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Response of potato plants to potassium fertilizer rates and soil moisture deficit

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ABSTRACT

Two Field experiments on potato (Solanum tuberosum, L.) crop were carried out at El-Qanater Horticultural Research station, Kalubiya, Governorate, Egypt for two successive seasons 2009 and 2010. The study concerned the use of different rates of potassium fertilization (72, 96 and 120 kg K_2O/fed.) under different irrigation schedulings (40, 60 and 80 % from available water) on potato crop in alluvial soil. Generally, in most cases, the treatment of the medium or/and highest soil moisture level (60 and 80 % from available water) gave the highest significant values for plant height, dry matter and K content of potato plant at 90 days from planting and potato yield tuber ton/fed N, P and K contents in tuber in addition to, total soluble solids and protein content in tuber as well as consumptive use. While the lowest one were recorded when the lowest soil moisture level (40% from available water) was applied. Generally, all k rates gave the highest significant values for all parameters under study. The second level of potassium 96 kg K_2O / fed. achieved the highest significant values of dry matter, content of N and K at 90 days from planting as well as N content in tuber. Whereas, the high values of tuber yield, protein content, water use efficiency and consumptive use were obtained when 120 kg K_2O/fed. was applied. In most cases, the high levels of potassium under 80 % from available water gave highest significant values for all parameters under study in both seasons.

Key words: Potato, yield and water use efficiency.

INTRODUCTION

Potato (Solanum tuberosum, L.) was selected for this study due to its economic importance in Egypt. It is the leading exportable vegetable crop and one of the important cash crops in Egypt. One of the major production factors of potato is the proper irrigation, due to the fact that potato is one of the drought sensitive plants which respond positively to irrigation Maintaining healthy and quality crop requires not only accurate crop water requirement determination, but also, optimum water use efficiency [1]. For potato production in Kalubiya region, Egypt, irrigation is needed, because rainfall occurred during growing season and stored soil moisture are insufficient to provide potato water requirement to acquire the optimum yield. Drought stress is a major adverse factor that can lower leaf water potential, leading to reduced tuber and some other responses and ultimately lower crop productivity in arid and semi arid zones. Soil moisture is one of the severe limitations of crop growth especially in arid and semiarid regions of the world as it has a vital role in plant growth and development at all growth stages [2]. Early studies have shown that water is the very important limiting factor for potato production and it is possible to increase production levels by well-scheduled irrigation programs throughout the growing period [3-8].

Moreover, fertilization especially potassium is considered one of the most important factors affecting the growth and yield of potato. Many researchers recorded an increase of potato tubers yield as a result of increasing the levels of potassium (K) fertilization [9-10]. Such increases in yield of potato tubers was either due to the formation of large size tubers or increasing of the number of tubers per plant or both [9]. Potassium also plays a key role in increasing crop yield and improving the quality of produce [11].

Its role is well documented in photosynthesis, increasing enzyme activity, improving synthesis of protein, carbohydrates and fats, translocation of photosynthetic, enabling their ability to resist pests and diseases. Potato plants require nutrient for enzyme functions and osmotic regulation (cell structure and strength). The nutrient is highly mobile within conductive tissues and aids in the transport of starch and sugars. Potash is an essential nutrient for all plants and has a major effect upon yield and quality of potatoes as well as the general health and vigour of the crop. It is involved in regulating the amount of water in the plant; in the absence of sufficient potassium crops do not use water efficiently. Also adequate potassium levels in the plant help it to withstand water stress during periods of drought. Potassium plays a vital role in maintaining the turgidity (rigidity) of plant cells. Because of its very importance in turgor maintenance, potassium is essential to obtain maximum leaf extension and stem elongation. This helps to achieve rapid ground cover so maximizing interception of sunlight and thus the rate of growth in the critical early periods of the growing season which is of particular importance for spring sown crops such as potatoes. Another need to ensure an adequate supply of potassium is because it plays a vital role in the movement of sugars, produced in the leaf by photosynthesis, to the tubers where the sugars are converted to starch. Potassium (K) also contributes to various aspects of tuber quality that may be vital for a marketable sample. The balance between nitrogen (N) and potassium supply is of particular importance for this crop.

