Cropping Systems Weed Science
UNIVERSITY OF WISCONSIN–MADISON

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Preemergence Herbicides, Not Carrier Volume, Impacted Weed Management in Conventional Tillage Systems[1]

Take Home Message

- PRE-emergence (PRE) herbicides are important tools for control of troublesome weed species with extended emergence window such as waterhemp.
- Spray carrier volume did not influence weed control of corn and soybean preemergence herbicides in conventional tillage systems but herbicide selection did.
- Effective preemergence herbicides can be utilized at lower spray carrier volumes without compromising their efficacy in conventional tillage systems.

Introduction

The ongoing challenge of controlling troublesome weed species in annual and perennial cropping systems supports the need for growers to incorporate integrated weed management strategies to increase sustainability (Mortensen et al., 2012; Norsworthy et al., 2012). Integrated weed management practices include, but are not limited to, shifting from the overreliance on POST herbicide applications to early-season weed control, such as the use of burndown herbicide applications, preplant tillage, cover crops, and use of effective PRE herbicides. Higher carrier volumes (15 gal ac^{-1} or greater) are generally recommended for POST applications to optimize spray performance of contact herbicide products (i.e., glufosinate, lactofen), while carrier volume has less of an influence on spray performance for systemic herbicide products such as glyphosate (Creech et al., 2015). Less research has been conducted evaluating the effect of various spray parameters on performance of preemergence (PRE) herbicide applications. The effectiveness of a soil residual herbicide applied PRE is highly influenced by environmental conditions, physiochemical characteristics of the herbicide (i.e., adsorption, volatility, and solubility), and soil properties, as the soil is the target of such herbicides (Ferreira et al., 2019; Ross and Lembi, 2008). Also, applying PRE herbicide products that contain multiple effective sites of action can help suppress diverse weed communities compared with a single active ingredient, especially if a herbicide-resistant weed population is present. Applying PRE herbicides at reduced carrier volumes could help applicators maximize the efficiency of the spraying operation in terms of time, labor, and equipment constraints that can occur during suitable weather conditions.

Experiment Overview

In 2018 and 2019 the UW-Madison Cropping Systems Weed Science Lab conducted field experiments evaluating the influence of spray carrier volume and selection of PRE herbicide products containing multiple sites of action on weed control in conventional tilled corn and soybean systems.

Objective

- Evaluate the influence of spray carrier volume and PRE herbicide selection on weed control in conventional tilled corn and soybean systems.

Table 1: Herbicide products and rates applied PRE in corn and soybean field experiments conducted at Arlington Agricultural Research Station near Arlington, WI in 2018 and 2019 and Rock County Farm near Janesville, WI in 2018.

Crop	Trade name	Herbicide	Rate	Minimum labeled carrier volume[a]
Corn	Resicore®	acetochlor + clopyralid + mesotrione	56 fl oz ac^{-1}	10
	Acuron®Flexi	bicylopyrone + mesotrione + S-metolachlor	72 fl oz ac^{-1}	10
	Anthem®Maxx	fluthiacet-methyl + pyroxasulfone	4 fl oz ac^{-1}	5
Soybean	Fierce®	flumioxazin + pyroxasulfone	4 fl oz ac^{-1}	10
	Verdict®	dimethanamid-P + saflufenacil	5 fl oz ac^{-1}	3
	Canopy®DF[b]	metribuzin + chlorimuron-ethyl	2.25 oz ac^{-1}	10

[a] Minimum labeled carrier volume (gal ac^{-1}) for each product.

[b] Product use rate cannot exceed 0.14 lb ac^{-1} per season in these experiment locations.

[1]Access the journal publication: https://doi.org/10.1002/cft2.20132

Table 2: Nozzle selection and operating pressure combinations used to attain the five spray carrier volumes for corn and soybean field experiments conducted at Arlington Agricultural Research Station near Arlington, WI, in 2018 and 2019 and Rock County Farm near Janesville, WI, in 2018.

Year	Carrier volume[a]	Nozzle selection[b]	Operating pressure[a]	Screen mesh size
2018	2.5	11001	17	50
	5.0	110015	27	100
	10	11003	44	50
	15	11005	58	50
	17.5	11008	59	50
2019	2.5	11001	12	50
	5.0	110015	21	100
	10	11003	25	50
	15	11005	22	50
	17.5	11008	15	50

[a] Carrier volumes are reported in gal ac^{-1}. Operating pressures are reported in lb sq inch^{-1}.

[b] Extended range (XR) flat fan nozzles (TeeJet Technologies, Spraying Systems Co., Wheaton, IL) were used for all treatments.

