Zagazig J. Agric. Res., Vol. 33 No. (3) 2006 453 - 478

EFFECT OF IRRIGATION AND NK FERTILIZATION ON GROWTH AND PRODUCTIVITY OF POTATO PLANTS UNDER SANDY SOIL CONDITIONS

Khalil, M.A.I.[1], A. Bardisi[1], A.A. Tawfik, [2] and M.E.A. Youssef [2]

[1].Hort. Dept., Fac. Agric., Zagazig Univ., Egypt.

[2].Hort. Res. Inst., Agric. Res. Center, Dokki, Egypt.

Accepted 10 / 5 / 2006

ABSTRACT: This work was carried out during two consecutive summer seasons of 2001 and 2002 at El-Salhyia El-Qadima region (Private Farm), Sharkia Governorate, to study the effect of irrigation water quantity and combination between nitrogen and potassium fertilizers on dry weight, plant water relations and yield of potato plants grown in sandy soil.

Irrigation water quantity at 2500 m^3/*fed* increased total dry weight/ plant, average tuber weight, number of tubers/plant, marketable and total yield/feddan. Water quantity at 2000 m^3/*fed* recorded maximum bound water, cell sap, osmotic pressure in leaf tissues and water use efficiency, whereas water quantity at 3000 m^3/*fed* recorded maximum free and total water contents in leaf tissues.

The combination between N+K_2O at 150+75 or 150+150 kg/*fed* recorded maximum total dry weight/plant, and free and total water in leaf tissues. Meanwhile, N+K_2O at 150+75 kg/*fed* recorded maximum bound water in leaf tissues, average tuber weight, yield /plant and marketable yield and total yield /feddan.

The interaction between 2500 m^3 water and N+K_2O at 150+150 kg/*fed* increased total dry weight/plant, and N+K_2O at 150+75 kg/*fed* increased average tuber weight, yield/ plant and marketable and total yield/feddan.

The interaction between 2000 m^3 water and N+K_2O at 150+75 or 150+150 kg/*fed* increased cell sap and osmotic pressure in leaf tissues, and N+K_2O at 100+75 kg/fed increased bound water in leaf tissues, but N+K_2O at 150+75 increased water use efficiency, while the interaction between 3000 m^3 water and N+K_2O at 150+75 or 150+150 kg/fed increased both free and total water in leaf tissues.

Key Words: Water quantity, N+K_2O, dry weight, yield and potato.

INTRODUCTION

Water quantity is considered as one of the main factors that greatly affect plant growth of potato, particularly, under sandy soil conditions. This may be due to that; sandy soil is very poor in its ability to preserve water against leaching. This soil, on the other hand, had a suitable texture for potato tubers growth and formation.

Increasing the irrigation water quantity increased yield of potato (Steyn *et al.*, 1992; Gunel and Karadugan, 1998; Ramnik *et al.*, 1999; Belanger *et al.*, 2000). Irrigation after the depletion of 20 % or 30 % of available soil moisture increased dry weight/ plant, total and free water (%) in leaf tissues of potato plant cv. Spunta (Abdel-Rheem, 2003), mean tuber weight, number of tubers/plant, yield/plant and yield/ *fed* as well as water utilization efficiency of potato plant cvs. Diamant, Alpha and Mondial (El-Masry and Abou-Arab, 2000), whereas, irrigation after the depletion of 80 % increased bound water (%) and osmotic pressure in leaf tissues of potato (Abdel-Rheem, 2003);

El-Ghamriny *et al.* (2005a and b), under sandy soil conditions, found that water quantity at 2000 m^3/*fed* showed enhancing effect on dry weight/plant, free and total water (%) in leaf tissues and total yield of potato cv. Diamant. Meanwhile, bound water (%) was at its maximum value under water stress (500 m^3/*fed*). Decreasing of water supply increased water use efficiency of potato plants (Gameh *et al.*, 2000; El-Banna *et al.*, 2001).

The combination between N and K_2O at 150+120 kg/ha (Satyanarayana and Arora, 1985) and at 80+72 kg/*fed* (Shehata and Abo-Sedera, 1994), and at 100+90 kg/*fed* (Abo-Sedera and Shehata, 1994) increased number of tubers/ plant, yield/ plant and total yield of potato.

Total and free water (%) in leaf tissues of tomato increased, while the bound water decreased with increasing N or K_2O fertilizers at 150 kg N or 100 kg K_2O/*fed* (Khalil, 1982).

Under sandy soil conditions, fertilization of sweet potato with N+K_2O as fertigation at 100+140 kg/*fed* increased dry weight of leaves and branches, while at 60+60 kg/*fed* increased total yield (Ayoub, 2005).

The interaction between water quantity at 904 or 1205 m^3/*fed* (75-100 % ETP) and N at 120 kg /*fed*

significantly increased average tuber weight, yield, total yield/*fed* and water use efficiency of potato *cv.* Spunta under El-Nubaria region (Hegaze and Awad, 2002). The irrigation treatment every 10 days by intervals combined with level of 80+72 kg NK/*fed* recorded maximum values of tuber yield of potato (Shehata and Abo-Sedera, 1994).

Therefore, the objective of this work was to study the effect of water quantity and combination between nitrogen and potassium fertilizers on growth, expressed as dry weight, plant water relations and yield and its components of potato plants grown in sandy soil.

MATERIALS AND METHODS

This work was carried out during two consecutive summer seasons of 2001 and 2002 at the Private Farm, El-Salhyia El-Qadima, Sharkia Governorate, to study the effect of irrigation water quantity and combination between nitrogen and potassium fertilizers on growth, plant water relations and yield of potato (*Solanum tuberous* L.) under sandy soil conditions.

The physical and chemical properties of the experimental soil (average two seasons) were 96.90 % sand, 0.90 % silt, 2.20 % clay, 1.0 % organic matter, 9.39 % FC, 2.62 % WP, 7.60 pH, 2.00 dSm^{-1} EC, 10.40 ppm available N, 2.98 ppm available P and 34.44 ppm available K. For irrigation water analysis, 7.72 pH, 1.83 dSm^{-1} EC, 5.86, 3.54, 9.28, 0.20, 9.84, 2.63 and 6.41 mq/100 gm soil for Ca^{++}, Mg^{++}, Na^{+}, K^{+}, SO_4^{--}, Cl^{-} and HCO_3^{-}, respectively.

