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Effect of Irrigation Interval Periods and Organic Fertilizer Levels on Production and Water Use Efficiency of Potato (*Solanum tuberosm L.*).

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ABSTRACT

Field experiment was carried out at irrigation technology station, soil and water resources center, Agricultural Researches Directorate in Twaitha 40 km south Baghdad. In order to study the effect of irrigation interval periods and the organic fertilizer application rates on production and water use efficiency of potato crop during the Fall season of 2015 . The study included two factors ,irrigation interval periods T1 (irrigation after 2days) , T2(irrigation after 4 days), and T3(irrigation after 6days), and organic fertilizer application rates L0 (without fertilizer) ,L1(20 ton ha-1).and L2(40 ton ha-1). Experiment was carried out in spilt plot design RCBD based on in three replicates. Result of the study indicated predomination the treatment of 4 days and 40 ton ha-1 with highest water use efficiency (8.65 kg m-3) and tuber yield (38.20 ton ha-1) and the accumulation of N,P and K in tubers 2.80, 0.34 and 2.80% respectively.

Keywords: Irrigation interval periods, potato, organic fertilizer

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INTRODUCTION

Water resources scarcity is one of the limiting factor for crop production in arid and semi arid regions. In this case crop production and water use efficiency decreases (Chaves et al 2002). Water considered as an important economic source in Iraq because 90% of the used water was related to the agriculture sector. Regarding to the importance of this resource several programs and strategic projects were took place to satisfy the requirement of agricultural sector (Yuan et al.,2003). Determination of crop water requirement of whole growth season at different growth stages is an important for management of irrigation water for any crop because the quantities of extra water above the plant requirement had a negative effect on the plant such as nutrient leaching from the root zone and create a good environments for insects and diseases in addition to the loss of water (Kashyap et al., 2001). Potato is considered one of the fourth important crops in the world after wheat, rice and corn (Fabeiro et al., 2001). Potato is one of the crops which is sensitive to water stress at all different growth stages especially in the stage of tuber formation due to that 80% of potato root zone were in 0-30m (Opena and Porter, 1999). Fouda et al.(2012) mentioned that water stress for potato crop affects carbon synthesis process which effect the production and the quality of the tubers yield.

Application of organic fertilizer to the soil affects some physical, chemical and fertile properties such as increasing soil water holding capacity and decrease the reaction degree of the soil which increases the availability of nutrients under Iraqi soil condition. Abdel Moez et al. (1999) mentioned that the addition of 30 ton ha-1 organic fertilizer increases the average of plant height and the total yield of tubers also increases the concentration of the available nitrogen , phosphorus and potassium in soil which increases it's uptake in the tubers. Mahmood and Salman (2017) found that total yield of potato tubers were 49.94 ton ha-1 and concentration of nitrogen ,phosphor and potassium reached 3.72, 0.41, 4.11% respectively at final maturity stage with addition of 30 ton ha-1 organic fertilizer .Abdel- Latif et al. (2011) found increasing in potato plant height by increasing of irrigation water and organic fertilizer application to the soil. Abou EL-khair et al. (2010) found increasing in nitrogen, phosphorus and potassium concentration in the tubers and total yield of tubers by increasing of irrigation water with application of organic fertilizer to the soil which was related with high water use efficiency. Addition of organic fertilizer to the soil increases the nutrient availability and nitrogen fixation in the rizosphere by biological activity which causes a good vegetative growth and efficiency in carbon assimilation which causing an increasing in the productivity and improve the quality. Mahmood et al. (2017) indicated that the increasing in the water use efficiency field and crop(7.8 and 8.1 kg m-3) respectively for potato crop by the addition of 30 ton ha-1 comparing with the control treatment (6.59kg m-3). AL-jubori .(2015) found a strong relationship between the quantity of irrigation water applied and the levels of added fertilizers , the application of organic matter decreases the quantity of irrigation water applied .The objective of this study is to find the effect of irrigation interval periods and the levels of organic fertilizer application on potato production and water use efficiency.

MATERIALS AND METHODS

Field experiment was carried out at Irrigation Technology Station, in Twaitha 40 km south Baghdad Agricultural Researches Directorate Ministry of Science and Technology in silty clay loam soil as classified to the sub group typical Torifluvent according to the American classification (Soil Survey Staff .2006) during fall season 2015. Some soil characteristics (Table 1) were determined such as: soil particle size distribution by hydrometer method, soil bulk density was determined by core method. Soil reaction (pH) and electrical conductivity(EC) were determined by pH-meter and electrical conductivity-bridge, respectively. Organic matter was determined according to Black (1965), nitrogen, phosphorous and potassium concentration in tubers were determined according to Page et al. (1982). The study was carried out in split plot design based on randomized complete block design (RCBD) in three replication. The main factors included three irrigation interval periodT1 (irrigation every 2 days) , T2(irrigation every 4 days), and T3(irrigation every 6 days),and the sub factor included three rates of organic fertilizer application L0 (without fertilizer), L1 (20 tan ha-1), and L2 (40 tan ha-1) . The experiment plots were 9 m2 area (3x3m) potato crop desirey spices was cultivated in August 2015.

