High Temperature Enhances the Efficacy, Absorption and/or Translocation of 2,4-D or Glyphosate in Giant Ragweed

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Introduction

- Giant ragweed (*Ambrosia trifida* L.) is an important broadleaf weed found in diverse agroecosystems, roadsides, and wastelands.
- Early spring emergence is a typical characteristic of giant ragweed. For example, in Nebraska 50% emergence occurs by March end to mid-April (Kaur et al. 2016).
- Preplant control of giant ragweed is essential to allow crop planting in weed free environment, which increases the effectiveness of PRE and POST herbicides (Ganie et al. 2016).
- Glyphosate and 2,4-D are very effective for giant ragweed control, however, limited information is available on the effect of environmental factors including temperature on the efficacy of these systemic herbicides.

Objectives

- To evaluate the efficacy, absorption, and translocation of 2,4-D or glyphosate on giant ragweed at different growth temperatures.
- To determine the effect of varying growth temperatures on the level of glyphosate resistance in giant ragweed.

Hypothesis

- The hypothesis of this study was that high temperature will increase the efficacy, absorption and/or translocation of 2,4-D or glyphosate in giant ragweed.

Materials and Methods

Dose-response experiments:

- 2,4-D/glyphosate dose-response studies were conducted under two growth temperatures (day/night, ^{0}C): high (HT) 29/17 and low (LT) 20/11, at a relative humidity of 70% (±5).
- Glyphosate-resistant and –susceptible biotypes (both susceptible to 2,4-D) of giant ragweed were used.
- Plants were treated at 8 to 12 cm height with 2,4-D or glyphosate rates varying from 0.06x to 8x (1x of 2,4-D and glyphosate were 560 and 1,260 g ae ha^{-1}, respectively).
- Control estimates and aboveground biomass reduction (21 days after treatment) data were fit to a four-parameter log logistic model in *drc* package of R.

Absorption and translocation experiments:

- Absorption and translocation studies were conducted by applying approximately 200,000 disintegrations per minute (dpm) ^{14}C-labelled 2,4-D or glyphosate on a newly mature leaf of 8 to 12 cm plants grown at LT and HT.
- Plants were harvested at 24, 48, 72 and 96 h after treatment and separated into treated leaf (TL), tissues above the TL, and below the TL.
- Treated leaves were washed with 5 ml wash solution (10% methanol and 0.05% polysorbate 20) for 1 min to measure unabsorbed radiolabeled herbicide.
- Plant sections were dried at 60 ^{0}C for 48 h and radioactivity absorbed or translocated was recovered by combusting the samples in biological oxidizer and quantified by liquid scintillation spectrometry.
- Herbicide absorption was calculated as; % absorption = (total radioactivity applied–radioactivity recovered in wash solution) × 100/total radioactivity applied;
- Herbicide translocation was calculated as; % translocation = 100–% radioactivity recovered in TL, where % radioactivity in TL = radioactivity in TL × 100/ radioactivity absorbed.
- Data were analyzed in R using a linear regression model, y = a + bx, where y = response (% absorption or translocation), a = intercept and x = time after treatment.

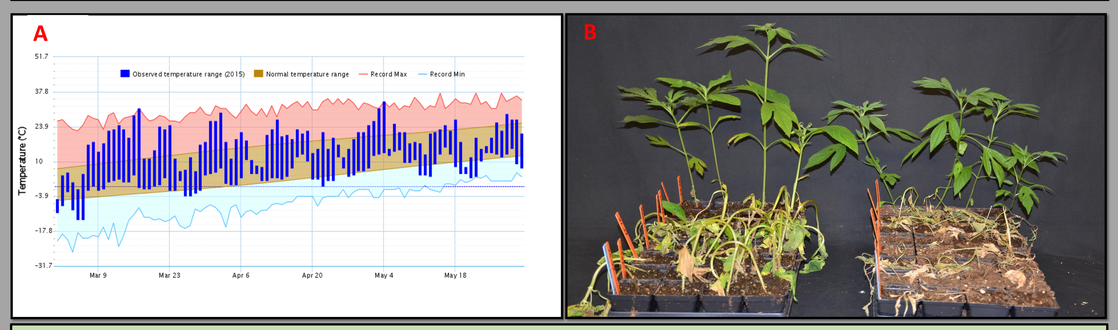

Figure 1. (A) Daily average temperature (^{0}C) from March to May in south-central Nebraska in 2016; (B) 2,4-D dose-response on giant ragweed at HT (29/17 ^{0}C d/n) and LT (20/11 ^{0}C d/n)

