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Differential Growth and Development Response of Sunflower Hybrid in Contrasting Irrigation Regimes

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ABSTRACT

Water is the most important factor limiting crop productivity at different growth stages of crop growth and development. The study was conducted to investigate the effect of irrigation scheduling on sunflower hybrid (Hysun-38) at vegetative versus reproductive stages during spring season 2010. The trial was laid out in randomized complete block design (factorial arrangement), replicated thrice, having net plot size of 3.5 m × 9 m. The treatments comprised of irrigation application of 75 mm each, at different growth and development stages. viz., I_1 = irrigation at plant establishment, I_2 = irrigation at plant establishment and irrigation at vegetative phase, I_3 = irrigation at plant establishment, irrigation at button stage and irrigation at flowering, and I_4 = irrigation at plant establishment, irrigation at vegetative phase, irrigation at button stage and irrigation at achene's formation. Days taken to 50% flowering was highest in I_2, where irrigation was applied at plant establishment and vegetative phase, and in I_4 treatment , where irrigation was given at seedling establishment, irrigation at vegetative phase, irrigation at button stage and irrigation at achene's formation. Leaf area index at different growth intervals was significantly affected by irrigation levels. Crop growth rate was highest for treatment I_4. Plant height (PH), stem girth (SG) head diameter (HD), 1000-achene's weight (AW) and achene's yield (AY) were significantly affected by different irrigation levels at various growth stages. Maximum AY (2415.68 kg·ha^{-1}) was obtained in I_4 treatment while, minimum AY (1275.35 kg·ha^{-1}) was obtained in case of those plots which were irrigated only at plant establishment stage. Sunflower productivity was affected with irrigation regime at different growth stages with the strongest responses seen at early growth stages which ultimately affected the final achene yield adversely.

Keywords: Growth; Irrigation; Leaf Area Index; Yield

1. Introduction

Sunflower (*Helianthus annus* L.) is a non-conventional oilseed crop and it is grown on an area of 1108 thousand acres with seed and oil production of 643 and 244 thousand tons, respectively, during the year 2009-2010 in Pakistan GOP [1], which is very low as compared to other countries. Application of irrigation at critical stages of plant growth not only regulates the metabolic process in plants but also increase effectiveness of other inputs and increases the crop yields. Chowdhry *et al.*, [2], Noorka *et al*. [3-5]. Both amount and distribution of water has a significant effect on yield in sunflower, Krizmanic *et al*., [6]; Reddy *et al*., [7]; Iqbal *et al*., [8]. Maximum yield of sunflower was obtained with irrigation at all critical growth stages, while most important when applied during flowering and yield formation periods, Stone *et al*., [9]. However, according to other scientists initial plant growth stages are more important for adequate water than to later irrigations (Tolga and Lokman [10]). Seed and oil yield were significantly affected by deficit Irrigation during critical growth period of a crop (Kazemeini *et al*. [11]). The deficiency of water modifies soil water relationship by lowering tissue water potential and improving metabolic process (Akhtar *et al*., [12]). Water stress during vegetative growth reduces leaf area and dry matter due to decrease in leaf water potential from less water update of more atmospheric demand, severely influences the leaf expansion. The most sensitive stages of sunflower to moisture stress are flowering, achene formation (Chimenti, *et al*. [13]). Khaziaie, *et al*., [14], Mehrpouyan *et al*., [15], Bakht *et al*., [16], Mirshekari *et*

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al., [17] concluded that irrigation deficit at late growth stages has less effect on yield than at early growth stages. The limited irrigation stress resulted in reduction of seed yield due to limited vegetative and reproductive development.

The present study, therefore, was carried out to determine the response of sunflower crop to irrigation distribution interval as regard to different growth and developmental stages for harvesting maximum economic return of sunflower.

2. Materials and Methods

2.1. Experimental Site

The experiment was conducted at the research farm of University College of Agriculture, Sargodha, Pakistan (320.04'N, 720.08'E) during spring season 2010. Randomized complete block design was used in experiment, replicated thrice, having net plot size of 3.5 m x 9m. The soil was silty loam and composite sample to a depth of 30 cm was obtained from experimental area and was analyzed (Nitrogen = 0.06%, available Phosphorus = 5.43 ppm and potassium 240 ppm). Hybrid Hysun-38 of sunflower was planted on ridges in the pattern of 70 cm ridge spaced and maintained 22.5 cm plant spacing, using a seed rate of 7 $kg \cdot ha^{-1}$.

