

Effects of Water Deficit on Seed Yield and Oil Content Yield of Sunflower Cultivars at Eastern Sudan

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Abstract

A field experiment was conducted for two consecutive winter season during 2019/2020 and 2020/2021 in the Demonstration Farm of Faculty of Agriculture University of Kassala at New Halfa to investigate the effects of water stress on performance of three sunflower hybrids (Hysun 33= V1 cultivated a lot in the area, Panar = V2 cultivated since the last three years and Resarch =V3 new introduce hybrid). The experiment was laid out in RCBD as split-plot trail with three replicates. The water stress treatments were irrigation every 10 days (W1), skipping one irrigation at flowering stage(W2) and skipping one irrigation at seed filling stage (W3). The results showed that water stress significantly reduced LAI, shoot dry weight and yield attributes. The significant increase in the yield due to sowing V1 under frequent irrigation was associated with significant increase in the yield components (head diameter, No seeds per head, 100-seed weight, seed weight per head and seed yield per ha). Also, W1xV1 had positive effects on seed oil content. In conclusion, a large genetic variation was observed for seed yield and seed oil content under well watered and water deficit conditions.

Keywords: water stress, Sunflower, seed oil content, *helianthus annuus*.

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INTRODUCTION

Sunflower *helianthus annuus* is an annual oil crop one of the member of the family compositae. The crop has been receiving steady attention by various scientists from diverse disciplines in recent past because sunflower oil is a premium oil with light color and is widely used in the diets of heart patients because it contains very low cholesterol patients [1]. According to [2], in the last three seasons (2018-2021) the average cultivated area of sunflower was 216.98 million hectares producing 208.25 million tons with average yield of 0.96 ton/ha. However, the effects of drought stress on sunflower productivity are not same for all the growth stages. Exposure to drought at some specific phenological phases like germination, anthesis and achenes filling is most critical factor causing up to 50% yield reduction in sunflower [3, 4]. During the seed-filling period sunflower decreased (shading treatments or decreased (thinning treatments, seed weight [5, 6]. The introduction of new yielding hybrids has increased the yield but still there is a wider gap between potential and farmer field yield. There are several reasons which

can be conceived reasonable for low productivity. Selection of appropriate hybrids is a key factor to get maximal yield. Adoption of good cultivars improvement only yield but also quality. Although much works has been done on sunflower agronomy in different agro ecological locations of the world with a view to gaining insight into the effects of the cultural practices that enhances seed yield is still less of information on the performance of newly released and improved and locally adapted sunflower varieties as affected by low water stress particularly in New Halfa area eastern Sudan. Although a lot of literature about water stress effects on sunflower was reported by [7, 8]. Information regarding the effect of normally irrigated and water deficit environment on seed yield and yield component and seed oil content of sunflower is scanty. Also, the major problems facing production of sunflower in Sudan are lack of adequate information about the crop under Sudan condition, distribution and fluctuation of rains irrigation water, high percent of empty seeds and high yielding cultivars. Therefore the objective of this study was to: Investigate the effects of

water stress at flowering and seed-filling on yield and seed oil content of three sunflower hybrids.

MATERIALS AND METHODS

A field experiment was conducted for two consecutive winter seasons (2019/20 and 2020/011) in the Demonstration Farm of the Faculty of Agriculture and Natural Resources, University of Kassala, Halfa Elgaidah, Sudan (latitude 15° 18' -15° 21' N). Longitude 35° 36' - 35° 37' E and Altitude 450 m asl). Three sunflower hybrids: Hysun33 (V1), Panar (V2) and Research (V3) were used in this study. The experiment was designed to study the Effect of Water Stress on Performance and protein quality of Sunflower Genotypes (*Helianthus annuus* L). The three water stress levels was designated as W1, W2 and W2, corresponding to normal irrigation every 10 days, skipping irrigation at flowering stage and skipping irrigation at seed filling stage, respectively. The sunflower hybrids` seeds used in this study for two seasons were obtained from Agricultural Research Station in Wad Madani. The experiment was arranged in Randomized Complete Blocks Design (RCBD) as split-plot trail with three replications in both seasons. The crop received equal quantities of water at every 10 days after sowing for 30 days.

Characters studied

Ten plants were randomly selected and tagged in each sub-plot to determine the following growth parameters: Stem diameter (cm), Shoot dry weight (g plant⁻¹), Leaf area index (LAI) Leaf area index, expresses the ratio of leaf surface area to the ground area occupied by the crop, was calculated using the formula suggested by [9].

