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EFFECT OF IRRIGATION ON PHYSIOLOGY AND YIELD OF SUNFLOWER HYBRIDS

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Abstract

The effect of four regimes of irrigation on physiological and morphological characteristics of sunflower hybrids was studied at National Agricultural Research Centre (NARC), Islamabad, Pakistan. The four irrigation levels were control (no-irrigation), heading stage, heading + flowering stages, and heading + flowering + grain filling stages. Sub plot size of 4.5 m x 5 m was maintained and randomized complete block design in split plot arrangement having 5 replications were used. Water regimes/ irrigation were kept in the main plot while hybrids (Parsum-1 and SF-187) in the sub plot. Maximum seed yield (2680 kg ha^{-1}) was obtained with three irrigations when compared with other treatments. Among the hybrids, SF-187 produced more yields (2440 kg ha^{-1}) than the hybrid Parsun-1 (2333 kg ha^{-1}). Oil content was lower (41.01%) in treatments receiving three irrigations. Seed yield with three irrigations was 24.83% higher than the control plot. Maximum leaf area index was observed when irrigation was given at 90 day interval after emergence of the sunflower (third irrigation). The same trend was also observed in dry matter accumulation and crop growth rate.

Introduction

In regions where water scarcity is the principal limiting factor for cultivation, farmers are interested in growing crops that are able to adapt to drought conditions (Bannayan *et al*., 2008). Sunflower has become an important crop for both farmers and consumers in Pakistan. Sunflower is a crop that fits well in the local cropping system and is considered the most important cash crop of the country. In Pakistan, sunflower is grown in two seasons i.e. spring and summer. Sunflower has been recognized as a crop with high potentials that can successfully meet future oil requirements. Pakistan should take full advantage from this crop, especially in the light of increasing demographic pressure and technological limitations, to further increase the sunflower production in new areas rather than in areas where sunflower and canola are already grown.

Crop growth rate (CGR) and crop growth duration along with other vegetative and reproductive parameters have great significance for development of high yielding variety. Information regarding dry matter accumulation, leaf area index (LAI), crop growth rate and duration are some of the key parameters for evaluation of cultivars in term of dry matter production and yield differences (Soriano *et al*., 2004; Nadjafi, 2006). There was positive correlation between maximum CGR, total LAD, number of fertile achenes $head^{-1}$ and concentration of oil in the achene and yield of achenes. Substantially high yields can

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be obtained from irrigated sunflowers, provided suitable varieties and watering techniques are used and the crop can be very profitable. Hybrid cultivars having high seed cost give the highest yield only when irrigated (Flagella *et al*., 2002). One of the needs of the hour is to adopt management techniques and technologies available for increasing irrigation efficiency (Khan, 2005).

Materials and Methods

To study the effect of different irrigation regimes on the growth and yield of two spring grown sunflower hybrids, field experiments were performed at the National Agricultural Research Centre (NARC), Islamabad, Pakistan during 2001 and 2002. Experiments were carried out in randomized complete block design (RCBD) with split plot arrangements replicated five times. The sub plot size was 4.5 m x 5 m with six rows of 5 m length spaced 75 cm apart keeping plant to plant distance of 20 cm. Standard agronomic practices were followed during the course of the experiment.

Experimental location and details: National Agricultural Research Center, Islamabad is located at 33° ′42 N latitude, 73 ′08 E longitudes and altitude of 518 m above sea level in Islamabad. Climatically it falls under sub humid to humid type and form a part of Pothwar land. Climatic data is shown in Table 1. The soils are alkaline (pH, 7.0 to 8.2), non saline (EC, 0.09 –0.76 ds m^{-2}) and slightly to moderately calcareous. Organic matter ranges between 0.31 to 2.50 % in the surface soils and 0.15 to 2.50 % in sub surface. Extractable P and K ranged from 1.6 to 39.0 mg kg^{-1} and 25 to 195 mg kg^{-1} respectively. Three treatments of surface irrigations triple, double and single in addition to one dry conditioned treatment were used. In triple irrigation water was applied at heading stage (R1), flowering stage (R4) and seed filling stages (R6). In double application water was applied at heading (R1) and flowering. The single irrigation was applied at heading stage (R1). Water was not applied to dry land treatment (control). Two hybrids i.e. Parsun-1 and SF-187 were used during the experiment. Data was recorded on crop phenology (days to R1, R4, R5.8, R9 stages), leaf area index, crop growth rate, dry matter accumulation, seed yield and oil content.

Table 1. Climatic data of the experimental site (NARC field station) during 2001-02.

Month	2001 Max temp. (°C)	Min temp. (°C)	R.H (%)	Rainfall (mm)	2002 Max temp. (°C)	Min temp. (°C)	R.H (%)	Rainfall (mm)
Jan.	19.0	1.1	36.7	0	19.0	1.5	39.3	17.9
Feb.	23.3	4.3	25.1	1	20.5	4.5	37.6	23.9
Mar.	27.5	9.2	25.9	27.0	26.9	9.5	34.4	41.4
Apr.	31.5	15.1	35.2	10.0	32.6	15.1	30.6	10.5
May	39.0	21.3	26.1	46.0	39.9	19.7	22.2	3.1
Jun.	35.6	23.5	49.5	157.0	38.4	23.2	37.1	130.4
Jul.	33.2	23.7	66.1	591.0	37.9	23.7	38.8	64.8
Aug.	33.9	23.7	65.6	141.0	32.6	23.5	68.1	407.9
Sep.	33.6	18.8	47.3	29.0	31.0	18.3	54.9	125.7
Oct.	31.4	13.9	41.1	23.0	29.8	14.4	57.9	49.7
Nov.	26.1	7.5	33.2	4.0	25.5	8.1	36.2	0
Dec.	21.2	3.9	40.6	1.0	20.0	4.4	44.4	25.80