2.2. Irrigation Application

The experiment comprised of four treatments viz.

I_1 = irrigation at plant establishment.

I_2 = irrigation at plant establishment + irrigation at vegetative phase.

I_3 = irrigation at plant establishment + irrigation at button stage + irrigation at flowering.

I_4 = irrigation at seedling establishment + irrigation at vegetative phase + irrigation at button stage + irrigation at achenes formation.

Each irrigation amount was of 75 mm and applied by flooded method in ridges. Mean monthly weather data for sunflower growing season March-June in 2010 (**Table 1**).

2.3. Fertilizer Application

Half of total nitrogen and full dose of phosphorus was applied at the time of field preparation by broadcast method in urea and diammonium phosphate form, respectively, while remaining 1/2 of nitrogen was applied after 30 days of sowing of crop. Whole dose of Potassium was also given as a basal @ 50 kg ha in the form of potassium sulphate. All other cultural and agronomic practices except under study were same for all the treatments. Thinning was done after 15 days of crop emergence to maintain required plant population.

2.4. Methodology

The observations recorded were; days taken to flowering, leaf area index, crop growth rate, plant height at maturity, stem girth, head diameter, thousand achene weight and achene's yield. Ten plants were randomly selected and tagged in each plot for measurement of phonological data. LAI-2200 plant canopy analyzer was used in the field for non-destructive leaf measurement.

2.5. Statistical Analysis

The data were thus collected for various growths and yield parameters and statistically analyzed by employing the Fisher's analysis of variance technique and then treatments means were compared least significant difference (LSD) test at 0.05 level of probability (Steel *et al*., [18]).

3. Results and Discussions

3.1. Days Taken to Flowering

Figure 1 showed that number of days taken to 50% flowering (60.03) were maximum in I2 treatment where the crop was irrigated twice at plant establishment and vegetative phase against the minimum days (50.32) in I_1, where the crop was irrigated only at plant establishment. But I_2 treatment remained statistically at par with I4 treatment where crop was irrigated at seedling establishment, vegetative phase, button stage, and at achenes for mation stage. Increase in number of days to flowering

Table 1. Mean monthly weather data for sunflower growing season March-June in 2010.

Months	Maximum Temperature (˚C)	Minimum Temperature (˚C)	Total Rainfall (mm)	Mean relative humidity (%)
February	20.5	8.3	7.11	60.3
March	27.4	14.1	9.2	58.5
April	37.7	23.4	4.06	44.2
May	39.6	25.3	2.04	44.9
June	40.01	26.5	14.74	44.6

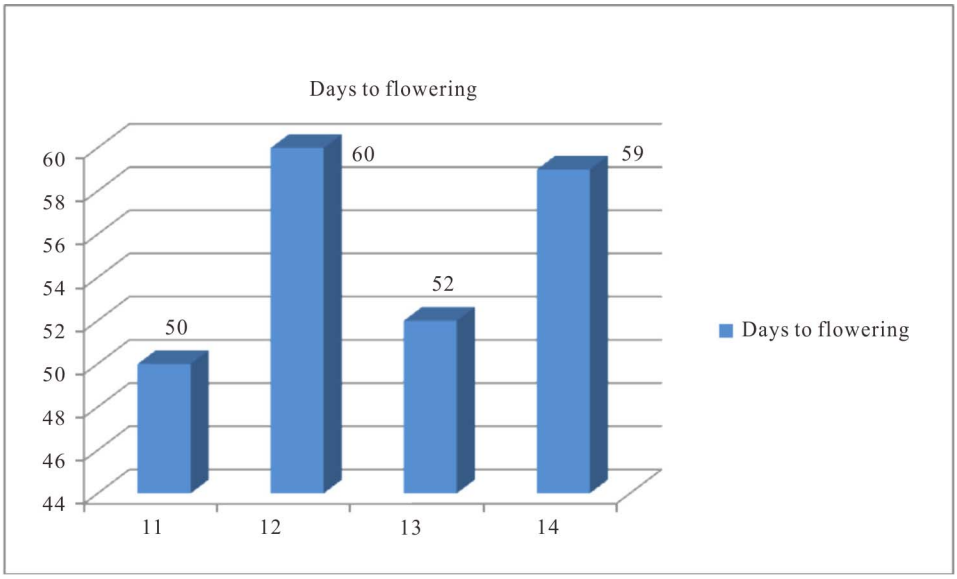

Figure 1. Effect of irrigation schedule on sunflower phenology.

may be due to the fact that application of water at vegetative stage increased vegetative growth and delayed flowering. These findings are in line with those of Jana *et al*., [19]; Teama & Mahmoud [20].

