IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 8, Issue 9 Ver. I (Sep. 2015), PP 82-90
www.iosrjournals.org

Growth and Productivity Improvement of some Potato Cultivars under Siwa Oasis Conditions

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Abstract: *The field work was carried out at the Experimental Farm of the Desert Research Center of Siwa Oasis, Marsa Matroh Governorate, during the two consecutive seasons of 2013/2014 and 2014/2015. The experiments were conducted to investigate the effect of humic acid at the rates of 0, 4, and 6 (gm/L) and foliar spray with red beet extract on growth, yield and chemical compositions of three potato cultivars (Spunta, Diamont and Cara) grown under sandy soil conditions. Results revealed that Diamont and Cara cultivars had the highest values in all most of growth and tuber parameters, total yield, nitrogen and potassium content as compared with Spunta cultivar which was surpassed in average tuber weight, shoot dry matter, total carbohydrates and phosphorus percentage. Humic acid application enhanced growth parameters and total yield, the highest values were obtained with 6 and 4g/L. Moreover, the highest value in N (%) in tubers was obtained with 6g/L, while the highest values in P and K (%) were recorded with 4g/L. Also, red beet extract enhanced all growth and tuber parameters, total yield and K (%) significantly when compared with control treatment.*

Keywords: *Potato – Humic acid – Red beet extract – Cultivars- Growth- Yield- Chemical composition.*

I. Introduction

Siwa Oasis is located in the northern part of the Western Desert of Egypt, about 65 km east of the Libyan frontier and 300 km south of the Mediterranean Coast. The total cultivated area is (20940 fed.). It is characterized by hot and dry climate conditions. The Oasis level is below sea level18 m, and displays numerous landforms: salt marshes, salt lakes and cultivated lands. The main activity in Siwa Oasis is agriculture which is depending on the groundwater.

Potato (*Solanum tuberosum* L.) is one of the Solanaceae family plants and considered as one of the most important vegetable crops in many regions of the world. It is the second vegetable crop after tomato according to the cultivated area and one of the most important exported crops. Egypt is ranked as the 15th one among the top potato producers and the 2nd one among the African countries according to **FAOSTAT (2012).**

Effect of cultivar and density on growth and dry matter in five cultivars of potato were reported, the differences among the cultivars were recorded in number of days after planting to emergence, flowering, number of stems per plant, stem and leaf dry weight and tuber dry weight **(Damavandi and Asle- Gorgani, 2005).** In another study, results showed that all potato cultivars have significant differences in all of growth traits **Ranjbar and Mirzakhan (2012). Patel et al. (2001)** investigated the effect of soil salinity on three potato cultivars (Kennebec, Norland and Russet Burbank), results showed that cultivars tubers weight of Kennebec and Russet Burbank Grade A which were not affected by the soil salinity**.** Moreover, **Rahman et al. (2008)** studied the effects of three potato cultivars with five NaCI levels. The results indicated that Shilbilaty cv enhanced in shoot length and shoot fresh mass than Shepody and Atlanta cvs.**.**

Humic substances are a heterogeneous mixture of naturally occurring organic materials that arise from the decay of plants and animal residues. These humic substances in soil are commonly referred to as organic matter or humus. Humus is comprised of three distinct groups namely, humic acid, fulvic acid and humin.

In general, increasing humus level has a number of benefits for plants i.e. increasing water holding capacity and soil warmth via the dark color that absorbs light energy and act as a glue to improve soil aggregation, **Piccolo et al. (1996).** Also, it is increased reserve of slow release nutrients, solubility of phosphorus to potato plants when it added at ratio of 1:10 v/v to phosphorus (**Hopkins and Stark, 2003).** In the same line humic substance increased dry matter production, **Singaroval et al. (1993).** As for, it is improved the availability of major and micronutrients viz., iron and zinc and enhanced their uptake, **(Tenshia and Singaram, 2005).** As regard, humic acid increased all growth and yield parameters on potato but the specific gravity did not affect (**Hopkins and Stark, 2003** and **Sarhan, 2011).** In Peas (*Pisum sativum L.***) Gad El-Hak et al. (2012)** and in tomato **Tenshia** and **Singaram (2005).**

Sugar beet (*Beta vulgaris*) is rich in sugars and glycine betaine (GB) in its juice **(Mack et al., 2007).** Glycine betaine (GB) is an amino acid derivative which is naturally synthesized in several plant species. However, many important crop species, like potato or tomato are unable to accumulate glycine betaine. Synthesis of glycine betaine is promoted by salt and drought stress as it functions as a compatible solute

regulating the intracellular osmotic balance **(Abou El -Yazied, 2011)**. GB increases the water retention of plant cells by protecting from osmotic inactivation **(Makela, 2004).** Moreover, exogenous application of sugar beet root extract is rich with GB and it can be used as a substitute cheaper source of GB for protecting plants against the destructive effects of salinity **(Abbas et al. 2010).** In another study, to investigate the effect of beet extract on germination of lentil seeds, which were soaked in solutions of sugar beet root extract (SRE) for 14 h using five concentrations (1%, 2%, 3%, 4% and 5%). Results obtained showed that 2% of extract (SRE) were the most effective in boosting up germination rate and succeeding seedling growth under chilling conditions **(Imran et al. 2014).**

The main objective of the work was to study the effect of humic acid and red beet extract on growth, yield and chemical composition of three cultivars of potato (Spunta, Diamont and Cara) under Siwa Oasis conditions.