The present investigation is, therefore carried out to study the effects of potassium fertilizer rates on potato yield and its components as well as its macronutrient contents under different levels of soil moisture contents.

MATERIALS AND METHODS

Two field experiments were carried out at El- Qanater Horticultural Research station, Kalubiya, Governorate representing Clay loam soil during the winter seasons 2009 & 2010 to study the effect of potassium levels under different irrigation schedulings (40, 60 and 80 % from available water) on yield, its components and macronutrients contents in leaves at 90 days from planting and tuber at harvesting of potato crop and including Water use efficiency (WUE) kg potatos /m3 water and consumptive use of water irrigation.

Some physical and chemical properties of the studied soil which were measured and determined before planting according to [12-13] were presented in Table 1 and Table 2.

Experiments were arranged in a split plot design with four replicates. The plot area was 20 m2 (4x5) planted in ridges, 70 cm part, and 25 cm between plants in which the main treatments were devoted for irrigation schedulings (40, 60 and 80 % from available water, while the sub-ones included soil applications of potassium fertilizer rates. Such treatments were as follows:-

- Irrigation treatments:

a- 40% from available water (AW 1).
b- 60% from available water (AW 2).
c- 80% from available water (AW 3).

- Potassium fertilizer rates

K fertilizer in the form of potassium sulphate (48% K2O) with four levels i.e., K0, K1, K2, and K3 which were 0,72, 96 and 120 kg K2O /fed., respectively. The fertilizer was applied before cultivation.

A basal application of nitrogen fertilizer was added at the rate 150 kg N / fed. as ammonium sulphate (20.6% N) nitrogen was given in three equal portions. Phosphorus fertilizer was added at the rate of 75 kg P2O5/fed. as triple superphosphate (37% P2O5) according to recommended dose by Ministry of Agriculture and Land Reclamation (Egypt) before cultivation.

Table 1: Physico - chemical properties of the soil

Seasons	BD	F.C	W.P	AW	Particle size distribution (%)				EC_e	pH	$CaCO_3$	OM
	(g cm^{-3})	%			Clay	Silt	Sand	Texture	(dSm^{-1})	(1:2.5)	%	
2009	1.21	35.8	18.8	17.0	31.4	33.5	35.1	CL	1.0	7.75	3.75	1.80
2010	1.24	36.0	18.5	17.5	32.6	34.5	32.9	CL	1.10	7.80	3.60	1.65

CL: Clay loam; F.C : Field Capacity; W.P.: Welting point; AW: Available water; OM: Organic matter

Table 2: Ionic properties of the soil

Seasons	HCO_3^-	SO_4^{2-}	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	N	P	K
	M mole L^{-1}							ppm		
2009	3.65	2.56	4.00	4.20	0.31	2.97	2.73	38.50	9.12	193.30
2010	3.75	2.78	4.20	4.42	0.49	2.94	2.88	37.00	10.15	190.40

N, P and K: Available.

Potato (Diamant, variety) were planted on 6th and 8th of February 2009 & 2010, respectively and harvested after 105 days (21st and 23rd of May 2009 & 2010, respectively). Plant height (cm) and dry weight of above - ground plant parts /plant (g/plant) were measured in five plants at 90 days from planting. Dry weight of tuber/ plant (g/plant) was estimated at harvesting in five plants taken randomly from each treatment. Tuber (ton/ fed.) were also measured and recorded.

Plant samples after harvesting, dried at 70ºC; ground, digested and assigned for analyzing N, P, K,. Nitrogen was determined using modified Kjeldahl method, phosphorous was determined colourimetrically using ammonium molybdate and ammonium metavanadate according to the procedure outlined by [13]. Potassium was determined using the flame spectrophotometry method [12]. A total soluble solid (TSS) in the fresh potato tubers sap was done using a hand refractometer [14]. Protein content was calculated by multiplying N content by 6.25 [15].

