EFFECT OF IRRIGATION WATER QUANTITY AND FARMYARD MANURE ON POTATO PLANT GROWN IN SANDY SOIL

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(Manuscript received 27 October 2010)

Abstract

This experiment was carried out during the two successive summer seasons of 2009 and 2010 at a Private Farm in EL-Salhaia El-Gadida region, Sharkia Governorate on potato plant (Solanum tuberosum L.) cultivar Diamant grown under sandy soil conditions using drip irrigation system to study the effect of quantity of irrigation water (750, 1250 and 1750 m3/ fed.) and farmyard manure (10, 20 and 30 m3/ fed.) as well as their interactions on growth, yield and its quality as well as water use efficiency.

Plant height, number of leaves/ plant, shoot dry weight, free and total water in leaf tissues, N, P and K percentages and their uptake by shoot significantly increased with increasing irrigation water quantity up to the highest level (1750 m3/ fed). Irrigation water quantity of 1250 or 1750 m3/ fed. recorded the maximum values of average tuber weight, tuber yield/ plant and total yield/ fed, N, P, carbohydrates, starch and DM percentages in tuber tissues. Bound water, cell sap, osmotic pressure and proline amino acid in leaf tissues as well as water use efficiency (WUE) by potato plants were significantly increased with decreasing irrigation water quantity up to the lowest level (750 m3/ fed).

Farmyard manure (FYM) at 20 m3/ fed. significantly increased plant height, number of leaves/ plant, shoot dry weight, free and total water percentages, P % and its uptake by shoot, N, P, total carbohydrates, starch and dry matter % in tubers, on the other hand, N and K contents and their uptake by shoot, average tuber weight, yield/ plant and total yield/ fed. as well as water use efficiency were significantly increased with increasing FYM up to 30 m3/ feddan.

Interaction treatment between water quantity at 1250 m3/ fed. and FYM at 30 m3/ fed. was the superior treatment for enhancing shoot dry weight/ plant, N % and its uptake by shoot, N, K and total carbohydrates in tubers. While, the interaction treatment between 1750 m3/ fed. water quantity and 30 m3/ fed. FYM gave the highest values of P and K percentages and their uptake by shoot, tuber yield/ plant and total yield/ feddan.

Key words: Potato, water quantity, farmyard manure, free, bound water, proline amino acid WUE and tuber yield.

INTRODUCTION

Potato plant (*Solanum tuberosum* L.) is sensitive to water stress. Sensitivity of potato plant to moisture stress may be mainly due to its sparse root system which approximately 85% of the root length is concentrated in the upper 30 cm soil layer

(Opena and Porter, 1999). At all stages of growth, water stress reduces photosynthetic efficiency, but the drought during the periods of tuber initiation and bulking has the most drastic effect on the yield (Yuan *et al.*, 2003). Ideal conditions for potato growth include high and nearly constant soil water potential along with a high soil oxygen diffusion rate (Phene and Sanders, 1976). Insufficient water leads to high soil moisture tension, plant stress and reduced tuber yield, while, excess water may also reduce yield below potential levels due to leaching of the applied nutrients, increased disease incidence or failure to stimulate growth of the commercially valuable parts of the plant (Solomon, 1993).Therefore, irrigation is an essential component in commercial potato production system through arid and semi arid regions.

It was found that plant height, biomass/ plant, shoot water content (%), total fresh tuber yield and marketable tuber yield (> 85 g) of potato were increased with increasing amount of irrigation water. Irrigation water increased tuber yield not only by increasing tuber number, but also by increasing the mean weight of the tuber. The specific gravity of potato tubers tended to decrease as water applied decreased. Trend of the water use efficiency showed that the lower amount of irrigation water received, the higher water use efficiency obtained for the drier plant biomass and the tuber yield (Yuan *et al.*, 2003). Also, it was detected that, in sandy soil during summer plantation of potato, irrigation water quantity at 2000 m^3/ fed. enhanced plant growth, free and total water in leaf tissues, N, P and K concentrations and their uptake as well as tuber yield and its components (El-Ghamriny *et al.* , 2005). From on other point of view the tuber yield was reduced by deficit irrigation (Wang *et al.*, 2007).

It is well known that sandy soil is low in its fertility, low water retention , poor in physical , chemical and biological properties, and has a high soil pH .To overcome most of all of these drawbacks the addition of organic matter, almost, can improve all soil properties, such as water holding capacity, soil aggregation, aggregation stability, soil fertility, and increase cation exchange capacity. Also, organic fertilizers were used to decrease soil pH and increase the availability of major and minor nutrients. Organic fertilizers of which the farmyard manure (FYM) is the principle one plays extraordinary role in potato cultivation, not only as the source of the nutrients, but also as improving agent to physical and chemical properties of the soil (Sujatha and Krishnappa, 1995). The organic matter content of the Egyptian soils is usually less than 2% in cultivated area. Frequent and high applications of organic manure are necessary to maintain soil fertility. Farmyard manure is usually used as the main organic fertilizer in Egypt (Abdel -Moez *et al.*, 1999). In this concern it was found that fertilization of potato with farmyard manure (FYM) at 30 m^3/ *fed* increased plant height, number of leaves/ plant, foliage dry weight and tuber yield of cvs Agria and Draga (Abd El-Kader, 2002).