Statistical analysis: The data are presented as mean values of five replicates. Data were analyzed statistically for analysis of variance (ANOVA) following the method described by Gomez & Gomaz (1984). MSTATC computer software was used to carry out statistical analysis (Russel & Eisensmith, 1983). The significance of differences among treatment means was compared by using Least Significant Difference (LSD) test (Steel & Torrie, 1980).

Results and Discussion

Crop phenology: Irrigation, had a significant ($p \leq 0.05$) effect on days to R1 stage (button stage), days to R4 stage (inflorescence begin to open), days to R5.8 stage ((80% anthesis) and days to R9 stage (physiological maturity) (Figs. 1-4). Maximum number of days to R1, R4, R5.8 and R9 stage were taken by the treatments receiving three irrigations during both growing seasons (2001-02). These results are in agreement with those reported by Aziz & Soomro (2001) who observed that days to maturity were increased due to increase in irrigation levels. Tan *et al*., (2000) reported that full and limited irrigation applied at different growth stages significantly increased vegetative growth particularly plant height in sunflower. Aziz & Soomro (2001) revealed that all the growth and yield contributing components (i.e. plant height, days to maturity, head diameter, seed yield and oil content) were affected significantly by different irrigation frequencies.

Crop growth rate: Leaf area index increased with an increase in interval from 30 to 90 days (Figs. 5 and 6). Similarly, increase in irrigation frequency resulted in maximum leaf area index. Maximum leaf area index was observed in 90 days interval with three irrigations in hybrid SF-187. Thakuria *et al*., (2004) reported that sunflower irrigated at various stages (seedling, buttoning and seed development stages) produced better leaf area index. Maximum crop growth rate was observed in 90 days interval with three irrigations. Minimum crop growth rate was observed when no irrigation was applied compared with other irrigation frequencies. (Figs. 7 and 8). These results are supported by Thakuria *et al*., (2004) who observed that crop growth rate, plant height, leaf number, dry matter accumulation, leaf area index and crop growth rate at various intervals in sunflower was improved under irrigated condition. Tan *et al*., (2000) reported that full and limited irrigation applied at different growth stages significantly increased plant height in sunflower. Aziz & Soomro (2001) revealed that all the growth, yield contributing components (i.e. plant height, days to maturity, head diameter, seed yield and oil content) were affected significantly by increased irrigation frequencies. Our results also suggested that dry matter production increased with increase in irrigation frequency. Maximum dry matter accumulation was observed when three irrigations were applied. Dry matter accumulation also increased with increase in days to interval (Fig. 9 and 10). Dry matter accumulation was found to be more in hybrids SF-187 than in Parsun-1. These results agree with the findings of Velu & Palanisami (2001), Baikas & Gajendra (2002) and Thakuria *et al*., (2004) who concluded that sunflower under irrigated condition produced better dry matter accumulation at various periodical intervals up to harvest.

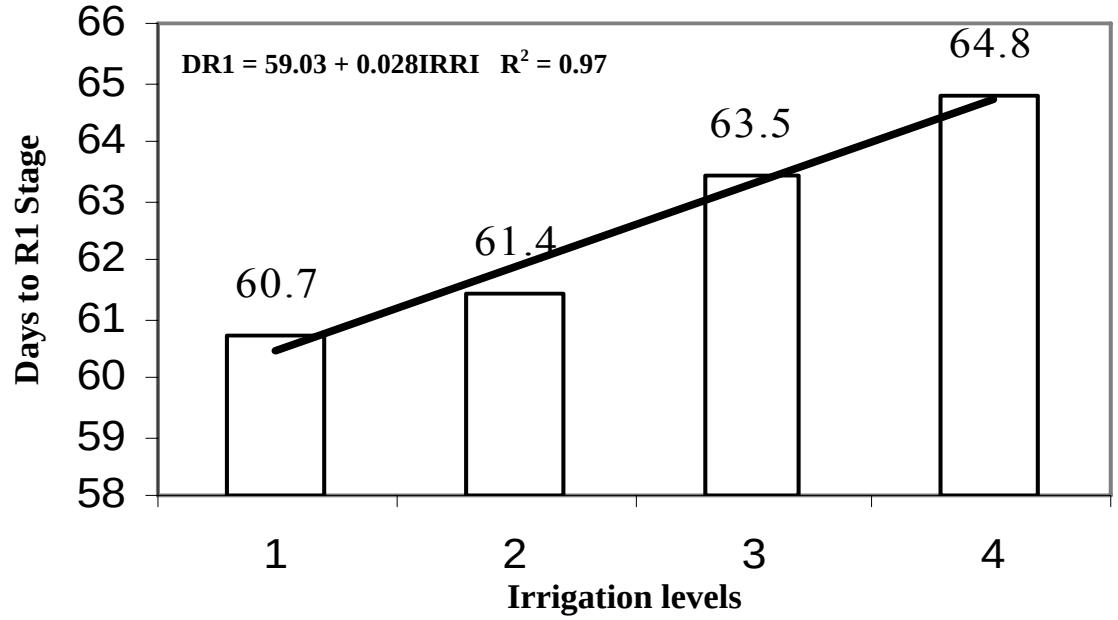

Fig. 1. Effect of irrigation on days to R1 stage of sunflower during spring 2001and 2002.