Triple super phosphate(20%) in rate 120 kg ha-1 was added with organic fertilizer before planting as well as urea (46%N) in rate 240 kg ha-1 and potassium sulfate (41.5%) in rate 400 kg ha-1 were added in three stage after planting . Potato tubers were collected at the end of the growing season in 2./1/2016. The amount

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of applied irrigation water (m3 ha-1) was measured correspond to each interval , irrigations were applied according to the irrigation intervals period carried out regarding to depletion of soil available water. Timing and how much of irrigation water application to each treatment was adjusted by using Diviner-2000 as soil moisture sensor during the whole growing seasons. the depth of irrigation water applied to reparation soil available water depleted by plant by using equation 1 and 2. (kovda et al. ,1973) :

$$Aw = \theta F.c - \theta wp \text{ ----------} \quad (1)$$

Where:

Aw = Applied water .
Θf.c = Soil volumetric water content at field capacity(33kpa) .
θwp = Soil volumetric water content at welting point(1500kpa) .

$$d = (\theta F.c - \theta irri.)D \text{ ----------} \quad (2)$$

Where:

d : depth of applied irrigation water (m).
θF.c : Soil volumetric water content at field capacity .
θirri. : soil volumetric water content at irrigation .
D : soil depth (m) .

water use efficiencies for potatoes crop were calculated by using following equations (Demir et al,2006)

$$WUEf=Yield/Water\ applied \text{ ----------(3)}$$

Where:
WUEf =field water use efficiency (kg m-3)

Table 1: Some soil physical and chemical characteristics

Characteristics	Unit	value
Sand	g kg-1	191.76
Silt		422.39
Clay		385.85
Texture		Sility clay loam
Bulk density	Mg m-3	1.30
Volumetric moisture content at 33kpa	cm3 cm-3	0.420
Volumetric moisture content at1500kpa	cm3 cm-3	0.273
Available water	cm3 cm-3	0.147
Hydraulic conductivity	cm hour-1	0.80
Percent of stable aggregates	%	9.30
ECe	dSm-1	4.00
pH		7.0
Organic matter	gm kg-1	3.25
Available nitrogen	mg kg-1	72.50
Available phosphor	mg kg-1	15.30
Available potassium	mg kg-1	102.3

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RESULTS AND DISCUSSION

Effect of irrigation interval periods and organic fertilizer on N,P, and K concentration in potato Tubers

Table 2 shows the effect of organic fertilizer application and irrigation treatments and their interaction on the nitrogen concentration in tubers .Results indicates that there is no significant difference between T1 (2.42%) and T2(2.40%) treatments in this trait. On the other hand T3 significantly lower compared with T1 and T2 .The impact of organic fertilizer level was significant in this trait. L2 treatment gave the highest average concentration of nitrogen reached to 2.26% which increased by 46.75% compared with control treatment L0(1.54%) .Treatment L2 gave the highest concentration reached to 2.26% which increased by 7.62% compared with L1 which gave(2.10). The interaction between TxL revealed that the treatment T1L2was outperformed to give highest concentration of nitrogen in the tuber which reached 2.82% with 190% rate compared to T3L0 treatment which reached 0.97%0. Similar results were reported by EL-Ghamring et al. (2005) Where they found increasing in applied irrigation water quantity may increase soil moisture content which in turn may increase minerals availability such as N,P, and K.

Table 2: Nitrogen concentration (%) in potato tubers as affected by irrigation interval periods and organic fertilizer application

Irrigation treatments	Amount of irrigation water (m 3 ha-1)	Organic fertilizer levels (tan ha-1)			Mean
		L0	L1	L2	
T1	4821	1.83	2.60	2.82	2.42
T2	4416	1.82	2.58	2.80	2.40
T3	3833	0.97	0.99	1.16	1.04
Mean		1.54	2.10	2.26	
		T	L	TxL	L.S.D (0.05)
		0.11	0.11	0.19	

Table 3 shows the effect of organic fertilizer application and irrigation treatments and their interaction on the phosphorus concentration in tubers .Results indicates that there was no significant difference between T1 (0.31%) and T2(0.30%) treatments in this trait . On the other hand T3 significantly lower compared with T1 and T2 .The impact of organic fertilizer level was significant in this trait L2 treatment gave the highest average concentration of phosphorus reached to 0.30% which increased by 7.14% and 36.36% compared with T1(0.28)and T0(0.22%) treatments respectively. The results show also the impact of the interaction between the amount of water irrigation applied and levels of organic fertilizer which added to the soil. Treatment T1L2 was outperformed to given height concentration of phosphorus in the tuber which reached 0.35% with 133.33% rate compared to the T3L0 treatment which reached 0.15%. These results agreed with those reported by Hammad *et* al .(2008) Which found supplying requirement of water to the effective root zoon with organic fertilizer application maintained a high soil metric potential in the rizosphere to reduce plant water stress and increase the exchangeable N,P, and K and the uptake of these elements.

