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Author(s): Ryan E. Rapp, Avishek Datta, Suat Irmak, Timothy J. Arkebauer, and Stevan Z. Knezevic
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Ryan E. Rapp, Avishek Datta, Suat Irmak, Timothy J. Arkebauer, and Stevan Z. Knezevic*

The nonnative biotype of common reed has invaded wetlands in many states including Nebraska, especially along the Platte River from Wyoming to the eastern edge of Nebraska. Therefore, three studies (disking followed by herbicide, mowing followed by herbicide, and herbicide followed by mechanical treatment) were conducted for 3 yr (2008 to 2010) at three locations in Nebraska. The objective was to evaluate common reed control along the Platte River using an integrated management approach based on herbicides (glyphosate or imazapyr), mowing, and disking, either applied alone or in combination. The level of weed control was determined by visual rating, percent flowering, and stem density. On the basis of visual rating, disking and mowing used alone provided common reed control for only a few months. However, the control was significantly prolonged (e.g., at least three seasons) when disking and mowing were combined with herbicide applications. Disking followed by herbicide and mowing followed by herbicide significantly reduced flowering and plant densities (P = 0.0001) compared to the untreated check. These results suggest that a combination of weed control methods has potential to control common reed.

Nomenclature: Imazapyr; glyphosate; common reed, *Phragmites australis* (Cav.) Trin. ex Steud. subsp. *australis* PHRCO.
Key words: Integrated weed management, invasive, mechanical treatment, herbicide.

El biotipo no nativo de *Phragmites australis*, ha invadido humedales en muchos estados incluyendo Nebraska, especialmente a lo largo del rio Platte de Wyoming hasta el borde este de Nebraska. Por lo tanto, tres estudios (arado de disco seguido de herbicida, corte mecánico seguido por herbicida y herbicida seguido por un tratamiento mecánico) se realizaron por tres años (2008-2010) en tres sitios de Nebraska. El objetivo fue evaluar el control de *P. australis* a lo largo del rio Platte usando un método de manejo integrado basado en el uso de herbicida (glifosato o imazapyr), corte, y arado de disco, ya sea aplicados por sí solos o en combinación. El nivel de control de maleza fue determinado por evaluación visual, porcentaje de floración y densidad de tallos. Basándose en la evaluación visual, el arado de disco o el corte mecánico usados solos, proporcionaron control de *P. australis* solamente por unos cuantos meses. Sin embargo, el control se prolongó significativamente (*e.g.* al menos tres estaciones) cuando el arado de disco y el corte se combinaron con aplicaciones de herbicida. El arado de disco seguido por herbicida o el corte seguido por herbicida, disminuyeron significativamente la floración y la densidad de plantas (P = 0.0001) en comparación con el testigo no tratado. Estos resultados sugieren que una combinación de los métodos de control de maleza, tiene el potencial para controlar *P. australis.*

Common reed, generally known by its Latin name, *Phragmites*, is a common invasive species in Nebraska's wetlands and in many other states of the United States. There are two biotypes of common reed, which include the native common reed [*Phragmites australis* (Cav.) Trin. ex Steud. subsp. *americanus* Saltonstall] and the nonnative one (*P. australis* subsp. *australis*). Both the native and nonnative biotypes can be found along the Platte River, from Wyoming to the eastern edge of Nebraska (Knezevic et al. 2008). The native populations of common reed generally pose no threat to plant communities; however, the nonnative one is a fast spreading biotype that impacts both species diversity and wildlife habitat (Derr 2008b; Knezevic et al. 2008). The nonnative common reed will hereafter be referred to as common reed. Common reed is a perennial grass that spreads vigorously through stolons, rhizomes, and seed dispersal (Ailstock et al. 2001; Blossey et al. 2003; Derr 2008a,b; Knezevic et al. 2008). Its large biomass blocks light to other plants and occupies the majority of growing space above and below ground, transforming the local plant communities into a common reed monoculture. These monotypic stands of common reed have reduced the width of some river systems by causing channelization and decreasing the overall amount and flow of water. Common reed is largely a weed of noncrop land, and its direct economic impact has not been assessed or reported (Blossey 1999; Blossey et al. 2003). The monoculture stands of common reed along the Platte River have reduced wildlife habitat and the aesthetic value of the land for tourism (Knezevic et al. 2008). As a result, there is an increased interest in managing this weed.

