Performance of Enlist One (2,4-D) and Liberty (glufosinate) applied in mixture or sequentially for weed control in soybean

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Introduction

Herbicides are recommended to be applied in mixtures to increase application efficiency, spectrum of weed control, and reduce selection pressure on resistant biotypes. 2,4-D (Enlist One; Herbicide Group 4) and glufosinate (Liberty; Herbicide Group 10) are often applied in mixture to additively manage various weed species and the commercial availability of herbicide tolerant soybean varieties (i.e., Enlist e3 [tolerant to 2,4-D, glufosinate and glyphosate]), which is supported by South Dakota State University Extension research (https://extension.sdstate.edu/sites/default/files/2025-04/P-00330.pdf).

While the mixture of Enlist One and Liberty provides increased control of weeds compared with the herbicides applied alone, there are some that apply the herbicides sequentially to potentially increase weed control. Since Enlist One nor Liberty have soil residual activity, the desire for sequential applications is to control later emerging weeds. The objective of this experiment was to determine the effectiveness of Enlist One and Liberty in mixture compared with sequential applications of these herbicides to control common weeds and the effect on soybean yield.

Materials and Methods

Field experiments were conducted in 2023 and 2024 near Beresford (SDSU Southeast Research Farm) and South Shore (SDSU Northeast Research Farm), SD, for a total of four site-years. The soil at the Beresford location is an Egan-Trent silty clay loam. The soil at the South Shore location is a Kranzburg-Brookings silty clay loam. Natural populations of common lambsquarters, common waterhemp, and velvetleaf occurred at Beresford (two site-years). Natural populations of redroot pigweed and yellow foxtail occurred at South Shore (two site-years). Each site was conventionally tilled prior to planting experiment establishment. Soybean seeds were planted at a density of 160,000 seeds per acre with 30-inch row spacing for all site years. Soybean varieties differed from year and location, but all varieties were selected for local conditions and tolerance to 2,4-D and glufosinate. Soybean varieties used for all site years were resistant to 2,4-D, glufosinate, and glyphosate. Preemergence herbicides were not applied to ensure the maximum weed seedling emergence.

Treatments were arranged as a randomized complete block design with four replications. Individual plots were 10 feet wide × 40 feet long. Herbicide treatments were applied to plots with a CO^2-pressurized backpack sprayer calibrated to deliver 15 gallons per acre with nozzles 20 inches above the target weed height. All weeds were treated at approximately 6 inches in height. All treatments were applied with TeeJet 8003 AIXR spray nozzles. Enlist One and Liberty were both applied at 32 fl oz per acre with 8.5 lbs per 100 gallons of ammonium sulfate. When applied alone, the herbicides were applied at the same rates but ammonium sulfate was not added to Enlist One. Sequential applications were applied 12 days after the initial herbicide application based on the restrictions on the Enlist One label. All combinations of Enlist One and Liberty were tested and are listed in Table 1. Clethodim (Select Max [16 fl oz per acre]) was applied in between the sequential applications with the same spray parameters described above, but only to the

Enlist One-only treatments for grass weed control. No response variable data were recorded for grass species in these plots.

Weed control evaluations were made using estimates based on a scale ranging from 0% to 100%, where 0% equals no control (i.e., no injury symptoms on any tissue) and 100% equals complete control (i.e., total necrosis). Control evaluations were made 28 days after the initial herbicide application. Soybean was harvested using a combine after reaching physiological maturity and yield was adjusted to 13% moisture.

Initial Application	Sequential Application
Enlist One + Liberty	No sequential treatment
Enlist One	Enlist One
Enlist One	Glufosinate
Liberty	Enlist One
Liberty	Liberty

Table 1. Enlist One (2,4-D choline; 32 fl oz per acre) and Liberty (glufosinate; 32 fl oz per acre) treatments used in the experiment conducted near Beresford and South Shore, SD in 2023 and 2024. The sequential application occurred 12 days after the initial application in compliance with the Enlist One label restriction.

Weed control and soybean yield data were subjected to analysis of variance (ANOVA) using the Glimmix procedure in SAS 9.4 (Statistical Analysis Software Institute, Cary, NC, USA) (a = 0.05). Herbicide was considered a fixed effect, whereas block and year and their interactions were considered random effects. Year was considered random to allow inferences to be made across broader conditions and locations. Treatment means were separated using Fisher's Least Significant Difference test (P ≤ 0.05).

Results

Common lambsquarters

All herbicide treatments provided similar common lambsquarters control ranging from 96 to 99% (Figure 1). These results suggest that Enlist One + Liberty and sequential applications of these herbicides are very effective in managing this species.