Materials and Methods (Technical Description)

Corn and soybean experiments were conducted in 2018 and 2019 at the University of Wisconsin-Madison Arlington Agricultural Research station near Arlington, WI and at the Rock County Farm near Janesville, WI in 2018. Corn and soybean experiments were conducted separately in adjacent fields and were planted following pre-plant tillage. Soil types of the experiment locations were either a silt loam or silty clay loam with pH ranging from 6.1-6.7 and organic matter ranging from 2.6-3.5%. Herbicides in the field experiments were applied within 3 d after crop planting using a John Deere Gator Utility Vehicle (UTV; Moline, IL) equipped with a CO_2-pressurized spray system and operated at a ground speed of 5 miles hour^{-1}. The boom was equipped with four nozzles spaced at 30 inches for a 10 ft spray swath. Herbicide carrier volumes were produced through a combination of different orifice extended range (XR) flat fan nozzles (TeeJet Technologies, Spraying Systems Co., Wheaton, IL) and adjustment of operating pressure (Table 2). Operating pressures were lower in 2019 due to improvements made to the sprayer following the 2018 season. Some spray volumes were lower than those specified on the respective herbicide labels (Table 1). **Herbicide treatments are provided in Table 1.**

The main weed species evaluated in these field experiments were **annual grasses (giant foxtail and green foxtail), common ragweed, and giant ragweed.** Annual grasses were the primary weed species in corn and soybean with an average density of 1.9 and 1.8 ft^{-2}, respectively, in Arlington. The secondary weed species in Arlington was common ragweed, with 0.1 and 0.7 plants ft^{-2} in corn and soybeans, respectively. In contrast, giant ragweed was the most abundant weed species in Janesville, with 0.5 plants ft^{-2} in corn and 1.3 plants ft^{-2} in soybean; followed by 0.02 and 0.5 plants ft^{-2} of annual grass species in corn and soybean, respectively. Weed control was assessed 6 weeks after treatment (WAT) between the center two rows of each plot from all treatments. Weed control was estimated using a visual scale of 0–100 %, where 0% indicated no control and 100% indicating complete control (e.g., no weeds present). Weed biomass was also collected 6 WAT from two arbitrarily placed 1 by 1 ft quadrats between the center two rows of each plot. Plants were identified, counted, clipped at ground level, then all weed species for both samples per plot were combined and bagged. Weed biomass was dried at 125 F for up to 2 weeks. Weed biomass data were expressed as percentage biomass reduction compared with the non-treated control (NTC) using the following equation (1):

$$PercentBiomassReduction = [(M - B)/B] \times 100 \quad (1)$$

where M is the mean weed biomass (lb) of NTC across replications within site, crop, and year combinations, and B is the weed biomass (lb) observed for an individual treated plot.

Statistical analysis – R 4.0.2 A generalized linear mixed model using the template model builder with a beta distribution (family logit - $0 < mu < 1$) (glmmTMB function of the 'glmmTMB' package 1.0.2.1; Brooks et al., 2017) was fit to each of the response variables. Sites were analyzed separately due to differences in weed community composition. Years were considered environments sampled at random from a population (Blouin et al., 2011; Carmer et al., 1989) thus treated as a random effect for the Arlington site. For the Arlington dataset, ANOVA was performed separately for common ragweed control, annual grass weed species control, and overall weed biomass reduction in the corn and soybean experiments. For Janesville, ANOVA was performed separately for giant ragweed control, annual grass weed species control, and overall weed biomass reduction in the corn and soybean experiments. Fixed effects for both sites were herbicide treatment and spray carrier volume; random effects were replication (for both sites) and year (for Arlington) at a .05 level of significance. The model assumption for homogeneity of residual variance was evaluated using the leveneTest function ('car' package 3.0–10; Fox Weisberg, 2019). The ANOVA was performed ('glmmTMB' package) and means were separated according to Fisher's Least Significant Difference ('emmeans' package 1.4.7; Lenth, 2020). The statistical analyses and associated R codes can be found online (Oliveira, 2021).

Results and Discussion

Our results indicate effective weed control can be attained in corn and soybeans under conventional tillage with PRE herbicides applied at reduced spray carrier volume rates, which offers applicators the opportunity to optimize ground herbicide applications. All experiments received measurable (0.43–1.02 inches) rainfall events within 6 days of treatment application, assuring herbicide incorporation and activation (data not shown).

