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EFFECT OF SOME IRRIGATION TREATMENTS ON YIELD, WATER CONSUMPTIVE AND WATER USE EFFICIENCY OF SESAME

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ABSTRACT

Two field experiments were conducted at Ismailia Agricultural Research station during 2000 and 2001 seasons to study the effect of some irrigation treatments on yield and yield components and seed oil percentage as well as some water relations of sesame variety Giza 32. Nine irrigation treatments represent the combination between three irrigation intervals i.e. 4,6 and 8 days both at initiative capsules stage and maturity.

Results showed that significant differences between irrigation treatments for plant height, fruiting zone length, number of capsules/plant, 1000 - seed weight, seed and straw yields/fed. Sesame was irrigated at long intervals (8 days) decreased yield and its components than irrigated at short intervals (4 days) in sandy soil. Results also indicated that increasing water stress at any development stage led to decreased seed oil percentage in sesame seeds.

Results showed that increasing irrigation interval of sesame led to decreased seasonal, monthly and daily consumptive use and water use efficiency. It was shown that irrigation of sesame at 4 days intervals during the growing season gave the highest seed yield/fed and water use efficiency in both seasons.

INTRODUCTION

Sesame (sesamum indicum, L.) is considered as one of the most important oil crops grown in Egypt. It is a summer crop grown in a wide range of soils especially sandy soils for oil production. Intensive research work is needed to increase the yield out put of the newly selected varieties through improvement of cultural practices of the crop such as irrigation and fertilization.

In sandy soils with a low water holding capacity and high permeability, water management is a very important factor influencing crop yield. Ibrahim et al. (1987) and Ayyasamy and Velu (1990) showed that sesame was irrigated at 40% available soil moisture depletion (ASMD) increased plant height, seed yield/plant, seed yield/fed, fruiting zone length, number of capsules/plant and seed oil content. Consumptive water use increased with available soil water in the root zone. Chaudhari et al. (1991) tested some irrigation treatments such as irrigated sesame pre sowing (ps), ps + 50 days after sowing (DAS), ps +30 +50 DAS, ps +30+70 DAS, ps +50 +70 DAS or ps +30 +50 +70 DAS. They indicated that seed yield increased from 357 to 442 kg/ha with increase irrigation from 1 to 4. Consumptive use increased and water use efficiency increased with increased number of irrigation.

Ayyaswanmy and Velu (1992), Majumdar and Roy (1992) and Sener *et al.* (1992) found that sesame was sown on sandy loam soil and irrigated at branching (Br) +flowering (Fl) produced seed yield, in the respective seasons, of 0.95 and 1.00 t/ha compared with 1.21 and 1.22 t/ha from irrigation at Br + Fl + capsules development stage. Jana et al. (1995) and Nikam et al. (1995) found that the highest yields of seed (1.28 t/ha) and oil (0.52 t/ha) were obtained by 3 irrigation applied at the branching, flowering and seed development stages. Water use efficiency was highest (47.23 kg/ha per cm) with 2 irrigation applied at branching and seed development, followed by 3 irrigations applied at branching, flowering and seed development (46.45 kg/ha per cm). Kumar and Prasad (1993) and Parhiar et al. (1999) demonstrated that in a field trial on a sandy loam soil sesame was rainfed, or irrigated at irrigation water : cumulative pan evaporation ratio of 0.3, 0.5 or 0.7 or was given 2 irrigation at 30 and 60 days after sowing. Seed yield was 0.13 t/ha in rainfed crops and highest (0.25 t) with irrigation at 0.7 IW: CPE. Ayyaswamy and Velu (1993), Zewdie (1996) and Duraisamy et al. (1999) showed that the highest seed yields (809 and 752 kg/ha) were obtained at irrigation intervals of 20 and 30 days. Vyas et al. (1999) reported that irrigation significantly increased the seed yield, dry matter production and consumptive use of water of sesame.

Ghosh and Biswas (1984), Mahalanobis (1996) and Dutta et al. (2000) indicated that sesame with three irrigation each applied at branching, flowering and capsule development stages recorded maximum yield (seed + oil) of sesame, followed by 2 irrigation (branching + flowering). Consumptive use and water use efficiency were also increased with increasing the irrigation levels.

The present investigation aimed to study the effect of irrigation treatments on yield, water consumptive and water use efficiency of sesame production in sandy soils.

MATERIALS AND METHODS

The field experiments were carried out at Ismailia Agricultural Research Station in 2000 and 2001 seasons, to study the effect of irrigation intervals on yield, yield components and seed oil percentage as well as some water relations of sesame variety Giza 32. Soil texture was sandy. Mechanical analysis of the soil of experimental site according to the standard method of Arnold (1986) are presented in Table 1.

