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Scheduling Irrigation as a Water Saving Practice for Corn (*Zea mays* L.) production in Iraq

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Abstract: A field experiment was conducted by using a factorial randomized complete block design (RCBD) in three replicates with four irrigation intervals (7, 8, 10 and12 days), which equivalent to 14, 12, 10, and 8 irrigations for two seasons of 2012 and 2013. Irrigation water was applied to the spring var. 5018. The results showed that different irrigation intervals applied had statistically significant effect on number of days to male and female flowering, plant height, leaf area, root dry weight, biological weight and yield. The results in both full irrigations (7and 8 days) which was equivalent to 14, 12 irrigation respectively indicated that no significant difference ($P<0.05$) between these two treatments, although the maximum yield was obtained from full irrigation 7 days, but these treatments have significant difference ($P<0.05$) with deficit irrigation treatments (10and 12 days) which equivalent to 10and 8 irrigation in above plant traits and yield. The treatment of 8 days irrigation interval gave highest productivity of irrigation water 0.631 and 0.693 kg/m3 than other irrigation intervals of 7,10 and 12 days which were 0.604, 0.622, 0.552 and 0.587, 0.415 , 0.575 kg/m3in the two seasons respectively. The irrigation interval of 8 days saved about 14% of irrigation water per hectare comparing with other intervals. It can be concluded that the deficit irrigation can improve and increase the water productivity of corn associated with increased yield within an acceptable level under Iraq's semi-arid conditions.

Keywords: Deficit Irrigation, Corn, Grain Yield, Water Productivity, Semi-Arid Conditions

1. Introduction

Deficit irrigation has been considered as sustainable production strategy in dry regions. By limiting water applications, this practice aims to maximize water productivity and yield. Vast research results confirm that deficit irrigation is successful increasing water productivity for corn without causing severe yield reductions. Corn is one of the most an important cereal crops in Iraq, and is cultivated in vast areas, as consequence of high potential for production it comes after wheat and rice in the terms of area and production. Corn grown principally during the summer season in Iraq.

Iraqi Statistical data shows that 110,000 ha was planted with corn and the production reached 2500000 tones with an average yield about 2272 kg $.ha^{-1}$

There are many factors affecting agricultural production in Iraq including land quality, change of agricultural land identity to different purposes, and water deficit (2). In the recent four decades Iraq faced a shortage in water supply because of the irrigation constructions which were built by the riparian states on Tigris and Euphrates rivers after upstream.

One of the most effective methods to improve the use of irrigation water is to control the water quantity applied in each time of irrigation and determine the irrigation intervals according to the plant growth stages to reach higher productivity and to increase water use efficiency by reducing the volume of consumed water(3).

Deficit irrigation is defined as the application of irrigation water below full crop-water requirements (evapotranspiration, ET), and it is an important tool to achieve the goal of reducing the volume of consumed water , in the line with maintaining the highest yield (4, 5), therefore, water demand for irrigation can be reduced and the water conserved can be divert to alternative uses. changes at the technical, socio-economical, and institutional levels (7). Water deficit is a critical issue limiting corn growth by having impact on anatomical, morphological, physiological and biochemical processes (8, 9, 10, and 11).

In this context, many studies were published on deficit irrigation for corn. Water stress reduced kernel number and weight, dry matter, and yield (12, 13, 14). In the same time an experiments were conducted to investigate on the effect of deficit irrigation role on biochemical processes such as sugar and protein content by many researchers, and they concluded that corn grain protein is decreasing as water stress increased (15, 16, and 17). As a result of an increase in water stress the protein content will increase as well (16).

Many researchers have evaluated the effect of water stress on corn yield in Iraq , their results indicated that the yield had not been reduced when corn was subjected to water stress for limited periods , and therefore can save irrigation water that can be exploited for the purposes of agricultural expansion in other place (18, 19, 20).

To gain higher productivity per unit of irrigation water used was expressed in the term of water productivity (WP), which is defined as yield per unit quantity of applied irrigation water.. They found that water productivity are 0.88, 0.78, 1.35 $kg.m^3$ respectively. Therefore, the present study was conducted to reveal the effect of deficit irrigation concept to improve and increase the water productivity and maintaining on corn yield within acceptable level.

2. Materials and Methods

A field experiment was carried out in two seasons of 2012and2013, at Abu-Ghraib (Akarkoof district), 20 km west of Baghdad. The study area is located near Baghdad and lies between latitudes 33^0 06‘and 33^0 50‘N and longitudes 43^0 50’ and 44^0 25’ E, with texture of silt clay loam. Some characteristics of the soil under investigation as average of two seasons are presented in table (1). The chemical properties of irrigation water are presented in Table 2.

