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RESPONSE OF SOME GRAIN SORGHUM GENOTYPES TO WATER STRESS UNDER SANDY SOIL CONDITIONS

BY

Mourad, A.E.A.A.* and Anton, N.A. **

* Sorghum Section, ** Crops Physiology Res. Sec.; Field Crops Res. Instit. A.R.C., Egypt.

ABSTRACT

A field trial was conducted at Ismailia Agricultural Research Station during the two successive seasons 2003 and 2004 to study the effect of three levels of soil moisture expressed as depletion available soil moisture (ASMD) namely wet (25-30%), Medium (45-50%) and dry (65-70%) on some grain sorghum genotypes i.e. Dorado variety, Shandaweel-6 hybrid, ICSR 92003 Line and ICSR 91022 Line. Results indicated that increasing soil moisture stress up to 65-70% ASMD significantly decreased plant height, leaf area index (LAI) at 51, 72 and 93 days after sowing (DAS), net assimilation rate (NAR) at the first period (30-51 DAS) and crop growth rate (CGR) at all growth periods, whereas root/shoot ratio was significantly increased at 72 and 93 DAS. Sorghum stressed plants (irrigation at 65-70 % ASMD) significantly showed a reduction in head weight /plant, grain weight/plant, 1000 kernel-weight and grain yield/fed compared with wet or medium treatments. Main while, insignificant difference was observed between wet and medium treatments for such traits. Total carbohydrate content of grains gradually decreased with increasing soil moisture stress from (25-30% ASMD) up to (65-70% ASMD). Seasonal water consumptive use (WCU), water use efficiency (WUE) and transpiration (Tr.) were gradually decreased with increasing water stress up to 65-70% ASMD (dry treatment), whereas stomatal resistance (SR) was gradually increased. Shandaweel-6 hybrid plants were the tallest whereas, those of Dorado variety were the shortest. The maximum and minimum values of LAI at all studied growth stages were obtained by Shandaweel-6 hybrid and Dorado variety, respectively. The highest values of net assimilation rate (NAR) were recorded by ICSR 92003 line at the first and third periods of growth i.e. (30-51 DAS) and (72-93 ADS), respectively, whereas Shandaweel-6 hybrid showed the maximum value at the second period of growth i.e. (51-72 DAS). Shandaweel-6 hybrid recorded the maximum values of crop growth rate (CGR) at all growth periods under study. Root/Shoot ratio recorded the highest value by ICSR 92003 line at all studied growth stages compared with other genotypes. These results proved that ICSR 92003 line was more tolerant to water stress conditions than the other genotypes. Yields and their components scored significant differences for all genotypes. The highest values of green leaves weight /plant, head weight/plant grain weight/plant as well as fodder and grain yields/fed. were obtained from Shandaweel-6 hybrid, while the maximum value of 1000 kernel-weight was recorded by ICSR 92003 Line. However, insignificant differences between Shandaweel-6 hybrid and ICSR 92003 Line with respect to fodder and grain yields/fed were observed. The maximum and minimum values of kernel total carbohydrates were obtained from Shandaweel-6 hybrid and ICSR 91022 line, respectively. The lowest values of seasonal water consumptive use and transpiration were obtained by ICSR 92003 line. However, the maximum values of water use efficiency and stomatal resistance were gained by the same line (ICSR 92003). Such findings revealed that ICSR 92003 Line seemed to be more tolerant to drought conditions. The interaction between soil moisture stress and sorghum genotype had a significant effect on leaf area index at the third period of growth (72-93 DAS), whereas other traits under study were not significantly affected by this interaction. The maximum fodder yield was obtained when Dorado variety received the wet treatment (25-30% ASMD). Whereas, the highest grain yield/fed was obtained by Shandaweel-6 hybrid irrigated at 45-50% ASMD (medium treatment).

INTRODUCTION

Grain sorghum (*Sorghum bicolor* (L.) Moench) is considered as one of the most adapted summer cereal crops to drought and salinity. In Egypt, water supply is the main limiting factor for increasing the cultivated area. Therefore estimating water consumptive use, water use efficiency and productivity of sorghum genotypes at different growth and reproductive stages is very important aspect to optimize crop water requiments and the optimum genotype for high production under drought conditions. With respect to the effect of water supply on grain sorghum production Dallyn (1983) found that grain yield was high with 10 cm irrigation water every 14 days. Bashir *et al.* (1994) reported that the maximum grain yield of sorghum crop was obtained from the wet soil moisture level. Also, water deficit significantly decreased grain yield compared with the wet conditions. Ibrahim (1995) found that grain and forage yields were significantly reduced by soil moisture stress. Sankarapandian and Sangarusamy (1996) revealed that the interaction between genotypes and water stress treatments was significant for grain and stover yield. Ragheb and Elnagar (1997) reported that irrigated grain sorghum plants at 30-days interval significantly reduced the grain yield by 20.14% and depressed the growth of sorghum plants compared to 10-day interval. Latif *et al.* (2000) showed that irrigation at 21 day intervals significantly decreased plant height, leaf area index (LAI), panicle length, panicle weight, panicle grain weight and grain yield comparing with 7 and 14 days intervals. Mourad *et al.* (2000) concluded that increasing number of irrigations from 2 to 5 irrigations increased panicle weight, grain weight per panicle, 1000 kernel weight, green yield, and total biomass and grain yield of Shandweel 2 hybrid.

The present investigation was carried out to study the behavior of some grain sorghum genotypes under water stress conditions. Growth, yield, yield components, total carbohydrate percentage in grains, water consumptive use, water use efficiency, transpiration rate and stomatal resistance were estimated.

MATERIALS AND METHODS

The present work was carried out at Ismailia Agric. Res. Station, A.R.C. under surface irrigation system during the two successive summer seasons 2003 and 2004 to study the effect of soil moisture stress on some grain sorghum genotypes. The experiment was laid out in a split plot design with four replicates. The main plots were occupied by soil moisture levels, while sub-plots contained genotypes of grain sorghum. Each sub-plot was 12 m^2 (3 x 4 m) and included 5 rows, 4 m long and 60 cm apart. Some physical and chemical properties of the experimental site are shown in Table (1).

Table (1): Physical and chemical properties of the experimental site, Ismailia Research Station farm.

Season	Particle size distribution				Tex.	O.M %	$CaCO_3$ %	pH (1:2.5)	EC Soil paste extract (ds/m)	Available nutrients (ppm)		
	Coarse sand %	Fine sand %	Silt %	Clay %						N	P	K
2003	82.47	10.6	1.62	5.31	Sandy	0.64	0.45	7.60	0.10	33.60	5.10	82.00
2004	82.70	10.7	1.53	5.07	sandy	0.61	0.47	7.50	0.12	35.10	5.40	73.20

The treatments are as follows:

I. Main plots (soil moisture levels):

A. Irrigation when 25-30 % of available soil moisture was depleted (ASMD) (designated as wet)
B. Irrigation when 45-50 % of ASMD (designated as medium)
C. Irrigation when 65-70 % of ASMD (designated as dry)

II. Sub-plots (Genotypes):

1. Dorado variety
2. Shandaweel-6 Hybrid
3. ICSR 92003 Line
4. ICSR 91022 Line

20 m^3, organic matter/fed in form of compost was added before planting to the experimental site. Grain sorghum seed was planted on 30/6/2003 and 16/6/2004 in the first and second seasons, respectively, in hills spaced 15 cm. Plants were thinned to two plants per hill 20 days after sowing. 30 kg P_2O_5 /fed was added as calcium superphosphate (15.5% P_2O_5) in two equal doses, the first before planting and the second at 21 days after sowing. 80 kg N/fed in the form of ammonium nitrate (33.5% N) was added in two equal doses, at 21 and 30 days after sowing. Potassium fertilizer at 24 kg K_2O / fed in the form of potassium sulphate (48% K_2O) were added at 21 days after sowing. To avoid the interference between irrigation treatments, 1.5 meter beds were left between the experimental plots. Irrigation treatments were applied at 30 days after sowing. Cultural practices were practiced according to the methods being adopted for growing grain sorghum crop in the locality.

