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INFLUENCE OF HUMIC ACID AND MINERAL NUTRITION ON THE GROWTH, YIELD OF FLOWERS AND THE CHEMICAL CONSTITUENTS OF *ROSA HYBRIDA*, L.

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ABSTRACT: The present study was designed to investigate the influence of humic acid (HA) as an organic nutrition and mineral NPK and their combined effects on growth, qualitative and quantitative characteristics and the chemical constituents of *Rosa hybrida*, L. cv. Santrix plants. Four different doses of humic acid (HA) fertilizer at levels of 0.0, 2.0, 4.0 and 6.0 g/plant and four concentrations of NPK fertilizer at 0.0, 0.5, 1.0 and 1.5% were applied. There was a significant effect of the interaction among the treatments of humic acid (HA) and NPK fertilizers. Using humic acid (HA) at a high level of 6.0 g/plant combined with 1.0% NPK mineral fertilizer as foliar application gave a good impact on growth and flower parameters such as the number of flowers/plant, flower stem length, flower length, stem diameter and flower dry weight. The maximum significant increases in chlorophylls (a+b), carbohydrates leaves and nitrogen, phosphorus and potassium contents were obtained by using the highest rate of humic acid (6.0 g/plant) with the mineral fertilizer at 1.0 or 1.5% NPK, compared to the untreated plants.

Keywords: *Rosa hybrida* L., shrubs, cut flowers, humic acid, organic fertilization, mineral fertilization, mineral content.

INTRODUCTION

The modern rose (*Rosa hybrida* L.; Rosaceae) is economically considered one of the most important cut flower crops for both Arabian and European markets in addition to the various colors, forms, and the high keeping quality of its flowers. It is the most widely grown outdoor flower under Egypt conditions and production over the entire world in the greenhouse. Rose is one of the most used flowers for florist-cut flower arrangements due to its excellent keeping quality. Rose shrubs can be grown in a wide range of soils from sandy soils to clay loam but deep well-drained, friable, soils rich in organic matter is required (Nooh and El-Naggar, 2021).

Humic substances have many beneficial impacts on soil and consequently on plant growth and are shown highly hormonal activity. These materials not only increase macronutrient contents and ions uptake but also enhance the micronutrients of the plant organs (Brunetti *et al*., 2005). Humic acids make important contributions to improve soil stability, soil fertility, soil texture, soil structure integrity, aeration and increase nutrient absorption as well as improve total production (Chen *et al*., 2004 and Ayas *et al*., 2005). Many investigators reported that using humic acid as organic fertilizer increased the growth of different cut flowers e.g. Nikbakht *et al*. (2008) on gerbera, Iftikhar *et al*. (2013) on gladioli, Fadhil *et al.* (2018) on Snapdragon, Ahmad *et al*. (2019)

on pot marigold plants and Lolo (2022) who found that producing high quality calendula (*Calendula officinalis*, L.) plants was obtained by growing in a mixture of calcareous soil (50%) + peatmoss (50%) with humic acid (HA) at 1.0 and/or 1.5 g/plant.

NPK nutrition is gaining more impact in cut flower crops especially rose shrubs. Many investigators working on ornamental plants such as chrysanthemum (Mazrou *et al*., 1988), tuberose (Amarjeet *et al*., 1996), rose (Al-Humaid, 2001), amaryllis or *Hippeastrum vittatum* (El-Naggar and El-Nasharty, 2009), spathiphyllum (Abbasniayzare *et al*., 2012). Mineral nutrition as a foliar technique is a good alternative to conventional soil application to avoid the loss of mineral elements by leaching and thereby minimize groundwater pollution (Al-Humaid, 2001).

So, the main objective of the present study was to evaluate the individual and combined effects of humic acid as organic fertilizer and mineral nutrition throughout the growing season on growth, flower production and quality as well as the chemical constituents of *Rosa hybrida* L. cv. Santrix.

MATERIALS AND METHODS

The present work was carried out to investigate the effects of different levels of humic acid and mineral nutrition on the yield production of *Rosa hybrida* L. cv. Santrix during two successive seasons (2019 and 2020).