The experiment was laid out in a randomized complete block design with three replications.

Each experiment included nine irrigation treatments as follows:

1- Irrigation every 4 days to the end of growing season.
2- Irrigation every 6 days to the end of growing season.
3- Irrigation every 8 days to the end of growing season.
4- Irrigation every 4 days to initiative capsules stage and every 6 days to the end of growing season.
5- Irrigation every 4 days to initiative capsules stage and every 8 days to the end of growing season.

6- Irrigation every 6 days to initiative capsules stage and every 4 days to the end of growing season.
7- Irrigation every 6 days to initiative capsules stage and every 8 days to the end of growing season.
8- Irrigation every 8 days to initiative capsules stage and every 4 days to the end of growing season.
9- Irrigation every 8 days to initiative capsules stage and every 6 days to the end of growing season.

Table 1: Mechanical analysis of the soil of experimental site during 2000 and 2001 seasons.

Mechanical Analysis		
	2000	2001
Coarse sand (%)	60	58
Fine sand (%)	37	39
Silt (%)	1.3	1.5
Clay (%)	1.0	1.0
O.M. (%)	0.1	0.1
Texture class	Sand	Sand

The previous crop was faba bean in both seasons.

Initiative capsule stage for irrigation every 4, 6 and 8 days until maturity, were : 56, 48 and 43 days from sowing in the two seasons.

The irrigation treatments were applied after 21 days from sowing. The surface irrigation system was used, stopping irrigation was after 108 days from sowing in the two seasons and harvesting time was after 116 and 115 days from sowing in the first and second seasons, respectively. Phosphorus fertilizer at the rate of 31 kg P_2O_5/fed as superphosphate (15.5% P_2O_5) and potassium fertilizer at the rate 48 kg K_2O/fed. as potassium sulphate (48 % K_2O) were applied during land preparation. Nitrogen fertilizer was added at the rate of 70 kg N/fed in the form of ammonium nitrate (33.5% N) and divided into three portions, at sowing, and after 21 and 45 days from sowing date under the rates 10, 25 and 35 kg N/fed, respectively.. The area of plot was 12 m^2 (3m X 4m) with five ridges.

Sowing dates 11 and 14 May in the first and second seasons, respectively. Agronomic practices were followed according to the usual methods being adopted for such crop.

Studied characters:

At harvesting ten individual plants were chosen at random from the middle rows of each plot in the both seasons and the following data were recorded.

1- Plant height (cm).
2- Fruiting zone length.
3- Number of capsules/plant.
4- Seed index (1000 - seed weight in grams).

The plants of each plot were cut to determine:

5- Seed yield/fed. (kg).

6- Straw yield/fed. (ton).

7- Seed oil percentage was estimated according to A.O.A.C. (1970) by using Soxhelt apparatus and petroleum ether as a solvent, after extracting oil the residue was used for determining the other chemical constituents.

Water relations:

Moisture content and water consumptive use (cu) per unit area was calculated according to the equation described by Israelson and Hansen (1962). The physical properties of experimental soil site i.e. field capacity, wilting point percentage, available moisture and bulk density were determined and recorded in Table 2.

Table 2: Physical properties of the experimental soil site during 2000 and 2001 seasons.

Depth in (cm)	Field capacity %		Wilting point %		Available Moisture %		Bulk density g/cm	
	2000	2001	2000	2001	2000	2001	2000	2001
0 – 15	6.92	6.89	1.70	1.68	5.22	5.21	1.66	1.63
15 – 30	6.12	6.12	1.22	1.21	4.90	4.91	1.54	1.56
30 – 45	7.85	7.81	1.73	1.69	6.12	6.12	1.65	1.68
45 – 60	7.71	7.66	1.76	1.71	5.95	5.95	1.66	1.65

Consumptive use was determined for all irrigation treatments from sowing until harvesting. The measure consumptive use between irrigation treatments was divided by the number of days to obtain the daily water use. The sum of daily rates in each month is the monthly value from which seasonal water consumptive use was obtained.

Water consumptive use per unit area was calculated according to the

equation described by Israelson and Hansen (1962) as follow:

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

Where:

Cu = water consumptive use (ET) in mm.

D = Soil depth (cm).

Bd = Bulk density in gm/cm^3.

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

Water use efficiency (W.U.E).