Growth analysis:-

For growth analysis, five plants were randomly taken from the outer rows of the four replications. The sampling dates were 30, 51, 72 and 93 days after sowing (DAS). In each sample, plants were separated into their components i.e. root, leaves, stems and panicle. Plant parts were dried at 70° C in a ventilated oven to the constant weight. To determine leaf area/plant (LA), 10 disks (r = 0.5 cm) were taken from leaves for each treatment and dried, the disks area equal (10 X 3.14 X 0.5^2 = 7.85 cm^2). The following characters were collected:-

1. Leaf area index (LAI)
2. Net assimilation rate (NAR), in mg/dm^2/week.
3. Crop growth rate (CGR), in gm/m^2/week.
4. Root / Shoot ratio

The following formulae were used to determine such characters according to Watson (1952).

LA = 7.85 x dry weight of leaves per plant) / dry weight of leaves disks.

LAI= Unit leaf area per plant/unit ground area occupied by plant.

NAR= $(W_2 - W_1)$ (Loge A_2-Loge A_1)/ (A_2-A_1) (t_2-t_1).

CGR = 1/planting area $((W_2-W_1)/(t_2-t_1))$.

Where: A2-A_1= differences in leaf area between two successive samples in dm^2.

W_2-W_1= differences in dry matter accumulation of whole plants between two successive samples in gm.

t_2-t_1= Number of days between two successive samples (in week).

Log_e =Natural logarithm (e).

Root/Shoot ratio = root dry weight per plant/shoot dry weight per plant.

Harvesting took place 23/10/2003 and 5/10/2004 in the first and second seasons, respectively.

At harvesting time, five individual guarded plants were randomly taken from the central row in each sub-plot to determine:

1. Plant height. (cm)
2. Green weight/plant. (gm)
3. Head weight/plant. (gm)
4. Grain weight /plant. (gm)
5. 1000 kernels weight. (gm)

Fodder and grain yields were obtained and calculated from a central area (4.8 m^2) in each sub-plot to avoid the border effect. Mature grains samples from the two growing seasons were subjected to chemical analysis to determine the total carbohydrate content as glucose % according to Dubois *et al.* (1956).

Water relation:-

A. Water consumptive use (WCU):

Soil samples were taken, using a regular auger, at planting time, just before and 48 hours after each irrigation and at harvesting time for soil moisture determination. Irrigation water was applied when the moisture content reached the desired available soil moisture of each treatment. At each sampling date, duplicate of soil samples were taken from 0-15, 15-30, 30-45 and 45-60 cm depths and their moisture contents were determined gravimetrically. Field capacity, permanent wilting point, bulk density and available moisture were determined for the experimental site and presented in Table (2).

Table (2): Soil moisture constants of the experimental site.

Depth (cm)	Field Capacity (%)	Wilting point (%)	Available moisture (%)	Bulk density (g/cm^3)
0-15	6.85	2.91	3.94	1.76
15-30	6.71	2.89	3.82	1.79
30-45	6.42	2.77	3.65	1.88
45-60	6.12	2.69	3.43	1.90

The depleted soil moisture was detected after each irrigation and the following equation was used to calculating water consumptive use according to (Israelsen and Hansen, 1962):

Cu=D x Bd x $(e_2-e_1)/100$

Where:-

Cu= Water consumptive use (ET) in mm

D=Soil depth (cm).

Bd= Bulk density in g/cm^3.

e_1, e_2 =Soil moisture content before and after each irrigation.

B. Water use efficiency (WUE):-

Water use efficiency was calculated for each treatment according to the equation described by Vites (1965). As follows:-

WUE=grain yield (kg/fed.)/seasonal water consumption in m^3/fed.

C. Parameter measurements:-

After 60 days from sowing, a Portable Steady Parameter (LI-COR Model LI 1600) was used to determine stomatal resistance S/cm (S.R.) and transpiration rate (Tr.) □g $H_2O/cm^{-2}/S$. Data of the two seasons were combined and statistically analyzed according to Steel and Torrie (1980).

The discussion of the results was carried out on the basis of combined analysis for the two seasons.

RESULTS AND DISCUSSION

I. Growth and growth analysis:

1. Plant height:-

Results in Table (3) indicated that both soil moisture stress and genotypes had significant effects on plant height. The tallest plants were obtained from the wet treatment which was watered at 25-30% depletion of available soil moisture (ASMD) followed by the medium one i.e. irrigation at 45-50% ASMD. However, the shortest plants were obtained from irrigation at 65-70% ASMD. These findings explain that, increasing available moisture level enhanced plant height by controlling the elongation of the above ground part of the plant. In this respect, Noureldein *et al.* (1986) reported that the reduction in plant height of maize plants exposed to stress conditions may be due to the reduction in internodes length. Also, Bashir *et al.* (1994) found that irrigated grain sorghum plants at 25-30% ASMD increased plant height.

Table (3): Plant height, leaf area index and net assimilation rate of some grain sorghum genotypes as affected by soil moisture stress in 2003 and 2004 summer seasons.

