http://dx.doi.org/10.22161/ijeab/3.2.22 *ISSN: 2456- 1878*

The Effect of Irrigation systems and Planting Methods on Soil Porosity and Soil Electrical Conductivity and Potato Yield sunder Two Irrigation Intervals

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Abstract**—** *The experiment was conducted to evaluate the effect of irrigation systems, planting methods and irrigation intervals on soil porosity and soil electrical conductivity and potato yields for fall season of 2016 in Yousufia Area. Three irrigation systems included Sprinkler Irrigation (S), Drip irrigation (D),and Furrow Irrigation (F), two different irrigation intervals included (4 day irrigation interval (I_1) and 8 day irrigation interval (I_2)) and two methods of planting included (Mechanical planting (M) and Manual (Hand) planting (H) were used in the experiment. Soil Porosity, electrical conductivity of a saturated soil extract (Ece), average weight of potato tuber, and plant yield were measured in this study. Split split plots arrangment under Randomized Complete Block Design (RCBD) with three replicates, were used in this experiment. The means of treatments were compared by using least significant difference (LSD=0.05) under probability of 0.05.*

The results can be summarized as follows:

1- *Drip irrigation was superior in obtaining the least value of the electrical conductivity stood 2.76 ds.m^{-1}, highest potato yield stood 811 gm. plant^{-1} and highest value for the average weight of potato tuber was 150 gm. Also, the furrow irrigation treatment was superior in obtaining the highest value of soil porosity stood, 0.44 cm^3.cm^{-3}.*
2- *4 days irrigation interval got a significant higher single plant yield stood 731 gm.plant^{-1}, and potato tuber weight average stood 117.83 gm and got the least value of electrical conductivity stood 3.40 ds.m^{-1}, whereas 8 days irrigation interval was superior in getting the highest value of porosity, stood 0.40 cm^3.cm^{-3}.*
3- *Mechanical planting method resulted in obtaining the highest value of porosity, stood 0.40 cm^3.cm^{-3}, and the highest yield for a single plant value stood 703 gm.plant^{-1}, and the highest value of potato tuber average weight stood 131.33 gm.*
4- *The interaction between drip irrigation and 4 days irrigation interval was superior compared to other interactions in obtaining the least value of the electrical conductivity (Ece) stood 2.52 ds.m^{-1}, and highest value of single plant yield stood 884 gm.plant^{-1}, and highest value for the average weight of potato tuber stood 161.17 gm. On the other hand, the interaction between furrow irrigation method and the 8 days irrigation interval in obtaining the highest value for porosity which stood 0.44 cm3.cm^{-3}.*
5- *The interaction between drip irrigation method and mechanical planting method was superior compared to other interactions in obtaining the highest yield value for single plant which stood 846 gm.plant^{-1}, and the highest value for the weight average of potato tuber stood 157.50 gm. while, the interaction between furrow irrigation method and mechanical planting recorded the highest value for porosity which stood 0.46 cm^3.cm^{-3}.*
6- *The interaction between 4 days irrigation interval and mechanical planting showed a superiority in obtaining the highest value for single plant yield which stood 770 gm.plant^{-1}, and highest value for the weight average for potato tuber stood 140.44 gm, compared to other interactions, and the interaction between 8days irrigation interval and mechanical planting method was superior to obtain the highest value of porosity stood 0.42 cm^3.cm^{-3}. Also, the interaction between 4 days irrigation interval and the manual (hand) planting methods was superior to obtain the least value for electrical conductivity for soil solution stood 3.34 ds.m^{-1}.*
7- *The triple interaction between drip irrigation, 4 days irrigation interval, and mechanical planting method*

http://dx.doi.org/10.22161/ijeab/3.2.22 *ISSN: 2456- 1878*

was superior in obtaining the highest yield for a single plant which stood 936 gm.plant^{-1} and the highest value of the weight average of potato tuber which stood 169.33 gm and the lowest value for electrical conductivity of soil solution which stood 2.50 ds.m^{-1} compared to other interactions. While the interaction between furrow irrigation method, 8 days irrigation interval, and mechanical planting method was superior to obtain the highest value of soil porosity stood 0.48 cm^3.cm^{-3}.

Keywords— Sprinkler Irrigation, drip irrigation, soil porosity, mechanical planting, irrigation interval.

