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Effect of Irrigation Periods on Growth Characteristics and Yield Components of *Sorghum bicolor* (L.) Moench Varieties

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Abstract: A field experiment was carried out during the autumn 2019 in Maysan province. The experiment was laid out in split plot in randomize complete block design with three replicates. The irrigation periods had a significant effect on the different traits, as the irrigation period every 5 days gave the higher average of plant height, stem diameter, leafy area, number of grains, weight of 1000 grains, total grain yield. The varieties differed significantly in the growth and yield, where the variety Giza attained maximum plant height and leafy area while the Inkath cultivar outperformed in the diameter of the stem and the number of grains in the head and overall grain yield. The maximum weight of 1,000 grains was in Cafier cultivar. The sowing Inkath cultivar with irrigated every 5 days provided the highest yield.

***Keywords*:** Cultivars, Irrigation periods, Sorghum

Sorghum bicolor (L.) Moench is a cereal crop belonging the grass family Poaceae and is cultivated since ancient times for various purposes. In Iraq crop is the cultivated area of was 14954 dunums with a productivity of 29793 tons and an average productivity of 1992.3 kg dunums^{-1} during 2018 while the area cultivated in the world on 41.18 million hectares and total productivity were 59.48 million tons with an average production of 1.44 tons ha^{-1} (Mladenova et al 2019). In order to optimize the use of this crop, there are some good management technologies that can be used for higher productive varieties and resistant to climatic conditions. Among these operations is the irrigation process. The irrigation is the main determining factor for agricultural production especially in the summer growing season and in arid and semi-arid regions due to the prevailing climatic conditions in it, especially in the southern region of Iraq. In addition to the high rate of water loss due to evaporation and transpiration and relatively high temperatures led due to the aggravation of the shortage of water available to the agricultural sector. Therefore it has become important to reduce irrigation water consumption and increase the efficiency of using available water sources and reducing the losses of water using in irrigation in order to increase agricultural production per unit area. There are many ways to reduce the effects of water stress by relying on good varieties with high drought tolerance. Shakeri et al (2017) observed complete irrigation (100% of the water requirement of the crop) gave the highest average number of grains and grain yield. Wuhaib et al (2017) indicated that the varieties varied significantly in the growth characteristics. Jameel and Aldoghachi (2019) also reported similar trend. The aim of this research was to assess the effect of irrigation periods on some growth characteristics and grain yield components of four varieties of Sorghum.

MATERIAL AND METHODS

This experiment was carried out in Adla region of Iraq during the autumn 2019. The experiment included two factors using a split plot in randomize complete block design with three replicates, where the first factor were four varieties (Cavier V1, Giza V2 , Rabeh V3 and Inkath V4) in the main plots and the second factor was irrigation periods (5,10 and 15 days as T1, T2, and T3) in subplot. The land plowed two perpendicular plows with the Moldboard plow, with plot size of 3 x 4 m ^{2} and each experimental unit contained 4 lines with a length of 4 m and the distance between one line and another 70 cm and the distance between plants 15 cm, leaving a space of 1 meter between the experimental units and gap of 2 meters between the sectors. The phosphate fertilizer was applied before sowing time at 100 kg P2O5 ha^{-1} in the form of triple superphosphate (6 % P2O5). Nitrogen fertilizer also was applied in two equal batches, at 200 kg N ha^{-1} in the form of urea fertilizer (46% N). The first applied was after seven days of emergence and the second added was after 52 of emergence time. The sowing was done in July 27, 2019. Each line included 24 plants, bringing the plant density to 80,000 plants ha^{-1}. The irrigation was given immediately after the completion of the planting according to the irrigation

periods. Chemical and physical analyzes of the field soil were conducted according to Page et al (1982) Table 1.

Plants height (cm) stem diameter in (mm) and leaf area in (cm) was recorded from 10 plants. The leaf area was recorded according to Liang et al (1973). After that when signs of maturity were clear observed on the plants (complete yellowing of leaves and heads). Then ten plants were randomly selected from each plot and r number of grains per head (1), weight of 1000 grains (g) and grain yield (ton ha^{-1}) was recorded. The data were collected and analyzed statistically using the Genstat statistical program.