A number of methods such as disking, mowing, burning, drainage, flooding, grazing, excavating, and herbicide applications have been suggested or attempted for controlling common reed (Derr 2008a,b; Güsewell et al. 2000; Knezevic et al. 2008; Monteiro et al. 1999). The most common method of control of any weed species has been by herbicides; however, the level of control may be increased by combining chemical and mechanical treatments (Derr 2008a,b; Mozdzer et al. 2008). The use of multiple management strategies may

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* First, second, and fifth authors: Graduate Research Assistant, Postdoctoral Research Associate, and Professor, Department of Agronomy and Horticulture, University of Nebraska, Northeast Research and Extension Center, 57905-866 Road, Concord, NE 68728-2828; third author: Associate Professor, Department of Biological Systems Engineering, University of Nebraska, 241 Chase Hall, Lincoln, NE 68583-0726; fourth author: Department of Agronomy and Horticulture, University of Nebraska, Lincoln, NE 68583-0817. Corresponding author's E-mail: sknezevic2@unl.edu

prove beneficial for improved control of common reed. Mechanical treatments of mowing or disking can reduce initial plant stands by decreasing plant densities. However, such reduction is only temporary, and it does not last long enough to establish native vegetation (Knezevic et al. 2008). There are two major limitations to mechanical control of common reed, including: (1) promotion of soil erosion after heavy rains and/or during high water levels, and (2) difficulty in accessing the areas when water levels are high (Knezevic et al. 2008). Herbicide treatments applied by air tend to be the most efficient method for common reed control from the land-access standpoint, but are costly or even cost prohibitive for many landowners (Knezevic et al. 2008).

Glyphosate and imazapyr have shown the most promising results in chemical control of common reed (Derr 2008a, 2008b). An application of glyphosate followed by burning of dead biomass reduced common reed abundance and increased plant diversity (Ailstock et al. 2001). Research has also shown that a single control measure does not provide long-term and sustainable control of invasive species (Anderson et al. 2003; Monteiro et al. 1999; Moreira et al. 1999; Paynter and Flanagan 2004). Weed management programs based on an integrated approach that includes the use of a variety of mechanical, cultural, chemical, and biological control methods may provide longer and greater control than a single control method. Integrated weed management (IWM) provides strategies for the whole system, rather than focusing on one part of the system (Holt 2004).

To develop an effective IWM plan, additional information is needed on control measures applied alone and in combination to determine the effectiveness of the management techniques in Nebraska. The objective of this research was to evaluate common reed control using an integrated management approach along the Platte River, based on two mechanical methods (disking and mowing) each used alone or in combination with each of two herbicides (glyphosate and imazapyr).

Materials and Methods

Study 1: Disking Followed by Herbicide. In 2008, a disking followed by herbicide trial was initiated at three locations along the Platte River in Nebraska, including: (1) Bassway strip near Gibbon (hereafter referred as disking site 1), (2) Darr strip near Darr (hereafter referred as disking site 2), and (3) Brady (hereafter referred as disking site 3). The trials were established on land with well established common reed stands ranging from 150 to 250 stems m^{-2}. A total of six treatments were tested, including: (1) disking alone in the summer of 2008, (2) disking in the summer of 2008 followed by application of imazapyr in the fall of 2008, (3) disking in the summer of 2008 followed by application of glyphosate in the fall of 2008, (4) disking in the summer of 2008 followed by application of imazapyr in the summer of 2009, (5) disking in the summer of 2008 followed by application of glyphosate in the summer of 2009, and (6) untreated control (no disking or herbicide treatments). Treatments, application timing, and application dates for the trial are listed in Table 1. The study at each location was arranged in a randomized complete block design with three replications. Plot size was 15 m wide and 30 to 90 m long depending on the location. Disking was done on July 15, July 18, and July 16 in 2008 for sites 1, 2, and 3, respectively (Table 1). All locations were disked with a large Tracked Tractor (CAT Challenger 3500 series tractor, Caterpillar Corporate Headquarters, Peoria, IL) pulling a 3.5-m-wide disk set to till at least 30 cm of the soil surface. After disking, each site was divided into individual plots for herbicide application. Imazapyr or glyphosate was applied broadcast as fall treatments on September 15, September 18, and September 17 in 2008 at disking sites 1, 2, and 3, respectively. Summer treatments of herbicides were applied on July 16, July 15, and July 21 in 2009 (Table 1). Treated plants were 2 to 5 m tall and had no flowers. Herbicide treatments were applied utilizing a sprayer with boomless nozzles mounted on the back of a six-wheeler, calibrated to deliver 122 L ha^{-1} at site 1. Marsh Master (Marsh Master MM-2 tracked amphibious vehicle, Coast Machinery LLC, Baton Rouge, LA) was used for sites 2 and 3 to deliver 122 L ha^{-1}. Each sprayer was equipped to apply spray solution above the canopy of common reed. Imazapyr and glyphosate were applied at 1.12 kg ae ha^{-1} (4.7 L ha^{-1} spray solution) and 3.02 kg ai ha^{-1} (4.7 L ha^{-1} spray solution), respectively. A mixture of methylated seed oil (MSO) (1% v/v) (MSO was Cornbelt® Methylated Soy-Stik [100% total principle functioning agents, active ingredients include methylated soybean oil], Van Diest Supply Co., Webster City, IA) and ammonium sulfate (2 kg L^{-1}) was added with each treatment.

