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Research Article

Effects of different irrigation and fertilization treatments on growth and yield of potato (*Solanum tuberosum L*.) in Iraq

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The experiment was implemented during the autumn season 2013, to study the effect of three methods of irrigation and fertilization on the development and yield of the potato (*Solanum tuberosum L*.) cv Rivera. Two methods of drip irrigation (putting the pipe at the bottom and at the top of furrows) and furrow irrigation with three types of fertilizers (chemical fertilizer at rate of 300 kg urea, 180 kg superphosphate triple, 240 kg potassium sulphate per hectare) and organic fertilizer at 30 kg.100 $m^{2\ -1}$ with half amount of the chemical fertilizers mentioned. The organic fertilizers were added in two ways: by scattering dry fertilizer and irrigation with fertilizer solution near plant roots. Results showed that the highest total water content of leaves was 86.665%, leaf area 2285 cm^2, roots dry weight 13.60 g., average tuber weight 69.56 g., and the percentage of dry matter in tubers 19.26% was produced from applying organic fertilizer by irrigation, whereas the highest total tubers yield was 16.345 tons.ha^{-1} and water use efficiency 9.855 kg. ha^{-1} resulted from organic fertilizer by scattering method, also the treatment of drip irrigation by putting the pipe at the top of the furrows was superior in all studied parameters except the average tuber weight and total soluble solids compared with the other two treatments.

Key words: Potato, drip irrigation, furrow irrigation, chemical fertilizer, organic fertilizer, tubers.

INTRODUCTION

Potato (*Solanum tuberosum L*.) belongs to Solanaceae family is one of the most important vegetable crops in the world and in terms of human consumption it comes in the fourth grade after wheat, rice, and corn, it is rich in carbohydrates, nutrients and amino acids (Hassan 1999). Many factors affected potato production, including cultivar, weather conditions, planting date, plant nutrition and irrigation. Potato plants are sensitive to the alteration in the soil moisture content and any decline or un uniformity in irrigation (water stress), especially during initiation and growth phases of tubers resulted in a significant damage to plants, and decrease the quantity and quality of tubers yield (Bao-Zhong *et. al.*, 2003, Al-Aubiady, 2005). Numerous studies on the best methods to provide appropriate moisture for plant growth has been conducted, perhaps the drip irrigation is one of the modern methods used to irrigate potatoes.Shae *et al*., (1999) found an increase in the number of branches, leaf area and dry weight of the total vegetative growth of plant when using drip irrigation method as compared with surface irrigation method. Bao-Zhong *et. al.*,(2003) noted that potato plants are sensitive to water stress, and soil moisture is one of the important factors affecting the quantity and quality of tubers yield and they used a different amounts of irrigation water which are 0.25, 0.5, 0.75, 1.0 and 1.25 times of the pan evaporation and they

found that plant height, total water content of the leaves, number of tubers, average tuber weight and total tubers yield increased by increasing the amount of irrigation water, while the specific weight of tubers dropped. Wang *et al*. (2006) used sixes drip irrigation frequencies in potato which irrigate one times every (1, 2, 3, 4, 6 and 8 days) with uniform water amount per treatments and noted that the greater the frequency of irrigation the greater is the length and density of roots and stimulate tuber growth with increased water use efficiency.

Neelam and Raiput (2007) noticed that the under surface drip irrigation is one of the modern methods of irrigation, which ensures taking advantage of the few irrigation water quantities in the soil through drip irrigation tubes that are placed under the soil surface, and five depths were used to place the pipes, namely, (0, 5, 10, 15 and 20 cm) below the soil surface and he studied the movement of water to the top of soil surface by capillary action and found that the treatment of placing the pipes at a depth of 5 cm led to move the water to the top of soil surface and the soil moisture reached to 21.5%, while the other depths, the water movement was low and soil surface remained relatively dry. Al-Janaby (2012) when irrigated potato by drip irrigation with three levels (100%,75% and 50%) of pan evaporation, he found that increasing irrigation level led to a significant increase in plant height, number of aerobic stems of the plant, leaf area, dry weight of plant and the total yield of tubers.

