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Effect of irrigation intervals on growth, flowering and fruits quality of okra *Abelmoschus esculentus* (L.) Monech

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This study was done to investigate the influence of irrigation intervals and cultivars on growth, flowering and fruits qualities of okra (*Abelmoschus esculentus* L.). The experiment was conducted using Randomize Complete Block Design (RCBD) in Split-Plot Design at the vegetable field, Department of Horticulture and Gardening Landscape, College of Agriculture, University of Baghdad, Iraq. Two cultivars of okra were used: Local investigated (V1) and Copra cultivar (V2). The irrigation was done every 3 (T1), 5 (T2) and 7 days (T3) or irrigation depends on plants need (T4). The cultivars were used as main factor and irrigation intervals as subfactor. The local cultivar showed a significant increase in (V1) in the time of flowering initiation, no. of flowers/plant, and fruits total soluble solids (TSS), while copra cultivar gave a significant increase in the no. of branches/plant, no. of leaves/plant and the fruit length. There are no significant influences between cultivars in plant height, the fruit diameter, dry matter % and fruit firmness. Irrigation every 3 days (T1) positively affected the growth parameter and thus enhanced the flowering initiation, the flower initiation, and increased fruit diameter and fruit firmness. The irrigation every 5 days (T2) increased the number of flowers and the length of fruits, while the irrigation every 7 days (T3) influenced the fruit dry matter percentage and TSS. The interaction between the experimental factors was significant in all the studied parameters.

Key words: Okra, irrigation intervals, vegetative growth, flowering, total soluble solids (TSS), dry matter %.

INTRODUCTION

It is well known that okra (*Abelmoschus esculentum* L.) Malvaceae family is one of the most important summer vegetable crops and it is consumed in large scale in Iraq and other countries. It can be used fresh, frozen or dried especially when it is not available in the markets. It is common in different countries in Asia, Africa and areas

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around the Mediterranean Sea (Matlob et al., 1989). The largest cultivated area of okra under okra crop was in Ethiopia, India, Nigeria, Sudan and Iraq (FAO, 2010).

Okra needs a long warm season, so this crop needs to be watered and it differs from place to other according to the climatic conditions. The irrigation intervals requirements and the quantities of water, which have been supplied to the crops, must be adjusted to increase the productivity and reduce the washing of the mineral elements from the soil and prevent water stress (Boras et al., 2011; Oppongdanso, 2014).

The irrigation water allows the minerals element to be dissolved and transported to different parts of the plant and the water is very imported in the photosynthesis, so the water is an important factors influencing the growth of the plants (El-Sahookie et al., 2009). From their point of view, many research works were carried out to investigate the impacts of irrigation frequency for many crops and the okra is one of them and especially it a summer crop and the crop needs high quantity or water. Ghannad et al. (2014a) found that irrigating okra plants every seven days influenced the intervals to flowering initiation and gave the highest yield and no. of fruits/plant and seed/pod. Irrigating of okra plants every seven days significantly increased the plant height, the no. of branches and no. of leaves, leaf area, the length of fruit and no. of fruit per plant (Ghannad et al., 2014b).

The aim of this study was to investigate the effect of different irrigation intervals on growth, flowering and qualitative characters of okra plants cultivated at the middle of Iraq.

MATERIALS AND METHODS

This study was carried out to investigate the effect of the two okra (*A. esculentus* L.) cultivars and the irrigation intervals and their interaction on vegetative growth, flowering, quantitative, and qualitative characters of fruits. An experiment was carried out in vegetable fields, Department of Horticulture and Landscape Gardening, College of Agricultural, University of Baghdad, Iraq. Two okra cultivars were used: local cultivar (V1) with green medium pods, large leaves and early maturity and Copra cultivar (V2) with milky long pods, medium leaves and late maturity. Three irrigation intervals were used: 3, 5, and 7 days (T1, T2, and T3), respectively and the control (T4) was irrigation when needed.