This experiment included 18 treatments, which were the combinations between three irrigation water quantities and six rates of combination between nitrogen and potassium fertilizers as follows:

Irrigation water quantity: 2000, 2500 and 3000 m^3 /*fed.*

Amounts of combination between nitrogen and potassium fertilizers: 100 + 75, 100 + 150, 125 + 75, 125 + 150, 150 + 75 and 150 + 150 kg $N+K_2O$/*fed*, respectively.

These treatments were arranged as split plot in a randomized block design with three replications. The irrigation water quantities were randomly distributed in the main plots and amounts of combination between nitrogen and potassium fertilizers were randomly arranged in the sub plots.

The plot area was 22.5 m^2. It contains two dripper lines with 12.5m length and 0.9 m width. One line was used for samples to measure the plant growth (dry weight) and the other line was used for yield determination. Drip irrigation system was used and the distance between drippers was 50 cm. In addition, one row was left between each two experimental plots as a guard area to avoid the over lapping infiltration of irrigation or fertilization.

All experimental units received equal amounts of water during germination (100 m^3 water/*fed).* The irrigation treatments started 20 days after planting and were added by two days intervals. The water was added using water counter and pressure gauge at 1 bar. The amounts of added water at different treatments were calculated and expressed in terms of time based on the rate of water flow through the drippers (4 liter /h.) to give such amounts of water. The irrigation treatments were stopped five days before harvesting time. Irrigation numbers, the time (min.) and water quantity (m^3) in every irrigation are shown in Schedule 1.

Schedule 1: The time (minute) and amounts of applied irrigation water (m^3/*fed* as well as /plot) in every irrigation during the growth period of potato via dripper lines with discharge of 4 liter /h. for each dripper at 1 bar

Water quantity (m^3/fed.)	Irrigation numbers	Irrigation time in every irrigation (min.)	Water quantity every irrigation (m^3)		
			(m^2)	Plot	feddan
2000	45	71	0.0105	0.235	44.44
2500	45	89	0.0132	0.294	55.55
3000	45	107	0.0158	0.353	66.66

Tuber seeds were sown on Feb.10th and Jan.29 th in both summer seasons of 2001 and 2002, respectively and spaced at 25 cm apart. The weight of potato tuber seed was about 60 gm. Tuber seeds were sown in hills on one side of ridge.

Tuber seeds of potato cultivar (Diamant) were used and its source was Hort. Res. Ins., Agric. Res. Center. The sources of nitrogen and potassium fertilizers were ammonium nitrate (33% N) and potassium sulphate (48-52% K_2O), respectively. One third of amount

of ammonium nitrate and potassium sulphate and all amount of calcium superphosphate (15.5% P_2O_5) were added during soil preparation with farmyard manure (30 m^3/*fed*) in the center of planting rows and the fertilizers were covered by sand. The rest of ammonium nitrate and potassium sulphate were splited into 30 equal portions and then added to the plants every two days, beginning 21 days after planting through irrigation water (fertigation). Other recommended agricultural practices for commercial potato production were followed.

Data Recorded

A random sample of six plants was taken from every plot at 75 days after planting, in both seasons of study, to determine the following parameters:

Plant growth: (expressed as dry weight): Different plant parts were dried at 70 ^{0}C till constant weight and the following data were recorded: Dry weight of roots, stems, leaves, tubers and total dry weight/ plant.

Plant water relations: Total, free, bound water, cell sap and osmotic pressure in the fourth upper leaf of potato plants were determined for every experimental unit at 75 days after planting in both seasons, according to the method described by Gosev (1960).

Yield and its components: At harvest (115days after planting) tubers from each plot were calculated, weighed, counted and graded into three sizes according to specification laid down by the Ministry of Economic for potato exportation (1963) as follows: Grade 1: tubers with diameter above 5.5 cm, grade 2: tubers with diameter between 3.5- 5.4 cm, grade 3: tubers with diameter less

than 3.5 cm and marketable yield (grade 1+ grade 2) ton/*fed.* After that each grade was weighted separately. Also the following data were recorded: Number of tubers/plant, average tuber weight (gm), tuber yield per plant (gm), total yield (ton/*fed*) and relative yield (%).

Water use efficiency (WUE.): It was calculated according to equation of Begg and Turner (1976) as follows:

$$\text{Water use efficiency} = \frac{\text{Water quantity } (m^3/fed)}{\text{Yield } (kg/fed)} \quad (kg/m^3)$$

Statistical Analysis

The data were subjected to proper statistical analysis of variance according to Snedecor and Cochran (1980) and means separation were done according to L.S.D. at 5 % level of probability.

RESULTS AND DISCUSSION

Plant Growth

Effect of water quantity

Data in Table 1 indicate that the growth, expressed as dry weight of roots, stems and leaves/ plant significantly increased with increasing water quantity up to 3000 m^3/fed, whereas dry weight of tubers and total dry weight significantly increased with increasing water quantity up to 2500 m^3/fed without significant differences between 2500 and 3000 m^3/fed, in the first season, with respect to total dry weight/ plant. The increases of total dry weight were about 16 and 20 % for water quantity at 2500 m^3/fed and 18 and 10 % for water quantity at 3000 m^3/fed over the water quantity at 2000 m^3/fed in the first and second season, respectively.

It could be suggested that increasing water quantity applied to potato plant led to keep higher moisture content in the soil, and this in turn might favoured the plant metabolism that leads to increase the plant growth characters and to produce higher dry matter. Water stress, on the other hand, led to cause a reduction in the uptake of nutritional elements; that might causes a disturbance in the physiological processes need for plant growth (Salter and Goode, 1967). Obtained results are in good line with those reported by El-Ghamriny *et al.* (2005a) on potato.