Irrigation level	Genotype	Plant height (cm)			Leaf Area Index (LAI)									Net Assimilation Rate (NAR) ($mg/dm^2/week$)								
					51 days after sowing			72 days after sowing			93 days after sowing			(30-51)days after sowing			(51-72) days after sowing			(72-93) days after sowing		
		2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.
(25-30)% in ASMD (Wet)	Dorado	118.67	121.00	119.83	3.03	2.97	3.00	6.39	6.53	6.46	13.22	12.05	12.64	1.182	0.914	1.048	0.615	0.622	0.619	0.683	0.632	0.657
	Shandaweel 6	145.67	137.00	141.83	3.69	3.34	3.52	7.82	7.78	7.80	14.77	14.21	14.49	0.796	0.659	0.727	0.676	0.647	0.662	0.615	0.637	0.626
	ICSR 92003	141.67	147.33	144.50	2.38	2.21	2.30	5.07	5.27	5.17	10.62	10.20	10.41	1.383	1.195	1.289	0.698	0.711	0.705	0.728	0.724	0.726
	ICSR 91022	136.00	136.67	136.33	2.90	2.68	2.79	6.49	6.67	6.58	11.51	11.66	11.59	0.928	0.641	0.784	0.574	0.663	0.619	0.638	0.598	0.618
Mean		135.75	135.50	135.63	3.00	2.80	2.90	6.44	6.56	6.50	12.53	12.03	12.28	1.072	0.852	0.962	0.641	0.661	0.651	0.666	0.648	0.657
(45-50)% in ASMD (Medium)	Dorado	107.33	110.00	108.67	2.62	2.38	2.50	5.24	5.22	5.23	11.22	10.54	10.88	1.184	0.842	1.013	0.683	0.640	0.661	0.701	0.677	0.689
	Shandaweel 6	135.00	130.00	132.50	2.97	2.69	2.83	6.53	6.09	6.31	11.99	12.01	12.00	0.812	0.576	0.694	0.725	0.693	0.709	0.693	0.663	0.678
	ICSR 92003	128.33	128.67	128.50	1.97	1.78	1.88	4.40	4.32	4.36	9.35	8.65	9.00	1.432	1.035	1.233	0.678	0.714	0.696	0.787	0.759	0.773
	ICSR 91022	111.00	122.33	116.67	2.53	2.19	2.36	5.31	5.21	5.26	10.19	10.02	10.10	0.901	0.583	0.742	0.551	0.669	0.610	0.698	0.669	0.683
Mean		120.42	122.75	121.58	2.52	2.26	2.39	5.37	5.21	5.29	10.69	10.31	10.50	1.082	0.759	0.921	0.659	0.679	0.669	0.720	0.692	0.706
(65-70)% in ASMD (Dry)	Dorado	101.67	101.33	101.50	2.13	1.78	1.96	4.29	4.17	4.23	9.26	8.61	8.94	1.059	0.703	0.881	0.691	0.645	0.668	0.476	0.732	0.604
	Shandaweel 6	125.00	121.00	123.00	2.42	1.98	2.20	5.78	4.94	5.36	10.01	9.95	9.98	0.707	0.448	0.577	0.690	0.710	0.700	0.484	0.705	0.595
	ICSR 92003	111.00	110.33	110.67	1.74	1.40	1.57	4.01	3.59	3.80	7.30	6.93	7.12	1.318	0.814	1.066	0.623	0.695	0.659	0.571	0.737	0.654
	ICSR 91022	104.00	102.67	103.33	2.05	1.73	1.89	4.59	4.31	4.45	8.86	8.35	8.61	0.758	0.428	0.593	0.587	0.661	0.624	0.481	0.684	0.582
Mean		110.42	108.83	109.63	2.09	1.72	1.91	4.67	4.25	4.46	8.86	8.46	8.66	0.961	0.598	0.779	0.648	0.678	0.663	0.503	0.714	0.609
General mean of genotypes	Dorado	109.22	110.78	110.00	2.59	2.38	2.49	5.31	5.31	5.31	11.23	10.40	10.82	1.141	0.820	0.981	0.663	0.635	0.649	0.620	0.680	0.650
	Shandaweel 6	135.56	129.33	132.44	3.03	2.67	2.85	6.71	6.27	6.49	12.26	12.06	12.16	0.771	0.561	0.666	0.697	0.684	0.690	0.597	0.668	0.633
	ICSR 92003	127.00	128.78	127.89	2.03	1.80	1.92	4.49	4.39	4.44	9.09	9.60	9.35	1.378	1.015	1.196	0.666	0.707	0.687	0.695	0.740	0.718
	ICSR 91022	117.00	120.56	118.78	2.51	2.20	2.36	5.46	5.40	5.43	10.19	10.01	10.10	0.862	0.550	0.706	0.571	0.664	0.618	0.605	0.650	0.628
L. S. D 0.05	Irrig.	8.03	9.74	6.15	0.16	0.14	0.10	0.48	0.37	0.26	0.56	0.35	0.29	0.043	0.061	0.031	N.S.	N.S.	N.S.	0.098	0.047	0.045
	Geno.	9.28	11.24	7.1	0.19	0.16	0.12	0.48	0.43	0.30	0.65	0.41	0.34	0.050	0.070	0.035	0.044	0.047	0.031	N.S.	0.055	0.052
	irrig.X Geno.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	0.59	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

ASMD=available soil moisture depletion

The difference between grain sorghum genotypes was found to be significant with respect to plant height. Table (3) show that Shandaweel 6 hybrid had the tallest plants, while the shortest plants were obtained from Dorado variety. However, ICSR 92003 and ICSR 91022 lines had an intermediate values. These results are in agreement with those reported by Bakheit (1990) and Badawy *et al* .(1992) who concluded that the differences between the long-stem and the short stem cultivars could be attributed to the genetic makes up of cultivars.

Data of Table (3) showed that the interaction between soil moisture stress and genotype had an insignificant effect on plant height. However, the tallest plants were obtained from ICSR 92003 line irrigated at 25-30% ASMD. The genotypic differences in plant height might be due to water stress treatments (Plum, 1982).

2. Leaf area index (LAI):

Data in Table (3) show that leaf area index (LAI) increased with increasing plant age up to 93 days after sowing (DAS). This is mainly due to the production of new leaves as well as leaves expansion. The wet treatment had the highest values of LAI followed by the medium one at different stages of growth under study i.e. 51, 72 and 93 DAS. However, the dry soil moisture level gave the lowest values of leaf area index at different growth stages. This reduction may be due to the decrease in leaf area and number of leaves/plant. These results are in harmony with those obtained by Osman *et al.* (1989), Hefni *et al.* (1993) and Mourad *et al.* (2000).

Regarding the behavior of grain sorghum genotypes, data of Table (3) recorded a significant difference. The maximum values of LAI were obtained from Shandaweel-6 hybrid, whereas the lowest values were gained from ICSR 92003 line at 51, 72 and 93 DAS. It can be noticed that Dorado variety and ICSR 91022 line recorded intermediate values of LAI.

Concerning the interaction between soil moisture stress and grain sorghum genotypes, data of Table (3) showed an insignificant effect in the first and second periods, whereas it was significant at the third period. The maximum values of LAI at different stages of growth were obtained when Shandweel-6 hybrid was irrigated with wet treatment (25-30 % ASMD). Blum (1982) recorded similar results.

3. Net Assimilation Rate (NAR):

It was observed from Table (3) that there were significant difference in NAR values observed among the three irrigation levels at the first and third growth periods i.e. (30-51 DAS) and (72-93 DAS). At the first period (30-51 DAS), NAR was significantly decreased by increasing water stress from 25-30% ASMD up to 65-70% ASMD. Such reduction could be attributed to the low accumulation of dry matter or photosynthesiate compounds in proportion to leaf area. In other words, when plants exposed to severe water stress the reduction in dry matter accumulation seemed to be more than the reduction in leaf area reduction. In this connection, Hefni *et al.* (1993) found that NAR of maize plants decreased by increasing available soil moisture depletion up to 80%. At third period (72-93 DAS), the value of NAR was significantly increased with increasing water stress from wet up to medium treatment, whereas the dry treatment significantly decreased NAR compared with the other two irrigation levels i.e. wet and medium. Such finding revealed that medium treatment to grain sorghum plants at the third period i.e. (72-93 DAS) is more suitable for dry matter accumulation (Table 3).

