Effect of Degree of Water Stress on the Growth and Fecundity of Palmer amaranth

Parminder S. Chahal*, Suat Irmak, and Amit J. Jhala
University of Nebraska-Lincoln
*Email: parminder.chahal@huskers.unl.edu

Introduction

- Water is one of the most limiting factors for optimum crop production and plant species respond differently to water stress conditions.
- Palmer amaranth is the most problematic weed in agronomic crop production fields in the United States.
- Being a C_4 species, Palmer amaranth can adapt to drought/water stress conditions using drought tolerance (Ehleringer 1983).
- Limited information is available in the scientific literature regarding the growth response of Palmer amaranth to different water stress levels.
- This information may be useful for evaluating weed-crop interaction using competition models.

Objective

- To determine the effect of degree of water stress on the growth and fecundity/seed production of Palmer amaranth biotypes.

Hypothesis

- Palmer amaranth plants maintained at the lowest water stress will have the highest growth and seed production than the plants maintained at highest water stress levels.

Materials & Methods

Location – Greenhouse, Lincoln, Nebraska- 2016.

Treatment Information –

- Palmer amaranth plants from two different biotypes (collected from Shickley and Kearney, NE) were grown in the soil maintained at 100%, 75%, 50%, 25%, and 12.5% of the soil field capacity (FC) using moisture sensors in 20 cm wide and 40 cm deep plastic pots.

Treatment Application –

- 10 kg of loam soil (sand 37%, silt 44%, clay 19%) was filled in each pot and one 6-8 cm tall plant was transplanted. Gravimetric FC of soil (by weight) = 28% or 33.5% by volume. Total 4 reps for each treatment.
- A Watermark sensor was buried in each pot for 100% and 75% FC and one Decagon 5TE sensor for 50%, 25%, and 12.5% FC treatments to maintain the desired soil water content.
- A retention curve was developed for soil using the Soil-Water Characteristics Software to convert the Watermark sensors-measured matric potential values to volumetric water content (Irmak et al. 2016).

% Volumetric water content = -5.818 * ln(soil matric potential) + 51.228

Fig 1. Palmer amaranth plants were maintained at desired water stress levels using (A) Watermark and Decagon 5TE sensors, and daily soil moisture level was recorded from (B & C) Watermark data loggers and (D) Decagon data loggers in each pot and required amount of water was added.

Data Collection and Statistical Analysis –

- Daily Observations – Water content per pot from data loggers (Fig 1).
- Periodic observations – Plant height, plant width, and leaves per plant were recorded every 7 d from 21 to 77 d after transplanting. Growth Index was calculated using following equation (Irmak et al. 2004):

Growth Index (cm³) = 3.14 * (width/2)² * Height

- Observations at Harvest – Leaf area index, seed weight, seed number, seed germination, leaf and shoot biomass weight.
- Data were subjected to ANOVA using PROC GLIMMIX in SAS (9.3).
- A four-parameter log-logistic sigmoid growth function was regressed on leaves per plant, plant height (cm), and growth index (cm³) for each water stress treatment at different d after transplanting using R statistical software.