The fertilization, provides necessary nutrient elements for plant growth are important factors to improve plant growth and production of potato plants (Westerman, 2005), and because of the large interest in recent times about the quality of production and food safety from contamination remains of chemical fertilizers and pesticides raised the question of clean plant production, free from residual effects of pesticides and mineral fertilizers and increased the interest in organic agriculture (El- Ghamring *et al*. 1999).The use of organic fertilizers, (local and manufactured) tend to substitute chemical fertilizers and many researchers reported this, (Al-Zahawy,2007, Abdul- Rasoul *et al*., 2009, Mahmoud and Al-Salamany, 2010). Al- Zouby *et al*. (2007) found an increase in the soil content of total nitrogen from 0.154% to 0.212%, the available phosphorus from 15.82 to 44.22 mg. kg^{-1} and potassium from 164.5 to 312 mg. kg^{-1} and organic matter from 3.02% to 4.51% in the control treatment and the treatment of organic and bio-fertilizer which led to an increase in the total yield of the tubers from 13.75 to 21.88 ton. ha^{-1}. Al-Sahaf and Atti(2007) found that the addition of animal manure (the remnants of sheep, cattle and poultry) at a rate of 20% of the soil weight to the potato crop led to a significant increase in the number of aerobic stems,total and marketable yield of tubers and the percentage of dry matter in the tubers. Al-Khafagy, (2009) also found that adding a local poultry fertilizer at 5 and 10 tons. ha^{-1} for potato plants led to a significant increase in plant height, number of tubers and total yield. Kahlel, (2015) indicate that the addition of poultry manure as a solution fertilizer near the plants roots led to a significant increase in plant height, number of stems per plant, leaf area,fresh and dry weight of the plant, number of tubers, average tuber weight, tubers yield per plant, total and marketable yield compared with the control treatment. Irrigation methods of vegetable crops have been evolved in order to minimize the amount of irrigation water and increase water use efficiency, which reduces the crops production costs, and most of the Iraqi farmers still follows the old irrigation methods especially furrows irrigation. In addition to that Iraqi farmers applying an excessive amount of chemical fertilizers which caused a problems for the soil and increase crop production costs, while there are a large amounts of local organic fertilizers (animal residues) available with very low costs,in additional to its benefits for soil and produce a clean crops free from the remnants of chemical fertilizer. Therefore, the aim of this experiment is to study the possibility of applying drip irrigation instead of furrow irrigation to reduce the amount of irrigation water, and also the possibility of substitute a part of chemical fertilizer by applying organic fertilizer in potato production in Iraq.

MATERIALS AND METHODS

The experiment was implemented in the vegetable crops farm of Plant Production Department at Technical Agricultural College, Mosul, Iraq during the autumn season 2013, to study the effect of three methods of irrigation and three types of fertilization on the growth and yield of potato.

Irrigation treatments:

Furrow irrigation (surface irrigation).
Drip irrigation by putting the pipes at the bottom of the furrow.
Drip irrigation by putting the pipes at the top of the furrow.
The irrigation pipes used is in the form of T- Tape 16 mm in diameter with drippers at 20 cm distance.

Fertilization treatments:

Chemical fertilization at a rate of 300 $Kg.ha^{-1}$ urea (45% N), 180 $Kg.ha^{-1}$ triple superphosphate (45% P2 O5) and 240 $Kg.ha^{-1}$ potassium sulfate (50% K 2O).
Organic fertilizer: poultry manufactured manure (Italpollina) by scattering under the plants at a rate of 30 kg. 100 m^{2-1} with half amount of the chemical fertilizer above.

Table 1. Some physical and chemical properties of the field experiment soil.

Properties	Value
PH	7.3
Organic Matter g. Kg^{-1}.	21
E.C. ds m^{-1}	3.380
Cation Exchange Capacity Meq.100 g.$soil^{-1}$	14.87
available N (ppm)	42
available P (ppm)	0.89
soluble K (ppm)	141
CaCO3 g. Kg^{-1}.	225
Particle Size g. Kg^{-1}.	
Sand	493.5
Clay	161.8
Silt	344.7
Texture Class	Loamy

Organic fertilizer: poultry manufactured manure (Italpollina) by irrigation the fertilizer solution near the roots of the plants at a rate of 30 kg. 100 m^{2-1} two doses, the first after germination and the second after a month with half amount of the chemical fertilizer above.
The organic fertilizer (Italpollina) is a poultry manufactured fertilizer produced by the Italian company Italpollina according to the European Union laws and it is rich in mineral elements and organic active humic material (humic acid).