Another experiment illustrated that FYM application increased tuber dry matter and starch content, as well as tuber yield. The response of tuber yield to farmyard manure was not consistent over growing season, possibly the positive yield response was due to K rather than N (Makaraviciute, 2003). It was show that increasing rates of FYM up to 20 m^3/ *fed* markedly increased tuber yields of potato plants (Hammad *et al.*, 2008).

Thus, the present work aimed to study the effect of quantities of irrigation water and farmyard manure on growth, tuber yield and tuber quality as well as water use efficiency of potato plant grown under sandy soil conditions using drip irrigation system.

MATERIALS AND METHODS

This experiment was carried out during the two successive summer seasons of 2009 and 2010 at a Private farm in El-Salhyia El-Gadida region Sharkia Governorate, on potato plant cv. Diamant to study the effect of irrigation water quantity and farmyard manure as well as their interactions on growth, yield and its quality beside the water use efficiency under sandy soil conditions using drip irrigation system.

The physical and chemical properties of the used experimental soil in the two seasons showed that it was sandy in texture and had 0.05 and 0.06 % organic matter, 8.02 and 8.07 pH, 2.11 and 2.04 mmhos/cm EC, 4.61 and 4.82 ppm available N, 3.24 and 3.57 ppm available P and 9.63 and 9.21 ppm available K , respectively. The analysis of irrigation water indicated 1.58 dsm^{-1} for Ec, 8.06 for pH, 1.27, 1.11, 12.78, 0.14, 1.51, 5.93 and 7.42 mol/L for Ca, Mg, Na, K, SO_4, Cl, HCO_3 and Sodium adsorption ratio, respectively. The used Farmyard manure properties were: 12.17 and 12.27 % organic matter, 0.79 and 0.81% total N, 0.13 and 0.12 % P, 0.74 and 0.63 % K during the 1st and 2nd seasons, respectively.

The experiment included 9 treatments, which were the combinations between three irrigation water quantities (750, 1250 and 1750 m^3/ fed.) and three rates of farmyard manure (10, 20 and 30 m^3/ feddan). These treatments were arranged in a split plot design with three replicates. The irrigation water quantities were randomly arranged in the main plots and the farmyard manure levels were randomly distributed in the sub plots.

Tuber seeds were sown at 25 cm apart on January 7th and 10th during the 1st and 2nd seasons, respectively. The experimental unit area was 12.6 m^2. It contains three dripper lines with 6m length each and 70 cm distance between the two drippers lines. One line was used to measure the morphological and physiological traits and the other two lines were used for yield determinations. In addition, one row was left between each two experimental units as guard area to avoid the overlapping

infiltration of irrigation water. All the experimental units received 100 m^3 water/*fed* during germination. The amounts of irrigation water (m^3/fed) were added by using water counter and pressure gauge at 0.5 bar, which were calculated and expressed in terms of time based on the rate of water flow through the drippers (2Liter/h.) to give such amounts of water. Irrigation times in every irrigation was 21.46, 35.77 and 50.08 min. for 750, 1250 and 1750 m^3 water/*fed*, respectively and irrigation number was 44 for each treatment. The irrigation treatments were added each two days intervals began 27 and 30 Jan. (20 days after planting) and ended 25 and 27 April (7 days before harvesting) in the 1st and 2nd seasons, respectively.

Farmyard manure (FYM) levels, *i.e.,* 10, 20 and 30 m^3/ *fed* were applied during soil preparation at about 20 – 25 cm depth in the center of planting rows and covered by sand. All treatments received 120 kg N, 80 kg P_2O_5 and 100 kg K_2O kg/ *fed* as ammonium sulfate (20.6 % N), calcium super phosphate (15.5 % P_2O_5) and potassium sulfate (48-52 % K_2O), respectively. One third of N and K_2O and all P_2O_5 were added during soil preparation with FYM. The rest of N and K_2O (two thirds) were added as fertigation at 4 days interval beginning one month after planting. The normal agricultural practices were carried out as commonly followed in the district of this investigation.

Data Recorded

Growth traits and leaf chemical analyses were determined at 90 days after planting, while yield determinations were recorded at harvesting on 2 and 4 May in the 1st and 2nd seasons, respectively. Plants of one dripper line for each experimental plot were used to measure the growth traits and the other two lines were used for yield determinations. The recorded data were:

1. **Plant growth**: It was recorded as plant height, number of aerial stems/ plant and leaves number/ plant as well as shoot dry weight/ plant (g).

2. **Plant water relations**: it was recorded in the fourth upper leaf of potato plant as: total, free and bound water as well as cell sap and osmotic pressure according to the method **described by Gosev (1960).**

3. **Proline amino acid content:** it was determined in dry leaves according to the method described by Bates (1973).