The heads of two inner ridges of each experimental sub-plot were bagged at early seed development to avoid damage that could be caused by birds until maturity. At harvest, ten guarded plants were randomly taken from the inner ridges of each experimental plot and dried under sunshine, then, the seeds were separated and cleaned. And the following yield parameters were determined: Head diameter (cm), Number of seeds per head, Seed weight/ head (g), Percentage of empty seeds (%) and Seed yield (kg/h). Also, seed oil content percentage was determined by using extraction method by [10] using hexane with a boiling range of 60-80°C for eight hours from duplicating the random samples.

Statistical analysis

Data was statistically analyzed using Statistix software package, version 10 for RCBD as split-plot trail according to [11]. Means comparison was worked out by Duncan's Multiple Range Test (DMRT) at 5% level of probability. Correlation analysis was carried out by using SPSS computer software package version 22.

RESULTS AND DISCUSSION

The thicker stems and heavier dry weight were recorded for Hysun 33 hybrid (V1) as compared with the two other hybrids (V1,V2) particularly under frequent watering in both seasons. Skipping irrigation at flowering or at seed filling stages significantly reduced stem diameters, dry weight per plant of sunflower hybrids during the two seasons (Table 1). On the other hand, the hybrid V2 recorded the highest values of ALI as compared to V1 and V3 hybrids in both seasons particularly under frequent watering treatment. The lowest values of LAI were recorded from V3 hybrid under water stress treatments (Table 1). Water stress imposed during flowering or seed filling stages significantly decreased these growth attributes as reported by many researchers [12, 13]. They attributed the reduction in these characters as a result of water stress due to the negative effect of water stress on cell division and hastened leaf senescence. Furthermore, the increased in LAI observed under normal watering might be due to better availability of moisture content for leaf growth which resulted in increase of stem thickness and shoot dry weight. The significant differences in growth parameters of all sunflower hybrids (Hysun33, Panar and Research) in this study might be due to difference in genotypes in similar environmental condition. This findings were in agreement with those reported by [14] who stated that difference in plant growth parameters between sunflower hybrid were under genetic control as well as phenotypic differences.

The skipping of one irrigation at flowering or at seed filling stages significantly reduced the mean head diameter, seeds number per head, seeds weight per head and seed yield (kg/h) in both seasons (Tables 2 & 3). On contrast, water stress at or at seed filling stages significantly increased the mean empty seed %. Regarding sunflower cultivars, Panar hybrids V2 recorded the largest head diameter, number of seeds and highest empty seed % as compared with the two other hybrids in both seasons (Tables 2 & 3). The fewer seeds and oil yield per unit area were recorded at skipping irrigation in the seed filling stages for Research hybrid V3 in both seasons. Normal watering significantly gave the highest oil content (36.28) as average of two seasons while stressed at seed filling stage significantly reduced the mean oil content by more than average (19.60%) relative to W1 treatment. Hysun33 V1 significantly out yielded the two other hybrids in oil content. Furthermore, sowing of V1 under frequent watering significantly increased the seed oil content sunflower plants in both seasons (tables3). The reduction in seed yield per head obtained in this study due to water stress was associated with significant difference in all yield components measured in this study. This could be attributed to the reduction in number of seeds/head , head diameter and high number of empty seeds. These results were in agreement with those reported by [15] who stated that, water stress during flowering stage reduced head diameter and seed

weight per head in sunflower plant. Also, [16] reported that water stress reduced grain number, grain yield but percentage of unfilled grains were increased. Surprisingly the reduction in seed weight was associated with substantial increase in the empty seeds per head. It hypothesized that, water stress particularly during flowering stage reduced fertilization and seed set due to dehydration of pollen grains [17]. Furthermore [13], reported that water stress reduced grain yield per unit area. the difference in yield components (head diameter, seed number, seed weight per plant and final seed yield) between the three sunflower hybrids might be due to the higher genetic potential and better adaptability under New Halfa climate conditions. These results were agreement with [18]. Also, [19] reported supporting evidence, who found that yield and its

components were significantly affected by genotypes. The reduction in oil percentages under water stress conditions could be attributed to negative effect of water stress during seed filling stages and could be attributed to the fact that water stress caused shortening seed-filling period and decrease of transferring assimilates in grains and as a result seed oil percentage was decreased. Similar results were reported by [20, 16] they concluded that water stress significantly reduced oil content and oil in sunflower genotypes. In conclusion, under condition of this investigation irrigation Hysun33 hybrid sunflower every 10days could be recommended for increasing seed yield oil and protein percentage in sunflower plant in New Halfa area.