The difference among grain sorghum genotypes, (Table 3) in NAR was significant in the three periods under study i.e. (30-51 DAS), (51-72 DAS) and (72-93 DAS). The maximum values of NAR were obtained by ICSR 92003 Line at the first and third periods. However, Shandaweel-6 hybrid was found to be higher at the second period, whereas the minimum values of NAR were obtained from ICSR 91022 line at the second and third periods. Shandaweel 6 hybrid recorded the lowest value of NAR at the first period. This may explain the lower growth of the hybrid in the early stage.

Data in Table (3) show also that the soil moisture stress and genotypes interaction effect on NAR was insignificant at the three periods of growth under study. Hsiao *et al.* (1976) recorded similar results.

4. Crop growth rate (CGR):

Table (4) shows CGR of grain sorghum genotypes as affected by water stress. CGR for all genotypes was higher in the second period (51-72 DAS) than in the third one (72-93 DAS). Such decrease at the third period is mainly due to that grain sorghum plants directed its effort to flowering and grain formation. It is worthy to mention that the lowest value of CGR was gained at the first period (30-51 DAS).

In addition, the maximum value of CGR at the second period (51-72 DAS) revealed that such period is considered the peak period of growth for grain sorghum plants. It is clear that water stress treatments recorded a significant effect on CGR at the three growth periods.

Increasing soil moisture depletion level from 25-30% up to 65-70% significantly decreased CGR at all studied growth periods. Such trend may be due to the importance of water to dry matter accumulation or photosynthesiate compounds. These results are in harmony with those obtained by Hefni *et al.* (1993), who found that CGR of maize plants was significantly decreased by increasing available soil moisture depletion to 80%. Also, Abdel-Aziz and El-Bialy (2002) reported that CGR of maize plants significantly decreased by increasing soil moisture depletion from 35-40% to 75-80% at all studied growth periods.

Regarding the behavior of grain sorghum genotypes, results of Table (4) recorded a significant effect on CGR character at second and third periods. It could be observed that Shandaweel-6 hybrid gave the maximum values of CGR at the three growth periods under study. Whereas, ICSR 92003 line recorded the lowest values of CGR at the second and third periods i.e. (51-72 DAS) and (72-93 DAS), respectively.

Table (4): Crop growth rate and root/shoot ratio of some grain sorghum genotypes as affected by soil moisture stress in 2003 and 2004 summer seasons.

Irrigation level	Genotyp	Crop Growth Rate (CGR) ($gm/m^2/week$)									Root/Shoot Ratio								
		(30-51) days after sowing			(51-72) days after sowing			(72-93) days after sowing			51 days after sowing			72 days after sowing			93 days after sowing		
		2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.
(25-30)% in ASMD (Wet)	Dorado	26.21	21.87	24.04	274.84	280.54	277.69	90.80	81.11	85.95	0.437	0.379	0.408	0.235	0.245	0.24	0.181	0.176	0.178
	Shandaweel 6	27.63	22.56	25.10	369.63	339.80	354.72	95.88	97.10	96.49	0.414	0.353	0.383	0.291	0.293	0.292	0.234	0.231	0.232
	ICSR 92003	26.45	21.98	24.22	247.73	249.28	248.51	78.03	77.04	77.53	0.672	0.521	0.597	0.377	0.348	0.362	0.275	0.241	0.258
	ICSR 91022	27.87	18.54	23.21	255.38	289.65	272.52	79.64	76.24	77.94	0.465	0.449	0.457	0.239	0.248	0.243	0.207	0.177	0.192
	Mean	27.04	21.24	24.14	286.90	289.82	288.36	86.08	82.87	84.48	0.497	0.425	0.461	0.285	0.283	0.284	0.224	0.206	0.215
(45-50)% in ASMD (Medium)	Dorado	23.98	17.68	20.83	258.12	230.49	244.31	78.21	72.97	75.59	0.434	0.366	0.400	0.214	0.228	0.221	0.173	0.158	0.165
	Shandaweel 6	25.02	17.52	21.27	326.25	288.35	307.30	88.89	82.42	85.66	0.445	0.325	0.385	0.278	0.278	0.278	0.229	0.222	0.226
	ICSR 92003	24.41	16.85	20.63	204.69	204.32	204.51	73.86	67.30	70.58	0.649	0.538	0.594	0.397	0.370	0.384	0.262	0.226	0.244
	ICSR 91022	25.10	15.15	20.13	206.77	233.58	220.17	74.17	70.15	72.16	0.430	0.336	0.383	0.250	0.243	0.246	0.197	0.151	0.174
	Mean	24.63	16.80	20.71	248.96	239.19	244.07	78.78	73.21	76.00	0.489	0.391	0.440	0.285	0.280	0.282	0.215	0.189	0.202
(65-70)% in ASMD (Dry)	Dorado	18.88	12.47	15.68	212.57	180.99	196.78	43.15	63.70	53.43	0.431	0.376	0.404	0.226	0.231	0.228	0.221	0.144	0.183
	Shandaweel 6	19.49	11.64	15.57	265.60	230.86	248.23	53.02	71.88	62.45	0.441	0.356	0.399	0.279	0.298	0.289	0.291	0.198	0.245
	ICSR 92003	20.96	11.57	16.26	169.21	161.43	165.32	44.80	53.41	49.11	0.686	0.523	0.605	0.421	0.415	0.418	0.357	0.233	0.295
	ICSR 91022	18.89	9.87	14.38	184.94	186.59	185.77	44.66	59.29	51.98	0.473	0.361	0.417	0.241	0.256	0.249	0.257	0.144	0.200
	Mean	19.55	11.39	15.47	208.08	189.97	199.02	46.41	62.07	54.24	0.508	0.404	0.456	0.292	0.300	0.295	0.282	0.180	0.231
General mean of genotypes	Dorado	23.02	17.34	20.18	248.51	230.67	239.59	70.72	72.59	71.66	0.434	0.373	0.404	0.225	0.234	0.230	0.192	0.159	0.175
	Shandaweel 6	24.05	17.24	20.64	320.49	286.34	303.42	79.26	83.80	81.53	0.434	0.345	0.389	0.274	0.283	0.286	0.251	0.217	0.234
	ICSR 92003	23.94	16.80	20.37	207.21	205.01	206.11	65.56	65.91	65.74	0.669	0.527	0.598	0.373	0.358	0.388	0.298	0.233	0.266
	ICSR 91022	23.96	14.52	19.24	215.70	236.61	226.15	66.16	68.56	67.36	0.456	0.382	0.419	0.243	0.247	0.246	0.220	0.157	0.189
LSD 0.05	Irrig.	0.64	1.64	1.02	10.25	14.63	12.03	8.41	3.11	5.29	N.S.	N.S.	N.S.	0.017	N.S.	0.011	0.034	0.015	0.016
	Geno.	0.74	1.96	N.S.	11.83	16.89	13.89	9.71	3.59	6.11	0.032	0.053	0.029	0.020	0.023	0.014	0.039	0.017	0.019
	Irrig. X Geno.	1.28	N.S.	N.S.	20.49	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

ASMD=available soil moisture depletion

The interaction between the two factors i.e. water stress and genotypes on CGR was found to be insignificant at the three periods of growth. However, the maximum value of CGR was obtained when Shandaweel-6 hybrid received the wet treatment at the three growth periods i.e. (30-51 DAS), (51-72 DAS) and (72-93 DAS). Hsiao *et al.* (1976) found similar results.