Table 1. *Some physical and chemical properties of soil.*

Depth (m)	Ece $dS.m^{-1}$	pH	Soluble cations and anions $meq.l^{-1}$								P.S.D.* $g.kg^{-1}$		
			Na	Ca	Mg	K	Cl	SO4	HCO^3	CO_3	Sand	Silt	Clay
0-0.3	4.18	7.5	9.89	32.0	12.0	0.53	14.5	27.4	2.4	0	188 Silt clay loam	448	364

* Particle size distribution

Table 2. *Chemical properties of irrigation water used .*

Location	Ece $dS.m^{-1}$	pH	Cations and anions $meq.l^{-1}$							
			Na	Ca	Mg	K	Cl	SO_4	HCO_3	CO_3
Abu-Ghraib Canal	0.94	7.15	30.7	3.1	28.0	0.16	3.1	5.2	1.3	0.2

The experiment was conducted in a factorial randomized complete block design (RCBD) in 3 replicates on the furrows, with 0.75m spacing, 5 m length and 4m width for each treatment. Seeds were sowing at 0.20 x 0.75m spacing on 18, 15 March for year of 2012, 2013 respectively. Treatments were consisted of four irrigation intervals which were 7, 8, 10 and 12 days and these equivalent to 14, 12, 10 and 8 irrigation respectively. Irrigation water was delivered to the treatments by plastic pipes with gage meter to determine the quantity of irrigation water applied. All treatments received the same quantity of irrigation water in each irrigation. Fertilizers were used based on the soil test analysis. Corn plots were fertilized with rate of 400 kg ha^{-1} of compound NP fertilizer (27: 27) in the stage of soil preparation and 400 kg ha^{-1} Urea (46%N)on two doses, first when 6 leaves appears and second after 30 days of the first one . Atrazine (80%) herbicide was sprayed on each plot at the manufacturer’s recommended rate of 3.6 $kg.ha^{-1}$ for weed control. Experimental treatments were harvested at the same time, i.e. on 9, 7 July for year of 2012, 2013 respectively. Ten plants were selected randomly from rows of each treatment for measuring of plant height, leaf per plant, leaf area and yield. To measure the dry biological yield, dry root weight which takes off by special tools (25); the samples were placed in oven with 70C for 48 hours (24). Number of days to 50% flowering stage of male inflorescences, and number of days to 50% silk emergence were calculated. Water productivity was calculated based on the grain yield for each treatment and the volume of consumed irrigation water. Data were analyzed using advanced statistical program according to (26).

3. Results and Discussion

It was found that the traits determined were higher in full irrigation treatments

(7and 8 days irrigation intervals) as compared to the deficit irrigation treatments (10and 12 days). The sequence of flowering for male and female as 66.3 and 67.1 , 65.1 and 65.7, 69.5 and 69.9 , 69.2 and 68.2 days for season of 2012 and 2013 respectively . While there were significant differences in the rest of the irrigation intervals (10and 12) days. The periods to male and female flowering took the follow sequence 61.7 and 62.5, 58.6 and 59.3, 64.0 and 65.1, 61.3 and 62.8 days for two seasons of 2012 and 2013 respectively. The reason for this difference is due to flowering period is very sensitive to water stress. This stress lead to low carbon synthesis outputs which is responsible for the growth and formation of cob, because a part of outputs address to male inflorescence which will push to early flowering. Similar findings were reported by (27, 28, 29) who mentioned that the flowering stage affecting by water stress , and the decrease in soil–water content in flowering stage caused delay in silk emergence and their growth disorders, so anthesis–silking interval increased in water deficit treatments greatly. Delay in silk emergence resulted in non-simultaneous pollination and silking.

Deficit irrigation treatments with irrigation intervals of 10 and 12 days for seasons of 2012, 2013 showed significant differences (P<0.05) for plant height when compare with those of full irrigation treatments (no water stress) with irrigation intervals of 7, 8 days. In the same time, there was no significant difference between treatments for irrigation intervals of 7, 8 days (Table 3). Taller plants were found at 7, 8 days irrigation treatments whereas short plants were seen at 10 and 12 days treatments for seasons of 2012, 2013. Researchers were mentioned that deficit irrigation shortened plant height (12, 30, 31, and 32).