Study 2: Mowing Followed by Herbicide. A mowing followed by herbicide study was initiated at three locations along the Platte River in Nebraska in 2008. Mowing locations were within a few hundred meters of the previously mentioned sites in study 1. Hereafter, the sites will be referred as mowing sites 1, 2, and 3. Each site had six treatments, including: (1) mowing applied once in the summer of 2008 plus once in the fall of 2008, (2) mowing in the summer of 2008 followed by imazapyr applied in the fall of 2008, (3) mowing in the summer of 2008 followed by glyphosate applied in the fall of 2008, (4) mowing in the summer of 2008 followed by imazapyr applied in the summer of 2009, (5) mowing in the summer of 2008 followed by glyphosate applied in the summer of 2009, and (6) untreated control (no mowing or herbicide treatments). List of treatments, application timing, and application dates for the study are presented in Table 1. Each study was set up in a randomized complete block design with three replications. Plot sizes were the same as in study 1. At mowing site 1, mowing was done by a Skid Steer (CAT Skid Steer 277B series, Caterpillar Corporate Headquarters) with a shredder head attachment. Mowing sites 2 and 3 were mowed with a Marsh Master, which is a tracked amphibious vehicle with an attached rotary mower powered by a hydraulic motor. Mowing was conducted on July 15, July 18, and July 16 in 2008 for sites 1, 2, and 3, respectively (Table 1). Mowing equipment removed aboveground biomass to heights of 5 to 8 cm. The fall applications of imazapyr and glyphosate were applied on September 15, September 18, and September 17 in 2008 for sites 1, 2, and 3, respectively. The summer applications of imazapyr and glyphosate were applied on July

Table 1. List of treatments, application timing, and application dates for study 1 (disking followed by herbicide), study 2 (mowing followed by herbicide), and study 3 (herbicide followed by mechanical treatment) for three locations in Nebraska, including Bassway strip near Gibbon (site 1), Darr strip near Darr (site 2), and Brady (site 3).