II. Material And Methods

Field experiment was carried out in the Experimental Station of Desert Research Center in Siwa Oasis, Marsa Matroh Governorate, Egypt during the winter seasons of 2013/2014 and 2014/2015. The experiments were conducted to study the response of potato cultivars grown in sandy soil to humic acid as soil application and water extract of red beet (Beta vulgaris) as foliar spray. Eighteen treatments were used which were the combination of three potato cultivars namely Cara, Diamont and Spunta and three levels of humic acid as a soil conditioner i.e., 0, 4, and 6 (gm/L), in addition two foliar spry i.e., water extract of table beet and tap water as a control treatment.

The physical and chemical soil characteristics of the studied site were determined according to **Page et al. (1982)** and **Klute (1986)** respectively, as recorded in Table (1). The chemical analysis of irrigation water was carried out using the standard method of **Page et al., (1982)** and presented in Table (2).

Table (1). Some physical and chemical properties of the experimental soil site.

Soil depth (cm)	Texture class	Soluble anions (me/l)			pH soil paste	E.C dSm^{-1}	Soluble cations (me/l)			
		HCO_3^-	$SO_4^=$	Cl^-			Ca^{++}	Mg^{++}	Na^+	K^+
0 – 25	Sandy loam	0.75	0.85	4.25	6.7	0.58	1.15	0.45	3.92	0.33

pH: Acidity E.C.: Electrical conductivity me/l: milli equivalent per liter

Table (2). Chemical analysis of the irrigation water.

Samples	pH	E.C. dSm^{-1}	Soluble cations (me/l)				Soluble anions (me/l)		
			Ca^{++}	Mg^{++}	Na^+	K^+	HCO_3^-	$SO_4^=$	Cl^-
1 st. season	7.1	5.54	10.1	13.32	39.4	1.17	9.35	15.1	39.5

pH: Acidity, E.C.: Electrical conductivity, dSm^{-1}: decimenz per meter,

Organic manure was added at the rate of 20 m³/fed., while calcium super-phosphate (15.5% P2O5) at the rate of 300 kg /fed., during land preparation. Nitrogen fertilizer as ammonium sulphate (20.5% N) and potassium sulphate (48% K2O) at the rate of 300 and 200 kg /fed. respectively. Nitrogen and potassium quantities were divided and applied three times after 30, 60 and 90 days from planting. Tubers were planted in 6Th. and 5Th. of October over the two growing seasons respectively. Experimental area was 1/400 fed., (3 m. L x 3.5 m. W) which is consisted of five ridges and 25 cm apart between plants, two ridges were dedicated for the vegetative growth samples and three ridges for the yield under flood irrigation system.

After 30 and 60 days from planting, Humic acid treatments were applied to the soil at concentration of 0, 4, 6 g/L. sprayed on the soil surface. In the same time 200g of fresh red beat roots were chopped and soaked in 1 Litter of tap water at temperature 40 Cº for 24 hour then filtered to obtain the water extract of beet and sprayed on plants , while tap water was sprayed as a control treatment.

Vegetative growth parameters:

Vegetative growth samples were taken after 90 days from planting, four plants were selected randomly from each plot and the following characteristics were recorded i.e., plant fresh weight (g.), plant height (cm.), shoots number per plant and dry matter percent.

Tubers and yield parameters:

At harvesting stage (110 days from planting date), a sample of 20 plant tubers were randomly taken from each experimental plot for tuber characteristics, i.e., tubers number and weight/plant, average tuber fresh weight and tuber dry matter percentage were recorded. In addition to tubers yield (ton/fed.). Tuber specific gravity was calculated according to the following equation

Dry matter percent = 3.33+211(specific gravity -1). **Wilson and Lindsay (1969**)

Chemical constituents:

Three samples of tubers from each experimental unit were taken and oven dried at 70ºC until stable weight then grinded to fine particles and used to determine chemical contents N, P and K. Phosphorus was determined using the colorimetric method for phosphorus content using spectrophotometer according to **Cottenie et al.(1982)**, Total nitrogen was determined using the modified micro Kjeldahl method. Potassium percentage was measured using Flame photometer by method as described by **Brown and Lilliland (1964).** Total carbohydrate contents were determined according to **A.O.A.C. (1990).**

Experimental design and statistical analysis:

The experimental treatments were arranged in a split- split plot design with three replicates. Main plots were assigned for potato cultivars, whereas, humic acid rates were randomly arranged in the sub plots, foliar spray by beet extract or without were assigned in sup –sup plot. Obtained data were subjected to statistical analysis according to **Sendecor and Cochran (1989).**

