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Article *in* PLANT ARCHIVES · November 2018

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Plant Archives Vol. 18 No. 2, 2018 pp. 1533-1540 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF HUMIC ACIDS ON GROWTH, YIELD AND QUALITY OF THREE POTATO VARIETIES

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Abstract

An experiment was conducted at AL-Musaib Technical College-Babylon, during winter 2017 - 2018 to investigate the "Humic acids affect the production of three potato varieties. The experiment was laid out in Completely Randomized Design (CRD) with three replications. Humic levels (0, 1.5, 2 and 2.5 m/L^1), all treatment applied two times separately at the first spray after 30 days of planting, the second spray after 35 days from first spry of potato (Rivera, Rudolph and Elmundo) varieties . The growth and yield parameters to varieties were significantly influenced by various levels of Humic, as variety Elmundo presented additional height number of nodes 46.17, number of leafs 43.73, fresh and dry 71.79 and 8.88, respectively. The proposed work based on that in interaction of Elmundo variety × 2 m/L^1 concentration of Humic acid the and the second of spray ,showed best performance for most of the growth and yield parameters may hold a hope for achieving maximum economic efficiency for growing plants of potato.

Key words : *Solanum tuberosum* L, humic acids, yield, growth and potato.

Introduction

The potato (*Solanum tuberosum* L.) is one of the most important food crops belonging to the Solanaceae family. The world has shown a cumulative attention in the planting potatoes (Altindal and Karadogan, 2010) for the potatoes have a high portability for the conservation and germplasm exchange (Agud *et al*., 2010). By the application of Humic substance to plants, the growing plants are supplied with food, its request also results in fecund and fertile soil, which increase the water holding capacity of soil. It plays a pivot role in making the plants more resistant against drought stress, and also stimulates sprouting (Abdel-Monaim *et al*., 2011). Application of Humic decreases the obligation of new fertilizers. It also upsurges yield, soil ventilation, and drainage can also be better by Humic, the founding of wanted environment for the expansion of microorganisms. Upsurge in the protein and mineral contents of greatest harvests is likely by the request of Humic substances (Tufenkci *et al*., 2006). The application of Humic substances increased the yield in soybeans, potatoes, and algae cultures. It also plays an important role in increasing the fruit yield, also the quality of squash plants are increased by Humic materials application. 100% increase in the produce of potatoes and cabbage can be attained by combined request of NPK fertilizers and Humics (Syabryai *et al*., 1965). Humic is technically not a fertilizer, although in some walks, people do consider it that, Humic is an effective agent use as a complement to synthetic or organic fertilizers. In many examples, use of Humic frequently, will decrease the must for fertilization due to the soil's and plant's aptitude to make improved use of it. In some occurrences, fertilization can be removed entirely if adequate organic material is current and the soil can develop self-sustaining through microbial procedures and humus manufacture. When likely the use of Humic with fertilizer, Humics' aptitude to engross fertilizer mechanisms and increases their announcement to plants is well recognized. The sensible use of Humic and fertilizer, will improve the presentation of slightly fertile soils, of soils with little innate carbon-based matter, and of crops grown in arid areas (Chen and Aviad, 1990; Munazza *et al*., 2010). Humic acid is a natural product, which is current in Pakistan's lignitic petroleum in sensible

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attentiveness and is used in cultivation and manufacturing but on incomplete scale (Sutton and Sposito, 2005). Inappropriately, there is little information on the Humic acids on development, yield and (combined) despite the large amount of data available for the development of fertilizer requests have a through effect on potato plantlets. This study is used to recover the plantlets performance throughout dissimilar stages of growth and to know the best concentration of Humic acids.

Materials and Methods

This investigation aimed to determine the most effective concentrations (0, 1.5, 2 and 2.5 m/L^1) of Humic acids on three potato varieties Rivera, Rudolph and Elmundo (very early cultivar). All treatment applied two times separately at the first spray after 30 days of planting, the second spray after 35 days from first spry. Was conducted during 2017-2018, 15/09/ 2017 – 20/12/2017 at Iraq, AL-Musaib Technical College-Babylon. The plantlets tubers, are transplanted plastic bags (40 cm diameter) (fig. 1) containing Sand and compound fertilizer (N.P.K) (table 1). The experiment was laid out in Completely Randomized Design (CRD) each treatment had nine seedlings, three replications per variety. All the cultural practices such sprays against insect pests and diseases except fertilizer application were done consistently. The research consisted of as three concentrations of Humic levels with control (0, 1.5, 2, and 2.5 m/L ^{1}) applied two times separately, and three potato varieties (Rivera, Rudolph and Elmundo).