Treatment	Application timing	Site 1	Site 2	Site 3
Study 1				
Disking alone	Summer 2008	July 15, 2008	July 18, 2008	July 16, 2008
Disking + imazapyr	Summer 2008 + fall 2008	September 15, 2008	September 18, 2008	September 17, 2008
Disking + glyphosate	Summer 2008 + fall 2008	September 15, 2008	September 18, 2008	September 17, 2008
Disking + imazapyr	Summer 2008 + summer 2009	July 16, 2009	July 15, 2009	July 21, 2009
Disking + glyphosate	Summer 2008 + summer 2009	July 16, 2009	July 15, 2009	July 21, 2009
Untreated	—	—	—	—
Study 2				
Mowing alone (applied twice)	Summer 2008 + fall 2008	July 15, 2008, September 15, 2008	July 18, 2008, September 18, 2008	July 16, 2008, September 17, 2008
Mowing + imazapyr	Summer 2008 + fall 2008	September 15, 2008	September 18, 2008	September 17, 2008
Mowing + glyphosate	Summer 2008 + fall 2008	September 15, 2008	September 18, 2008	September 17, 2008
Mowing + imazapyr	Summer 2008 + summer 2009	July 16, 2009	July 15, 2009	July 21, 2009
Mowing + glyphosate	Summer 2008 + summer 2009	July 16, 2009	July 15, 2009	July 21, 2009
Untreated	—	—	—	—
Study 3				
Glyphosate only	Summer 2008	July 15, 2008	July 18, 2008	July 16, 2008
Glyphosate + mowing	Summer 2008 + fall 2008	July 15, 2008, September 15, 2008	July 18, 2008, September 18, 2008	July 16, 2008, September 17, 2008
Glyphosate + disking	Summer 2008 + fall 2008	July 15, 2008, September 15, 2008	July 18, 2008, September 18, 2008	July 16, 2008, September 17, 2008
Imazapyr only	Summer 2008	July 15, 2008	July 18, 2008	July 16, 2008
Imazapyr + mowing	Summer 2008 + fall 2008	July 15, 2008, September 15, 2008	July 18, 2008, September 18, 2008	July 16, 2008, September 17, 2008
Imazapyr + disking	Summer 2008 + fall 2008	July 15, 2008, September 15, 2008	July 18, 2008, September 18, 2008	July 16, 2008, September 17, 2008
Glyphosate only	Fall 2008	September 15, 2008	September 18, 2008	September 17, 2008
Imazapyr only	Fall 2008	September 15, 2008	September 18, 2008	September 17, 2008
Imazapyr only (applied twice)	Fall 2008 + summer 2009	September 15, 2008, July 16, 2009	September 18, 2008, July 15, 2009	September 17, 2008, July 21, 2009
Glyphosate only (applied twice)	Fall 2008 + summer 2009	September 15, 2008, July 16, 2009	September 18, 2008, July 15, 2009	September 17, 2008, July 21, 2009
Glyphosate + mowing	Fall 2008 + summer 2009	September 15, 2008, July 16, 2009	September 18, 2008, July 15, 2009	September 17, 2008, July 21, 2009
Glyphosate + disking	Fall 2008 + summer 2009	September 15, 2008, July 16, 2009	September 18, 2008, July 15, 2009	September 17, 2008, July 21, 2009
Imazapyr + mowing	Fall 2008 + summer 2009	September 15, 2008, July 16, 2009	September 18, 2008, July 15, 2009	September 17, 2008, July 21, 2009
Imazapyr + disking	Fall 2008 + summer 2009	September 15, 2008, July 16, 2009	September 18, 2008, July 15, 2009	September 17, 2008, July 21, 2009
Untreated	—	—	—	—

16, July 15, and July 21 in 2009 for sites 1, 2, and 3, respectively. The fall applications of herbicides were sprayed on plants 1 to 2 m tall in a vegetative stage of growth. For the summer applications of herbicides, treated plants were 2 to 5 m tall. Herbicide treatments were applied using the same methods as discussed in study 1 with the same rates and additives.

Study 3: Herbicide Followed by Mechanical Treatment. In 2008, a herbicide followed by mechanical treatment study was initiated at three locations along the Platte River in Nebraska. Locations for study 3 sites were within few hundred meters of the mowing and disking sites. Plant heights and densities were collected in a similar fashion as in studies 1 and 2. A total of 15 treatments were tested, including: (1) glyphosate applied in the summer of 2008, (2) glyphosate applied in the summer of 2008 followed by mowing in the fall of 2008, (3) glyphosate applied in the summer of 2008 followed by disking in the fall of 2008, (4) imazapyr applied in the summer of 2008, (5) imazapyr applied in the summer of 2008 followed by mowing in the fall of 2008, (6) imazapyr applied in the summer of 2008 followed by disking in the fall of 2008, (7) glyphosate applied in the fall of 2008, (8) imazapyr applied in the fall of 2008, (9) imazapyr applied in the fall of 2008 followed by imazapyr applied in the summer of 2009, (10) glyphosate applied in the fall of 2008 followed by glyphosate applied in the summer of 2009, (11) glyphosate applied in the fall of 2008 followed by mowing in the summer of 2009, (12) glyphosate applied in the fall of 2008 followed by disking in the summer of 2009, (13) imazapyr applied in the fall of 2008 followed by mowing in the summer of 2009, (14) imazapyr applied in the fall of 2008 followed by disking in the summer of 2009, and (15) untreated control (no herbicide, mowing or disking treatments). The application dates and treatments can be found in Table 1. The experimental design was the same as described for the previous two studies. The plot size was 8 m wide and 30 to 90 m long, depending on the location. Initial herbicide treatments were applied at sites 1, 2, and 3 on July 15, July 18, and July 16 in 2008, respectively (Table 1). Treated plants were 2 to 5 m tall and in vegetative stage of growth. After the summer of 2008 herbicide applications, mowing or disking was applied to plots that were previously sprayed with an herbicide treatment. Plants in plots that were previously sprayed with herbicide in the summer were not at the flowering stage and were 2 to 5 m tall when mechanical treatments were applied. Fall treatment of herbicides and mowing and disking were applied at sites 1, 2, and 3 on September 15, September 18, and September 17 in 2008, respectively. Plants in plots without previously applied treatments were 2 to 5 m tall and were flowering. Summer treatments of herbicide and mechanical treatments were applied to sites 1, 2, and 3 on July 16, July 15, and July 21 in 2009, respectively. Plants were 1 to 3 m tall and were in a vegetative stage of growth. Application of all treatments discussed above were the same as previously mentioned in studies 1 and 2.

