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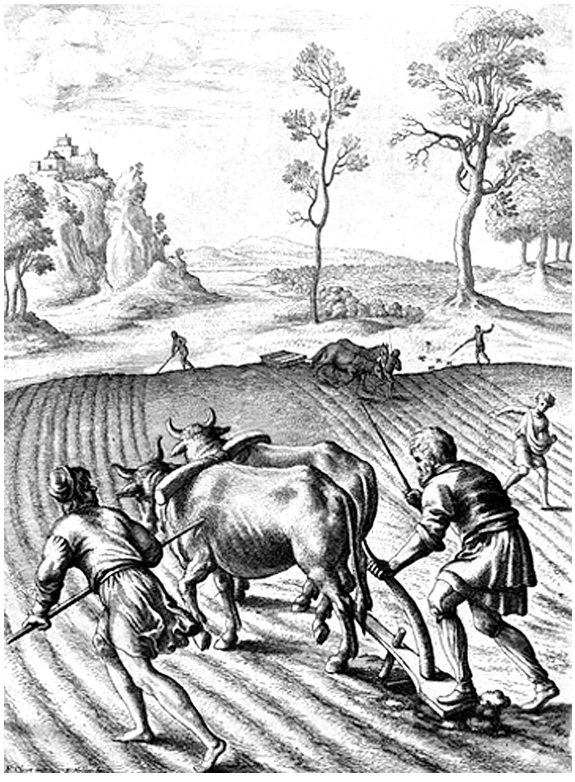

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Influence of Some Irrigation Systems and Water Regimes on Growth and Yield of Sesame Plants

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Abstract: Two field experiments were carried out at the Agricultural Experimental Station of National Research Centre at Shalakan, Kalubia Governorate during 2000 and 2001 seasons to study the effect of some irrigation systems i.e. controlled surface irrigation, sub-surface drip irrigation and surface drip irrigation and irrigation levels, i.e. 100% (control), 80 and 60% from normal irrigation requirements (ETc calculated from meteorological data) on growth, yield and its related characters as well as seed oil content and yield of sesame variety Giza 32. The results indicated that controlled surface irrigation system surpassed the other two ones in growth characters i.e. plant height, number of leaves, branches and capsules per plant; dry matter of leaves, stem, capsules and root per plant as well as total dry matter per plant. There were increases in yield, its related characters and seed oil content and yield due to controlled surface irrigation system as compared with the other two irrigation systems. As for water use efficiency, it was also obvious that the sub-surface drip irrigation system gave the best results. Irrigation regime of 100% (i.e. 1839 m^3/fed in controlled surface irrigation and 999 m^3/fed in sub-surface drip and surface drip irrigation) caused significant increases in the growth characters, yield and its related traits as well as seed oil content, yield and WUE. The obtained results suggested that controlled surface irrigation system and irrigation regime of 100% could be recommended for improving productivity of sesame plants under similar conditions.

Key words: Irrigation system, water requirements, water use efficiency, growth, yield, sesame

INTRODUCTION

Sesame (*Sesame indicum* L.) is considered as one of the most important oil crops in Egypt due to its high seed oil content (47-52%). It is the most appropriate crop for growing in the newly reclaimed land, which is expanded on a large scale outside the Nile Valley in Egypt.

El-Gindy[1] revealed that drip irrigation method increased the pepper yield by 64% over the furrow irrigation method beside its higher water use efficiency El-Berry *et al.*[2] mentioned that subsurface drip irrigation system provides a great potential for increasing crop production in arid lands since it minimizes the consumed amount of irrigation water which gives a way for expanding the cultivated areas. Saad and Frizzonet[3] found that careful management of sub-surface drip irrigation system can reduce net irrigation needs by about 25% while is still maintaining a yield of 12.5 t ha^{-1} of corn. Kassem [4] on clay soil for sunflower crop, found that the maximum value of total applied water (112.9 cm) was obtained by applying furrow irrigation, while the minimum value of total applied water was obtained by applying sub-surface drip irrigation at 30 cm depth. The growth of sunflower plants, the crop yield and water use efficiency were increased by using sub-surface drip irrigation system.

The irrigation water regimes affect growth, yield and oil content of sesame plants. In this connection Hong *et al.*[5] indicated that drought stress during vegetative growth reduced seed yield of sesame from 8.5 to 4.3 t ha^{-1} and that the main factor in yield reduction was plant height. El-Wakil and Gaaffar[6] indicated that applying six irrigations to sesame crop without skipping any one gave the highest values of yield and its attributes, whereas the lowest values were resulted from applying five irrigations and skipping one at the beginning of flowering. Applying three, four, five and six irrigations gave seasonal ETc of 1323, 1382, 1487 and 1647 m^3/fed, respectively. Moreover, applying six irrigations gave the highest WUE value, i.e. 350 kg seeds/m^3 water consumed. Sekhara and Reddy [7] suggested that selection for improving seed yield should be based on harvest index, 1000-seed weight, total dry matter production and seed weight/capsule.

