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EFFECT OF IRRIGATION TREATMENTS ON GROWTH, YIELD AND SOME WATER RELATIONS OF SESAME CROP.

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ABSTRACT

Two field experiments were carried out at Giza Agricultural Research Station, Agricultural Research Center, Egypt, during 2005 and 2006 seasons to identify the effective Penman Monteith coefficient (selected from 0.8, 1.0 and 1.2 irrigation levels) needed for scheduling irrigation of sesame crop (cv. Giza 32).

Results indicate that irrigation treatments had a significant effect on sesame yield and growth parameters. Sesame seed yields were 252.2, 445.0 and 484.0 kg/ fed in the first season, and 221.6, 324.2 and 380.6 kg/ fed in the second season for Penman Monteith coefficients of 0.8, 1.0 and 1.2, respectively. Results clear that increasing Penman Monteith coefficients from 0.8 to 1.2 caused a significant increase in no. of capsules/ plant, seed weight/ plant, 1000- seed weight and no. of seeds/ capsules. At the same time, the irrigation treatment of 1.2 caused increment of seed yield by 91.9 and 71.8 % as compared with 0.8 irrigation treatment in the first and second seasons, respectively. On the other hand, the same irrigation treatment caused increased seed yield by 8.8 and 17.4 % as compared with 1.0 irrigation treatment in the same respective seasons.

Results indicate also that oil yield was significantly increased by 101.9 and 82.8 % for 1.2 irrigation treatment as compared with 0.8 irrigation treatment.

Crop water use varied from 1902 to 2082 m^3/ fed in the first season and from 1857 to 2015 m^3/ fed in the second season for the same respective Penman Monteith coefficients. Water use efficiency values were increased as Penman Monteith coefficients increased. Increasing Penman Monteith coefficients from 0.8 to 1.2 increased WUE by 76.9 and 58.3 % in the first and second seasons, respectively.

From the previous results it could be concluded that the effective Penman Monteith coefficient for sesame crop is 1.2. The effective coefficient could be used to determine the optimum irrigation water amounts which should be applied to obtain the highest values of seed yield, oil yield and water use efficiency (i.e. irrigation water amount equals 120 % from Penman Monteith formula for each irrigation).

INTRODUCTION

Arid regions face difficult problems in irrigation water for agriculture. Water management permits greater control of production factors than any other agricultural practices. Oil crops become more and more important, and research studies on water requirements are limited. Sesame is one of the most important crops grown for oil production in A.R.E.

Water consumptive use of sesame crop was 2152, 2009 and 1953 m^3/ feddan for Upper, Middle and Lower Egypt respectively (Eid *et al.*, 1966). The water use by sesame reached 1700, 2200 and 2300 m^3/feddan for Delta, Middle and Upper Egypt respectively (Ministry of Irrigation Report, 1972). In the sandy soils of Wadi El-Natrun in the Western desert of Egypt, the highest seed yield of sesame was obtained with six-day irrigation intervals. The same author added that total water applied amounted to 5500 m^3/feddan (Batra, 1967). Ayasamy and Kulandiavelu (1992) found that seed yield increased by increasing soil moisture content through different stages of plant development. Methew and Kunju (1993) found that seed yield sesame increased by increasing the number of irrigation's. Ghosh *et al.* (1997) found that among irrigating treatments, seed yield highest (0.76t/ha) with irrigation at branching, flowering and pod development (30, 50 and 70 days after sowing). At Upper Egypt, El-Serogy *et al.* (1977) studied the effect of planting dates and water regimes on sesame yield and its water requirements. Their results showed that seed yield was significantly decreased with decreasing number of irrigations (e. g. increasing soil moisture stress). They also mentioned that, sesame plants consumed more water as number of irrigations increased. El-Serogy *et al.* (1977) and Metwaly *et al.* (1984) Indicated that seed oil percentage increased with increasing water availability to the crop. Ibrahim *et al.* (1987) found that increasing soil moisture content increased yield components, consequently seed yield/ unit area. Rao and Raju (1991) studied in field trail, 7 irrigation treatments designed to give moderate or severe evapotranspiration deficits (ETd) at vegetative, reproductive or ripening growth stages. Seed yield decreased with increasing water stress and lowest with ETd at the reproductive stage (0.56 t/ha). El-Serogy *et al.* (1998) determined the optimal time of terminal irrigation and harvesting date of some sesame varieties. They indicated that higher growth measurements of sesame were recorded from 6 irrigations and harvesting after 105 days from sowing. They added that water use efficiency was increased by 6 irrigations, delaying harvest date from 90 to 105 days after sowing and sowing Giza 32 variety in both season.