Experimental Design

The study included nine treatments carried out in a factorial experiment in Randomized Complete Block Design with three replicates. Potato seed (cv. Rivera) were planted on 2 September on furrows 75 cm wide at a distance 30 cm. between the tubers in loamy soil (Table 1). Tubers were harvested on 20 December 2013.

Evaluation

The following measurements were recorded:
1. Total water content of the leaves %: determined by using the following equation:
Total water content % = wet weight – dry weight / wet weight x 100 (Mohammed, 1985).
2. Relative water content of leaves %: determined by the following equation:
Relative water content% = wet weight – dry weight /saturated weight – dry weight X 100 (Mohammed, 1985)
3. Leaf area per plant (cm^2).
4. The dry weight of roots (g.).
5. Number of tubers per plant.
6. Average tuber weight (g.).
7- Plant yields (g.)
8. Total tubers yield per unit area ($tons.ha^{-1}$)
9. Marketable yield of tubers ($tons.ha^{-1}$)
10. Water use efficiency ($kg.m^{3\ -1}$) was calculated by the following equation:
Water use efficiency ($kg.m^{3\ -1}$) = total yield ($Kg.ha^{-1}$) / amount of water added ($m^3.ha^{-1}$) (Al-Janaby, 2012).
The amount of water added was calculated for the furrow treatment by using a water meter, connected to the irrigation pipe, the total amount of water added to this treatment during the season was (2230 $m^3.ha^{-1}$). The amount of water added to the two drip irrigation treatments has been calculated through the discharge of drippers in drip irrigation pipe for several times, which record 1.40 $L.h^{-1}$ multiplied by the number of drippers in the experimental unit multiplied by the number of irrigation hours for all irrigations during the growing season and calculated for hectare area and the amount of water added was (1490 $m^3.ha^{-1}$).
11. Tubers hardness ($kg.m3^{)}$:was measured by Pressure Tester.
12. Total soluble solids in the tubers: was measured by Hand Refractometer.
13. Percentage of dry matter in the tubers.

Statistical analysis

The results were analyzed statistically according to the SAS System (SAS, 1998) and compared the averages by Duncan multiple range test at 0.05 level (Al-Rawy and Kalaf, 2000).

RESULT AND DISCUSSION

Table (2) shows the effect of fertilization, irrigation treatments, and their interaction on the total and relative water content, leaf area and dry weight of roots. Results indicated that applying organic fertilizer by irrigation produced the highest total water content 86.66%, leaf area 2285 cm^2, and roots dry weight 13.60 g. whereas the highest relative water content 80.71% result from applying organic fertilizer by scattering. The irrigation treatments resulted significant differences in the four mentioned traits and the highest total water content 87.88%, relative water content 81.55% was from the treatment of drip irrigation by putting the pipe at the top of

Table 2. Effects of fertilization and irrigation treatments and their interaction on total and relative water content, plant leaf area and roots dry weight of potato plant.

Parameters				Treatments	
Roots dry weight (g.)	**Plant Leaf area (cm^2.)**	**Relative water content (%)**	**Total water content (%)**	**Irrigation Treatments**	**Fertilization Treatments**
Effects of interaction between fertilization and irrigation treatments					
12.84 b	1853 b	79.26 f	84.82 c	Furrow Irrigation	Chemical Fertilization
13.22 ab	2121 ab	80.79 cd	86.40 b	Bottom of furrow	
13.69 a	2345 a	81.74 a	87.99 a	Top of furrow	
12.89 b	2083 ab	79.82 e	85.22 c	Furrow Irrigation	Organic Fertilization By scattering
13.22 ab	2261 a	80.64 d	86.23 b	Bottom of furrow	
13.82 a	2342 a	81.68 ab	87.63 a	Top of furrow	
13.33 ab	2103 ab	79.21 f	85.32 c	Furrow Irrigation	Organic Fertilization By irrigation
13.55 ab	2341 a	80.43 d	86.66 b	Bottom of furrow	
13.92 a	2411 a	81.23 bc	88.02 a	Top of furrow	
Effects of fertilization treatments					
13.25 a	2106 a	80.59 a	86.40 a	Chemical Fertilizer	Fertilization Treatments
13.31a	2228 a	80.71 a	86.36 a	Organic by Scattering	
13.60 a	2285 a	80.29 b	86.66 a	Organic by Irrigation	
Effects of irrigation treatments					
13.02 b	2013 b	79.43 c	85.12 c	Furrow Irrigation	Irrigation Treatments
13.33 b	2241 a	80.62 b	86.43 b	Bottom of furrow	
13.81 a	2366 a	81.55 a	87.88 a	Top of furrow	