I. INTRODUCTION

The agricultural mechanization is one of the continuously developed requirements of agricultural production that aims to reduce the costs and increase the production, faster accomplishment of field operations, minimized manual labor and efficient use of time. Therefore, the trend had started towards the ideal use of agricultural machines and equipment from the stage of soil preparation through planting and crop service operation up to harvesting of crops and post-harvesting. Potato cultivators had an important role in developing the potato crop planting through the precise planting operation in terms planting depth and dimensions, the speed of accomplishment and the efficient use of the unit of area.

Some studies and experiments have proven that using the drip irrigation system will save large amounts of water compared to conventional irrigation methods, and as for sprinkle irrigation system which is also contributes in saving large amounts of water relatively (Altaif and Alhadithi, 1988).

The problem of water scarcity had emerged in the irrigated fields in dry and semi-dry areas in which our country is located where farmers in the mid and southern parts of Iraq are suffering from that problem. The severe reduction of the annual average of water income of Tigris and Euphrates rivers and level fluctuation from one season to another had affected and deteriorated these resources (AL- shahrabali, 2009). Therefore, there were suggestions and studies including the use of many methods to possibly confront the scarcity of water somehow. For example, the efficient management in controlling the amount of water at every single watering and the number of irrigations (irrigation scheduling) and the use of modern and proper irrigation systems with less water losses. Also, irrigation scheduling has a significant effect in potato crop production and components (Demelash, 2013).

Solanumtuberosum L Potato is an important vegetable crop that follows the solanaceae family. Its name came from solanum gender. It is one of four crops in the world in terms of the nutritious importance after wheat, corn, and rice where it comes first in terms of tuberculosis crops (Hasan, 1990). Potato tubers are important source for energy because it is rich of carbohydrates and has many proteins, vitamins, salts, minerals, and amino acids. It contains 18 out of 20 amino acidsthat are necessary to human being which gives it a high biological value (NAPCO, 2005). According to the importance of choosing the best irrigation methods, irrigation interval and potato planting methods for potato planting, this experiment was done.

II MATERIALS AND METHODS:

A field experiment has been conducted to evaluate the effect of different irrigation systems and planting methods on soil porosity and soil electrical conductivity and Solanumtuberosum L potato crop yield for fall season of 2016 in Yousufia region which is located 15 km south west of Baghdad at 75.18.44 meridian east and 84.07.33 latitude north. This land features a flat to semi-flat ground with altitude of 34.1 m above sea level.

Three irrigation systems included Sprinkler Irrigation (S), Drip irrigation (D),and Furrow Irrigation (F), two different irrigation intervals included (4 day irrigation interval (I1) and 8 day irrigation interval (I2)) and two methods of planting included (Mechanical planting (M) and Manual (Hand) planting (H) were used in the experiment. Soil Porosity, electrical conductivity of a saturated soil extract (Ece), average weight of potato tuber, and plant yield were measured in this study. Split split plots arrangement under Randomized Complete Block Design (RCBD) with three replicates, were used in this experiment. The means of treatments were compared by using least significant difference (LSD=0.05) under probability of 0.05.

Samples of field soil were taken from five different locations randomly for analysis. Chemical and physical analysis was illustrated in table (1) and the soil texture was classified as silt clay loam.

Soil was prepared by plowing using mold board plow after drenching the soil with water to get the right moisture for plowing which is (16-18) %. After primary tillage, secondary tillage was conducted using rotary harrow then leveling was conducted with leveling machine. Then, the field was divided into the experimental units.

Potato tubers type (Riviera) rank (A) were planted at 15/9/2016 on furrows with a distance of 75 cm between each line, 25 cm between each tuber, and depth of (10-18)

http://dx.doi.org/10.22161/ijeab/3.2.22 *ISSN: 2456- 1878*

cm and through the extension of planting lines. The number of the lines on a single experimental unit were 8 lines. The length of the line for one experimental unit 11 m. the number of the plants on a single line were 44. The density was 352 plants / unit. Every irrigation method had 4224 plants. The total number of plants in the field were 12672 plant.

After maturity signs appeared (vegetative growth halt, yellow leaves appearance with tuber crust hardening and colored with light brown and aerial stems hardening) the vegetative parts were cut from the contact spot with soil. After two days, i.e at 24/12/2016 the tuber was extracted manually. Then, the tuber yield was calculated from each experimental unit separately after sorting the damaged tubers.

Urea fertilizer was used (46% N) with average of 70 kg/hectare with three doses, one quarter was with planting, another quarter was with the growth of tubers, the last half was used in the stage of tuber filling. Super tri-phosphate (46% P2O5) was used by 70 kg / hectare added as a whole with soil preparation for planting. Potassium sulfate was used (52% K2O) with 80/hectare added as two doses, This procedure was according to the recommendations from Ibaa center for Agricultural research 1994 (Alzawbai, 2000).