Actual evapotranspiration (ET) could be estimated from the soil sampling method and calculated according to the equation suggested by [16].

$$Cu = \frac{\mathrm{D.Bd.[Q2 - Q1]}}{100}$$

Where:
CU = actual evapotranspiration.
D = the irrigation soil depth (cm).
Bd = bulk density of soil (g/cm3).
Q2 = the percentage of soil moisture two days after irrigation.
Q1 = the percentage of soil moisture before next irrigation.

The sum of results of each formula for all layers of 0-15, 15-30, 30 - 45 and 45 - 60 cm for all irrigations represents the seasonal Cu within the entire soil depth of 0 - 60 cm. over the entire season.

Water use efficiency (WUE) is used to describe the relationship between production and the amount of water used. It was determined according to the [19] is defined as:

$$\mathbf{WUE} = \frac{\mathbf{Crop\ Yield\ (kg/fed.)}}{\mathbf{Total\ amount\ of\ water\ delivered\ to\ the\ crop\ (m3/fed.)}}$$

The results were statistically analyzed using Mstat computer package to calculate F ratio according to [17]. Least significant differences method (L.S.D) was used to differentiate means at the 0.05 level [18].

RESULTS AND DISCUSSION

Dry matter and plant height as well as N, P, and K content at 90 days from planting.
Data presented in Table (3) shows that the highest soil moisture level (80 % from available water) gave the highest significant values for plant height and dry matter of potato plant at 90 days of planting, whereas, the lowest values were recorded when the lowest soil moisture level (40% from available water) was practiced in both seasons. For N content in leaves, the highest significant values were obtained when 40 % from available water is applied, while, the treatments of 60 and 80 % from available water gave the lowest values in both seasons. On the contrary, the 2nd and 3rd levels from filed capacity gave a pronounced significant effect on K content in/ leaves at 90 days from planting compared with the 1st levels from filed capacity in both seasons. While, P content in leaves wasn't affected by irrigation levels in both seasons. These results are in harmony with those reported by [19] who found that plant height significantly increased with increasing the amount of irrigation water. [20] reported that application of K increased potato plant height. [21] who showed that high irrigation caused high values of K content of plant foliage. On the other hand, [22] reported that high irrigation was associated with low N content in potato foliage.

The effect of potassium fertilizer rates, data tabulated in Table (3) show that the 120 kg k2O/ fed. gave the highest significant values for plant height compared with other treatments in both seasons. On the other hand, the best dry matter of leaves at 90 days was recorded when 72 or / and 96 kg K2O/ fed. are applied compared to control treatment (without K fertilizers) was practiced in both seasons. Whereas, N content in leaves at same time was increased significantly by addition 96 kg K2O/ fed. compared with other treatments under this study in two seasons. Potassium content in leaves is affected significantly by all K rates compared with control treatment (without K fertilizers), while, P content in leaves wasn't affected by K rates in both seasons. This increment in vegetative growth of potato plants by increasing the levels of potassium fertilizer application may be due to the role of potassium on plant nutrition, i.e. promotion of enzymes activity and enhancing the translocation ofassimilates and protein synthesis. In this connection, [23-24] reported that highest content of N, P and K was caused by highest level of N, P and K fertilization. [25] found that the vegetative growth parameters i.e. plant length, and dry weight of leaves and shoots were gradually and significantly increased by increasing the level of potassium application from 40, 80 up to 120 kg K2O/fed.

Table (3): Effect of K levels on dry matter, plant height as well as N, P, and K content soil moisture deficit levels at 90 days of planting in both seasons