Plant materials, preparation and growing conditions:

The study was conducted at a commercial private nursery in Alexandria Governorate, Egypt. The plants of one-year-old *Rosa hybrida* L. cv. Santrix with uniform sizes and shapes were transplanted on 11th March 2019 and 18th March 2020 in pots 30 cm in diameter, filled with 7 kg of growing media containing sand, clay and composted leaves (2:2:1 v/v/v) under an open field (full sunlight) conditions with a light intensity of 9000-10000 lux. Three main evenly distributed branches were chosen per plant and pruned to 40 cm in length according to Al-Humaid (2001). The used medium contained 285 ppm N, 17 ppm P, and 675 ppm K, with EC at 2.9 dS m^{-1} and pH at 8.10.

The experiment procedures and treatments:

Two factors were involved in the present study, the first was humic acid (HA) treatments (main factor) the second was foliar nutrition (subfactor). Four different doses of humic acid (HA) fertilizer at concentrations of 0.0, 2.0, 4.0 and 6.0 g/pot as a dressing application were applied four times at 15-day intervals, the first one was applied after 15 days from the final transplanting. The chemical properties of humic acid (HA) are presented in (Table, 1).

The plants were sprayed with mineral fertilizer 19:19:19: ($N:P_2O_5:K_2O$) at concentrations of 0.0 (control), 0.5, 1.0 and 1.5% which was sprayed monthly four times throughout the growing season until the run-off point after transplanting, starting two weeks after the final transplanting. Flowering stems were cut when the petal loosed leaving three buds at the base.

Design of the experiment:

The experiment was designed in a split-plot design. Humic acid levels were randomly arranged in the main plots, while the foliar nutrition concentrations were occupied in sub-plots. Each treatment contained three replicates; each replicate contained 6 plants.

Table 1. Chemical properties of humic acid (HA).

pH	EC (dSm^{-1})	OM (%)	C (%)	C/N (%)	N (%)	P (%)	K (%)	Mn (ppm)	Zn (ppm)	Fe (ppm)
2.8	1.13	52.03	30.25	14.14	2.14	0.27	3.16	168	213	393

Measurements:

- Vegetative growth characteristics: plant height (cm), number of leaves/flower stem and leaves dry weights/flower stem (g).
- Flowering parameters: number of flowers/plant, flower stem length (cm), flower length (cm), flower stem diameter (mm) and flower dry weight (g).

Chemical analysis of rose leaves:

- Chlorophyll content (mg/100 g F.W.): chlorophyll content in the fresh leaves was determined according to Moran and Porath (1980).
- Carbohydrate content (mg/g D.W.) in dried leaves was determined according to the method of Herbert *et al*. (1971).
- Nitrogen content (%): at the end of the experiment, the leaves of each treatment were collected and dried at 70 °C to a constant weight, and then they were ground and digested with H_2SO_4 and H_2O_2 (Guzman and Romero, 1988). It was determined by the distillation in the micro-Kjeldahl method.
- Phosphorus and Potassium content (%): was done at the end of the experiment. The dried leaves in each treatment ached in a muffle furnace at 550 °C. The ash was then dissolved in 2N HNO_3 (Chapman and Pratt, 1961). The vanadate molybdate method was used to determine the P content in the solution at 470 nm on a spectrophotometer (Spectronic 20). Potassium content was measured in the solution using a Flame photometer (Chapman and Pratt, 1961).

The recorded data were statistically analyzed and the mean separation was performed using the method described by Snedecor and Cochran (1990).

RESULTS AND DISCUSSION

Effect of humic acid and mineral nutrition on vegetative growth:

The results recorded in the two growing seasons illustrated in Table (2) show that treated rose plants (*Rosa hybrida* L. cv. Santrix with the humic acid (HA) fertilization separately and plus mineral nutrition had a considerable effect on the different vegetative growth characteristics; plant height, number of leaves/flower stem, and dry weight of leaves/flower stem. In most cases, the application of organic fertilizer (HA) plus NPK treatments promoted vegetative growth, and resulted in significant increases in the values recorded for the different growth parameters, compared to the untreated control plants.

The highest increase was recorded with the high fertilizer rate of humic (HA) at 6.0 g/plant combined with NPK fertilizer concentration at 1.0% for several vegetative growth characteristics, such as plant height, number of leaves/flower stem, and dry weight of leaves/flower stem giving values of 67.76 cm, 15.40 and 6.92g, and 72.87 cm, 14.52 and 7.50 g, for the two growing seasons, respectively.

