Confirmation of a Common Waterhemp Biotype Resistant to Protoporphyrinogen Oxidase (PPO) Inhibitors in Nebraska

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WEED SCIENCE

Introduction

- Common waterhemp (*Amaranthus rudis* Sauer) is one of the most problematic weed in corn and soybean production fields in Nebraska.
- The widespread presence of acetolactate synthase (ALS) inhibitor- and glyphosate-resistant common waterhemp was reported in eastern Nebraska (Sarangi et al. 2015; Vieira et al. 2017).
- Therefore, PPO-inhibiting herbicides (such as acifluorfen, fomesafen, and lactofen) become the primary POST-choice of the glyphosate-resistant soybean growers for controlling common waterhemp.
- In 2016, a common waterhemp biotype was identified in a soybean field in Saunders County, Nebraska, that survived the POST application of lactofen.

Objectives

- To quantify the response of suspected PPO inhibitor-resistant common waterhemp biotype (NER) to different POST-applied PPO-inhibiting herbicides in whole-plant dose-response bioassays.
- To evaluate the response of NER to soybean POST herbicides.

Hypothesis

- We hypothesized that the biotype NER was resistant to multiple POST-applied PPO-inhibiting herbicides.

Materials and Methods

Whole-plant dose-response bioassays:

- Greenhouse dose-response bioassays were conducted in 2017, and experiments were repeated in time.
- Common waterhemp biotypes: suspected resistant from Nebraska (NER), confirmed resistant from Illinois (ILR), two susceptible (S1 and S2)
- Herbicide doses: eight doses (0 to 16× for NER and ILR; and 0 to 4× for S1 and S2). The 1× was the labeled doses of acifluorfen (420 g ai ha^{-1}), fomesafen (263 g ai ha^{-1}), and lactofen (220 g ai ha^{-1}). Plants were sprayed at 8-10 cm height.
- Experimental design: randomized complete block design (RCBD) with a factorial arrangement of 8 herbicide doses and 4 biotypes. Replicated 10 times.
- Data collection: common waterhemp control was assessed visually at 7 days after treatment (DAT) & 21 DAT, and aboveground biomass was collected at 21 DAT.
- Statistical analysis: common waterhemp control and biomass data were regressed over herbicide treatments using four parameter log-logistic function in R (Knezevic et al. 2007):

$$Y = c + \{d - c / 1 + exp [b (log\ x - log\ e)]\}$$

Efficacy of soybean POST herbicides:

- Single-dose bioassays were conducted to evaluate the response of NER to soybean POST herbicides applied at labeled doses (Table 1).
- Data were subjected to ANOVA using PROC GLIMMIX in SAS.
- Experimental run-by-treatment interaction was not significant; therefore, data from both the runs were combined.

Table 1: Details of the soybean POST herbicide treatments.

MOA	Herbicide Treatments (g ai/ae ha^{-1})	MOA	Herbicide Treatments (g ai/ae ha^{-1})
2	Chlorimuron-ethyl (13.1) – Classic	14	Fluthiacet-methyl (7.2) – Cadet
2	Imazethapyr (70.0) – Pursuit	14	Saflufenacil (50.0) – Sharpen
2	Chlorimuron-ethyl + thifensulfuron-methyl (7.5) – Synchrony XP	14	Fluthiacet-methyl + fomesafen (190.0) – Marvel
2 + 9	Imazethapyr + glyphosate (910.0) – Extreme	14 + 9	Fomesafen + glyphosate (1,110.0) – Flexstar GT
9	Glyphosate (1,400.0) – Touchdown HiTech	4	Dicamba-DGA salt (1,120.0) – Xtendimax
10	Glufosiante (740.0) – Liberty	4 + 9	2,4-D choline + glyphosate (2,200.0) – Enlist Duo
6	Bentazon (1,120.0) – Basagran		

** Abbreviations: MOA, mode of action; ai, active ingredient; and ae, acid equivalent

Figure 1: Dose-response of NER biotype at 21 DAT to the application of (A) acifluorfen, (B) fomesafen, and (C) lactofen.

Results and Discussion

ILR: Illinois Resistant; NER: Nebraska Suspected Resistant; S1: Susceptible 1; S2: Susceptible 2

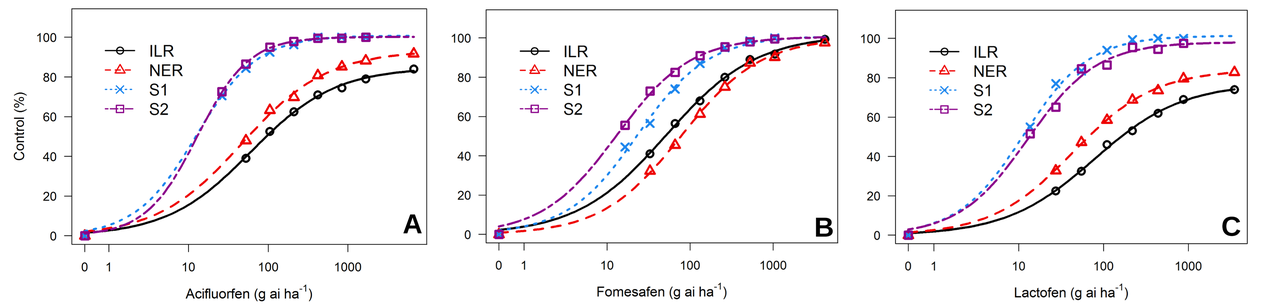

Figure 2: Response of common waterhmp biotypes at 21 DAT to POST-applied PPO Inhibitors, (A) acifluorfen, (B) fomesafen, and (C) lactofen.