Table 1 : Physicochemical characteristics of soil and water used in the study.

Analysis	Soil	Water
Sand (%)	88.3	-
Silt (%)	1.8	-
Clay (%)	1.1	-
PH	-	7.7
EC	-	1.5

Plant data recorded

The data was recorded on the growth and yield parameters for each treatment and three replications, at the end of the growth period for several traits individually such as the plant height is measured in (cm) from the soil surface up to the uppermost leaf. Stems are upheld vertically during the measurement. The node and leaf number is measured. Also the shoot fresh weights are taken immediately after harvesting roots were washed with water to remove all soil particles adhered to the roots and the longest root length (cm). The shoot are weighted with digital balance (g)/plant. Number of tuber is counted for each concentration in three replicates for each variety. Dry weights are taken after complete drying of the plant material in an oven at 85°C until a constant weight then weighted by the same balance (g)/plant.

Statistical analysis

Data are analyzed by using the Statistical Analysis System program package (12) for three samples in each test. Significant differences between means were determined using the Least Significant Difference (LSD) test at $P < 0.05$.

Results and Discussion

Morphological characteristics of potato plants

The results recorded for plant length, number of nodes and number of leafs wide contrast is exposed under at concentrations of Humic acids and varieties. The concentration of Humic acids at 2 m/L^1 surpasses other concentrations significantly as shown in table 2. The variety Rudolph surpasses other varieties significantly as shown in (table 2 A). The highest rate is up to 33.07 cm. This highest is achieved in the 2 m/L^1 concentration of Humic Acid and the high rate to plant length is 35.42 cm, so it surpassed to other transactions. With control 1.5 m/L^1 of Humic Acid treatment who gave the lowest average 29.25 and 31.81 cm, respectively, plants grown under number of spray is significantly observed with The second of spray In these period the length rates surpass other The first of spray period give the longest plant length 35.05 cm. The (T× C× V) interaction gave of high rate to plant length in table 2 A is up to 41.11 cm with Rudolph variety and the second of spray, so it surpassed to other transactions with control and Elmundo variety who gave the lowest rate 25.98 cm in the first of spray. In table 2 B., with variety Elmundo, who performed better when compared to corresponding varieties, which showed the highest rate up to 33.68, while, Rivera variety recorded lowest rate up to 31.20. Analyses of variance revealed significant differences among concentrations of Humic Acid, indicating that the 2 m/L^1 of Humic Acid recorded highest rate up to 36.39 while correspondingly control is recorded the lowest rate up to 28.25. The number of node ratio increased with the second of spray of number of spray, which recorded highest rate up to 35.16. Meanwhile, the intersection (T× C× V), in the number of nodes table 2 B. The recorded the highest rate about 46.17 node at 2 m/L^1 of Humic acids and Elmundo variety with the second of spray. Furthermore, the recorded data of number of nodes gave less rate 26.55 nodes at control and Elmundo. The variety Elmundo surpassed others varietes, and recorded highest rates up to 33.82. The

Table 2 A : Effect of different concentration of Humic acids on the plant height (cm) of potato.

Number of Spray*T	Concentration of Humic Acid*C	Variety*V			*T *C
		Rivera	Rudolph	Elmundo	
The first of Spray	0	28.69	27.94	25.98	27.53
	1.5	28.98	29.45	27.49	28.64
	2	30.67	31.82	30.56	31.01
	2.5	33.34	32.54	30.21	32.06
The second of Spray	0	31.88	31.15	29.92	30.98
	1.5	34.11	36.48	34.39	34.99
	2	38.52	41.11	39.90	39.84
	2.5	35.73	34.14	33.32	34.39
					***T**
*T *V	**The First of Spray**	30.42	30.43	28.56	29.80
	The Second of Spray	35.06	35.72	34.38	35.05
				***C**	
*V *C	0	30.28	29.54	27.95	29.25
	1.5	31.54	32.96	30.94	31.81
	2	34.59	36.46	35.23	35.42
	2.5	34.53	33.34	31.76	33.21
*V	—	32.73	33.07	31.47	—

Note: LSD (0.05),*T= 2.53, LSD *V = 2.21, LSD *C = 2.15, LSD *S V = 3.11, LSD *S C = 3.16, LSD *V C = 3.22 and LSD *SVC = 4.74.