Results and Discussion

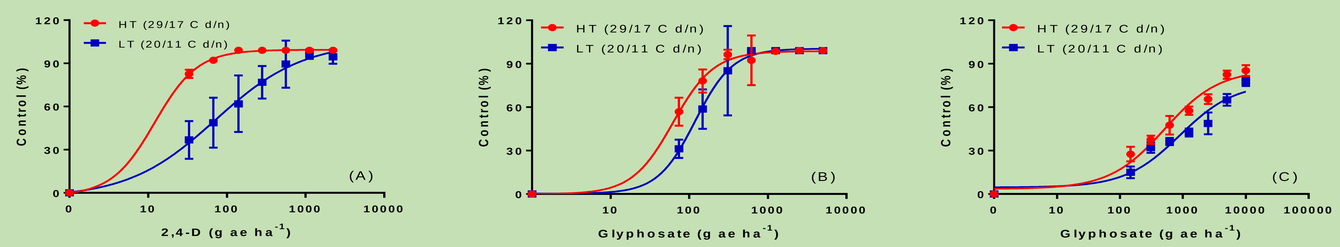

Figure 2. Dose-response curves based on estimates of giant ragweed control at two different temperatures (^{0}C, day/night): high temperature (HT) 29/17; and low temperature (LT) 20/11; (A) 2,4-D, (B) glyphosate on glyphosate-susceptible, and (C) glyphosate on glyphosate-resistant giant ragweed.

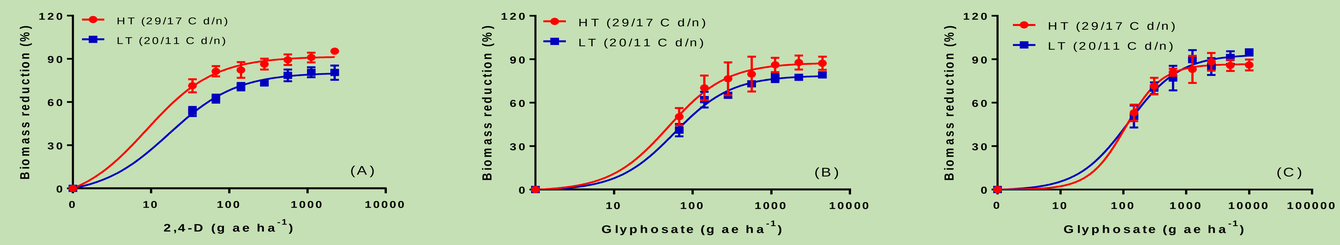

Figure 3. Dose-response curves based on biomass reduction of giant ragweed at two different temperatures (^{0}C, day/night): high temperature (HT) 29/17; and low temperature (LT) 20/11; (A) 2,4-D, (B) glyphosate on glyphosate-susceptible, and (C) glyphosate on glyphosate-resistant giant ragweed.

- 2,4-D dose-response study suggested ED_{90} of 49 (±2) and 792 (±192) g ae ha^{-1} based on estimates of giant ragweed control at HT and LT, respectively (Figure 2A).
- Glyphosate dose-response study suggested ED_{90} of 244 (±35) and 468 (±168) g ae ha^{-1} for susceptible biotype (Figure 2B, 3B) and 5,751 (±1,445) and 66,207 (±20,918) g ae ha^{-1} for resistant biotype (Figure 2C, 3C) at HT and LT, respectively.
- The level of resistance in glyphosate-resistant giant ragweed biotype reduced from 141× at LT to 23× at HT.
- Similarly, previous studies have reported higher efficacy of 2,4-D (Kelly 1948) and glyphosate (Jordan 1977) at warm temperatures (≥ 25 ^{0}C) compared to cool temperatures (< 20 ^{0}C).

