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IMPACT OF IRRIGATION INTERVALS ON PRODUCTIVITY OF SESAME UNDER SOUTHERN EGYPT CONDITIONS

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Abstract: *The effect of irrigation regimes on yield, yield attributes and IWUE of two sesame cultivars (Giza 32 and Toushki 3) was assessed. A field experiment was carried out in the Experimental Farm of the Faculty of Agriculture, South Valley University at Qena during two years on a sandy soil. A randomized complete block design in split plot arrangement with three replicates was used in this study. Irrigation treatments were randomly assigned to the main plots and the two cultivars were assigned to the split plots. The studied irrigation regimes affected significantly plant height, fruiting zone length, number of fruiting branches plant^{-1}, number of capsules plant^{-1}, 1000-seed weight, seed weight plant^{-1} and seed and oil yields ha^{-1}. The highest values of the studied characteristics were recorded under high regime (irrigation every 7 days) or medium regime (irrigation every 9 days). The highest value of IWUE was obtained from medium regime. Giza 32 cv. overcame significantly Toushki 3 cv. in seed yield, yield attributes, IWUE and seed oil percentage, while seeds of Toushki 3 were richer in protein content (%). According to the results of seed and oil yields ha^{-1} and IWUE, it is recommended to apply medium irrigation regime (8883 m^3 ha^{-1}). In addition, growing sesame Giza 32 cv. is recommended under similar soil and climatic conditions.*

Key words: *Sesame, irrigation intervals, seed yield, oil yield, IWUE*

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1. INTRODUCTION:

Sesame, (*Sesamum indicum* L.), is an ancient oil crop supplying seeds for confectionery purposes, edible oil, paste (tahini), cake and flour. It is typically a crop of small farmers in the developing countries. Sesame is considered as a drought tolerant crop [1]. The number and timing of irrigations will depend on soil type, location and seasonal conditions. Irrigation water is currently primary limiting factor in Egyptian agricultural. Egypt is considered one of the countries suffering from water scarcity as the total amount of water /capita/year is less than 1000 m^3. Thus, it is with importance also, to address great efforts to the fundamental issue of increasing crops production while reducing their water consumption especially on the new reclaimed sandy soils. Adequate water supply is one of the most important factors in crop production. The amount of irrigation water needed for crop depends on climate, crop and soil characteristics. Several investigators found that increasing irrigation frequency increased seed sesame yield and its attributes as well as oil yield [2]-[9]. El-Sayed [10] on sandy soil, found that irrigation at long intervals (8 days) decreased yield and its components comparing with short one (4 days). Meanwhile, Mendez–Natera *et al* [11] found that irrigation sesame every 6, 9 or 12 days had no effect on yield as well as oil %. El Naim *et al* [12] showed that the highest water quantity (750 mm) significantly increased the number of capsules per plant, number of seeds per capsule, 1000 seed weight (g), seed yield per plant (g) and seed yield (t/ha).On the other hand, non favorable effects for increasing soil moisture on seed protein content were reported by El- Emery *et al* [13] and Alpaslan *et al* [14]. In general, water use efficiency of sesame (kg seed/m3 water) decreased with increasing number of irrigation as reported by Kumar *et al* [15] and Mitra and Pal [16]. While, Dutta *et al* [6] and El-Sayed [10] reported that water use efficiency increased with increasing the irrigation levels.

Varietal differences in yield and yield attributes were stated by several workers [17]-[20]. Information on quantity of irrigation water and effects of deficit irrigation on yield and growth of sesame cultivars are needed under field conditions in southern Egypt. Therefore, this experiment was undertaken to evaluate two sesame cultivars under variable water regimes under sandy soil conditions.

2. MATERIALS AND METHODS

The field experiments were conducted at the Experimental Farm, Faculty of Agriculture, South Valley University, during 2012 and 2013 seasons. The soil of the experimental site is sandy throughout its profile (73.7% coarse sand, 16.8% fine sand, 5.8% silt and 3.7% clay). Its pH value of 7.62, 1.75 EC (dSm^{-1}), 0.45% organic matter content, 0.25% total N, and available P and K of 7.42 and 170 ppm, respectively. The weather is very hot and dry from May to October where temperatures can reach up to 40 °C.