III. Results And Discussion

Vegetative growth characteristics:

The presented data in Tables (3- 4) showed the effect of potato cultivars, humic acid and water extract of red beet on plant height, No. of aerial stems/plant, fresh weight and dry matter percentage of shoot. Obtained results showed significant differences among cultivars, humic acid application and foliar spray of beet extract on all growth parameters. From the data obtained it could remark the following:

1- The highest values on plant height and No. of aerial stem/plant recorded significant increase in Diamont and Cara cvs. Cara cv. showed the highest value in plant fresh weight, while, Spunta cv. recorded significant increases in shoot dry matter percentage in both growing seasons.
2- The highest values in plant height and No. of aerial stem/plant recorded significant increase with humic acid treatments at rates of 4 and 6 g/L when compared with control treatment. The results are true in both growing seasons.

Table (3): Effect of potato cultivars, humic acid and beet extract on plant height and number of aerial stems/plant during 2013/2014 and 2014/2015 growing seasons.

Characters		Plant height (cm)						number of aerial stem/plant					
Seasons		First season			Second season			First season			Second season		
Treatments													
cv.	Humic acid	Beet Extract	Control	X⁻	Beet Extract	Control	X⁻	Beet Extract	control	X⁻	Beet Extract	control	X⁻
Cara	6 gm/L	51.20	46.05	48.63	48.60	41.75	45.18	4.50	4.50	4.50	4.75	4.25	4.50
	4 gm/L	67.28	45.63	56.45	60.30	40.73	50.51	4.75	3.75	4.25	5.00	3.50	4.25
	control	62.75	41.90	52.33	55.15	36.70	45.93	4.00	3.00	3.50	4.25	3.50	3.88
	X⁻	60.41	44.53	52.47	54.68	39.73	47.20	4.42	3.75	4.08	4.67	3.75	4.21
Diamont	6 gm/L	55.85	60.25	58.05	50.88	56.05	53.46	5.50	4.00	4.75	5.00	3.50	4.25
	4 gm/L	56.88	51.50	54.19	51.08	46.60	48.84	5.25	4.25	4.75	5.00	4.25	4.63
	control	46.65	43.93	45.29	42.85	41.03	41.94	4.25	3.50	3.88	5.25	3.00	4.13
	X⁻	53.13	51.89	52.51	48.27	47.89	48.08	5.00	3.92	4.46	5.08	3.58	4.33
Spunta	6 gm/L	52.25	42.78	47.51	47.45	37.48	42.46	3.75	3.00	3.38	3.75	2.75	3.25
	4 gm/L	50.73	41.18	45.95	45.03	34.28	39.65	3.50	2.75	3.13	4.25	3.75	4.00
	control	42.48	37.43	39.95	34.78	28.53	31.65	4.25	3.00	3.63	4.00	2.25	3.13
	X⁻	48.48	40.46	44.47	42.42	33.43	37.92	3.83	2.92	3.38	4.00	2.92	3.46
X⁻	6 gm/L	53.10	49.69	51.40	48.98	45.09	47.03	4.58	3.83	4.21	4.50	3.50	4.00
	4 gm/L	58.29	46.10	52.20	52.13	40.53	46.33	4.50	3.58	4.04	4.75	3.83	4.29
	control	50.63	41.08	45.85	44.26	35.42	39.84	4.17	3.17	3.67	4.50	2.92	3.71
	X⁻	54.01	45.63		48.46	40.35		4.42	3.53		4.58	3.42	
L. S. D. (0.05) for:													
Cultivar			3.54			3.17			0.77			0.72	
Humic acid			3.36			2.90			0.43			0.42	
Beet extract			2.59			2.30			0.41			0.45	
Cultivar X Humic			5.82			5.03			NS			NS	
Cultivar X Beet extract			4.49			2.30			NS			NS	
Humic X Beet extract			4.49			3.98			NS			NS	
Cultivar X Humic X Beet extract			NS			NS			NS			NS	

Table (4): Effect of potato cultivars, humic acid and beet extract on fresh plant weight and shoot dry matter percentage during 2013/2014 and 2014/2015 growing seasons.