These results could be explained through the synergistic effect of humic acid (HA) and NPK fertilizer in promoting growth and accumulation of dry matter. This increase in the leaves number of plants may be due to cell multiplication, cell enlargement and cell differentiation, which have resulted in increasing in plant height, number and dry weight of leaves, and it may have been related to the favorable effects of humic acid application contain some macro elements (Dore and Peacock, 1997 and Sharif *et al*., 2002). In addition, the stimulating impact of humic (HA) and/or NPK fertilization may be due to activated areal meristems and increased protoplasm formation, cell division and elongation, which increased the biosynthesis of proteins and carbohydrates in the plant. Similar results are observed by Haikal (1992) on gladiolus, Al-Humaid (2001) on rosa and Lolo (2022) on calendula (*Calendula officinalis* L.). On the other hand, the highest concentration of NPK nutrition (1.5%) reduced the plant height, number of leaves/flower stem as well as their dry weights impacted to accumulation of salts on the surface of leaves, which causes scorching

Table 2. Effect of humic acid and mineral nutrition on growth of *Rosa hybrida* L. cv. Santrix.

NPK % (A)	Humic acid (HA) (g/plant) (B)									
	0.00	2.00	4.00	6.00	Mean	0.00	2.00	4.00	6.00	Mean
	1st season					2nd season				
	Plant height (cm)									
0.00	32.15	36.03	38.87	43.12	37.54	34.50	38.78	41.93	48.18	40.84
0.50	38.99	39.69	42.65	48.49	42.45	43.13	43.88	45.51	54.38	46.72
1.00	51.80	54.60	59.71	67.76	58.47	52.60	61.02	69.98	72.87	64.12
1.50	46.49	48.30	49.00	54.97	49.69	56.08	54.00	56.98	61.35	75.10
Mean	42.36	.44.65	47.56	53.58		46.58	49.42	53.60	59.19	
$LSD_{0.05}$	A= 4.02		B= 2.16	A×B= 4.33		A= 10.26		B= 3.58	A×B= 7.16	
	Number of leaves/flower stem									
0.00	7.76	8.19	8.83	9.80	8.64	7.86	7.91	8.56	9.83	8.54
0.50	8.41	9.02	9.69	11.02	9.53	8.97	8.95	9.29	11.10	9.58
1.00	11.77	12.41	13.57	15.40	13.29	11.85	12.45	14.28	14.52	13.27
1.50	10.57	10.98	11.14	12.49	11.29	10.94	11.02	11.63	12.87	12.11
Mean	9.63	10.15	10.81	12.18		9.90	10.08	10.94	11.83	
$LSD_{0.05}$	A= 2.18		B= 1.05	A×B= 2.12		A= 2.09		B= 0.73	A×B= 1.46	
	Leaves dry weight (g)/flower stem									
0.00	4.33	4.76	5.19	5.24	4.88	4.76	5.04	5.71	5.77	5.32
0.50	5.16	5.68	6.18	6.24	5.18	5.68	6.34	6.80	6.87	6.42
1.00	5.47	6.01	6.96	6.92	6.34	6.01	6.69	7.66	7.50	6.96
1.50	5.83	6.42	6.55	7.06	6.46	6.42	7.16	7.21	7.28	7.02
Mean	5.20	5.72	6.22	6.36		5.72	6.31	6.84	6.85	
$LSD_{0.05}$	A= 0.05		B= 0.03	A×B= 0.05		A= 0.05		B= 0.04	A×B= 0.08	

and burning of the leaves (Mengel and Kirkby, 1987). These results are in the same line with those obtained by Al-Humaid (2001) on rosa, Evans and Li (2003) on annual ornamental, Ahmad *et al*. (2015) on *Tulipa gesneriana* and Lolo (2022) on *Calendula officinalis* L.

Effect of humic acid and mineral nutrition on flowering parameters:

The data in Tables (3 and 4) show a pronounced impact on the flowering stem as a result of supplying the plants with humic acid (HA) and NPK nutrition compared to the control. Flowers number, flowers stem length, flower length, flower dry weight, and flower stem diameter were increased with humic acid (HA) application up to 6.0 g/plant combined with 1.0% NPK as foliar fertilization. This may be due to that using the humic acid at a suitable level, led to absorb of elements and activated growth and enhanced biosynthesis, which led to increasing flowering stem and flowers number/plant, besides mineral fertilizer (1.0%) which contains the required macro and micro nutrients for optimum growth as the synthesis of organic N- compounds in the plant depends on a number of inorganic ions such as magnesium elements for chlorophyll formation, phosphorus for the synthesis of nucleic acids and potassium which is an essential element for nitrate reduction, photosynthesis, starch synthesis, sugars translocation and carbohydrates transformation necessary for nitrogen assimilation into protein (Hassan *et al*., 2016). The findings are in harmony with those obtained by Mazrou (1991) on rose, Ahmad *et al*. (2019) on pot marigold, Ibrahim *et al*. (2016) on statice and El-Nashar (2021) and Lolo (2022) on calendula.