Table 1: Effect of irrigation water quantity on the dry weight of potato plants grown in sandy soil at 75 days after planting

Irrigation water quantity (m^3/*fed*)	Dry weight (gm/plant)					Relative (%)
	Roots	Stems	Leaves	Tubers	Total	
				2001 season		
2000	7.92	11.15	63.73	171.42	254.23	100
2500	9.17	12.01	75.55	200.14	297.10	116
3000	9.89	13.18	86.81	191.37	301.73	118
L.S.D. at 0.05 level	0.43	1.02	2.71	4.51	6.76	--
				2002 season		
2000	5.63	8.01	23.55	175.84	213.03	100
2500	5.65	9.75	27.56	213.63	256.59	120
3000	6.28	10.91	32.60	185.73	235.57	110
L.S.D. at 0.05 level	0.23	0.26	0.99	3.55	3.57	--

Effect of combination between N and K_2O

Data in Table 2 show that fertilization of potato plants with N+K_2O at 150 +150 kg/fed significantly increased dry weight of roots, stems, leaves, tubers and total dry weight/ plant, except tuber dry weight in the first season, without significant differences among N+K_2O at 150 +150, 125 +150 and 150 +75 kg/*fed* in the second season with respect to total dry weight/ plant. The increases of total dry weight were about 41 and 30 % for N+K_2O at 150 +150 over the N+K_2O at 100+75 kg/fed in the first and second season, respectively.

The increase in plant growth may be attributed to the beneficial effects of N on stimulating for aerostatic activity for producing more tissues and organs, since N plays major roles in the synthesis of structural proteins and other several macromolecules, in addition its vital contribution in several biochemical processes in the plant related to growth (Marcher, 1995). Besides, nitrogen is an important constituent of protoplasm. Also, enzyme, the biological catalytic agents, which speed up life processes, have N as their major constituents (Mengel and Kirkby, 1978). Moreover, potassium element is very important in overall metabolism of plant enzymes activity, it was found to serve a vital role in photosynthesis by direct increasing in growth and leaf area. Potassium also has a beneficial effect on water consumption (Mengel and Kirkby, 1978; Gardener *et al.* 1995). These results are in harmony with those reported by Ayoub (2005) on sweet potato under sandy soil conditions.

Effect of the interaction between water quantity and combination between N and K_2O

Data in Tables 3 and 4 show that the interaction between water quantity at 3000 m^3/fed and N+K_2O at 150+150 kg/*fed* significantly increased dry weight of roots, stems and leaves, except roots dry weight in the second season. The interaction between water quantity at 2500 m^3/*fed* and N+K_2O at 150+75 kg/*fed* significantly increased dry weight of tubers and total dry weight/ plant and without significant differences between the interaction of water quantity at 3000 m^3/*fed* and N+K_2O at 150+150 kg/*fed* in the second season. The increases in total dry weight were about 81 and

Table 2: Effect of combination between nitrogen and potassium fertilizers on the dry weight of potato plants grown in sandy soil at 75 days after planting

Amount of $N + K_2O$ (kg/*fed*)	Dry weight (gm/plant)					Relative (%)
	Roots	Stems	Leaves	Tubers	Total	
			2001 season			
100 + 75	6.88	9.63	55.72	156.24	228.47	100
100 + 150	7.77	10.91	60.63	182.86	262.23	114
125 + 75	8.82	11.97	68.00	182.72	271.96	119
125 + 150	8.98	12.38	78.87	204.13	304.37	133
150 + 75	10.55	12.66	86.82	206.91	316.89	138
150 + 150	10.95	15.13	102.14	193.00	322.21	141
L.S.D. at 0.05 level	0.41	0.64	2.44	4.99	3.00	---
			2002 season			
100 + 75	4.45	7.49	21.84	162.85	196.63	100
100 + 150	5.37	8.70	24.65	189.07	227.78	115
125 + 75	5.61	9.14	26.55	187.19	228.48	114
125 + 150	5.77	9.94	28.07	214.82	258.60	131
150 + 75	7.01	10.54	30.80	193.85	242.35	123
150 + 150	6.92	11.52	35.54	202.60	256.58	130
L.S.D. at 0.05 level	0.28	0.50	0.68	4.61	13.93	---

Table 3: Effect of the interaction between irrigation water quantity and combination between nitrogen and potassium fertilizers on the dry weight of potato plants grown in sandy soil at 75 days after planting

Water quantity (m^3/*fed*)	X	Amount of N + K_2O (Kg/*fed*)	Dry weight (gm/plant)					Relative (%)
			Roots	Stems	Leaves	Tubers	Total	
					2001 season			
2000		100 + 75	5.63	8.10	41.77	147.93	203.43	100
		100 + 150	6.96	9.71	49.43	175.44	241.66	118
		125 + 75	7.51	11.10	58.90	169.93	247.44	121
		125 + 150	7.56	11.97	62.19	206.34	288.06	141
		150 + 75	9.61	12.40	70.27	183.44	275.72	135
		150 + 150	10.23	13.64	99.81	145.42	269.08	132
2500		100 + 75	7.33	9.60	54.36	163.25	234.54	115
		100 + 150	7.63	11.30	61.01	205.83	285.83	140
		125 + 75	8.93	12.20	62.72	177.37	262.55	129
		125 + 150	9.30	12.28	83.70	205.16	310.44	152
		150 + 75	10.64	12.42	91.60	246.20	360.86	177
		150 + 150	11.20	14.26	99.90	203.02	328.38	161
3000		100 + 75	7.69	11.17	71.02	157.53	247.43	121
		100 + 150	8.72	11.72	71.44	176.32	259.20	127
		125 + 75	10.03	12.62	82.38	200.86	305.89	150
		125 + 150	10.07	12.89	90.73	200.90	314.62	154
		150 + 75	11.41	13.17	98.60	191.08	314.09	154
		150 + 150	11.42	17.50	106.71	230.54	369.17	181
L.S.D. at 0.05 level			0.70	1.14	4.23	8.64	10.39	---

Table 4: Effect of the interaction between irrigation water quantity and combination between nitrogen and potassium fertilizers on the dry weight of potato plants grown in sandy soil at 75 days after planting

Water quantity (m^3/*fed*)	X	Amount of N + K_2O (Kg/*fed*)	Dry weight (gm/plant)					Relative (%)
			Roots	Stems	Leaves	Tubers	Total	
					2002 season			
2000		100 + 75	3.93	6.16	17.60	147.66	175.35	100
		100 + 150	5.57	6.80	19.96	188.45	220.78	125
		125 + 75	5.08	7.05	21.19	163.41	196.74	112
		125 + 150	5.30	8.40	22.41	226.78	262.89	149
		150 + 75	7.30	8.92	27.86	165.32	209.40	119
		150 + 150	6.62	10.71	32.27	163.41	213.01	121
2500		100 + 75	4.52	7.19	22.18	196.34	230.19	131
		100 + 150	4.79	8.47	23.96	227.25	264.48	150
		125 + 75	5.22	9.37	26.08	203.20	243.88	139
		125 + 150	5.48	10.32	28.67	209.01	253.48	144
		150 + 75	6.76	11.35	29.14	230.34	277.69	158
		150 + 150	7.11	11.77	35.33	215.62	269.84	153
3000		100 + 75	4.89	9.13	25.62	144.55	184.19	105
		100 + 150	5.75	10.83	30.02	151.50	198.10	112
		125 + 75	6.52	10.99	32.38	194.95	244.83	139
		125 + 150	6.53	11.10	33.14	208.68	259.44	147
		150 + 75	6.96	11.35	35.40	185.90	239.96	136
		150 + 150	7.03	12.08	39.02	228.78	286.91	163
L.S.D. at 0.05 level			2.49	0.87	1.18	8.00	24.13	---