Characters		Fresh plant weight (gm)						Shoot dry matter percentage					
Seasons		First season			Second season			First season			Second season		
Treatments													
cv.	Humic acid	Beet Extract	Control	X⁻	Beet Extract	Control	X⁻	Beet Extract	control	X⁻	Beet Extract	control	X⁻
Cara	6 gm/L	416.0	240.0	328.0	423.8	277.5	350.6	15.4	13.5	14.4	16.0	14.9	15.5
	4 gm/L	369.5	263.8	316.6	374.3	274.8	324.5	17.4	13.6	15.5	17.3	14.6	15.9
	control	301.3	290.0	295.6	327.5	278.8	303.1	16.1	13.9	15.0	15.6	13.9	14.7
	X⁻	362.3	264.6	313.4	375.2	277.0	326.1	16.3	13.7	15.0	16.3	14.5	15.4
Diamont	6 gm/L	338.8	271.3	305.0	341.3	271.8	306.5	13.4	13.7	13.5	14.0	14.0	14.0
	4 gm/L	322.5	232.5	277.5	318.0	258.0	288.0	12.9	14.6	13.7	13.9	15.4	14.7
	control	267.8	244.5	256.1	329.3	279.0	304.1	11.8	13.4	12.6	12.3	13.8	13.0
	X⁻	309.7	249.4	279.5	329.5	269.6	299.5	12.7	13.9	13.3	13.4	14.4	13.9
Spunta	6 gm/L	345.8	262.3	304.0	354.8	268.0	311.4	16.1	17.0	16.5	15.8	16.7	16.2
	4 gm/L	283.5	260.5	272.0	316.3	253.5	284.9	19.0	16.7	17.8	18.8	16.6	17.7
	control	277.0	217.5	247.3	295.8	228.8	262.3	23.6	21.3	22.4	22.8	20.5	21.7
	X⁻	302.1	246.8	274.4	322.3	250.1	286.2	19.6	18.3	18.9	19.1	17.9	18.5
X⁻	6 gm/L	366.8	257.8	312.3	373.3	272.4	322.8	15.0	14.7	14.8	15.3	15.2	15.2
	4 gm/L	325.2	252.3	288.7	336.2	262.1	299.1	16.4	14.9	15.7	16.7	15.5	16.1
	control	282.0	250.7	266.3	317.5	262.2	289.8	17.1	16.2	16.7	16.9	16.1	16.5
	X⁻	324.7	253.6		342.3	265.6		16.2	15.3		16.3	15.6	

L. S. D. (0.05) for:				
Cultivar	24.44	28.81	0.96	1.42
Humic acid	30.05	21.35	0.58	1.29
Beet extract	19.02	16.50	0.59	0.67
Cultivar X Humic	NS	NS	1.00	2.23
Cultivar X Beet extract	NS	NS	1.03	NS
Humic X Beet extract	32.94	28.57	NS	NS
Cultivar X Humic X Beet extract	57.05	49.49	1.78	NS

The highest plant fresh weight was significantly recorded with humic acid application at the rate of 6 g/L when compared with other treatments, moreover, control treatment recorded significant increases of shoot dry matter percentage in the first season only.

3- Obtained results showed significant increase with foliar spray of beet extract on all growth parameters when compared with control (water spray) treatment in both growing seasons.
4- The interaction between cultivars and humic acid showed that the highest values in plant height significantly were recorded with Diamont cv. with humic acid at rate of 6 g/L followed by Cara with humic acid at rate of 4g/l in both growing seasons than other treatments. On the other hand, Spunta cv. with control treatment surpassed significantly in shoot dry matter percentage when compared with other treatments in both growing seasons.
5- The interaction between cultivars and beet extract showed that the highest value in plant height was recorded with Cara cv. with beet extract in both growing seasons. Moreover, significant increases cleared in shoot dry matter percentages which were recorded in Spunta cv. with beet extract in the both growing seasons.
6- Significant increases in plant height and plant fresh weight were recorded with combination between beet extract and humic acid treatments at rate of 4 g/L and 6g/L in both growing seasons.
7- The interaction among the three study factors showed that the highest value in plant fresh weight were recorded in the combination between Cara cv. and humic acid at rate of 6 g/L and beet extract in both growing seasons. On the other hand the positive effect in shoot dry matter percentage were recorded with the combination among Spunta cv. and humic control treatment and beet extract in both growing seasons.

Differences between cultivars could be due to genetic differences. Obtained results were in agreement with those obtained by **Damavand and Asle- Gorgani, (1995)** they reported that there are significant differences among the cultivars in number of stem per plant, stem and leaf dry weight of potato at maturity. Also, **Ranjbar and Mirzakhan (2012)** showed that all cultivars have significant differences in all of growth characters. The positive effect of humic acid application may be due to its important role as a soil conditioner to increase water holding capacity and soil warmth (**Piccola et al., 1996)** also, it cause increasing in dry matter production (**Singarovel et al., 1993)** as well as increases in all growth parameters of potato (**Hopkins and Stark, 2003** and **Sarhan, 2011).**

Beet extract (*Beta vulgaris*) is rich in sugars and glycine betaine. However, synthesis of glycine betaine is promoted by salt and drought stress as a function as a compatible solute regulating the intracellular osmotic

balance **(Abou El -Yazied, 2011)**. glycine betaine increase the water retention of plant cells by protecting from osmotic inactivation **(Makela, 2004).**

Tubers and yield parameters:

The presented data in Tables (5-7) showed the effect of potato cultivars, humic acid and water extract of red beet on tubers number/plant, average tuber weight, tuber dry matter percentage, tuber specific gravity, plant yield and total yield. The results could remark the following:

Table (5): Effect of potato cultivars, humic acid and beet extract on tubers number/plant and average of tuber weight during 2013/2014 and 2014/2015 growing seasons.

