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Influence of different NPK fertilization levels and humic acid rates on growth, yield and chemical constituents of roselle (*Hibiscus sabdariffa* L.)

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ABSTRACT

In order to study the influence of NPK fertilization levels (0.0, 50, 75 and 100 of recommended dose), humic acid rates (0.0, 2.0 and 4.0 l/fed.$^{-1}$ as foliar spray) and their combinations on growth and productivity of roselle, two field experiments were conducted for two summer seasons of 2017 and 2018 at the Experimental Farm of Faculty of Agriculture (Ghazala Farm), Zagazig University, Egypt. The recommended dose (RD) of NPK were (N fertilizer at 68 + P_2O_5 fertilizer at 32 + K_2O fertilizer at 24 kg/fed.$^{-1}$). The experimental design was split-plot which arranged in three replicates. Furthermore, the obtained results referred that the highest values of plant height, number of branches/plant and total dry weight/plant were achieved with 100% of RD compared to the other levels. Also, the same trend were obtained toward the yield components (fruit number/ plant, sepals and seed yield per plant and per fed.$^{-1}$) and chemical constituents (N, P and K percentages as well as total soluble solids). In addition, the highest values of abovementioned parameters were recorded by 4 l Fed.$^{-1}$ humic acid which followed by 2 l Fed.$^{-1}$ humic acid with significant difference between them and control (untreated plants). Generally, it could conclude that humic at 4 l/fed.$^{-1}$ combined with 100% RD, showed a uniform influence in enhancing of roselle growth and its productivity under Sharkia Governorate conditions.

***Keywords*: *Hibiscus sabdariffa*, NPK, humic, Growth, Sepals and Chemical constituents.**

Introduction

Roselle (*Hibiscus sabdariffa*, L.) belongs to the family Malvaceae. It is known commonly as "karkade" in Egypt and most Arab countries (Mohamed *et al*., 2007). The part of the flower used by customers is the dried and fleshly calyces which have large quantities of organic acids (that is, oxalic, malic, citric and tartaric acids). Peng-Kong *et al*. (2002) reported that the sepals have, also, the properties of therapeutic and diuretic acids and vitamin C, in addition to anthocyanin. Roselle is planted in tropical zone, Africa, and Mexico and India has a special position in traditional medicine. Plants have been rich medicinal sources for a very long time and have had a special status in health caring from both prevention aspects and remedy. Aziz *et al*. (2007) demonstrated that roselle sepals kills various types of micro-organisms and bacteria, and as such, decreases causes relaxation of the rest parts of the body and blood pressure. The red beverage is also used in tea pies, jams, sauces and deserts. The roselle flowers are suitable for utilize as natural food coloring agents. It is used for controlling blood pressure. Also, it has been found that it is restorative, sexual stimulator, cancer-protective, appetizer, cathartic, refrigerant and anti-cough (Lin *et al*., 2007).

The macronutrients, nitrogen, phosphorus and potassium, are often classified as a primary macronutrients, because deficiencies of these nutrients are more common than the secondary macronutrients, calcium, magnesium and sulfur. Moreover, the macronutrients represent 0.1 to 5 % of dry plant tissue, whereas the micronutrients generally comprise less than 0.025 % of dry plant tissue (Wiedenhoeft, 2006). Moreover, the use of organic fertilizers such as humic acid is gaining more importance for getting higher yield and quality.

In addition, humic acid (HA) is a promising natural resource that can be utilized as an alternative to synthetic fertilizers to improve crop production. Humic acid exerts either a direct effect, such as on permeability of membrane as well as enzymatic activities, or an indirect effect, mainly by changing the soil structure (Biondi *et al*., 1994).It has a high molecular weight also it has high complexation ability (Mikkelsen, 2005). In connection, it is found that humic acid application caused

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a significant increase in soil organic matter which improves growth and crop production (Magdi*et al*., 2011).

The aim of the present study was to investigate the influence of different levels of NPK fertilization and rates of humic acid on growth, yield and some chemical constituents of *Hibiscus sabdariffa* plant to under Sharkia Governorate conditions.

Materials and Methods

A field experiment was done during the two successive summer seasons of 2017 and 2018 at Experimental Farm (Ghazala), Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt, to study the influence of different levels of NPK on the plant growth, yield components and some chemicals of roselle plant (dark color) grown under Sharkia Governorate conditions. The experimental soil analysis was presented on Table A.

