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Humic Acid to Decrease Fertilization Rate on Potato (*Solanum tuberosum* L.)

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Abstract: The current study aimed at decreasing fertilizers applications on potato (*Solanum tuberosum* L.) cultivar Spunta. Plants were subjected to six treatments as follows: unfertilized control (T0), fertilization program (166-N+ 80-P_2O_5+ 80-k_2O + 30M^3 cattle manure ha^{-1}) of Ministry (MAP) of Agriculture (T1), 100% MAP + 20kg humic acid (HA) ha^{-1} (T2), 100% MAP + 15 kg HA ha^{-1} (T3), 50% MAP + 20 kg HA ha^{-1} (T4), 50% MAP+15 kg HA ha^{-1} (T5). Vegetative growth increased after the different fertilization applications than control where T1, T4 and T3 had the longest plants; T1, T2 and T4 emerged the significant highest number of main stems; T1 and T4 produced the significant highest leaf area and T4 in both seasons and T3 and T2 in the first season had the significant heaviest plant fresh weight. Yield components in general significantly increased where T2 and T3 produced the significant highest tubers number $plant^{-1}$; T3 yielded the significant highest tubers weight $plant^{-1}$; T4, T1 and T2 significantly had the highest number of tubers >60 mm diameter $plant^{-1}$. Tuber physical properties were also significantly and positively affected as compared to control where T3 and T4 resulted in the significant longest tubers. T5, T3 and T1 had the significant widest tubers and T3 and T4 produced the significant heaviest tubers. It could be recommended under similar conditions to add 83-N+40-P_2O_5+ 40-k_2O + 15M^3 cattle manure ha^{-1} + 20kg humic acid ha^{-1}.

Keywords: Humic Acid, Potato Yield, Tuber Properties, Vegetative Growth

1. Introduction

Potato is the world's fourth largest food crop where it plays an important role as a staple food in the Mediterranean Basin countries. The crop occupied an overall area about 1 million hectares which produced 28 million tons of tubers (FAO, 2011). Potato locally is considered as one of the most important vegetable crops where the crop total cultivated area reached about 1380 hectares constituting 52% of the vegetables area (MoA, 2010).

Humic acid contains many elements and it acts as an amendant to improve soil fertility. This increases the availability of nutrients and consequently it increases plant growth and yield. Humic acid particularly is used to ameliorate or reduce the side effect of chemicals. The acid application increased organic matter in soil which improved plant growth and yield (Chen and Aviad., 1990; David, et al., 1994; Hartwigson and Evans., 2000; Hafez., 2003; Erik, et al., 2000; El-Desuki., 2004). Humic substances are able to capture more moisture content that will increase the water use efficiency in the sandy soil. This may be attributed to the swelling and retention of water by the amended soil (Suganya and Sivasamy, 2006). Humic acid efficiently improves soil fertility and crop productivity (Chen and Aviad, 1990; Rajpar et al., 2011). Humic acid affects chemical and biological properties of soil as well as morpho-physiological processes of a plant (Ohta et al., 2004).

Vegetative growth, yield and tuber quality as well as the tuber nutritive value of potato significantly increased with humic acid level increase where no significant differences were noticed between 1 and 2 $kgfed^{-1}$ (Mahmoud and Hafez, 2010). Humic acid application led to positive changes in vegetative growth, leaf area index due to increase in root growth and nutrients availability (El-Hefny, 2010). Tuber yield increased by 16.47% after addition of humic substances compared to the recommended rate solely. These substances + 75% of the recommended NPK fertilizer was beneficent (Selim et al., 209). Soil application of humic acid significantly increased plant growth, photosynthetic pigments, total and marketable yield and tuber root quality (El-Sayed Hameda et al., 2011). Humic acid at 0, 10, 20 and 30 cm L^{-1} of irrigation water enhanced potato growth parameters, yield and tuber physical and chemical properties. The highest dose of the acid resulted in highest plant vigor increase, the heaviest tuber yield and the best tuber properties (Rizk et al., 2013). Soil application of humic acid did not affect tuber size, total yield or other chemical composition of tubers. However, 80g m^{-2} increased incidence of tubers with hollow heart (Suh et al., 2014).

This study aimed at investigation the effect of Humic acid application levels and fertilization rate on growth and productivity of potato crops.

2. Material and Methods

2.1. Location and Season

This trial was carried in the two seasons of 2013 and 2014 at a farm of the privates sector in Gaza Strip, Palestine. Spunta cultivar which is the most favorite and cultivated variety was used in this experiment.

2.2. The Experiment Layout and Treatments

It was arranged in the Randomized Complete Block Design (RCBD), with four replications. The plot area was 26.25 m^2 containing 150 plants which were spaced at 70 x 25 cm. Six fertilization treatments were used as they follow in table (1).

