Kufa Journal For Agricultural Sciences 2018 96 – 108 : 10 (4)

Role of Humic fertilization on reducing water deficit and its relation to fruit yield of Okra and water productivity

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Abstract

A experimental was conducted during summer season 2016 at *Agricultural College- Baghdad University, Iraq* to determine the actual consumptive use by okra crop (*Abelmoschus esculentus* L.) under deficit irrigation conditions and humic fertilizer, as well as the assessment the productivity of water and yield. Four irrigation treatments were used 1.Full irrigation (traditional - control), irrigation was imposed at 50% depletion of available water (T_0). 2. Deficit irrigation: cutting or omitting irrigation for 15 days in initial vegetative growth stage (T_1). 3. Deficit irrigation: cutting or omitting irrigation for 15 days in middle vegetative growth stage (T_2). 4. Deficit irrigation: cutting or omitting irrigation for 15 days in flowering stage (T_3). Humic acid treatments included application of 4 rates (0, 10, 20 and 40)kg ha^{-1}. The results show the depth water applied was varied with irrigation treatment reached 1115, 1065, 1000 and 994 mm $season^{-1}$ and water productivity recorder 0.60, 0.44, 0.65 and 0.56 kg m^{-3} for (T_0, T_1, T_2 and T_3) respectively. The humic fertilization increased N, P and K content in okra fruit and theses indicated the role of humic acid to increasing vegetative growth (plant height, leafs number and leaf width), and leading to increase the amount of processed food and fruit yield.

Key word: Humic fertilizer. Water deficit. NPK content in fresh fruit. Water productivity. Okra

Receiving date:22/4/2018

Acceptance date: 27/6/2018

Introduction

Climatic conditions for agricultural production have been undergoing changes with global warming (4 and 14), causing changes not only in crop growth and development, yield and quality but also in phonological time (9 and 15).

Irrigation technologies and irrigation scheduling must be adapted more effective and rational uses of limited supplies of water, these technologies must not necessarily be based on full crop water requirement, but ones which will be designed to ensure the optimal use of allocated water such us tillage practices, mulching which can reduce the demand for irrigation water and water deficit is another way can be maximized for higher yields per unit of irrigation water (3), many research has been conducted for development of simple models to predict crop yield from evapotranspiration for irrigation project planning (5 and 6).

The consumptive use of okra ranged 326 - 374 mm, and the weekly Kc values from 0.38 at the initial stage of crop growth to 1.05 at the mid-season stage and dropped to 0.40 at the end of the late season stage (10). Okra (*Abelmoschus esculentus L.*) is a traditional vegetable crop in many countries, and it is a member of the malvaceae family and cultivated widely in middle and south Iraq. The nutritional composition of okra includes: magnesium, iron, oil and carbohydrates, protein, calcium and phosphorus; okra fruit contain approximately 21% protein, 14% lipids and 5% ash (8). The present study aims to investigate the role of humic fertilizers on reducing water deficit, fruit yield of okra and water productivity. There is very little information regarding optimum humic fertilizer doses for okra in Iraq especially when water is scarce. Hence, it is important to estimate the humic fertilizer optimum dose and water requirement. Therefore, the aim of this study were to investigate the effect of level of humic fertilizer and water applied on the fruit yield and water productivity of okra.

Material and Methods

A field experiment *was carried out in the field of Agricultural Collage*- *University Baghdad/* Al - Jadriya *during spring season 2016*. Some soil properties (Table 1) were determined according to methods described in Black(2) and Page *et. al.* (11).

Okra (*Abelmoschus esculentus L.*) (synthetic cv. local, Batra) was transplanted manually at a depth of 3-5 cm on 15/April/ 2016, and harvested every 4 days and accumulative total pod yield at the end of experiment in 30/August/2016. The experiment was a Split Plot Design with Randomized Complete Block Design (R.C.B.D) with three replications. Irrigation treatment represents the main plot and humic acid fertilizer treatment as sub plot. Experimental plots were 6 m^2 (3m × 2m) and plants spaced 0.30 m × 0.80 cm between rows. Plots were separated 2 m from each other. Irrigation treatments included: 1.Full irrigation (traditional - control), irrigation was imposed at 50% depletion of available water (T_0). 2. Deficit irrigation: cutting or omitting irrigation for 15 days in initial vegetative growth stage (T_1). 3. Deficit irrigation: cutting or omitting irrigation for 15 days in middle vegetative growth stage (T_2). 4. Deficit irrigation: cutting or omitting irrigation for 15 days in flowering vegetative growth stage (T_3).Humic acid treatments included application of 4 rates 0, 10, 20 and 40 kg ha^{-1}. The properties of humic acid fertilizers used its: Humidity 7%, Dissolution 99.8%, Humic Acid 90% and Organic Matter 85%). Nitrogen, phosphorus and potassium were applied in the rates of 100 N ha^{-1} , 50 P ha^{-1} and

50 kg K ha^{-1} respectively to all treatments. Fertilizers were placed in bands on the side of each row and covered by soil (side dressed). Weeds and all the required farming management were done as recommended.