Means followed with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 levels.

the furrow, followed by the treatment of drip irrigation by putting the pipe at the bottom of the furrow then followed by the treatment of furrow irrigation. On the other hand, the highest leaf area 2366 cm^2 obtained from drip irrigation treatment by putting the pipe at the top of the furrow, which is not significantly vary with the treatment of putting the pipe at the bottom of the furrow 2241 cm^2, but it was significantly superior over the furrow irrigation treatments 2013 cm^2, the dry weight of the roots increased by drip irrigation treatment at the top of the furrow 13.81 g which was significantly surpass than the other two treatments. The interaction between fertilization and irrigation treatments had a significant effect in the four mentioned traits,the highest total water content 88.02% produced from the interaction between the organic fertilizer by irrigation method and drip irrigation at the top of the furrow and the lowest water content 84.82% resulted from the interaction between

the chemical fertilization and furrow irrigation method, whereas, the highest relative water content 81.74% obtained from the interaction between the chemical fertilization and drip irrigation at the top of the furrow and the lowest relative water content 79.21% was from the interaction between the organic fertilization by irrigation and furrow irrigation method. The highest leaf area 2411 cm^2 and higher dry weight of roots 13.92 g. were obtained from the interaction between the organic fertilizer by irrigation and drip irrigation at the top of the furrow. The significant increase in the total water content, relative water content, leaf area and dry weight of roots by application of drip irrigation treatment when putting the pipe at the top of furrow may be due to the increase in the amount of irrigation water provided by this treatment as compared with the other two treatments as a result of reducing the loss of water through evaporation process as a result of reducing the evaporation space because of putting the irrigation pipes at the top of the furrow and the water goes down inside the furrow soil where the roots system of the plant, which absorb a large amount of water and translocation to the leaves of the plant which cause increasing the water content of leaves and increase the efficiency of photosynthesis process as the water is the necessary factor in this process (Mohammed, 1985) and that led to increase the leaf area per plant, this result agree with the findings of Shae *et al*.,(1999) whom found an increase in the leaf area and dry weight of the total vegetative growth of potato plant when using drip irrigation method as compared with surface irrigation method, Bao- Zhong *et al*. (2003) whom noticed an increase in the total water content of plants leaves when increasing the irrigation water amounts from 0.25 to 1.25 of the pan evaporation, Al-Janaby (2012) who mentioned an increase in leaf area per plant by using drip irrigation, and Kahlel and Al-Othman, (2014) reported that sub-surface drip irrigation increase total and relative water content and leaf area of potato plant as compare with surface drip irrigation.