3.2. Leaf Area Index (LAI)

Figure 2 represents the effect of treatments on LAI development during the growing season. Figure shows that LAI was significantly affected by irrigation levels. First data obtained after 20 days of sowing showed non-significant difference for all the treatments. However maximum LAI (2.10) was recorded after 40 days of sowing for I4 treatment which was statistically at par with I2 treatment. These results are in line with findings of Ghani *et al*., [21] who reported decrease in LAI with increase in sporadic water stress.

3.3. Crop Growth Rate (g-2d-1)

The data regarding the effect of different irrigation levels have been presented in **Figure 3**. Regarding irrigation, the highest growth rate (14.07) was recorded in I_4 treatment and followed by I_3 and I_2 treatments, which were statistically at par with each other while minimum crop growth rate was (8.13) in I_1 treatment where irrigation was given only at plant establishment.

3.4. Plant Height at Maturity (cm)

The data regarding the plant height at harvest affected by different levels of irrigation are given in **Table 2**. Maximum plant height was recorded in I_4 treatment which is statistically at par with I_2 treatment against the minimum plant height (146.4) in I1 where the crop was irrigated only at plant establishment. In irrigation levels, maximum stem girth (1.694) was recorded in I_4 treatment followed by I_2 and I_3 treatment while minimum stem girth was obtained in I_1 where crop was irrigated only at plant establishment stage. The increase in stem girth may be attributed to optimum irrigation levels at crop developmental stages which primarily produced more stem girth. Similar results were also reported by Iqbal [22], Mirshekari [17] and found that application of water at establishment and vegetative stages increase vegetative growth of sunflower.

3.5. Yield Components and Achene Yield ($kg \cdot ha^{-1}$)

Head diameter is one of the most important factors affecting yield and production potential of sunflower, the data pertaining to head diameter has been presented in table which reveal that maximum head diameter (15.67) was noted for I4 treatment where the crop was irrigated at all the critical stages of irrigation, which did not differ significantly from I_3 and I_2 treatments where head diameter (15.00) and (14.37) was recorded respectively, while minimum head diameter (12.85) was found in I_1 treatment where irrigation was applied only at crop establishment stage. Irrigation levels had significant influence on seed weight and the highest 1000-achene weight (65.43) was recorded in I_4 treatment against the minimum 1000-achene weight (38.20) in I_1 where the crop was irrigated once at plant establishment. These results are similar with the findings of, Unger *et al*., [23], Akhtar *et al*., [12] and Baksh *et al*., [24], who reported increase in 1000-achene weight with application of water at flowering and seed development stages. Data given in **Table 2** showed that achene yield was significantly influenced by different irrigation levels. It increased significantly

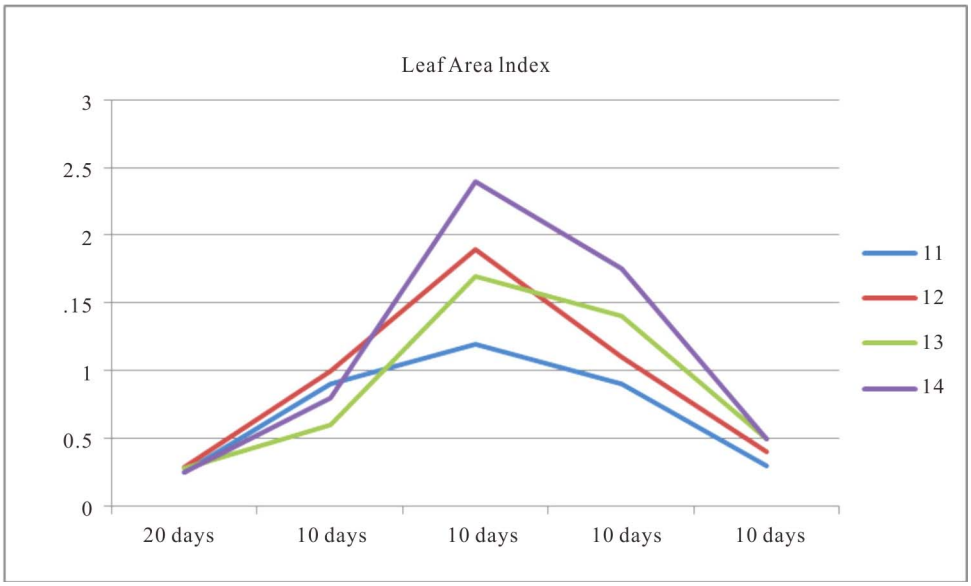

Figure 2. Sunflower leaf area index at different growth interval affect by irrigation scheduling.