Data collection in all three studies at each site were conducted for three growing seasons (2008 to 2010), and the response of common reed was evaluated in terms of effects on plant injury, flowering, and stem density. Weed control was estimated visually approximately every 30 d after treatment (DAT) using a scale from 0 to 100%, with 0 representing no weed control and 100 representing complete weed control. Percent flowering in each plot was rated visually and was based on a scale of 0 to 100%, with 0% indicating no flowering and 100% indicating complete flowering. Percent flowering and stem density were measured at the end of each growing season. Stem density was assessed in each plot using a 1-m^2 quadrat.

Statistical Analyses. For each study, ANOVA was performed by PROC MIXED procedure in SAS (SAS Institute 2005) to test for the significance ($P < 0.05$) of years, treatments, replications, and their interactions on the basis of plant injury and flowering ratings, and stem density data. There was no treatment-by-location interaction in any study; therefore, the data from the three locations were combined. However, there was a significant effect of year and year-by-treatment interaction; therefore, the data from each study are presented separately for each year. Treatment means in all three studies were separated by Fisher's protected LSD procedure at $P = 0.05$.

Results and Discussion

Study 1: Disking Followed by Herbicide. On the basis of visual ratings, disking alone provided only short-term control (e.g., 90 d) of common reed, whereas control was significantly improved when disking was followed by herbicide applications (Table 2). Disking alone provided 8 to 47% control and decreased over time. For example, disking alone provided about 42% control at the end of the first growing season (90 DAT), whereas it was significantly reduced to 8% by the end of the third growing season (817 DAT, Table 2). In contrast, excellent control ($\geq$ 93%) was obtained when disking was followed by an application of imazapyr or glyphosate, either applied in the same year or a year later. Common reed control ranged from 97 to 100% at 817 DAT with disking followed by an application of imazapyr either 3 mo after disking (fall 2008) or 12 mo later (summer 2009), and there was no significant difference between the timing of herbicide application by 817 DAT. Although disking combined with glyphosate provided greater control of common reed with glyphosate application a year later (99%) compared with the same- year application (93%), the level of long-term control with both application timings was excellent up to the end of the third season (Table 2).

It is also important to note that applications of herbicide in the same year of disking provided faster and more consistent control of common reed up to 440 DAT compared to applications of herbicide a year after disking. Weed control was between 97 and 99% at 440 DAT when disking was followed by imazapyr or glyphosate applied in the same year compared with 63 to 72% control when imazapyr or glyphosate was applied a year after disking (Table 2). Control was almost similar with both timings of herbicide applications at 670 and 817 DAT, indicating that differences in common reed control during the second growing season were due to herbicide application timing rather than efficacy of the treatment. The above results suggest that disking alone could be used for suppression of common reed on a year-to-year basis, but long-lasting control cannot be achieved with disking operations on an annual basis.

All treatments significantly reduced flowering and plant densities ($P = 0.0001$) compared to the untreated check during all three growing seasons (Table 2). In the first growing season (2008), disking alone and disking followed by herbicide treatments prevented flowering; however, only disking followed by herbicide decreased flowering by greater than 95% throughout the third growing season. For example, disking-alone plots had 0% flowering in the first growing season, 40% flowering by the end of the second growing season, and 90% flowering by the end of the third season. Disking followed by glyphosate or imazapyr, either applied in the fall of 2008 or in the summer of 2009, almost completely prevented flowering throughout the third growing season (Table 2). This is important for preventing seed production and reducing the further expansion of common reed colonies through seeds infestations.

Plant densities were significantly reduced by all treatments in the first growing season. The largest decreases in plant densities occurred by the end of the third growing season (2010) with treatments of disking followed by herbicide (imazapyr or glyphosate). Disking followed by imazapyr applied in the same year (2008) had 2 stems m^{-2} by the end of the third growing season (2010) compared to 193 stems m^{-2} in the untreated check (Table 2). The difference between disking followed by herbicide applied in the same year and disking followed by herbicide applied a year later was likely a result of herbicide timing. However, by the end of the third season, there was no significant difference in plant densities with either timing of herbicide application. Disking followed by glyphosate applied in the same year had 5 stems m^{-2} while disking followed by glyphosate applied a year later had a plant density of 0 stems m^{-2} (LSD of 6 stems m^{-2}) at the end of the third growing season (Table 2).

