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Impact of water deficit on critical period of pigweed (*amaranthus retroflexus* l.) in sunflower

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ABSTRACT- The critical period of weed control is a part of crop life cycle during which weeds must be kept weed-free to avoid yield losses due to competition. In order to evaluate the effect of deficit irrigation on critical period of redroot pigweed (*Amaranthus retroflexus* L.) in sunflower (*Helianthus annuus* L.), an experiment was carried out as split plot based on randomized complete block design with three replications at the experimental farm of College of Agriculture, Shiraz University, during 2010 and 2011 growing seasons. Factors were water deficit at three levels (100%, 75% and 50% of field capacity) as main plots and weed interference periods in weedy and weed-free plots at five sunflower growth stages (8-leaf, 12-leaf, head emergence, flowering and maturity) as subplots. Results showed that water deficit decreased grain yield and grain yield components in both years. Critical period of redroot pigweed in normal irrigation with accepting 5% yield loss in sunflower was 35-86 DAP (days after planting) in the first year and 49-94 DAP in the second year. By decreasing irrigation water to 75%FC and 50%FC, the length of critical period increased to 34-100 and 32-105 DAP in the first year and 50-101 DAP and 44-98 DAP in the second year of the study, respectively. Generally, our results showed water deficit extended the length of critical period of redroot pigweed in sunflower.

INTRODUCTION

Weeds continue to be a constant threat to the productivity of field crops despite decades of weed control practices aimed at their elimination (Jordan, 1995). The development of herbicide-resistant weeds continues to challenge the effectiveness of modern weed control practices. The ability of weed communities to change in response to selective pressure posed by chemical control suggests the need for more integrated and diverse approaches of weed management (Buhler et al., 2000).

The critical period of weed control, is the basis of integrated weed management; hence, it can be seen as a first step to design a strategy for weed control (Anwar et al., 2012; Hodi et al., 2006). The development of integrated weed management (IWM) programs has been intended for agriculture over many years to fulfill weed control with more focus on environmental and health issues. Thus, IWM includes different cropping methods to use herbicides in a more efficient way to both control weeds and respect safety to people and the environment. The critical period of weed control (CPWC) is one of the most important components of an IWM program (Knezevic et al., 2002).

Knowledge of the CPWC and its affecting factors are essential for making decisions on the appropriate timing of weed control and achieving efficient use of herbicides (Knezevic et al., 2002; Mulugeta and Boerboom, 2002). A study on sunflower showed that the critical period of weed control in this plant was determined four weeks after emergence (Kropff and Van Loar, 1993). In another study, it was shown that sunflower stem elongation that coincides with rapid growth is a critical period of weed control in this crop (Duke, 1985).

Weeds, especially broadleaf weeds, have shown to cause a significant reduction in sunflower yield (Bruniard and Miller, 2001). Redroot pigweed is one of the most important weeds in Iran that can cause substantial yield losses through direct competition (Abbasian et al., 2001). Redroot pigweed benefits from a C_4 photosynthetic pathway, indicating that under conditions with high temperature and intense light, it has advantages over tropical and summer crops such as sunflower (Ronal, 2000; Ronald and Smith., 2000). Competitiveness of four redroot pigweed species was studied by Horak and Loughin (2000) through growth analysis with respect to various growth parameters (i.e., Dry weight, leaf area, height, etc.). They ranked these species as: Palmer amaranth (*Amaranthus palmeri* L.), common water hemp (*Amaranthus Rudis* L.), redroot pigweed (*Amaranthus retroflexus* L.), and tumble pigweed (*A. albus* L.). Bensch et al. (2000) reported that the negative interference impact of *A. retroflexus* on sunflower yield is more than *A. palmeri*and and the *A. rudis* is the highest. Grain Yield losses of the crops may reach 100% without accounting for grass weeds if broadleaf weeds are not controlled (Dimson, 2001).

Estimation of CPWC depends on several environmental factors whose estimation requires a good understanding of these factors and their interactions. Moisture is one of the most crucial factors over competition that affects CPWC. Basically, due to high stress resistance in weeds rather than crops, it is conceivable that environmental stresses can increase CPWC in weeds (Abelleyra, 2008).