Treatments	Season 2009					Season 2010				
	at 90 days									
	plant height	Dry matter	Content g/kg in leaves			Plant height	Dry matter	Content g/kg in leaves		
soil moisture levels			N	P	K			N	P	K
40% AW	53.69	30.33	23.67	2.49	25.98	49.34	29.06	23.00	2.31	25.35
60% AW	63.84	40.68	21.64	2.61	27.17	56.09	37.56	20.92	2.48	26.40
80% AW	72.34	46.14	22.22	2.60	28.03	61.91	47.08	21.61	2.48	27.05
L.S.D	2.196	1.29	0.90	NS	0.86	1.06	3.20	0.87	NS	0.87
K-fertilizer rate										
72 kg K_2O/fed. (K_1)	64.34	41.07	22.45	2.61	28.41	53.23	36.41	21.78	2.46	27.71
96 kg K_2O/fed. (K_2)	67.00	43.83	24.02	2.55	28.90	59.11	43.55	23.34	2.36	28.30
120 kg K_2O/fed. (K_3)	69.12	42.79	22.70	2.60	29.23	62.00	43.47	21.78	2.46	28.34
Control (without K-fertilizer)	52.70	28.51	20.84	2.50	21.71	48.77	28.18	20.48	2.41	20.72
L.S.D	1.64	2.830	0.70	NS	0.95	1.81	1.98	0.96	NS	1.10
irrigation water deficit * K- rate										
40% AW + K_1	55.34	31.53	25.21	2.42	27.34	46.01	28.31	24.67	2.47	26.86
40% AW + K_2	56.33	33.73	24.64	2.51	27.39	53.33	32.10	24.01	2.22	26.93
40% AW + K_3	59.04	34.43	24.00	2.51	28.24	56.33	33.21	23.33	2.25	27.63
40% AW + Control	44.08	21.63	20.81	2.53	20.96	41.67	22.64	20.00	2.30	20.00
60% AW + K_1	63.66	42.51	19.17	2.80	27.90	51.34	30.76	18.00	2.45	27.06
60% AW + K_2	68.34	46.03	25.08	2.58	29.04	60.66	45.93	24.67	2.45	28.73
60% AW + K_3	69.68	44.71	21.74	2.62	29.24	63.66	45.27	20.67	2.55	28.27
60% AW + Control	53.67	29.47	20.57	2.45	22.50	48.68	28.28	20.33	2.45	21.53
80% AW + K_1	74.02	49.17	22.99	2.63	29.99	62.34	50.15	22.67	2.45	29.21
80% AW + K_2	76.33	51.71	22.35	2.57	30.28	63.34	52.61	21.33	2.40	29.23
80% AW + K_3	78.65	49.24	22.37	2.67	30.20	66.02	51.93	21.33	2.57	29.11
80% AW + Control	60.36	34.42	21.15	2.52	21.66	55.96	33.62	21.10	2.48	20.63
L.S.D. 0.05	2.68	4.90	1.15	0.33	1.55	2.96	3.43	1.57	NS	1.79

AW: Available Water

Regarding the effect of interaction between irrigation treatments and K levels, results reveal that the highest mean values of plant high were recorded when the 3rd level of potassium fertilizers is applied under 80 % from available water in two seasons. On the other hand, the lowest values was obtained when the 1st levels of potassium fertilizers was applied under 40 % from available water, whereas, the same trend was observed when control treatment (without addition of K fertilizers) under 60 % from available water in first season and 40 % from available water in second season respectively. The significant values of dry matter of potato plant at 90 days was observed when all treatments of K fertilizers under 80 % from available water compared to control treatment (without addition of K fertilizers) under 40 % from available water in both seasons. For N content in leaves of potato at 90 days of planting, the rate of 72 K_2O kg/fed. under 40 % from available water has increased significantly the N contents in first season, while, the lowest one was obtained when treatment of 72 k_2O kg/fed. under 40 % from available water is practiced. But in the second one N content has increased significantly when 72 or and 96 K_2O kg/fed. was applied under 40 % from available water, whereas, the control (without addition of K fertilizers) with all irrigation treatment decreased significantly N content of leaves at 90 days from planting. Phosphorus content in leaves at 90 days was increased significantly by the 1st level of K (72 K_2O kg/fed.) with 60 % from available water, while, the lowest one was recorded when 72 k_2 O kg/fed. with 40 % from available water and/or control (without addition of K fertilizers) under 60 % from available water were practiced in the first season. Conversely, P content in leaves at 90 days wasn't affected by interacted treatments in the second seasons. With regard to potassium content in leaves of potato at 90 days, data reveal that the all treatments of K levels under 80 % from available water gave the highest values compared to control (without addition of K fertilizers) under all treatments of irrigation in both seasons. In this connection, [26] pointed out that the lower water loss of plants well supplied with K is due to a reduction in transpiration rate, which not only depends on the osmotic potential of the mesophyll cells but is also controlled to a large extent by the opening and closing stomata and also found that the low water loss of plant well supplied with K+ was due to a reduction in transpiration rate.