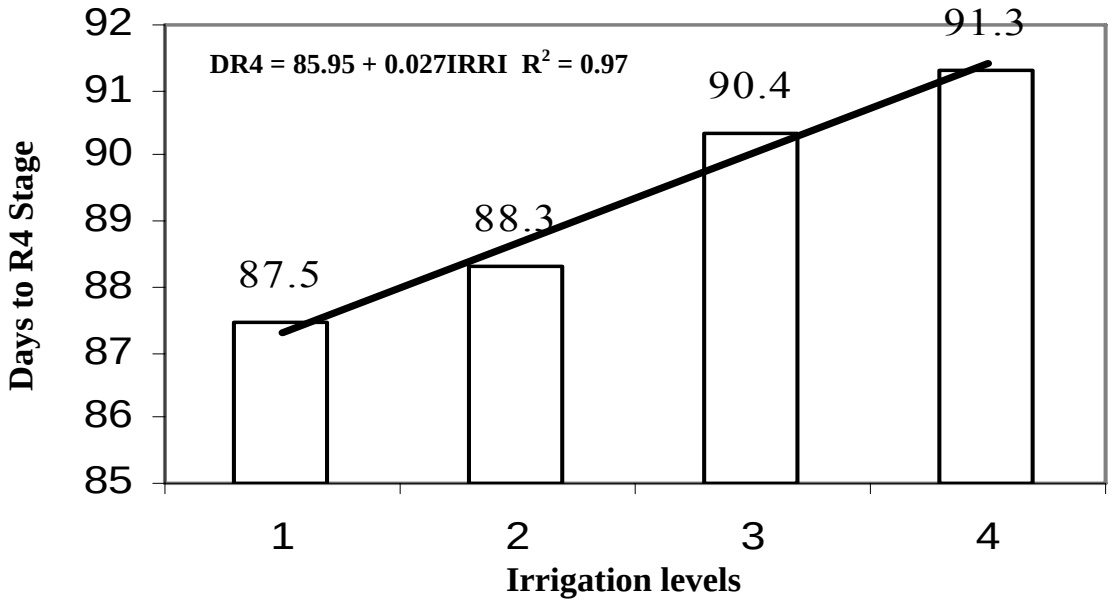

Fig. 2. Effect of irrigation on days to R4 stage of sunflower during spring 2001and 2002.

Seed yield (kg ha^{-1}): Seed yield was significantly ($p \leq 0.05$) affected by years and interaction between years x irrigations, while the effect of hybrids and their all possible interactions were non significant (Table 2). Between years, maximum seed yield was produced during 2002 compared with 2001. Similarly, maximum seed yield was observed for SF-187 compared with Parsun-1. More yields were noted when applied with three irrigations. Year x hybrid interaction revealed maximum seed yield during 2002 by Parsun-1. Treatments receiving three irrigations produced maximum seed yield when sown with Parsun-1. Mahendar *et al*., (2000) reported that seed yield was enhanced with increase in number of irrigations. Velu & Palanisami (2001) reported that water stress at the flowering stage could reduce the seed yield up to 29%. Similarly, Taha *et al*., (2001) and Khot & Patil (2002) reported that 100 seed weight was linearly related to the amount of irrigations. Velu & Palanisami (2001) reported that water stress at the flowering stage could reduce the seed yield up to 29%.

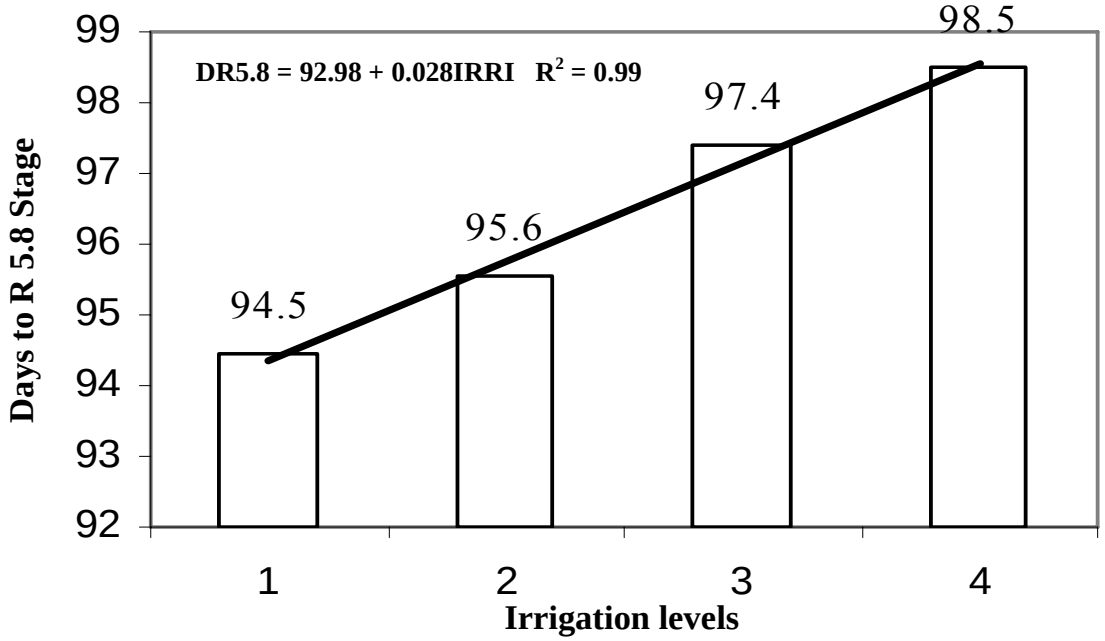

Fig. 3. Effect of irrigation on days to R5.8 stage of sunflower during spring 2001and 2002.