4. **Percentages and Uptake of N, P and K in shoot**: Total Nitrogen, phosphorus and potassium percentages were determined in dried and wet digested shoot according to the methods described by A.O.A.C. (1990), then uptake of N, P and K by shoots was calculated.

5. Yield and its components: It included number of produced tubers/ plant, average tuber weight (g), tuber yield per plant (kg), total yield (ton/ *fed*) and the relative yield (%).

6. Water use efficiency (WUE.): It was determined by dividing the tuber yield/ *fed* by the water quantity/ *fed* and expressed as kg tuber/ m^3 water (Begg and Turner 1976) .

7. Tuber quality: Tuber quality included:

N, *P and K Contents:* Total nitrogen, phosphorous and potassium were determined in dryed tuber tissues using the same methods which previously described to determine these elements in shoot.

Carbohydrate percentage: It was determined colorimetrically in dry tubers following the methods described by A.O.A.C. (1990).

Starch content: It was determined in dried tubers using the methods of A.O.A.C. (1990).

Specific gravity: Tubers Specific gravity was determined according to the method of Murphy and Govern (1959).

Dry Matter (%): it was determined by drying 100 g of grated tuber tissues at 105 ^{0}C till constant weight, and then DM (%) was calculated.

Statistical Analysis: Collected data were subjected to statistical analysis of variance according to Snedecor and Cochran (1980), and means separation was done using L.S.D. at 5 % level of probability.

RESULTS AND DISCUSSION

1. Plant Growth

Irrigation water quantity reflected significant differences for plant height, number of leaves and shoot dry weight/ potato plant, while this quantity did not significantly affect number of aerial stems/ plant in both seasons (Table, 1). Plant height, number of leaves/ plant and dry weight of shoot significantly increased with increasing irrigation water quantity up to the highest level (1750 m^3/ fed.) Phene and Sanders (1976) found that high frequency water management by drip irrigation minimized soil as a storage reservoir for water, supplied at least daily requirements of water to a portion of the root zone of each plant and maintained a high soil metric potential in the rizosphere to reduce plant water stress. Also, these results coincided with those reported by Yuan *et al.* (2003) and El-Ghamriny *et al.* (2005).

Concerning the effect of FYM, it is quite clear from data in Table (1) that fertilization of potato plants with FYM at 20 m^3/ fed. was the superior treatment for

enhancing plant height, number of leaves/ plant and dry weight of shoot/ plant, with no significant differences with FYM at 30 m^3/feddan. Farmyard manure had no significant effect on number of produced aerial stems/ plant. Since sandy soil had low organic matter and also low mineral content, farmyard manure can improve its content of organic matter and this in turn led to improve soil conditions. For maximization exploitation of organic matter, mineralization of the manure by its flora needs of N-supply induced multiplication of such flora to utilize the organic manure. Therefore, application of organic and mineral nitrogen fertilizers together may increase the exchangeable NPK and the uptake of these elements as found by Cooke, 1972 which consequently increasing cell division and cell enlargement and as a result this might be reflected on the plant growth. These results agreed with those obtained by Abd El-Kader (2002).

Table 1. Effect of irrigation water quantity and farmyard manure on growth of potato plants during 2009 and 2010 seasons

Treatments	Plant height (cm)		No. of aerial stems /plant		No. of leaves / plant		Shoot dry weight/ plant (g)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Effect of water quantity (m^3/fed.)								
750	32.3	33.7	3.61	4.20	32.0	39.7	25.9	26.7
1250	33.9	38.3	3.74	4.63	33.9	42.2	28.6	28.4
1750	36.0	44.1	3.44	4.46	35.7	43.6	28.9	29.7
LSD at 0.05 level	2.58	4.16	NS	NS	1.14	1.11	0.91	1.02
Effect of farmyard manure (m^3/fed.)								
10	32.2	35.4	3.45	4.28	32.1	38.3	25.2	25.7
20	35.2	38.5	3.84	4.25	34.0	41.7	28.0	28.8
30	34.8	40.7	3.63	4.02	35.2	43.0	30.2	30.3
LSD at 0.05 level	1.56	3.60	NS	NS	1.56	3.86	1.82	1.86

As for interaction between water quantity and FYM , it is evident from data presented in Table 2 that the interaction treatments between irrigation quantity at 1750 m^3/ *fed* and FYM at levels of 20 or 30 m^3/fed. recorded the maximum values of plant height and dry weight of shoot with no significant differences between them and treatment of irrigation quantity 1250 m^3/ fed. interacted with 30 m^3 FYM /fed. with respect to dry weight of shoot. The interaction between irrigation water quantity at 1250 m^3/fed. and FYM at 20 or 30 m^3/ fed. or the interaction between 1750 m^3 water/ fed. and FYM at 10, 20 or 30 m^3/ fed. recorded the maximum increments regarding leaves number/ plant.