Yield ton/fed. of potato tuber as well as N, P, and K content in tuber.

Data presented in Table (4) show that the treatments of 80 % from available water gave the highest significant values of potato yield tuber ton/fed., while, the lowest one was recorded when the treatment of 40 % from available water was practiced in both seasons. Data also reveal that the N, P and K contents in tuber were increased significantly when 60 % from available water was used in both seasons, whereas, the lowest one was observed when 40 % from available water was applied in 2nd season and N and K only in 1st one. On the other hand, the lowest P- content in tuber was recorded by 60 % from available water in the first season. [3-8.] Also, [27] found that tubers yield were highest in the 75-80% available water. This was equivalent to a water requirement of 460 - 480 mm / season. [28] found that tuber yield decreased with decreasing soil moisture with the greatest reduction at 45% AW.

Examining the effect of potassium levels on potato yield tuber ton/fed., the highest significant values were obtained when plants treated with 120 K_2O kg/fed. compared to other treatments of K fertilizers, while, the lowest one were recorded when control (without addition of K fertilizers) was practiced in both seasons. N content in tuber has increased significantly by adding 96 k_2O kg/fed., while, P content has increased when 72 K_2O kg/fed. was applied, at the same time as, K-content in tuber has increased by adding the high level of K fertilizers (120 K_2O kg/fed.). On the other hand, the lowest N, P and K contents were recorded when control (without addition of K fertilizers) was practiced in both seasons. This trend was obtained by [25] found that the total tuber yield was gradually and significantly increased with increasing the level of potassium application as shown in both growing seasons. Also, they concluded that the nutritive values of potato tubers were significantly affected by potassium application from (40, 80 up to 120 kg K_2O/fed.).

With respect to the interacted factors under this study, data tabulated in Table (4) reveal that the high level of K fertilizers (120 K2O kg/fed.) gave the high significant values of potato yield tuber ton/fed. under 80 % from available water, whereas, the lowest one was recorded when control (without addition of K fertilizers) with 40 % from available water was practiced in both seasons. Alternatively, K3 and K2 had a similar effect on potato yield tuber ton/fed. under 80 % from available water in 2nd season only. For the N content in potato tuber, 96 and 120 k2O kg/fed. with 60 % from available water gave a similar significant effect compared to other treatments, while, P content was affected significantly by 1st and 2nd levels of potassium fertilizers with 60 % from available water. The treatment of 120 K2O kg/fed. under 80 % from available water gave a highest significant value of K- content in potato tuber in both seasons. On the contrary, in most cases the control (without addition of K fertilizers) with any treatments of irrigation gave lower significant values of N, P and K contents of potato tuber in both seasons. Increased irrigation from 40% up to 80% from available water caused increased in yield of potato tubers. The extent in yield increase seemed considerable to a level which led to increase uptake of N, P and K. Increased soil moisture seemed to have facilitated availability of K since with increased irrigation there is an increase in K-uptake. Similar results were obtained by [26].

Table (4): Effect of K levels on yield ton/fed. of potato tuber and N, P, and K content in tuber soil moisture deficit levels in both seasons