63 % for the interaction between 3000 m^3 water/*fed* combined with N+K_2O at 150 +150 over the interaction between 2000 m^3 water/*fed* combined with N+K_2O at 100+75 kg/*fed* in the first and second season, respectively.

Plant Water Relations

Effect of water quantity

Data in Table 5 indicate that the percentage of free and total water in leaf tissues significantly increased with increasing water quantity at 3000 m^3/*fed*, while bound water, cell sap and osmotic pressure significantly decreased with increasing water quantity up to 3000 m^3/*fed*. This means that water quantity at 3000 m^3/*fed* significantly increased free and total water, while water quantity at 2000 m^3/*fed* significantly increased bound water, cell sap and osmotic pressure in leaf tissues.

The increase in the bound water and decrease in free water under water stress was mainly due to the increases in cell sap concentration and its osmotic pressure resulted from the conversion of starch into soluble carbohydrates (Lancher, 1993). These results are in harmony with those reported by El-Ghamriny *et al.* (2005a) on potato.

Effect of combination between N and K_2O

Data in Table 6 show that fertilization of potato plants with N+K_2O at 150+75 or 150+150 kg/*fed* significantly increased free and total water (%), cell sap and osmotic pressure without significant differences among 150 + 150, 150 + 75, 150 + 125 and 125 + 75 kg/*fed* with respect to total water (%) in leaf tissues, while N + K_2O at 100 + 75 kg/*fed* significantly increased bound water (%) in leaf tissues without significant differences among N + K_2O at 100 + 75, 100 + 150, 125 + 75 and 150 + 150 kg/*fed* in the first season only.

It could be suggested that the highest levels of N or K_2O fertilizers (150 kg N or 120 kg K_2O/*fed*) enhanced free water and total water due to the depressive effect on bound water as well as cell sap and osmotic pressure. These results are in harmony with Khalil 1982 on tomato.

Effect of the interaction between water quantity and combination between N and K_2O

Data in Tables 7 and 8 indicate that the interaction between water quantity at 3000 m^3/*fed* and N + K_2O at 150 + 75 or 150 + 150 kg/*fed* significantly

Table 5: Effect of irrigation water quantity on the plant water relations of potato leaves grown in sandy soil at 75 days after planting

Irrigation water quantity (m^3/*fed*)	Free water (%)	Bound water (%)	Total water (%)	Cell sap	Osmotic pressure
			2001 season		
2000	32.77	54.32	87.09	6.75	5.36
2500	42.83	48.73	91.56	5.53	4.37
3000	55.46	38.28	93.74	4.06	3.20
L.S.D. at 0.05 level	7.16	4.91	2.45	1.27	1.04
			2002 season		
2000	33.87	55.04	88.91	9.19	7.52
2500	45.50	44.89	90.39	7.50	5.98
3000	60.61	31.04	91.65	5.56	4.39
L.S.D. at 0.05 level	7.60	4.58	0.56	0.59	0.53

Table 6: Effect combination between nitrogen and potassium fertilizers on the plant water relations of potato leaves grown in sandy soil at 75 days after planting

Amount of $N + K_2O$ (kg/*fed*)	Free water (%)	Bound water (%)	Total water (%)	Cell sap	Osmotic pressure
			2001 season		
100 + 75	38.90	49.71	88.61	4.83	3.81
100 + 150	40.92	48.02	88.94	4.89	3.85
125 + 75	42.26	48.47	90.73	5.17	4.08
125 + 150	44.65	47.60	92.25	5.61	4.44
150 + 75	46.67	45.07	91.74	6.00	4.76
150 + 150	48.71	43.79	92.5	6.17	4.90
L.S.D. at 0.05 level	2.46	3.64	2.28	0.41	0.34
			2002 season		
100 + 75	40.73	48.91	89.64	6.61	5.28
100 + 150	44.32	45.45	89.77	7.00	5.61
125 + 75	45.59	44.52	90.11	7.22	5.79
125 + 150	46.98	43.37	90.35	7.39	5.94
150 + 75	50.08	40.85	90.93	8.00	6.46
150 + 150	52.27	38.82	91.09	8.28	6.70
L.S.D. at 0.05 level	2.12	2.15	0.27	0.55	0.48

Table 7: Effect of the interaction between irrigation water quantity and combination between nitrogen and potassium fertilizers on the plant water relations of potato leaves grown in sandy soil at 75 days after planting

Water quantity (m^3/fed)	X	Amount of N + K_2O (Kg/*fed*)	Free water (%)	Bound Water (%)	Total water (%)	Cell sap	Osmotic pressure
					2001 season		
2000		**100 + 75**	30.10	52.52	82.62	6.17	4.87
		100 + 150	31.89	50.93	82.82	6.17	4.87
		125 + 75	32.46	55.44	87.9	6.33	5.01
		125 + 150	33.00	55.87	88.87	6.67	5.30
		150 + 75	34.02	55.36	89.38	7.33	5.83
		150 + 150	35.17	55.81	90.98	7.83	6.26
2500		**100 + 75**	36.22	54.87	91.09	5.00	3.95
		100 + 150	39.14	52.13	91.27	5.00	3.95
		125 + 75	41.91	49.64	91.55	5.33	4.21
		125 + 150	44.31	46.29	90.60	5.83	4.61
		150 + 75	46.73	45.14	91.87	6.00	4.74
		150 + 150	48.65	43.32	91.97	6.00	4.74
3000		**100 + 75**	50.39	41.75	92.14	3.33	2.60
		100 + 150	51.73	41.00	92.73	3.50	2.74
		125 + 75	52.41	40.34	92.75	3.83	3.02
		125 + 150	56.64	39.65	96.29	4.33	3.42
		150 + 75	59.26	34.72	93.98	4.67	3.69
		150 + 150	62.31	32.23	94.54	4.67	3.69
L.S.D. at 0.05 level			4.25	6.31	3.94	0.72	0.61