The experiment consisted of three irrigation regimes and two cultivars (Giza 32 and Toushki 3). The three regimes were based upon the intervals among irrigations, every 7, 9 and 11 days for I_1, I_2 and I_3, respectively. The total amounts of water applied for I_1, I_2 and I_3 throughout the growing season (average of two seasons) were 9851, 8883 and 8055 m^3 ha^{-1}, respectively. A randomized complete block design in split plot arrangement with three replicates was used in each season. Irrigation treatments were randomly assigned to the main plots and cultivars assigned to the split plots. Experimental unit measured 3.0 m in width and 4 m in length.

Sowing date was on May 17 and 16 in 2012 and 2013 seasons, respectively. Planting distance was 10 cm between each two hills within the row. Thinning carried out after one month from sowing to two plants $hill^{-1}$. The irrigation regimes were performed after the complete germination and well establishment of seedlings (after one month from sowing). The N, P_2O_5 and K_2O fertilizers were applied at 175, 55 and 60 kg ha^{-1}, respectively. The other agronomic practices were kept normal and uniform for all the treatments.

At harvest, ten plants were taken randomly from each sub-plot to determine plant height, fruiting zone length, number of fruiting branches $plant^{-1}$, number of capsules $plant^{-1}$, seed weight $plant^{-1}$ and 1000-seed weight. Seed yield (kg ha^{-1}) was estimated on plot basis. Seed oil content was determined using Soxhlet apparatus [21]. Oil yield (kg ha^{-1}) was calculated by multiplying seed yield by seed oil content (%). Protein percentage was calculated by multiplying the total nitrogen in sesame seeds meal 6.25 [22]. Irrigation water use efficiency (IWUE) was calculated according to the following formula [23]:

$$IWUE = \frac{Seed\ yield\ (kg/ha)}{Irrigation\ water\ applied\ per\ season\ (m^3)}\ \text{kg m}^{-3}.$$

The data were analyzed by analysis of variance (ANOVA) using MSTAT-C statistical software. Treatment means were compared using Duncan's multiple tests [24]. Probability levels lower than 0.05 or 0.01 were held to be significant. Since data followed the homogeneity test, pooling was done over the seasons and mean data are given.

3. RESULTS AND DISCUSSIONS

3.1 Yield attributes

Data given in Tables 1 show that irrigation regime affected significantly all studied yield attributes. Irrigation regime I_1 (9851 m^3 ha^{-1}) surpassed significantly the regime I_3 (8055 m^3 ha^{-1}) in plant height, fruiting zone length, branches per $plant^{-1}$, number of capsules $plant^{-1}$, 1000-seed weight, seed weight $plant^{-1}$ by 21.4, 17.2, 29.1, 23.5, 19.9 and 34.6% , respectively. Also, this regime (I_1) gave higher values for the studied yield attributes comparing with I_2 (8883 m^3 ha^{-1}) but the differences among the two regimes almost did not attain the statistical differences. Meanwhile, I_2 resulted yield attributes almost significantly higher in their values than those under I_3. Tables 1 indicate that, Giza 32 plants recorded at harvest higher significant values of all studied yield attributes than those of Toushki 3. Differences among sesame cultivars in yield attributes were mentioned by Tiwari and Namdeo [17], Subrahmaniyan and Arulmozhi [18], Basavarai *et al* [19] and Subrahmaniyan *et al* [20].

3.2 Seed and oil yields

The effects of irrigation regimes and cultivars were significant on seed and oil yields (Table 2). Means in Table 2 indicate the superiority of seed yield, oil yield achieved by irrigation every 7 days (I_1) with a seed yield and oil yield of 1541 and 788 kg ha^{-1}, respectively. In addition, planting Giza 32 variety recorded the highest seed and oil yields of 1495 and 785 kg ha^{-1}, respectively. The significant favorable effects of high irrigation regime (I_1) could be due to the more available moisture increased the availability of absorbed water and minerals which encouraged the vegetative growth of plants as expressed by plant height, length of fruiting zone and number of fruiting branches $plant^{-1}$. This in turn increased number of capsules $plant^{-1}$, 1000-seed weight and seed yield $plant^{-1}$ which subsequently resulted in higher seed and oil yields ha^{-1}. These results are in agreement with those of Shrivastava and Tripathi [2], Abdel-Hakem and Abou-Salama [3], Mondal *et al* [4], Duraisamy *et al* [5], Dutta *et al* [6], De *et al* [7], Boydark et al [8] and Nadeem et al [9].