Leaf area data were given in table 3,showed the effect of deficit irrigation (10, 12 days) reflected on reduced of leaf area's trait of corn when compared with full irrigation (7, 8 days) and this difference is significant(P<0.05) for two seasons. These results may be due to increase of leaves water stress which lead to reduce the photosynthesis process as a result of the reduction of stomata opining, also working on the reduction chlorophyll content which reduces carbohydrates formation, results which present by Cavero etal. indicate, that water stress reduces the expansion and elongation corn leaves which reduces the Leaf area exposed to sunlight, thus reduce reduces carbohydrates formation, and photosynthesis process. The same results were found by Traore etal. Meanwhile Yang R. was found that the phase II (II, from heading phase to milk) was the most sensitive phase to water deficit, with reductions in leaf area index (LAI).

In the present study, the results indicated that the non-significant differences between full irrigation treatments(7and 8 days) of dry biological yield for two seasons with the highest biological yield were achieved in comparison with deficit irrigation treatments of 10 and 12 days (Table 3), the difference between full irrigation and deficit irrigation treatments is significant (P<0.05). The dry biological yield affected by water stress through the affected components (leaves, stems and roots), which causes reduced in leaf area and accordingly reducing in dry matter accumulation in the stems and roots and cobs. These results agree with Igbadun etal.they reported that deficit irrigation at any crop growth stage of the maize crop led to decrease in grain yields and dry matter yields.

Table 3. *The Effect of use deficit irrigation for corn as an averages of some field traits for season of 2012-2013.*

Irrigation interval (days)	**No. of irrigation**	**50%Male flowering**		**50%Female flowering**		**Plant height (cm/plant)**		**Leaf area (m^2)**		**Dry root weightg/plant**		**Dry biological weightg/plant**	
		2012	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
7	14	66.3	67.1	69.5	69.9	170.6	177.6	0.5885	0.6242	49.8	53.6	373.5	396.4
8	12	65.1	65.7	69.2	68.2	168.0	173.5	0.5827	0.6195	47.6	51.8	369.3	389.1
10	10	61.7	62.5	64.0	65.1	162.4	165.9	0.5011	0.5787	42.3	46.3	298.4	301.7
12	8	58.6	59.3	61.3	62.8	153.1	158.2	0.4510	0.5005	39.6	41.0	281.2	287.5
$L.S.D_{0.05}$		2.00	1.88	1.05	2.00	4.71	5.22	0.0062	0.0055	2.51	2.47	5.11	12.61

Root growth is often less inhibited than shoot growth despite its importance. This trait was reflected in data of dry roots weight with full irrigation (7, 8 days) and deficit irrigation (10 and 12 days) which shows in table 3. There are no significant difference (P<0.05) for dry roots weight between the treatments of full irrigation with highest value when compare with that in deficit irrigation for two season, this results is agree with the results obtained by Mbagwu J.S.C. From these data it can be concluded that soil moisture availability to plant roots is very important for crop growth. When soil moisture is not available in the root zone, plants wilt and yield is reduced. This conclusion is reflected on the grain yield (table 4). The results of analysis of variance showed that the effect of irrigation on grain yield was significant in (P<0.05). The highest grain yield about 5072 and 5225, 4541 and 4992 kg/ha was obtained in full irrigation treatments (7and 8 days) of two seasons respectively. In the deficit irrigation treatments (10and 12 days) reduced grain yield by compared to the full irrigation condition which are 3312 and 3521, 1193 and 2761 kg/ha for two seasons respectively. The reason for this due to prolong irrigation intervals which puts the plant under water stress, and accordingly causes low growth rates and reducing of leaf area and increasing the possibility of stomata resistance for CO_2 gas exchange and it seclusion, therefore Low carbon synthesis process and lower metabolism take place, this process leads to reducing the grain yield. These results agreed with (36, 37).

It is very important a shift from maximizing productivity per unit of land area to maximizing productivity per unit of water consumed. This approach was used in calculating the Water productivity (WP) in this paper. The results in table (4) listed the quantity of irrigation water applied.

Table 4. *The Effect of deficit irrigation as an averages of corn yield and water productivity for season of 2012-2013.*

Irrigation interval (Days)	**No. of irrigation**	**Yield (kg/ha)**		**Quantity of water applied (m^3/h)**		**Water productivity kg/m^3**	
		2012	**2013**	**2012**	**2013**	**2012**	**2013**
7	14	5072	5224.8	8400	8400	0.604	0.622
8	12	4541.2	4989.6	7200	7200	0.631	0.693
10	10	3312	3522	6000	6000	0.552	0.587
12	8	1993.2	2760	4800	4800	0.415	0.575
L.S.D $_{0.05}$		550	251.7			0.017	0.010

Same quantity of irrigation water has been applied to each treatment of irrigation intervals for two seasons of 2012 and 2013 as shows in table 4 which are 8400, 7200, 6000, and 4800 m3/h for 7,8,10 and 12 days irrigation intervals respectively.