Table.1: Chemical and physical characteristics of the studied soil

Soil characteristic	**unit**		**value**
Electrical Conductivity (ECe)	$ds.m^{-1}$		2.80
PH			7.56
Soil elements	Nitrogen	$mgm.kg^{-1}$	34.50
	Phosphor		27.13
Soil compounds	Sand	$gm.kg^{-1}$	16
	Silt		540
	Clay		300
Texture	Silt Clay Loam		
Bulk Density	$Mgm.m^{-3}$		1.40

Studied Properties Measurments:

1-Electrical conductivity for the saturated dough solution (ECe), $ds.m^{-1}$

Electrical conductivity was measured for soil solution using electrical conductivity device for soil solution (EC-meter) according to the method mentioned in (Jackson 1958).

2-Porosity, %.

Total Porosity was calculated from the value of bulk and particle densities following the equation from (Audah, 1990)

$$f = \left(1 - \frac{\rho_b}{\rho_s}\right) \times 100 \quad \ldots\ldots (9)$$

Where:

f : Soil porosity %

ρ_b : Bulk density, $Mgm.m^{-3}$

ρ_s : Particle density, $Mgm.m^{-3}$

3-Plant yield,gm. $plant^{-1}$

The total number of plants selected from each experimental unit was calculated and then divided into the number of plants selected for the same unit to obtain the plant yield.

4-Weight of the tuber,gm

10 randomly selected plants were taken from the middle lines. The weight of each plant was measured on the number of tubers per plant to extract the weight of the tuber and the weight of the tuber = the weight of the crop / number of tubers.

III RESULTS AND DISCUSSION

Electrical conductivity:

Table (2) shows the effect of irrigation methods and intervals, and planting methods on soil electrical conductivity values. Sprinkle irrigation treatment got the highest value of soil electrical conductivity stood $4.27ds.m^{-1}$. Then furrow irrigation treatment gotsoil electrical conductivity stood $3.92ds.m^{-1}$, whereas drip irrigation treatment got 2.76 $ds.m^{-1}$. These results come in agreement with the results obtained by Francois and Bernstein, 1973.

http://dx.doi.org/10.22161/ijeab/3.2.22 *ISSN: 2456- 1878*

The table also showed that irrigation intervals have significant effect on electrical conductivity for soil solution where the highest value was at 8 days irrigation interval 3.89 ds.m^{-1} compared to a less value with 4 days irrigation interval 3.40 ds.m^{-1}.

Planting methods treatments had a significant effect on the response. Mechanical planting methods had a value of 3.71 Ds.m^{-1} compared to 3.59 Ds.m^{-1} with manual planting.

The interaction between irrigation methods and irrigation intervals indicates there are significant differences. The highest value was recorded between 8 days irrigation interval and sprinkle irrigation 4.59 ds.m^{-1} compared to drip irrigation and 4 days period 2.52 ds.m^{-1}.

Results show significant differences for electrical conductivity due to the dual interaction between irrigation and planting methods. The least value of interaction was with drip irrigation and manual planting2.72 ds.m^{-1} compared to the highest value between sprinkle irrigation and manual planting 4.29 Ds.m^{-1}.

The table showed significant differences between electrical conductivity due to the interaction between irrigation methods and intervals and planting methods. The highest value was recorded with sprinkler irrigation, second period, and manual planting 4.72 ds.m^{-1} compared to drip irrigation, 4 days irrigation interval, and mechanical planting 2.50 ds.m^{-1}.

Table.2: The effect of irrigation methods and intervals and planting methods on soil electrical conductivity, ds.m^{-1}

Irrigation method	**Irrigation interval (day)**	**interaction between irrigation method and intervals and planting methods**		**Interaction between irrigation methods and irrigation intervals**
		Planting methods		
		M	H	
S	I_1	4.02	3.86	3.94
	I_2	4.46	4.72	4.59
D	I_1	2.50	2.53	2.52
	I_2	3.08	2.91	3.00
F	I_1	3.86	3.64	3.75
	I_2	4.32	3.88	4.10
L.S.D =0.05		0.14		0.09
mean		3.71	3.59	
L.S.D =0.05		0.06		
Irrigation intervals		Interaction between irrigation intervals and planting methods		mean
I_1		3.46	3.34	3.40
I_2		3.95	3.84	3.89
L.S.D =0.05		N.S		0.07
Irrigation methods		Interaction between irrigation and planting methods		mean
S		4.24	4.29	4.27
D		2.79	2.72	2.76
F		4.09	3.76	3.92
L.S.D =0.05		0.09		0.07

Total Porosity,%.