Water use efficiency in kg/m^3 was calcultated for different treatments by the following

$$W.U.E. = \frac{\text{Grain yield kg/fed.}}{\text{Water consumption in m}^3\text{/fed.}}$$

Data obtained were statistically analyzed according to Snedecor and Cochran (1967) and the treatment means compared by the least significant differences test (LSD) at 5% level.

RESULTS AND DISCUSSION

Effect of irrigation treatments on yield, yield components and seed oil percentage of sesame variety Giza 32 in 2000 and 2001 seasons are presented in Table 3.

Results showed that the effects of irrigation treatments on plant height, length of fruiting zone, number of capsules/plant, 1000 seed weight and seed and straw yields/fed as well as oil percentage were significant in both seasons. Results indicated that the first irrigation treatment significantly increased seed yield/fed compared with other irrigation treatments in the two seasons. Results also showed that the differences between irrigation treatments of 3, 9 and 2, 6 and 7, 8 were insignificant in the first season only, while the difference between the irrigation treatments 4 and 5 was significant for seed yield/fed in the two seasons. The highest values in plant height, length of fruiting zone, number of capsules/plant, 1000 seed weight and straw yield/fed were obtained from the first irrigation treatment (Irrigation every 4 days during the growth stages) in the two seasons. The lowest values for the previous characters were obtained by the third irrigation treatment (Irrigation every 8 days during the growth stages) in 2000 and 2001 seasons. Similar results were reported by Kumar and Prasad (1993), Jana *et al.* (1995), Duraisamy *et al.* (1999) and Dutta et al. (2000).

The highest oil percentage (57.89 and 57.93) was obtained from the first irrigation treatment in the two seasons, while the lowest value of oil percentage (49.52 and 47.73) was gained from the third irrigation treatment in 2000 and 2001 seasons. These results are in agreement with those obtained by Atta (1980) suggested that there were positive relation between seed oil content and soil moisture content. In this connection El-Wakil (1984) found that oil content increased by increasing soil moisture content. From these results it could be concluded that high soil moisture deficit by irrigation every 8 days during different stages, would also reduce the capacity of plant in building up metabolites and this may account in turn to depression of photosynthetic efficiency of the leaves with consequent reduction in yield of sesame and its components.

Water Relations:

1-Water consumptive use:

Effect of irrigation treatments on daily, monthly and seasonal water consumptive use of sesame variety Giza 32 in 2000 and 2001 seasons are presented in Tables 4 and 5. The results show that seasonal rates varied widely between 407.78 and 600.34 mm, 409.71 and 595.84 mm in the first and second season, respectively. It seems that water use by sesame was lower in the first season compared with those recorded from the second season.

Table 3: seed and straw yields/fed and seed oil percentage of sesame during 2000 and 2001 seasons.
Effect of irrigation treatments on plant height, fruiting zone length, number of capsules/plant, seed index,

Irrigation treatment	Plant height (cm)		Fruiting zone length		Number of capsules/plant		Seed index (g)		Seed yield/fed (kg)		Straw yield/fed (ton)		Seed oil percentage%	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
1-(4) days	165.1	157.63	73.57	71.53	38.67	36.66	4.30	4.35	461.66	428.40	3.98	3.76	57.89	57.93
2-(6) days	126.6	121.50	56.83	55.55	30.00	29.33	3.34	3.37	341.60	320.60	3.32	3.30	55.67	54.98
3-(8) days	85.9	80.53	37.80	37.00	17.66	16.33	2.94	2.92	200.20	191.20	2.37	2.28	49.52	47.73
4-(4+6) days	150.3	143.20	65.60	64.13	34.67	33.33	3.87	3.89	394.67	363.13	3.68	3.51	55.66	52.76
5-(4+8) days	120.93	116.73	51.60	49.67	27.00	26.00	3.26	3.32	289.87	275.50	2.53	2.46	50.52	49.82
6-(6+4) days	138.53	127.43	60.47	59.66	32.67	31.00	3.56	3.61	356.40	343.27	3.48	3.41	53.89	55.95
7-(6+8) days	105.96	102.10	43.57	42.80	22.33	21.16	3.11	3.15	245.43	226.40	2.86	2.68	49.61	48.89
8-(8+4) days	115.23	109.43	47.03	46.16	25.33	23.33	3.18	3.26	266.26	262.17	3.16	2.99	56.63	56.08
9-(8+6) days	97.83	92.73	40.57	39.86	20.00	18.33	3.03	3.08	213.86	210.56	3.01	2.89	53.16	52.45
LSD at 5% for	4.31	4.42	4.42	2.30	3.55	1.17	0.20	0.23	20.60	19.13	0.58	0.39	2.77	1.67

Table 4: Daily, monthly and seasonal evapotranspiration (m^3) and water use efficiency (kg seed/m^3 water consumed) during 2000 season.