Table 8: Effect of the interaction between irrigation water quantity and combination between nitrogen and potassium fertilizers on the plant water relations of potato leaves grown in sandy soil at 75 days after planting

Water quantity (m^3/fed)	X	Amount of $N + K_2O$ (Kg/*fed*)	Free water (%)	Bound Water (%)	Total water (%)	Cell sap	Osmotic pressure
					2002 season		
2000		**100 + 75**	26.48	61.63	88.11	8.33	6.74
		100 + 150	32.38	55.96	88.34	8.83	7.17
		125 + 75	33.04	55.80	88.84	9.00	7.33
		125 + 150	34.79	54.24	89.03	9.17	7.49
		150 + 75	37.07	52.36	89.43	9.67	7.95
		150 + 150	39.49	50.23	89.72	10.17	8.40
2500		**100 + 75**	41.14	48.74	89.88	6.83	5.42
		100 + 150	43.05	46.88	89.93	7.17	5.70
		125 + 75	43.61	46.72	90.33	7.33	5.83
		125 + 150	44.87	45.72	90.59	7.50	5.68
		150 + 75	49.57	41.17	90.74	8.00	6.41
		150 + 150	50.74	40.12	90.86	8.17	6.56
3000		**100 + 75**	54.57	36.38	90.95	4.67	3.69
		100 + 150	57.52	33.51	91.03	5.00	3.95
		125 + 75	60.11	31.05	91.16	5.33	4.21
		125 + 150	61.27	30.15	91.42	5.50	4.34
		150 + 75	63.61	29.03	92.64	6.33	5.01
		150 + 150	66.59	26.10	92.69	6.50	5.15
L.S.D. at 0.05 level			3.67	3.73	1.46	0.95	0.82

increased free and total water, while the interaction between water quantity at 2000 m^3/*fed* and N + K_2O at 100 + 75 kg/*fed* significantly increased bound water, without significant differences between water quantity at 2000 m^3/*fed* and N + K_2O at 100 + 75, or 100 + 75 or 125 + 75 or 150 + 75 or 150 + 75 or 150 + 150 kg/ *fed* and the interaction between water quantity at 2500 m^3/fed and N + K_2O at 100 + 75 , or 100 + 150 or 125 + 75 kg/ *fed* in the first season. The interaction between water quantity at 2000 m^3/ *fed* and N + K_2O at 150 + 75 or 150 + 150 kg/*fed* significantly increased bound water, cell sap and osmotic pressure in leaf tissues. This finding might be due to depressive effect on free and total water contents. The results hold true in the two growing seasons.

Yield and Its Components

Effect of water quantity

Presented data in Table 9 show that water quantity at 2500 m^3/*fed* significantly increased average tuber weight, number of tuber/plant, yield of grade 1, marketable and total yield/*fed* in both seasons and yield of grade 2 in the second season, while water quantity at 2000 m^3/*fed* significantly increased water use efficiency of potato plants. The increases in yield were about 5 and 5 % for water quantity at 2500 m^3/ *fed* over the water quantity at 2000 m^3/*fed* in the first and second season, respectively. The increase of total yield/*fed* might be due to the increase in average tuber weight (Table 9). Also this might be due to the favourable effect of higher amounts of irrigation water on dry weight (Table 1).

Higher water quantity applied (2500 m^3/*fed*) to plants led to keep higher water content in the plant tissues and this in turn produced heavier tubers than those under water stress. Water stress causes an increase in ABA/CYT ratio, which in turn decreased plant growth (Marchner, 1995). He added that under sufficient water conditions there was a decrease in ABA and increase in CYT, GA (Gibberellic acid) and IAA (Indole acetic acid) reflecting good growth, dry matter content and yield. Moreover, under water stress the synthesis of ABA from carotenoids in roots occurs and then transport to different parts of plant especially leaves and this in turn affect the dry matter accumulation in leaves and different organs (Lancher, 1993).

These results meant that increasing the amount of irrigation water (3000 m^3/*fed*) could lead to

Table 9: Effect of irrigation water quantity on the yield and its components as well as water use efficiency (W.U.E.) of potato plants

Irrigation water quantity (m^3/*fed*)	Average tuber weight (gm)	Tubers/ plant		Ton/*fed*					Relative yield (%)	W.U.E. (Kg/m^3)
		Number	Weight (kg)	Grade 1	Grade 2	Grade 3	Marketable yield	Total yield		
2001 season										
2000	68.20	14.733	1.003	3.971	12.558	2.202	16.530	18.732	100	9.366
2500	74.76	14.111	1.055	4.461	12.943	2.288	17.403	19.691	105	7.877
3000	70.81	14.481	1.024	4.151	12.748	2.214	16.899	19.113	102	6.371
L.S.D. at 0.05 level	2.70	N.S.	0.018	0.330	N.S.	N.S.	0.335	0.334	--	0.146
2002 season										
2000	80.581	14.308	1.145	7.787	11.622	1.646	19.409	21.056	100	10.528
2500	84.198	14.330	1.207	8.423	12.099	1.709	20.522	22.230	105	8.892
3000	81.892	14.265	1.167	8.260	11.729	1.628	19.989	21.617	102	7.206
L.S.D. at 0.05 level	2.78	N.S.	0.047	0.290	0.217	N.S.	0.454	0.559	--	0.237

N.S.: Not significant at 0.05 level of probability.

nitrogen deficiency according to leaching of NO_3^- from the root zone of potato plants, in sandy soil.

Similar findings were reported by Steyn *et al.* (1992), Gunel and Karadugan (1998), Ramnik *et al.* (1999), Belanger *et al.* (2000), El-Masry and Abou-Arab (2000), Gameh *et al.* (2000), El-Banna *et al.* (2001), Abdel Rheem (2003) and El-Ghamriny *et al.* (2005b).