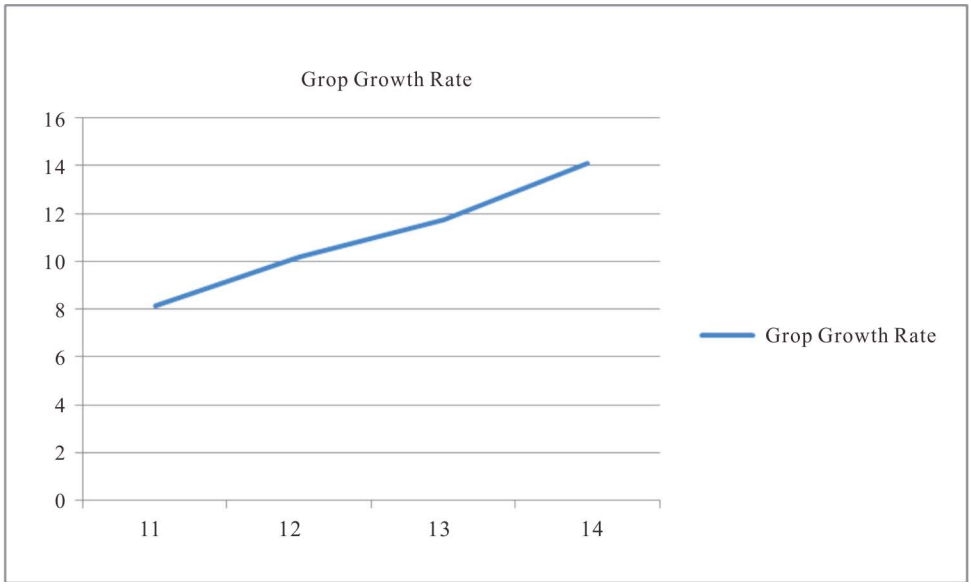

Figure 3. Crop growth rate as affected by different irrigation levels.

Table 2. Effect of different levels of irrigation on growth and yield parameters sunflower hybrid.

Treatments. (irrigation schedules)	Plant height at maturity (cm)	Stem girth (cm)	Head diameter (cm)	1000 - achene's Weight (g)	Achene yield ($kg \cdot ha^{-1}$)
I_1	141.4 c	1.432 c	12.85 b	38.20 d	1275.35 d
I_2	157.2 a	1.522 b	14.37 ab	50.12 c	1563.36 c
I_3	149.0 b	1.568 b	15.00 a	57.36 b	1876.29 b
I_4	160.3 a	1.694 a	15.67 a	65.42 a	2415.68 a
LSD	6.55	0.09524	1.653	5.321	180.22

At 5% level of probability (LSD), any two means not sharing a letter differ significantly.

from (1275.35) to (2015.68) in treatment I_1 and I_4 treatment, respectively. There is an increase in yield of 47.20% of treatment I_4 over Treatment I_1, where irrigation was applied only at plant establishment stage. These findings are in line with those of Teama & Mahmoud [20] and Reddy *et al*., [7]; Andhale & Kalbhor [25] and Valad-Abadi *et al*., [26], Noorka [27], Bakht *et al*., [16], Mirshekari *et al*., [17] who reported that proper irrigation scheduling increases the grain yield in crop. The preservation and improvement of genetic diversity of field crop will be helpful in maintaining the best genotypes, Tadesse1 *et al.* [28], Gomez-Pando and Barra [29], Noorka, *et al.* [30], Safdar *et al.* [31]

4. Conclusion

Sunflower responded to irrigation stop at different growth and developmental stages and strongest response was seen at early growth stages. For obtaining maximum achene's yield of sunflower the crop should be irrigated (I_4) at seedling establishment, irrigation at vegetative phase, irrigation at button stage and irrigation at achene formation. Deficit irrigation, during critical growth and development periods should be avoided. Further research may be required in this area for sunflower crop to identify the irrigation scheduling effects for obtaining higher economic return.

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