5. Root/Shoot ratio:

Root/shoot ratio is presented in Table (4). Such character could indicate the efficiency of sorghum plant for root formation process. Data also showed that water stress significantly affected root/shoot ratio at the second and third grown stages, i.e. 72 and 93 DAS. Sorghum plants irrigated at 65-70% ASMD significantly increased root/shoot ratio at the second and third periods of growth compared with wet or medium treatments.

Such finding may explain that when plants are exposed to drought conditions their roots grow faster and deeper through the soil profile searching for water, thereby root weight increased, relative to the increase in shoot weight, which reflected on increasing root/shoot ratio.

Concerning the difference among genotypes, it could be noticed that there is a significant difference in root/shoot ratio among the three growth periods under study. It could be observed that ICSR 92003 line surpassed all genotypes under study regarding root/shoot ratio compared with the other genotypes under study. This results may indicate that ICSR 92003 is a tolerant to drought conditions.

The interaction between soil moisture stress and genotypes was found to be insignificant at all growth stages under study. The highest value of root/shoot ratio was obtained at the three growth stages when ICSR 92003 line was irrigated at 65-70% ASMD. Wright (1978) and Jordan *et al.* (1979) reported similar results.

II. Yield and yield components:

a. Yield components:

Data in Table (5) showed that soil moisture stress had a significant effect on head weight/plant, grain weight/plant and 1000 kernels weight only. Such characters significantly decreased when plants were exposed to severe water deficit (irrigated at 65-70% ASMD). These results revealed that increasing soil moisture stress reduced grain sorghum growth, which in turn affected yield components. On the contrary, high moisture level enhanced growth of plants thereby improved yield components. In this connection, Kramer (1980) showed that plants subjected to water stress not only showed a general reduction in size but exhibited modification in structure, leaf area, cell size and intercellular volume. Also, Bashir *et al.* (1994) concluded that irrigating grain sorghum at 25-30 % depletion of available soil moisture increased panicle length, panicle width, grain weight/panicle, number of grain /panicle and seed index.

Table (5): Yield and yield components of some grain sorghum genotypes as affected by soil moisture stress in 2003 and 2004 summer seasons

Irrigation level	Genotype	Green weight /plant (gm)			Head weight /plant (gm)			Grain weight/plant (gm)			1000 kernels weight (gm)			Fodder yield (ton./fed.)			Grain yield *(ard./fed.)		
		2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.	2003	2004	Comb.
(25-30)% ASMD (Wet)	Dorado	363.30	146.70	255.00	78.80	52.70	65.75	55.40	32.50	43.95	31.70	31.10	31.40	15.90	6.40	11.15	17.30	9.70	13.50
	Shandaweel 6	350.00	156.70	253.35	91.50	70.00	80.75	65.30	42.80	54.05	32.10	35.50	33.80	15.30	6.90	11.10	20.40	11.10	15.75
	ICSR 92003	270.00	226.70	248.35	71.80	63.30	67.55	56.30	43.40	49.85	33.20	33.00	33.10	11.80	9.90	10.85	17.60	10.30	13.95
	ICSR 91022	290.00	166.70	228.35	66.30	53.00	59.65	38.00	29.30	33.65	27.20	24.90	26.05	12.70	7.30	10.00	11.90	7.80	9.85
	Mean	318.33	174.20	246.26	77.10	59.75	68.43	53.75	37.00	45.38	31.05	31.13	31.09	13.93	7.63	10.78	16.80	9.73	13.26
(45-50)% ASMD (Medium)	Dorado	326.70	133.30	230.00	53.30	52.70	53.00	34.40	32.70	33.55	33.20	32.10	32.65	14.30	5.80	10.05	10.70	10.00	10.35
	Shandaweel 6	300.00	146.70	223.35	99.10	53.00	76.05	69.70	37.30	53.50	32.60	34.60	33.60	13.10	6.40	9.75	21.80	10.80	16.20
	ICSR 92003	253.30	156.70	205.00	91.40	46.00	68.70	64.70	30.90	47.80	38.50	35.00	36.75	11.10	6.80	8.95	20.20	10.90	15.55
	ICSR 91022	270.00	146.70	208.35	53.10	36.70	44.90	28.20	19.70	23.95	26.70	26.70	26.70	11.80	6.40	9.10	8.80	8.30	8.55
	Mean	287.50	145.85	216.68	74.23	47.10	60.66	49.25	30.15	39.70	32.75	32.10	32.43	12.58	6.35	9.46	15.38	10.00	12.66
(65-70)% in ASMD (Dry)	Dorado	340.00	76.70	208.35	41.90	27.70	34.80	24.70	15.40	20.05	26.40	28.30	27.35	14.90	3.40	9.15	7.70	8.90	8.30
	Shandaweel 6	336.70	123.30	230.00	54.90	26.70	40.80	29.60	30.90	30.25	25.10	31.30	28.20	14.70	5.40	10.05	9.30	9.80	9.55
	ICSR 92003	333.30	126.70	230.00	51.50	34.00	42.75	32.50	18.60	25.55	30.50	30.00	30.25	14.60	5.50	10.05	10.10	9.50	9.80
	ICSR 91022	243.30	80.00	161.65	26.20	34.30	30.25	9.70	14.80	12.25	20.80	19.90	20.35	11.00	3.50	7.25	7.30	6.70	7.00
	Mean	313.33	101.68	207.50	43.63	30.68	37.15	24.13	19.93	22.03	25.70	27.38	26.54	13.80	4.50	9.13	8.60	8.73	8.66
General mean of genotypes	Dorado	343.33	118.90	231.12	58.00	44.37	51.18	38.17	26.87	32.52	30.43	30.50	30.47	15.03	5.20	10.12	11.90	9.53	10.72
	Shandaweel 6	328.90	142.23	235.57	81.83	49.90	65.78	54.87	55.23	55.05	29.93	33.80	31.87	14.37	6.23	10.20	17.17	10.57	13.87
	ICSR 92003	285.53	170.03	227.78	71.57	47.77	59.67	51.17	30.97	41.07	34.07	32.67	33.37	12.50	7.40	9.95	15.97	10.23	13.10
	ICSR 91022	267.78	131.13	199.45	48.53	41.33	44.93	25.20	21.27	23.24	24.90	23.83	24.37	11.83	5.73	8.78	9.33	7.60	8.47
LSD 0.05	Irrig.	N.S.	46.20	N.S.	15.58	13.80	12.30	12.15	6.80	9.41	4.08	3.39	1.60	N.S.	2.04	N.S.	3.81	N.S.	2.36
	Geno.	57.95	34.57	27.75	14.92	N.S.	9.55	12.45	10.36	7.36	2.64	2.59	2.15	2.53	1.50	1.44	3.88	0.83	1.90
	Irrig. X Geno.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

ASMD=available soil moisture depletion.