Table 1. *Treatments applied.*

Treatments content	Treatment code
Unfertilized control	T0
100% Ministry of Agriculture recommended (166-N+ 80-P_2O_5+ 80-k_2O + 30M^3 cattle manure ha^{-1}) program	T1
100 % recommended program + Humic acid 20 kg ha^{-1}	T2
100% recommended program + Humic acid 15 kg ha^{-1}	T3
50% recommended program + Humic acid 20 kg ha^{-1}	T4
50% recommended program + Humic acid 15 kg ha^{-1}	T5

Humic acid at15 or 20 kg ha^{-1} was applied on soil by spraying before sowing the cut-seeds.

2.3. Data Recorded

2.3.1. Vegetative Growth

A random sample of five plants $plot^{-1}$ were devoted after 70 days of planting to determine plant length (cm), number of stems $plant^{-1}$, leaf area (cm^2) and plant fresh weight (g).

2.3.2. Yield Components

They were determined after 100 days of sowing as tubers weight $plant^{-1}$, number of tuber $plant^{-1}$ and number of tuber of diameter >60 mm $plant^{-1}$.

2.3.3. Tuber Quality

At harvesting time (after 100 days of sowing), a random samples of 20 tubers $plot^{-1}$ were devoted to determine the physical properties as an average of tuber weight (g), tuber length (cm) and tuber diameter (cm)

2.4. Statistical Analysis

Data were statistically analyzed according to Steel and Torrie (1980), where means comparison was carried out using Duncan's multiple range test. Means followed by the same letter/s within each columns are not significantly different at p= 0.05.

3. Results and Discussion

3.1. Vegetative Growth

Data reported in Table (2) show the different measurements of vegetative growth. It is clear that plant height generally showed a significant increase during the two seasons than control. Treatments T1 and T4 gave the significant longest plants in both seasons where T3 had the longest plants in the second season only. Number of stems $plant^{-1}$ increased in the fertilizers applications than control during the two seasons where T1and T2 had the highest significant increase in both seasons. In this concern, no significant changes were noticed among fertilizers treatments in both seasons. Leaf area increased after fertilizers applications than untreated control in the two seasons, where in general this increase was significantly in the first season only. In this concern, T1 produced the significant highest area in both seasons where T4 in the first season and T3 in the second one came to the second position. Plant fresh weight showed that the different fertilizers treatments had heavier plants than control in the two seasons where treatment T4 resulted in the significant heaviest plant in both seasons. In this issue, T2 and T3 respectively came to the second significant rank in the first season and the same trend insignificantly was also true in the second experiment. No significant differences were detected between T4 and the other fertilization treatments in the two seasons.

Humic substances such as humic acid is the main component (65-70%) of soil organic matter which enormously increases plant growth by increasing permeability of cell membrane, respiration, phosynthesis rate, oxygen and supplying root cell growth (Russo and Berlyn, 1990). The increase in plant height and stems number of potato is due to humic acid nutrient providing. These elements involve in plant bioactivities and finally encourage plant growth induction (Abdel-Mawgood et al., 2007 and Taha, 2011). This increment in vegetative growth may be attributed to the enhancing effect of humic acid on the availability of nutrients and the role of potassium in plant nutrition which in turn increased the vegetative growth of potato plants (Mahmoud and hafez, 2010). Humic acid increases the soil prosperity which improves root growth and to increase shoot system (Gracia et al., 2008). Humic acid is beneficial to shoot and root growth by playing a role in nutrient's uptake in vegetable crops (Dursun et al., 2002;

Cimrin and Yilmaz, 2005). Humic substances have a direct action on plant growth by influencing metabolic processes such as nucleic acid synthesis, ion uptake and regulation of hormone levels (Serenella et al., 2002).

These results were in harmony with those reported on potato by El-Hefny, (2010) Mahmoud and Hafez (2010), and El-Sayed Hameda et al., (2011) and Rizk et al., (2013).

Table 2. *Effect of humic acid and fertilization levels on potato vegetative growth.*

Treatments	Plant height (cm)		Main stems no.		Leaf area (cm^2)		Plant fresh weight (g)	
	First	Second	First	Second	First	Second	First	Second
T0	28.0 c	39.9 c	1.83 b	1.80 b	139 d	163 b	186 b	296 b
T1	36.0 a	51.9 ab	3.66 a	2.35 a	275 a	290 a	333 ab	372 ab
T2	33.3 ab	50.2 b	3.33 a	2.30 ab	193 c	210 ab	433 a	453 ab
T3	32.0 b	57.4 a	3.00 ab	2.15 b	187 cd	272 ab	342 a	458 ab
T4	36.6 a	53.2 ab	3.10 ab	2.25 b	258 ab	232 ab	445 a	508 a
T5	31.6 bc	50.9 b	2.66 ab	2.15 b	219 bc	204 ab	314 ab	389 ab

Means of same letter/s in a column don't differ significantly at $p= 0.05$ (Duncan's multiple range test).