Characters		Tubers number/ plant						Average of tuber weight (g.)					
Seasons		First season			Second season			First season			Second season		
Treatments													
cv.	Humic acid	Beet Extract	Control	X⁻	Beet Extract	Control	X⁻	Beet Extract	Control	X⁻	Beet Extract	control	X⁻
Cara	6 gm/L	7.00	5.67	6.33	7.50	5.50	6.50	101.05	92.25	96.65	78.71	82.67	80.69
	4 gm/L	7.33	5.50	6.42	7.25	5.25	6.25	102.89	97.43	100.16	79.87	85.28	82.57
	Control	5.83	4.50	5.17	6.00	4.75	5.38	83.17	75.00	79.09	66.86	86.33	76.59
	X⁻	6.72	5.22	5.97	6.92	5.17	6.04	95.70	88.23	91.96	75.14	84.76	79.95
Diamont	6 gm/L	5.33	6.67	6.00	6.00	5.75	5.88	103.35	86.17	94.76	99.42	101.83	100.62
	4 gm/L	6.00	5.00	5.50	5.50	5.25	5.38	100.69	96.27	98.48	102.26	94.84	98.55
	Control	5.33	5.67	5.50	5.25	5.00	5.13	93.58	85.17	89.38	94.18	88.65	91.41
	X⁻	5.56	5.78	5.67	5.58	5.33	5.46	99.21	89.20	94.20	98.62	95.11	96.86
Spunta	6 gm/L	6.50	3.33	4.92	5.75	4.50	5.13	134.10	105.68	119.89	147.13	98.33	122.73
	4 gm/L	5.00	4.00	4.50	5.50	4.50	5.00	94.65	98.10	96.37	122.98	74.73	98.85
	Control	4.08	3.75	3.92	4.25	4.00	4.13	102.56	98.28	100.42	97.59	90.58	94.08
	X⁻	5.19	3.69	4.44	5.17	4.33	4.75	110.44	100.69	105.56	122.56	87.88	105.22
X⁻	6 gm/L	6.28	5.22	5.75	6.42	5.25	5.83	112.83	94.70	103.77	108.42	94.27	101.34
	4 gm/L	6.11	4.83	5.47	6.08	5.00	5.54	99.41	97.27	98.34	101.70	84.95	93.32
	Control	5.08	4.64	4.86	5.17	4.58	4.88	93.11	86.15	89.63	86.21	88.52	87.36
	X⁻	5.82	4.90		5.89	4.94		101.78	92.70		98.77	89.25	

L. S. D. (0.05) for:				
Cultivar	1.02	0.66	9.68	14.9
Humic acid	0.52	0.55	6.20	7.2
Beet extract	0.56	0.45	6.20	7.9
Cultivar X Humic	NS	NS	10.74	12.5
Cultivar X Beet extract	0.97	0.78	NS	13.8
Humic X Beet extract	NS	NS	NS	NS
Cultivar X Humic X Beet extract	1.68	NS	NS	NS

Table (6): Effect of potato cultivars, humic acid and beet extract on tuber dry matter percent and tuber specific gravity during 2013/2014 and 2014/2015 growing seasons.

Characters		Tuber dry matter percent (%)						Tuber specific gravity					
Seasons		First season			Second season			First season			Second season		
Treatments													
cv.	Humic acid	Beet Extract	Control	X⁻	Beet Extract	control	X⁻	Beet Extract	control	X⁻	Beet Extract	control	X⁻
Cara	6 gm/L	21.16	20.22	20.69	20.29	19.70	19.99	1.085	1.080	1.082	1.080	1.078	1.079
	4 gm/L	20.41	19.11	19.76	19.92	18.98	19.45	1.081	1.075	1.078	1.079	1.074	1.076
	Control	19.56	19.11	19.33	20.83	18.33	19.58	1.077	1.075	1.076	1.083	1.071	1.077
	X⁻	20.38	19.48	19.93	20.34	19.00	19.67	1.081	1.077	1.079	1.081	1.074	1.077
Diamont	6 gm/L	21.54	19.66	20.60	20.64	19.41	20.03	1.086	1.077	1.082	1.082	1.076	1.079
	4 gm/L	19.76	19.30	19.53	19.90	19.32	19.61	1.078	1.076	1.077	1.079	1.076	1.077
	Control	19.27	18.51	18.89	19.60	19.22	19.41	1.076	1.072	1.074	1.077	1.075	1.076
	X⁻	20.19	19.16	19.67	20.05	19.32	19.68	1.080	1.075	1.077	1.079	1.076	1.077
Spunta	6 gm/L	19.22	18.66	18.94	19.78	19.03	19.40	1.075	1.073	1.074	1.078	1.074	1.076
	4 gm/L	19.44	18.63	19.04	18.85	18.30	18.58	1.076	1.073	1.074	1.074	1.071	1.072
	Control	18.49	18.38	18.44	18.53	18.09	18.31	1.072	1.071	1.072	1.072	1.070	1.071
	X⁻	19.05	18.56	18.81	19.05	18.47	18.76	1.075	1.072	1.073	1.075	1.072	1.073
X⁻	6 gm/L	20.64	19.51	20.08	20.24	19.38	19.81	1.082	1.077	1.079	1.080	1.076	1.078
	4 gm/L	19.87	19.01	19.44	19.56	18.87	19.21	1.078	1.074	1.076	1.077	1.074	1.075
	Control	19.11	18.67	18.89	19.65	18.55	19.10	1.075	1.073	1.074	1.077	1.072	1.075
	X⁻	19.87	19.06		19.81	18.93		1.078	1.075		1.078	1.074	