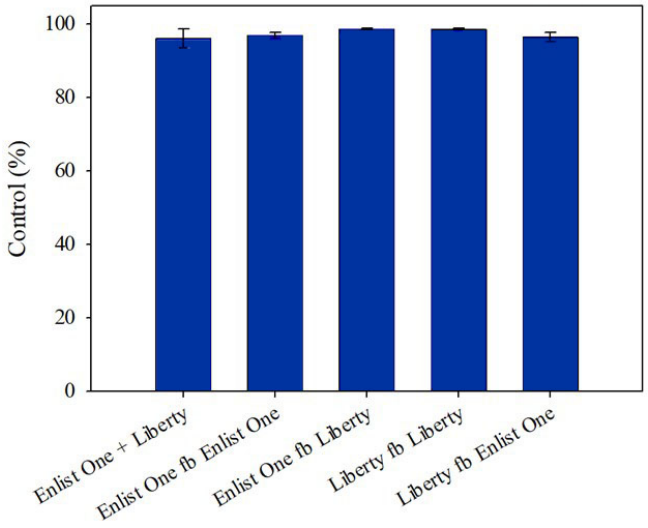

Figure 1. Control of common lambsquarters with Enlist One (2,4-D choline; 32 fl oz per acre) and Liberty (glufosinate; 32 fl oz per acre) applied in mixture or sequentially (fb denotes followed by; applications occurred 12 days apart) near Beresford combined from 2023 and 2024. Bars that share similar letters are not statistically different.

Common waterhemp

Enlist One + Liberty provided the least common waterhemp control at 88% compared with all sequential applications of these herbicides where control ranged from 94-98% (Figure 2). While Enlist One + Liberty provided less control than the sequential herbicide applications, providing 88% control is still considered effective.

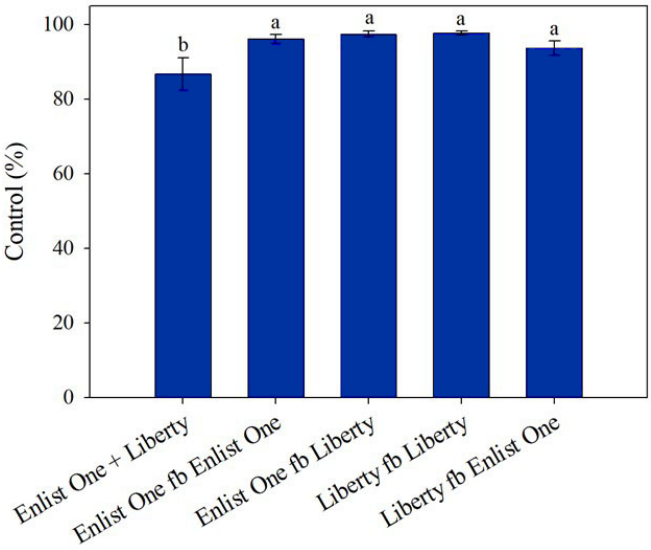

Figure 2. Control of common waterhemp with Enlist One (2,4-D choline) (32 fl oz per acre) and Liberty (glufosinate) (32 fl oz per acre) applied in mixture or sequentially (fb denotes followed by; applications occurred 12 days apart) at Beresford combined from 2023 and 2024. Bars that share similar letters are not statistically different.

Redroot pigweed

Enlist One + Liberty provided 96% control of redroot pigweed and most sequential applications of these herbicides provided similar control between 98 to 99% (Figure 3). Enlist One followed by Enlist One provided 88% control (Figure 3), which is still considered effective. However, since Enlist One does not provide control of grasses, reduced control between the first Enlist One application and the Select Max application is likely due to grass weed interference.

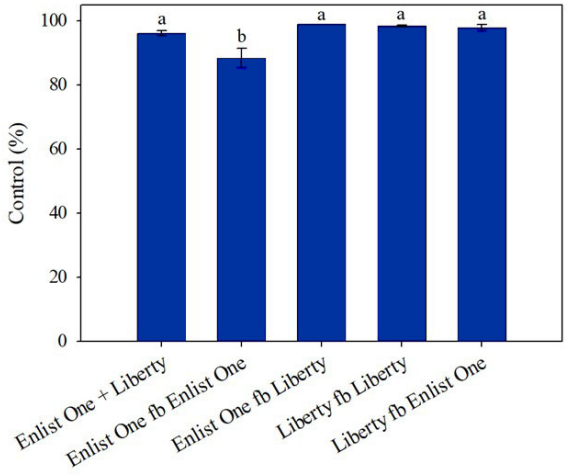

Figure 3. Control of redroot pigweed with Enlist One (2,4-D choline) (32 fl oz per acre) and Liberty (glufosinate) (32 fl oz per acre) applied in mixture or sequentially (fb denotes followed by; applications occurred 12 days apart) at South Shore combined from 2023 and 2024. Bars that share similar letters are not statistically different.