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The present research was designed to study the performance of some irrigation methods and levels on growth, yield and seed oil percentage and yield of sesame.

MATERIALS AND METHODS

Two field experiments were carried out during the two successive seasons of 2000 and 2001 at the Experimental Farm of the National Research Centre in Shalakan Kalubia Governorate, Egypt. The soil texture of the experimental site was clay loam in both seasons. The investigation included nine treatments which were the combination of three irrigation systems and three irrigation regimes. A split-plot design with six replications was employed. The main plots were devoted to irrigation system while the sub-plots were assigned for irrigation treatments. The area of the sub plot was 13.5 m^2 consisting of six rows 75 cm width and 3 m length. Irrigation systems were controlled surface (irrigation every 15 days), sub-surface drip irrigation and surface drip (irrigation every 3 days). Irrigation treatments were control, i.e. 100% from normal irrigation requirements (ETc calculated from meteorological data), 80 and 60% of the control, calculated as m^3/fed. Total water requirements of the first and second seasons are shown in Table 1. On July 1 and 3 in 2002 and 2001 seasons, respectively, sesame seeds (*Sesamum indicum* L.) cv. Giza 32 were sown in hills, 100 cm a part. Thinning to two plants per hill was done at 14 days after planting. The normal agricultural practices for growing sesame were followed as recommended in the region. Calcium super phosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O) at the rates of 200 and 50 kg/fed, respectively, were added before planting. Nitrogen fertilizer at the rate of 45 kg N/fed as ammonium nitrate 33.5% N was applied in one dose (at the first irrigations). At 85 days plant age, random samples from each treatment were taken to determine plant growth characters i.e. plant height (cm), number of leaves, branches and capsules per plant, dry matter of leaves, stem, capsules, root and total dry matter per plant (g). At harvest, random samples of nine plants were taken from each treatment to determine number of capsules/plant, weight of capsules and seeds/plant (g), weight of 1000-seeds (g). Moreover, seed, straw and biological yields/fed (kg) were estimated using the guarded plants of 3.00 m^2 from every sub-plot of three replicates. Oil percentage was estimated according to the method described by AOAC[8] using soxhlet apparatus and petroleum ether as a solvent. Oil yield kg/fed was calculated. At the end of the growing season, water requirements for the whole season were calculated including sowing irrigation as well as WUE (kg m^{-3}). Data were subjected to statistical analysis of variance described by Snedecor and Cochran[9] and the combined analysis of the two seasons was applied according to the method adopted by Steel and Torrie[10].

RESULTS AND DISCUSSION

Growth characters: Data shown in Table 2 indicated that irrigation systems had significant effects on growth characters. It was clear that controlled surface irrigation surpassed the other two irrigation systems in the aforementioned parameters.

There were significant reductions in plant height and number of capsules, weight of leaves, stem, capsules and root per plant as well as total plant dry matter of surface drip irrigation. These results are in general agreement with those obtained by Haikel and El-Badry[11], Haikel and Bassal[12] and Haikel and Farid[13].

The obtained results revealed also that irrigation regimes significantly affected growth characters (Table 2)

Increasing the irrigation regime to 100% ETc (i.e. 1839 m^3/fed in controlled surface irrigation and 999 m^3/fed in sub surface drip and surface drip irrigation) caused significant increases in the aforementioned characters.