L. S. D. (0.05) for:				
Cultivar	0.62	0.39	0.0018	0.0029
Humic acid	0.54	0.39	0.0018	0.0026
Beet extract	0.49	0.34	0.0016	0.0023
Cultivar X Humic	NS	NS	NS	NS
Cultivar X Beet extract	NS	NS	NS	NS
Humic X Beet extract	NS	NS	NS	NS
Cultivar X Humic X Beet extract	NS	NS	NS	NS

Table (7): Effect of potato cultivars, humic acid and beet extract on plant yield and total yield during 2013/2014 and 2014/2015 growing seasons.

Characters		Plant yield (g.)						Total yield (Ton/fed.)					
Seasons		First season			Second season			First season			Second season		
Treatments													
cv.	Humic acid	Beet Extract	Control	X⁻	Beet Extract	control	X⁻	Beet Extract	control	X⁻	Beet Extract	control	X⁻
Cara	6 gm/L	571.7	475.0	523.3	604.1	451.0	527.5	13.31	11.06	12.18	13.84	11.14	12.49
	4 gm/L	485.8	513.3	499.6	577.5	442.5	510.0	11.19	11.83	11.51	13.44	10.30	11.87
	control	465.7	426.7	446.2	416.5	403.0	409.7	10.17	9.32	9.74	10.54	10.31	10.42
	X⁻	507.7	471.7	489.7	532.7	432.2	482.4	11.56	10.73	11.15	12.61	10.58	11.60
Diamont	6 gm/L	573.3	463.3	518.3	567.0	460.3	513.6	12.03	10.45	11.24	12.25	9.94	11.09
	4 gm/L	558.6	450.0	504.3	566.3	481.0	523.7	12.69	10.04	11.37	13.20	10.27	11.74
	control	461.8	451.7	456.7	508.3	443.3	475.8	9.97	9.76	9.86	11.57	9.26	10.41
	X⁻	531.2	455.0	493.1	547.2	461.5	504.4	11.57	10.08	10.83	12.34	9.82	11.08
Spunta	6 gm/L	461.7	431.7	446.7	503.5	394.3	448.9	9.97	9.32	9.65	11.00	8.61	9.80
	4 gm/L	443.3	346.8	395.0	484.5	338.8	411.6	9.26	6.12	7.69	10.23	7.15	8.69
	control	430.0	336.7	383.3	432.5	349.8	391.1	8.88	6.95	7.91	9.57	7.58	8.57
	X⁻	445.0	371.7	408.3	473.5	360.9	417.2	9.37	7.47	8.42	10.27	7.78	9.02
X⁻	6 gm/L	535.5	456.7	496.1	558.2	435.2	496.7	11.77	10.28	11.02	12.36	9.90	11.13
	4 gm/L	495.9	436.7	466.3	542.8	420.8	481.8	11.05	9.33	10.19	12.29	9.24	10.77
	control	452.5	405.0	428.7	452.4	398.7	425.5	9.67	8.67	9.17	10.56	9.05	9.80
	X⁻	494.6	432.8		517.8	418.2		10.83	9.43		11.74	9.40	

L. S. D. (0.05) for:					
Cultivar	51.9	22.73	1.32	0.840
Humic acid	40.57	39.96	0.896	0.825
Beet extract	30.21	24.04	0.674	0.481
Cultivar X Humic	NS	NS	NS	NS
Cultivar X Beet extract	NS	NS	NS	NS
Humic X Beet extract	NS	41.64	NS	0.833
Cultivar X Humic X Beet extract	NS	NS	2.023	NS

1- It was quite evident from Tables (5-7) that Cara cv. followed by Diamont cv. showed significant increase in number of tubers/plant, tuber dry matter percentage, tuber specific gravity and total yield in both growing seasons. Moreover, Diamont cv. followed by Cara cv. showed the highest values in plant yield in both growing seasons. But spounta cv. followed by Diamont cv. showed significant increase in average tuber weight. Differences between cultivars could be due to genetic differences. Obtained results were in agreement with those obtained by (**Patel et al., 2001., Rahman et al., 2008 and Ranjbar and Mirzakhan 2012).**