Table 1. Some chemical and physical characteristics of the soil of the experiment before planting

Soil characteristic		Units	Value
E.Ce		DC Siemens M^{-1}	1.48
PH		-	7.82
The organic matter		gm kg^{-1} soil	9.80
Available elements	N	mg kg^{-1} soil	28.50
	P		16.25
	K		21.00
Dissolved positive ions	Ca^{+2}	M mol kg^{-1} soil	1.78
	Mg^{+2}		0.24
	Na^{+2}		8.95
	K^{+}		0.17
Dissolved nagative ions	SO_4^{-}		2.50
	HCO_3^{-}		0.80
	Cl^{-}		8.62
Soil texture	Sand	G kg^{-1} soil	62.00
	Silt		678.00
	Clay		257.00
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RESULTS AND DISCUSSION

Plant height (cm): The irrigation intervals significantly increased in the height of the plant, and was maximum in T1 (198.57 cm) as compared to T2 and T3. Khaton et al (2016) also observed that plant height decreases with less irrigation water due to the influence on cell division and elongation. The plant height differed significantly in different cultivars, Giza cultivar gave the maximum height of 243.84 cm as compared to the Rabeh cultivar (143.53 cm). The differences among cultivars in plant height could be attributed to the genetic differences between the cultivars and their responses to environment. This result agree with Jameel and Aldoghachi (2019).

Stem diameter (mm): The irrigation intervals significantly increased in the stem diameter characteristic, where the T1 irrigation period gave the maximum diameter of 18.75 mm compared to the T2 and T3 irrigation periods (17.57 and 16.22 mm) respectively (Table 3). The plant exposed to water stress during the vegetative growth period causes a

Table 2. Effect of irrigations and varieties the plant height (cm)

Variety	Interval			Average
	T1 (5 days)	T2 (10 days)	T3 (15 days)	
Cavier V1	196.68	170.54	156.99	174.74
Giza V2	268.42	241.37	221.74	243.84
Rabeh V3	158.58	140.26	131.74	143.53
Inkath V4	170.60	153.37	135.96	153.31
Average	198.57	176.39	161.61	
L.S.D (p=0.05)	Varieties	Periods	Interaction	
	2.70	1.66	N.S	

Table 3. Effect of irrigation and varieties on the stem diameter (mm)

Variety	Irrigation period			Average
	T1 (5 days)	T2 (10 days)	T3 (15 days)	
Cavier V1	13.34	11.76	11.35	12.15
Giza V2	19.65	17.37	16.28	17.77
RabehV3	20.09	19.96	17.31	19.12
InkathV4	21.93	21.19	19.94	21.02
Average	18.75	17.57	16.22	
L.S.D (p=0.05)	Varieties	Periods	Interaction	
	0.18	0.12	0.50	

decrease in stem diameter (Hud et al 2016). The varieties significantly affected the stem diameter, being maximum in V4 (21.02 mm) compared to the V1 (12.15 mm). This difference between the varieties in that trait is due to the difference in the genetic nature and its interference with climatic and soil conditions (Idris and Mohammed 2012). There was significant overlap between irrigation and cultivation periods, T1 and V4 combination was superior with the maximum stem diameter of 21.93 mm, while was minimum in the T3 and V1 combination (11.35 mm).

Leaf area (cm^2): The irrigation intervals significantly affected the leaf area, where the irrigation period of 5 days gave the maximum leaf area9 5330.69 cm^2) as compared to the irrigation interval of 10 and 15 days (4844.57 and 4244.93 cm^2, respectively) (Table 4). The low leaf area due to moisture may be due to reduced growth processes, division and expansion of cells (Abraha et al 2017). The leaf area in cultivars differed significantly. The leaf area in V2 was maximum (5980.09 cm^2) as compared to the V1 cultivar (2919.66 cm^2). Qadir (2016) observed that difference between the varieties in that trait is due to the difference in the genetic nature and also the differences of growth and flowering stage between the cultivars. The interaction was significant between irrigation periods and cultivars, where the combination of T1 and V2 resulted in maximum leaf area (6977.10 cm^2) as compared to the combination of T3 and V1 (2510.00 cm^2).