Table A: Physical and chemical properties of the experimental farm soil site

Mechanical analysis				
Clay (%)	**Silt (%)**	**Fine sand (%)**	**Coarse sand (%)**	**Soil texture**
46.50	26.10	10.52	16.88	Clay

Chemical analysis												
pH	**E C. (m.mohs / cm)**	**Organic mater (%)**	**Soluble cations (meq. / l)**				**Soluble anions (meq. / l)**			**Available (ppm)**		
			Mg^{++}	**Ca^{++}**	**K^{+}**	**Na^{+}**	**Cl^{-}**	**HCO_3^{-}**	**SO_4^{--}**	**N**	**P**	**K**
7.87	1.2	1.76	2.8	1.5	1.3	3.8	4.5	1.5	3.4	520	50	590

This experiment was included twelve treatments which were the combination between four levels of NPK fertilization (0.0, 50, 75 and 100 of recommended dose) as soil application and three rates of humic acid (0.0, 2.0 and 4.0 l Fed^{-1}) as foliar application. The recommended dose (RD) of NPK were (N fertilizer at 68 + P_2O_5 fertilizer at 32 + K_2O fertilizer at 24 kg/feddan as 4200 m^2). These treatments were distributed in a split plot design with three replications. The levels of NPK fertilization were randomly distributed in the main plots, while humic acid rates were randomly distributed in the sub plots.

All roselle plants received normal agricultural practices whenever they needed. All plants were fertilized with nitrogen as ammonium sulphate (20.5%N) and phosphorus fertilization as calcium super phosphate (15.5% P_2O_5) as well as potassium as potassium sulphate (48 % K_2O). Phosphorus fertilizer was added during soil preparation as a soil dressing application. While, nitrogen and potassium fertilizers were divided into three equal portions and were added to the soil after 35, 55 and 75 days from sowing. The plants were sprayed with humic acid rates (84 %) at 45, 65 and 85 days after sowing date.

Seeds of roselle were obtained from Research Centre of Medicinal and Aromatic Plants, Dokki, Giza. Seeds of roselle were sown, on 12th May during both seasons, at space of 50 cm in one side of the row just after irrigation. After three weeks from planting, germinated plants were thinned to one plant/ hill. Experimental plot was 10.80 m^2 (3 × 3.60 m) included 6 rows; each row was 60 cm apart and 3 m in length.

Data Recorded:

A random sample of three plants from each sub plot was taken after 160 days from planting and the following data were recorded:

1. **Plant growth:** Plant height (cm), number of branches/plant and total dry weight/plant (g) of roselle were recorded after 160 days after sowing.
2. **Yield components:** At harvest stage of roselle fruits (about 160 days after sowing), number of fruits /plant and dry sepals yield /plant (g) then total yield (kg/feddan) were calculated.
3. **Chemical constituents:** At harvest time, dry sepals were randomly taken from each treatment and oven dried at 70°C till constant weight and N, P and K percentages of sepals according to the methods described by Bremnerand Mulvaney (1982), Olsen and Sommers (1982) and Jackson (1970), respectively were determined. The anthocyanin content (mg/100 g) in dried sepals was determined

cholorimetrically according to the method described by (Abou-Arab *et al*., 2011) and adopted by Francis (2000) for *Hibiscus sabdariffa*. Also, total chlorophyll (SPAD unit) was determined in roselle fresh leaves by using SPAD- 502 meter as reported by Markwell *et al*. (1995). As well total soluble solids (TSS) as Brix° by using a hand refractometer of roselle fresh sepals were determined.

Statistical Analysis: The statistical layout of this experiment was a split-plot experiment in completely randomized block design. Where, NPK fertilization levels were randomly distributed in the main plots, while humic acid rates were randomly arranged in sub-plots. Each treatment was included three replicates. Collected data were analyzed according to Gomez and Gomez (1984). Least significance difference (L.S.D.) was used to differentiate means at the at 5 % level of probability. The means were compared using computer program of Statistix version 9 (Analytical software, 2008).

Results and Discussion

Plant growth:

Results of both seasons in Table 1 indicate that the highest values of plant height, number of branches/plant and total dry weight /plant of roselle plant were achieved by plants which treated with 100 % of recommended dose compared to control and the other levels under study. Plant growth parameters of roselle were gradually increased with increasing NPK fertilization levels with significant difference between them, in most cases, in both seasons. These results may be attributed to the role of N, P and K elements in metabolism and many processes wanted to sustain and encourage plant growth and development. Moreover, its play a major role in many physiological and biochemical processes such as cell division and elongation and metabolism of carbohydrates and protein compounds (Marschner, 1995). Moreover, Golzarfar *et al*. (2011) found that increasing nitrogen and phosphorus rates increased plant height, number of branches per safflower plant in both season.