Water deficit is a limiting factor that influences plant growth and yield worldwide (Flexas et al., 2004; Lawlor, 2002). The sunflower plant is drought tolerant and has an extensive, heavily branched root system (Angadi and Entz, 2002); so, it is considered as a suitable crop in arid and semi-arid regions. Several researchers have studied the effect of water stress and deficit irrigation on sunflower's phonological, morphological, agronomic and physiological traits (Erdem et al., 2006; Angadi and Entz, 2002; Kiani et al., 2007; Göksoy et al., 2004; Khani et al., 2005; Jafarzadeh and Postini, 1998). Due to limited irrigation water, it is generally accepted that deficit irrigation should be used in dry land conditions (Anonymous, 1999; Flagella et al., 2002).

A study on the effect of environmental factors such as moisture on weed emergence time is necessary to develop effective models to predict the consequences of sunflower weed management. Sunflower crop was chosen for this study because of its well-known adaptability to water stress conditions. The objectives of the present study were to quantify the critical period of redroot pigweed control (CPPC) in sunflower to optimize redroot pigweed control and evaluate the effect of deficit irrigation on the CPWC.

MATERIALS AND METHODS

Site Description

To investigate the critical period of CPPC in sunflower to optimize redroot pigweed control and evaluate the effect of deficit irrigation on the CPWC, a field experiment was conducted in 2010 and 2011 at the College of Agriculture, Shiraz University, Shiraz, Iran, located at Badjgah (1810 m above the sea level with longitude of 52° 35´ N and 39°4´E). Soil type was silty loam (Fine) at both years with 2.13% organic matter and pH of 7.8. The field was fallow in the previous season. The meteorological data of the experiment site are shown in Table 1. Field received urea in two times, 100 kg ha^{-1} at sowing and 100 kg ha^{-1} at 6-leaf growth stage.

The experiment was a split plot based on a randomized complete block design, with three replications. Land preparation included plowing, disking and ridging the plots (4 × 3 m^2). The sunflower seeds (var. Tekney, early maturing, semi tall and drought resistant) were sown by planter in plots of 4 m effective width and 3 m long, in June 12, 2010 and June 4, 2011. The seeds were planted 18 cm apart in each row spaced 60 cm across all plots (75,000 plants ha^{-1}).

The main-plot factor was deficit irrigation in three levels: full irrigation (WD_0), 50% and 25% of the water deficit (WD_{50}; 50% deficit and WD_{25}; 25% deficit, respectively). Deficit irrigation treatments started at 8-leaf stage and continued until maturity. In each plot, irrigation interval was 10 days for all treatments. The soil water content was monitored in each plot by using the gravimetric method in the root distribution zone. The water requirement for each treatment was calculated using time volume technique (Hassanlee, 2000). Subplot was in two groups: 5 plots with different levels of redroot pigweed interference (weedy up to eight-leaf, twelve-leaf, head emergence, flowering and maturity stage of sunflower) and 5 plots with different levels of weed free period (weed removing up to eight-leaf, twelve-leaf, head emergence, flowering and maturity stage of sunflower). Subplots measured 3 m in length by four rows wide (4.0 m). Sunflower growth stages based on growing degree days (GDD) and days after planting (DAP) for both years are shown in Table 2.

The other set of treatments, increasing the length of weed-free period, was established by maintaining weed control from planting until the above-presented crop growth stages before allowing subsequent emerging weeds to remain for the rest of the season. In addition, season-long weedy and weed-free treatments were included. Weed removal (redroot pigweed as the only aggressive weed in region) for establishing the duration of interference and length of weed-free period treatments consisted of hand-hoeing and hand-weeding.

Table 1. Meteorological data of the experimental field during 2010 and 2011

Year	Temperature(°C)			Relative Humidity	Precipitation
	Maximum	Minimum	Mean	%	(mm)
2010	24.48	4.73	14.56	42.44	265.3
2011	23.66	2.51	14.55	44.21	348.5

Table 2. Sunflower growth stages based on growing degree days (GDD) and days after planting (DAP) during 2010 and 2011.

		Sunflower growth stages						
Year		Germination	8-leaf	12-leaf	Head emergence	Flowering	Ripening	Season-long
2010	DAE	10	25	39	50	61	113	121
	GDD	202.25	487.45	781.85	1004.80	1194.35	1999	2090
2011	DAE	12	29	38	55	69	125	135
	GDD	226.60	559.55	741.55	1072.60	1342.70	2229.15	1320.3

Data Collection

Plant height and head diameter were measured by randomly selecting four plants in each plot. The central two rows of each plot were harvested in October 7, 2010 and October 12, 2011 to determine the number of seeds per head, 1000 seeds weight, total dry matter and seed yield.