The present study aim at identifying the effective Penman Monteith coefficient (selected from 0.8, 1.0 and 1.2 coefficients) needed to determined the optimum irrigation water should be applied for sesame crop in Middle Egypt (represented by Giza area) to obtain the highest seed yield, oil yield and water use efficiency.

MATERIALS AND METHODS

Two field trials on sesame c.v. Giza 32 carried out during the summer season of 2005 and 2006 at Giza Agricultural Research Station, Agricultural Research Center. The aim of this study is to clarify the effect of irrigation water amounts on growth, yield, oil yield, water consumptive use and water use efficiency for sesame crop. Three irrigation treatments were tested. Data were statistically analyzed according to Snedecor and Cochran (1980).

Four replications were employed giving a total of 12 subplots having a size 5*5 m (25 m^2). Sowing date was June 9^{th} in both seasons (2005 and 2006).

Mechanical analysis of soil according to Piper (1950) is shown in Table (1). The soil moisture constants and meteorological data of Giza agricultural research station are shown in Table (2) and (3), respectively.

Table (1): Mechanical analysis of the experimental plots at Giza area.

Soil fractions	Content
Coarse sand	2.91 %
Fine sand	13.04 %
Silt	30.51 %
Clay	53.18%
Textural class	Clay

Table (2): The soil moisture constants (% by weight) and bulk density (gm/ cm^3) of experimental field in the 0-60 cm depth.

The constants / Depth (cm)	Field capacity (%)	Wilting point (%)	Available water (%)	Bulk density (g/cm^3)
00 –15	41.85	18.61	23.24	1.15
15- 30	33.68	17.50	16.18	1.24
30-45	28.38	16.92	11.46	1.20
45-60	28.05	16.54	11.51	1.28

Table (3): Meteorological data for Giza agricultural research station in 2005 and 2006.

Season	2005					
Month	T. Max	T. Min	S R	R.H	W.S	n/N
June	34.5	21.5	627	50	2.9	0.86
July	36.5	22.9	613	52	2.7	0.85
August	36.9	24.0	577	54	2.1	0.85
September	35.1	22.5	512	53	1.9	0.85
Season	2006					
June	34.6	21.2	627	48	2.9	0.86
July	34.8	21.6	613	51	2.7	0.85
August	35.7	22.9	577	51	2.1	0.85
September	34.6	21.4	512	51	1.9	0.85

Where: Tmax., Tmin.=maximum and minimum temperature °C, S.R.=solar radiation cal/cm² /day., R.H. = relative humidity %, W.S. = wind speed (m/sec), and n/N = ratio between actual sunshine hours and possible sunshine duration, in hours.

[Data were obtained from the agrometeorological station at Giza]

The description of the experimental treatments was as follows:

Irrigation treatments: (Penman Monteith coefficients)

1- I_1: 0.8 . Penman Monteith coefficient (irrigation with amount of water equals 80 % of potential evapotranspiration determined by Penman Monteith formula).
2- I_2: 1.0 Penman Monteith coefficient (irrigation with amount of water equals 100 % of potential evapotranspiration determined by Penman Monteith formula).
3- I_3: 1.2. Penman Monteith coefficient (irrigation with amount of water equals 120 % of potential evapotranspiration determined by Penman Monteith formula).