Table 2. Effect of interaction between irrigation water quantity and farmyard manure on growth of potato plants during 2009 and 2010 seasons

Treatments			Plant height (cm)		No. of aerial stems/ plant		No. of leaves/ plant		Dry weight of shoots (g)	
Water quantity (m^3/fed.)	X	FYM (m^3/fed.)	1st	2nd	1st	2nd	1st	2nd	1st	2nd
750		10	30.7	30.8	3.54	4.20	30.2	36.1	24.1	25.9
		20	32.8	34.6	3.80	4.07	32.0	39.1	25.1	26.9
		30	33.5	35.7	3.54	3.68	33.2	41.1	28.5	27.3
1250		10	31.9	36.3	3.54	4.46	31.8	38.6	26.5	25.3
		20	35.4	37.9	3.94	4.46	34.3	41.8	26.1	28.8
		30	33.9	39.9	3.94	4.46	35.7	43.9	30.1	30.9
1750		10	34.1	39.1	3.28	4.20	34.4	40.3	25.0	25.8
		20	37.3	43.1	3.80	4.20	35.7	44.2	29.8	30.6
		30	37.0	46.4	3.41	3.94	36.9	44.0	32.0	32.8
LSD at 0.05 level			2.71	6.25	NS	NS	2.71	6.70	3.17	3.23

2. Plant Water Relations

Irrigation water quantity reflected a significant effect on percentages of free water, bound water, total water, cell sap, osmotic pressure and proline amino acid in leaf tissues of potato in both seasons (Table, 3). Free and total water significantly increased with increasing water quantity whereas bound water, cell sap , osmotic pressure and proline amino acid had opposite trend with increasing water quantity in both seasons. So, water quantity of 1750 m^3/ fed. significantly increased free and total water % in leaf tissues whereas 750 m^3 water quantity/fed. significantly increased bound water, cell sap , osmotic pressure and proline amino acid in leaf tissues. The increase in bound water and the decrease in free water under water stress were mainly due to the increases in cell sap concentration and its osmotic pressure resulted from the conversion of starch into soluble carbohydrates as indicated by Lancher, 1993. These results coincided with those reported by El-Ghamriny *et al.* (2005).

Obtained results in Table (3) show that FYM had significant effect on plant water relations in potato leaf tissues during both seasons. Free and total water percentages were significantly increased with increasing FYM up to 30 m^3/ fed. whereas, bound water, cell sap, osmotic pressure and proline amino acid were significantly decreased with this increase.

Table 3. Effect of irrigation water quantity and farmyard manure on plant water relations of potato leaves during 2009 and 2010 seasons

Treatments	Free water (%)		Bound water (%)		Total water (%)		Cell sap		Osmotic pressure		Proline (mg/100 gm D.W.)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Effect of water quantity (m^3/fed.)												
750	36.4	31.6	39.2	43.2	75.6	76.3	6.64	9.43	5.26	7.71	170.22	191.86
1250	44.6	41.9	36.2	39.5	80.7	81.4	5.44	7.44	4.30	5.85	121.56	144.72
1750	47.2	55.2	33.3	32.8	80.6	84.4	4.21	5.93	3.32	4.69	94.92	94.75
LSD at 0.05 level	1.68	2.47	2.89	2.64	2.58	2.29	0.65	0.75	0.37	0.64	1.30	1.99
Effect of farmyard manure (m^3/fed.)												
10	38.2	37.4	36.8	40.6	75.0	79.4	5.99	8.03	4.75	6.36	142.84	160.39
20	43.7	44.4	36.4	38.1	80.0	81.2	5.55	7.81	4.39	6.31	133.49	143.47
30	46.4	46.9	35.5	36.8	81.9	81.4	4.74	6.95	3.74	5.57	110.36	127.46
LSD at 0.05 level	1.78	2.52	1.17	2.48	2.62	1.15	0.66	0.70	0.34	0.60	1.22	1.87

Presented data in Table 4 show that, interaction treatments between water quantity and FYM reflected significant differences on free water, bound water, total water, and cell sap , osmotic pressure and proline amino acid contents in leaf tissues in the 1st and 2nd seasons. The interaction between water quantity at 1750 m^3/ fed. and FYM at 30 m^3/ fed. was the superior treatment for increasing free and total water contents in leaf tissues whereas interaction treatment between 750 m^3 water/ fed. and FYM 10 or 20 m^3/ fed. resulted the highest values represented bound water, cell sap , osmotic pressure and proline amino acid in leaf tissues.