Two days before each weed removal, weeds were harvested from two 0.25 m^2 quadrates located on each side of the second sunflower row within each split-plot experimental unit. Harvests were excluded from a 50-cm portion of both the front and rear of each experimental unit (i.e. sub-plot) to minimize marginal effects. At each harvest, the height of the weed canopy was measured. Weeds were clipped at the soil surface, counted and weighed after oven-drying at 70 ºC.

GDD was determined using minimum and maximum air temperature from Shiraz University Weather Station and subtracting it from the base temperature needed for sunflower growth (6 ºC). The time of crop emergence was used as the reference point for the accumulation of GDD.

Statistical Analysis

A three-parameter logistic equation modified slightly by Hall et al. (1992) (Eq.1) was used to examine the effect of increasing the duration of weed interference on relative yield and to determine the beginning of the CPWC for each planting date:

$$Y = 1/\{\exp[c \times (T-d)] + f\}) + [(f-1)/f\}]] \times 100 \quad \text{[Eq.1]}$$

Where Y is the relative seed yield (% of season-long weed free yield), T is the duration of weed interference after crop emergence (x-axis expressed in GDD), d is the point of inflection (GDD) and c and f are constants.

The three-parameter Gompertz equation was used to provide a good fit to relative yield as it is influenced by increasing the length of the weed-free period (Hall et al., 1992; Knezevic et al., 2002) and determine the end of the CPWC for each planting date:

$$Y = a \times \exp[-b \exp(-kT)] \quad \text{[Eq.2]}$$

Where Y is again relative seed yield (% of season-long weed-free yield), a is the asymptote, b and k are constants, and T is the length of weed-free period after crop emergence (x-axis expressed in GDD).

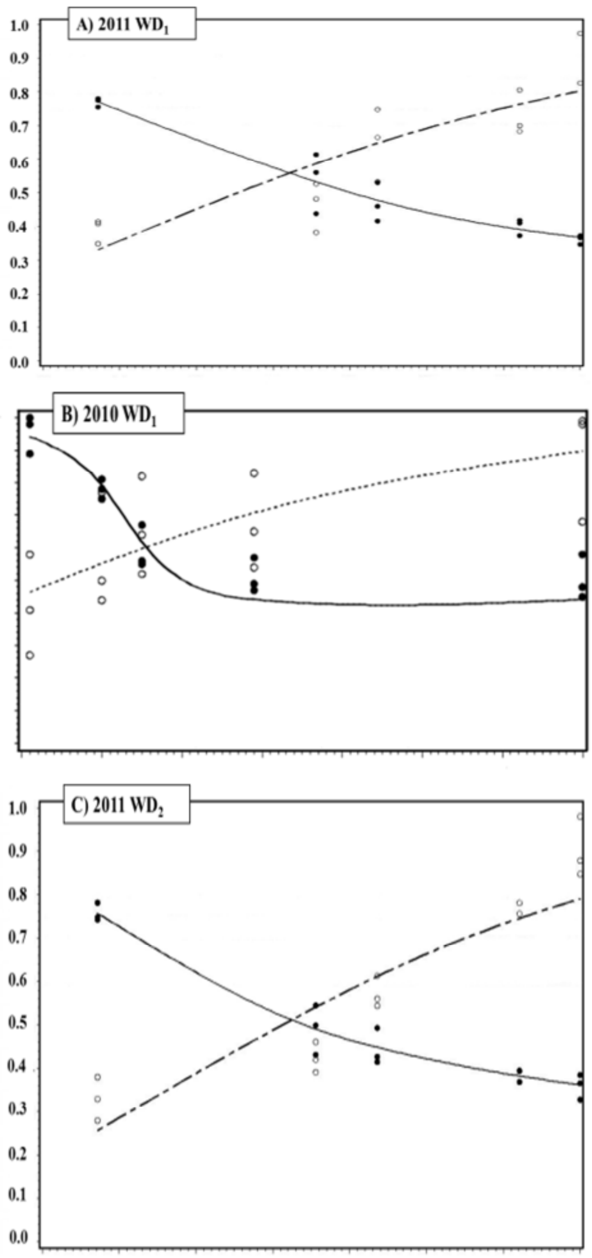
In this study, the CPWC was determined on the basis of arbitrarily chosen yield loss levels of 5% and 10%. The goodness of fit of models was measured in terms of minimum mean square of error (MSE) and maximum R^2. Standard error of parameters was also provided as an estimate of their confidence; hence, if it was large, the parameter was poorly estimated.