The okra seeds were planted on the 20th of April in rows (4 m in length and 0.75 m in width), and the experimental unit with three rows and with the area (10 m^2) with three replicates and 24 experimental units. The soil texture was loamy clay and irrigation system was flood irrigation. The agronomic aspects were carried out as reported by Matlob et al. (1989). The experimental design used in this experiment was Randomize Complete Block (RCBD) with Split Plot Design. The cultivars were the main factor (less important) and were put in the main-plot, while the irrigation intervals were the secondary factor (most important) and were put in sub-plot. Data were recorded after 12 weeks from seeds planting. The study included the vegetative parameters such as plant hieght, number of branches/plant, number of leaves/plant, flowering parameters, time to flower initiation, number of flowers/plant, fruit quantities and qualities parameters such as fruit length and diameter by using vernier, percentage of dry matter, firmness by using penetrometer, total soluble solids (TSS) by hand refractometer (A.O.A.C., 1970). The results were analyzed using SAS (2004) program and the means were compared using least significant difference (LSD) at 0.05 probability level (El-Sahookie and Wahaib, 1990).

RESULTS AND DISCUSSION

The vegetative parameters

The results of vegetative parameters are shown in Table 1. It can noticed that there is no significant influence of the cultivars on the height of the plant while the cultivar (V2) gave the highest number of branch $plant^{-1}$ (12.16) and number of leaves (38.58) leaf $plant^{-1}$ as compared with 7.66 branch $plant^{-1}$ and 33.33 leaf $plant^{-1}$ in the local cultivar (V1). The irrigation every three days significantly gave the highest plant height reaching 287.7 cm and the highest number of branches (12.33 branch $plant^{-1}$) and number of leaves (40 leaf $plant^{-1}$) as compared with 133.5 cm and 6.833 branch $plant^{-1}$ and 32.00 leaf $plant^{-1}$ in the irrigation when needed (T4), respectively.

Table 1 shows the interaction of vegetative parameters between experimental factors. The local cultivar (V1) and irrigation every three days (V1T1) gave the highest value of plant height reached 197.5 cm as compared to 103.9 (cm) in plants from same cultivar and irrigation every seven days (V1T3). The plants from the cultivar copra (V2) and irrigation every three days (V2T1) gave the highest number of branches (16 branch $plant^{-1}$) and the highest number of leaves per plant (41.66 leaf $plant^{-1}$) as compared to the local cultivar and irrigated when needed (V1T4) which gave 5.667 branch $plant^{-1}$ and 29.33 leaf $plant^{-1}$, respectively.

The flowering parameters

The cultivars significantly influenced the flowering parameters studied in this experiment. Local cultivar (V1) initiated flowers significantly earlier than copra cultivar; local cultivar takes 63.50 days compared with 68.00 days in copra cultivar plants (V2). The local cultivar (V1) gave the highest number of flowers (82.24 flower $plant^{-1}$) as compared to 77.40 flower $plant^{-1}$ in copra cultivar plants (V2). Plants irrigated every three days (T1) initiated flowers earlier and took 59.00 days compared with plants which have been irrigated when needed (T4) which the plants take 70.66 days to flower. Table 2 also shows the influence of the interaction between the cultivars and irrigation intervals on flowering parameters of okra plants. The local cultivars plants irrigated every three days (V1T1) initiated flowers earlier and took 55.33 days to produce 85.98 flower $plant^{-1}$ compared with copra cultivar

Table 1. The influence of cultivars, irrigation intervals, and their interaction on vegetative parameters of okra plants local cultivar (V1) and cultivar (V2) grown in Iraq.