All plots were irrigated with river water (ECi =1.4 dS m^{-1}). The soil depth of the effective root zone is increased from 0.20m at planting *till shoot growth* to 0.50 m at vegetative growth and the stage of fruit formation. Irrigation system was surface flow irrigation through line pipe provided with meter gages for measuring water applied. Soil water content was measured gravimetrically. The amount of water depth was calculated according to Allen *et al*. (1).

$$d = D \times P_b \times \frac{(Q_2 - Q_1)}{100}$$

Where:

d = Depth of water added (mm)

D = irrigation root zone depth (mm)

P_b= Bulk density of soil (Mg m^{-3})

Q_2= Percentage of soil moisture at field capacity

Q_1= Percentage of soil moisture before irrigation

At harvest time, a sub sample of 10 plants was taken from each plot to measure plant height, leaf number $plant^{-1}$, leaf width and fresh fruit yield (kg ha^{-1}) and concentration of N, P and K in Okra fruit(11). Least significant differences(L.S.D)were used to differentiate means at the 0.05 level (12). Water productivity was calculated according to the following equation:

$$water\ productivity = \frac{yield\ (kgh^{-1}\ )}{Total\ water\ applied\ (mm)}$$

Table 1: Some chemical and physical soil properties

Properties	Unit	Value
pH	---	7.12
EC(1:1)	dS m^{-1}	2.60
Organic matter	g kg^{-1}	12.30
Available N		46.4
Available P	mg kg^{-1}	68.18
Available K		93.93
Sand		410
Silt	g kg^{-1}	250
Clay		340
Texture		clay loam
Bulk density	Mg m^{-3}	1.33
Water content at FC		0.243
Water content at WP	cm^3 cm^{-3}	0.094
Available water		0.149

Result and Discussion

Results of depth water applied are presented in Fig.1. It is appeared that number of irrigations were 22 and 20 for traditional and deficit irrigation treatment consuming 1115, 1065, 1000 and 994 mm for the four water treatments T_0, T_1, T_2 and

T_3 respectively. The differences in the amount applied are due to the cuttings of some irrigation in the deficit treatment.

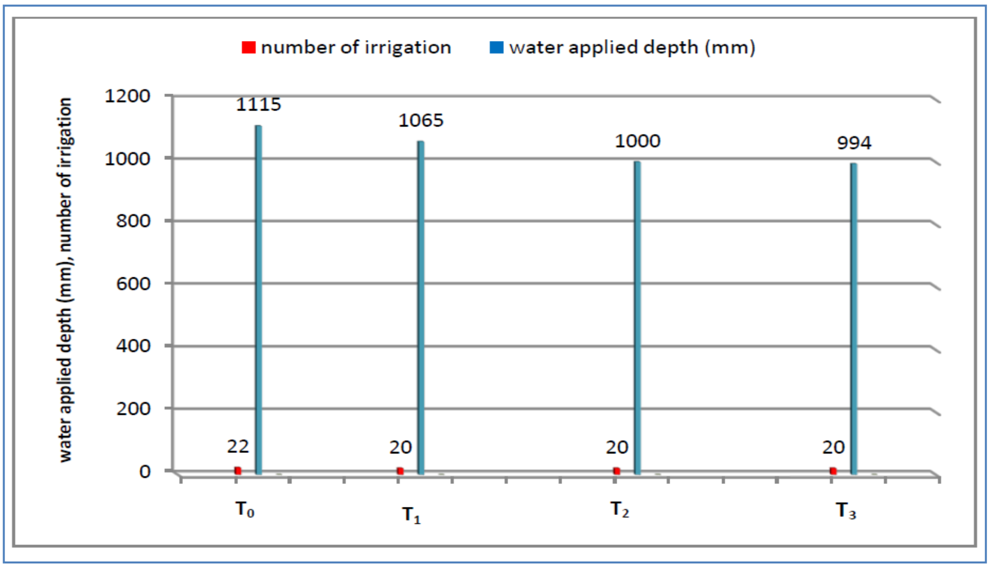

Figure 1: The mean water applied depth and number of irrigation for traditional and deficit irrigation.