3.2. Yield Components

The different components of yield i.e., number of tubers of $plant^{-1}$, weight of tubers $plant^{-1}$ and tuber number size >60 mm are reported in Table (3). It is evident that number of tubers $plant^{-1}$ increased by the different fertilization treatments than control in both seasons. In this respect, T4, T2 and T3 respectively in the first season and T2 in the second one resulted in the highest significant increase. In addition, T3 came to the second position in second season only with no significant differences among T3 and the other fertilization treatments. Tubers weight $plant^{-1}$ in general significantly increased due to the fertilization treatments as compared to control in the two seasons. Treatment T3 in the first season and all the fertilization applications in the second season showed the highest significant increase. Generally, no significant differences were observed among fertilization treatments in the two seasons. Number of tubers $plant^{-1}$ (diameter >60 mm) increased in both seasons where the increase was significantly higher than that of control in T4 in the first season and T4, T1 and T3 in the second one. No significant changes were noticed among all fertilization treatments in the first season while T3 was significantly lower than T4, T1 and T2 in the second season. Humic acid and nitroxin leads to increase plant yield through positive physiological effect such as impact on metabolism of plant cells and increasing the concentration of leaf chlorophyll (sure, et al. 2012). Humic acid is a promising natural resource that can be used as an alternative to synthetic fertilizers to increase crop production. It exerts either a direct effect, such as on enzymatic activities and membrane permeability, or an indirect effect, mainly by changing the soil structure (Biondi, et al., 1994).

Yield components in this trial came to the same trend of the results reported on potato by El- Selim et al., (2009), Hefny., (2010), Mahmoud and Hafez., (2010), El-Sayed Hameda et al., (2011) and Rizk et al., (2013). On the other hand, soil application of humic acid did not affect potato yield components (Suh et al., 2014).

Table 3. *Effect of humic acid and fertilization level on yield components.*

Treatments	Tuber number $plant^{-1}$		Tubers weight g $plant^{-1}$		Tuber number $plant^{-1}$ (diameter>60 mm)	
	First	Second	First	Second	First	Second
T0	5.6 b	5.5 b	753 c	632 b	2.43 b	2.20 c
T1	7.3 ab	7.2 ab	955 abc	1004 a	3.80 ab	4.85 a
T2	9.0 a	8.5 a	1133 ab	1016 a	3.96 ab	4.60 a
T3	8.6 a	7.8 ab	1177 a	1209 a	4.20 ab	3.80 b
T4	9.3 a	7.3 ab	893 bc	1084 a	4.86 a	5.17 a
T5	7.6 ab	7.3 ab	1024 ab	1115 a	3.73 ab	4.47 ab

Means of same letter/s in a column don't differ significantly at $p= 0.05$ (Duncan's multiple range test).

3.3. Tuber Properties

The physical traits i.e., tuber length, tuber diameter and average of tuber weight are reported in Table (4). Tuber length in the different fertilization treatments was significantly higher than that of the respective control in the first season. The significant longest tuber was obtained by treatments T3 and T4 respectively in comparison with other fertilizers applications in the first season where the different fertilization treatments also showed longer tuber than control in the second season. This increase was significantly the highest in T3 only where T4 came to second position in this concern. Tuber diameter generally showed significant increase in all fertilization treatments compared to control in both seasons. In this issue, T5 in the first season and T3, T5 and T1 in the second one had the significant widest tubers. Average of tuber weight in general produced higher significant increase in fertilization treatments than control in the first season. This increase was significantly in T3 and T4 in the second seasons only where T3 produced the heaviest tubers in the first seasons.

The current results found support in the work of Mohmoud and Hafes., (2010), El-Sayed Hameda et al., (2011), and Rizk et al (2013). Contrary results were reported by Suh et al., (2014) that soil application of humic acid had no effect on potato physical or chemical properties.

Table 4. *Effect of humic acid and fertilization level on tuber physical properties.*

Treatments	Tuber length (cm)		Tuber diameter (cm)		Average of tuber weight (g)	
	First	Second	First	Second	First	Second
T0	7.66 c	8.62 b	4.3 c	5.4 b	130 c	169 b
T1	9.66 ab	9.37 b	6.0 ab	6.1 a	161 ab	190 ab
T2	9.83 ab	8.92 b	6.0 ab	5.7 ab	167 ab	196 ab
T3	10.50 a	10.27 a	6.0 ab	6.2 a	184 a	237 a
T4	10.16 a	9.55 ab	5.8 b	5.8 ab	149 bc	224 a
T5	8.83 b	9.32 b	7.3 a	6.1 a	159 ab	206 ab

Means of same letter/s in a column don't differ significantly at p= 0.05 (Duncan's multiple range test).

4. Conclusion

The local farmers have accustomed to use excess of chemical fertilizers which increased nitrate level in wells water for domestic use. Humic acid was applied on soil grown with potato cv. Spunta at 15 or 20 kg ha^{-1} to decrease level of fertilization program of Ministry of Agriculture. The two humic acid doses under the different fertilizers applications could improve vegetative growth, yield and tuber properties. The most economic and effective results were obtained by application of 83-N+40-P_2O_5+ 40-k_2O kg ha^{-1} + 15M^3 cattle manure ha^{-1} + 20kg humic acid ha^{-1}.

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