Table (3) shows the effect of fertilization and irrigation treatments and their interaction on the number of tubers per plant, average tuber weight and plant yield. The highest number of tubers 5:46 was obtained from application of organic fertilizer by scattering which is significantly superior over the other two treatments, and the treatment of organic fertilizer by irrigation led to a significant increase in the average tuber weight 69.56 g., in addition to that the two treatments of organic fertilizer by scattering and irrigation were significantly superior in plant yield (367.73 and 351.04 g) than the chemical fertilization 309.62 g. The treatment of drip irrigation by putting the pipes at the top of the furrow better than the other two treatments in the number of tubers 5.85 g. and plant yield 395.77 g. While the largest weight of tuber 65.33 g. were produced from the treatment of drip irrigation at the bottom of the furrow. The interaction between fertilization and irrigation treatments were significantly affected the three traits, and the highest number of tubers per plant 6.04 was from the interaction between the organic fertilizer by irrigation and drip irrigation at the top of the furrow and it is significantly superior over most of the other interactions, while the highest weight of the tuber 82.64g resulted from the interaction between the organic fertilizer by irrigation and drip irrigation at the bottom of the furrow which had significant effect over all other interactions. The interaction between organic fertilizer by irrigation and drip irrigation at the top of the furrow gave the highest yield per plant 431.10 g. which significantly surpassed all other treatments. The increase in number of tubers, average tuber weight, and yield per plant as a result of adding organic fertilizer by scattering or irrigation near the plants roots may be due to the role of organic fertilizer in improving the physical, chemical, and biological characters of the soil and increase its ability to maintain water and increase its nutrients content, especially nitrogen, phosphorus and potassium (Al-Zouby *et al*., 2007, Al-Sahaf and Atti, 2007). Also, Atti and Al-Sahaf, (2007) mentioned that the addition of organic fertilizer (Organo Fert.) led to increase variability of phosphorus element by 50% than the control treatment. The increase in the nutrients available in the soil increased the absorption efficiency of elements by plant roots, which was reflected on raising the efficiency of biological processes, especially photosynthesis process which led to increase vegetative growth which contributed in increasing tuber weight and plant yield. These results were in harmony with the finding of (Al-Zahawy, 2007, Abdul-Rasoul *et. al.*, 2009, Al-Khafagy, 2009, Mahmoud and Al-Salamany, 2010).

The increase in the number of tubers and plant yield as a result of drip irrigation treatment by putting the pipes at the top of the furrow may be due to the efficiency of this method in reducing water loss through evaporation and increase water use efficiency (Table 4) and the increasing of water amounts in the soil may increase the length and the density of roots through the optimal regulation of soil water, in addition to maintain a high water potential in the root zone (Wang *et al*., 2006), which increase the water absorption, and total water content in leaves (Table 2) as well as the absorption of nutrients as a result of increasing its availability in the soil reflecting the efficiency of the biological processes in the plant. These results are in agreement with data reported by Shae *et al*., (1999) and, Al-Janaby, (2012).

Table (4) shows the effect of fertilization, irrigation treatments and their interaction on the total yield, marketable yield, and water use efficiency. The highest total tubers yield 16.345 $ton.ha^{-1}$, marketable tubers yield 15.078 $ton.ha^{-1}$ and water use efficiency 9.855 $kg.m^{3\ -1}$ resulted from applying organic fertilizer by scattering method with significantly surpass over chemical fertilizer treatment.. Treatment of drip irrigation by putting the pipe

Table 3. Effect of fertilization and irrigation treatments and their interaction in number of tubers, average tuber weight and plant yield of potato.

Parameters			Treatments	
Plant yield (g.)	**Average tuber weight (g.)**	**Number of tubers per plant**	**Irrigation Treatments**	**Fertilization Treatments**
Effects of interaction between fertilization and irrigation treatments				
270.83 ef	50.72 e	4.46 c	Furrow Irrigation	Chemical Fertilization
306.38 dc	56.42 cde	4.62 c	Bottom of furrow	
351.66 c	52.57 de	5.62 ab	Top of furrow	
334.70 cd	56.27 cde	5.05 bc	Furrow Irrigation	Organic Fertilization By scattering
363.50 bc	56.94 cd	5.43 ab	Bottom of furrow	
405.00 ab	58.52 c	5.91 a	Top of furrow	
257.60 f	54.69 cde	4.71 c	Furrow Irrigation	Organic Fertilization By irrigation
364.44 bc	82.64 a	4.41 c	Bottom of furrow	
431.10 a	71.37 b	6.04 a	Top of furrow	
Effects of fertilization treatments				
309.62 b	53.23 c	4.90 b	Chemical Fertilizer	Fertilization Treatments
367.73 a	57.24 b	5.46 a	Organic by Scattering	
351.04 a	69.56 a	5.05 b	Organic by Irrigation	
Effects of irrigation treatments				
287.71 c	53.89 c	4.74 b	Furrow Irrigation	Irrigation Treatments
344.77 b	65.33 a	4.82 b	Bottom of furrow	
395.77 a	60.80 b	5.85 a	Top of furrow	

Means followed with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 levels.