Parameter	Height of plant (cm)		Mean of irrigation intervals	Number of branches plant^{-1}		Mean of irrigation intervals	Number of Leaves plant^{-1}		Mean of irrigation intervals
Cultivars	**V1**	**V2**		**V1**	**V2**		**V1**	**V2**	
Irrigation intervals									
T1	197.5	178.5	**188.5**	8.667	16.00	12.33	38.33	41.66	40.00
T2	107.4	181.4	144.4	8.000	12.00	10.00	33.66	38.33	36.00
T3	103.9	175.6	139.7	8.333	12.66	10.50	32.00	39.66	35.83
T4	115.2	151.8	133.5	5.667	8.000	6.833	29.33	34.66	32.00
Mean of cultivars	131.0	171.0	-	7.66	12.16	-	33.33	38.58	-
LSD 5% cultivars	NS		-	1.961		-	2.647		-
LSD 5% Irrigation intervals	132.36		-	2.773		-	3.489		-
LSD 5% interaction	221.38		-	3.761		-	6.690		-

Table 2. The influence of cultivars and irrigation intervals and their interaction in flowering parameters of okra plants local cultivar (V1) and cultivar (V2) grown in Iraq.

Cultivars	Time to flower initiation (day)		Mean of irrigation intervals	Number of flowers per plant (flower.plant^{-1})		Mean of irrigation intervals
Irrigation intervals	**V1**	**V2**		**V1**	**V2**	
T1	55.33	62.66	59.00	85.98	75.53	80.76
T2	63.00	70.00	66.50	85.55	81.18	83.36
T3	64.00	69.66	66.83	81.56	81.61	81.59
T4	69.00	71.66	70.66	75.87	71.26	73.57
Mean of cultivar	63.50	68.00	-	82.24	77.40	-
L.S.D.5% cultivars	0.864		-	1.989		-
L.S.D.5% irrigation intervals	1.222		-	2.813		-
L.S.D.5% interaction	2.577		-	3.685		-

plants that irrigated as needed watering (V2T4) which took 71.66 days to produce 71.26 flower plant^{-1}.

The morphological parameters of pods

The cultivars copra (V2) gave the highest length of fruits (4.041 cm) compared with 3.191 cm in local cultivar (V1) (Table 3). While there were no significant differences between the cultivars in the diameter of the fruit. The irrigation intervals significantly influence the length and diameter of the fruit. Irrigation every five days (T2) increases the length of the fruit up to 4.216 cm compared with 2.5 cm in plants irrigated when the plants need irrigating (T4). The highest diameter of the fruit was 2.083 cm in plants irrigated every three days (T1) while the lowest fruit diameter 1.3 cm in plants irrigated as needed (T4). The influence of the interaction between the cultivars and irrigation intervals was significant when the plants irrigated every five days (V2T2) giving the highest fruit length (4.833 cm) compared with lower fruit length (2.166 cm) in local cultivar wateredas plants needed (V1T4). The highest diameter (2.166 cm) was in copra fruits when plants irrigated every three days (V2T1) compared with 1.1 cm the local cultivar plants that irrigated as plants needed.

The qualitative parameters of the yield

Table 4 shows that local cultivar (V1) okra fruits characterized by high TSS (5.758%) compared with 4.908% in copra cultivar (V2), while there was no significant difference between the two cultivars in influences of irrigation intervals in TSS and the percentage of dry matter and firmness of fruits. Also, there was a significant effect of the okra fruits TSS, the irrigation every seven days (T3) significantly increased TSS and the percentage of dry matter up to 6.5 and 19.35%, respectively compared with values in plants

Table 3. The influence of cultivars and irrigation intervals and their interaction in the morphology of okra fruits local cultivar (V1) and cultivar (V2) grown in Iraq.

Cultivars	Fruit length (cm)		Mean of irrigation intervals	Fruit diameter (cm)		Mean of irrigation intervals
Irrigation intervals	**V1**	**V2**		**V1**	**V2**	
T1	4.000	4.333	4.166	2.000	2.166	2.083
T2	3.600	4.833	4.216	1.500	1.833	1.666
T3	3.000	4.166	3.583	1.833	2.000	1.916
T4	2.166	2.833	2.500	1.100	1.500	1.300
Mean of cultivars	3.191	4.041	-	1.608	1.875	-
L.S.D.5% cultivars	0.639		-	NS		-
L.S.D.5% irrigation intervals	0.904		-	0.410		-
L.S.D.5% interaction	1.268		-	0.746		-

Table 4. The influence of cultivars and irrigation intervals and their interaction in qualitative of okra fruits local cultivar (V1) and cultivar (V2) grown in Iraq.

