



EFFECTS OF SPRAYING OF HUMIC ACID AND THE ADDITION OF DIFFERENT LEVELS OF ORGANIC FERTILIZER ON GROWTH AND YIELD OF TWO VARIETIES OF POTATOES (*SOLANUM TUBEROSUM* L.) UNDER DRIP IRRIGATION

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Abstract

The experiment were performed in the field of the technical College of agriculture, Mosul, Iraq during the spring season, 2019 to investigate the effect of humic acid spraying on potato plants during the vegetative stage after 45 days of planting using two concentrations 1.5 and 3.0 gm per liter in addition to the control 0.0 mg concentration.

The second factor is the organic manure at two levels 5 and 10 tons/ donum, in addition to the control without organic manure which were added in a trench running lengthwise with the planting line after 45 days of planting using two potato varieties, Montreal and Barcelona. Results showed that the Montreal variety responded significantly to humic acid spraying at both 1.5 and 3.0 gm/L compared with the control. The Montreal variety was superior over the Barcelona variety in all studied traits. The effect of the organic manure at the higher level 2.5 tons/donum was significantly higher than the lower level used and the control. While the effect of the interaction among the three factors showed superiority of the Montreal variety supplied with humic acid and organic manure overall the other treatments and studied traits especially the yield of single plant which reached 1.923 kg/plant and the total yield which reached 18.764 tons /donum, compared with the control which gave 6.174 tons/donum.

Key words: Humic acid, Organic manure, Montreal, Barcelona, Drip irrigation.

Introduction

Potatoes (*Solanum tuberosum* L.) is one of the most popular and nutritive vegetable crops worldwide with an annual production approaching 388.1 million tonnes cultivated in 19.3 million hectares. Potatoes are cultivated in more than 164 countries around the world. Consumption of organic potatoes promote human health and nutritional safety (FAO, 2019). Potatoes is one of the summer strategic crops with high economical income (Matlob, 1980).

Humic acid (polymeric polyhydroxy acid) is one of the most important organic fertilizers of humic compounds derived from organic matter decomposition which include C, H, N and O₂ at variable levels. The addition of HA. Increase the absorption of nutrient elements and increase protein content and soil microorganisms and improve the physical, chemical and biological properties of the soil and water retention. (Alalaf, 2012 and Puglisi *et al.*, 2013).

Humic acid is a natural substance in the soil and is a byproduct of organic matter decomposition. Several crops were successfully grown using humic acid such as potatoes, tomatoes, maize and blueberry. (Suh *et al.*, 2014) and schoepitz *et al.*, 2016). Also, a significant increase in the total marketable yield of potatoes were achieved when organic manure was used at rates of 23.8 and 35.7 tons/ha. (Sayed *et al.*, 2015).

The addition of humic acid significantly increased the peanut yield by 78.9% compared with the control and increased soil minerals such as NPK, with improving soil properties, enzymatic activity and microbial diversity. (Yan *et al.*, 2019).

Organic manure added at a rate of 25 tons/ha. Gave the highest yield of potatoes per plot 43.2 kg/ 12 m². Sayed *et al.*, (2015) also found significant increase in total marketable yield of potatoes when they used organic manure at 23.8 and 35.7 tons/ha. Baniuniene and Zekaite,

Table 1: Effect of potato varieties on vegetative growth and total tuber yield tons/donum.

Variety	Plant height cm.	No. of aerial shoots	Average no. of tubers/plant	Mean weight of tubers/plant gm.	Average yield of tuber/plant gm.	Total yield tons /donum
Montreal	29.8 a	8.21 a	12.8 a	55.6 a	711.7 a	11.102 a
Barcelona	25.5 b	5.5 b	10.6 a	45.2 b	524.3 b	8.179 b

Table 2: Effect of humic acid on vegetative growth and total tuber yield in tons/donum on both varieties.

Humic acid conc. gm/L	Plant height cm.	No. of aerial shoots	Average no. of tubers/plant	Mean weight of tubers/plant gm.	Average tuber yield/plant gm.	Total yield tons /donum
0	19.5 c	4.35 b	7.1 c	42.6 c	302.1 c	4.713 b
1.5	28.3 b	8.3 a	11.8 b	50.3 b	593.5 b	9.259 b
3	35.2 a	9.8 a	16.1 a	58.6 a	942.7 a	14.703 a

Table 3: Effect of organic fertilizer on vegetative growth and total tuber yield in tons/donum on both varieties.