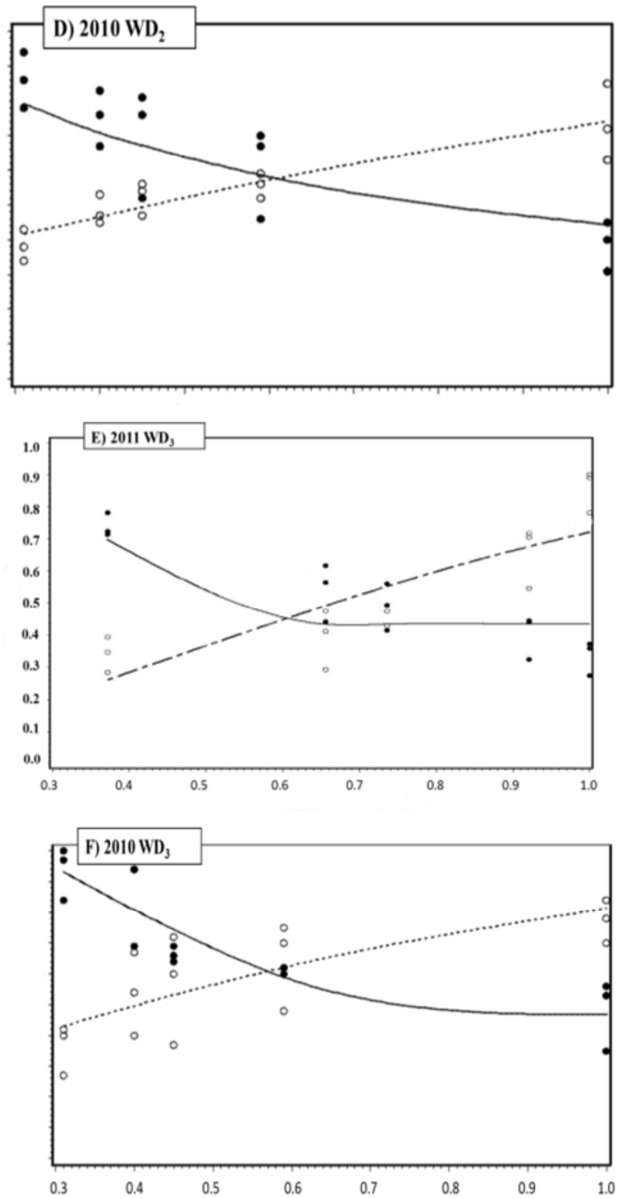
RESULTS AND DISCUSSION

Sunflower seed yield increased by extending the duration of weed-free period and decreased by increasing the length of weed infestation in both years. By increasing the weed-free period from 8 to 12-leaf and from 12-leaf to the flowering stage, seed yield increased to 15.72% and 14% in 2010, and 11.37% and 19.45% in 2011, respectively. Yield reduction in weed infested plots in head emergence, flowering stage and whole crop cycle relative to weed-free were 29.71, 36.88 and 43.9 percent, respectively in 2010 (Table 3). This reduction in the second year was lower. Increment of sunflower yielded by increasing the duration of weed control due to decreasing the intensity of weed- crop competition.

Redroot Pigweed *(Amaranthus retroflexeus* L.) was the only present weed species with constant density (90±15 plants/m^{-2} in 2010 and 100±15 plants/m^{-2} in 2011) in two years. Different stages of sunflower growth (Tekni cultivar) in Badjgah region, according to GDD and DAP were noted. Two components of the weed control critical period, critical weed-free period and critical time of weed removal, according to 5 and 10 percent acceptable yield loss in 3 water deficit levels, were investigated separately. Total redroot pigweed dry weight increased as the duration of weed-infested period increased. Furthermore, the total redroot pigweed biomass in all plots decreased as the weed-free period increased. Logistic and Gompertz equation parameters were used with the combined data for both years to estimate the beginning and end of CPWC (Table 4 and Fig.1).

The variation in critical time of weed-free and weed-infested periods was observed in both years at all acceptable yield loss levels. The beginning of the critical period of redroot pigweed control in sunflower with normal irrigation was 726.4 and 787GDD in 2010 and 959 and 1071 in 2011, accepting 5 and 10% yield loss level, respectively. If the specified level of irrigation decreased to 75% FC, the weed-free period varied from 706 to 789 GDD in the first year and from 959 to 1071 GDD in the second year according to 5 and 20% AYL, respectively. The critical redroot pigweed free period in 50% FC occurred earlier than 75% and 100% FC. The beginning of this period with 5 and 10% AYL was 666 and 726.4 GDD in 2010 and 892.4 and 982 in 2011, respectively.