*1 ardab= 140 kg

Results in Tables (5) showed significant differences among genotypes in green weight/plant, head weight/plant, grain weight/plant and 1000 kernel-weight. Shandaweel 6 hybrid had the maximum values of green weight, head weight and grain weight/plant, on the contrary ICSR 91022 line scored the lowest values of such characters. ICSR 92003 line and Dorado variety were intermediate. It is worthy to mention that the maximum value of 1000 kernel-weight was obtained from ICSR 92003 line however the lowest one was gained by ICSR 91022 line. The interaction between water stress and genotypes had insignificant effect on all yield components characters under study. The maximum values of head weight and grain weight/plant were obtained by Shandaweel 6 hybrid watered at 25-30 % ASMD. The highest value of 1000 kernel-weight was gained when ICSR 92003 line watered at 45-50% ASMD. It is worthy to mention that Dorado variety recorded the highest value of green weight/ plant when watered at 25-30% ASMD.

b. Fodder and grain yields:

The effect of soil moisture stress and genotypes on the productivity of grain sorghum expressed as fodder yield (ton/fed.) and grain yield (ard./fed.) is presented in Table (5) and Fig (1). Soil moisture stress resulted in an insignificant effect on fodder yield/fed.. Whereas, grain yield/fed. recorded a significant effect. The highest value of grain yield was scored from the wet treatment (irrigated at 25-30 % ASMD) followed by the medium treatment (irrigated at 45-50% ASMD). The lowest productivity of grain yield/fed. was recorded from severe water deficit (dry treatment) with significant difference between such treatment and wet or medium treatments. This trend could be due to the effect of water deficit on grain sorghum growth and yield components which were in turn reflected on grain sorghum productivity. It can be observed that the difference in grain yield production between the wet and medium treatments was found to be insignificant. From the previous results, it could be concluded that the best irrigation treatment for grain sorghum productivity at Ismailia Governorate is the medium treatment (which irrigated when 45-50% ASMD). Such treatment is recommended from economic point of view as there is no significant yield reduction by applying irrigation at 45-50% ASMD and at the same time saving water. These results are in line with those reported by Stewart (1986) who stated that each additional millimeter of water available for evapotranspiration increased grain sorghum by 15.5 kg per hectare. In addition, Latif *et al.* (2000) found that, no significant effect was observed between irrigating Shandaweel 2 hybrid every 7 and 14 days on panicle weight, panicle grain weight and grain yield /fed.

Concerning grain sorghum genotypes, data in Table (5) and Fig. (1) indicated that both fodder and grain yield /fed. recorded significant differences among genotypes under study. The maximum values of fodder and grain yield/fed were obtained by Shandaweel-6 hybrid. It could be observed that fodder yield/fed recorded insignificant differences between Shandaweel-6 hybrid, Dorado variety and ICSR 92003 line, whereas grain yield /fed was insignificant difference between Shandaweel 6 hybrid and ICSR 92003 line. Significant reduction in fodder and grain yields/fed were showed by ICSR 91022 line compared with all genotypes under study i.e. Dorado variety, Shandaweel 6 hybrid and ICSR 92003 line.

Data in Table (5) and fig (1) showed that the interaction between soil moisture stress and genotypes for fodder and grain yields/fed was found to be insignificant. The highest value of fodder yield/ fed was obtained when Dorado variety was irrigated by wet treatment (irrigated at 25-30% ASMD). However, the maximum value of grain yield/fed was scored when Shandaweel 6 hybrid received medium treatment (irrigated at 45-50% ASMD).

III. Chemical composition of grain sorghum grains:-

Total carbohydrates content:

Table 6 show that total carbohydrate in grain sorghum kernels was increased under wet conditions. While, increasing water deficit by prolonged irrigation intervals (dry treatment) decreased total carbohydrates of grains. Whereas, the medium treatment had an intermediate value of such trait. Similar results on maize plants were obtained by El-Kalla *et al.* (1985), who explained such carbohydrates reduction, to that water shortage causes stomatal closure and this in turn prevents CO_2 diffusion into the air inside the tissue of plants and consequently the photosynthetic efficiency becomes low.

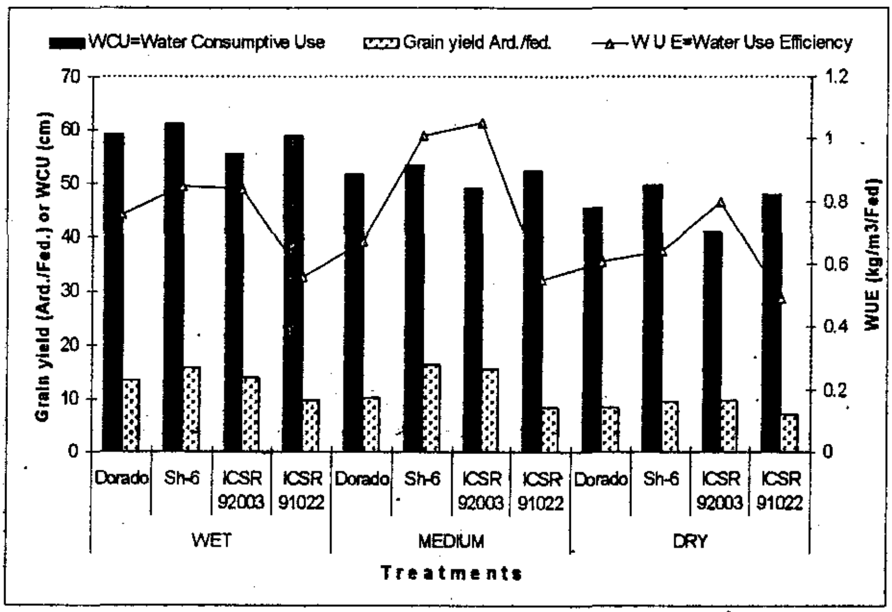

Fig. (1): Effect of the interaction between soil moisture stress and sorghum genotypes on grain yield, water consumptive use (WCU) and water use efficiency (WUE).

As for the difference between genotypes, it could be observed that Shandaweel 6 hybrid had the maximum value of total carbohydrates content in kernels; On the contrary the lowest value was obtained by ICSR 91022 line. Whereas, values of Dorado variety and ICSR 92003 line were intermediate.

Table (6): Seasonal water consumptive use, water use efficiency, transpiration rate, stomatal resistance and total grain carbohydrate percentage of some grain sorghum genotypes as affected by soil moisture stress in 2003 and 2004 summer seasons.