Velvetleaf

All herbicide treatments provided 99% control of velvetleaf (Figure 4). These results suggest that Enlist One + Liberty and sequential applications of these herbicides are very effective in managing this species.

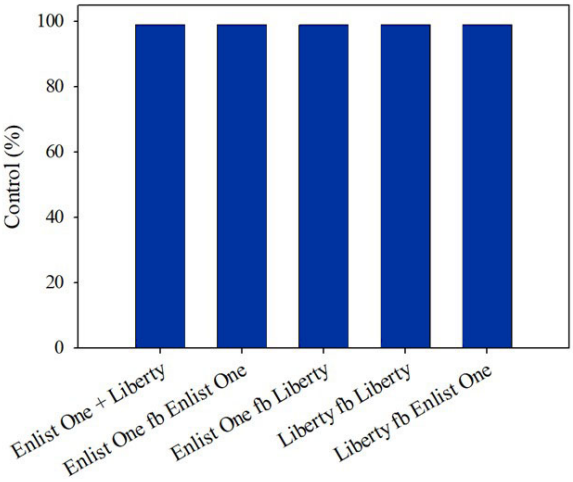

Figure 4. Control of velvetleaf with Enlist One (2,4-D choline) (32 fl oz per acre) and Liberty (glufosinate) (32 fl oz per acre) applied in mixture or sequentially (fb denotes followed by; applications occurred 12 days apart) at South Shore combined from 2023 and 2024.

Yellow foxtail

Enlist One + Liberty provided 62% yellow foxtail control (Figure 5). Liberty followed by Liberty provided the greatest control at 92%. Next was Enlist One followed by Liberty at 79% control. Lastly, Liberty followed by Enlist One provided 63% control (Figure 5). These results suggest that Liberty followed by Liberty is the most effective treatment to manage yellow foxtail.

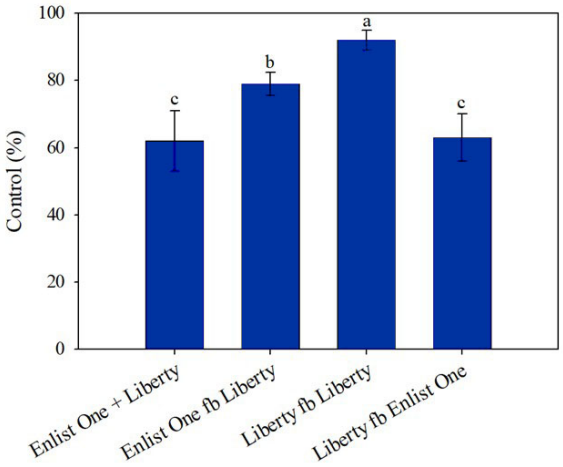

Figure 5. Control of yellow foxtail with Enlist One (2,4-D choline) (32 fl oz per acre) and Liberty (glufosinate) (32 fl oz per acre) applied in mixture or sequentially (fb denotes followed by; applications occurred 12 days apart) at South Shore combined from 2023 and 2024. Enlist fb Enlist was not analyzed for yellow foxtail control as the herbicide provides no activity. Bars that share similar letters are not statistically different.

Yield

Herbicide treatments significantly increased yield compared with the nontreated control (Figure 6). Overall, Liberty followed by Liberty resulted in the greatest yield (41 bushels per acre). Although, it was not different from Liberty followed by Enlist One (39 bushels per acre) or Enlist One + Liberty (38 bushels per acre). Enlist One followed by Enlist One produced intermediate yield (35 bushels per acre), while Enlist One followed by Liberty resulted in slightly lower yields among other treatments (33 bushels per acre).