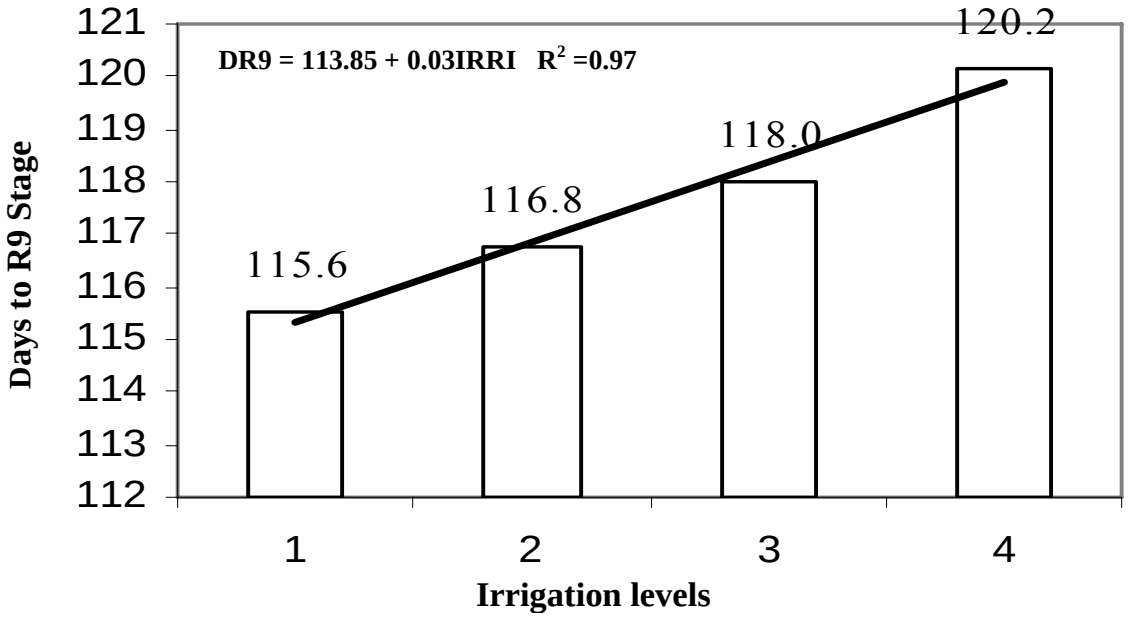

Fig. 4. Effect of irrigation on days to R9 stage of sunflower during spring 2001and 2002.

Oil content (%): Our results also revealed that oil contents was significantly affected $p \leq 0.05$ by hybrids, years and interaction between years x hybrids, while the effect of irrigation and interaction between year x irrigation, irrigation x hybrid and year x irrigation x hybrid was non significant (Table 3). The data indicated that maximum oil content was produced during 2001 compared with 2002. Similarly, oil content was more in Parsun-1 compared with SF-187. Among irrigation levels, maximum oil content was noted when irrigated twice. Year x hybrid interaction revealed maximum oil content during 2001 in Parsun-1 compared with hybrid SF-187 during 2002. Hybrid x irrigation interaction indicated that maximum oil content was produced in Parsun-1 at control treatment (no irrigation). These results do not agree with those reported by Khazaie *et al*., (2008). Tan *et al*., (2000), Flagella *et al*., (2000), Aziz & Soomro (2001) and Santonoceto *et al*., (2003) reported an increase in oil content due to increase in irrigation frequency.