Treatments	Season 2009				Season 2010			
	yield	content g/kg in tuber			yield	content g/kg in tuber		
soil moisture levels	**ton/f**	**N**	**P**	**K**	**ton/f**	**N**	**P**	**K**
40% AW	7.53	11.86	2.770	13.61	6.16	11.25	2.68	13.48
60% AW	9.66	13.47	3.215	13.93	7.91	13.01	3.17	13.87
80% AW	10.49	12.45	2.659	13.83	9.22	12.01	2.65	13.74
L.S.D	0.31	0.52	0.10	0.27	0.81	0.42	0.26	0.14
K-fertilizer rate								
72 kg K_2O/fed. (K_1)	9.24	11.75	3.03	13.81	7.66	11.12	2.95	13.61
96 kg K_2O/fed. (K_2)	10.06	13.71	3.00	14.12	8.38	13.23	2.92	13.94
120 kg K_2O/fed. (K_3)	10.31	13.32	2.83	14.39	8.94	12.78	2.78	14.31
Control (without K-fertilizer)	7.30	11.60	2.67	12.85	6.07	11.23	2.69	12.93
L.S.D	0.18	0.39	0.19	0.16	0.54	0.49	0.24	0.29
irrigation water deficit * K- rate								
40% AW + K_1	7.54	12.22	2.58	13.74	6.51	11.67	2.52	13.53
40% AW + K_2	7.93	12.66	2.83	13.79	6.45	12.01	2.67	13.55
40% AW + K_3	8.68	11.68	2.96	14.04	7.17	11.01	2.82	13.98
40% AW + Control	5.97	10.88	2.70	12.90	4.52	10.33	2.68	12.87
60% AW + K_1	9.35	11.77	3.73	13.84	7.55	11.01	3.58	13.73
60% AW + K_2	11.26	14.85	3.48	14.33	8.59	14.67	3.35	14.17
60% AW + K_3	10.36	15.25	2.91	14.72	8.75	14.67	2.90	14.63
60% AW + Control	7.65	12.03	2.73	12.83	6.75	11.67	2.85	12.93
80% AW + K_1	10.82	11.27	2.77	13.85	8.92	10.67	2.75	13.57
80% AW + K_2	10.98	13.63	2.68	14.23	10.11	13.01	2.72	14.11
80% AW + K_3	11.88	13.02	2.62	14.42	10.89	12.67	2.62	14.31
80% AW + Control	8.29	11.90	2.57	12.81	6.95	11.69	2.52	12.97
L.S.D. 0.05	0.30	0.63	0.31	0.26	0.88	0.81	0.40	0.48

AW: Available Water

Total soluble solids and protein in potato tuber as well as water use efficiency and consumptive use

Available data in Table (5) revealed obviously that the total soluble solids and protein content in tuber and consumptive use were affected significantly by irrigation treatments, the treatment of 80 % from available water gave a highest significant values, while, the lowest one were obtained when 40 % from available water was applied in both seasons. On the other hand, water use efficiency wasn't affected significantly by irrigation treatments in both seasons. Similar results were recorded by; [29] shown that the seasonal water consumptive use by potato grown at Qalubia region, Egypt, varies between 300.4 mm and 419.3 mm. The variation is mainly due to climatic conditions and to the irrigation treatments; the highest water use value was obtained under the low water deficient. Increasing soil moisture stress by prolonged irrigation intervals resulted in decreasing water consumptive use. [22] reported that increased irrigation caused very slight increases in TSS. [30] found that protein content increased with increasing irrigation.

For the potassium rates, the high level of potassium fertilizer (120 K_2O kg/fed) gave the positive significant of all parameters in Table (5) compared with other levels of potassium in both seasons. Whereas, the lowest one were obtained when control (without addition of K fertilizers) was practiced with one exception, for total soluble solids wasn't affected significantly by K fertilizer rates in first season only. On the contrary, K_1, K_2 and K_3 had a similar significant effect of water use efficiency in first season only. [31] reported that tuber protein content increased with increasing K application.