The amount of applied irrigation water was measured by water gauge and was calculated according to the following equation (Vermeiren and Gopling, 1984):

$$AIW = \frac{ETp \times Kc \times Kr \times I\ interval}{Ea} + LR$$

Where:

AIW = applied irrigation water depth (mm)

ETp = potential evapotranspiration (mm/ day) values obtained by Penman Monteith formula using "CROPWAT" model (Smith, 1991).

Kc = crop coefficient for sesame crop (FAO no. 33).

Kr = reduction factor that depends on ground cover. A kr value of 1.0 was used since plants spacing were less than 1.8 m apart (James, 1988).

Ea = irrigation efficiency (surface irrigation system efficiency = 0.70 for the surface system at the site).

I interval = irrigation intervals (days) = 12 days interval between each irrigation.

LR = leaching requirements (no additional water for leaching was added as a result of low EC values on irrigation water and soil profile).

Studied characters:

I. Growth and yield parameters:

1- Number of capsules/ plant.
2- Seed weight/ plant (g).
3- 1000- seed weight (g).
4- Number of seeds/ capsule.
5- Seed yield (kg/ fed).

II. Chemical analysis:

Seed oil percentage. At harvest time, seed samples were collected to determine seed oil percentage as described by Winton (1947).

III. Water relation parameters:

1. Actual water consumptive use (evapotranspiration).
2. Water use efficiency.

III. 1. Actual water consumptive use (evapotranspiration):

Actual evapotranspiration was estimated from the soil sampling method and calculated according to the equation of Israelson and Hansen (1962):

$$C.U = D \times Bd \times (Q2 - Q1) / 100$$

where:

C.U= actual evapotranspiration.
D = the irrigation soil depth (cm).
Bd = bulk density of soil (gcm^{-3}).
Q2 = the percentage of soil moisture two days after irrigation.
Q1 = the percentage of soil moisture before next irrigation.

Soil samples for moisture determination were taken from each 15 cm depth for a depth of 60 cm from the ground surface by a regular augur. The samples were weight after taken immediately and dried in an electric oven to a constant weight at 105 °C. Percent of soil moisture content at four soil depths was calculated on oven dry basis. The amount of water consumed in each irrigation was obtained from the difference between soil content after and before the following irrigation.

Seasonal water use:

The seasonal water use values were obtained from the sum of water consumptive use for all irrigations per treatment, from sowing until harvesting.

III. 2. Water use efficiency (W.U.E):

W.U.E. was calculated for different treatments by the following equation (Vites, 1965):

$$W.U.E = \frac{\text{Seed yield (kg/ fed.)}}{\text{Seasonal ET (m}^3\text{/ fed.)}}$$

RESULTS AND DISCUSSION

1.Growth, yield and yield component parameters:

Values of number of capsules/ plant, seed weight/ plant, 1000- seed weight, no. of seeds/ capsule and seed yield kg/fed for sesame crop as affected by irrigation treatments were recorded in Tables (4-5).

Results indicate that number of capsules/ plant, seed weight/ plant, 1000-seed weight, no. of seeds/ capsule and seed yield kg/fed were significantly affected by irrigation treatments. The highest values were obtained for I_3 irrigation treatment (1.2 Penman Monteith coefficient). The differences between seed yields for I_3 and I_2 irrigation treatments didn't reach of significant in the first season. Average seed yield for I_1 irrigation treatment was 43.3 and 47.9 % less than average seed yields obtained from I_2 and I_3 irrigation treatments in the first season. In the second season the reduction for seed yield with same treatment were 31.6 and 41.8 % as compared with the same respective irrigation treatments. This may be due to that reducing available soil moisture resulted in reducing absorption of soil solution (water and food elements), so, growth, yield and yield components were decreased accordingly. These results are in agreement with those obtained by El-Serogy *et al.* (1977), Metwaly *et al.* (1984), Ibrahim *et al.* (1987) and Rao and Raju (1991).