at the top of furrow produced the highest total tubers yield 17.595 ton.ha^{-1}, marketable tubers yield 16.372 ton.ha^{-1} and water use efficiency 11.792 kg.m$^{3\ -1}$ with significantly surpass over the other two treatments. The interaction between fertilization and irrigation treatments had significant effect in the yield traits, the interaction between organic fertilizer by irrigation and drip irrigation by putting the pipe at the top of the furrow obtained the highest total tubers yield 19.159 ton.ha^{-1}, marketable tubers yield 17.842 ton.ha^{-1} and water use efficiency 12.841 kg.m$^{3\ -1}$ which was significantly surpass over all other interactions. The superiority of applying organic fertilizer by the both methods (scattering and irrigation) in total tubers yield, marketable tubers yield and water use efficiency over the chemical fertilizer treatment may be due to the above mentioned role of organic fertilizer

Table 4. Effect of fertilization and irrigation treatments and their interaction in total tubers yield, marketable tubers yield,and water use efficiency in potato.

Parameters			Treatments	
Water use Efficiency ($Kg.m^{3\ -1}$)	**Marketable Tubers yield ($Ton.h^{-1}$)**	**Total tubers yield ($Ton.h^{-1}$)**	**Irrigation Treatments**	**Fertilization Treatments**
Effects of interaction between fertilization and irrigation treatments				
5.397 e	10.832 e	12.036 ef	Furrow Irrigation	Chemical Fertilization
9.125 c	12.814 d	13.616 dc	Bottom of furrow	
10.474 b	14.512 c	15.628 c	Top of furrow	
6.670 d	13.461 d	14.875 cd	Furrow Irrigation	Organic Fertilization By scattering
10.833 b	15.012 c	16.163 bc	Bottom of furrow	
12.063 a	16.762 b	17.999 ab	Top of furrow	
5.133 e	10.132 e	11.448 f	Furrow Irrigation	Organic Fertilization By irrigation
10.855 b	14.981 c	16.196 bc	Bottom of furrow	
12.841 a	17.842 a	19.159 a	Top of furrow	
Effects of fertilization treatments				
8.332 b	12.719 c	13.726 b	Chemical Fertilizer	Fertilization Treatments
9.855 a	15.078 a	16.345 a	Organic by Scattering	
9.609 a	14.318 b	15.601 a	Organic by Irrigation	
Effects of irrigation treatments				
5.733 c	11.475 c	12.753 c	Furrow Irrigation	Irrigation Treatments
10.271 b	14.269 b	15.325 b	Bottom of furrow	
11.792 a	16.372 a	17.595 a	Top of furrow	

Means followed with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 levels.

in improving the physical and chemical soil properties and its content of various nutrient elements, as well as organic fertilizer encourages microorganisms and increased microbial activity which increase the activity of microbial enzymes such as Nitrogenase, Urease and Dehydragenase (Fathy *et al*., 2000). Atti and Al-Sahaf (2007) reported that using organic fertilizer (poultry fertilizer) led to increase the percentage of mycorrhiza colonies in potato roots which attributed to the manure containing of unspecified types of mycorrhiza spores, which participate increase in the proportion of roots injury,also organic fertilizer contains some fungi such as *Trichoderma spp.* that share with mycorrhiza fungi in positive interactions to stimulate growth. Al-Sahaf and Atti, (2007) also reported that the decomposition of organic fertilizers, resulting

Table 5. Effects of fertilization and irrigation treatments and their interaction in tubers hardness, total soluble solid, and dry matter in tubers of potato.

Parameters			Treatments	
Dry Matter In Tubers (%)	Total Soluble Solids in Tuber (%)	Tubers Hardness (Kg. $cm^{2\ -1}$)	Irrigation Treatments	Fertilization Treatments
Effects of interaction between fertilization and irrigation treatments				
17.24 c	5.50 bc	14.00 b	Furrow Irrigation	Chemical Fertilization
17.86 bc	6.00 ab	14.00 b	Bottom of furrow	
18.31 b	5.50 bc	15.00 a	Top of furrow	
17.57 bc	6.00 ab	11.50 d	Furrow Irrigation	Organic Fertilization By scatting
18.44 b	5.50 bc	15.00 a	Bottom of furrow	
19.52 a	5.00 c	14.50 ab	Top of furrow	
18.01 bc	5.50 bc	11.50 d	Furrow Irrigation	Organic Fertilization By irrigation
19.66 a	5.00 c	13.50 c	Bottom of furrow	
20.13 a	6.50 a	15.00 a	Top of furrow	
Effects of fertilization treatments				
17.80 c	5.66 a	14.33 a	Chemical Fertilizer	Fertilization Treatments
18.51 b	5.50 a	13.66 b	Organic by Scatting	
19.26 a	5.66 a	13.33 b	Organic by Irrigation	
Effects of irrigation treatments				
17.60 c	5.66 a	12.33 c	Furrow Irrigation.	Irrigation Treatments
18.65 b	5.50 a	14.33 b	Bottom of furrow	
19.32 a	5.66 a	14.83 a	Top of furrow	