Effect of combination between N and K_2O

Results in Table 10 indicate that the fertilization of potato plants with N+K_2O at 150+75 kg/*fed* significantly increased average tuber weight, yield/ plant, yield of grades 1, 2 and 3, marketable and total yield in both seasons as well as water use efficiency of potato plants and number of tubers/ plant in the second season. The increases in yield were about 31 and 33 % for N+K_2O at 150+75 kg/*fed* over the N+K_2O at 100+75 kg/*fed* in the first and second season, respectively. The increase in total yield/*fed* might be due to the increase of average tuber weight (Table 10). Also this might be due to the favourable effect of N + K_2O at 150 + 75 kg/*fed* on dry weight (Table 2).

This might be related to the favorable effects of nitrogen on the plant leaf area that possibly, increased the efficiency of photosynthesis and resulted in more accumulation of stored food in the tubers. Also, this might be due to the results of increasing the nitrogen concentration in the soil solution, which increases potato vegetative growth, which activates the photosynthesis and other physiological processes, and forms strong root system, which absorb adequate amount of water. These results are in harmony those reported by Styanarayan and Arora (1985), Shehata and Abo-Sedera (1994), Abo-Sedera and Shehata (1994), Hegazi and Awad (2002) on potato and Ayoub (2005) on sweet potato.

Effect of the interaction between water quantity and combination between N and K_2O

Presented data in Tables 11 and 12 show that the interaction between water quantity at 2500 m^3/*fed* and N+K_2O at 150+75 kg/ *fed* significantly increased average tuber weight, yield/ plant, yield of grades 1, 2 and 3, marketable and total yield/ *fed* in both seasons and number of tubers/ plant in the second season. The interaction

Table 10: Effect of combination between nitrogen and potassium fertilizers on the yield and its components as well as water use efficiency (W.U.E.) of potato plants

Amount of fertilizers $N+K_2O$ (kg/*fed*)	Average tuber weight (gm)	Tubers/ plant		Ton/*fed*					Relative yield (%)	W.U.E. (Kg/m^3)
		Number	Weight (kg)	Grade 1	Grade 2	Grade 3	Marketable yield	Total yield		
2001 season										
100 + 75	58.41	14.422	0.840	2.724	11.178	1.786	13.902	15.687	100	6.427
100 + 150	67.35	14.731	0.990	3.973	12.481	2.019	16.454	18.473	117	7.582
125 + 75	72.26	14.175	1.022	4.240	12.667	2.171	16.908	19.079	121	7.815
125 + 150	74.15	14.489	1.074	4.567	13.124	2.358	17.691	20.049	127	8.225
150 + 75	76.98	14.383	1.106	4.660	13.479	2.515	18.139	20.654	131	8.527
150 + 150	78.37	14.450	1.132	5.002	13.569	2.559	18.571	21.130	134	8.651
L.S.D. at 0.05 level	2.45	N.S.	0.024	0.254	0.329	0.165	0.452	0.452	--	0.186
2002 season										
100 + 75	68.294	14.710	0.997	6.522	10.715	1.223	17.237	18.460	100	7.552
100 + 150	79.170	13.990	1.107	7.605	11.334	1.490	18.940	20.430	110	8.383
125 + 75	83.366	13.420	1.117	7.630	11.604	1.552	19.234	20.786	112	8.506
125 + 150	83.915	14.246	1.192	8.285	11.991	1.783	20.276	22.059	119	9.016
150 + 75	89.283	15.049	1.342	9.664	12.986	1.964	22.650	24.614	133	10.170
150 + 150	89.315	14.391	1.283	9.235	12.269	1.954	21.504	23.458	127	9.624
L.S.D. at 0.05 level	2.98	0.80	0.044	0.282	0.451	0.247	0.511	0.600	--	0.245

N.S.: Not significant at 0.05 level of probability

Table 11 : Effect of the interaction between irrigation water quantity and both nitrogen and potassium fertilizers on the yield and its components as well as water use efficiency (W.U.E.) of potato plants

Water quantity (m^3/*fed*)	X	Amount of N and K_2O (Kg/fed.)	Average tuber weight (g)	Tubers/ plant		Ton/*fed*					Relative yield (%)	W.U.E. Kg/m^3
				Number	Weight (Kg)	Grade 1	Grade 2	Grade 3	Marketable yield	Total yield		
2001 season												
2000		100 + 75	54.75	14.575	0.797	2.198	10.727	1.960	12.925	14.885	100	7.443
		100 + 150	63.35	15.042	0.950	3.771	11.989	1.974	15.760	17.734	119	8.867
		125 + 75	67.81	14.792	1.003	4.195	12.461	2.060	16.656	18.716	125	9.358
		125 + 150	72.22	14.833	1.071	4.622	13.130	2.242	17.752	19.994	134	9.997
		150 + 75	74.65	14.742	1.099	4.315	13.635	2.573	17.950	20.523	137	10.261
		150 + 150	76.39	14.417	1.100	4.726	13.409	2.405	18.135	20.540	137	10.270
2500		100 + 75	64.23	13.942	0.894	3.504	11.424	1.759	14.928	16.687	112	6.675
		100 + 150	73.66	14.375	1.058	4.408	13.315	2.024	17.723	19.747	132	7.899
		125 + 75	74.32	13.517	1.003	4.194	12.326	2.200	16.520	18.720	125	7.488
		125 + 150	74.22	14.000	1.039	4.292	12.728	2.371	17.019	19.390	130	7.756
		150 + 75	84.67	14.308	1.211	5.448	14.274	2.882	19.722	22.605	151	9.042
		150 + 150	77.46	14.525	1.125	4.917	13.589	2.492	18.507	20.999	141	8.399
3000		100 + 75	56.25	14.750	0.830	2.469	11.384	1.637	13.852	15.490	104	5.163
		100 + 150	65.05	14.775	0.961	3.739	12.140	2.060	15.878	17.938	120	5.979
		125 + 75	74.64	14.217	1.061	4.332	13.215	2.254	17.546	19.801	133	6.600
		125 + 150	76.02	14.633	1.112	4.787	13.515	2.462	18.302	20.764	139	6.921
		150 + 75	71.61	14.100	1.009	4.216	12.529	2.088	16.745	18.833	126	6.278
		150 + 150	81.26	14.408	1.171	5.362	13.709	2.780	19.071	21.851	146	7.284
L.S.D. at 0.05 level			4.25	N.S.	0.041	0.440	0.569	0.286	0.783	0.334	--	0.323

N.S.: Not significant at 0.05 level of probability.