Table 4. Effect of the interaction between irrigation water quantity and farmyard manure on plant water relations of potato leaves during 2009 and 2010 seasons

Treatments			Free water (%)		Bound water (%)		Total water (%)		Cell sap		Osmotic pressure		Proline (mg/100 gm D.W.)	
Water quantity (m^3/ fed.)	X	FYM (m^3/ fed.)	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
750		10	33.0	26.3	39.2	44.0	72.3	74.4	7.46	9.86	5.93	8.01	185.10	203.10
		20	36.8	33.9	39.9	43.0	76.8	76.9	6.47	9.70	5.12	8.01	179.88	190.54
		30	39.2	34.7	38.6	42.7	77.8	77.5	5.98	8.73	4.72	7.11	145.69	181.96
1250		10	42.2	37.8	37.1	41.2	79.3	79.0	5.82	7.92	4.60	6.07	127.56	170.71
		20	45.4	43.1	35.8	39.1	81.1	82.2	5.66	7.60	4.46	6.07	122.35	142.98
		30	46.2	44.7	35.6	38.3	81.8	83.1	4.85	6.79	3.83	5.40	114.78	120.46
1750		10	39.2	48.2	34.3	36.7	73.5	84.9	4.69	6.31	3.71	4.99	115.87	107.35
		20	48.7	56.2	33.3	32.3	82.1	84.6	4.53	6.14	3.59	4.86	98.26	96.91
		30	53.7	61.3	32.4	29.4	86.2	83.7	3.40	5.34	2.66	4.21	70.63	79.99
LSD at 0.05 level			3.09	4.37	2.03	4.30	4.55	1.99	1.14	NS	0.59	NS	2.12	3.25

3. Percentages and Uptake of N, P and K in shoot

Presented data in Table 5 show that, in general, the high amount of irrigation water of 1750 m^3/ fed. was the most effective treatment for increasing percentages of N and K and uptake of N, P and K by potato shoot. Similar results were previously reported by El-Ghamriny *et al.* (2005). Where they found that in sandy soil during summer plantation, irrigation of potato plants with 2000 m^3 water/ fed. increased N, P and K concentrations and their uptake. However, increasing applied water quantity may increase soil moisture content which in turn may increase minerals availability.

As for FYM effects (Table, 5), significant increases in N, P and K percentages and their uptake were noticed during the two tested seasons under the effect FYM applications. Applied FYM at 30 m^3/ fed. was the best treatment for enhancing N and K percentages and their uptake by shoot, while P percentage and its uptake were increased with 20 m^3 FYM / fed. Reynders and Vlassak (1982) stated that FYM contains microorganisms as *Azotobacter ,Azospirillum, etc.* which fix N and release phytohormones as GA, IAA,CYT, etc. necessary for stimulating plant growth and dry matter content. These observations may indicate that micro-organisms have the ability to supply growing plants with N, P, K and photohormones which in turn may increase N , P and K concentrations in soil solution and their uptake by plant.

Table 5. Effect of water quantity and farmyard manure on N, P, K percentages and their uptake by potato shoots plant during 2009 and 2010 seasons

Treatments	Mineral (%)						Mineral uptake (mg/plant)					
	N		P		K		N		P		K	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Effect of water quantity (m^3/fed.)												
750	4.14	3.17	0.52	0.45	5.32	4.69	1019	848	121	121	1310	1255
1250	4.23	3.37	0.44	0.43	5.42	4.82	1158	1017	114	117	1473	1392
1750	4.34	3.45	0.45	0.53	5.49	4.93	1349	1097	134	156	1661	1575
LSD at 0.05 level	0.12	0.25	0.03	0.04	0.12	0.21	72.5	28.1	7.31	10.8	137	111
Effect of farmyard manure (m^3/fed.)												
10	4.03	3.35	0.44	0.43	5.05	4.69	976	861	108	112	1224	1204
20	4.38	3.44	0.48	0.49	5.42	4.84	1170	972	128	1386	1447	1367
30	4.74	3.70	0.46	0.47	6.10	5.40	1379	1128	133	143	1772	1651
LSD at 0.05 level	0.21	0.11	0.01	0.04	0.20	0.26	107.5	79.5	9.71	6.75	85.5	111

Interaction treatments between irrigation water quantity and FYM (Table 6) reveal that water quantity at 1750 m^3 interacted with 30 m^3 FYM / fed. gave the highest values of N, P and K percentages and their uptake in plant shoot (mg/ plant) without significant differences with the interaction treatment of 1250 m^3 water/ *fed* X 30 m^3 FYM / *fed* with respect to N content and its uptake in the both seasons.

Table 6. Effect of interaction between irrigation water quantity and farmyard manure on N, P and K percentages and their uptake by potato shoot during 2009 and 2010 seasons

Treatments			Mineral (%)						Mineral uptake (mg/ plant)					
Water quantity (m^3/fed.)	X	FYM (m^3/fed.)	N		P		K		N		P		K	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
750		10	3.70	3.05	0.47	0.44	5.06	4.65	929	790	119	115	1271	1205
		20	4.29	3.17	0.49	0.44	5.12	4.52	1036	853	120	120	1236	1217
		30	4.44	3.29	0.50	0.46	5.79	4.91	1091	899	124	128	1423	1342
1250		10	3.99	3.48	0.42	0.39	5.02	4.82	900	882	96	100	1133	1221
		20	4.31	3.47	0.43	0.43	5.78	4.86	1124	933	113	116	1508	1306
		30	4.80	3.99	0.44	0.43	5.89	5.32	1448	1236	134	135	1777	1648
1750		10	4.39	3.53	0.43	0.46	5.07	4.59	1098	911	108	120	1268	1185
		20	4.53	3.69	0.45	0.51	5.36	5.15	1350	1129	135	156	1598	1576
		30	4.99	3.81	0.50	0.58	6.61	5.98	1597	1250	161	193	2116	1963
LSD at 0.05 level			0.36	0.19	0.029	NS	0.35	0.46	186	138	16.8	11.7	148.36	193