Table 1: Mean of stem diameter, shoot dry weight and Leaf area index of plant as affected by Water stress on Performance and Protein content of sunflower Varieties during 2019/2020 and 2020/2021

Parameters		stem diameter(cm)		Shoot dry weight(g)		Leaf area index(LAI)	
		2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021
Seasons							
Treatments							
W1		2.92	2.39	239.67	183.11	11.57	11.97
W2		2.46	2.15	220.67	142.33	9.34	9.37
W3		2.27	2.04	214.83	134.56	7.06	7.78
LSD _{0.05}		0.36	0.13	20.67	14.79	1.14	1.45
V1		2.69	2.32	242.79	183.44	8.85	8.72
V2		2.51	2.25	225.78	153.78	11.44	11.70
V3		2.44	1.97	206.67	127.78	7.09	8.08
LSD _{0.05}		0.19	0.12	17.40	14.25	0.82	0.78
W1	V1	2.70	2.67	243.17	225.00	11.05	10.44
	V2	3.20	2.50	267.50	197.00	15.76	16.06
	V3	2.86	1.99	208.33	142.33	8.93	9.02
W2	V1	2.35	2.17	201.67	168.67	8.02	7.82
	V2	2.54	2.00	249.00	119.33	11.05	11.25
	V3	2.47	1.94	210.00	115.67	8.96	9.03
W3	V1	2.46	2.12	213.17	156.67	8.10	8.29
	V2	2.34	2.24	211.67	145.00	7.49	7.79
	V3	2.00	2.00	209.67	125.33	5.67	5.97
LSD _{0.05}		0.44	0.21	31.83	24.84	1.61	1.06

Table 2: Mean of some yield attributes as affected by Water stress on Performance and Protein content of sunflower Varieties during 2019/2020 and 2020/2021 seasons

Parameters		Head diameter(cm)		No. of seeds/head ¹		Empty seeds%		
		2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021	
Seasons								
Treatments								
W1		18.28	17.33	1270.7	1185.4	8.68	11.01	
W2		17.92	16.57	948.3	936.9	11.23	12.23	
W3		16.04	15.91	1097.8	861.0	10.23	13.01	
LSD _{0.05}		1.07	0.42	50.82	57.35	1.31	0.85	
V1		16.65	16.92	1083.4	1006.9	7.55	9.72	
V2		18.88	17.92	1283.8	1132.4	13.67	16.01	
V3		16.73	15.74	949.6	844.0	8.91	10.74	
LSD _{0.05}		0.73	0.43	113.03	55.40	.84	0.80	
W1	V1	16.83	17.57	1228.1	1207.2	5.27	7.77	
	V2	20.95	18.72	1593.4	1427.4	11.49	14.50	
	V3	17.06	15.70	990.6	921.7	9.28	10.79	
W2		V1	17.89	15.95	914.3	970.6	8.85	9.86

W3	V2	18.38	17.95	1040.1	993.2	16.31	17.13
	V3	17.51	15.80	890.6	846.8	8.53	9.54
	V1	15.24	14.90	1040.1	842.8	8.54	11.54
LSD _{0.05}	V2	17.30	17.10	1217.9	976.6	13.24	16.24
	V3	15.61	15.73	967.7	767.6	8.91	11.91
LSD _{0.05}		1.48	0.72	167.4	99.33	1.76	1.46

Table 3: Mean of some yield attributes and seed oil (%) as affected by Water stress on Performance and Protein content of sunflower Varieties during 2019/2020 and 2020/2021 seasons

Parameters	Weight of seeds head ¹ (g)		Seed yield (kg / ha)		Seed oil (%)		
	2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021	
Seasons							
Treatments							
W1	66.67	72.67	3427.8	3755.9	36.14	36.43	
W2	54.78	55.91	2876.9	2945.0	31.12	31.42	
W3	52.67	53.50	2474.2	2692.8	29.04	29.34	
LSD _{0.05}	4.60	2.86	224.03	128.80	0.82	0.79	
V1	66.00	69.64	1368.3	3354.0	34.30	34.60	
V2	55.78	60.34	2888.4	3178.1	32.22	32.52	
V3	52.33	51.78	2711.1	2866.6	29.78	30.08	
LSD _{0.05}	2.70	2.81	130.00	121.8	0.81	0.84	
W1	V1	77.67	87.50	2833.3	4119.4	38.92	39.22
	V2	62.67	74.00	3375.00	3932.8	36.85	37.45
	V3	59.67	56.50	3070.0	3215.6	32.64	32.95
W2	V1	59.33	59.50	3058.8	3071.8	33.04	33.34
	V2	54.00	55.33	3060.8	2902.5	31.35	31.65
	V3	51.00	51.91	2811.7	2860.7	28.96	29.26
W3	V1	61.00	61.91	2613.3	2870.7	30.93	31.25
	V2	50.67	51.67	2562.5	2684.1	28.44	28.74
	V3	46.33	46.98	2246.7	2523.5	27.72	28.03
LSD _{0.05}	5.96	4.95	287.71	223.1	0.43	0.40	

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