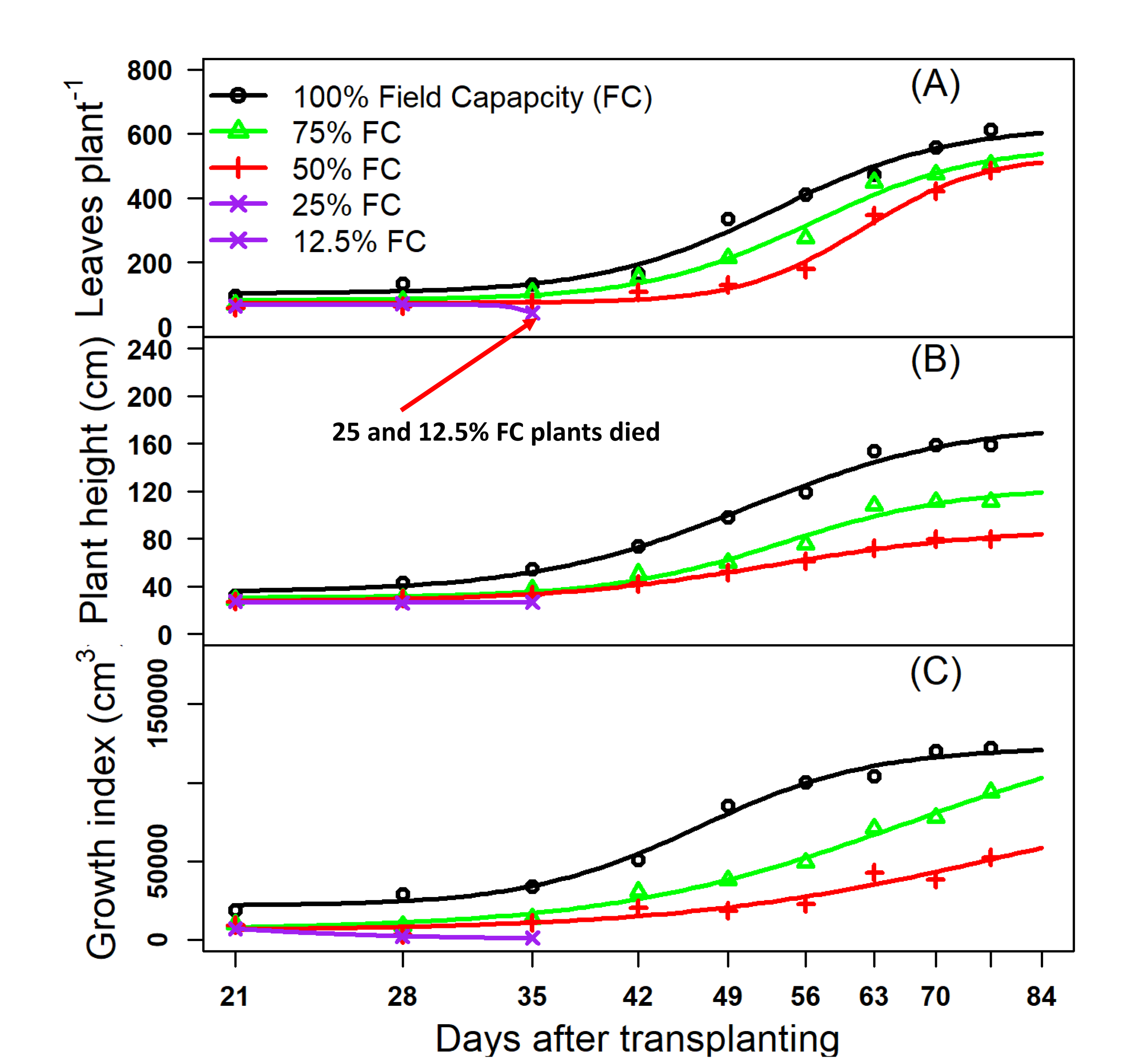

Fig 2. Effect of degree of water stress on Palmer amaranth (A) number of leaves produced plant⁻¹, (B) plant height, and (C) growth index in a greenhouse study conducted in Nebraska.