4- Yield and its Components and Water use Efficiency (WUE)

Data presented in Table 7 showed that irrigation water quantity had significant effects on average tuber weight, tuber yield per plant and per *fed* as well as water use efficiency. The highest average tuber weight and tuber yield/ plant and / *fed* were obtained by increasing irrigation water quantity up to 1750 m^3 water/ fed. and simultaneously reduced gradually the water use efficiency for tuber production by plant. The relative increases in total yield / *fed* were 31 and 43 % for water quantity of 1750 m^3/ *fed* over the water quantity of 750 m^3/ *fed* in the 1^{st} and 2^{nd} seasons, respectively. In general, the trends for the WUE related to the total amount of irrigation water, the dry plant biomass and the production of total fresh tuber yields for the various treatments showed that the lower the amount of irrigation water received, the higher the water use efficiency. However, water stress causes reduction of tuber yield by reducing of crop canopy and biomass (Yuan *et al.,* 2003). On the other hand, higher water quantity applied to plants led to keep higher water content in plant tissues, and this in turn produced tubers heavier than those under water stress These results agree with those reported by Wang *et al.* (2007).

As regards the effect of FYM, it is evident from the data in Table (7) that fertilization of potato plants with FYM had a significant effects on average tuber weight, yield/ plant and total yield/ fed. as well as water use efficiency in both seasons. Fertilization with FYM at 30 m^3/ fed. recorded the maximum increment of average tuber weight, yield/ plant and total yield/ fed. as well as water use efficiency. The increase in total yield/ fed. was about 44 and 27 % for FYM at 30 m^3/ fed. over the FYM at 10 m^3/ *fed* in the 1^{st} and 2^{nd} seasons, respectively. Obtained results can be explained in the light of the facts that using FYM increases organic matter, availability of nutrients, nitrogen fixation, rizosphere microorganisms that release phyotohrmones and substances which led to increase growth and dry matter accumulation and this in turn might increase average tuber weight, hence increase the total yield. These results are in agreement with those reported by Abd El-Kader (2002), Makaraviciute (2003) and Hammad *et al.* (2008).

Table 7. Effect of irrigation water quantity and farmyard manure on yield and its components and water use efficiency (WUE) of potato plant during 2009 and 2010 seasons

Treatments	Number of tubers/ plant		Average weight/ tuber (g)		Yield/ plant (kg)		Total yield (ton/ *fed*)		Relative yield (%)		WUE (kg/m³)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Effect of water quantity (m³/fed.)												
750	7.79	7.59	54.6	53.7	0.42	0.41	10.3	9.22	100	100	13.7	12.3
1250	7.98	7.66	68.8	59.3	0.55	0.45	13.2	10.3	128	111	10.6	8.20
1750	7.87	8.44	70.9	69.5	0.56	0.58	13.5	13.2	131	143	7.69	7.56
LSD at 0.05 level	NS	NS	11.4	15.2	0.12	0.12	0.50	0.178	--	--	0.20	0.21
Effect of farmyard manure (m³/fed.)												
10	7.45	7.55	56.3	56.3	0.42	0.43	10.1	9.63	100	100	8.68	8.18
20	7.79	7.91	66.0	60.8	0.51	0.48	12.3	10.9	122	113	10.7	9.31
30	8.41	8.23	72.0	65.5	0.60	0.54	14.5	12.2	144	127	12.6	10.5
LSD at 0.05 level	NS	NS	2.14	3.12	0.03	0.04	0.22	0.27	-	-	0.19	0.23

It is quite clear from the data in Table (8) that the interaction between irrigation water quantity at 1250 or 1750 m^3/ fed. and FYM at all tested rates increased average tuber weight without significant differences with the interaction between water quantity at 750 m^3/ fed. and FYM at 30 m^3/ fed. The interaction between water quantity of 1750 m^3/ fed. and FYM at 30 m^3/ fed. gave the highest values of yield/ plant and total yield/ fed. in both seasons, whereas the interaction between water quantity at 750 m^3/ fed. and FYM at 30 m^3/ fed. recorded the highest values of WUE by potato plants. The increase in total yield/ fed. was about 93 and 84 % for the interaction between water quantity at 1750 m^3/ fed. and FYM at 30 m^3/ fed. over the interaction between water quantity at 750 m^3/ fed. and FYM at 10 m^3/ fed. in the 1st and 2nd seasons, respectively.