statistical analysis in concentrations of humic acid, showed a significant effect on a number of leafs, where the highest up to 37.15 with 2 m/L^1 of Humic acid, while control gave the lowest rate up to 28.25. Thus, it is very clear that concentrations of Humic Acid affects significantly the number of leafs. The highest with the second of spray was recorded up to 35.29, while, the first of spray of number of spray recorded the lower values up to 29.77 in the table 2 C. At the same time, the results showed significant differences among the intersection (T × C × V) in table 2 C, recorded highest ratio 43.73 leaf in the Elmundo variety with 2 m/L^1 of Humic acid for number of leafs in the second of spray. The increase in neck height plant height (cm), number of nodes and number of leafs of potato plants may be due to the differences in genetic makeup of the various varieties under different concentrations of Humic acid and adaptation ability of these varieties to particular environment (Muhammad *et al*., 2012). The influence of Humic acid significantly affect the total yield, it might be due to the properties of Humic acid in increasing the fertility level of the soil, and also providing and make obtainable the essential nutrients for the better growth of the plant and hence the increase in the yield of the crop these results also agree with the findings of Kim *et al*., 2010). Also, researchers specified that the greatest of the pepper plant development parameters and nutrient fillings remained positively affected by Humic acid applications, Humic acid improved the effects in salty conditions (Tufenkci *et al*., 2006; Turkmen *et al*., 2005).

Root, yield and wet weight of potato plants

The length of roots (cm), number of tuber, plant fresh weight (g) and plant dry weight (g) of all varieties increased significantly with different concentrations of Humic acid , as shown in (table 3). In table 3A, root's rate is closely related with different the nutrients whether in the soil or soilless culture, the growing plants are supplied with food, also which reflects the balance among nutrients transported to the plantlets. In this experiment, the highest average of the number of root up to 31.85 with variety Rudolph. For this, no- significant difference for the number of roots is obtained by all the varieties. 2 m/L1 concentration of Humic Acid is recorded the lowest rate up to 32.87 of number of roots, but with control is at the lowest rate up to 30.75. In the Number of spray revealed to significantly affect the number of roots in the second of spray recorded highest rate up to 32.68. The maximum reduction in the number of roots induced the first of spray which recorded lowest rate up to 30.44. The triple intersection (T× C× V), has a significant effect on the root's length was observed in the average length

Table 2 B : Effect of different concentration of humic acids on the number of nodes of potato.

Number of Spray*T	Concentration of Humic Acid*C	Variety*V			*T *C
		Rivera	Rudolph	Elmundo	
The first of Spray	0	26.94	27.76	26.55	27.08
	1.5	25.45	26.98	27.56	26.66
	2	28.98	31.87	34.90	31.91
	2.5	29.66	30.76	31.59	30.67
The second of Spray	0	28.52	29.97	29.80	29.43
	1.5	36.75	32.13	34.06	34.31
	2	39.26	37.17	46.17	40.86
	2.5	34.04	35.31	38.86	36.07
					*T
*T *V	The First of Spray	27.75	29.34	30.15	29.08
	The Second of Spray	34.64	33.64	37.22	35.16
					*C
*V *C	0	27.73	28.86	28.17	28.25
	1.5	31.10	29.55	30.81	30.48
	2	34.12	34.52	40.53	36.39
	2.5	31.85	33.03	35.22	33.36
*V	—-	31.20	31.49	33.68	——

Note: LSD (0.05),*T= 1.12, LSD *V = 1.42, LSD *C = 1.60, LSD *S V = 1.98, LSD *S C = 2.14, LSD *V C = 2.08 and LSD *TVC = 2.95.

Table 2 C : Effect of different concentration of humic acids on the number of leafs of potato.

Number of Spray*T	Concentration of Humic Acid*C	Variety*V			*T *C
		Rivera	Rudolph	Elmundo	
The First of Spray	0	25.67	26.98	27.88	26.84
	1.5	28.44	28.90	30.56	29.18
	2	31.21	31.45	34.65	32.43
	2.5	28.99	29.91	32.69	30.53
The Second of Spray	0	29.55	28.48	30.95	29.66
	1.5	33.85	36.78	33.84	34.83
	2	39.73	42.15	43.73	41.87
	2.5	33.01	35.13	36.32	34.82
					*T
*T *V	The First of Spray	28.57	29.31	31.44	29.77
	The Second of Spray	34.03	35.63	36.21	35.29
					*C
*V *C	0	27.61	27.73	29.41	28.25
	1.5	31.14	32.84	32.20	32.06
	2	35.47	36.80	39.19	37.15
	2.5	31.00	32.52	34.50	32.67
*V	—	31.30	32.47	33.82	—

Note: LSD (0.05),*T= 1.39, LSD *V = 1.74, LSD *C = 1.81, LSD *S V = 198, LSD *S C = 2.08, LSD *V C = 2.33 and LSD *SVC = 3.21.