Number of grains per head: The irrigation intervals significantly increased in the number of grains in the head, where the irrigation period 5 day recorded maximum grains per head (2354.51 grains) compared to the irrigation periods of T2 and T3 (2138.92 and 1954.33 grains per head, respectively) (Table 5). The decrease in the number of grains in the head may be attributed to the effect of the water stress on the vegetative growth and consequently leads to the reduction of the biological yield which leads to a decrease in the number of grains in the head (Jabereldar et al 2017). The varieties significantly differed in the number of grains in the head, where the V4 variety gave the maximum of 2569.23 grains per. head compared to the V1 (1526.93 grains per head) and may due genetic difference in cultivar abilities to form a number of grains, under water stress conditions (Shakeri et al 2017). The interaction between irrigation periods and varieties, indicated that T1 and V4 gave the highest average number of grains per head of 2891.27 grains compared to the T3 and V1 which gave the lowest of 1297.87 grains per head^{-}

Weight of 1000 Grains (g): The irrigation periods significantly increased in the weight of 1000 grains, where the 5-day irrigation period gave the maximum 100 gains (36.72 g) as compared to the 10 and 15 days irrigation periods (34.41 and 29.31 g respectively. This indicates that water stress that affected the size of the grain, especially in the milky stage, so grains weight decreased (Jabereldar et al 2017). The varieties differed significantly in the weight of 1000 grains, where the V1 gave the highest 1000 grain weight of 38.66 g compared to V4 (28.79 g). The interaction was significant between irrigation and cultivar periods, whereby the T1 and V1 combination was superior (42.93 g) as compared to the T3 and V4 combination (23.32 g).

Grain yield (tons ha^{-1}): The irrigation intervals significantly

Table 4. Effect of irrigation and varieties on foliar area (cm^2)

Variety	Irrigation period			Average
	T1 (5 days)	T2 (10 days)	T3 (15 days)	
CavierV1	3182.27	3066.72	2510.00	2919.66
Giza V2	6977.10	5799.79	5163.39	5980.09
RabehV3	5303.21	4906.60	4623.04	4944.28
InkathV4	5860.17	5605.16	4683.31	5382.88
Average	5330.69	4844.57	4244.93	
L.S.D (p=0.05)	Varieties	Periods	Interaction	
	30.98	15.84	63.36	

Table 5. Effect of irrigation and varieties on number of grains per head

Variety	Irrigation period			Average
	T1 (5 days)	T2 (10 days)	T3 (15 days)	
Cavier V1	1767.57	1515.37	1297.87	1526.93
Giza V2	2396.43	2377.43	2171.53	2315.13
Rabeh V3	2362.77	2207.47	1986.87	2185.70
Inkath V4	2891.27	2455.40	2361.03	2569.23
Average	2354.51	2138.92	1954.33	
L.S.D (p=0.05)	Varieties	Periods	Interaction	
	21.88	11.32	45.26	

Table 6. Effect of Irrigation and varieties on the weight of 1000 grains (g)

Variety	Irrigation period			Average
	T1 (5 days)	T2 (10 days)	T3 (15 days)	
Cavier V1	42.93	38.42	34.64	38.66
Giza V2	36.83	33.13	26.98	32.32
Rabeh V3	35.84	34.30	32.32	34.15
Inkath V4	31.27	31.79	23.32	28.79
Average	36.72	34.41	29.31	
L.S.D (p=0.05)	Varieties	Periods	Interaction	
	0.74	0.28	1.14	

Table 7. Effect of irrigation and varieties grain yield (ton ha^{-1})

Variety	Irrigation period			Average
	T1 (5 days)	T2 (10 days)	T3 (15 days)	
Cavier V1	4.22	3.56	2.94	3.57
Giza V2	7.87	7.40	5.88	7.05
RabehV3	8.56	6.12	4.64	6.44
InkathV4	9.83	8.28	6.08	8.06
Average	7.62	6.34	4.89	
L.S.D (p=0.05)	Varieties	Periods	Interaction	
	0.08	0.05	0.21	

affected the grain yield, irrigation period T1 gave the highest yield (7.62 tons ha^{-1}) as compared to 10 and 15 days irrigation interval. (6.34 and 4.89 tons ha^{-1}, respectively) (Table 7). Similar trend was observed by Shakeri et al (2017). The cultivars also showed significant effect on yield whereby the V4 gave maximum yield of 8.06 tons ha^{-1} as compared to V1, which gave the lowest yield of 3.57 tons ha^{-1}. The irrigation and cultivation periods, T1 and V4 n was superior with maximum yield (9.83 tons ha^{-1}) as compared to the T3 and V1 (2.94 tons ha^{-1}).

CONCLUSIONS

The irrigation period of every 5 days exceeded in all traits, which gave the highest grain yield. Inkath cultivar was significantly better in growth and yield parameters. This suggest the farmers in south of Iraq to cultivate Inkath with irrigation period every 5 or 10 days, because of Inkath show tolerance of prevailing environmental conditions.

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