Level of organic manure tons/donum	Plant height cm.	No. of aerial shoots	Average no. of tubers/plant	Average weight of single tubers/plant gm.	Average of tuber yield/plant gm.	Total yield tons /donum
0	22.1 c	5.7 b	10.9	47.8	521.1	8.128
1.25	27.5 b	6.6 ab	12.4	50.8	629.9	9.827
2.50	30.4 a	8.2 a	13.3	54.4	723.5	11.287

(2008) found that farmyard manure (FYM) increased potato tuber yield by 35.82%.

Radwan and El-shall, (2011) sprayed potato plants with 4 kg/feddan (feddan = 4000 m²) which resulted in a high plant growth and yield. While the combination of 2 kg. of humic acid with 100 kg. of K₂O increased the yield and its components. Alenazi *et al.*, (2016) applied humic acid by spraying on potato plants 30 days after planting at a rate of 1.5 g/L which increased vegetative growth, tuber weight and total yield.

Materials and Methods

The experiment is performed in the field of the

technical agricultural college, department of plant production techniques in Mosul, Iraq during the spring season started on the 20th of February, 2019 to study the effects of three factors, these are: first two varieties of potatoes Montreal (V1) and Barcelona (V2), the second is the addition of humic acid (H1) sprayed at 1.5 gm/l and (H2) at 3.0 gm/l and the control treatment with zero humic acid. The third factor is the addition of organic animal manure at a rate of 1.5 and 2.5 tons/donum by inoculation after planting. Randomized complete block design (RCBD) were used as a factorial experiment with three replicates 2×3×3=18.

Soil preparation such as plowing and leveling were performed and drip irrigation were established for the experiment. Seed tubers were planted in the field on the 20th of February, 2019 at 25 cm apart and 80 cm between the irrigation lines, with twelve tubers for each treatment. Tuber seeds weight ranges between 50-55 gm. Cultural

practices were carried out from planting to harvest, such as irrigation, weed, pest and disease control. The following data were recorded: plant height in cm. number of aerial stems, number of tubers /plants, average weight of tubers in gm. obtained by dividing the yield of the experimental unit by the total number of tubers of the experimental unit. The yield of single plant was also calculated by dividing the yield of the experimental unit by the number of plants. Then the total tuber yield in tons/donum were also calculated on basis that one donum is equal to 2500 m².

Results and Discussion

It is obvious from table 1, that clear differences appeared in all studied traits between both varieties

Table 4: Effect of interaction between cultivars and humic acid on vegetative growth and total tuber yield in tons/donum.

Total yield tons/donum	Average weight of tubers/plant gm.	Average weight of single tuber/plant gm	Average no. of tubers/plant	No. of aerial shoots	Plant height cm.	Conc. of HA.	Variety
7.583 cd	486.1 de	49.1 cd	9.9 de	4.9 cd	20.3 d	0	Montreal
10.170b	651.9 bc	53.0 ab	12.3 bc	7.8 b	30.5 b	1.5	
12.916a	827.9 a	57.1 a	14.5 a	12.0	38.6 a	3	
6.437 d	412.7 e	43.9 d	9.4 e	3.8 d	18.6 d	0	Barcelona
8.724 c	559.3 cd	47.8 cd	11.7 cd	5.3 c	26.2 c	1.5	
11.254 b	721.4 b	51.9 bc	13.9 ab	7.7b	31.7 b	3	

Table 5: Effect of interaction between cultivars and organic fertilizer on vegetative growth and tuber yield in tons/donum.

Total yield tons/donum	Average weight of tubers/plant gm.	Average weight of single tuber/plant gm	Average no. of tubers/plant	No. of aerial shoots	Plant height cm.	Level of organic manure tons/donum	Variety
9.598 c	615.2 b	51.7 cd	11.9 bc	6.8 c	26.8 c	0	Montreal
10.457 b	670.3 b	53.2 bc	12.6 ab	7.9 bc	29.8 b	1.25	
11.240 a	720.5 a	55.0 ab	13.1 a	9.9 a	32.9 a	2.5	
7.834 e	502.2 c	46.5 d	10.8 c	4.7 e	23.4 e	0	Barcelona
8.611 d	552.0 de	48.0 cd	11.5 bc	5.9 de	25.2 de	1.25	
10.577 b	678.0 b	56.5 a	10.0 ab	6.4 cd	27.9 bc	2.5	

Montreal and Barcelona such as plant height, number of aerial stems, number of tubers per plant, average of single tuber weight (gm), single plant yield (gm) and yield of unit area in tons per donum.