Table 1: Influence of NPK fertilization and humic acid rates as well as interaction treatments on plant growth of roselle plant during the two seasons of 2017 and 2018

Treatments		Plant height (cm)		Number of branches / plant		Total dry weight /plant (g)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
NPK fertilization rates (% of recommended dose*)							
0.0		133.44	136.22	9.33	9.44	307.84	314.98
50		136.11	138.11	11.00	11.00	334.18	343.01
75		140.22	140.67	12.22	12.56	354.88	351.58
100		141.89	146.44	12.89	13.67	363.90	365.09
LSD 5%		**2.07**	**1.15**	**0.70**	**0.63**	**8.15**	**12.47**
Humic acid rates (l Fed.$^{-1}$)							
0.0		134.83	137.67	8.92	9.67	312.92	316.92
2.0		138.00	140.50	11.83	11.75	340.43	331.55
4.0		140.92	142.92	12.89	13.58	367.26	375.78
LSD 5%		**1.38**	**1.13**	**0.62**	**0.48**	**5.49**	**3.62**
Interaction between NPK fertilization and humic acid rates							
0.0	**0.0**	132.67	135.67	7.33	8.33	285.16	296.80
	2.0	132.67	135.00	9.00	8.67	308.67	310.77
	4.0	135.00	138.00	11.67	11.33	329.68	337.37
50	**0.0**	134.00	136.00	9.00	9.33	309.90	314.88
	2.0	136.67	138.33	11.67	11.00	330.60	322.50
	4.0	137.67	140.00	12.33	12.67	362.04	364.65
75	**0.0**	135.67	137.00	9.33	10.33	322.24	324.02
	2.0	140.00	141.67	13.00	12.67	360.50	341.75
	4.0	145.00	143.33	14.33	14.67	381.90	388.97
100	**0.0**	137.00	142.00	10.00	10.67	334.37	331.98
	2.0	142.67	147.00	13.67	14.67	361.94	351.17
	4.0	146.00	150.33	15.00	15.67	395.40	412.13
LSD 5%		**3.05**	**2.17**	**1.23**	**1.00**	**12.09**	**13.78**

* Recommended dose = N fertilizer at 68 + P fertilizer at 32 + K fertilizer at 24 kg/feddan

In addition, plant height (cm) and branch number per plant as well as total dry weight per plant (g) were significantly affected by humic acid rates (Table 1). In the meantime, the plant growth of roselle were significantly increased by the highest humic rate (4 l Fed.$^{-1}$) compared to control in the two seasons. Furthermore, El-Khateeb *et al*. (2017) stated that application of humic acid significantly increased the growth attributes of marjoram plants including plant height, number of branches, fresh and dry weights of marjoram plant compared to control plants.

Similarly, the combination between the different levels of NPK and humic acid rates in the two seasons can be seen in Table 1. The results indicated that the prevalence of applying the different combinations in improving roselle growth parameters as plant height, number of branches per plant and total dry weight per plant especially the treatment of 100 % RD of NPK fertilization combined with 4 l Fed.$^{-1}$humic acid compared to control in both seasons. Generally, as mentioned just before, both NPK fertilization levels and humic acid treatments (each alone) increased plant growth of roselle plant, in turn, they together might maximize their effects leading to better results in this regard. However, Mohammed *et al*. (2019) indicated that the maximum values of plant height, branch and leaf number/plant and total dry weight/plant of stevia plant were detected when plants were applied with the highest rate of humic acid and fertilized with 75% recommended rate of NPK.

Yield and its components:

It is quite clear from the results in Tables 2 and 3 that, increasing NPK fertilization level significantly increased fruits and seed yield components of roselle during the two consecutive seasons. In addition, all fertilization levels increased fruit number per roselle plant, sepals as well seeds yield per plant (g) and per feddan (kg) compared to control in both seasons. Furthermore, the best treatment in this concern was that 100 % of RD (N fertilizer at 68 + P_2O_5 fertilizer at 32 + K_2O fertilizer at 24 kg/feddan) compared to the other ones under study. However, mineral fertilizers NPK improved dry weight of marketable fruits and yield contributors through better nutrient uptake, growth and development of pepper plants (Obidiebube *et al*., 2012).