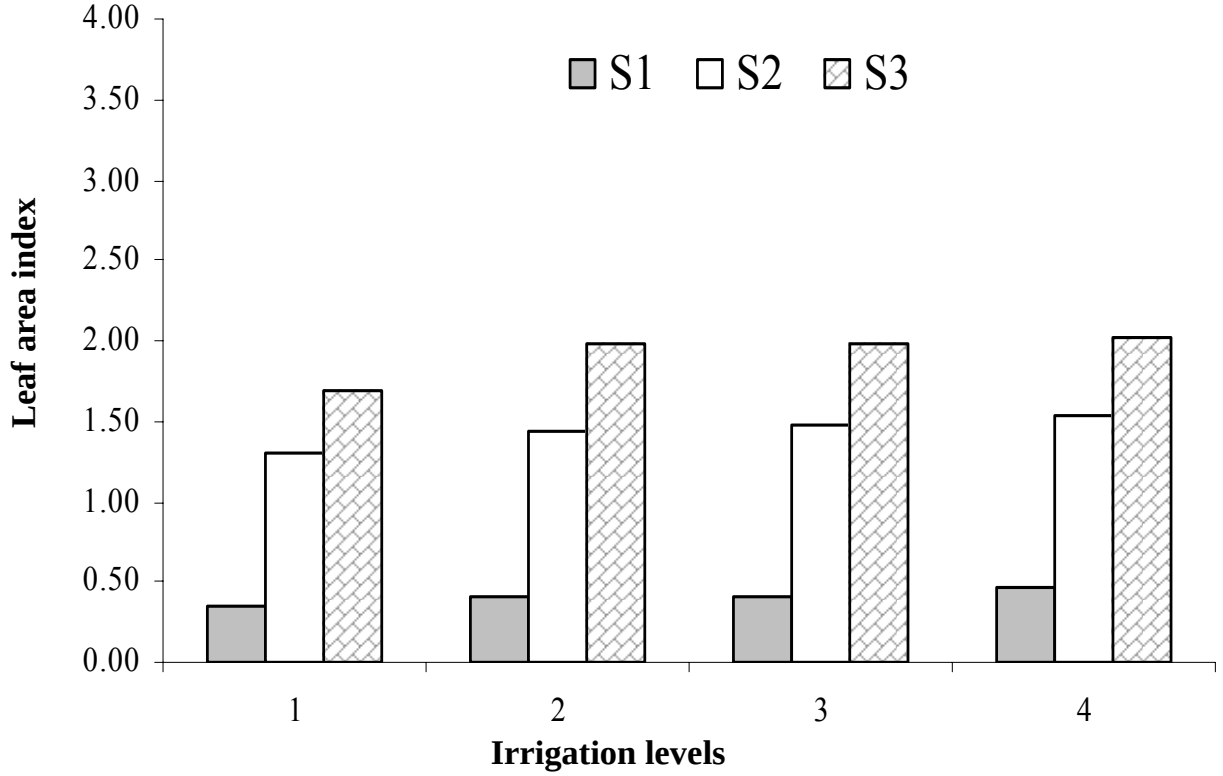

Fig. 5. Effect of irrigation treatments on the leaf area index of sunflower hybrid Parsun-1 during spring 2001-2002. (S1 = 30, S2 =60 and S3 = 90 days).

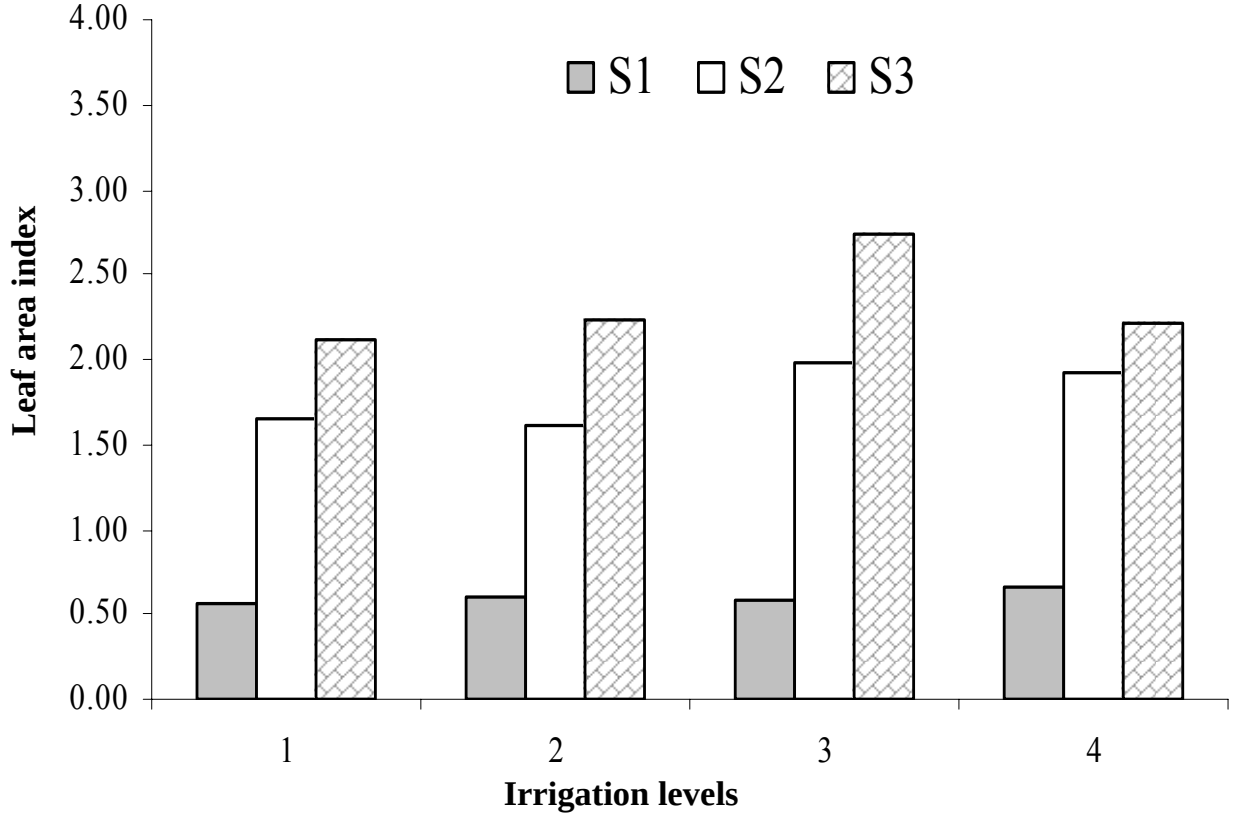

Fig. 6. Effect of irrigation treatments on the leaf area index of sunflower hybrid SF-187 during spring 2001-2002 (S1 = 30, S2 =60 and S3 = 90 days).