3.3 Seed oil and protein contents

Results of seed oil and protein contents are given in Tables 2 indicate that irrigation regimes did not affect significantly seed oil and protein contents. In this respect, Abdel-Hakem and Abou-Salama [3] and Mendez Natera [11] found that seed oil content was not affected significantly by irrigation treatments, while favorable effects for increasing soil moisture on this trait was recorded by Dutta *et a*l [6] and El-Sayed [10]. Seeds of Giza 32 were significantly higher in their oil content than those of Toushki 3 and (Table 2). This could be mainly due to differences in the genetic make-up of the two studied cultivars. These results are in a good line with those of Venkateswaran *et al* [25], Moorthy *et al* [25] and Tiwari *et al* [26]. In reverse to the varietal differences in oil percentage, seeds of Toushki 3 contained significantly higher protein percentage than these of Giza 32 (Tables 2). This could be mainly attributed to genetically constitution of each variety as well as to differences between them concerning their response to the environmental conditions.

3.4 Irrigation water use efficiency (IWUE)

Availability of water is usually the ultimate limiting factor in plant growth under dry land agriculture. Consequently, the amount of products produced per unit of water used is of major importance in determining the efficiency of any crop production system. Variation of irrigation water use efficiency (IWUE) was significant for the irrigation regime. The highest value of IWUE (0.170 kg seed m^{-1}) was obtained from irrigation every 9 days (I_2), whereas, irrigation every 11 days (I_3) which produced the lowest (0.135 kg seed m^{-1}) IWUE (Table 2). The Giza 32 plants used water more efficiently (0.167 kg seed m^{-1}) than Toushki 3 plants (0.142 kg seed m^{-1}). Favorable effects of increasing amounts of water irrigation on IWUE were reported by Dutta *et al* [6] and El-Sayed [10]. While, Kumar *et al* [15] and Mitra and Pal [16] stated negative effect in this respect. The absence in improvement of IWUE at low irrigation regime (I_3) is due to the fact that seed yield was correspondingly reduced as the soil water deficit amount increased (Table 2).

4. CONCLUSION

The irrigation every 11 days (I_3) in this study, reduced yield attributes, seed yield and oil yield as well as irrigation water use efficiency. The highest value of IWUE was obtained from irrigation every 9 days (I_2). Giza 32 plants recorded at harvest higher significant values of all studied yield attributes, seed yield, oil yield and seed oil content than those of Toushki 3. Also, the plants of this variety used water more efficiently than Toushki 3 plants.

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Table 1. Effect of irrigation regimes on yield attributes of two sesame cultivars (Data over two seasons)

Treatments	Plant height (cm)	Fruiting zone length (cm)	Number of fruiting branches plant^{-1}	Number of capsules plant^{-1}	1000-seed weight (g)	Seed weight plant^{-1} (g)
Irrigation regimes (I):						
Irrigation every 7 days (I_1)	144.1 a	67.4 a	2.350 a	64.2 a	3.405 a	6.495 a
Irrigation every 9 days (I_2)	139.1 a	63.8 a	2.105 a	61.5 a	3.320 a	6.335 a
Irrigation every 11 days (I_3)	118.7 b	57.5 b	1.820 b	52.0 b	2.840 b	4.825 b
Cultivars (C):						
Giza 32	142.6	69.1	2.735	62.3	3.300	6.280
Toushki 3	125.4	56.0	1.445	56.2	3.095	5.485
F test						
I	*	*	**	**	**	**
C	**	**	**	**	**	**
I x C	N.S	N.S	N.S	N.S	N.S	N.S

The same letters within columns means not significant differences at 5% level.

* and **: Significant at 0.05 and 0.01 probability levels, respectively. N.S: indicates not significant.

Table 2. Effect of irrigation regimes on seed yield, oil yield, seed oil content, seed protein content and IWUE of two sesame cultivars (Data over two seasons).

Treatments	Seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})	Seed oil content (%)	Seed protein content (%)	IWUE (kg seed /m^3)
Irrigation regimes (I):					
Irrigation every 7 days (I_1)	1541 a	788 a	51.1 a	20.9 a	0.156 b
Irrigation every 9 days (I_2)	1507 a	767 a	50.9 a	20.8 a	0.170 a
Irrigation every 11 days (I_3)	1091 b	559 b	51.2 a	20.0 a	0.135 c
Cultivars (C):					
Giza 32	1495	785	52.5	19.7	0.167
Toushki 3	1264	628	49.7	21.4	0.142
F test					
I	**	**	N.S	N.S	**
C	**	**	**	**	**
I x C	N.S	N.S	N.S	N.S	N.S

The same letters within columns means not significant differences at 5% level.

* and **: Significant at 0.05 and 0.01 probability levels, respectively. N.S: indicates not significant.