Relative cumulative Growth Degree Day (GDD)

Fig.1. Determination of weed control critical period for redroot pigweed in sunflower by using GDD. Crop relative yield is expressed as a percentage of weed-free period (- - - - -) and length of weed interference (———) over three irrigation levels in 2010 and 2011. Increasing the duration of weed-free period (empty circles) and weed-infested (bold circle) period and fitted curves as calculated by the Gompertz and logistic models, respectively. Equation 1 and 2 in the text explained the models. Tables 1 and 2 showed the parameters that estimated the models.

The critical time of redroot pigweed control for 5 and 10% AYL ended at 1655 and 1653GDD in the year 2010 and 1807 and 1740GDD in 2011 in normal irrigation. By increasing the level of water stress, the CPWC ended later. The duration of redroot pigweed infested in 75% FC with 5 and 10% AYL was 1439 and 1655GDD in 2010 and 1869 and 1740GDD in 2011. This period ranged from 1776 to 1917 GDD in the first year and from 1785 to 1941 GDD in the second year with 10 and 5% AYL in 50% FC (Table 3).

Differences at the beginning and end of Critical Period (CP) between years may have resulted from actual weed densities and differences in the relative weed emergence time. Weed emergence occurred 6 and 3 days sooner than the crop in 2010 and 2011, respectively. Thus, early beginning of CP in the first year was resulted from early establishment and growth of redroot pigweed in this year. Delaying at the end of redroot pigweed critical period in 2011 may be attributed to the more redroot pigweed density in the second year relative to the first year.

Regardless of the acceptable yield loss levels, reduction in the length of CP in the two years of research can be due to different environmental and climatological variables. For example, climatic data showed that the mean temperature was higher in 2011 which caused a faster sunflower growth rate and establishment and improved crop competitive ability; therefore, it reduced the duration of redroot pigweed control in 2011.

In this study, the redroot pigweed critical period was longer in 50% FC than 75% than normal irrigation. It shows that normal irrigation increased crop tolerance in competition with weed.

Results indicated that by increasing water deficit level, the critical period of redroot pigweed control began earlier and ended later. In other words, sunflower can be weed-free in normal irrigation for a longer time. Accepting 5% yield loss, critical period of redroot pigweed in normal irrigation in the first year was 35-86 days after planting (DAP) (49-94 DAP in the second year). By decreasing irrigation water to 75% FC and 50% FC, the length of critical period increased to 34-100 and 32-105 DAP in the first year (50-101 DAP and 44-98 DAP in the second year), respectively. This trend was similar to other levels of acceptable yield loss.

The mechanism through which water deficit increased the negative impact of redroot pigweed presence is not well known; but, it is clear that normal irrigation favored crop growth and its corresponding LAI, and consequently crop overshadowed the redroot pigweed plant which resulted in greater sunflower competitive ability and impaired redroot pigweed infestation.

High range of the critical period of redroot pigweed in sunflower could be attributed to different photosynthetic pathway (C_3 vs. C_4) of crop and weed, considering that in summer planting and high temperature, C_4 would have high photosynthetic and relative growth rates, then redroot pigweed competes more with sunflower and would prolong CPWC length (Stratonovitch et al., 2012). Water resources as a limiting critical factor can affect crop-weed competition and sunflower with a C_3 metabolism is more susceptible to water deficit especially if competing with a C_4 weed (Stratonovitch et al., 2012).

The length of CPWC can vary a lot among locations and years even when the same agronomical practices and genotypes are used (Buchanan and MC Laughlin, 1975; Snipes et al., 1987; Lindsquist et al., 1999; Rajcan and Swanton, 2001; Tingel et al., 2003; Erman, 2008; Swanton et al., 2010; Kavumarci, 2010). For instance, Hodl et al., (2006) reported that CPWC length is 28 to 56 DAP. However, Wanjari et al. (2001) showed that critical period of weed competition was 20 to 49 DAP. A practical aspect of this study is that in areas with water limitation like arid and semiarid regions, the crop needs more intensive weed management than areas with adequate water.

CONCLUSIONS

This research indicated that the differences between CPWC in water deficit treatments can play an important role in time of weed control and management. Compared to 100%FC, seed yield was reduced considerably in plots irrigated with 75% and 50% FC and similar results for yield reductions were recorded in the second year of the experiment. Generally, the length of critical period control of redroot pigweed extended by increasing water deficit.