Table 3A : Effect of different concentration of humic acids on the length of roots (cm) of potato.

Number of Spray*T	Concentration of Humic Acid*C	Variety*V			*T *C
		Rivera	Rudolph	Elmundo	
The First of Spray	0	29.54	28.99	28.48	29.00
	1.5	31.11	29.68	30.08	30.29
	2	32.89	31.43	31.87	32.06
	2.5	31.33	29.90	30.09	30.44
The Second of Spray	0	32.22	33.31	31.99	32.50
	1.5	31.26	34.39	31.22	32.29
	2	33.34	34.90	32.81	33.68
	2.5	32.98	32.16	31.89	32.34
					*T
*T *V	The First of Spray	31.21	30.00	30.13	30.44
	The Second of Spray	32.45	33.69	31.90	32.68
					*C
*V *C	0	30.88	31.15	30.23	30.75
	1.5	31.18	32.03	30.65	31.28
	2	33.11	33.16	32.34	32.87
	2.5	32.15	31.03	30.99	31.39
*V	—	31.83	31.85	31.05	—

Note: LSD (0.05),*T= 1.02.53, LSD *V = N.S, LSD *C = 0.90, LSD *T V = 1.10, LSD *T C = 1.13, LSD *V C = 1.23 and LSD *TVC = 1.20.

Table 3B : Effect of different concentration of humic acids on the number of tuber of potato.

Number of Spray*T	Concentration of Humic Acid*C	Variety*V			*T *C
		Rivera	Rudolph	Elmundo	
The First of Spray	0	3.88	4.68	6.73	5.09
	1.5	3.97	5.41	7.63	5.67
	2	4.90	5.98	7.81	6.17
	2.5	3.81	4.61	6.48	4.96
The Second of Spray	0	4.16	6.13	7.11	5.80
	1.5	6.19	6.98	6.86	6.67
	2	8.97	7.79	6.91	7.89
	2.5	6.38	6.22	8.23	6.94
					*T
*T *V	The First of Spray	4.14	5.17	7.16	5.49
	The Second of Spray	6.42	6.78	7.27	6.82
					*C
*V *C	0	4.02	5.40	6.92	5.44
	1.5	5.08	6.19	7.24	6.17
	2	6.93	6.88	7.36	7.05
	2.5	5.10	5.41	7.34	5.95
*V	—	5.28	5.97	7.21	—

Note: LSD (0.05),*T= 1.02, LSD *V = 1.06, LSD *C = 1.10, LSD *T V = 1.30, LSD *T C = 1.20, LSD *V C = 1.21 and LSD *TVC = 2.06.

Table 3C : Effect of different concentration of humic acids on the plant fresh weight (g) of potato.

Number of Spray*T	Concentration of Humic Acid*C	Variety*V			*T *C
		Rivera	Rudolph	Elmundo	
The First of Spray	0	34.75	35.97	31.87	34.19
	1.5	35.82	37.23	33.96	35.67
	2	41.76	40.79	36.51	39.68
	2.5	41.65	38.45	36.99	39.03
The Second of Spray	0	46 .54	47.34	48.15	47.34
	1.5	51.95	53.22	56.54	53.90
	2	67.76	68.94	71.79	69.49
	2.5	55.89	59.48	69.33	61.56
					***T**
*T *V	The First of Spray	38.49	38.11	34.83	37.14
	The Second of Spray	55.53	57.24	61.45	58.07
					***C**
*V *C	0	40.64	41.65	40.01	40.76
	1.5	43.88	45.22	45.25	44.78
	2	54.76	54.86	54.15	54.59
	2.5	48.77	48.96	53.16	50.29
*V	—	47.01	47.67	48.14	—

Note: LSD (0.05),*T= 3.53, LSD *V = N.S, LSD *C = 3.78, LSD *T V = 5.11, LSD *T C = 3.16, LSD *V C = 3.10 and LSD *TVC = 7.42.

Table 3D : Effect of different concentration of humic acids on the plant dry weight (g) of potato.