Means followed with the same latter are not significantly different according to Duncan multiple range test at the probability of 0.05 levels.

in some amino and organic acid production, all these factors play an important role in biological processes in plants and led to an increase in the number of tubers, average tuber weight and plant yield (Table 3), which was reflected on the characteristics of the total tubers yield, marketable tubers yield. These results were in agreement with the findings of (Al-Zahawy, 2007, Abdul- Rasoul *et al*., 2009, Al-Khafagy,.2009, Mahmoud and Al-Salamany,.2010) whom reported that the use of different organic fertilizer increased total and marketable tubers yield of potato. The significant increase in the yield characters as a result of drip irrigation by putting the pipe at the top of the furrow as compared with the other two treatments are in agreement with the results of (Bao-Zhong *et. al.*, 2006, Neelam and Raiput,2007,Badr *et. al*, 2012, Al- Janaby, 2012).

Perhaps the reason for this is due to the efficiency of this irrigation method in providing adequate amounts of water in the root zone and reduces water loss through evaporation and we

have noted that this treatment led to a significant increase in the total water content in the leaves and roots dry weight (Table 2) and water availability in the soil increased the ability of elements for absorption, so all that provided suitable conditions for biological processes in the plant, especially photosynthesis where water is an essential factor for this process as well as the role of nitrogen as one of the essential elements of the plant because it introduces a number of organic compounds, amino acids, proteins and nucleic acids and its important in photosynthesis it participate with magnesium element in the formation of chlorophyll molecule (Mohammed,1985, Abu-Dahy and Al- Younis,1988). In addition to the role of phosphorus element in plant growth which is considered as one of the nucleoprotein components and enters in the composition of phospholipids which is one of the living cell membrane components, as phosphorus associated with the organic compounds within the cell to produced ATP and ADP (Abu-Dahy and Al-Younis,1988). Hence the importance of potassium element to transport photosynthesis products and collected in the reservoir parts (tubers) (Habib *et. al.*, 2011).

Table (5) shows the effect of fertilization, irrigation and their interaction on some of qualitative characteristics of the tubers, where it obviously been found that the chemical fertilizer led to significant increase in tubers hardness 14.33 kg. cm2 -1 as compared with the two organic fertilizer treatments, while there is no significant effects has been noticed in total soluble solid in tubers by fertilization treatments, whereas the highest percentage of dry matter in tubers 19.26% resulted from the treatment of organic fertilization by irrigation. The treatment of drip irrigation by putting the pipe at the top of the furrow gave a significant increase in tubers hardness 14.83 kg.cm2 -1 and the percentage of dry matter in tubers 19.32% which surpassed the other two irrigation treatments. Interaction between fertilization and irrigation significantly affected the quality characteristics of the tubers and the highest tubers hardness 15.00 kg.cm2 -1 produced from the three treatments while the highest percentage of total soluble solids 6.5 was obtained from interaction between organic fertilizer by irrigation and drip irrigation at the top of the furrow which is the same treatment that gave the highest percentage of dry matter in the tubers.

CONCLUSIONS

It can be concluded from this research that it could be decreased the irrigation water amount of potato crop by applying drip irrigation system instead of furrow irrigation (which used by Iraqi farmers now), and the irrigation pipes should be putted at the top of the furrow to increased productivity, maintain soil fertility by decreasing nutrient elements leaching resulted from furrows irrigation, and decreased production costs. Also it could be applying organic fertilizer to substituted chemical fertilization partially with maintaining the productivity, improve soil chemical and physical characteristics, and decreased production costs.

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