Table 8. Effect of interaction between irrigation water quantity and farmyard manure on yield and its components and water use efficiency (WUE) of potato plants during 2009 and 2010 seasons

Treatments		Number of tubers/plant		Average weight of tuber (g)		Yield/ plant (kg)		Total yield (ton/*fed*)		Relative yield (%)		WUE (kg/m³)	
Water quantity (m³/fed.) X	FYM (m³/fed.)	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
750	10	7.23	7.13	46.7	48.4	0.33	0.34	8.11	7.77	100	100	10.8	10.3
	20	7.79	7.49	56.3	53.8	0.43	0.40	10.5	9.08	129	116	14.0	12.1
	30	8.36	8.16	60.7	58.8	0.50	0.48	12.1	10.8	150	139	16.2	14.4
1250	10	7.79	7.40	59.7	55.2	0.46	0.40	11.1	9.20	137	118	8.93	7.36
	20	7.79	7.79	68.2	58.2	0.53	0.45	12.7	10.2	157	131	10.2	8.17
	30	8.36	7.79	78.5	64.6	0.65	0.50	15.7	11.3	194	145	12.6	9.06
1750	10	7.32	8.13	62.4	65.2	0.45	0.53	10.9	11.9	135	153	6.27	6.81
	20	7.79	8.45	73.4	70.5	0.57	0.59	13.7	13.4	169	172	7.84	7.66
	30	8.51	8.73	76.7	73.0	0.65	0.63	15.6	14.3	193	184	8.96	8.19
LSD at 0.05 level		NS	NS	3.71	5.42	0.05	0.07	0.37	0.46	--	--	0.33	0.39

5- Tuber Quality

Results in Table 9 show that as irrigation water quantity was increased from 750 to 1750 m³/ fed. percentages of N, P, and K, total carbohydrates, starch and dry matter (DM) in tuber tissues were significantly increased. At the same time, the tested water quantities had no significant effect on P % and tuber specific gravity. Irrigation water quantity at 1250 or 1750 m³/ fed. recorded the maximum percentages of N, P, carbohydrates, starch and DM during the two seasons. These results agree with those obtained by Yuan *et al.* (2003) where they found that specific gravity of potato tubers tended to decrease as water applied decreased.

With respect to the effect of FYM, fertilized potato plants with FYM at 20 or 30 m³/ fed. resulted tubers had more percentages of N, P, total carbohydrates, starch and DM in both seasons (Table, 9). These results are in line with those obtained by Makaraviciute (2003) as he found that FYM application increased dry matter and starch contents in tuber.

Table 9. Effect of irrigation water quantity and farmyard manure on tuber quality of potato plant during 2009 and 2010 seasons

Treatments	N (%)		P (%)		K (%)		Carbohyd-rates (%)		Starch (%)		DM (%)		Specific gravity	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Effect of water quantity (m^3/ fed.)														
750	1.58	1.64	0.39	0.41	2.48	2.60	73.3	75.1	65.0	65.6	16.4	16.9	1.18	1.10
1250	2.20	1.94	0.40	0.43	2.48	2.76	78.0	77.0	64.3	65.6	16.8	16.9	1.10	1.07
1750	2.21	1.98	0.39	0.42	3.36	2.84	79.9	76.8	68.9	67.3	17.4	17.1	1.10	1.10
LSD at 0.05 level	0.15	0.19	NS	NS	0.16	0.13	1.28	1.10	0.75	1.53	0.26	0.14	NS	NS
Effect of farmyard manure (m^3/ fed.)														
10	1.57	1.68	0.37	0.41	2.39	2.62	75.5	71.7	64.8	63.0	16.0	15.9	1.08	1.09
20	2.29	1.87	0.41	0.42	3.00	2.77	77.1	79.4	67.7	68.0	17.3	17.2	1.19	1.09
30	2.21	1.99	0.41	0.42	2.89	2.85	78.3	79.3	65.3	67.9	17.2	17.8	1.09	1.11
LSD at 0.05 level	0.16	0.17	0.02	NS	0.12	0.11	0.82	4.22	1.40	2.36	0.36	0.37	NS	NS

As for the effect of interaction (Table 10), in general, the interaction treatments between water quantity at 1750 m^3/ fed. and FYM at 20 or 30 m^3/ fed. recorded the maximum values of N, K, carbohydrates, starch and DM % in tubers with no significant differences with the interaction treatment between 1250 m^3 water quantity/ fed. and 20 or 30 m^3 FYM/ fed. with respect to N, K and carbohydrates in tubers.

From the previous mentioned results it could be concluded that, under sandy soil conditions and drip irrigation system, water quantity at 1250 m^3/ *fed* interacted with FYM at 30 m^3/ *fed* resulted high tuber quality expressed as high percentages of N, K and total carbohydrates in tuber tissues while, the interaction between 1750 m^3 water quantity / *fed* and 30 m^3 FYM /*fed* was the best treatment for enhancing tuber yield per plant and per *fed.*

Table 10. Effect of irrigation water quantity and farmyard manure on tuber quality of potato plant during 2009 and 2010 seasons