Irrigation level	Genotype	Seasonal water consumptive use (cm)			Water use efficiency (Kg/m^3/fed.)			Transpiration rate ($\mu g\ H_2O/cm^2/s$)			Stomatal resistance (s/cm)			Total carbohydrate %		
		2003	2004	Mean	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean	2003	2004	Mean
(25-30)% ASMD (Wet)	Dorado	60.04	58.30	59.17	0.96	0.55	0.76	5.62	5.88	5.75	3.32	3.09	3.21	62.51	59.87	61.19
	Shandaweel 6	60.11	60.21	61.16	1.09	0.61	0.85	6.23	6.49	6.36	2.80	2.61	2.71	66.22	63.98	65.10
	ICSR 92003	56.63	54.43	55.53	1.04	0.63	0.84	4.10	4.51	4.31	4.92	4.77	4.85	64.25	61.44	62.85
	ICSR 91022	60.45	57.65	59.05	0.66	0.45	0.56	5.98	6.20	6.09	2.99	2.75	2.87	60.30	59.12	59.71
	Mean	59.80	57.65	58.73	0.94	0.56	0.75	5.48	5.77	5.63	3.51	3.31	3.41	63.32	61.10	62.21
(45-50)% ASMD (Medium)	Dorado	52.33	50.71	51.52	0.68	0.66	0.67	3.70	3.99	3.85	4.14	3.98	4.06	57.26	56.46	56.86
	Shandaweel 6	54.95	52.06	53.51	1.32	0.69	1.01	4.65	4.96	4.81	3.36	3.03	3.20	61.13	60.22	60.68
	ICSR 92003	49.81	48.42	49.12	1.35	0.75	1.05	3.31	3.60	3.46	5.71	5.52	5.62	59.05	58.20	58.63
	ICSR 91022	52.62	51.85	52.24	0.56	0.53	0.55	4.22	4.56	4.39	3.81	3.50	3.66	55.72	54.27	55.00
	Mean	52.43	50.76	51.60	0.98	0.66	0.82	3.97	4.27	4.13	4.26	4.01	4.14	58.29	57.29	57.79
(65-70)% ASMD (Dry)	Dorado	46.01	45.25	45.63	0.56	0.66	0.61	2.69	2.81	2.75	5.21	5.04	5.13	51.42	50.85	51.14
	Shandaweel 6	50.52	49.08	49.80	0.61	0.67	0.64	3.60	3.90	3.75	4.10	3.96	4.03	56.36	54.03	55.20
	ICSR 92003	41.62	40.70	41.16	0.81	0.78	0.80	2.41	2.62	2.52	6.33	6.12	6.23	53.81	52.15	52.98
	ICSR 91022	48.33	47.51	47.92	0.50	0.47	0.49	3.35	3.73	3.54	4.89	4.65	4.77	50.67	50.16	50.42
	Mean	46.62	45.64	46.13	0.62	0.65	0.64	3.01	3.27	3.14	5.13	4.94	5.04	53.07	51.80	52.44
General mean of genotypes	Dorado	52.79	51.42	52.11	0.73	0.62	0.68	4.00	4.23	4.12	4.22	4.04	4.13	57.06	55.73	56.40
	Shandaweel 6	55.86	53.78	54.82	1.01	0.66	0.84	4.83	5.12	4.97	3.42	3.20	3.31	61.24	59.41	60.33
	ICSR 92003	49.35	47.85	48.60	1.07	0.72	0.90	3.27	3.58	3.43	5.65	5.47	5.57	59.04	57.26	58.15
	ICSR 91022	53.80	52.34	53.07	0.57	0.48	0.53	4.52	4.83	4.67	3.90	3.63	3.77	55.56	54.52	55.04

ASMD=available soil moisture depletion.

The highest carbohydrates content of sorghum grains could be achieved when Shandaweel-6 hybrid irrigated with wet treatment (which irrigated at 25- 30% ASMD).

IV. Water relations:-

a. Seasonal water consumption (WCU):

Seasonal water consumptive use by grain sorghum plant under the various treatments are presented in Table (6) and Fig. (1). Results indicated that the values of seasonal water consumptive use for grain sorghum plant ranged from 41.16 to 61.16 cm with respect to the mean of both seasons under study. The results revealed that water consumption increased with increasing soil moisture by frequent irrigations. The highest water consumptive use was achieved under wet conditions (irrigated at 25-30% ASMD), however the lowest value obtained when dry soil moisture level was practiced (65-70% ASMD). The medium treatment had intermediate values. Such results could be explained on the basis that frequent irrigation provides chance for more luxuriant use of water. These finding could be ascribed to the availability of soil water to grain sorghum plants in addition to higher evaporation rate from wet soil surface than the dry one. In this connection, Bashir et al. (1994) reported that the value of water use by grain sorghum crop increased as soil moisture stress decreased. They added, when soil moisture was kept wet by frequent irrigations, higher seasonal evapotranspiration was attained.

Regarding the difference between genotypes for seasonal water consumptive use data of Table (6) and Fig. (1) revealed that the maximum value of seasonal water consumptive use was obtained by Shandaweel 6 hybrid, whereas the lowest value was obtained by ICSR 92003 line. It is worthy to mention that both Dorado variety and ICSR 91022 line had intermediate values of seasonal water consumptive use. In other words, the values of seasonal water consumptive use by different genotypes could be arranged in the order:

ICSR 92003 < Dorado < ICSR 91022 < Shandaweel 6. The lowest value of seasonal water consumptive use by ICSR 92003 line could be explained on the basis that, this line had the less leaf area index (LAI) among the three stages of growth i.e. 51,72 and 93 DAS as shown in (Table 3).

Data in Table (6) and Fig (1), showed that the highest value of seasonal water consumptive use was obtained when Shandaweel 6 hybrid was irrigated by wet treatment (irrigated at 25-30% ASMD), whereas the lowest value was obtained when ICSR 92003 line irrigated by dry treatment (irrigated at 65-70% ASMD). Also, it could be observed that ICSR 92003 line had the lowest values of seasonal water consumptive use under the three irrigation levels i.e. wet, medium and dry treatments. Such results could be explained on the basis that ICSR 92003 line had a lower shoot system as its root/shoot ratio, had higher value compared with the other genotypes (Table 4). Such finding revealed that ICSR 92003 line seemed to be tolerant to drought conditions. In this respect, Shaw and Laing (1966) pointed out that under stress conditions, transpiration is reduced when water deficit reached a critical characteristic value for the species, turgor induced changes in stomatal aperture which causes an increase in the resistance to transpiration in gaseous phase, which caused a reduction in transpiration to prevent or limit desiccation rather than to maintain flow at the level of evaporation demand.

b. Water use efficiency (WUE):

Water use efficiency by grain sorghum expressed as kg kernels produced per m^3 of water consumed in complete evapotranspiration for both seasons under study is presented in Table (6). Water use efficiency was higher under medium soil moisture stress (irrigated at 45-50% ASMD), while it was lower under wet condition and severe soil moisture stress. These results may be due to the higher grain yield/fed of grain sorghum gained from medium treatment and the low water consumed by such treatment. It could be concluded that medium soil moisture level seemed to be more efficient in consuming water compared with either low water deficit (wet treatment) or severe soil moisture stress (dry treatment). In other words, maintaining soil moisture level at 45-50 % ASMD (medium treatment) not only increased crop productivity but also allows the plants to use water more efficiently. In this connection, Vites (1965) concluded that water use efficiency is not clearly depend on the water available and evapotranspiration limit, even the crop yields and the opportunity to increase crop yields do depend on the adequacy of water supply.

As for the difference between genotypes under study with respect to the values of water use efficiency, results of Table (6) and Fig. (1) show that the maximum value of such character was obtained by ICSR 92003 line followed by Shandaweel 6 hybrid, Dorado variety and ICSR 91022 line. Such results indicated that ICSR 92003 line gave the higher grain yield more than the increase in water consumed by grain sorghum plants. In other words, ICSR 92003 line yielded higher grain yield and had a less water consumption.

As for the effect of water stress treatments on grain sorghum genotypes, results of Table (6) and Fig.(1) revealed that the maximum value of water use efficiency was obtained when ICSR 92003 line received the medium treatment (which irrigated at 45-50% ASMD). It can be noticed that, under dry condition (irrigated at 65-70% ASMD), ICSR 92003 line had the maximum value of water use efficiency, these results may be revealed that such line produced the maximum grain yield under drought conditions.

c. Porometer measurements:-

Transpiration rate (Tr.) and Stomatal resistance (SR):

Results of Table (6) show that the values of transpiration rate (Tr.) decreased, while stomatal resistance (SR) values were increased by increasing soil moisture stress from 25-30% ASMD up to 65-70% ASMD. In this regard, Abu-Grab and Othman (1999) mentioned that maize plants exposed to drought conditions resulted in significant increase in stomatal resistance (SR) whereas, transpiration rate (Tr.) was decreased.