Irrigation treatment (days)		May 17 day	June 30 day	July 31 day	August 31 day	Sept. 6 days	Seasonal rates mm/fed.	Seasonal rates m^3/fed.	No. of irrigation/season	Water use efficiency W.U.E Kg/m^3
(4)	M. Rate	45.89	140.92	215.24	180.96	17.33	600.34	2521.4	26	0.18
	D. Rate	2.29	4.70	6.94	5.83	4.33				
(6)	M. Rate	38.65	115.15	175.83	147.78	14.15	491.56	2064.6	18	0.16
	D. Rate	1.93	3.84	5.67	4.77	3.54				
(8)	M. Rate	32.31	94.23	144.90	124.37	11.97	407.78	1712.7	12	0.11
	D. Rate	1.62	3.14	4.67	4.01	2.99				
(4+6)	M. Rate	45.89	140.92	175.83	147.78	14.15	524.57	2203.2	21	0.17
	D. Rate	2.29	4.7	5.67	4.77	3.54				
(4+8)	M. Rate	45.89	140.92	144.90	124.37	11.97	468.06	1965.8	17	0.14
	D. Rate	2.29	4.7	4.67	4.01	2.99				
(6+4)	M. Rate	38.65	115.15	215.24	180.96	17.33	567.33	2382.8	20	0.14
	D. Rate	1.93	3.84	6.94	5.83	4.33				
(6+8)	M. Rate	38.65	115.15	144.90	124.37	11.97	435.04	1827.2	15	0.13
	D. Rate	1.93	3.84	4.67	4.01	2.99				
(8+4)	M. Rate	32.31	94.23	215.24	180.96	17.33	540.07	2268.3	22	0.11
	D. Rate	1.62	3.14	6.94	5.83	4.33				
(8+6)	M. Rate	32.31	94.23	175.83	147.78	14.15	464.30	1950.1	16	0.10
	D. Rate	1.62	3.14	5.67	4.77	3.54				

Table 5: Daily, monthly and seasonal evapotranspiration (m^3) and water use efficiency (kg seed/m^3 water consumed) during 2001 season.

Irrigation treatment (days)		May 17 day	June 30 day	July 31 day	August 31 day	Sept. 6 days	Seasonal rates mm/fed.	Seasonal rates m^3/fed.	No. of ririgation/season	Water use efficiency W.U.E Kg/m^3
(4)	M. Rate	42.19	145.33	209.91	176.66	21.75	595.84	2502.5	26	0.17
	D. Rate	2.48	4.84	6.77	5.70	3.62				
(6)	M. Rate	39.09	119.64	169.55	146.33	18.05	492.66	2069.2	18	0.15
	D. Rate	2.30	3.99	5.47	4.72	3.01				
(8)	M. Rate	35.24	95.23	142.72	120.52	16.00	409.71	1720.8	12	0.11
	D. Rate	2.07	3.17	4.60	3.89	2.67				
(4+6)	M. Rate	42.19	145.33	169.55	146.33	18.05	521.45	2190.1	21	0.16
	D. Rate	2.48	4.84	5.47	4.72	3.01				
(4+8)	M. Rate	42.19	145.33	142.72	120.52	16.00	466.76	1960.4	17	0.14
	D. Rate	2.48	4.84	4.60	3.89	2.67				
(6+4)	M. Rate	39.09	119.64	209.91	176.66	21.75	567.05	2381.6	20	0.14
	D. Rate	2.30	3.99	6.77	5.70	3.62				
(6+8)	M. Rate	39.09	119.64	142.72	120.52	16.00	437.97	1839.5	15	0.12
	D. Rate	2.30	3.99	4.60	3.89	2.67				
(8+4)	M. Rate	35.24	95.23	209.91	176.66	21.75	538.79	2262.9	22	0.11
	D. Rate	2.07	3.17	6.77	5.70	3.62				
(8+6)	M. Rate	35.24	95.23	169.55	146.33	18.05	464.4	1950.5	16	0.10
	D. Rate	2.07	3.17	5.47	4.72	3.01				

This may be related to the differences in climatic factors from year to year. In this connection Jensen (1968) indicated that crops such as small grains would not necessarily require the same amount of water when grown at different regions.

Results clearly show that water consumption increased with increasing of number of irrigation in the two seasons. The highest evapotranspiration rate was brought about under wet conditions (irrigation every 4 days during the growing season) where as the lowest water use was attained under dry conditions (irrigation every 8 days during the growing season).