Number of Spray*T	Concentration of Humic Acid*C	Variety*V			*T *C
		Rivera	Rudolph	Elmundo	
The First of Spray	0	2.98	3.86	2.76	3.20
	1.5	3.87	3.51	3.71	3.69
	2	4.01	4.13	3.69	3.94
	2.5	3.35	3.96	3.48	3.59
The Second of Spray	0	3.96	4.43	4.74	4.37
	1.5	5.73	5.99	6.81	6.17
	2	7.18	7.12	8.88	7.72
	2.5	5.54	5.98	6.90	6.14
					***T**
*T *V	The First of Spray	3.55	3.86	3.41	3.60
	The Second of Spray	5.60	5.88	6.83	6.10
					***C**
*V *C	0	3.47	4.14	3.75	3.78
	1.5	4.80	4.75	5.26	4.93
	2	5.59	5.62	6.28	5.83
	2.5	4.44	4.97	3.46	4.29
*V	—	4.57	4.87	4.68	—

Note: LSD (0.05),*T= 0.98 ., LSD *V = N.S, LSD *C = 1.02, LSD *T V = 1.11, LSD *T C = 1.16, LSD *V C = 1.22 and LSD *TVC = 2.02.

Fig. 1 : Preparation the Middle and Seedling are Transplanted into Plastic Bags (40 cm diameter).

of roots per plants in both varieties. The highest rate is up to 34.90 cm with Rudolph variety and concentration 2 m/L1 of Humic acid in the Second of spray, while Elmundo variety and control the lowest rate is obtained up to 28.48 cm with the first of spray (table 3B). The Elmundo variety is recorded the highest rate up to 7.21; while the Rivera is recorded the lowest rate up to 5.28. At 2 m/L^1 concentrations of Humic acid, a significant effect on number of tuber is recorded and the highest rate is up to 7.05, while at control, there is a significant decrease in the number of tuber and the lowest rate is recorded up to 5.44. The highest rate of the second of spray is obtained and recorded up to 6.82, while the first of spray recorded the lowest rate up to 5.49. Intersection between (T× C× V), has an important effect on the number of tubers in table 3.B, which gives a highest rates 8.97 with Rivera and concentration of Humic acid 2 m/L^1 to the Second of spray. At the same time, recorded lowest rate up to 3.81 with Rivera variety and 2.5 m/L^1 concentration of Humic at the first of spray. This study established that fresh and dry weights of shoot are significantly increasing under different concentrations of Humic acid, as compared with control (tables 3C, D). A non-significant all the varieties under conditions in the experiment of plant fresh weight, while the Elmundo variety surpassed significantly other treatments and recorded the highest rate up to 48.14. The 2 m/L^1 of Humic Acid affected the plants behavior such as increasing the plant fresh weight who recorded the highest rate up to 54.59 g and at control who recorded lowest rate up to 40.76 g . The results showed that the plant fresh weight is significantly different in number of spray. Anyway, under the second of spray who the highest rate up to 58.07, but with the first spray of Humic Acid gave the lowest average leaf size rate up to 37.14g. The results showed significant differences among the intersection (T× C× V), with the Elmundo variety and the second of spray under concentration of Humic Acid 2 m/L^1, who recorded the highest rate up to 71.79 g compared to the control, recorded the lowest value of 31.87 with Elmundo variety and the first of spray. In the table 3.D. No significant differences among varieties. In contrast, Rudolph variety is recorded the highest rate up to 4.87 g, while the Rivera is recorded the lowest rate up to 4.57g. At 2 m/L^1 of Humic Acid, a significant effect on dry weight is recorded and the highest rate is up to 5.83 g, while at level control, there is a significant decrease in the weight of plant and the lowest rate is recorded up to 3.78 g. The highest rate of the second of spray is obtained and recorded up to 6.10 g, while the first spray recorded the lowest rate up to 3.60 g. Anyway, growth parameters revealed important interaction between Concentrations of Humic Acid and varieties in the dry weight of plant at intersection (T× C× V), The maximum dry weight (8.88 g) was obtained from 2 m/L1 of Humic Acid and the second of spray with variety Elmundo. Whereas, the control under the first of

spray and variety Elmundo is recorded the lowest rate up to 2.76 g. The findings of present research is in line with the findings of Mahmoud and Hafez (2010), who reported that the vegetative growth parameters, potato yield and tuber size, weight and quality as well as nutritive value of potato tuber were significantly augmented with increasing the level of Humic acid application from 0 up to 2.5 2 m/L^1 Humic acid/ha, also by increasing the nutrients availability to the plant. Different cultivars had various genetic potential in relation to their development and yield component (Pinaka *et al*., 2004; Young *et al*., 2004). Also, Arancon *et al*. (2006) described that pepper plants treated with Humic acid significantly produced more fruits and flowers than unprocessed plants.

Conclusion

Plant growing pointers, plant nutritional status, and tubers excellence parameters responded positively to Humic acids application rates, followed by Elmundo variety, the most arresting answers are effect of Humic acid concentrations on three potato varieties, are concerned the results concluded that 2 m/L^1 gives the higher potato yield and the lowest yield was gotten in control treatment, with the second spray period after 35 days from first spry.

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