Table 12: Effect of the interaction between irrigation water quantity and both nitrogen and potassium fertilizers on the yield and its components as well as water use efficiency (W.U.E.) of potato plants

Water quantity (m^3/*fed*)	X	Amount of N and K_2O (Kg/fed.)	Average tuber weight (g)	Tubers/ plant		Ton/*fed*					Relative yield (%)	W.U.E. Kg/m^3
				Number	Weight (Kg)	Grade 1	Grade 2	Grade 3	Marketable yield	Total yield		
2002 season												
2000		**100 + 75**	59.53	15.991	0.947	5.701	10.422	1.254	16.123	17.377	100	8.689
		100 + 150	74.697	14.151	1.057	7.194	10.920	1.288	18.115	19.403	111	9.701
		125 + 75	83.961	13.067	1.093	7.366	11.566	1.478	18.931	20.409	117	10.205
		125 + 150	84.934	13.744	1.164	7.801	11.848	1.890	19.649	21.539	123	10.770
		150 + 75	91.022	14.780	1.346	9.816	12.732	2.218	22.548	24.676	142	12.338
		150 + 150	89.338	14.115	1.261	8.845	12.245	1.839	21.090	22.929	131	11.465
2500		**100 + 75**	73.527	14.330	1.053	7.154	11.077	1.263	18.231	19.494	112	7.798
		100 + 150	84.183	14.444	1.215	8.353	12.110	1.831	20.463	22.294	128	8.918
		125 + 75	80.244	13.451	1.079	7.311	11.206	1.454	18.517	19.972	114	7.989
		125 + 150	81.592	13.958	1.134	7.611	11.785	1.594	19.396	20.990	120	8.396
		150 + 75	92.957	15.746	1.458	10.629	13.907	2.224	24.536	26.760	153	10.704
		150 + 150	92.685	14.050	1.303	9.481	12.507	1.884	21.988	23.872	137	9.549
3000		**100 + 75**	71.819	13.808	0.991	6.712	10.645	1.151	17.357	18.508	106	6.169
		100 + 150	78.632	13.375	1.050	7.268	10.973	1.352	18.241	19.592	112	6.531
		125 + 75	85.893	13.742	1.177	8.213	12.040	1.724	20.253	21.977	126	7.326
		125 + 150	85.217	15.037	1.278	9.442	12.340	1.865	21.783	23.648	136	7.883
		150 + 75	83.870	14.620	1.221	8.546	12.320	1.540	20.866	22.406	128	7.469
		150 + 150	85.920	15.007	1.285	9.380	12.054	2.139	21.434	23.573	135	7.858
L.S.D. at 0.05 level			5.17	1.400	0.077	0.488	0.782	0.429	0.886	1.030	--	0.496

between water quantity at 2000 m^3/*fed* and N + K_2O at 150 + 75 kg/*fed* increased water use efficiency of potato plants.

The increases in the yield were about 51 and 53 % for the interaction between water quantity at 2500 m^3/*fed* and N + K_2O at 150+75 kg/ *fed* over the interaction between water quantity at 2000 m^3/*fed* and N + K_2O at 100 + 75 kg/*fed* in the first and second season, respectively. These results suggested that increasing the amount of irrigation water could lead to nitrogen deficiency according to leaching of NO_3 from the root zone of potato plants in sandy soil. These results agree with those reported by Shehata and Abo-Sedera (1994), and Hedges and Awad (2002) on potato.

In general, it could be concluded that the interaction between 2500 m^3 water/*fed* and N + K_2O at 150 + 75 kg/*fed* was the superior treatments for increasing average tuber weight, yield/plant and marketable and total yield/ feddan.

REFERENCES

Abdel-Rheem, H. A. 2003. Effect of water stress and potassium fertilization on yield quantity and quality of potato. Ph.D. Thesis, Fac. Agric., Minia Univ., Egypt.

Abo-Sedera, F.A. and S.A. Shehata. 1994. Effect of NK fertilization level and foliar spray with Mn and Mo on growth, yield and chemical composition of potatoes. Zagazig J. Agric. Res. 21 (1): 145-156.

Ayoub, I.I. 2005. Effect of fertigation and plant population on growth, yield and storability of sweet potato under sandy soil conditions. Ph.D. Thesis, Fac. Agric., Zagazig Univ., Egypt.

Begg, J.E. and N. C. Turner. 1976. Crop water deficits. Advances in Agron. 28, pp. 189.

Belanger, G., J.R. Walsh, J. E. Richard, P. H. Milburn and N. Ziadi. 2000.Yield response of two potato cultivars to supplemental irrigation and N fertilization in New Brunswick, Amer. J. Potato Res. 77(1): 11-21.

El-Banna, E.N., A.F.H. Selim, and H.Z. Abd El-Salam. 2001. Effect of irrigation methods and water regimes on potato plant (*Solanum tuberosum* L.) under delta soil conditions. J. Agric. Sci., Mansoura Univ. 26(1): 1-11.

El-Ghamriny, E.A., A. Bardisi, A.N. Fayad, and R.S. Anwar. 2005a. Growth, plant water relations and chemical constituents of potato plants as affected by water quantity and some antitranspirants under sandy soil conditions. Zagazig J. Agric., Res. 32 (3): 739-766.

El-Ghamriny, E.A., A. Bardisi, A.N. Fayad, and R.S. Anwar. 2005b. Yield and tuber quality of potato plants as affected by water quantity and some antitranspirants under sandy soil conditions. Egypt. J. Appl. Sci. 20 (9): 313-332.

El-Masry, T. A. and A.A. Abou-Arab. 2000. Effect of irrigation regimes on yield, tuber quality and water use efficiency by potato. Egypt. J. Appl. Sci. 15 (8): 143-158.

Gameh, M.A., M. M. A. Abdalla, and M. H.Aboul –Nasr.2000. Improving water use efficiency using drip and sprinkler irrigation to grown potatoes at two locations in the new valley. J. Agric. Sci., Mansoura Univ. 25(1): 541-554.

Gardener, F.D., R. B. Pearce, and R.L.Mitchell.1985. Physiology of Crop Plants. The Iowa State Univ. Press. Amer. 327 pp.

Gosev, N. A. 1960. Some methods in studying plant water relations. Leningrad Acad. of Science, U.S.S.R. (C.F. Hussein, M.H., Ph.D. Thesis, Fac. Agric., Ain Shams Univ., Cairo, Egypt, 1973).