2- The highest values in all tubers and yield parameters were recorded with humic acid at rate 6g/L followed by 4g/L in both growing seasons. The humic substances in soil are commonly referred to as organic matter or humus, its play important role to increase all growth and yield parameters in potato. The results agree with those obtained by (**Hopkins and Stark 2003** and **Sarhan 2011), also, Gad El-Hak et al. (2012)** on Peas (*Pisum sativum L.***)**

3- Beet extract showed significant increase in tubers number, average tuber weight, dry matter percentage and specific gravity, plant yield and total yield compared with control treatment. The positive effect of beet extract in enhancement tuber and yield parameters, may be due to exogenous application of beet root extract is superior with glycine betaine and it can be used as a substitute cheaper source of glycine betaine for protecting plants against the destructive effects of salinity **(Abbas et al., 2010).**

4- The results of interaction between cultivars and humic acid application, showed that the highest values in average tuber weight recorded with Spunta cv. combined with humic acid at the rate of 6g/L in both growing seasons.

5- The combination between cultivars and beet extract showed significant increased in tubers number with Cara cv. with beet extract treatment in both growing seasons, while the highest values in average tuber weight was recorded with Spunta cv. with beet extract in the second season.

6- The interaction results as shown in table (7) between humic acid and beet extract revealed that humic acid at the rate of 6 or 4g/L with beet extract recorded the highest values in plant yield and total yield of potatoes, the values were significant when compared to control treatment in the two growing seasons.

7- The interaction results among the three study factors showed that the highest values in tubers number/plant and total yield were increased significant with Cara cv., beet extract and humic application at rate of 4g/L and 6g/L respectively in both growing seasons.

Chemical constituents:

Data recorded in Tables (8-9) are presented the studied chemical constituents of potato tubers. The data could be conclude the following:

1- The highest values in total carbohydrates were recorded with Diamonta cv. followed by Spunta cv. and the highest values in N percentage were increased significant with Diamonta cv. followed by Cara cv. in both growing seasons. Moreover, the highest values in P and K percentage occurred with Spounta cv. followed by Diamont cv. in both growing seasons. The differences were significant when compared to Cara cv. and these could be due to genetic differences among cultivars. These results agree with those obtained by **Patel et al. (2001) and Rahman et al. (2008).**

2- Humic acid application at the rate of 6g/L showed significant positive effect in N (%) of potato in both growing seasons. But, humic acid at the rate of 4g/L showed the highest values in P and K (%) when compared with other treatments, the values were significant in the first season only as compared to control treatment. The enhancement effect of himic on nutrient content**s** may be due to its effect on improving soil water holding capacity and soil structure, as well as increasing availability nutrients which were needed for plant growth. Such suggestions agree with **Hopkins and Stark (2003).** Also, it could be improving the availability of major and micronutrients viz., iron and zinc and enhancement their uptake **(Tenshia and Singaram 2005).**

3- Foliar spray by beet extract showed significant increase in total carbohydrates in the first season only, while K (%) content in tubers increased significantly with beet extract treatment than control in both growing seasons. The enhancement effect of beet extract on nutrients content may be due to its functions as a compatible solute regulating the intracellular osmotic balance **(Abou El -Yazied, 2011)**. Also, it helps in increases the water retention of plant cells by protecting from osmotic inactivation **(Makela, 2004).**

4- The results of interaction between cultivars and humic acid application showed that the highest values in total carbohydrate in the second season and in N (%) content in the first season only which were recorded with Diamont cv. with humic acid at the rate of 6g/l. while, the highest value in P (%) are recorded with Spunta cv. with humic acid at the rate of 4g/l in the second season only.

5- The combination between cultivars and beet extract showed significant increase in K(%) which is recorded with Diamont cv. with beet extract in both growing seasons.

Table (8): Effect of potato cultivars, humic acid and beet extract on Total carbohydrate (ppm) and N (%) during 2013/2014 and 2014/2015 growing seasons.