Treatments			N (%)		P (%)		K (%)		Carbohyd-rates (%)		Starch (%)		DM (%)		Specific gravity	
Water Quantity (m^3/fed.)	X	FYM (m^3/fed.)	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
750		10	1.46	1.51	0.36	0.40	2.42	2.46	69.0	69.0	61.7	59.1	14.7	15.7	1.08	1.10
		20	1.67	1.60	0.37	0.42	2.49	2.68	72.7	78.9	67.5	69.1	17.8	16.9	1.37	1.11
		30	1.60	1.81	0.41	0.40	2.53	2.65	78.1	78.1	66.0	70.9	16.8	18.2	1.09	1.11
1250		10	1.50	1.72	0.35	0.41	2.36	2.69	77.7	73.4	66.2	64.3	16.6	16.4	1.10	1.10
		20	2.64	1.99	0.42	0.43	2.73	2.66	79.1	78.6	66.3	67.2	16.7	17.0	1.11	1.04
		30	2.46	2.12	0.40	0.43	2.36	2.93	77.2	79.1	60.4	65.3	17.1	17.4	1.10	1.11
1750		10	1.75	1.82	0.37	0.42	2.39	2.72	79.9	72.7	66.5	65.7	16.8	15.6	1.08	1.11
		20	2.32	2.09	0.39	0.42	3.89	2.81	80.3	77.2	70.9	68.7	17.8	18.0	1.11	1.11
		30	2.57	2.03	0.41	0.42	3.79	2.98	79.6	80.5	69.3	67.4	17.6	17.6	1.11	1.12
LSD at 0.05 level			0.27	0.29	NS	NS	0.20	0.19	1.42	7.33	2.43	4.09	0.62	0.65	NS	NS

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تأثير كمية مياه الري والسماد البلدي على نبات البطاطس النامي في ارض رملية

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أجريت هذه التجربة خلال الموسمين الصيفيين المتتاليين لعامي ٢٠٠٩ ، ٢٠١٠ في مزرعة خاصة – بمنطقة الصالحية الجديدة – محافظة الشرقية على نبات البطاطس الصنف ديامونت النامي في ارض رمليه باستخدام نظام الري بالتنقيط بهدف دراسة تأثير كميات ماء الري (٧٥٠ ، ١٢٥٠ ، ١٧٥٠ م^3/ فدان) والسماد البلدي (١٠، ٢٠ ، ٣٠ م^3/ فدان) والتفاعل بينهما على النمو والمحصول وجودته وكفاءة استخدام المياه.

ازداد كل من ارتفاع النبات ، عدد الأوراق/ نبات ، الوزن الجاف للمجموع الخضري ، محتوى أنسجة الورقة من الماء الحر والماء الكلى ، محتوى المجموع الخضري من النتروجين والفوسفور والبوتاسيوم (كنسب مئوية) والممتص منهم بزيادة كمية مياه الري حتى ١٧٥٠ م^3/ فدان ، بينما سجل إضافة كميه مياه الري بمعدل ١٢٥٠ ، ١٧٥٠ م^3/ فدان أعلى القيم لمتوسط وزن الدرنة، لمحصول الدرنات لكل نبات و للفدان ، والنسب المئوية لكل من النتروجين والفوسفور، الكربوهيدرات والنشا والمادة الجافة بأنسجة الدرنات. ازداد معنوياً محتوى أوراق البطاطس من الماء المرتبط والضغط الاسموزى ، محتوى الأوراق من البرولين ، وكذلك كفاءة استخدام النبات للمياه بتناقص كمية مياه الري حتى ٧٥٠ م^3/ فدان.

ازداد معنويا كل من ارتفاع النبات ، عدد الأوراق/ نبات ، الوزن الجاف للمجموع الخضري ، محتوى أنسجة الورقة من الماء الحر والكلى ، محتوى المجموع الخضري والممتص من الفوسفور، النسبة المئوية لمحتوى الدرنات من النتروجين والفوسفور، الكربوهيدرات والنشا وكذلك المادة الجافة بتسميد نباتات البطاطس بالسماد البلدي بمعدل ٢٠ م^3/ فدان ، بينما ازداد محتوى المجموع الخضري من النتروجين والبوتاسيوم والممتص منهما ، متوسط وزن الدرنة ، محصول النبات و محصول الفدان، كفاءة استخدام مياه الري وذلك بزيادة كمية السماد البلدي حتى ٣٠ م^3/ فدان.

كانت معاملة للتفاعل بين كمية مياه الري ١٢٥٠ م^3/ فدان والسماد البلدي ٣ م^3/ فدان هي المعاملة الأكثر تأثيراً في زيادة كل من الوزن الجاف للمجموع الخضري ، محتوى المجموع الخضري والممتص من النتروجين، و النسب المئوية للنتروجين والبوتاسيوم، الكربوهيدرات الكلية بالدرنات ، بينما أعطت معاملة التفاعل بين ١٧٥٠ م^3 ماء ري/ فدان و ٣٠ م^3 سماد بلدي / فدان أعلى القيم للنسب المئوية للفوسفور والبوتاسيوم بالأوراق والممتص منهما بالمجموع الخضري، ولمتوسط وزن الدرنة ، ومحصول الدرنات للنبات وللفدان.