Table 3. The critical timing of weed removal and the critical weed-free period for redroot pigweed in sunflower calculated based on logistic and Gompertz equations at three irrigation levels during two years (2010 and 2011) and two acceptable yield loss levels (AYL) expressed in growing degree days (GDD), corresponding days after planting (DAP) and crop growth stages (CGS).

		Beginning of CPWC at specified Yield loss						**End of CPWC at specified Yield loss**					
		5%			**10%**			**5%**			**10%**		
Year	**WDL**	**GDD**	**DAE**	**CGS**	**GDD**	**DAE**	**CGS**	**GDD**	**DAE**	**CGS**	**GDD**	**DAE**	**CGS**
2010	WD_0	726.4	35	V10.3	787	38	V11.3	1655	89	R7.6	1653	89	R7.6
	WD_{25}	706.26	34	V10.2	787	38	V11.3	1439	75	R6.7	1655	89	R7.6
	WD_{50}	666	32	V10.1	726/4	35	V10.2	1917	106	R8.6	1776	95	R7.9
2011	WD_0	959	49	R2	1071	57	R3.5	1807	94	R7.2	1740	90	R7.1
	WD_{25}	959.33	49	R2	1049	57	R3.5	1896	101	R7.6	1740	90	R7.1
	WD_{50}	892.4	44	R1.1	982	52	R2.5	1941	98	R7.5	1785	87	R6.9

Abbreviations: WD_0, WD_{25} and WD_{50}, full irrigation, 25% and 50% of water deficit, respectively; V10, sunflower with ten true leaves; V11, sunflower with eleven true leaves;R1, appearance of miniature floral head; R2, the immature bud elongates 0.5 to 2.0 cm above the nearest leaf; R3, the immature bud elongates more than 2.0 cm above the nearest leaf;R6, flowering is complete and the ray flowers are wilting; R7, the back of the head has started to turn a pale yellow color; R8, the back of the head is yellow.

Table 4. Coefficient estimates (standard errors in parentheses) of the three-parameter logistic and Gompertz model to determine sunflower relative yield. Refer to equations 1 and 2 in the text for model descriptions.

Year	WDL	Logistic model parameters			Gompertz model parameters	
		A	B	C	A	B
2010	WD_0	0.44(0.008)	0.96(0.063)	8.84(4.29)	1.85(0.866)	2.83(1.052)
	WD_{25}	0.08(14.634)	3.32(221.800)	0.31(16.579)	1.42(0.181)	1.55(0.246)
	WD_{50}	0.46(0.062)	1.15(0.310)	2.27(1.730)	1.57(0.469)	2.03(0.612)
2011	WD_0	5.60(3.054)	0.31(0.097)	2.07(0.382)	1.22(0.260)	1.07(0.382)
	WD_{25}	0.50(0.016)	0.93(0.056)	3.60(1.457)	2.03(0.581)	2.82(0.630)
	WD_{50}	3.35(1.649)	0.04(0.095)	0.83(0.192)	2.10(0.492)	2.32(0.465)

Abbreviations: WD_0, WD_{25} and WD_{50}, full irrigation, 25% and 50% of water deficit, respectively.

REFERENCES

Abbasian, A., Babaeian Jelodar, N. A., & Bararpour, M. T. (2001).Smooth pigweed (*Amaranthus hybridus L.*) interference with soybean (*Glycine max* L. *Merrill). Iranian Journal Agricultural Science and Natural Resources*, 8(3),103-112.

Angadi, S. V. & Entz, M. H. (2002). Root system and water use patterns of different height sunflower cultivars. *Journal of Agronomy*, 94, 47-62.

Anonymous. (1999). Sunflower crude and refined oils. In: Agribusiness Handbooks. Food and Agric. Organization, Eur. Bank Reconstruction Dev.

Anwar, M. P., Juraimi, A. S., Samedani, B., Puteh, A., & Man, A. (2012). Critical Period of Weed Control in Aerobic Rice.Scientific World .

Association of Official of Analytical Chemists (AOAC). (1970). Official method of analysis. 11th Edition, Washington D. C., USA.

Bensch, C. N., Horak, M. J., & Peterson, D. E. (2000). Amaranthus competition in sunflower. Proc. North. *Cent Weed Science Society*, 61, 55-81.

