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

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Introduction

- Palmer amaranth is the most problematic weed in agronomic crop production fields in the United States (WSSA 2016).
- Water is one of the most limiting factors for optimum crop production and plant species respond differently to water stress conditions created by climatic change.
- C4 plants, including Palmer amaranth, usually have high tolerance to water stress allowing them to grow in a wide range of water stress conditions (Long 1999).
- Limited information is available in the scientific literature regarding the growth response of Palmer amaranth to different water stress levels.

Hypothesis

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

Objective

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

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 field capacity 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. Palmer amaranth seeds were germinated and 6-8 cm tall plants were transplanted in the plastic pots.
- Gravimetric field capacity of soil (by weight) = 33.46% or 28% by volume as calculated from following soil water retention equation of watermark sensor for given soil.

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

- Two types of sensors, watermark (for 100% and 75%) and Decagon 5TE (for 50%, 25%, and 12.5%), were buried in the pots to measure the moisture level to maintain the desired soil water content.

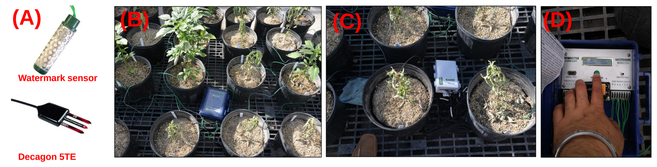

Fig 1. Palmer amaranth plants were maintained at desired water stress levels using Watermark and Decagon 5TE sensors (A), and daily soil moisture level was recorded from watermark data loggers (B & D) and Decagon data loggers (C) in each pot and required water was added.

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 each week from 3 to 10 weeks after transplanting. Growth Index was calculated using following equation (Irmak et al. 2004):

$$Growth\ Index\ (cm^3) = 3.14 * (width/2)^2 * Height$$

- 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).
- Means separated using Fisher's protected LSD at alpha=0.05.
- A four-parameter log-logistic sigmoid growth function was regressed on leaves per plant, plant height (cm), and growth index (cm^3) for each water stress treatment at different weeks after transplanting using R statistical software.

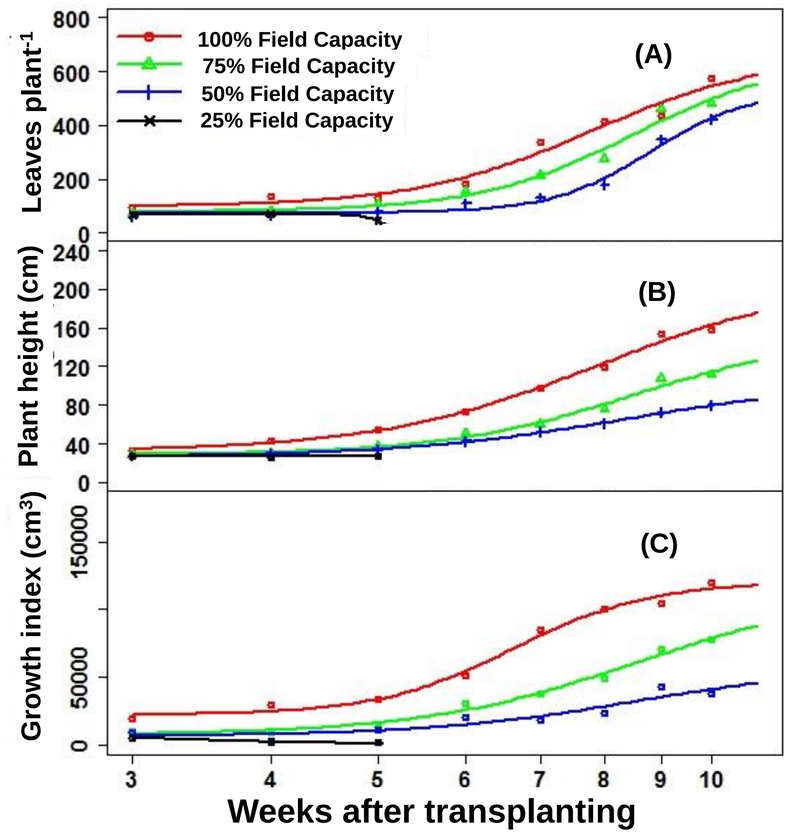

Fig 2. Effect of degree of water stress on leaves plant $^{-1}$ (A), plant height (B), and growth index (C) of Palmer amaranth in a greenhouse study conducted in Nebraska.