Table 1: Total water requirements of the 2000 and 2001 seasons

Treatments		Name of irrigation: Sowing	First irrig.	Second irrig.	Third irrig.	Fourth irrig.	Total water requirements	
Irrigation systems	Irrigation regimes	Irrigation dates 1/7/2000	30/7/2000	16/8/2000	2/9/2000	18/9/2000	m^3/fed	mm/fed
	ETc	3/7/2001	30/7/2001	15/8/2001	1/9/2001	17/9/2001		
Controlled	100%	400	320	373	373	373	1839	437.85
surface	80%	400	320	299	299	299	1617	385.00
irrigation	60%	400	320	224	224	224	1392	331.42
					From 16/8 - 18/9/2000			
					From 15/8 - 17/9/2001			
					Irrigation every 3 days			
Sub-surface	100%	400	320	18.6 18.6	18.6 18.6 18.6 18.6 18.6 18.6	18.6 18.6 18.6 18.6 18.6 18.6	999	237.85
drip	80%	400	320	15.0 15.0	15.0 15.0 15.0 15.0 15.0 15.0	15.0 15.0 15.0 15.0 15.0 15.0	945	225.00
irrigation	60%	400	320	11.2 11.2	11.2 11.2 11.2 11.2 11.2 11.2	11.2 11.2 11.2 11.2 11.2 11.2	888	211.42
Surface	100%	400	320	18.6 18.6	18.6 18.6 18.6 18.6 18.6 18.6	18.6 18.6 18.6 18.6 18.6 18.6	999	237.85
drip	80%	400	320	15.0 15.0	15.0 15.0 15.0 15.0 15.0 15.0	15.0 15.0 15.0 15.0 15.0 15.0	945	225.00
irrigation	60%	400	320	11.2 11.2	11.2 11.2 11.2 11.2 11.2 11.2	11.2 11.2 11.2 11.2 11.2 11.2	888	211.42

Table 2: Growth characters of sesame plants as affected by irrigation systems, irrigation regimes and their interaction at 85 days from sowing (combined analysis of 2000 and 2001 seasons)

Irrigation systems	Irrigation regimes ETc	Plant height (cm)	No. of leaves/ plant	No. of branches/ plant	No. of capsules/ plant	Dry matter of leaves/ plant	Dry matter of stem/ plant	Dry matter of capsules/ plant	Dry matter of root/ plant	Total dry matter/ plant
Controlled surface irrigation										
	100%	173.44	73.78	3.11	52.55	15.44	32.11	23.22	9.89	80.33
	80%	168.11	94.55	2.00	45.00	11.78	28.11	18.78	8.67	67.33
	60%	160.44	59.33	1.44	37.67	9.11	23.00	15.44	7.11	54.66
	Mean	167.33	65.98	2.18	45.07	12.11	27.74	19.15	8.55	67.44
Sub- surface drip irrigation										
	100%	168.78	70.00	2.44	47.22	13.33	29.00	19.78	8.78	71.00
	80%	161.11	61.67	1.44	39.22	10.44	24.11	14.33	7.00	55.89
	60%	155.33	55.00	1.00	34.33	8.11	20.44	12.11	6.11	46.77
	Mean	161.74	62.22	1.63	40.26	10.63	24.52	15.41	7.30	57.89
Surface drip irrigation										
	100%	166.44	67.55	2.00	42.33	11.89	27.11	16.78	7.78	63.55
	80%	162.55	63.11	1.44	37.00	10.89	22.33	13.44	6.44	53.11
	60%	152.11	53.44	1.00	32.00	7.33	18.00	12.11	6.00	43.44
	Mean	160.37	61.37	1.48	37.11	10.04	22.48	14.11	6.74	53.37
Mean values for irrigation regimes										
	100%	169.55	70.44	2.52	47.37	13.55	29.41	19.92	8.81	71.62
	80%	163.92	63.11	1.63	40.41	11.04	24.85	15.52	7.37	58.77
	60%	155.96	55.93	1.15	34.67	8.18	20.48	13.22	6.41	48.29
LSD at 5%										
	S	1.13	1.53	0.48	1.94	0.21	0.73	0.88	0.44	1.19
	I	1.65	1.31	0.36	1.64	0.69	1.17	0.82	0.55	2.54
	S x I	NS	2.26	NS	NS	1.20	NS	1.43	NS	NS

S= Irrigation systems, I = irrigation regimes S X I = Interaction, NS = Non significant

Similar results were obtained by Choi *et al.*[14], Sekhara and Reddy[7] and Abdel-Gawad[15].

The interaction effect between irrigation systems and irrigation regimes was not significant in all studied growth traits except for number of leaves per plant and dry matter of both leaves and capsules per plant, where irrigation regime of 100% ETc under controlled surface irrigation system gave the highest values in the same concern when compared with the other interaction (Table 2).

Yield, related characters, seed oil content and water use efficiency: Data presented in Table 3 showed that growing sesame plants to under different irrigation systems (controlled surface irrigation, sub-surface drip and surface drip irrigation) resulted in significant differences in yield and its related characters. There highest increases in yield, its related characters and seed oil content and yield were detected controlled surface irrigation as compared with the other two irrigation methods. These results are generally in agreement with those obtained by Saad and Frizzonet[3] Kassem[4] and Haikel and Farid[13]. On the other hand, sub-surface drip irrigation system produced the highest significant values of WUE compared to surface drip irrigation or controlled surface irrigation system.