Study 2: Mowing Followed by Herbicide. According to visual ratings, mowing provided temporary suppression of the stand (e.g., 30 to 90 DAT), while the control was significantly prolonged when mowing was combined with herbicide applications (e.g., up to the end of the third season, Table 3). Mowing twice during the same growing season provided 100% control at 90 DAT but had 0% control of common reed in the second and third season. The excellent control of common reed observed at 90 DAT using mowing alone was a result of mowing at the end of the growing season, which reduced the amount of time available for regrowth of common reed. In contrast, mowing followed by herbicide applied during the same season (fall 2008) provided excellent season-long control and up to three growing seasons (≥ 93%). Mowing in the summer of 2008 followed by glyphosate applied in the fall of 2008 had 99 to 100% control of common reed throughout the second growing season. The level of control decreased only slightly in the third growing season to 93% (670 to 817 DAT). Similar trends were observed when mowing was followed by herbicide application a year later (summer 2009). Mowing followed by imazapyr applied the following year provided excellent control (100%) at 817 DAT. Treatments of mowing followed by following-year application of imazapyr or glyphosate were significantly better than mowing followed by same-year application of imazapyr or glyphosate, but all mowing followed by herbicide application at either timing provided excellent control (≥ 93%) of common reed at 817 DAT. Similar to the results from study 1, mowing followed by same-season application of herbicide provided faster and consistent control (96 to 99%) of common reed up to 440 DAT compared with application of herbicide the following year, which ranged from 47 to 72% control (Table 3). Control of common reed at 670 and 817 DAT was similar when mowing was followed by either timing of herbicide application. Increasing the frequency of mowing alone applied over several years may improve the level of control of common reed; however, that is the hypothesis that needs to be tested because our data showed that mowing twice may only suppress common reed during the year of mowing.

All treatments significantly ($P = 0.0001$) reduced flowering and stem densities during all three growing seasons when compared to the untreated control (Table 3). During the first growing season, all treatments prevented flowering of common reed, which was similar to the results presented in study 1. By the end of the third growing season (2010), percent flowering in response to two mowing treatments was not significantly different from that observed for the untreated check. Treatments containing mowing followed by either herbicide at either timing prevented at least 95% of common reed from flowering and producing seed. Mowing followed by glyphosate applied in the same season had 5% flowering at the end of the 2010 growing season (817 DAT). Treatments with mowing followed by either herbicide applied in the following year were significantly better in preventing flowering by the end of the third growing season than mowing followed by glyphosate applied in the same season. Mowing followed by

Table 2. Impact of disking and disking followed by an application of either imazapyr or glyphosate applied in the fall of 2008 or in the summer of 2009 on common reed control, flowering, and stem density for three locations in Nebraska (study 1).[a]

		Common reed										
		Control										
		90 DAT	289 DAT	440 DAT	670 DAT	817 DAT						
		30 DAT[c]	229 DAT[c]	380 DAT[c]	610 DAT[c]	757 DAT[c]	Flowering			Density		
Treatment	Application timing			90 DAT[d]	320 DAT[d]	467 DAT[d]	2008[e]	2009[f]	2010[g]	2008[e]	2009[f]	2010[g]
		%								stem m^{-2}		
Disking alone	Summer 2008	42	47	43	13	8	0	40	90	53	109	161
Disking + imazapyr	Summer 2008 + fall 2008	71	100	99	97	97	0	1	1	51	1	2
Disking + glyphosate	Summer 2008 + fall 2008	77	100	97	92	93	0	3	3	50	2	5
Disking + imazapyr	Summer 2008 + summer 2009	40	47	63	100	100	0	0	0	49	106	0
Disking + glyphosate	Summer 2008 + summer 2009	40	47	72	99	99	0	0	0	49	110	0
LSD (0.05)[b]		7	2	4	4	3	0	10	3	6	20	5

[a] There was no treatment-by-location interaction; therefore, data from the three locations were pooled. Abbreviations: DAT, days after treatment.

[b] Fisher's protected LSD ($P = 0.05$).

[c] Days after the fall 2008 herbicide treatment.

[d] Days after the summer 2009 herbicide treatment.

[e] End of growing season for 2008 corresponds with 90 DAT.

[f] End of growing season for 2009 corresponds with 440 DAT.