Cultivars	TSS (%)		Mean of irrigation intervals	Dry matter (%)		Mean of irrigation intervals	Fruit firmness ($Kg.cm^{-2}$)		Mean of irrigation intervals
Irrigation intervals	**V1**	**V2**		**V1**	**V2**		**V1**	**V2**	
T1	6.067	4.800	5.433	17.50	17.33	17.41	6.200	6.133	6.166
T2	5.433	5.000	5.216	13.00	12.33	12.66	5.433	5.400	5.416
T3	7.267	5.733	6.500	19.03	19.66	19.35	5.700	5.700	5.700
T4	4.267	4.100	4.183	12.03	11.93	11.98	5.700	4.700	5.200
Mean of cultivars	5.758	4.908	-	15.39	15.31	-	5.758	5.483	-
LSD 5% cultivars	1.972		-	NS		-	NS		-
LSD 5% irrigation intervals	1.693		-	4.115		-	0.732		-
LSD 5% interaction	2.345		-	5.456		-	0.979		-

irrigated when the irrigation (T4) is needed 4.183 and 11.98%, respectively. Irrigating okra plants every three days (T1) significantly increased fruit firmness to 6.166 $kg.cm^{-2}$ as compared to 5.2 $kg.cm^{-2}$ in plants irrigated days need (T4). Table 4 shows that the influence of the interaction of cultivars and irrigation intervals was significant, local cultivar and irrigated every seven days (V1T3) gave the highest TSS (7.267%) as compared to 4.100% in copra cultivar irrigated when the plant need irrigation (V2T4). The copra cultivar irrigated every seven days (V2T3) gave the highest percentage of dry matter (19.35%) compared with the lowest value reached 11.98% in the same cultivar but when the plants irrigated as the plants needed (V2T4).The fruit firmness was higher in local cultivars plants irrigated every three days (V1T1) (6.2 $kg.cm^{-2}$) compared with 4.700 $kg.cm^{-2}$ in fruits irrigated days needed (V2T4). These results are in agreement with those found by Ghannad et al. (2014a,b) who studied the impact of irrigation intervals and cultivation dates on vegetative parameters and flowering of okra palnts in Iran.

From the results of this experiment, the influence of the genetic factors can be noticed in the growth of the plants and their response to the ecological factors. The increases in the number of leaves may be due to the increase in the number of branches as shown in Table 1; this will increase the rate of photosynthesis activities, produce more biomass and early flowering, and increase the number of flowers in plants. The increase in the rate of growth will lead to increase in the hormones which increase the length of fruits (Hussein et al., 2011). The increase of total biomass production and the interaction with ecological factors will increase due to the differences in growth and flowering in plants (Jamala et al., 2011).

Irrigating okra plants at the right time will enhance the growth of vegetative parts, early flowering and fruit set as mentioned earlier, the okra crop need more water during growth and development (Matlob et al., 1989; Hassan, 1997). The influence of irrigation intervals of okra crop on different parameters may be due to stomata behavior of plants which affected plants by these intervals. The opening and closing of the stomata have been affected by the intervals between the irrigation, especially the stomata in the upper layer of the leaf (Anant et al., 2009)

and saving the plant from the drought. Abd-El-Kader et al. (2010) noticed that morphological characters of okra plants were reduced by increasing the intervals between irrigation and the plant would face a drought and less humidity which the plants needed for growth, flowering, and yield.

From the experimental results, it is clear that all studied characters were improved by reducing the time between the irrigation, and hence increasing the humidity in the soil and increasing the mineral elements needed by the plants which dissolved by water inside the plant tissues (El-Sahookie et al., 2009). In addition, from this experiment, we can suggest that irrigation every three days characterized by best vegetative growth, earlier flowering initiation, and using new cultivars of okra while being characterized by resisting the drought especially nowadays that Iraq faces a rise in the temperature and lowering available irrigation water.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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