Characters		Total carbohydrate (ppm)						N (%)					
Seasons		First season			Second season			First season			Second season		
Treatments													
cv.	Humic acid	Beet Extract	control	X⁻	Beet Extract	control	X⁻	Beet Extract	control	X⁻	Beet Extract	control	X⁻
Cara	6 gm/L	79.8	65.6	72.7	75.0	65.9	70.4	1.76	1.67	1.71	1.72	2.26	1.99
	4 gm/L	72.3	74.8	73.5	74.6	79.1	76.8	1.71	1.62	1.66	1.80	1.67	1.73
	control	78.3	70.7	74.5	80.2	69.2	74.7	1.68	1.43	1.55	1.80	1.63	1.71
	X⁻	76.8	70.4	73.6	76.6	71.4	74.0	1.71	1.57	1.64	1.77	1.85	1.81
Diamont	6 gm/L	86.4	84.2	85.3	90.0	87.7	88.9	2.12	2.06	2.09	1.98	2.06	2.02
	4 gm/L	85.0	84.6	84.8	87.8	80.7	84.2	1.50	1.60	1.55	1.81	1.75	1.78
	control	79.4	71.2	75.3	74.6	81.4	78.0	1.54	1.47	1.50	1.88	1.70	1.79
	X⁻	83.6	80.0	81.8	84.1	83.3	83.7	1.72	1.71	1.71	1.89	1.84	1.86
Spunta	6 gm/L	82.1	79.8	81.0	80.6	74.5	77.5	1.62	1.49	1.55	1.56	1.75	1.65
	4 gm/L	78.3	78.7	78.5	69.4	74.1	71.7	1.43	1.39	1.41	1.50	1.72	1.61
	control	78.6	82.9	80.7	77.6	78.6	78.1	1.31	1.41	1.36	1.52	1.61	1.57
	X⁻	79.7	80.5	80.1	75.8	75.7	75.8	1.45	1.43	1.44	1.53	1.69	1.61
X⁻	6 gm/L	82.8	76.5	79.6	81.8	76.1	79.0	1.83	1.74	1.78	1.76	2.02	1.89
	4 gm/L	78.5	79.4	78.9	77.2	77.9	77.6	1.55	1.53	1.54	1.70	1.71	1.71
	control	78.7	75.0	76.9	77.5	76.4	76.9	1.51	1.43	1.47	1.73	1.65	1.69
	X⁻	80.0	76.9		78.8	76.8		1.63	1.57		1.73	1.79	

L. S. D. (0.05) for:				
Cultivar	5.09	3.93	0.163	0.120
Humic acid	NS	NS	0.138	0.136
Beet extract	2.78	NS	NS	NS
Cultivar X Humic	NS	5.65	0.239	NS
Cultivar X Beet extract	NS	NS	NS	NS
Humic X Beet extract	NS	NS	NS	0.163
Cultivar X Humic X Beet extract	NS	8.78	NS	NS

Table (9): Effect of potato cultivars, humic acid and beet extract on P and K (%) during 2013/2014 and 2014/2015 growing seasons.

Characters		P (%)						K (%)					
Seasons		First season			Second season			First season			Second season		
Treatments													
cv.	Humic acid	Beet Extract	control	X⁻	Beet Extract	control	X⁻	Beet Extract	control	X⁻	Beet Extract	control	X⁻
Cara	6 gm/L	0.67	0.54	0.61	0.72	0.71	0.72	1.69	1.40	1.55	1.65	1.40	1.52
	4 gm/L	0.67	0.71	0.69	0.61	0.64	0.63	1.63	1.37	1.50	1.57	1.37	1.47
	control	0.68	0.62	0.65	0.68	0.80	0.74	1.46	1.55	1.51	1.47	1.55	1.51
	X⁻	0.68	0.62	0.65	0.67	0.72	0.69	1.60	1.44	1.52	1.56	1.44	1.50
Diamont	6 gm/L	0.59	0.78	0.68	0.58	0.66	0.62	1.91	1.57	1.74	1.67	1.45	1.56
	4 gm/L	0.71	0.74	0.73	0.71	0.76	0.74	1.80	1.79	1.79	1.80	1.76	1.78
	control	0.80	0.78	0.79	0.80	0.75	0.77	1.88	1.43	1.66	1.88	1.51	1.70
	X⁻	0.70	0.76	0.73	0.70	0.72	0.71	1.86	1.60	1.73	1.78	1.57	1.68
Spunta	6 gm/L	0.72	0.66	0.69	0.82	0.88	0.85	1.80	1.83	1.82	1.80	1.79	1.79
	4 gm/L	0.86	0.84	0.85	0.88	0.86	0.87	1.85	1.86	1.86	1.85	1.71	1.78
	control	0.74	0.78	0.76	0.75	0.75	0.75	1.45	1.71	1.58	1.60	1.81	1.71
	X⁻	0.77	0.76	0.77	0.82	0.83	0.82	1.70	1.80	1.75	1.75	1.77	1.76
X⁻	6 gm/L	0.66	0.66	0.66	0.71	0.75	0.73	1.80	1.60	1.70	1.70	1.55	1.62
	4 gm/L	0.75	0.76	0.75	0.74	0.76	0.75	1.76	1.67	1.72	1.74	1.61	1.68
	control	0.74	0.73	0.73	0.74	0.77	0.75	1.60	1.56	1.58	1.65	1.62	1.64
	X⁻	0.72	0.72		0.73	0.76		1.72	1.61		1.70	1.59	

L. S. D. (0.05) for:				
Cultivar	0.079	0.086	0.138	0.114
Humic acid	0.058	NS	0.101	NS
Beet extract	NS	NS	0.073	0.078
Cultivar X Humic	NS	0.094	NS	NS
Cultivar X Beet extract	NS	NS	0.127	0.135
Humic X Beet extract	NS	NS	NS	NS
Cultivar X Humic X Beet extract	NS	NS	0.221	0.234

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