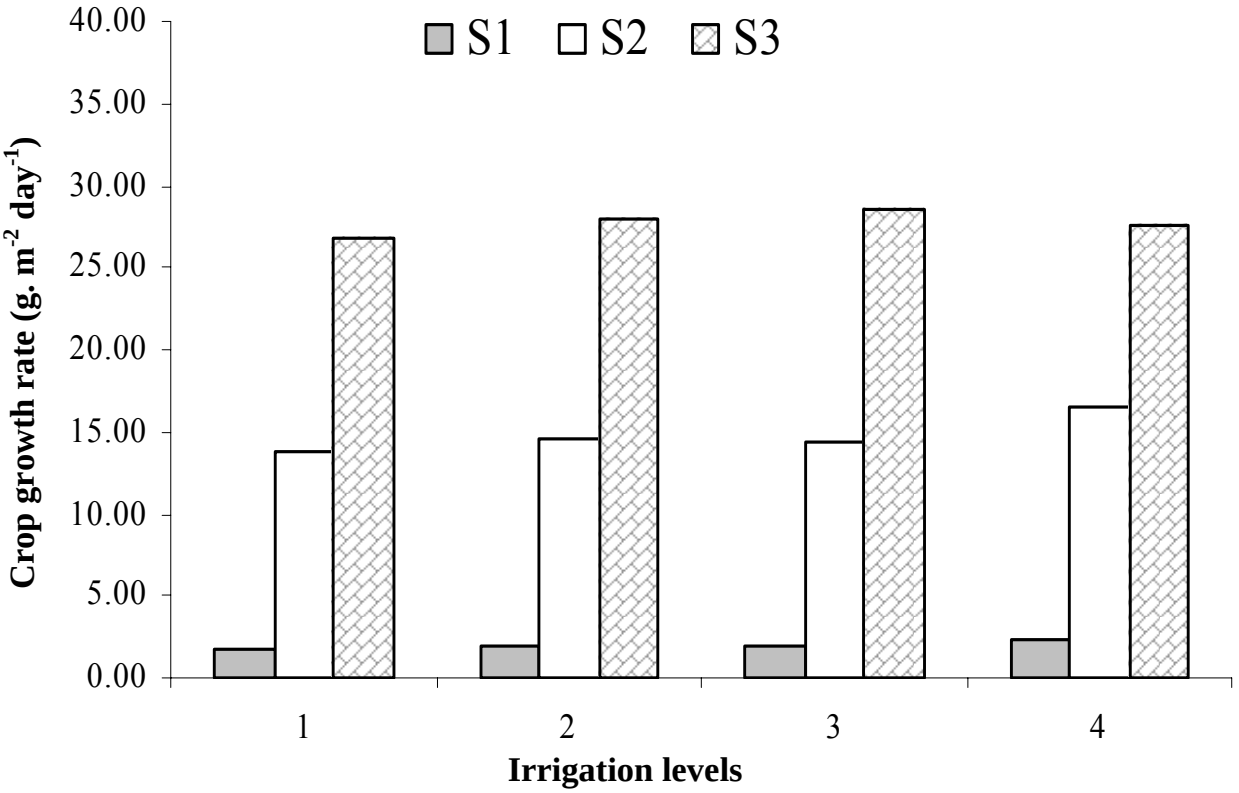

Fig. 7. Effect of irrigation treatments on the crop growth rate (g. m^{-2} day^{-1}) of sunflower hybrid Parsun-1 during spring 2001-2002 (S1= 30, S2 =60 and S3 = 90 days).