Effects of rates of humic acid and water applied on growth and yield of okra were presented in Table 2, 3, 4 and 5. All parameters were significantly higher at traditional irrigation excepted cutting or omitting irrigation for 15 days in middle vegetative growth stage (T_2) compared to T_1 and T_3. This can be due to the quality of water used and the stage growth during the growing season, as well as the water stress is usually the main physical limitation to yield and growth of vegetable (13). Studies of water requirements for okra under surface irrigation of calcareous soil in Iraq are very limited if any. Generally speaking and as a main effect of humic acid on growth and yield of okra, the rate 40 kg humic acid ha^{-1} was the best for all parameters with no significant differences than 20 kg humic acid ha^{-1}. This means the possibility of used 20 kg ha^{-1} and don't need to use more the rate of fertilizers dose, and achieved the good parameters of growth factors and production, as well as reduce the economical parameters of production costs and fertilizers added.

Table 2. Plant height (cm) of okra as affected by the irrigation treatments and humic acid levels

Irri. Treat.	Humic acid levels (kg ha^{-1}) 0	10	20	40	Mean
T_0	145	163	183	185	169
T_1	129	134	144	151	140
T_2	143	165	181	183	168
T_3	134	148	156	161	150
Mean	138	153	166	170	
LSD	Irrigation	Humic acid	Irrigation Treatment × Humic acid levels		
0.05	2.42	3.12	5.67		

These results reflex how much irrigation water can be saved and the same time to produce the available nutrients for plant with least possible. Humic acid increased N, P and K content in fruit Okra (Fig. 2), and theses indicated the role of humic acid to increasing vegetative growth (plant height, leafs number and leaf width), and leading to increase the amount of processed food and fruit yield, also the increase may be to the effect of humic acid in the plant's bio efficiencies, increasing nutrient uptake and thus increasing the rate of plant growth, as well as increasing the number and size of the cells as a result of increased biological and enzymatic activity in the plant's cells (7 and 16**).**

Table 3. Leaf number plant^{-1} as affected by the irrigation treatments and humic acid levels

Irri. Treat.	Humic acid levels (kg ha^{-1})				Mean
	0	10	20	40	
T_0	25	28	32	32	29
T_1	19	21	23	24	22
T_2	23	29	31	32	29
T_3	21	24	26	27	25
Mean	22	26	28	29	
LSD	Irrigation	Humic acid	Irrigation Treatment × Humic acid levels		
0.05	1.56	1.11	3.27		

Figure,3 show high value of water productivity at T_0 and T_2 compared to T_1 and T_3. The reason for the high value of water productivity for T_2 0.65 kg m^{-3} compare to T_0 , T_1 and T_3 recorder 0.60, 0.44 and 0.56 kg m^{-3} respectively to lower amounts of added water (1000 mm) and greater fruit yield (6440 kg ha^{-1}) as well as the availability of rain in season (37.7 mm during April and may months) and low temperatures help the formation the plant dry matter contributed to mainly in fresh fruit formation during the period of interruption rain. While the reason low efficiency, due to avoid exposure okra crop to reducing water in initial vegetative growth stage T_1 and flowering vegetative growth stage T_3 and this means that the plant's not ability to avoid stress in these two stages. Either this result indicted the role of irrigation treatment interaction with humic acid levels lead to increased wetted soil volume inside root zone and this mean increasing in water volume which was stored in root zone.

Table 4. Leaf width (cm) as affected by the irrigation treatments and humic acid levels

Irri. Treat.	Humic acid levels (kg ha^{-1})				Mean
	0	10	20	40	
T_0	22	25	30	31	27
T_1	18	20	23	25	22
T_2	23	27	30	32	28
T_3	20	24	27	28	25
Mean	21	24	28	29	
LSD	Irrigation	Humic acid	Irrigation Treatment × Humic acid levels		
0.05	1.35	1.63	1.97		

Table 4. Total fruit yield (kg ha^{-1}) as affected by the irrigation treatments and humic acid levels

Irri. Treat.	Humic acid levels (kg ha^{-1}) 0	10	20	40	Mean
T_0	5342	6120	7348	7468	6570
T_1	4121	4659	4876	4976	4658
T_2	5218	6131	7178	7231	6440
T_3	4855	5379	5874	6017	5531
Mean	4884	5572	6319	6423	
LSD	Irrigation	Humic acid	Irrigation Treatment × Humic acid levels		
0.05	138.54	142.1	213.12		