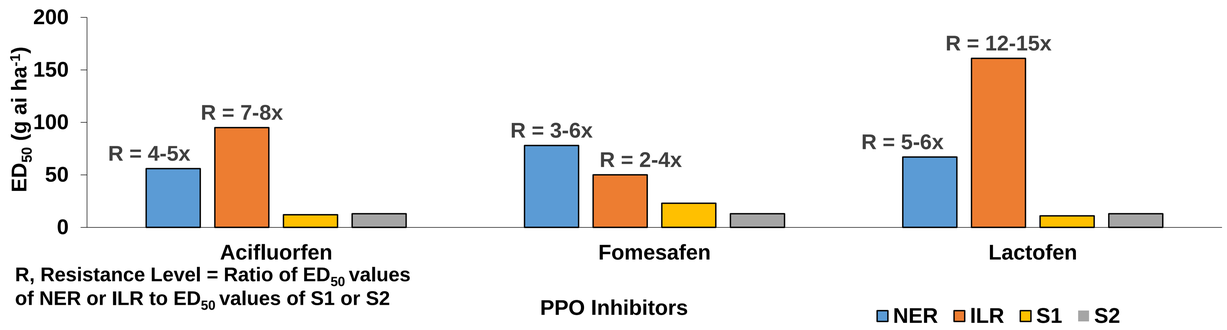

Figure 3: Estimated ED_{50} values for the four common waterhemp biotypes.

- Dose-response bioassays revealed that the NER biotype was resistant to acifluorfen (4- to 5-fold), fomesafen (3- to 6-fold), and lactofen (5- to 6-fold) (Figure 2 and 3). Similarly, Shoup et al. (2003) also reported about the differential response of PPO inhibitor-resistant common waterhemp to these three POST herbicides.
- Biomass data followed the same trend as the control estimates; where the resistance level of NER biotype ranged between 4- and 6-fold depending on the PPO-inhibiting herbicide tested and the susceptible biotypes used for the comparison. (Data not shown)
- The root mean square error (RMSE) values were ≤ 20.0 and the model efficiency coefficient (EF) ranged between 0.7 and 0.9, indicating a good-fit for the prediction model.
- The NER biotype had reduced sensitivity to ALS-inhibiting herbicides and glyphosate (Figure 4).

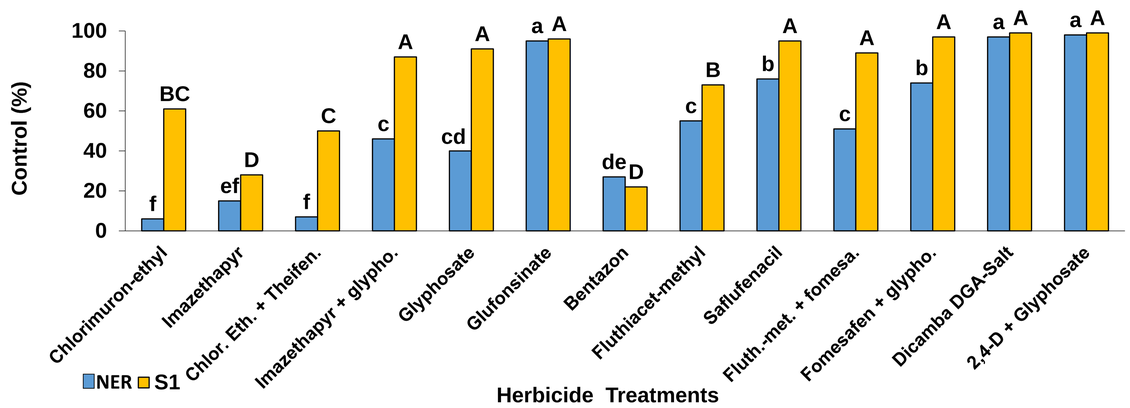

Figure 4: Efficacy of soybean POST herbicides for the control of PPO inhibitor-resistant common waterhemp.

Conclusions

- Common waterhemp biotype (NER) was cross-resistant to the POST-applied PPO inhibitors, and this is the first report of PPO inhibitor-resistant common waterhemp in Nebraska.
- The same biotype had a reduced sensitivity to the ALS inhibitors and glyphosate; indicating a significant reduction in the POST herbicide choices for the glyphosate-resistant soybean growers.
- Diverse weed management programs including rotation of herbicide mode of action, crop rotation, tillage, and rotational use of herbicide-tolerant crops are important.

Future research:

- The mechanism of resistance to PPO inhibitors will be determined with molecular analysis.
- Future dose-response studies on ALS inhibitors and glyphosate will be done with NER.

Literature Cited

- Knezevic et al. (2007) Weed Technol. 21:840-848
- Sarangi et al. (2015) Weed Technol. 29:82-92
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- Viera et al. (2017) Pest Manag. Sci. (in press)

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