Table 2. Impact of NPK fertilization and humic acid rates as well as interaction treatments on sepals yield components of roselle plant during the two seasons of 2017 and 2018

Treatments		Number of fruits/ plant		Sepals yield / plant (g)		Sepals yield / feddan (kg)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
NPK fertilization rates (% of recommended dose*)							
0.0		83.11	86.78	39.76	41.66	556.61	583.19
50		100.11	105.56	43.34	48.14	606.82	673.90
75		123.56	131.44	51.12	52.99	715.73	741.92
100		136.67	146.67	56.19	58.92	786.72	824.86
LSD 5%		**3.57**	**1.52**	**0.81**	**0.77**	**11.32**	**10.76**
Humic acid rates (l Fed.$^{-1}$)							
0.0		94.25	99.83	42.72	45.86	598.15	642.02
2.0		110.83	118.58	47.46	50.36	664.43	705.09
4.0		127.50	134.67	52.63	55.06	736.83	770.80
LSD 5%		**2.61**	**2.33**	**0.83**	**1.10**	**11.64**	**15.41**
Interaction between NPK fertilization and humic acid rates							
0.0	**0.0**	77.00	80.00	36.55	38.50	511.70	538.95
	2.0	83.00	87.33	39.05	40.99	546.70	573.91
	4.0	89.33	93.00	43.67	45.48	611.43	636.72
50	**0.0**	83.67	85.00	38.63	43.19	540.82	604.66
	2.0	100.67	109.67	41.20	48.63	576.85	680.87
	4.0	116.00	122.00	50.20	52.59	702.80	736.17
75	**0.0**	104.33	112.33	45.77	50.15	640.73	702.05
	2.0	126.67	135.00	52.70	53.45	737.85	748.35
	4.0	139.67	147.00	54.90	55.38	768.60	775.37
100	**0.0**	112.00	122.00	49.95	51.60	699.35	722.40
	2.0	133.00	142.33	56.88	58.37	796.32	817.23
	4.0	165.00	175.67	61.75	66.78	864.50	934.97
LSD 5%		**5.55**	**4.09**	**1.58**	**1.95**	**22.09**	**27.34**

* Recommended dose = N fertilizer at 68 + P fertilizer at 32 + K fertilizer at 24 kg/feddan

Humic acid treatments at 4 l Fed.$^{-1}$followed by 2 l Fed.$^{-1}$rates significantly increased *Hibiscus sabdariffa* sepals yield components as well as sepals yield components during both seasons compared to control (Tables 2 and 3). In addition, fruit number per roselle plant, sepals as well seeds yield per plant (g) and per feddan (kg) of roselle were gradually increased as humic acid rate increased in the two seasons. In this regard, Eledfawy (2017) indicated that foliar spraying followed by soil applications of humic acid led to significant increases in the mean values of No. of pods/plant as well as seed and straw yields of canola plant than the control.

Regarding to the interaction effect between NPK fertilization rates with foliar application of humic acid on yield components of roselle plant, results in Tables 2 and 3 showed a significant and positive effect in all plant yield parameters with plants received 100 % of RD of NPK-fertilizers with foliar application of humic acid at 4 l Fed.$^{-1}$. In addition results clear that the combined treatment of NPK-fertilizers at 75 % RD with humic acid as foliar application at the highest and medium rates in fruit number per roselle plant, sepals as well seeds yield per plant and per feddan gave values similar to or better than the treatment received full dose (100 % NPK) without humic acid application in both seasons. However, Suge *et al*. (2011) reported that soil fertilized with 100% recommended NPK combined with organic manures produced the superior growth of plants and the highest amount of total fruit yields of *Solanum melongena* plant. Also, Khater and Abd El-Azim (2016) demonstrated that the interaction between chemical fertilizers at 75% from the recommended dose combined with addition of humic acid at 4 kg Fed.$^{-1}$ gave a significant effect for seeds yield per plant and per feddan of *Plantago psyllium* plant.