In corn, there was only a significant interaction between carrier volume and PRE herbicide treatments resulting in a slight difference in annual grass control at Janesville ($P = 0.0002$). At Janesville, carrier volume influenced annual grass control of the acetochlor + clopyralid + mesotrione treatment (Fig. 1); at the 2.5 gal ac^{-1}, acetochlor + clopyralid + mesotrione resulted in the lowest annual grass control (> 96%; still considered as agronomically effective weed control level). Therefore, this interaction with carrier volume and acetochlor + clopyralid + mesotrione would likely not impact annual grass control in a producer's field where this reduced carrier rate was used for the application of such PRE herbicide. Common ragweed and giant ragweed control and biomass reduction for all weed species were not affected by carrier volume ($P > 0.05$) in the corn experiments. The main effect of PRE herbicide was significant for weed control and for biomass reduction at Arlington and Janesville ($P < 0.05$). Acetochlor + clopyralid + mesotrione and bicyclopyrone + mesotrione + S-metolachlor provided higher biomass reduction, broadleaf (common ragweed and giant ragweed) control, and annual grass control (Arlington only) than fluthiacet-methyl + pyroxasulfone at Arlington and Janesville (Fig. 1). These results indicate a clear benefit to inclusion of HPPD (Group 27) and VLCFA (Group 15) chemistry mix PRE for residual control of annual broadleaf and annual grass species.

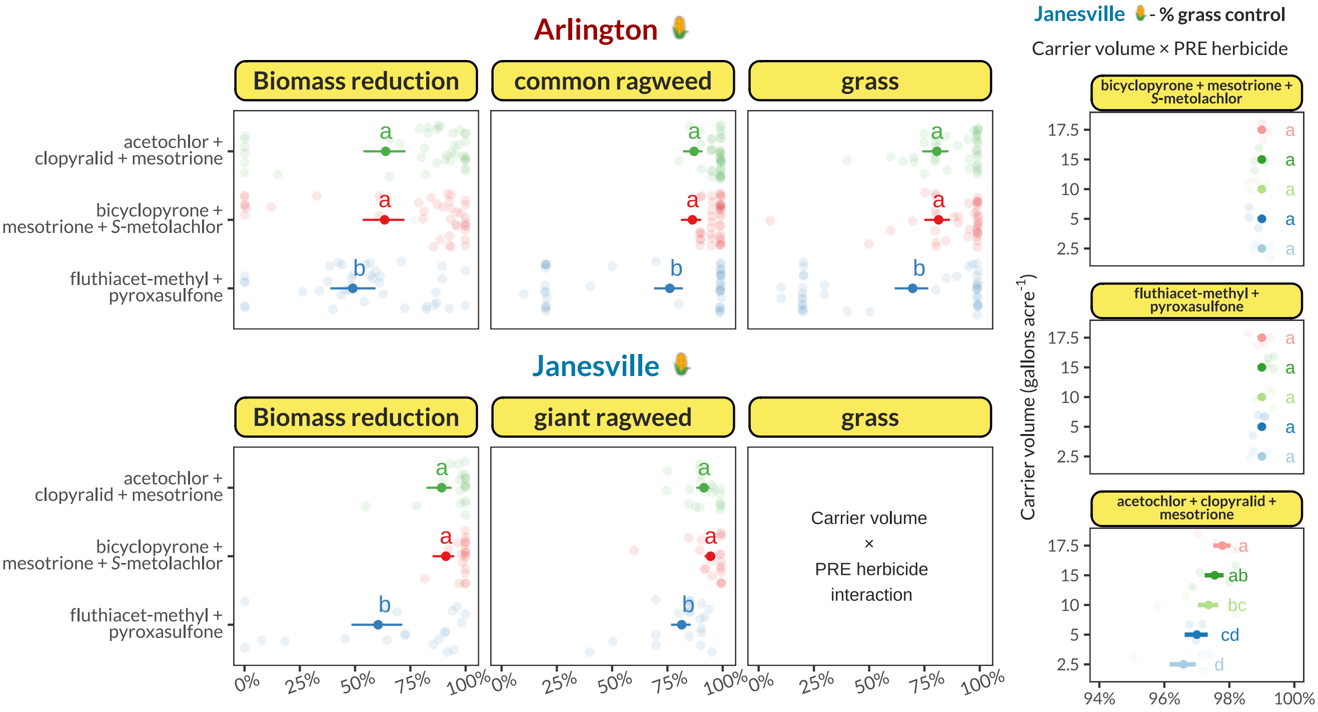

Figure 1. Efficacy (%) of pre-emergence herbicides in corn at Arlington and Janesville, WI. Weed biomass reduction (%) and control (%) of common ragweed, giant ragweed, and annual grasses from pre-emergence herbicides in corn are pooled over carrier volumes, except for annual grass control in Janesville. Data collected 6 weeks after treatment (WAT).

