and groundplum milkvetch (Astragalus cassinus L.).

Three herbicide treatments and an untreated control were randomly assigned and applied to an area approximately 3 m x 20 m. Within each treatment, 36 1 m² subplots were established and each of the species was randomly assigned to six subplots/treatment. Specific herbicide treatments included 0.035 kg ai/ha imazapic (2 oz/ac), 0.07 kg ai/ha imazapic (4 oz/ac), and 0.07 kg ai/ha imazapyr (4 oz/ha).

Seeds were broadcast by hand at ~500 PLS (pure live seed) m⁻² for prairie dropseed and slender wheatgrass and ~300 PLS m⁻² for showy tick trefoil and roundhead lespedeza. PLS calculations were not available for green needlegrass or groundplum milkvetch, so germination rates calculated by the University of Kentucky Seed Testing Laboratory were used in place of PLS to approximate 500 and 300 germinable seeds m⁻², respectively. All seeds were planted < 2 hours following herbicide application on 9 May 2006. Herbicides were mixed with methylated soybean oil at 2.34 l/ha and applied using an ATV-mounted sprayer with 4 TeeJet® 8003 flat fan nozzles, calibrated to deliver 187 L/ha at 241 kPa (35 psi) at 4.8 km/hr. Environmental conditions at the time of spraying included an ambient air temperature of 18 °C, 8 to 13 km/h winds, and 40% relative humidity.

Percent cover of non-planted (weed) species was visually estimated for each 1 m² plot on 27 July 2006, 1 October 2006, and 31 July 2007. The total number of plants that emerged of each species in each plot was counted on 1 October 2006 and again on 31 July 2007. Numbers of planted species were ranked and analyzed using a Kruskal-Wallis One-Way Analysis of Variance (Daniel 1990). Each species of grass and forb was analyzed separately to test for differences in density due to herbicide effects for each time period. If a significant difference was detected, multiple comparisons were made using the procedure described by Dunn (1964) using an experiment wise error rate of α = 0.20. Weed cover data were combined for each treatment, and arcsine squareroot (Zar 1999) transformed values for non-planted species cover were analyzed using the MIXED procedure in SAS (2002). Mean comparisons were made using the PDIFF option in SAS (2002) at the 5% significance level (Littell et al 1996).

RESULTS AND DISCUSSION

Native Grasses

Prairie dropseed did not germinate in untreated plots, and was < 1% in all herbicide-treated plots. Germination of green needlegrass and slender wheatgrass in untreated plots were 7% and 8%, respectively. Herbicide-treated plots ranged from 3% to 7% germination for green needlegrass and 7% to 10% germination for slender wheatgrass.

Pre-emergent applications of 0.07 kg ai/ha imazapic decreased (P = 0.028) density of green needlegrass when compared to control and 0.035 kg ai/ha imazapic and 0.07 kg ai/ha imazapyr 5 months after treatment (MAT), while slender wheatgrass density was similar (P = 0.103) across treatments (Table 1). Pre-emergent applications of 0.035 kg ai/ha imazapic had higher densities of green needlegrass and slender wheatgrass 14 MAT. Green needlegrass and slender wheatgrass densities were similar across the control, 0.07 kg ai/ha imazapic, and 0.07 kg ai/ha imazapyr treatments 14 MAT (Table 1).

Established stands of wheatgrass and needlegrass species are listed as tolerant to imazapic, but new seedlings are not (Anonymous 2002). Our findings suggest that slender wheatgrass and green needlegrass can survive a pre-emergent treatment of imazapic and imazapyr under the environmental conditions that occurred during our study.

Native Forbs

Germination in the untreated plots was 12%, 9%, and 4% for showy tick trefoil, roundhead lespedeza, and groundplum milkvetch, respectively. Herbicide-treated plots ranged from 8% to 16% germination for showy tick trefoil, 0 to 5% germination for roundhead lespedeza, and 5% to 9% germination for groundplum milkvetch.

Showy tick trefoil densities were higher (P = 0.013) in the 0.035 kg ai/ha imazapic and 0.07 kg ai/ha imazapyr treatments than in the 0.07 kg ai/ha imazapic treatment 5 MAT (Table 2), while untreated plots showed no significant difference from herbicide-treated plots. Showy tick trefoil densities were higher (P = 0.017) in the 0.035 kg ai/ha imazapic treatment than in the 0.07 kg ai/ha imazapic treatment 14 MAT, but densities in the 0.07 kg ai/ha imazapic and 0.07 kg ai/ha imazapyr treatments were not significantly different (Table 2). Roundhead lespedeza densities were higher in the control than the herbicide-
treated plots at 5 (P = 0.001) and 14 (P = 0.002) MAT. Canada milkvetch (Astragalus crassicarpus) densities were higher in the 0.035 kg ai/ha imazapic treatment 5 and 14 MAT (Table 2).