Table 3: Impact of NPK fertilization and humic acid rates as well as interaction treatments on seed yield components of roselle plant during the two seasons of 2017 and 2018

Treatments		Seed yield / plant (g)		Seed yield / feddan (kg)	
		1st season	2nd season	1st season	2nd season
NPK fertilization rates (% of recommended dose*)					
0.0		13.82	14.92	193.54	208.83
50		16.50	17.32	231.02	242.48
75		20.44	20.42	286.19	285.83
100		25.35	29.28	354.92	409.87
LSD 5%		**0.84**	**0.52**	**11.73**	**7.35**
		Humic acid rates (l Fed.$^{-1}$)			
0.0		15.11	15.83	211.53	221.68
2.0		18.95	20.80	265.29	291.22
4.0		23.03	24.81	322.43	347.36
LSD 5%		**0.53**	**0.59**	**7.46**	**8.20**
Interaction between NPK fertilization and humic acid rates					
0.0	**0.0**	10.83	12.14	151.67	170.01
	2.0	14.34	14.63	200.76	204.87
	4.0	16.30	17.97	228.20	251.63
50	**0.0**	14.19	13.38	198.71	187.32
	2.0	15.93	17.33	222.97	242.57
	4.0	19.38	21.25	271.37	297.55
75	**0.0**	17.17	15.80	240.33	221.20
	2.0	20.58	21.32	288.07	298.53
	4.0	23.58	24.13	330.17	337.77
100	**0.0**	18.24	22.01	255.41	308.19
	2.0	24.95	29.92	349.35	418.93
	4.0	32.86	35.89	459.99	502.51
LSD 5%		**1.20**	**1.09**	**14.91**	**15.25**

* Recommended dose = N fertilizer at 68 + P fertilizer at 32 + K fertilizer at 24 kg/feddan

Chemical constituents:

The presented results in Table 4 that, total nitrogen, total phosphorus and potassium percentages in roselle sepals increased by increasing NPK fertilization dose. Also, the highest values in this concern in the first and second seasons were obtained from the NPK fertilization dose of 100%

RD followed by 75% RD with no significant differences between them regarding nitrogen percentage in the two seasons. While, the highest values in roselle sepals anthocyanin content were obtained from the NPK fertilization dose of 75% RD followed by 100% RD compared to control and medium dose of NPK in the two seasons (Table 5). Generally, all NPK fertilization doses significantly increased total chlorophyll (SPAD) and total soluble solids (Brix°) compared to control in both seasons (Table 5). Abdelkader and Mostafa (2019) suggested that total chlorophyll content and nitrogen, phosphorus and potassium percentages increased by the highest rate of potassium under study (50 kg K_2O/feddan).

Table 4: Impact of NPK fertilization and humic acid rates as well as interaction treatments on N, P and K percentages in sepals of roselle plant during the two seasons of 2017 and 2018

Treatments		Total nitrogen (%)		Total phosphorus (%)		Potassium (%)	
		1st season	2nd Season	1st season	2nd season	1st season	2nd season
NPK fertilization rates (% of recommended dose*)							
0.0		2.668	2.690	0.336	0.334	2.502	2.520
50		2.789	2.786	0.346	0.342	2.571	2.558
75		3.062	3.081	0.357	0.354	2.646	2.667
100		3.070	3.066	0.371	0.366	2.830	2.757
LSD 5%		**0.029**	**0.015**	**0.002**	**0.002**	**0.015**	**0.011**
Humic acid rates (l Fed.$^{-1}$)							
0.0		2.575	2.572	0.343	0.338	2.582	2.571
2.0		2.917	2.923	0.354	0.349	2.638	2.638
4.0		3.200	3.222	0.361	0.359	2.692	2.667
LSD 5%		**0.016**	**0.014**	**0.001**	**0.001**	**0.016**	**0.010**
Interaction between NPK fertilization and humic acid rates							
0.0	**0.0**	2.390	2.397	0.331	0.327	2.443	2.487
	2.0	2.533	2.577	0.336	0.336	2.510	2.523
	4.0	3.080	3.097	0.341	0.338	2.553	2.550
50	**0.0**	2.510	2.477	0.338	0.335	2.527	2.493
	2.0	2.707	2.680	0.346	0.342	2.577	2.583
	4.0	3.150	3.200	0.354	0.349	2.610	2.597
75	**0.0**	2.687	2.737	0.347	0.342	2.583	2.617
	2.0	3.227	3.193	0.357	0.351	2.650	2.677
	4.0	3.273	3.313	0.368	0.368	2.703	2.707
100	**0.0**	2.713	2.677	0.356	0.348	2.773	2.687
	2.0	3.200	3.243	0.376	0.369	2.817	2.770
	4.0	3.297	3.277	0.380	0.379	2.900	2.813
LSD 5%		**0.039**	**0.027**	**0.003**	**0.004**	**0.030**	**0.020**