Results showed that the Montreal variety gave superior results over the Barcelona variety in all above studied traits. It is been noticed that the Montreal tubers germinated by ten days earlier than Barcelona variety, which is been reflected on single plant yield which reached 711.7 gm. and total yield /d which reached 11.162 tons/d compared with 524.3 gm. and 8.179 kg/plant respectively. This could be due to storage temperatures or genetic reasons (Matlob *et al.*, 1981).

The effect of humic acid on vegetative growth and yield constituents of the two potato varieties. It is been found that the higher level 3 gm./l caused a significant increase in yield and single plant yield which are 14.705 tons/d and 942.70 gm/plant respectively. This result agrees with Alenazi *et al.*, (2016) and yan *et al.*, (2019) as it improved the soil conditions and its physical state. Alalaf, (2013).

Whereas in table 3, the organic manure at a rate of 2.5 tons/d resulted in a significant increase in yield and vegetative growth compared with the second level and the control. Which comes in harmony with puglisi *et al.*,

(2013) and Alalaf, (2013).

Table 4, refers to the interaction between both varieties with the application of humic acid by spraying on plants after 45 days of planting. Results showed a clear response of the Montreal variety to the higher concentration of humic acid 3 gm./L significantly on all studied traits compared with the Barcelona variety. This result may support the role of humic acid on increasing the lateral branching of the roots and breaking of soil particles and eventually improvement of the chemical, physical and biological characteristics and increase the water holding capacity of the soil. This result is compatible with what were achieved by Alalaf, (2012) and Yan *et al.*, (2019).

Table 5, shows the effect of the interaction between potato varieties and the organic manure. Results revealed the significant superiority of the Montreal variety over the Barcelona in all measured traits, especially the total yield which reached 11.24 tons/d by applying the 2.5 tons/d compared with the 1.25 tons/d which gave 10.457 tons/d and 9.598 tons/d for the control of the Montreal variety.

The behavior of the Barcelona variety took the same direction as the yield reached 10.577, 8.611 and 7.834 tons/d for the, 2.5, 1.25 and 0.0 tons/donum respectively. While the increase in yield of the Montreal variety and its more response to humic acid than the Barcelona variety

Table 6: Effect of interaction between humic acid and organic fertilizer on vegetative growth and tuber yield tons/donum on both varieties.

Total yield tons/donum	Average weight of tubers/plant gm.	Average weight of single tuber/plant gm	Average no. of tubers/plant	No. of aerial shoots	Plant height cm.	Level of organic manure tons/donum	Conc. of humic acid
6.346 g	406.8 f	45.2 c	9.0 f	3.9 e	16.9 g	0	0
7.139 fg	457.7 ef	46.7 de	9.8 ef	4.3 de	19.4 df	1.25	0
7.717 ef	494.7 de	48.5 cd	10.2 de	4.9 de	22.3 ed	2.5	0
8.694 e	557.3 d	49.1 cd	11.4 cd	5.6 cd	24.9 e	0	1.5
9.551 d	612.3 c	50.6 bc	12.1 cd	6.7 cd	28.3 d	1.25	1.5
10.259 cd	657.6 c	52.4 bc	12.6 bc	7.3 bc	31.9 cd	2.5	1.5
11.898 bc	762.8 b	56.5 b	13.5 b	7.9 b	33.6 bc	0	3
12.202 b	782.2 b	54.7 b	14.3 ab	9.3 b	34.9 b	1.25	3
14.642 a	938.6 a	63.9 a	14.7 a	12.3 a	37.0 a	2.5	3

Table 7: Effect of interaction between cultivars and organic fertilizer on vegetative growth and tuber yield in tons/donum.