The results showed that there are significant differences in water productivity between treatments, the 8 days irrigation interval gave highest irrigation water productivity compared with 7, 10 days for two seasons. That is mean use of 8 days irrigation intervals led to saving 1200 m^3 (14%) of irrigation water when compared with irrigation intervals which used by farmers as traditional practices, which can be use in another place for the cultivation of new land. The results confirm that deficit irrigation is successful in increasing water productivity for corn crops without causing severe yield reductions.

4. Conclusions

It can be conclude that deficit irrigation practice was successful in saving water by (14%) without sharp reduction in grain yield of corn in regions where water is a limiting factor for crop production.

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References

[1] Food and Agriculture Organization , FAO stat, 2013.

[2] A. Al-Falihi, A. Al-Aini, E.andA. Taha, "Developing Land Suitability Maps for Some Crops in Abu-Ghraib Using Remote Sensing and GIS". Journal of Remote Sensing and GIS., Vol. 2. Issue 1, 2014

[3] T. Oweis, T. Zhang and H. Pala," Water use efficiency of rainfed and irrigation bread wheat in Mediterranean environments". Agron.J, 92: 231-238, 2000.

[4] L. Pereira, T. Oweis and A. Zairi, "Irrigation management under water scarcity". Agr. Water Manage, 57: 175–206,2002.

[5] E. Fereres and M. Soriano," Deficit irrigation for reducing agricultural water use. Special issue on ‘Integrated approaches to sustain and improve plant production under drought stress".J. Exp. Bot, 58: 147–159, 2007

[6] M.English, "Deficit irrigation. I. Analytical framework". Journal of Irrigation and Drainage Engineering, 116: 399–412, 1990.

[7] F. Elias and M. Soriano, "Deficit irrigation for reducing agricultural water use". Journal of Experimental Botany, Vol. 58, No. 2: 147– 159, 2007

[8] T. Setter , B. Flannigan and J. Melkonian. "Loss of kernel set due to water deficit and shade in maize". Crop Sc, 41: 1530–1540, 2001.

[9] M. Westgate." Physiology of flowering in maize: Identifying avenues to improve kernel set during drought", 1997.

[10] C. Zinselmeier, M. Westgate, J. Schussler and R. Jones." Low water potential disrupts carbohydrate metabolism in maize (Zea mays L.) ovaries". Plant physiol, 107: 385-391, 1995.

[11] H. Igbadun, B. Salim, R. Tarimo and H.Mahoo." Effects of deficit irrigation scheduling on yields and soil water balance of irrigated maize".Irri. Sci, 27: 11–23, 2008.

[12] K. Pandey W. Maranville A. Admou." Deficit irrigation and nitrogen effects on maize in a Sahelion environment I. Grain yield and yield components". Agric. Water Manage, 46: 1–13, 2000.

[13] .B. Viswanatha, B. Ramachandrappa and H. Nanjappa." Soil-plant water status and yield of sweet corn as influenced by drip irrigation and planting methods". Agric. Water Manage, 55: 85–91, 2002.

[14] F. Karam , J. Breidy, C. Stephan and J. Rouphael ."Evapotranspiration, yield and water use efficiency of drip irrigated corn in the Bekaa Valley of Lebanon". Agric.Water Manage, 63 (2): 125–137, 2003.

[15] M. Tarighaleslami, R. Zarghami, M. Mashhadi and M. Oveysi." Effects of drought stress and different nitrogen levels on morphological traits of proline in leaf and Protein of corn seed (Zea mays L.)". Am-Euras. J. Agric. & Environ. Sci, 12 (1): 49–56, 2012.

[16] A. Koksal, E. Sekip, B. Dursun, B. Ruhi and T. Ramazan."The influence of regular deficit irrigation applications on water use, yield, and quality components of two corn (Zea mays L.) genotypes". Agricultural Water Management, 128 : 65– 71, 2013.

[17] H. Shivakumar, B. Ramachandrappa and N. Mudalagiriyappa." Effect of phenophase based irrigation schedules on growth, yield and quality of baby corn (Zea mays L.)". Agric. Sci, 2 (3): 267–272, 2011.