[g] End of growing season for 2010 corresponds with 817 DAT.

Table 3. Impact of mowing and mowing followed by an application of either imazapyr or glyphosate applied in the fall of 2008 or in the summer of 2009 on common reed control, flowering, and density for three locations in Nebraska (study 2)[a].

Treatment	Application timing	Common reed: Control 90 DAT	289 DAT	440 DAT	670 DAT	817 DAT	Flowering			Density		
		30 DAT[c]	229 DAT[c]	380 DAT[c]	610 DAT[c]	757 DAT[c]						
				90 DAT[d]	320 DAT[d]	467 DAT[d]	2008[e]	2009[f]	2010[g]	2008[e]	2009[f]	2010[g]
		%								stem m^{-2}		
Mowing alone	Summer 2008 + fall 2008	100	32	36	0	0	0	17	99	9	155	186
Mowing + imazapyr	Summer 2008 + fall 2008	74	100	99	95	95	0	0	3	85	1	4
Mowing + glyphosate	Summer 2008 + fall 2008	81	100	96	93	93	0	1	5	86	3	6
Mowing + imazapyr	Summer 2008 + summer 2009	25	27	47	99	99	0	0	1	87	150	1
Mowing + glyphosate	Summer 2008 + summer 2009	25	27	72	100	100	0	0	0	86	153	0
LSD (0.05)[b]		5	12	4	2	2	0	11	2	13	17	3

[a] There was no treatment-by-location interaction; therefore, data from the three locations were pooled. Abbreviations: DAT, days after treatment.

[b] Fisher's protected LSD (P = 0.05).

[c] Days after the fall 2008 herbicide treatment.

[d] Days after the summer 2009 herbicide treatment.

[e] End of growing season for 2008 corresponds with 90 DAT.

[f] End of growing season for 2009 corresponds with 440 DAT.

[g] End of growing season for 2010 corresponds with 817 DAT.

glyphosate applied in the following year had 0% common reed flowering by the third year, while mowing followed by glyphosate applied in the same season allowed 5% common reed flowering (Table 3).

The data show that all treatments during all three growing seasons significantly reduced stem densities when compared to the untreated control (Table 3). Mowing alone decreased stem densities initially, but common reed regrew as time progressed. For example, at the end of the first growing season (2008), mowing alone had 9 stems m^{-2}, while at the end of the third growing season (2010) there were 186 stems m^{-2} (Table 3). Treatments of mowing followed by either herbicide (imazapyr and glyphosate) at either timing provided the lowest stem densities among treatments. Mowing followed by glyphosate applied in the summer of 2009 had 0 stems m^{-2} at the end of the 2010 growing season. Thus, all data suggest that mowing followed by either herbicide application at either timing provided common reed control for over three seasons, whereas mowing alone provided suppression of common reed for one growing season only.

Study 3: Herbicide Followed by Mechanical Treatment. On a basis of visual ratings alone, all herbicide treatments had at least good control (≥ 84%), with most having excellent control (≥ 92%) up to 817 DAT (Table 4). Lowest control ratings were observed with glyphosate treatments applied in the summer of 2008 alone or followed by a same-year application of mowing or disking. Glyphosate applied alone in the summer of 2008 provided good control (88%) by 817 DAT. Slightly lower control was achieved with the addition of mowing or disking, which had 84 and 86% control of common reed, respectively.

In general, it is important to note that the addition of a mechanical treatment did not improve the level of common reed control. Imazapyr applied alone during the summer of 2008 or combined with same-season mechanical treatment had similar results, giving excellent control (95%) of common reed at 817 DAT (Table 4). All treatments had complete control of common reed at the beginning of the growing season in 2009, and most maintained excellent control through the third growing season. Either herbicide applied alone in the summer of 2008 or in the fall of 2008 or followed by a mechanical treatment had excellent control (100%) of common reed by 289 DAT (Table 4).

All treatments had excellent control (≥ 92%) of common reed by 817 DAT, except for those containing glyphosate applied in the summer of 2008. Multiple applications of imazapyr, once in the fall of 2008 and again in the following year, provided the greatest control of common reed over three growing seasons. Control of common reed was excellent (≥ 99%) in the 2009 and 2010 growing seasons using imazapyr applied twice (Table 4). However, there was no significant difference between imazapyr applied twice and all other treatments containing imazapyr applied at either timing, or glyphosate applied alone in the fall of 2008 or two applications of glyphosate once in the fall of 2008 and again in the summer of 2009.