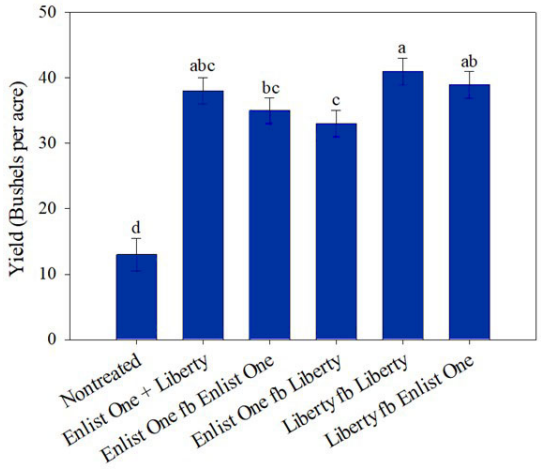

Figure 6. Soybean yield with Enlist One (2,4-D choline) (32 fl oz per acre) and Liberty (glufosinate) (32 fl oz per acre) applied in mixture or sequentially (fb denotes followed by; applications occurred 12 days apart) combined across years (2023 and 2024) and locations (Beresford and South Shore). Bars within herbicide that share similar letters are not statistically different.

Conclusions

Enlist One + Liberty and sequential applications of these herbicides provided effective control (88 to 99%) of broadleaf weed species evaluated in this experiment. Common lambsquarters, redroot pigweed, and velvetleaf were effectively managed by all herbicide treatments, while sequential applications generally improved control of common waterhemp compared with the Enlist One + Liberty. However, yellow foxtail control varied among herbicide treatments. Sequential Liberty applications provided the most consistent control of this grass species. These differences in weed control were reflected in yield, where sequential Liberty-based programs tended to produce the highest yields. These results indicate that while Enlist One + Liberty is effective for broadleaf weed management, sequential programs that include Liberty may provide improved overall weed control and yield protection. While weeds were sprayed at approximately 6" for research purposes, weeds should be sprayed at 4" or less for the most consistent and effective control.

Even though all sequential herbicide applications could provide similar or greater weed control and soybean yield compared with Enlist One + Liberty, applying only one herbicide sequentially alone is not recommended because it increases selection pressure on resistant weed species. For example, 2,4-D-resistant waterhemp has been confirmed in Nebraska, Illinois, Minnesota, and Missouri (Bernards et al. 2012; Evans et al. 2019; Singh et al. 2024; Shergill et al. 2018). More recently, glufosinate-resistant waterhemp has been confirmed in Illinois and control failures are often reported across the North Central United States (Hager 2026). Therefore, applying Enlist One and Liberty along with other herbicides can help increase the longevity of the remaining effective herbicides in South Dakota. In addition, preemergence herbicides were not used in this experiment to ensure multiple weed species were present. Utilizing multiple herbicides in a preemergence application can reduce the selection pressure on herbicide-resistant weeds. Weed control and soybean yield would be greatly improved with the addition of a strong preemergence herbicide program as well.

Overall, our recommendation is to utilize Enlist One + Liberty over sequential applications of these herbicides. While the sequential applications of these herbicides in some cases provided better weed control and soybean yield, recall that the sequential applications were made 12 days apart to abide to restrictions in the Enlist One label. A lot can happen in 12 days to impede a timely sequential application: rain, wind, machinery breakdown, and other life happenings. If a timely sequential application is not made, weeds may continue to grow to a size much too large to control effectively with herbicides. The surviving weeds can potentially reduce yield potential and produce seeds that need to be managed in future growing seasons. While sequential applications of Liberty-only are restricted to 7 days apart, we do not recommend this application in favor of resistance management.

Acknowledgements

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References

Bernards ML, Crespo RJ, Kruger GR, Gaussoin R, Tranel PJ (2012) A waterhemp (Amaranthus tuberculatus) population resistant to 2,4-D. Weed Sci 60:379–384

Evans CM, Strom SA, Riechers DE, Davis AS, Tranel PJ, Hager AG (2019) Characterization of a waterhemp (Amaranthus tuberculatus) population from Illinois resistant to herbicides from five sites-of-action. Weed Technol 33:400–410

Hager AG (2026) Glufosinate-resistant waterhemp (Amaranthus tuberculatus) confirmed in Illinois. Department of Crop Sciences, University of Illinois at Urbana-Champaign. https://farmdoc.illinois.edu/field-crop-production/weeds/glufosinate-resistant-waterhemp-amaranthus-tuberculatus-confirmed-in-illinois.html

Shergill LS, Barlow BR, Bish MD, Bradley KW (2018) Investigations of 2,4-D and multiple herbicide resistance in a Missouri waterhemp (Amaranthus tuberculatus) population. Weed Sci 66: 386–394

Singh N, Peters TJ, Miller RP, Naeve SL, Sarangi D (2024) Profile and extent of herbicide-resistant waterhemp (Amaranthus tuberculatus) in Minnesota. Weed Sci 72: 673–682

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