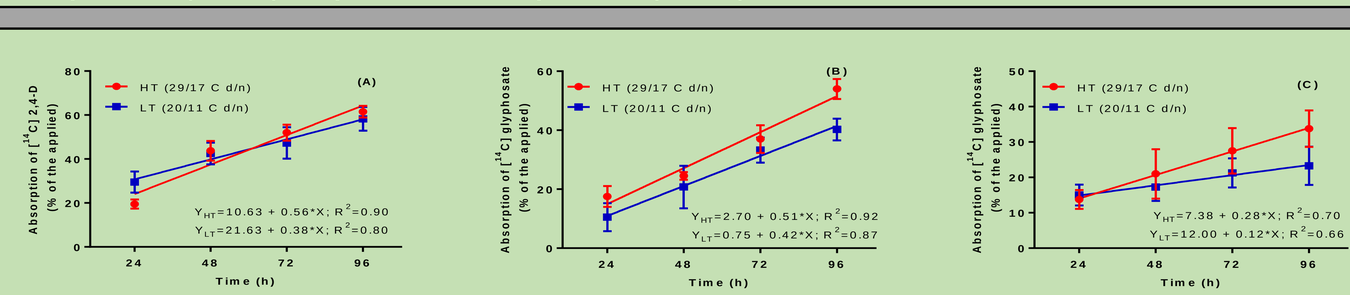

Figure 4. Absorption of 2,4-D or glyphosate in giant ragweed at two temperatures (^{0}C, day/night): high temperature (HT) 29/17; low temperature (LT) 20/11. (A) 2,4-D absorption; (B) glyphosate absorption in glyphosate-susceptible, and (C) glyphosate absorption in glyphosate–resistant biotype.

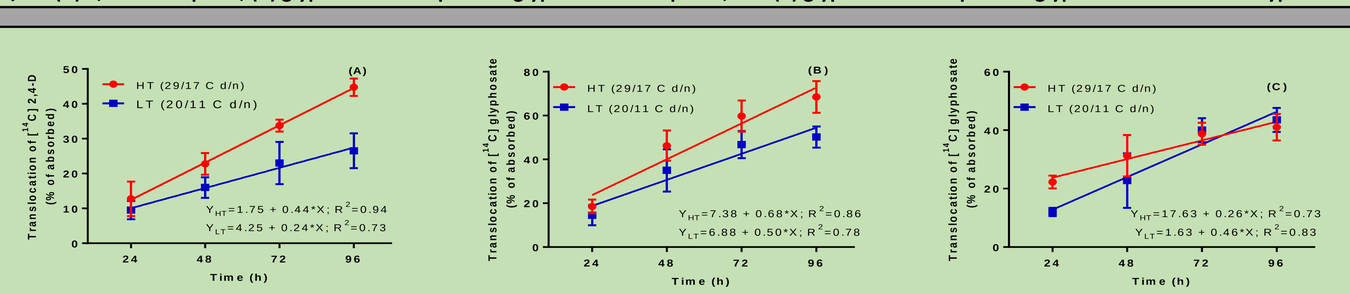

Figure 5. Translocation of 2,4-D or glyphosate in giant ragweed at two temperatures (^{0}C, day/night): high temperature (HT) 29/17; low temperature (LT) 20/11. (A) 2,4-D translocation; (B) glyphosate translocation in glyphosate-susceptible, and (C) glyphosate translocation in glyphosate–resistant biotype

- Absorption and translocation experiments indicated higher translocation for both 2,4-D (Figure 5A) and glyphosate (Figure 5B and 5C) at HT compared to LT.

Conclusions and Future Direction

- The efficacy of 2,4-D and glyphosate on giant ragweed control improved at warm temperatures (29/17 ^{0}C d/n) (Figure 2 and 3) due to increase in translocation of these herbicides (Figure 5) compared to cooler temperatures (20/11 ^{0}C d/n).
- Further investigation including metabolism (2,4-D), and gene expression (*EPSPS* gene) is needed to fully understand the molecular basis of differences in 2,4-D or glyphosate efficacy under varying temperatures.

Literature Cited

- Ganie et al. (2016) Weed Tech 30:45–56
- Jordan TN (1977) Weed Sci 25:448–451
- Kaur et al. (2016) Can J Plant Sci 96:726–729
- Kelly S (1949) Plant Physiol. 24:534–536