Total yield tons/donum	Average weight of tubers/plant gm.	Average weight of single tuber/plant gm	Average no. of tubers/plant	No. of aerial shoots	Plant height cm.	Level of organic manure tons/donum	Conc. of HA.	Variety
5.501 ij	352.7 h	14.5 fg	8.5 fg	4.6 ef	18.3 hi	0	0	Montreal
6.986 gh	447.8 gh	-	9.8 f	4.8 ef	20.6 gh	1.25	0	
8.520 f	546.2 fg	50.6 de	10.8 e	5.2 cd	22.5 g	2.5	0	
8.706 f	558.1 f	50.9 de	11.0 e	6.3 cd	25.1 ef	0	1.5	
9.686 ef	620.8 e	52.3 d	11.9 e	8.2 bc	30.8 de	1.25	1.5	
11.987 e	768.4 d	38.7 e	12.8 de	8.8 bc	35.6 c	2.5	1.5	
14.239 cd	912.8 bc	60.2 c	15.3 c	9.5 b	37.1 bc	0	3.0	
16.441 b	1053.9 b	60.1 c	16.4 bc	10.6 b	38.1 a	1.25	3.0	
18.764 a	1202.8 a	71.5 a	18.5 a	14.8 a	40.6 a	2.5	3.0	
3.471 k	228.5 i	36.7 g	6.5 h	3.1 g	15.5 i	0	0	Barcelona
4.637 jk	297.2 hi	38.6 fg	7.7 gh	3.8 fg	18.1 hi	1.25	0	
5.859 hi	375.6 h	42.2 fe	8.9 f	4.6 ed	22.1 g	2.5	0	
7.027 gh	450.5 g	44.6 e	10.1 ef	4.8 ef	24.6 fg	0	1.5	
9.199 f	589.1 f	46.8 e	12.6 de	5.2 dc	25.8 ef	1.25	1.5	
9.553 f	612.4 fe	48.6 e	12.6 de	5.8 ed	28.1 ef	2.5	1.5	
10.999ef	705.1 de	52.6 a	14.2 cd	6.3 ed	30.1 de	0	3.0	
13.085 d	828.8 cd	52.1 d	16.1 bc	7.9 cd	31.6 d	1.25	3.0	
13.847 d	887.8 c	54.8 cd	16.2 bc	8.8 bc	33.4 d	2.5	3.0	

gave 11.240, 10.457 and 9.598 for the levels of the manure 2.5, 1.25 and 0.0 kg/d respectively. This could be due to the more suitability of the Montreal variety to the new climatic conditions in the Mosul region. This agrees with Alali and Alhamed, (2017) when they used poultry manure and humic acid on local and foreign variety and also in agreement with Suh, (2014) and schoepitz *et al.*, (2016).

The results in table 6, showing the effect of spraying with humic acid and application of organic manure on all studied traits. The vegetative growth and yield were increased by the application of 3 gm/L of humic acid which gave 14.642 tons/d and 2.5 tons/d of organic manure compared with the lower level of HA 1.5 gm/L which produced 12.202 tons/d and the control which result in 11.898 tons/d while the last amount of yield is 6.346 tons/d were obtained from the control 0.0 HA and 0.0 organic manure.

Table 7, illustrates the triple interaction among the three factors, varieties, humic acid and organic fertilizer on vegetative growth, yield and its constituents. It is clear that the Montreal variety treated with 3.0 gm/L of HA and 2.5 tons/d of organic manure resulted in the higher yield 18.764 tons/d, while the least amount of yield were obtained from the control 0.0 concentration of both HA and organic manure, compared with the Barcelona variety which gave 13.847 tons/d using the same above levels. While the control resulted in the lower amount of yield 3.471 tons/d. This difference in yield may be due to genetic

reasons in the Montreal variety over the Barcelona for the studied traits. This factor is been reflected on the total yield, which is in harmony with the results found by Al-Ali and Abdulhameed, (2017). Sanli Arif *et al.*, (2013) found an increase in four potato varieties by 22% of tuber number and 38% in yield by using organic leonardite.

Conclusions and Recommendations

It is clear from the results shown in tables 1-7, that the Montreal variety is significantly superior over the Barcelona variety for all studied traits, when they were sprayed with humic acid at 3 gm/L plus organic manure at a rate of 2.5 tons/d.

Thus, we recommend carrying on more future studies on these varieties and other varieties under Mosul climatic conditions using HA and organic manure at more or higher concentrations to improve potato yield and quality.

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