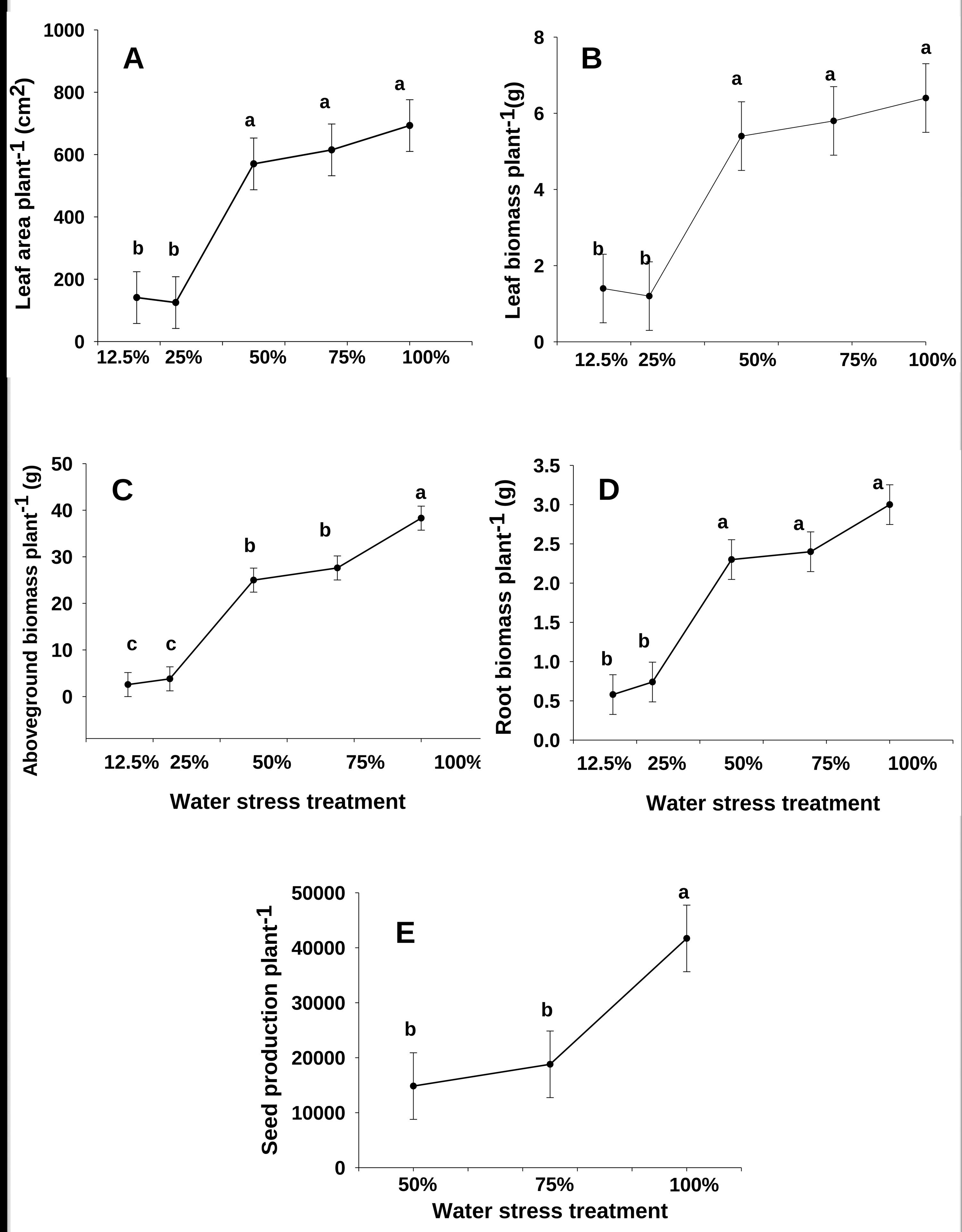

Fig 3. Effect of degree of water stress on Palmer amaranth (A) leaf area plant⁻¹, (B) leaf biomass plant⁻¹, (C) aboveground biomass plant⁻¹, (D) root biomass plant⁻¹, and (E) seed production plant⁻¹ at harvest.