Gunel, E. and A. Karadugan. 1998. Effect of irrigation applied at different growth stages and length of irrigation period on quality characters of potato tubers. Potato Res. 41(1): 9-19.

Hegaze, H.H. and A. M. Awad. 2002. Irrigation trickle, mineral N and biofertilization effects on potato yield, tubers quality and water use efficiency. Alex. J. Agric. Res. 47 (1): 89-105.

Khalil, M.A.I. 1982. Effect of irrigation and fertilization on tomato plants. Ph.D. Thesis, Fac. .Agric., Zagazig Univ. Egypt.

Lancher. 1993. Physiological plant ecology. Ecophysiology and stress physiology of functional groups. Third ed. springier press. Berlin, New York, London , Paris ,Tokyo.

Marschner, H. 1995. Mineral Nutrition of Higher Plants. Second ed., acad. press Limeted. Text Book.

Mengel, K. and E.A. Kirkby. 1978. Principles of Plant Nutrition. International Potash Inst., P.O.Box CH. 3048, Worblaufed Bern, Switzerland.

Ministry of Economic, Egypt. 1963. To control exported potato. Ministerial order No. 652.

Ramnik, S, Y.P. Dubey, and R. Sharma. 1999. Influence of irrigation and nitrogen on total yield. II.Water expense and water use efficiency of potato in Cahaul Valley of Himalayas. J. Otllic Indian Soc. Soil Sci. 47 (1): 19-22

Salter, P .J. and T. E. Goode. 1967. Crop response to water at different stages of growth. Franham Reyal, Common Welth Agric., Bureaux.

Satyanarayana, V. and P. N. Arora. 1985. Effect of nitrogen and potassium on yield and yield attributes of potato (var. *Kufri bahar*). Indian J. Agron. 30 (3): 292:295.

Shehata, S.A. and F.A. Abo-Sedera. 1994. Effect of irrigation frequency and NK levels on growth, yield and chemical composition and storageability of potatoes. Zagazig .J. Agric. Res. 21 (1): 129-143.

Snedecor, G.W., and W.G. Cochran. 1980. Statistical Methods. 7th ed., Iowa State Univ., Press, Ames., Iowa, U.S.A.

Steyn, J. M, H.F. Duplessis, and P.E. Novtie. 1992. The effect of different water regimes on up to date potatoes. II. Yield, size, distribution, quality and water use. South African J. Plant and Soil 9 (3): 118-122.

تأثير الري والتسميد النيتروجيني والبوتاسي على النمو والإنتاجية لنباتات البطاطس تحت ظروف الأراضي الرملية

محمود عبد العزيز إبراهيم خليل[1]، عبد الله برديسى [1]، أحمد عبد المنعم توفيق[2]،
محمد السيد عبد السلام يوسف[2]

[1] قسم البساتين – كلية الزراعة – جامعة الزقازيق – مصر.

[2] معهد بحوث البساتين – مركز البحوث الزراعية – جيزة – مصر.

أجرى هذا العمل خلال الموسمين الصيفيين ٢٠٠١، ٢٠٠٢ فى منطقة الصالحية القديمة (مزرعة خاصة) بمحافظة الشرقية، بهدف دراسة تأثير كمية مياه الرى، والتوليفات بين الأسمدة النيتروجينية والبوتاسية ن + بو٢أ على الوزن الجاف، والعلاقات المائية، والمحصول فى نباتات البطاطس النامية في الأراضي الرملية.

وقد أوضحت النتائج المتحصل عليها أن الري بمعدل ٢٥٠٠ م٣ /فدان أدى إلى زيادة كل من الوزن الجاف الكلى للنبات، ومتوسط وزن الدرنة، وعدد الدرنات على النبات، والمحصول القابل للتسويق والكلى للفدان، بينما سجل الري بمعدل ٢٠٠٠ م٣ /فدان أعلى زيادة في محتوى الأوراق من الماء المرتبط، والعصير الخلوي، والضغط الاسموزى فى أنسجة الورقة، وكفاءة استخدام مياه الري، وبالإضافة إلى ذلك فقد سجل الرى بمعدل ٣٠٠٠ م٣ للفدان أعلى زيادة في محتوى الأوراق من الماء الحر والماء الكلى.

ومن ناحية أخرى فقد سجل التسميد بـ ن + بو٢ أ بمعدل ١٥٠ + ٧٥ أو ١٥٠ + ١٥٠ كجم /فدان أعلى زيادة في الوزن الجاف الكلى للنبات، ومحتوى الأوراق من الماء الحر والكلى، بينما سجل التسميد بـ ن + بو٢أ بمعدل ١٥٠ + ٧٥ كجم/فدان أعلى زيادة في كل من متوسط وزن الدرنة، محصول النبات، والمحصول القابل للتسويق والكلى للفدان، وأدى التسميد بـ ن + بو٢أ بمعدل ١٠٠ + ٧٥ كجم/فدان إلى زيادة محتوى الأوراق من الماء المرتبط.

وبالإضافة إلى ما سبق فقد أدى التفاعل بين ٢٥٠٠ م٣ ماء وبين التسميد بـ ن+ بو٢أ بمعدل ١٥٠ +١٥٠ كجم/فدان إلى زيادة الوزن الجاف الكلى للنبات، وبمعدل ١٥٠ + ٧٥ كجم/فدان إلى زيادة متوسط وزن الدرنة، ومحصول النبات، والمحصول القابل للتسويق و الكلى للفدان، بينما أدي التفاعل بين ٢٠٠٠ م٣ وبين السماد بـ ن+ بو٢أ بمعدل ١٥٠ +٧٥ أو ١٥٠ +١٥٠ كجم/ فدان إلى زيادة تركيز العصير الخلوى والضغط الأسموزى في أنسجة الورقة، وبمعدل ١٠٠ +٧٥ كجم /فدان إلى زيادة الماء المرتبط بأنسجة الورقة، وبمعدل ١٥٠ +٧٥ كم/فدان إلى زيادة كفاءة استخدام مياه الري، بينما التفاعل بين ٣٠٠٠ م٣ ماء وبين ن+ بو٢أ بمعدل ١٥٠ + ٧٥ أو ١٥٠ +١٥٠ كجم/فدان فقد أدى زيادة الماء الحر والماء الكلى في أنسجة الورقة.