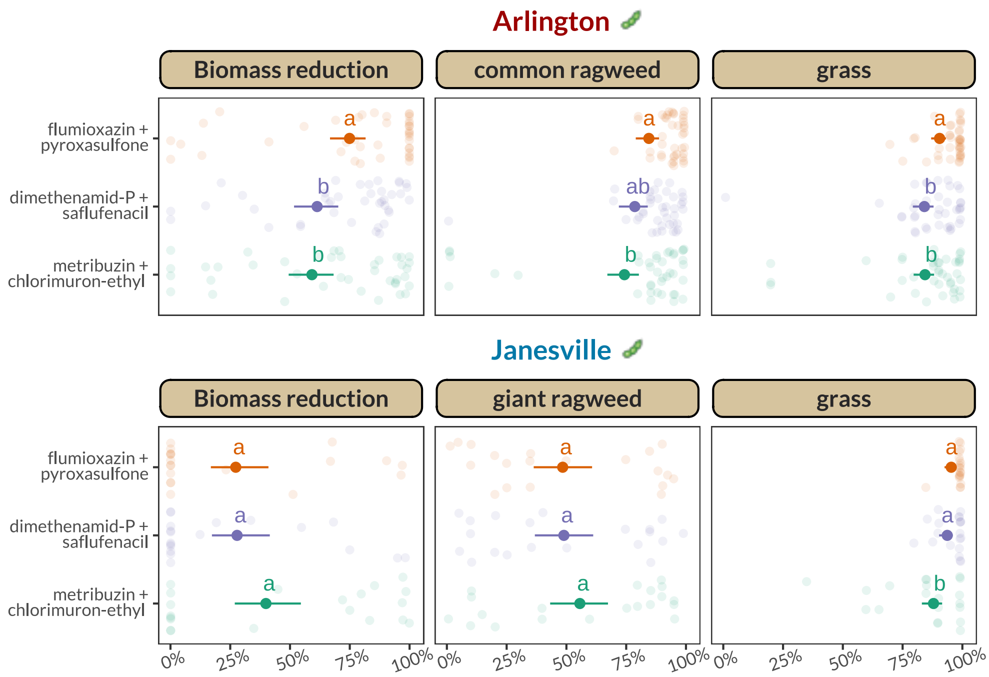

Figure 2. Efficacy (%) of pre-emergence herbicides in soybean at Arlington and Janesville, WI. Weed biomass reduction (%) and control (%) of common ragweed, giant ragweed, and annual grasses from pre-emergence herbicides in corn are pooled over carrier volumes. Data collected 6 weeks after treatment (WAT).

In soybean, carrier volume was not significant in any interactions with PRE herbicide treatments nor as a main effect for weed control and biomass reduction ($P > 0.05$). The PRE herbicide treatment was significant as a main effect for weed control and biomass reduction ($P < 0.05$), except for giant ragweed control at Janesville ($P = 0.693$) and biomass reduction at Janesville ($P = 0.293$). At Arlington, flumioxazin + pyroxasulfone resulted in higher control of common ragweed than metribuzin + chlorimuron-ethyl and better control of annual grasses than both dimethenamid-P + saflufenacil and metribuzin + chlorimuron-ethyl (Fig. 2). A similar trend was observed with biomass reduction as flumioxazin + pyroxasulfone resulted in 75% weed biomass reduction, followed by dimethenamid-P + saflufenacil (61%) and metribuzin + chlorimuron-ethyl (59%). At Janesville, flumioxazin + pyroxasulfone (95%) and dimethenamid-P + saflufenacil (94%) treatments provided higher annual grass control than the metribuzin + chlorimuron-ethyl (88%; Fig. 2). There were no differences in giant ragweed control (48–56%) among the herbicide treatments. Also, herbicide treatments resulted in no differences on biomass reduction (<50%) at Janesville. A contributing factor to the poor broadleaf weed control (<80%) observed with the metribuzin + chlorimuron-ethyl treatment in this research could be the lower amount of chlorimuron-ethyl included in the use rate selected for this pre-mix. These results indicate a benefit to utilizing either or both ALS- (Group 2) and PPO- (Group 14) inhibiting herbicides as part of an effective PRE program for residual control of ragweed species reinforcing the importance of selecting effective premix or tank mixtures where individual active ingredients are delivered at appropriate rates.

Recommendation for Soybean Growers

Weed control differences across PRE herbicide treatments highlight the importance of proper herbicide selection; thus growers should consider the most troublesome species present in the soil seedbank when selecting a PRE herbicide program for their operations. Selecting premixes or tank mixtures of effective active ingredients applied at maximum rates can help growers improve PRE control of targeted weed species. Effective preemergence herbicides can be utilized at lower spray carrier volumes (following label requirements) without compromising their efficacy in conventional tillage systems.

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Additional Resources

- 2020 Wisconsin Weed Science Research Report.
- Residual Control of Waterhemp with PRE-emergence Herbicides in Soybean.
- PRE-emergence Herbicide Selection for Early Planted Soybeans.
- 2021 WiscWeeds Herbicide Comparison for Residual Control in Soybeans on Sandy Soils.
- 2021 WiscWeeds Herbicide Comparison for Residual Weed Control in Corn.

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