All treatments significantly (P = 0.0001) reduced flowering and stem densities of common reed (Table 4). All treatments significantly reduced flowering in common reed by

Table 4. Impact of herbicide applied in the summer of 2008 or in the fall of 2008 and herbicide followed by mechanical treatment of either mowing or disking applied in the fall of 2008 or in the summer of 2009 on common reed control, flowering, and stem density for three locations in Nebraska (study 3)[a].

		Common reed										
		Control										
		90 DAT	289 DAT	440 DAT	670 DAT	817 DAT						
		30 DAT[c]	229 DAT[c]	380 DAT[c]	610 DAT[c]	757 DAT[c]	Flowering			Density		
Treatment	Application timing			90 DAT[d]	320 DAT[d]	467 DAT[d]	2008[e]	2009[f]	2010[g]	2008[e]	2009[f]	2010[g]
		%								stem m^{-2}		
Glyphosate only	Summer 2008	34	100	95	86	88	11	4	8	180	9	9
Glyphosate + mowing	Summer 2008 + fall 2008	100	100	92	85	84	0	6	11	58	13	14
Glyphosate + disking	Summer 2008 + fall 2008	100	100	93	87	86	0	6	9	60	12	11
Imazapyr only	Summer 2008	27	100	99	95	95	4	1	3	161	3	3
Imazapyr + mowing	Summer 2008 + fall 2008	100	100	96	95	95	0	3	3	57	7	4
Imazapyr + disking	Summer 2008 + fall 2008	100	100	97	95	95	0	1	2	58	5	3
Glyphosate only	Fall 2008	78	100	97	96	96	88	0	1	179	4	3
Imazapyr only	Fall 2008	71	100	99	97	97	99	1	1	134	2	2
Imazapyr only (applied twice)	Fall 2008 + summer 2009	67	100	99	99	99	88	0	0	131	3	1
Glyphosate only (applied twice)	Fall 2008 + summer 2009	73	100	99	96	95	99	0	2	154	1	3
Glyphosate + mowing	Fall 2008 + summer 2009	76	100	100	91	92	98	1	4	119	0	7
Glyphosate + disking	Fall 2008 + summer 2009	76	100	99	92	92	87	1	4	148	2	6
Imazapyr + mowing	Fall 2008 + summer 2009	68	100	100	94	94	98	0	2	128	0	5
Imazapyr + disking	Fall 2008 + summer 2009	68	100	100	96	96	99	0	2	131	0	3
LSD (0.05)[b]		4	0	2	5	5	15	2	4	78	6	4

[a] There was no treatment-by-location interaction; therefore, data from the three locations were pooled. Abbreviations: DAT, days after treatment.

[b] Fisher's protected LSD ($P = 0.05$).

[c] Days after the fall 2008 herbicide treatment.

[d] Days after the summer 2009 herbicide treatment.

[e] End of growing season for 2008 corresponds with 90 DAT.

[f] End of growing season for 2009 corresponds with 440 DAT.

[g] End of growing season for 2010 corresponds with 817 DAT.

the end of the 2009 and 2010 seasons. For example, imazapyr applied alone during the summer of 2008 had 4, 1, and 3% flowering in 2008, 2009, and 2010, respectively. By the end of the second and third growing seasons, all treatments reduced flowering of common reed when compared to the untreated control (Table 4).

All treatments reduced stem densities of common reed when compared to the untreated control. Glyphosate applied in the summer of 2008 followed by mowing had 58 stems m^{-2} and was not significantly different than glyphosate applied in the summer of 2008 followed by disking, imazapyr applied in the summer of 2008 followed by mowing, and imazapyr applied in the summer of 2008 followed by disking (Table 4).

Implications for IWM. Mechanical control methods applied alone provided good, but temporary control of common reed. In order to provide longer-term control of common reed along the Platte River in Nebraska (e.g., at least three seasons), mechanical control must be combined with herbicides (imazapyr or glyphosate). Our results are similar to those of Derr (2008a), who also reported that mowing alone provided lower control of common reed; however, including glyphosate to the mowing regime increased the level of control by decreasing the number of shoots and dry weight. Herbicides applied alone or followed by a mechanical treatment also provided excellent control of common reed for multiple seasons. This is similar to the results found in herbicide studies conducted for common reed control (Derr 2008a,b; Monteiro et al. 1999; Moreira et al. 1999). We believe that there is no benefit of utilizing mechanical methods after herbicide applications unless there is a need for site preparation for future uses (e.g., site revegetation with beneficial species).

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