Native legumes such as Illinois bundleflower (Desmanthus illinoensis (Michx.) Mac-Mill. ex B.L. Rob. & Fernald), partridge pea (Chamaecrista fasciculata (Michx.) Greene), and purple prairie clover (Dalea purpurea Vent.) have exhibited tolerance to imazapic (Beran et al. 1999b; Beran et al. 2000; Vollmer and Vollmer 1998). Our findings with roundhead lespedeza are consistent with research conducted in Nebraska showing that it is susceptible to injury from imazapic (Beran et al. 1999b). Beran et al. (1999b) reported significant injury to showy tick trefoil at imazapic rates of 0.07 kg ai/ha during the year of establishment, and could potentially be responsible for the lower numbers observed during our study.

Weed Cover

Weed cover was lower (P = < 0.0001) in all treated plots as compared to untreated plots throughout the study (Table 3). Weed cover was similar across herbicide treatments 2.5 MAT. Both levels of imazapic had lower weed cover estimates than the imazapyr treatment 5 MAT, while weed cover was similar across herbicide treatments 14 MAT.

Higher germination rates of green needlegrass, slender wheatgrass, showy tick trefoil, and groundplum milkvetch observed in the 0.035 kg ai/ha imazapic treatment and showy tick trefoil in the 0.07 kg ai/ha imazapyr treatment could be due to lower weed competition as compared to untreated plots (Masters et al. 1996; Beran et al. 1999a; Washburn and Barnes 2000).

We found that these species of native grasses and forbs can become established following pre-emergent applications of imazapic and imazapyr under these growing conditions and soil type. More information is needed to examine other species, soil types, and environmental variables to help broaden applicability of our results. Similar or higher densities of all species, with the exception of roundhead lespedeza, were found in herbicide-treated plots when compared to untreated plots. Roundhead lespedeza showed some tolerance to the 0.035 kg ai/ha imazapic treatment 5 MAT, but establishment 14 MAT was similar to the other herbicide treatments (Table 2). The potential for using roundhead lespedeza is probably limited in restoration projects using pre-emergent treatments of imazapic and imazapyr. This information will allow a greater number of species to be included during the initial stages of the restoration process, potentially reducing costs.

<table>
<thead>
<tr>
<th>Herbicide rates (kg ai/ha)</th>
<th>5 MAT</th>
<th>14 MAT</th>
<th>5 MAT</th>
<th>14 MAT</th>
<th>5 MAT</th>
<th>14 MAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>37 A</td>
<td>10 B</td>
<td>42 A</td>
<td>30 AB</td>
<td>0 A</td>
<td>0 A</td>
</tr>
<tr>
<td>Imazapic (0.035)</td>
<td>36 A</td>
<td>26 A</td>
<td>49 A</td>
<td>42 B</td>
<td>2 AB</td>
<td>1 AB</td>
</tr>
<tr>
<td>Imazapic (0.07)</td>
<td>15 BC</td>
<td>7 B</td>
<td>34 A</td>
<td>22 A</td>
<td>4 AB</td>
<td>2 AB</td>
</tr>
<tr>
<td>Imazapyr (0.07)</td>
<td>28 AC</td>
<td>13 AB</td>
<td>34 A</td>
<td>21 A</td>
<td>6 B</td>
<td>4 B</td>
</tr>
</tbody>
</table>

1 Means within the same column with the same letter are not significantly different (P = 0.05).

Table 2. Average number (rounded to nearest whole number) of native forb seedlings 5 months after treatment (MAT) and adult plants 14 MAT with pre-emergent applications of imazapic and imazapyr.
Table 3. Percent cover of non-planted (weed) species 2.5, 5, and 14 months after treatment (MAT) with pre-emergent applications of imazapic and imazapyr.

<table>
<thead>
<tr>
<th>Herbicide rates</th>
<th>2.5 MAT</th>
<th>5 MAT</th>
<th>14 MAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(kg ai/ha)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated</td>
<td>82 A</td>
<td>100 A</td>
<td>100 A</td>
</tr>
<tr>
<td>Imazapic (0.035)</td>
<td>18 B</td>
<td>62 C</td>
<td>72 B</td>
</tr>
<tr>
<td>Imazapic (0.07)</td>
<td>13 B</td>
<td>52 C</td>
<td>58 C</td>
</tr>
<tr>
<td>Imazapyr (0.07)</td>
<td>27 B</td>
<td>87 B</td>
<td>69 BC</td>
</tr>
</tbody>
</table>

Means within the same column with the same letter are not significantly different (P = 0.05).

ACKNOWLEDGMENTS

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Matt Bahm received a BS in Wildlife Ecology from Oklahoma State University and an MS in Biology from Sul Ross State University. He recently completed his PhD in Wildlife Science from South Dakota State University and is now the Invasive Species Ecologist for Sequoia and Kings Canyon National Parks. His research interests include invasive species (both plant and animal), native habitat restoration, and wildlife responses to restoration practices.

Tom Barnes is an extension professor and extension wildlife specialist at the University of Kentucky. His extension programs focus on urban wildlife conservation, biodiversity protection and conservation, and wildlife damage management. His research interests focus on creation and restoration of native grassland habitats in North America. He is also an author and has published three books including Kentucky’s Last Great Places, which showcases the state’s natural areas and nature preserves in both words and photographs, and which was nominated for the KY Literary Award.

LITERATURE CITED