[18] C. Kirda, R. Kanber, K. Tulucu and H. Gungor."Yield response of cotton, maize, soybean, sugarbeet, sunflower and wheat to deficit irrigation". In: Nuclear Techniques to Assess Irrigation Schedules for Field Crops. IAEA, TECDOC 888, 243-260, Vienna,1996.

[19] A. Fahid, R. Shehib, A. Ali and A. Mohammed. "Irrigation managemen of Maize (Zea mays L.) to increase of water use efficiency in middle of Iraq". Arab Organization for Agricultural Development, 2002.

[20] A. Salih, and A . Falih ".Management of corn irrigation to increase water efficiency in middle of Iraq". Diyala Journal for Agricultural Sciences, 4(1): 62-75, 2012

[21] K. Kawaiz and B. Abdulsatter." Guide for Irrigation of some crops in middle region of Iraq". Report No. 15,Water requirements Research Unit. Institute of Natural Resources Research and Center of Soil Research and Land Reclamation. General Organization for soil and land reclamation, Baghdad Iraq, 1977.

[22] A. Al-Dhferi."The impact of mulching on evaportranspiration and its relationship to soil moisture and maize growth and yield". Ph.D thesis, Baghdad.Iraq, 1998.

[23] A. Fahid, A. Al-Zubadi, K. Hamudi and A. Alrawi." The use of saline water for agricultural purposes. Seminar on water resources, currently and future".Baghdad – Iraq,Ministry of Irrigation, 2002.

[24] A.O.A.C. Association of official Analytical chemists. "Official methods of Analysis". A.O.A.C. 10th (Ed) republished by A.O.A.C Washington D.C., USA, Vol.58 (4): 1015, 1975.

[25] M. Al-Aalwsi." Response of corn Hybrids and strains to deficit nitrogen and irrigation water". PhD thesis, Univ. of Baghdad. Iraq, 2005.

[26] R. Steel and H. Torrie."Principles and procedures of statistics. A biometrical approach". McGraw–Hill, New York: 186–187, 1980.

[27] G. Edmeads, J. Bolanos, M. Hernandez and S. Bello." Causes for silk delay in a lowland tropical maize population". Crop Sci, 33: 1029-1035, 1993.

[28] E. Sadler, J. Bauer W. Busscher and A. Millen."Site specific analysis of a drought corn crop: Part II. Water use and stress". Agron. J, 92: 403–410, 2000.

[29] H. Campos, M.Cooper, J. Habben, G. Edmeades and R. Schussler." Improving drought tolerance in maize: a view from industry".Field Crop.Res, 90: 19–34, 2004.

[30] K. Khera, S. Prihar Sandhu B. Sandhu and K. Mulch." nitrogen and irrigation effects on growth , yield and nutrient uptake of forage corn". Agron. J, 68: 937-940, 1976.

[31] S. Anac, M. Ul and I. Tuzel."Corn yield as affected by deficit irrigation". In: Fyen, J., Mwendera, E., Badji, M. (Eds.). Advances in Planning Design and Management of Irrigation Systems as Related to Sustainable Land Use. Center for Irrigation Engineering (CIE), European Committee for Water Resources Management (ECOWARM), Belgium, 1992.

[32] J. Cavero, I. Farre, P. Debaeke and T. Faci." Simulation of maize yield under water stress with EPIC phase and Cropwat models". Agron. J, 92: 679–690, 2000.

[33] S. Traore, R. Carlson, C. Pilchera and M. Rice." Bt and Non-Bt maize growth and development as affected by temperature and drought stress". Agron. J, 92:1027–1035, 2000.

[34] R. Yang." Estimation of maize evapotranspiration and yield under different deficit irrigation on a sandy farmland in Northwest China". African Journal of Agricultural Research, Vol. 7(33), 4698-4707, 2012.

[35] J. Mbagwu. "Effect of bulk density and irrigation frequency on the root growth and dry matter yields of corn and cowpea for three Nigerian and sub profiles". Beitrage Trop. Land-wirtsch veterinrmed, 23: 277-275, 1985.

[36] A. Fonseca, J. Lizasob, M. Westgate, L. Grass and, D. Dornbos ."Simulating potential kernel production in maize hybrid seed field". Crop Sci, 44: 1696- 1709, 2004.

[37] T. Al-Khish, M. Al-Abed and K.Ismail." The effect of water stress on the growth and yield of some varieties and hybrids of maize in Deir Ezzor".7th Scientific Conference of the State Board for Agricultural Research, Syria, 2009.