The obtained results are agree with Haikel and Bassal[12], Kassem[4], Haikel and Farid[13] and El-Sayed[16].

The obtained results revealed also that irrigation regimes significantly affected the yield and its related characters (Table 3). Increasing the irrigation regime to 100% caused a significant increases in the aforementioned characters. These results are in the same line of the results reported by El-Wakil and Gaafar[6] Duraisamy *et al.* [17] Dutta *et al.*[18] and Ghallab *et al.*[19].

The highest oil percentage (60.37%) and oil yield (562.46 kg/fed) was shown by the irrigation regime of 100% (i.e. 1839 m^3/fed in controlled surface irrigation and 999 m^3/fed in sub-surface drip and surface drip irrigation) while the lowest value of oil percentage (55.87%) and oil yield (372.56 kg/fed) was gained from the irrigation regime of 60% (i.e. 1392 m^3/fed in controlled surface irrigation and 888 m^3/fed in sub-surface drip and surface drip irrigation).

These results are in agreement with these obtained by El-Wakil[20] and El-Sayed[16] who found that oil content increased by increasing soil moisture content.

The interaction effect between irrigation systems and irrigation regimes was not significant in all studied yield and oil characters except number of capsules per plant, straw yield/fed oil percentage and WUE. Irrigation regime 100% ETc under all irrigation systems gave the highest number of capsules plant, straw yield/fed and oil percentage as compared with the other treatments (Table 3). The highest WUE (0.93 kg m^{-3}) was shown by

Table 3: Yield characters, oil content (%), oil yield/fed and water use efficiency of sesame plants as affected by irrigation systems, irrigation regimes and their interaction (combined analysis of 2000 and 2001 seasons)

Irrigation systems	Irrigation regimes ETc	No. of capsules/ plant	DM of capsules/ plant (g)	DM of seeds/ plant (g)	Seed index (1000-seed WT.) (g)	Seed yield/ fed (kg)	Straw yield/ fed (kg)	Biological yield/ fed (kg)	Oil yield/ fed (kg)	Oil content (%)	Water use efficiency (kg m^{-3})
Controlled surface irrigation											
	100%	71.67	27.22	13.11	4.63	986.33	1682.67	2669.00	609.46	61.79	0.546
	80%	64.11	22.11	11.00	3.61	854.33	1524.67	2379.00	509.37	59.62	0.528
	60%	55.00	18.11	9.00	2.96	719.00	1439.00	2158.00	407.35	56.65	0.516
	mean	63.59	22.48	11.04	3.73	853.22	1548.78	2402.00	508.73	59.35	0.530
Sub-surface drip irrigation											
	100%	69.11	26.00	12.33	4.34	943.33	1652.33	2595.67	566.84	60.10	0.943
	80%	60.00	20.67	10.55	3.32	778.00	1395.33	2173.33	453.24	58.26	0.823
	60%	50.00	16.22	8.11	2.70	656.33	1294.67	1951.00	366.13	55.78	0.739
	mean	59.70	20.96	10.33	3.45	792.56	1447.44	2240.00	462.07	58.04	0.835
Surface drip irrigation	100%	65.00	23.78	11.22	3.86	863.00	1621.67	2484.67	511.08	59.22	0.863
	80%	56.33	18.11	9.00	3.10	707.67	1390.33	2098.00	406.60	57.45	0.748
	60%	47.33	14.11	7.11	2.33	623.67	1251.67	1875.33	344.19	55.19	0.702
	mean	56.22	18.67	9.11	3.09	731.44	1421.22	2152.67	420.62	57.29	0.771
Mean values for irrigation regimes	100%	68.59	25.67	12.22	4.28	930.89	1652.22	2583.11	562.46	60.37	0.784
	80%	60.15	20.30	10.18	3.34	780.00	1436.78	2216.78	546.40	58.44	0.700
	60%	50.78	16.15	8.07	2.66	666.33	1328.44	1994.78	372.56	55.87	0.652
LSD at 5%	S	1.20	1.33	0.64	0.30	40.08	63.40	80.36	24.04	0.33	0.004
	I	0.44	0.59	0.43	0.18	33.26	31.24	45.61	19.92	0.27	0.032
	S x I	0.76	NS	NS	NS	NS	54.10	NS	NS	0.48	0.056

S= Irrigation systems, I = Irrigation regimes, S X I = Interaction, NS=Non Significant

the irrigation regime of 100% under sub-surface drip irrigation system while the lowest value of WUE (0.546 kg m^{-3}) was gained from the irrigation regime of 60% in controlled surface irrigation.

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