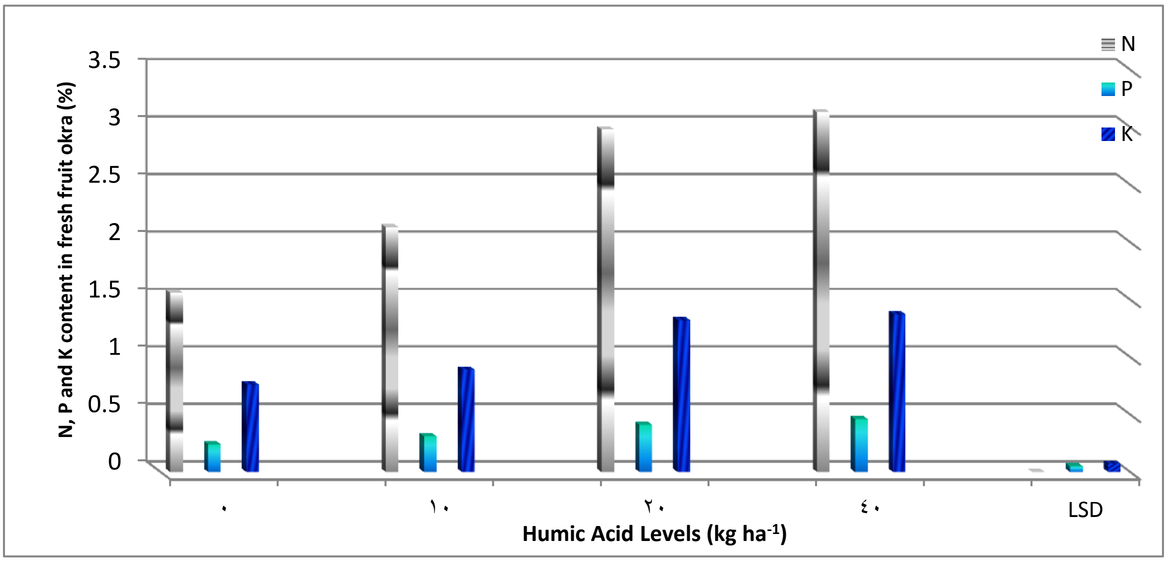

Fig. 2 The effects addition of humic acid levels in N, P and K content in fresh fruit Okra.

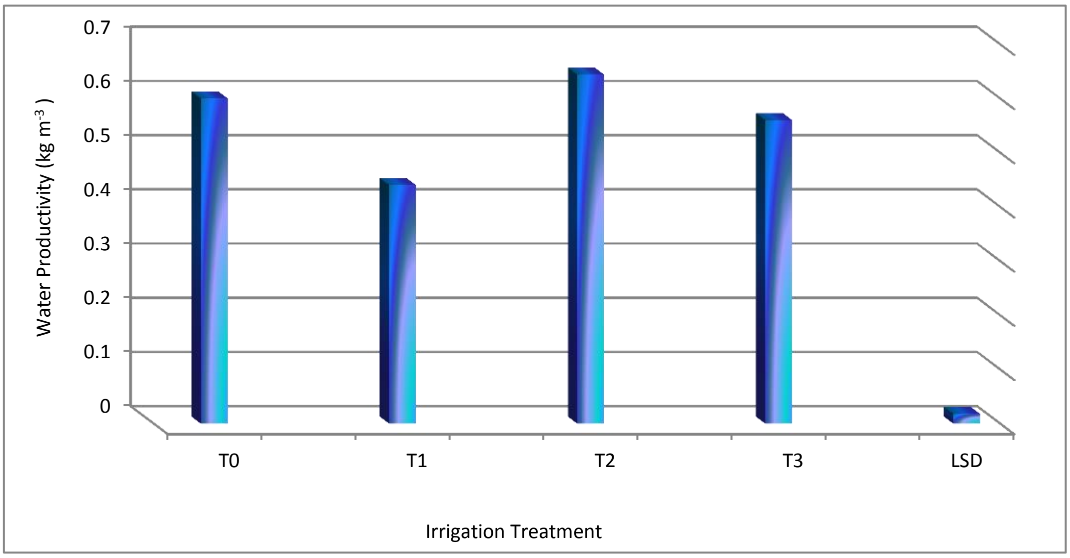

Figure 3: The effects of irrigation treatments in water productivity.

Recommended

It can be recommended to the inability crop okra to the interruption of irrigation in the middle stage of vegetative growth. Also humic acid fertilizer application doses have been reported to cause significant effect on plant height, leaf width and number, fresh fruit yield of okra in middle region of Iraq.

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