This trend reveal that the increase in water consumptive use depends on the available soil moisture in the root zone. The obtained data are due to availability of soil moisture for plants as well as to high evaporation opportunity from wet soil surface (irrigation every 4 days during the growing season) compared with dry one (irrigation every 8 days during the growing seasons). In this respect, Shaw and Laing (1965) pointed out that under stress conditions, transpiration is reduced when water deficit reached a critical value characteristic 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.

Water use efficiency

Water use efficiency is an important measure used to reflect the effect of crop management with respect to water that has been used. The values of water use efficiency could be increased by increasing crop yield or decreasing evapotranspiration and/or by both. Water use efficiency by sesame expressed as kg sesame seeds per m^3 water in complete evapotranspiration in the two seasons is presented in Tables 4 and 5. The results showed that water use efficiency rates varied widely between 0.18 and 0.10 kg seed/m^3 and 0.17 and 0.10 kg seed/m^3 in the first and second seasons, respectively. The highest value of water use efficiency was gained from the first irrigation treatment which irrigated every 4 days until maturity. The lowest water use efficiency was consumed by nine irrigation treatment which irrigated every 8 days to initiative capsules stage and every 6 days to the end of growing season. These results may prove the importance of maintaining soil moisture at a short irrigation intervals fro maximum production of dry matter thereby higher water use efficiency values. On the contrary, sever soil moisture at a long irrigation intervals (water stress), reduced plant growth more than water consumption which resulted in lower water use efficiency values. The results were in agreement with these obtained by Jana *et al.* (1995) and Dutta *et. al.* (2000).

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تأثير بعض معاملات الري على المحصول و الإستهلاك المائي و كفاءة استخدام مياة الري للسمسم.

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بالإسماعلية خلال موسمي ٢٠٠٠ و ٢٠٠١ لدراسة تأثير معاملات الري على النمو و المحصول و مكوناته و نسبة الزيت لبذور السمسم صنف جيزة ٣٢

معاملات الري:-

١- الري كل ٤ يوم حتى نهاية موسم النمو.
٢- الري كل ٦ يوم حتى نهاية موسم النمو.
٣- الري كل ٨ يوم حتى نهاية موسم النمو.
٤- الري كل ٤ يوم حتى طور بدأ تكشف أول كبسولة ثم كل ٦ يوم حتى نهاية موسم النمو.
٥- الري كل ٤ يوم حتى طور بدأ تكشف أول كبسولة ثم كل ٨ يوم حتى نهاية موسم النمو.
٦- الري كل ٦ يوم حتى طور بدأ تكشف أول كبسولة ثم كل ٤ يوم حتى نهاية موسم النمو.
٧- الري كل ٦ يوم حتى طور بدأ تكشف أول كبسولة ثم كل ٨ يوم حتى نهاية موسم النمو.
٨- الري كل ٨ يوم حتى طور بدأ تكشف أول كبسولة ثم كل ٤ يوم حتى نهاية موسم النمو.
٩- الري كل ٨ يوم حتى طور بدأ تكشف أول كبسولة ثم كل ٦ يوم حتى نهاية موسم النمو.

استخدم تصميم القطاعات الكاملة العشوائية في ثلاث مكررات و تتلخص أهم النتائج المتحصل عليها فيما يلي:-

١- أظهرت النتائج اختلافات معنوية بين معاملات الري حيث أدى تطبيق الري كل ٤ أيام حتى نهاية موسم النمو إلى زيادة معنوية في طول النبات و طول المنطقة الثمرية و عدد كبسولات النبات ووزن ١٠٠٠ بذرة و محصول بذور الفدان و كذلك محصول القش للفدان بالمقارنة بالمعاملات الأخرى المدروسة في الموسمين.
٢- أدى تطبيق معاملة الري كل ٤ أيام حتى نهاية الموسم إلى زيادة نسبة الزيت عن المعاملات الأخرى المدروسة في الموسمين.
٣- زاد الإستهلاك المائي اليومي - الشهري - الموسمي للنبات عند تطبيق معاملة الري كل ٤ أيام حتى نهاية موسم النمو بينما قل الإستهلاك المائي للنبات عند تطبيق معاملة الري كل ٨ أيام حتى نهاية موسم النمو.
٤- زادت كفاءة استخدام مياة الري عند تطبيق معاملة الري كل ٤ أيام عن باقي المعاملات الأخرى تحت الدراسة.

و من النتائج يتضح أن ري السمسم كل ٤ أيام يؤدي إلى زيادة محصول البذور و مكوناته و أيضا كفاءة استخدام مياة الري في الأراضي الرملية.