Concerning the differences between genotypes in (Tr.) and (SR), Table (6) show that the maximum value of (SR) and the lowest value of (Tr.) were obtained by ICSR 92003 line compared with other genotypes. Such result indicated that ICSR 92003 line owing good tolerance to drought conditions compared with other genotypes under study. With regard to water stress on genotypes data in Table (6) show that the maximum value of (SR) and the minimum value of (Tr.) were obtained when ICSR 92003 line received the dry treatment (irrigated at 65-70% ASMD). These results may be confirm that ICSR 92003 line more tolerant to drought conditions which has high (SR) and lowest (Tr.).

CONCLUSION

In the light of the present results, sorghum irrigation could be practiced at 45-50% depletion of available soil moisture (medium treatment) for high grain yield under Ismailia conditions. Such treatment can be recommended from the stand point of water conservation. ICSR 92003 and Shandaweel-6 genotypes did not differ in grain yield; however, ICSR 92003 consumed lower water, recording higher water use efficiency value than Shandaweel-6 hybrid. Therefore, such genotype can endure water deficit conditions.

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استجابة بعض التراكيب الوراثية للذرة الرفيعة للإجهاد الرطوبى الأرضي تحت ظروف الأراضي الرملية

أحمد الرفاعى عبد العظيم أحمد مراد*، ناجى عبده انطون**

* قسم بحوث الذرة الرفيعة، ** قسم بحوث فسيولوجيا المحاصيل ـ معهد بحوث المحاصيل الحقلية.- مركز البحوث الزراعية

أجرى البحث بمحطة بحوث الإسماعلية في موسمي ٢٠٠٣ و ٢٠٠٤ لدراسة تأثير ثلاثة مستويات من الرطوبة الارضية وهى الري عند استنفاذ ٢٥-٣٠% و ٤٥-٥٠% و ٦٥-٧٠% من الماء الميسر(وهى معاملات رطبة ومتوسطة وجافة على التوالى) على نمو ومحصول أربعة تراكيب وراثية من الذرة الرقيعة للحبوب وهى الصنف دورادو وهجين شندويل-٦و السلالة ICSR 92003 وICSR 91022 وقد أوضحت النتائج الاتى-:

- أدى زيادة الإجهاد الرطوبى الأرضي حتى معاملة الري عند استنفاذ ٦٥-٧٠% من الماء الميسر الى نقص معنوى لطول النبات ودليل مساحة الأوراق (LAI)فى مراحل النمو المختلفة (٥١ و ٧٢ و ٩٣ يوم من الزراعة) وصافى معدل التمثيل الضوئى (NAR) عند الفترة الاولى من النمو (٣٠-٥١ يوم من الزراعة) وكذلك معدل نمو المحصول (CGR) فى جميع مراحل النمو .وعلى العكس ارتفع معنويا نسبة المجموع الجذرى /المجموع الخضرى عند المرحلة الثانية والثالثة من النمو (٥١-٧٢ و٧٢-٩٣يوم من الزراعة على الترتيب).
- أدى تعرض نباتات الذرة الرفيعة لظروف الجفاف (الرى عند استنفاذ ٦٥-٧٠% من الماء الميسر) الى نقص معنوى فى وزن القنديل ووزن حبوب النبات ووزن الألف حبة ومحصول الحبوب للفدان وذلك مقارنة بكل من المعاملة الرطبة والمتوسطة اللتان لم تختلفا معنويا.
- انخفض محتوى الحبوب من الكربوهيدرات الكلية بزيادة الاجهاد الرطوبى الارضى .
- بزيادة الاجهاد الرطوبى الارضى حتى معاملة الرى عند استنفاذ ٦٥-٧٠% من الماء الميسر)المعاملة الجافة نقصت قيم كل من الاستهلاك المائى الموسمى (WCU) وكفاءة استخدام المياه (WUE) ومعدل النتح (Tr.) وعلى العكس ارتفعت قيمة مقاومة الثغور (SR).
- سجل هجين شندويل-٦ أعلى قيمة لطول النبات عند الحصاد وكذلك دليل مساحة الاوراق (LAI) فى مراحل النمو المختلفة بينما كانت نباتات الصنف دورادو الاقصر طولا عند الحصاد والاقل فى دليل مساحة الاوراق (LAI) فى مراحل النمو المختلفة.
- أعطت السلالة ICSR 92003 أعلى قيمة لصافى معدل التمثيل الضوئى (NAR) عند المرحلة الاولى والثالثة من النمو بينما سجل هجين شندويل-٦ أعلى قيمة لصافى معدل التمثيل الضوئي في المرحلة الثانية من النمو.

- كان هجين شندويل-٦ الأعلى في معدل نمو المحصول (CGR) فى كل مراحل النمو تحت الدراسة.
- أعطت السلالة ICSR 92003 أعلى قيمة لصفة نسبة المجموع الجذري /المجموع الخضري في جميع مراحل النمو المختلفة مقارنة بجميع التراكيب الوراثية الأخرى وهذه النتيجة توضح أن هذه السلالة أكثر تحملا لظروف الجفاف.
- اختلفت التراكيب الوراثية تحت الدراسة معنويا فى صفات المحصول ومكوناته وقد أعطى هجين شندويل-٦ أعلى قيمة للوزن الأخضر ووزن القنديل ووزن الحبوب /نبات وكذلك المحصول الأخضر ومحصول الحبوب للفدان بينما كانت السلالة ICSR 92003 الأعلى قيمة في وزن الألف حبة ولم يلاحظ أي فرق معنوي للمحصول الأخضر ومحصول الحبوب للفدان بين هجين شندويل-٦ والسلالة ICSR 92003.
- كانت أعلى قيمة للكربوهيدرات الكلية للحبوب لهجين شندويل-٦ وأقل قيمة للسلالة ICSR 91022.
- أعطت السلالة ICSR 92003 أقل قيم للاستهلاك المائي الموسمي (WCU) ومعدل النتح (Tr.)كما سجلت أعلى قيم لكفاءة استخدام الماء (WUE) ومقاومة الثغور (SR).هذه النتيجة توضح تحمل هذه السلالة لظروف الجفاف.
- كان تأثير التفاعلات بين معاملات الإجهاد الرطوبى الارضى والتراكيب الوراثية للذرة الرفيعة معنويا لدليل مساحة الأوراق (LAI)في المرحلة الثالثة للنمو (٧٢-٩٣ يوم من الزراعة) فقط.
- كانت أعلى قيمة للمحصول الأخضر للفدان عند ري الصنف دورادو بالمعاملة الرطبة) الري عند استنفاذ ٢٥-٣٠% من الماء الميسر (بينما كانت أعلى قيمة لمحصول الحبوب للفدان عند ري هجين شندويل-٦ بالمعاملة المتوسطة (الري عند استنفاذ ٤٥-٥٠% من الماء الميسر).