Table (5): Effect of K levels total soluble solids and protein in potato tuber as well as water use efficiency (WUE) kg potato tuber/m^3 irrigation water and consumptive use (CU) mm soil moisture deficit levels in both seasons

Treatments	Season 2009				Season 2010			
soil moisture levels	TSS g/l	protein g/kg	WUE	C U	TSS g/l	protein g/kg	WUE	C U
40% AW	43.78	72.73	5.05	353.7	42.82	71.71	4.19	363.3
60% AW	44.28	84.42	5.505	412.3	43.26	83.54	4.43	424.1
80% AW	47.17	88.40	5.64	437.8	46.10	87.33	4.66	472.8
L.S.D	0.69	1.26	NS	5.92	0.87	1.31	NS	2.69
K-fertilizer rate								
72 kg K_2O/fed. (K_1)	44.70	79.59	5.40	405.5	43.60	78.56	4.30	422.9
96 kg K_2O/fed. (K_2)	45.31	81.88	5.76	413.5	44.32	80.83	4.59	431.3
120 kg K_2O/fed. (K_3)	45.50	89.97	5.79	422.7	44.45	89.06	4.81	439.8
Control (without K-fertilizer)	44.81	75.96	4.64	363.2	43.86	75.00	4.01	386.3
L.S.D	NS	1.11	0.68	8.11	0.85	1.20	0.32	2.99
irrigation water deficit * K- rate								
40% AW + K_1	42.79	72.18	5.05	355.5	41.70	71.10	4.26	363.9
40% AW + K_2	44.16	73.92	5.24	360.5	43.13	72.92	4.15	369.8
40% AW + K_3	44.37	79.25	5.53	373.7	43.43	78.25	4.53	377.1
40% AW + Control	43.79	65.57	4.37	325.0	43.03	64.58	3.84	342.3
60% AW + K_1	44.16	82.19	5.31	419.2	43.07	81.25	4.19	429.2
60% AW + K_2	44.01	85.20	6.25	428.8	43.10	84.16	4.65	439.6
60% AW + K_3	44.75	98.59	5.67	434.8	43.63	97.92	4.67	446.0
60% AW + Control	44.22	71.70	4.78	366.3	43.23	70.83	4.21	381.5
80% AW + K_1	47.14	84.40	5.83	441.9	46.03	83.33	4.46	475.7
80% AW + K_2	47.74	86.51	5.79	451.2	46.73	85.42	4.97	484.4
80% AW + K_3	47.39	92.06	6.16	459.7	46.30	91.00	5.23	496.2
80% AW + Control	46.41	90.61	4.78	398.2	45.33	89.58	3.97	435.0
L.S.D. 0.05	1.47	1.82	1.11	13.24	1.39	1.96	0.51	4.88

AW: Available Water

As a general view, data of interacted factors under this investigation illustrate in Table (5) indicate that the all treatments of K levels with 80 % from available water gave a highest significant value of total soluble solids, while, the lowest one was obtained when control (without addition of K fertilizers) or/and K_1 under 40 % from available water was practiced in both seasons. For the protein content in potato tuber, the 2nd level of K fertilizer (96 K_2O kg/fed.) with 60 % from available water has increased significantly protein content in first season, but in the 2nd one the higher level of K fertilizer (120 K_2O kg/fed.) with 60 % from available water gave highly significant in same one. Whereas, the protein content was decreased significantly by adding control (without 60 % from available water in 1st and 2nd seasons respectively. In most cases, water use efficiency was affected significantly when potassium is added by any rates with any soil moisture levels in this study compared to control (without addition of K fertilizers) in the first season. In 2nd one the K2 and K3 with 80 % from available water had a similar significant effect, while, the lowest one was recorded when control (without addition of K fertilizers) under 80 % from available water is added. Additionally, data reveal that the treatment of 120 K2O kg/fed. with 80 % from available water gave highly significant in consumptive use in both seasons, even as, the lowest one was obtained when control (without addition of K fertilizers) under 60 and 40 % from available water was added in 1st and addition of K fertilizers) or/and K1 under 40 and 2nd seasons, respectively.

CONCLUSION

Potato is sensitive to water stress and irrigation has become an essential component of potato production in comparison with the other crops. Potassium is the nutrient taken up by potato in the greatest quantity; it also takes up much nitrogen and appreciable amounts of phosphorus, calcium, magnesium and sulphur. Therefore, based on water use efficiency values, it is recommended that potato cv. Diamant should be fertilized within (120 K_2O kg/fed.) with irrigation of 80% from available water to achieve the optimum quantity and quality of tuber yield and water use efficiency.

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