Table (3) shows the effect of irrigation methods and intervals on porosity. It can be noticed that there are significant differences in porosity values attributed by irrigation treatments where the highest value recorded with furrow irrigation stood 0.44 %. Then, drip irrigation came with a lower porosity value of 0.4 %compared with sprinkle irrigation with a value stood 0.34 %. The reason is due to the movement of soil particles with each other especially the fine ones during the irrigation and

precipitated in the big pores thus reducing the porosity from one irrigation method to another. These results come to agreement with Rose, (1961).

The table also shows significant differences between porosity values due to the effect of irrigation intervals treatments. The highest value recorded at 8 days irrigation interval 0.4 %compared to 4 days irrigation interval 0.38 %.

Also, one can notice from table (5) that there are significant differences for porosity values due to planting methods. The mechanical method gave 0.4 %whereas manual method was 0.38 %.

The table indicates a significant effect for the two-way interaction between irrigation methods and intervals on porosity. The results were 0.44 % for interaction of furrow irrigation and 8 days irrigation interval compared with 0.32 %with sprinkle irrigation and 4 days irrigation interval.

There is a significant effect for the interaction between irrigation and planting methods on porosity. Furrow irrigation and mechanical planting gave the highest values for porosity 0.46 % compared to sprinkle irrigation and manual planting where gave the least value of 0.33 %.

Results showed significant effect on porosity when using the interaction between irrigation intervals and planting methods. Porosity value was 0.42 % with 8 days period and mechanical planting compared to 0.37 % with first irrigation interval and manual planting.

Table (3) showed no significant effect for the interaction between irrigation methods and intervals, and planting methods on porosity.

Table.3): The effect of irrigation methods and intervals and planting methods on porosity,%

Irrigation method	**Irrigation interval (day)**	**Interaction between irrigation method and intervals, and planting methods**		**Interaction between irrigation methods and intervals**
		Planting methods		
		M	**H**	
S	I_1	0.32	0.32	0.32
	I_2	0.37	0.35	0.36
D	I_1	0.40	0.40	0.40
	I_2	0.42	0.39	0.41
F	I_1	0.45	0.41	0.43
	I_2	0.48	0.41	0.44
L.S.D =0.05		N.S		0.01
mean		0.40	0.38	
L.S.D =0.05		0.007		
Irrigation intervals		Interaction between irrigation intervals and planting methods		mean
I_1		0,39	0.37	0.38
I_2		0.42	0.38	0.40
L.S.D =0.05		0.008		0.005
Irrigation methods		Interaction of irrigation and planting methods		mean
S		0.34	0.33	0.34
D		0.41	0.39	0.40
F		0.46	0.41	0.44
L.S.D =0.05		0.01		0.01

http://dx.doi.org/10.22161/ijeab/3.2.22 *ISSN: 2456- 1878*

Plant yield,gm.plant^{-1}

Table 4 shows the effect of irrigation methods, and intervals, and planting methods and their interferences on the plant yield of the potato. Drip irrigation got the highest plant yield stood 811 gm.plant^{-1}followed by the sprinkler irrigation method got 642 gm.plant^{-1}and then the furrow irrigation method got the lowest yield stood 546 gm.plant^{-1}. These results are consistent with the results obtained by Nagazet.al., (2000).

The irrigation interval had a significant effect on the yield of the plant. 4 days irrigation interval was significant superior in getting higher yield stood 731gm.plant^{-1}, whereas 8 days irrigation intervals got the lowest value of the plant yield stood 601 gm.plant^{-1}.This was due to the lack of vegetation and therefore less surface area of the plant, which is the process of photosynthesis, and these results are consistent with the results obtained by Aldjoy (1999).

The table also showed significant differences in plant yield attributed by planting methods, where mechanical planting treatment got highest plant yield stood 703 gm.plant^{-1}compared with manual planting, and may The reason for the regularity of agriculture in the mechanical way in terms of the distance between the tubers and the depth of agriculture. The overlap between irrigation methods and irrigation intervals showed no significant effect.

Table 4 showed significant differences due to the double interference between the irrigation methods and planting methods. The interaction between drip irrigation and mechanical planting method got The highest value of the plant yield stood 846 gm.plant^{-1}, and also showed no significant differences in plant yield due to the bilateral interference between irrigation intervals and planting methods.