Table (4): Number of capsules/ plant, seed weight/ plant and 1000-seed weight for sesame crop as affected by irrigation treatments in 2005 and 2006 seasons.

Treatments	No. of capsules/ plant		Seed weight/ plant (g)		1000- seed weight (g)	
Seasons	2005	2006	2005	2006	2005	2006
I_1	66.8	88.0	19.16	12.46	3.38	3.18
I_2	109.8	115.8	23.38	17.96	3.78	3.52
I_3	134.6	139.6	24.76	19.42	4.06	3.68
LSD 5%	27.33	12.81	N.S.	4.67	0.59	0.36

Table (5): Number of seeds/ capsule and seed yield for sesame crop as affected by irrigation treatments in 2005 and 2006 seasons.

Treatments	No. of seeds/capsule		Seed yield (kg/ fed)	
Seasons	2005	2006	2005	2006
I_1	75	53.20	252.2	221.6
I_2	81	57.80	445.0	324.2
I_3	85	66.2	484.0	380.6
LSD 5%	1.28	8.5	46.67	28.77

II. Chemical analysis

Oil yield

Averages of oil yield in 2005 and 2006 seasons as affected by irrigation treatment are shown in Table (6). They were significantly affected by irrigation treatments in the two seasons. Application of I_3 irrigation treatment produced the highest oil yield in the two seasons. Meanwhile the application of I_1 irrigation treatment gave the lowest ones. Increasing available soil moisture before irrigation as a result of more water applied (I_3) compared to less water applied (I_1) caused increase in oil yield by 101.9 and 82.8 % in the first and second seasons, respectively. This may be due to exposing sesame plants to water stress as a result of decreasing amount of applied water especially during translocation of the sugars from the leaves to seeds.

Table (6): Oil yield for sesame crop as affected by irrigation treatments in 2005 and 2006 seasons.

Treatments	Oil yield (kg/ fed)	
Seasons	2005	2006
I_1	130.7	113.8
I_2	237.5	174.6
I_3	263.8	208.1
LSD 5%	56.5	54.7

In this connection, El-Tantawy *et al.* (2003) found that seed oil percent increased with increasing water availability to the crop. Similar results were reported by El-Serogy *et al.* (1977) and Metwaly *et al.* (1984).

III Crop Water Relations

III- 1- Actual water consumptive use:

Values of actual water consumptive use as affected by different irrigation treatments are recorded in Table (7). In 2005 season, the values were 1902, 1999 and 2082 m^3/ fed for I_1, I_2 and I_3 irrigation treatments, respectively. In 2006, the respective values were 1857, 1924 and 2015 m^3/ fed. Increasing water consumption in the first season as compared with the second season may be due to increasing maximum and minimum temperatures especially in mid season. Results indicate that increasing amount of applied water (I_3) increased water consumptive use by 9.5 and 4.2 % as compared with I_1 and I_2 irrigation treatments, respectively, in the first season. In the second season increasing water consumption for I_3 treatment reached about 8.5 and 4.7 % as compared with the same respective treatments.

III- 2- Water use efficiency (W.U.E.):

Values of W.U.E in 2005 were 0.13, 0.22 and 0.23 kg seeds / m^3 of water consumed for I_1, I_2 and I_3 respectively. Values in 2006 were 0.12, 0.17 and 0.19 kg seeds/ m^3 of water consumed for the same respective treatments (Table 7). The highest WUE values of 0.23 and 0.19 kg seeds/ m^3 of water consumption resulted from I_3 in the first and second seasons, respectively. Values of WUE for I_3 irrigation treatment were 76.9 and 4.5 % more than WUE obtained from I_1 and I^2, respectively, in the first season. However, increasing WUE in the second season for I_3 reached about 58.3 and 11.8 % as compared with I_1 and I_2, respectively. It is clear that increasing amount of applied water for sesame plants (I_3) increased seed yield more than increased water consumption. While, under decreasing of amount of applied water (I_1), decreasing seed yield more than decreasing in water consumption was happened.