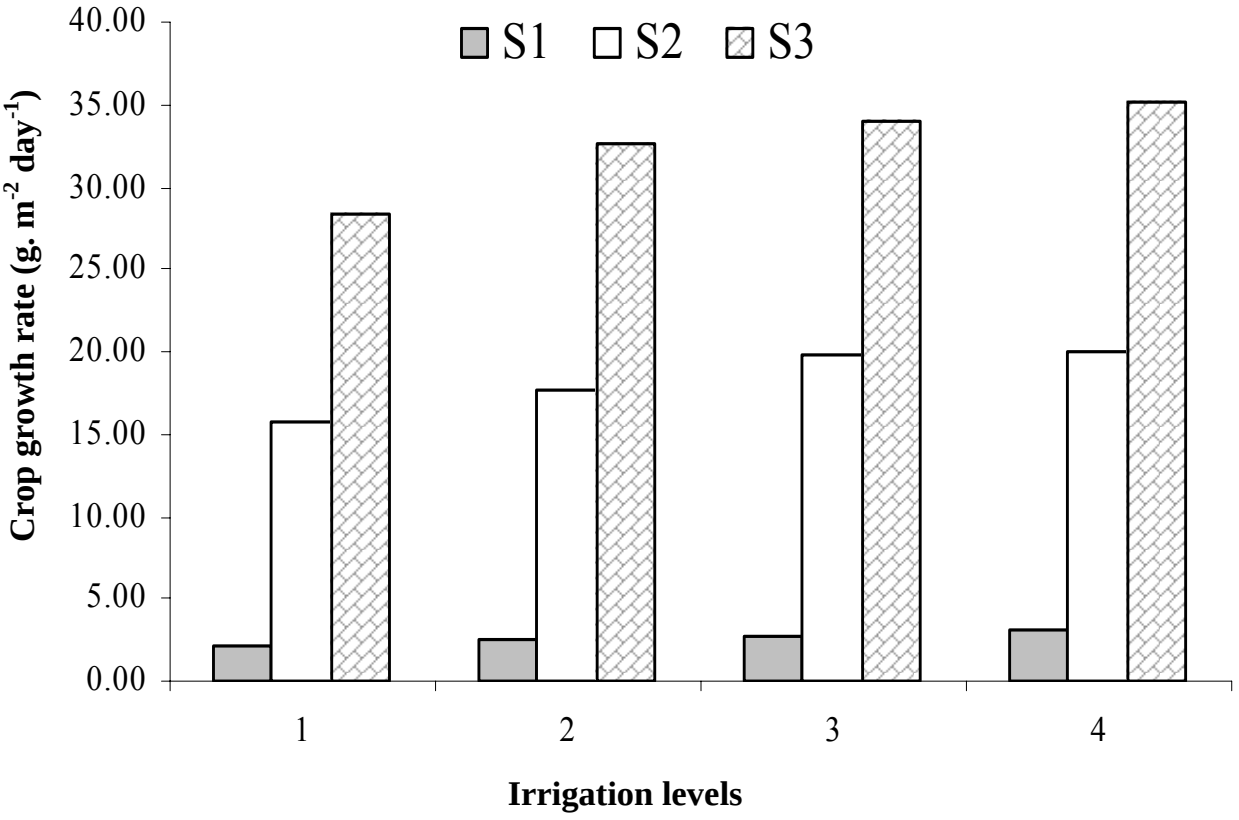

Fig. 8. Effect of irrigation treatments on the crop growth rate (g. m^{-2} day^{-1}) of sunflower hybrid SF-187 during spring 2001-2002 (S1 = 30, S2 =60 and S3 = 90 days).

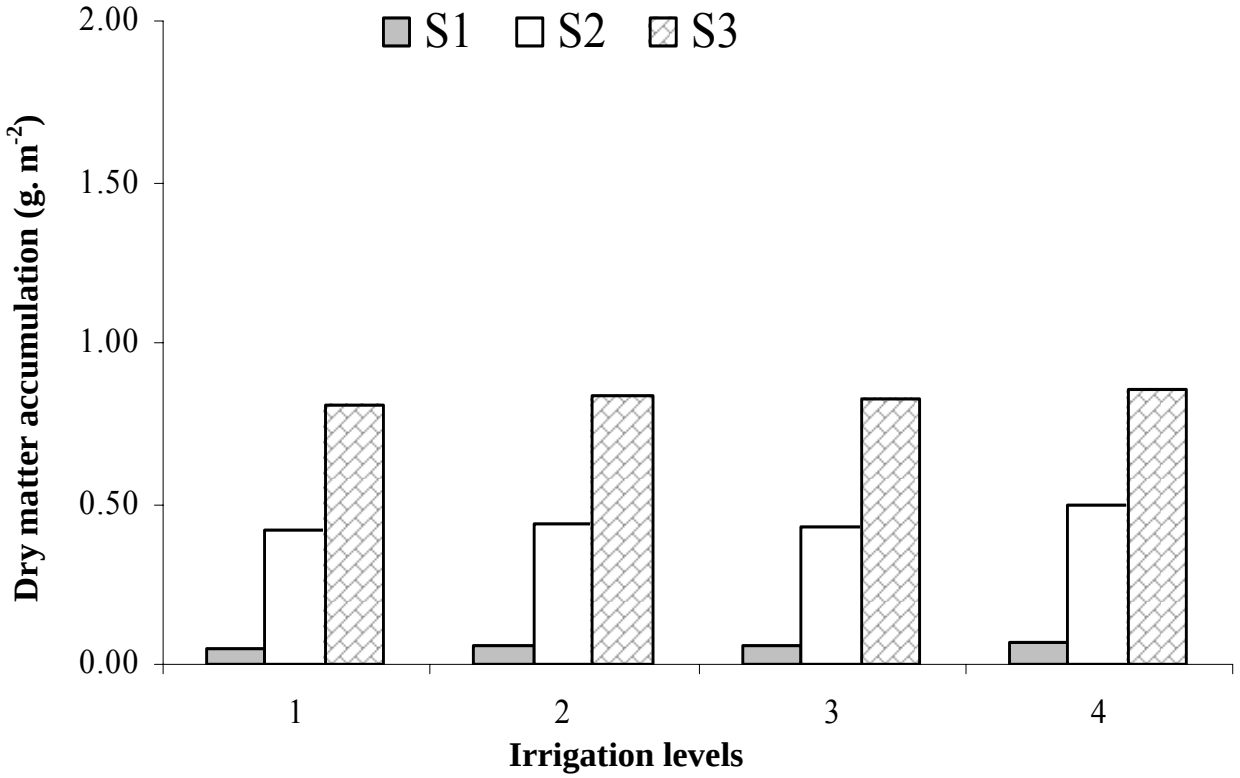

Fig. 9. Effect of irrigation treatments on the dry matter accumulation (g. m^{-2}) of sunflower hybrid Parsun-1 during spring 2001-2002 (S1 = 30, S2 =60 and S3 = 90 days).