Bensch, C. N., Horak, M. J., & Peterson, D. (2003). Interference of redroot pigweed (*Amaranthus retroflexus* L.), Palmer amaranth (*A. Palmeri*) and common waterhemp (*A. Rudis*) in soybean. *Weed Science*, 51, 37-43.

Breccia, G., Vega, T., Nestares, G., Mayor, M. L., Zorzoli, R., & Picardi, L. (2011). Rapid test for detection of imidazolinone resistance in sunflower (*Helianthus annuus* L.). *Plant Breeding*, 130, 109-113.

Bruniard, J. M., & Miller, J. F. (2001). Inheritance of imidazolinone- herbicide resistance in sunflower. *Helia*, 24, 11-16.

Buhler, D. D., Liebman, M., & Obrycki, J. J. (2000). Theoretical and practical challenges to an IPM approach to weed management. *Weed Science*, 48, 274-280.

Dimson, E. V. (2001). Cauliflower production in Arizona, weeds. Available at: http://pestdata.ncsu.edu/ cropprofiles/ docs /azcauliflower.html.

Duke, S. O. (1985). Weed physiology. Vol. 1: Reproduction and ecophysiology. CRS press, Inc. Boca Raton, FI. U.A.A.

Erdem, T., Erdem, Y., Orta, A. H., & Okursoy, H. (2006).Use Of crop water stress index for scheduling the irrigation of sunflower (*Helianthus annuus* L.). *Turkish Journal Agriculture and Forestry*, 30,11-20.

Erman, M, Tepe, I, Yazlik, A, Levent, R., & Ipek, K. (2008). Effect of weed control treatments on weeds, seed yield, yield components and nodulation in winter-lentil. *Weed Research*, 44, 305-312.

Flagella, Z., Rotunno, T., Tarantino, R., Di Caterina, R., & De Caro, A. (2002). Changes in seed yield and oil fatty acid composition of high oleic sunflower (*Helianthus annuus* L.) hybrids in relation to the sowing date and the water regime. *European Journal of Agronomy*, 17, 221-230.

Flexas, J., Bota, J., Loreto, F., Cornic, G., & Sharkey, T. D. (2004). Diffusive and metabolic limitations to photosynthesis under drought and salinity in C3 plants.Plant Biology. 6:269-279. In sunflower cultivars under drought. II. Growth and water relations. *Australian Journal of Agricultural Research*, 37, 583-597.

Göksoy, A. T., Demir, A. O., Turan, Z. M., & Dağüstü, N. (2004). Response of sunflower (*Heliantusannuus* L.) to full and limited irrigation at different growth stages. *Field Crops Research*, 87, 167-78.

Grimes, D. W., Yamada, H., & Hughes, S. W. (1987). Climate-normalized cotton leaf water potentials for irrigation scheduling.Agric. *Water Management*, 12, 293-304.

Hall, M. R., Swanton, C. J., & Anderson, G. W. (1992). The critical period of weed control in grain corn (*Zea mays* L.). *Weed Science*, 40, 441-447.

Hassanlee, A. (2000). Different methods of water measurements.1st Edition, Shiraz University Press, Shiraz, Iran.

Hódi, L., Torma, M., Krisztina, M., & Kazinczi, G. (2006). Critical periods for weed control in sunflower in South-Eastern region of Hungary. *Cereal Research Communications*, 34, 469-472.

Horak, M. J., & Loughin, T. M. (2000). Growth analysis of four Amaranthus species. *Weed Science*, 48, 347-355.

Jafarzadeh Kenarsari, M., & Postini, K. (1998). Investigating the effect of drought stress at different growth stages on some morphological characteristics and yield components of sunflower (cv. Record). *Iranian Journal of Agricultural Science*, 29(2), 353-362.

Jordan, N. (1993). Prospects for weed control through crop interference. *Ecological Applications*, 3, 84-91.

Knezevic, S. Z., Evans, S. P., Blankekship, E. E., Van Acker, R. C., & Lindquist, J. L. (2002). Critical period for weed control: the concept and data analysis. *Weed Science*, 50, 773-786.

Kropff, M. J., & Van Loar, H. H. (1993). Modeling crop-weed interactions. Cab international, Walling ford, UK.

Lawlor, D. M. (2002). Limitation to photosynthesis in water-stressed leaves: Stomata vs. metabolism and the role of ATP. *Annals of Botany*, 89, 871-885.

Mulugeta, D., & Boerboom, C.M. (2002). Critical time of weed removal in glyphosate-resistant *Glycine max*. *Weed Science,* 48, 35-42.