Table (7): Actual water consumptive use and water use efficiency for sesame crop as affected by irrigation treatments in 2005 and 2006 seasons.

Characters	2005			2006		
	I_1	I_2	I_3	I_1	I_2	I_3
Actual water consumptive use (m^3/ fed)	1902	1999	2082	1857	1924	2015
Water use efficiency (Kg/ m^3 water consumption)	0.13	0.22	0.23	0.12	0.17	0.19

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تأثير معاملات الري على النمو والمحصول وبعض العلاقات المائية للسمسم

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اقيمت تجربتان حقليتان بمحطة البحوث الزراعية بالجيزة خلال موسمى ٢٠٠٥ ، ٢٠٠٦ وذلك بهدف جدولة رى محصول السمسم باستخدام معادلة بنمان مونتيث وقد استخدم لهذا الغرض ثلاث معاملات اطلق عليها معاملات بنمان مونتيث الهدف منها اختيار المعامل الفعال الذى يحدد أنسب كمية مياه رى يمكن اضافتها لنباتات السمسم لاعطاء أعلى محصول من البذور والزيت وأعلى كفاءة لاستعمال المياه. هذا وقد تمت دراسة أثر معاملات الرى الثلاث على كل من محصول البذور ومكونات المحصول ومحصول الزيت والاستهلاك المائى وكفاءة استعمال المياه لمحصول السمسم صنف جيزة ٣٢.

معاملات الرى هى:

١- I_1: ٠,٨ معامل بنمان مونتيث (الرى عند ٨٠% من كمية المياه المحسوبة بواسطة معادلة بنمان مونتيث).

٢- I_2: ١,٠ معامل بنمان مونتيث (الرى عند ١٠٠% من كمية المياه المحسوبة بواسطة معادلة بنمان مونتيث).

٣- I_3: ١,٢ معامل بنمان مونتيث (الرى عند ١٢٠% من كمية المياه المحسوبة بواسطة معادلة بنمان مونتيث).

وقد أوضحت النتائج تفوق معامل بنمان مونتيث ١,٢ لجميع الصفات تحت الدراسة. وقد بلغت نسبة الزيادة فى محصول البذور مع معامل بنمان مونتيث ١,٢ حوالى ٩١,٩، ٧١,٨ % بالمقارنة بمعامل بنمان مونتيث ٠,٨فى الموسم الاول والثانى على الترتيب . بينما بلغت الزيادة لنفس المعامل حوالى ٨,٨، ١٧,٤ % بالمقارنة بمعامل بنمان مونتيث ١,٠ لنفس مواسم الدراسة على الترتيب. ومن ناحية اخرى زادت كفاءة استعمال المياه مع المعامل ١,٢ بنسبة ٧٦,٩، ٥٨,٣ % بالمقارنة بالمعامل ٠,٨ فى الموسم الاول والثانى على الترتيب.

ومن حيث تأثير معاملات الرى المختلفة على محصول الزيت فقد أوضحت النتائج تفوق معامل بنمان مونتيث ١,٢ بنسبة ١٠١,٩، ٨٢,٨ % بالمقارنة بالمعامل ٠,٨ فى الموسم الاول والثانى على الترتيب.

مما تقدم يمكن استنتاج أن معادلة بنمان مونتيث يمكن استخدامها بكفاءة عالية فى جدولة رى محصول السمسم فى منطقة الجيزة كما يمكن استنتاج أن معامل ١,٢ لبنمان مونتيث هو المعامل الفعال الذى يحدد أنسب كمية مياه يمكن اضافتها لنباتات السمسم لاعطاء أعلى محصول من البذور والزيت وأعلى كفاءة لاستعمال المياه.