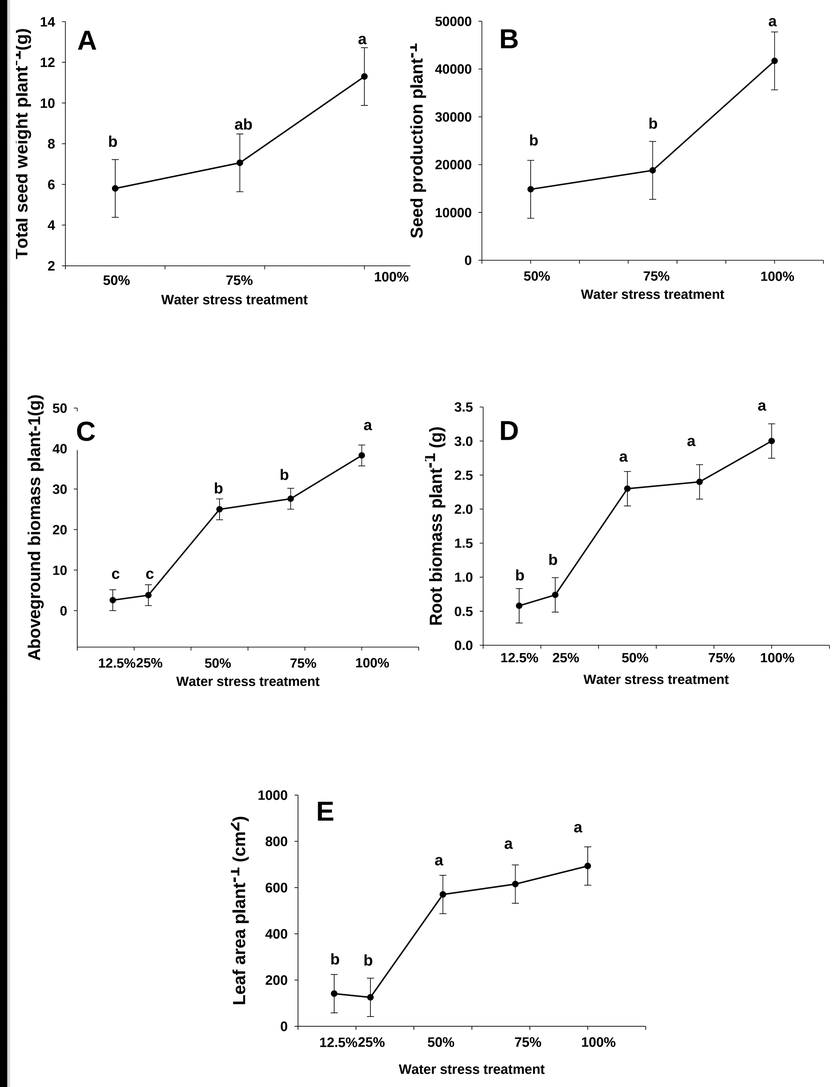

Fig 3. Effect of degree of water stress on Palmer amaranth total seed weight plant^{-1} (A), seed production plant^{-1} (B), aboveground biomass plant^{-1} (C), root biomass plant^{-1} (D), and total leaf area plant^{-1} (E) at harvest.

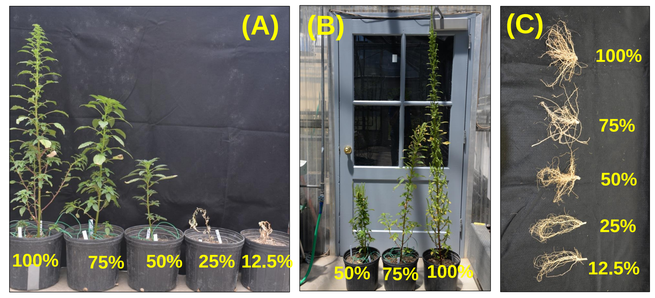

Fig 4. Effect of degree of water stress on Palmer amaranth growth at 6 weeks (A) and 10 weeks after transplanting (B), and on roots at harvest (C).

Table 1. Effect of degree of water stress on Palmer amaranth flowering period.

Water Stress Treatment	Flowering period (Days after transplanting)	
	1st run	*2nd run*
100%	29 to 51	25 to 45
75%	31 to 66	31 to 59
50%	41 to 71	38 to 73

Results and Discussion

- No difference was observed in the growth, development, and seed production between Palmer amaranth biotypes, except root biomass weight, and between two experimental runs; therefore, data were combined over biotypes .
- Plants maintained at ≥ 75% FC produced the highest number of leaves (≥ 664 plant^{-1}) (Fig 2A) and plants at ≥ 50% FC capacity produced highest dry root biomass (≥ 2.3 g plant^{-1}) (Fig 2D).
- The highest plant height (211 cm), seed production (41,696 plant^{-1}), and growth index (120,272 cm^3) was observed among plants maintained at 100% FC and reduced with increasing water stress (Fig 2A & C and Fig 3B).
- Plants maintained at ≥ 50% FC had the highest total leaf area plants^{-1} (≥ 570 cm^2) (Fig 3E).
- A cumulative seed germination (%) was similar (18 to 26%) when plants were exposed to ≥ 50% FC.
- Palmer amaranth plants maintained at ≤ 25% FC did not survive more than 5 weeks after transplanting and were not able to produce seeds.
- Similarly, Sarangi et al. (2015) reported highest common waterhemp plant height, seed production plant^{-1}, total aboveground biomass, and growth index at 100% field capacity.
- The model efficacy coefficient for curves fitted to leaf number, plant height, and growth index was >0.90.

Conclusions

- Palmer amaranth growth and seed production was effected by degree of water stress and it has capacity to survive and reproduce under low to moderate water stress.

Future Research

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

Literature Cited

- Irmak S, Haman DZ, Irmak A, Jones JW, Campbell KL, Crisman TL (2004) Measurement and analysis of growth and stress parameters of *Viburnum odoratissimum (Ker-gawl) grown* in a multi-plot box system. HortSci 39:1445–1455
- Long SP (1999) Ecology of C4 photosynthesis-environmental responses. Pages 215–249 *in Sage* RF and Monson RK, eds. C4 Plant Biology. San Diego, CA: Academic Press
- Sarangi D, Irmak S, Lindquist JL, Knezevic SZ, Jhala AJ (2015) Effect of water stress on the growth and fecundity of common waterhemp (*Amaranthus rudis*). Weed Sci 64:42-52
- [WSSA] Weed Science Society of America (2016) WSSA survey ranks Palmer amaranth as the most troublesome weed in the U.S., Galium as the most troublesome in Canada. http://wssa.net/2016/04/wssa-survey-ranks-palmer-amaranth-as-the-mosttroublesome-weed-in-the-u-s-galium-as-the-most-troublesome-in-canada/ Accessed: October 24, 2016