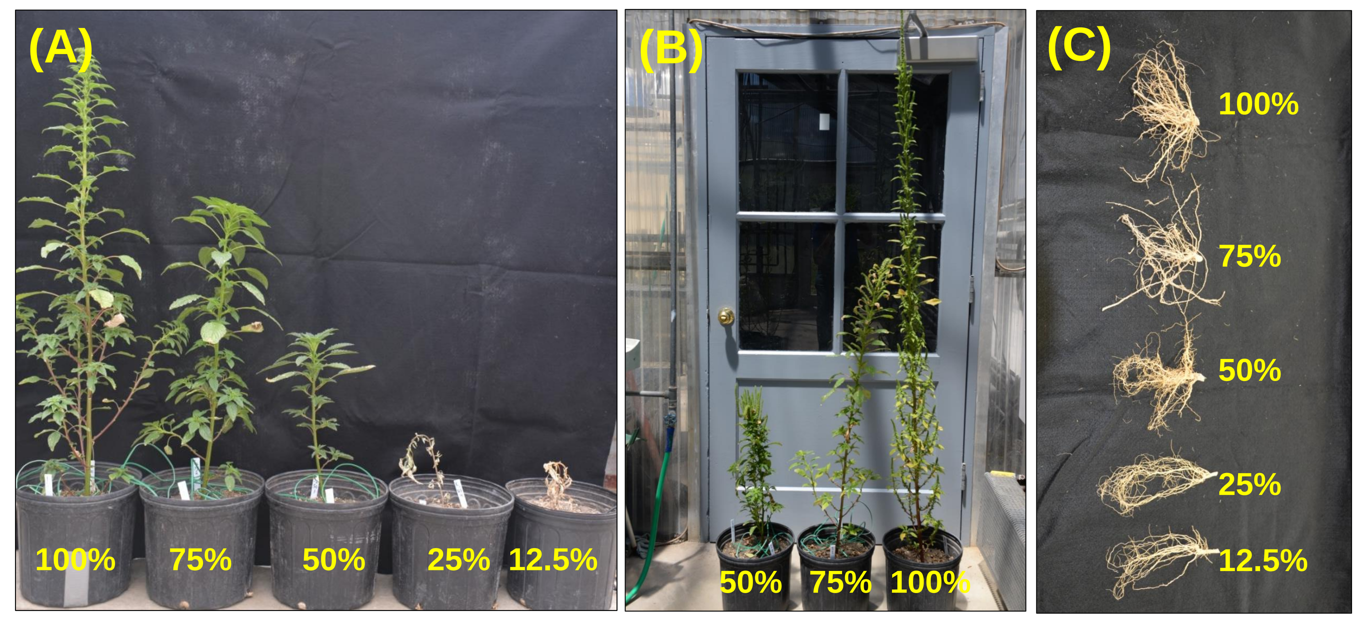

Fig 4. Effect of water stress on Palmer amaranth growth at (A) 42 d and (B) 70 d after transplanting, and (C) effect on root growth at harvest.

Results and Discussion

- The model efficacy coefficients for curves fitted to leaf number, plant height, and growth index were > 0.90, indicating that fitted model was correct.
- No differences were observed between two Palmer amaranth biotypes and experimental runs for growth and seed production; therefore, data were combined over biotypes and runs.
- Palmer amaranth plants maintained at ≤ 25% FC did not survive more than 35 d after transplanting and were not able to produce seeds.
- Model predicted that plants at 100, 75, and 50% FC produced a maximum of 588 to 670 leaves plant⁻¹. However, plants at 25 and 12.5% FC produced only 60 to 68 leaves plant⁻¹ (Fig 2A). Similarly, plants maintained at ≥ 50% FC had the highest total leaf area of 571 to 693 cm² plants⁻¹ and leaf biomass of 5.4 to 6.4 g plants⁻¹ (Fig 3A; 3B).
- Plants at 100% FC achieved maximum height of 178 cm compared to 124 cm height at 75%, 88 cm at 50%, and 25 to 36 cm at 25 and 12.5% FC (Fig 2B; 4A; 4B). Similarly, growth index did not vary (1.1 to 1.4 × 105 cm³ plant⁻¹) among 100, 75, 50% FC treatments (Fig 2C).
- Plants at 100% FC produced 38 g aboveground biomass plant⁻¹ compared to 25 to 27.6 g at 75 and 50% FC and 4.5 to 5 g at 25 and 12.5% FC (Fig 3C). Plants at ≥ 50% FC capacity produced dry root biomass of 2.3 to 3 g plant⁻¹ compared to 0.6 to 0.7 g plant⁻¹ at 25 and 12.5% FC (Fig 3D).
- The seed production was greatest (42,000 seeds plant⁻¹) at 100% FC compared to 75 and 50% FC (14,000 to 19,000 seeds plant⁻¹) (Fig 3E). A cumulative seed germination was similar (18 to 26%) when plants were exposed to ≥ 50% FC.
- Similarly, Sarangi et al. (2015) reported highest common waterhemp (*Amaranthus rudis* Sauer) plant height, seed production plant⁻¹, and total aboveground biomass at 100% field capacity.
- However, spiny amaranth (*Amaranthus spinosus* L.) produced greatest height of 128 to 137 cm at 100 and 75% FC compared to 73 cm at 50% FC (Chauhan and Abugho 2013).

Conclusions

- Palmer amaranth growth and seed production was affected by degree of water stress and it has capacity to survive and reproduce under low (100% FC) to moderate (50% FC) water stress.

Future Research

- To evaluate the effect of different durations of water stress on growth and fecundity of Palmer amaranth.

Literature Cited

- Chauhan BS, Abugho SB (2013). Am J Pl Sci 4:989-998
- Irmak S, Haman DZ, Irmak A, Jones JW, Campbell KL, Crisman TL (2004). HortSci 39:1445–1455
- Irmak S, Payero JO, VanDeWalle B, Rees J, Zoubek G, Martin DL, Kranz WL, Eisenhauer D, Leininger D (2016). Nebraska Extension Circular (EC783).
- Ehleringer J (1983). Oecologia 57:107–112
- Sarangi D, Irmak S, Lindquist JL, Knezevic SZ, Jhala AJ (2015). Weed Sci 64:42-52