Table 3: Phosphorus concentration (%) in potato tubers as affected by irrigation interval periods and organic fertilizer application

Irrigation treatment	Amount of irrigation water (m3 ha-1)	Organic fertilizer levels (tan ha-1)			Mean
		L0	L1	L2	
T1	4821	0.26	0.33	0.35	0.31
T2	4416	0.24	0.31	0.34	0.30
T3	3833	0.15	0.19	0.22	0.19
Mean		0.22	0.28	0.30	
		T	L	TxL	L.S.D (0.05)
		0.02	0.02	0.04	

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Table 4 shows the effect of organic fertilizer application and irrigation treatments ,and their interaction on the potassium concentration in tubers .Results indicates that there is no significant difference between irrigation treatment T1 (0.250%) and T2 ((% 2.46) in concentration of potassium in tubers . On the other hand T3 significantly lower compared with T1 and T2 treatments. The impact of organic fertilizer level was significant in this trait L.2 treatment gave the highest average concentration of potassium reached to 2.49% which increased by 8.78% and 33.15% compared with LI and L0 treatments which grieved 2.29% and 1.87% respectively. The treatment T1L2 was outperformed to given height concentration of potassium in the tuber which reached 2.84% increased by 88.08% compared with L0 T3 treatment which reached 0.15% .Increasing of water amount in the soil my increase the length and the density of root through the optimal regulation of soil water which increase the water absorption as well as organic fertilizer added encourage microorganisms and increase microbial activity which increase the element such as N,P, and K .These result agreed with Abou EL-Khair et al. (2011) which found added amount of water with organic fertilizer gave highest values of N,P, and K percentage and their uptake in plant .

Table 4: Potassium concentration (%) in potato tubers as affected by irrigation interval periods and organic fertilizer application

Irrigation treatment	Amount of irrigation water (m3 ha-1)	Organic fertilizer levels (tan ha-1)			Mean
		L0	L1	L2	
T1	4821	2.07	2.59	2.84	2.50
T2	4416	2.02	2.56	2.80	2.46
T3	3833	1.51	1.72	1.84	1.69
Mean		1.87	2.29	2.49	
		T	L	TxL	L.S.D (0.05)
		0.06	0.06	0.11	

2 - Effect of the interaction between irrigation interval periods and organic fertilizer levels on the total tubers yield and water use efficiency

A-Total yield of tubers

Table 5 shows there were a significant influence for interaction between the irrigation periods and organic fertilizer levels on total yield of potato tubers. Highest value of total yield was found in T1L2 treatment which reached 38.40 tan ha-1 this increase of yield reaches 64% as compared with T3L0 treatment. The results revealed that there were no significant difference in total yield between T1L2and T2L2 alsoT1L1and T2L1 treatments. There were significant differences between T1L2, T2L2 and T3L2 also between T1L1,T2L1 and T3L1 in total yield of potato crop. Water stress caused a reduction of tuber yields du to reducing of crop biomass on other hand ,higher water quantity applied to plants led to keep higher water content in plant tissues ,and this in turn produced tuber heavier than those under water stress. This finding agrees with many studies which have found that increasing of organic fertilizer application led to increase growth dry matter accumulation and total yield(Wang et al. ,2007 , Abd El-Kader et al., 2002, Hammad et al., 2008).

B-Water use efficiency for potato crop

Table 5 shows this order for water use efficiency for the treatments T2L2 > T1L2 >T3L 0 > with 8.65, 7.97, 6.10 Kg m-3 seson-1 respectively. This means that we can get higher water use efficiency by using lower amount of irrigation water with adding organic fertilizer as in T2L2 treatment without affected significantly on production of tubers compared with T1L2 treatment . Similar result were previously reported by AL-Juboori (2015) which found that organic fertilizer application to the soil improves soil physical properties such as water holding capacity and reduces the loss of nutrients.

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Table 5: Effect of water irrigation amount and organic fertilizer levels on total yield of tubers and water use efficiently

Irrigation treatment	Amount of irrigation water(m3 ha-1)	Organic fertilizer levels (ton ha-1)		Total yield of tubers (ton ha-1)	Water use efficiency (kg m-3)
T1	4821	0	L0	33.00	6.84
		20	L1	35.00	7.26
		40	L2	38.40	7.97
T2	4416	0	L0	32.90	5.41
		20	L1	34.60	7.84
		40	L2	38.20	8.65
T3	3833	0	L0	23.40	6.10
		20	L1	24.42	6.37
		40	L2	29.40	7.67
LSD (0.05)				1.27	

CONCLUSIONS

Irrigation of potato crop by every 4days instead of 2 days can save quantities of irrigation water which can be used to increase the area of cultivated land. As well as application of organic fertilizer to soil can be improve soil physical and chemical characteristics such as N,P, and K availability and uptake by plant and decreases the amount irrigation water application because the organic fertilizer has high water holding capacity which can get high production in terms quantity and quality.

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