Table 4 showed significant differences in the values of the plant yield due to the triangular interference between the irrigation methods, irrigation interval and planting methods, where the highest value was recorded at the triple overlap between the drip irrigation and 4 days interval and the mechanical planting stood 936 gm.plant^{-1} while the lowest value when the overlap between irrigation furrow and 8 days interval and hand-planting method stood 470 gm.plant^{-1}**.**

Table.4: The effect of irrigation methods, irrigation intervals and planting methods on the plant yield, gm.plant^{-1}

Irrigation method	***Irrigation interval (day)***	***Interaction between irrigation method and intervals and planting methods***		***Interaction between irrigation methods and irrigation intervals***
		Planting methods		
		M	*H*	
S	I_1	*745*	*672*	*708*
	I_2	*634*	*517*	*575*
D	I_1	*936*	*833*	*884*
	I_2	*757*	*718*	*737*
F	I_1	*631*	*571*	*601*
	I_2	*515*	*470*	*492*
L.S.D =0.05		*37.27*		*N.S*
		703	*630*	
L.S.D =0.05		*13.47*		
Irrigation intervals		*Interaction between irrigation intervals and planting methods*		*mean*
I_1		*770*	*692*	*731*
I_2		*635*	*568*	*601*
L.S.D =0.05		*N.S*		*12.47*
Irrigation methods		*Interaction between irrigation and planting methods*		*mean*
S		*689*	*594*	*642*
D		*846*	*775*	*811*
F		*573*	*520*	*546*
L.S.D =0.05		*18.34*		*11.62*

http://dx.doi.org/10.22161/ijeab/3.2.22 *ISSN: 2456- 1878*

Weight of the tuber,gm

Table 5 showed the effect of irrigation methods, and intervals and planting methods on the weight of the tuber. There are significant differences in the weight of the tuber due to the irrigation methods. Sprinkler irrigation was superior in getting the highest value of the tuber weight stood121.67 gm and drip irrigation got 150 gm, and furrow irrigation got weight, of tuber stood 107.67 gm. The table also showed that there are significant differences between the weights of the tuber attributed by irrigation interval. The highest value of the weight of the tuber was recorded at the time of 4 days irrigation interval stood 135.06 gm. This is due to a relationship between water shortage and the production of potato tubers. The dryness of soil during the time of tuber formation should reduce the number and size of tubers per plant. Table 5 showed significant differences in the mean weight of the tuber due to the effect of the treatment of planting methods. Mechanical planting got the highest weight of the tuber stood 131.33 gm. may be due to the regularity of agriculture in the mechanical method in terms of distance between the tubers and the order of the depths of agriculture, which leads to consistency in germination and inequality and this increases production.

There were significant differences in the mean weight of tuber due to the double interference between the irrigation methods and irrigation interval. The interaction between drip irrigation method and 4 days irrigation interval gave the highest value of the tuber weight stood 161.17 gm. The table also showed significant differences in the mean weight of the tuber due to the interference between irrigation methods and planting methods. The highest value of the tuber weight was obtained by the drip irrigation method with mechanical planting stood 157.50 gm, furrow irrigation and manual planting got 106.33 gm. The table showed that there are no significant differences in the values of plant yield due to the bilateral interference between irrigation method and intervals and planting methods.

Table.5: The effect of irrigation methods, and intervals and planting methods on the of weight of tuber, gm.

Interaction between irrigation methods and irrigation intervals	**Interaction between irrigation method and intervals and planting methods**		**Irrigation interval (day)**	**Irrigation method**
	Planting methods			
	H	**M**		
130.67	124.67	136.67	I_1	S
112.67	107.00	118.33	I_2	
161.17	153.00	169.33	I_1	D
138.83	132.00	145.67	I_2	
113.33	111.33	115.33	I_1	F
102.00	101.33	102.67	I_2	
1.95	N.S			L.S.D =0.05
126.44	121.56	131.33		
	1.58			L.S.D =0.05
mean	Interaction between irrigation intervals and planting methods			Irrigation intervals
135.06	129.67	140.44		I_1
117.83	113.44	122.22		I_2
1.40	N.S			L.S.D =0.05
mean	Interaction between irrigation and planting methods			Irrigation methods
121.67	115.83	127.50		S
150.00	142.50	157.50		D
107.67	106.33	109.00		F
1.43	2.18			L.S.D =0.05

http://dx.doi.org/10.22161/ijeab/3.2.22 *ISSN: 2456- 1878*

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