* Recommended dose = N fertilizer at 68 + P fertilizer at 32 + K fertilizer at 24 kg/feddan

Results under discussion in Tables 4 and 5 indicate that, using humic acid treatments at higher rates of 2 and 4 l Fed.$^{-1}$increased total NPK percentages as well as anthocyanin content, total chlorophyll content and TSS in roselle plants compared to control and the lowest rate (0.0l Fed.$^{-1}$) during the two seasons. There was a gradual increase in the all chemical constituents parameters as increase in humic acid rates. Humic acids are molecules that regulate many processes of plant development including macro and micro nutrient adsorption (Atiyeh *et al*., 2002). Furthermore, Awad (2016) suggested that foliar application of humic acid significantly increased N, P and K contents of caraway plants compared to untreated plants. Meanwhile, Bajeli *et al*. (2016) showed that Japanese mint plants fertilized with organic manures recorded the highest values in volatile oil percentage compared to control.

From results recorded in Tables 4 and 5, the different interaction treatments gave significant increases in N, P and K percentages as well as anthocyanin content, total chlorophyll content and TSS compared to control in both seasons, in most cases. Also, the highest values in this connection were obtained from the interaction treatment between humic acid rate (4 l Fed.$^{-1}$) with 100% RD of NPK in the two seasons, in most cases. However, Ahmed *et al*. (2010) reported that N, P and K contents of bulbs and leaves of garlic were increased by applying humic acid (HA) or potassium fertilizer (K) and their interaction treatments.

Table 5: Impact of NPK fertilization and humic acid rates as well as interaction treatments on anthocyanin content (mg/100g), total chlorophyll (SPAD) and total soluble solids (Brix°) of roselle plant during the two seasons of 2017 and 2018

Treatments		Anthocyanin content (mg/100g)		Total chlorophyll (SPAD)		Total soluble solids (Brix°)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
NPK fertilization rates (% of recommended dose*)							
0.0		10.67	10.92	37.11	37.67	6.39	6.41
50		11.25	11.58	39.00	39.78	6.44	6.46
75		12.50	12.74	42.11	42.11	7.10	7.20
100		12.19	12.38	41.78	42.44	7.17	7.34
LSD 5%		**0.48**	**0.33**	**0.74**	**0.58**	**0.05**	**0.01**
Humic acid rates (liter/feddan)							
0.0		10.75	10.95	38.08	38.25	6.43	6.48
2.0		11.66	12.01	39.92	40.25	6.89	6.98
4.0		12.54	12.76	42.00	43.00	7.00	7.10
LSD 5%		**0.26**	**0.22**	**0.58**	**0.66**	**0.04**	**0.01**
Interaction between NPK fertilization and humic acid rates							
0.0	**0.0**	10.21	10.37	35.33	36.33	6.36	6.38
	2.0	10.43	10.88	37.33	37.33	6.40	6.41
	4.0	11.37	11.51	38.67	39.33	6.42	6.45
50	**0.0**	10.39	10.73	37.33	38.00	6.40	6.42
	2.0	11.12	11.49	39.00	40.00	6.43	6.46
	4.0	12.25	12.53	40.67	41.33	6.49	6.50
75	**0.0**	11.24	11.45	40.00	39.33	6.41	6.42
	2.0	12.58	13.07	42.67	41.67	7.39	7.51
	4.0	13.67	13.70	43.67	45.33	7.51	7.68
100	**0.0**	11.15	11.27	39.67	39.33	6.57	6.72
	2.0	12.53	12.58	40.67	42.00	7.34	7.54
	4.0	12.90	13.30	45.00	46.00	7.59	7.78
LSD 5%		**0.64**	**0.49**	**1.21**	**1.22**	**0.08**	**0.02**

* Recommended dose = N fertilizer at 68 + P fertilizer at 32 + K fertilizer at 24 kg/feddan

Conclusion

From above-mentioned results, it was generally concluded that growth, yield and its component of *Hibiscus sabdariffa* plant are widely affected by applying NPK fertilizers and humic acid. In general, the increase in growth and productivity of roselle plants is closely related to the amount of the applied 4 l Fed.$^{-1}$ in interacted with 100 % of recommended dose of NPK, which led to the increase in total dry weight and sepals yields that are considered as the main components of growth and development of roselle plant.

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