Ronald, A. E., & Smith, C.E. (2000). The flora of the Nova Scotia. Halif Nova Scotia museum.

Ronald, A. E. (2000). Amaranthus retoflexus/pigweed. U.S. Department of agriculture. Rang Pub.

Stone, L. R., Schlegel, R. E., & Khan, A. H. (1996). Response of corn, grain sorghum and sunflower to irrigation to the High Plains of Kansas. *Agricultural Water Management*, 30, 251-259.

Stratonovitch, P. Storkey, J., & Semenov, A. A. (2012). A process-based approach to modelling impacts of climate change on the damage niche of an agricultural weed. *Global Change Biology*, 18, 2071-2080.

Swanton, C. J. & Weise, S. F. (1991). Integrated weed management: the relationship and approach. *Weed Technology*, 5, 648-656.

Swanton, C. J., Sullivan, J. O., & Robinson, D. F. (2010). The critical weed-free period in carrot. *Weed Science*, 58, 229-233.

Tolga, E., & Lokman, D. F. (2003). Yield response of sunflower to water stress under Tekirdag conditions. *Helia*, 26(38), 149-158.

Turhan, H., & Baser, I. (2004). In vitro and In vivo water stress in sunflower (*Helianthus annuus* L.). *Helia*, 27(40), 227-236.

Wanjari, R. H., Yaduraju, N. T., & Ahuja, K. N. (2001). Critical period of crop-weed competition in rainy-season sunflower (*Helianthus annuus*). *Indian Journal of Agronomy,*46, 309-313.

Zimdahl, R. L. (1988). The concept and application of the critical weed-free period. Pages 145-155 in M. A. Altieri& M. Liebman, ed. Weed Management in Agroecosystems: Ecological approaches. Boca Raton, FL: CRC Press.

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اثر کم آبیاری بر دوره ی بحرانی کنترل علف هرز تاج خروس (*Amaranthus retroflexus* L.) در آفتابگردان

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دوره بحرانی کنترل علف هرز

کاهش عملکرد قابل قبول

مدل گامپرتز

مدل لجستیک

چکیده- دوره بحرانی کنترل علف هرز یکی از بخش های چرخه زندگی گیاه زراعی است که با کنترل علف هرز از تلفات عملکردی گیاه زراعی در رقابت با علف هرز جلوگیری می‌کند. به منظور بررسی اثر کم آبیاری و دوره بحرانی تاج خروس (*Amaranthus retroflexus* L) بر رشد و عملکرد آفتابگردان (*Helianthus annuus* L.)، آزمایشی مزرعه ای در سال های زراعی ۸۹-۱۳۸۸ و ۹۰-۱۳۸۹ در ایستگاه تحقیقاتی دانشکده کشاورزی دانشگاه شیراز به صورت کرت های خرد شده در قالب طرح بلوک های کامل تصادفی در سه تکرار انجام شد. فاکتور اصلی شامل آبیاری به عنوان عامل اصلی(آبیاری نرمال، آبیاری در ۷۵ درصد ظرفیت مزرعه و آبیاری در ۵۰ درصد ظرفیت مزرعه) و علف هرز در دو سطح با و بدون تاج خروس هر کدام در ۵ مرحله رشدآفتابگردان (۸ برگی، ۱۲ برگی، ظهور طبق، گلدهی و رسیدگی) به عنوان عامل فرعی انتخاب شدند. نتایج نشان داد که کم آبیاری، عملکرد دانه و اجزاء عملکرد دانه آفتابگردان (تعداد دانه در طبق و وزن هزار دانه) در هر دو سال را کاهش داد. طول دوره بحرانی کنترل تاج خروس، با پذیرش افت ۵ درصدی عملکرد دانه در تیمار آبیاری نرمال، در سال اول ۳۵ تا ۸۶ و در سال دوم ۴۹ تا ۹۴ روز بعد از کشت بود و با کاهش میزان آب مصرفی تا ۷۵ درصد ظرفیت مزرعه طول دوره بحرانی علف هرز به ترتیب ۳۴ تا ۱۰۰ روز در سال اول و ۵۰ تا ۱۰۱ روز بعد از کشت در سال دوم و در ۵۰ درصد ظرفیت، در سال اول ۳۲ تا ۱۰۵ روز بعد از کشت و در سال دوم ۴۴ تا ۹۸ روز بعد از کشت افزایش یافت. به عبارت دیگر، کم آبیاری طول دوره بحرانی کنترل تاج خروس را افزایش داد.