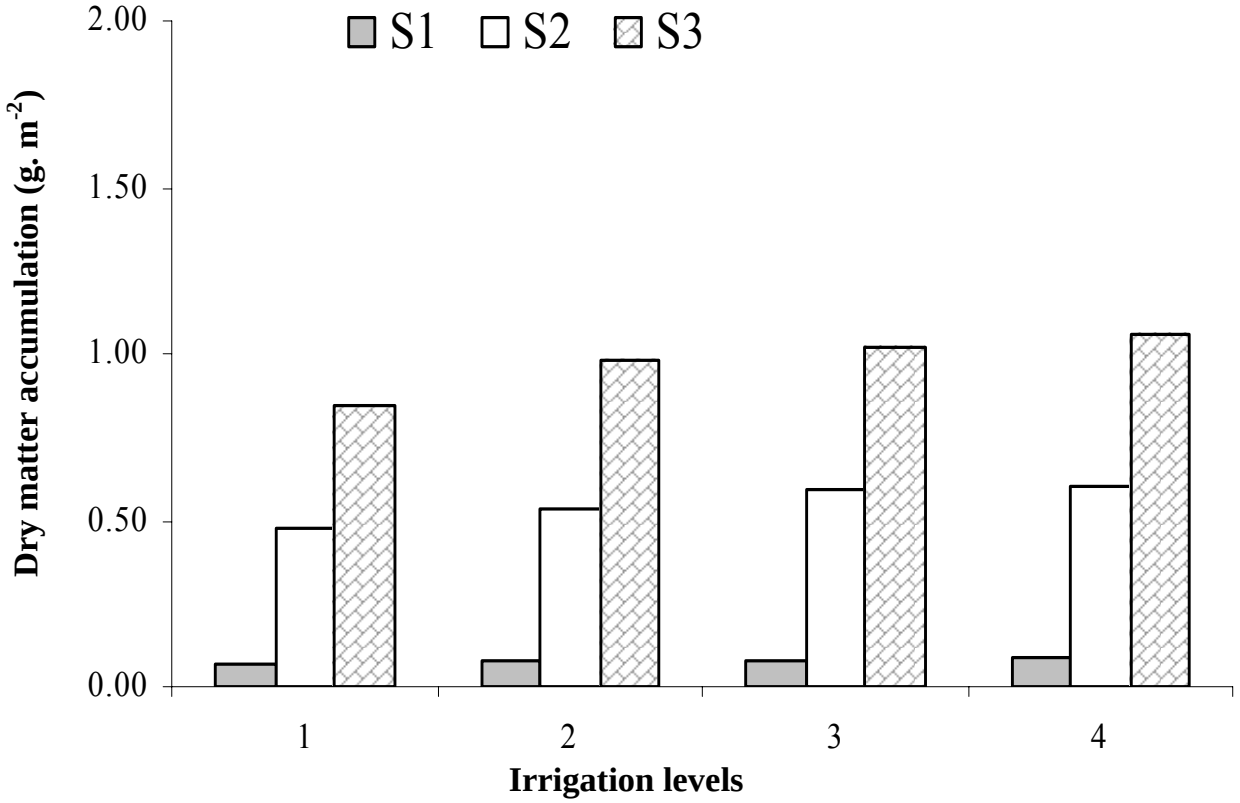

Fig. 10. Effect of irrigation treatments on the dry matter accumulation (g. m^{-2}) of sunflower hybrid SF-187 during spring 2001-2002(S1 = 30, S2 =60 and S3 = 90 days).

Table 2. Effect of irrigation on seeds yield (kg ha^{-1}) of sunflower hybrids (Parsun-I and SF-187) during spring 2001 and 2002.

Irrigation treatments	Parsun-1			SF-187			Mean (irrigation)
Number of irrigation	Year 2001	Year 2002	Mean (Parsun-1)	Year 2001	Year 2002	Mean (SF-187)	
00 (Control)	1540	2460	2000	2053	2533	2293	2147
01	1653	2480	2067	2033	2647	2340	2203
02	1900	2940	2420	2240	2960	2600	2510
03	2087	3593	2840	2140	2900	2520	2680

	Hybrids		
	Parsun-I	SF-187	Means (Y†)
Year 2001	1880	2138	2009b
Year 2002	3004	2836	2920a
Means (H††)	**2442**	**2487**	

Table 3. Effect of irrigation on oil content (%) of sunflower hybrids (Parsun-I and SF-187) during spring 2001 and 2002.

Irrigation treatments	Parsun-1			SF-187			Mean (irrigation)
Number of irrigation	Year 2001	Year 2002	Mean (Parsun-1)	Year 2001	Year 2002	Mean (SF-187)	
00 (Control)	45.71	41.50	43.61	40.92	38.78	39.85	41.73
01	45.35	39.87	42.61	40.00	39.15	39.58	41.09
02	45.68	40.15	42.92	41.76	39.51	40.64	41.78
03	44.99	39.90	42.45	42.10	37.04	39.57	41.01

	Hybrids		
	Parsun-I	SF-187	Means (Y†)
Year 2001	45.34	41.29	43.32a
Year 2002	39.97	38.57	39.27b
Means (H††)	**42.66a**	**39.93b**	

† = Years, †† = Hybrids

Means followed by different letters in the same column are statistically significant at $p \leq 0.05$.

Acknowledgments

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