Table 3. Effect of humic acid and mineral nutrition on flowers yield of *Rosa hybrida* L. cv. Santrix.

NPK % (A)	Humic acid (HA) (g/plant) (B)									
	0.00	2.00	4.00	6.00	Mean	0.00	2.00	4.00	6.00	Mean
	1st season					2nd season				
	No. of flowers/plant									
0.00	4.10	4.72	5.15	5.20	4.79	3.95	4.69	5.18	5.18	4.75
0.50	4.22	6.25	8.73	8.92	7.03	4.16	6.21	8.71	8.90	5.99
1.00	4.96	7.65	10.13	10.20	8.23	4.81	7.42	10.12	10.56	8.23
1.50	4.32	7.10	9.19	9.39	7.50	4.29	7.00	9.12	9.28	7.42
Mean	4.40	6.43	8.37	8.43		4.30	6.33	8.28	8.48	
$LSD_{0.05}$	A= 0.22		B= 0.30	A×B= 0.52		A= 0.30		B= 0.30	A×B= 0.51	
	Flower stem length (cm)									
0.00	27.31	28.83	31.10	34.50	30.43	30.80	31.02	33.54	38.54	33.47
0.50	29.59	31.75	34.12	38.79	33.56	35.14	35.10	36.41	43.50	37.54
1.00	37.19	38.64	39.20	43.98	39.76	42.88	43.20	45.59	49.08	45.44
1.50	41.44	43.68	47.77	54.21	46.77	46.46	48.82	55.98	58.30	52.39
Mean	33.88	35.72	38.05	42.87		38.82	39.78	42.88	47.35	
$LSD_{0.05}$	A= 2.32		B= 1.73	A×B= 3.47		A= 8.21		B= 2.86	A×B= 5.73	
	Flower length (cm)									
0.00	3.31	3.98	4.21	5.09	4.15	3.36	4.08	4.28	5.34	4.27
0.50	3.56	4.76	5.26	6.91	5.12	3.99	4.73	5.30	6.88	5.23
1.00	4.25	7.52	8.37	9.76	7.48	4.29	7.56	8.49	9.58	7.48
1.50	4.12	7.36	7.57	8.43	6.87	4.16	7.39	7.49	8.76	6.95
Mean	3.81	5.91	6.35	7.55		3.95	6.22	7.63	8.02	
$LSD_{0.05}$	A= 0.12		B= 0.18	A×B= 0.21		A= 0.12		B= 0.18	A×B= 0.21	

Effect of humic acid and mineral nutrition on chemical analysis:

1. Chlorophylls content:

Chlorophyll content was considerably affected by using different rates of humic (HA) and foliar fertilizers (Table, 4). The highest amount of total chlorophyll (a+b) content was found at 6.0 g/plant of humic acid in both seasons. Also, in the same Table, total chlorophylls content seemed to be increased with all NPK fertilizer treatments compared with the control (unfertilized plants). The highest value was observed after treatment with 1.0% of NPK fertilizers in the first and second seasons. As for the effect of different combinations of humic acid (HA) and the concentrations of NPK fertilizer, Table (4) showed that considerable differences in total chlorophyll content were detected in the leaves of plants receiving the different combinations of humic acid (HA), and foliar NPK treatments. The highest significant impact in chlorophylls content was obtained by 6.0 g/plant humic fertilizer plus NPK fertilizer at a concentration of 1.0% with values of 257.80 and 259.38 mg/100 g for the first and second seasons, respectively, compared to the other treatments. The significant increase in leaf chlorophylls content as a result of applying humic acid and foliar NPK application could be due to increasing the availability of nitrogen, consequently increasing its absorption by the plant the acceleration of N uptake, enhancing N metabolism and production of a protein that ultimately increase chlorophyll contents (Haghighi *et al*., 2012). The results are in accordance with those obtained by El-Naggar and El-Nasharty (2009) on *Hippeastrum vittatum*, and Mohammadipour *et al*. (2012) on marigold (*Calendula officinalis* L).

Table 4. Effect of humic acid and mineral on flower dry weight, flower stem diameter and total chlorophyll of *Rosa hybrida* L. cv. Santrix.

NPK % (A)	Humic acid (HA) (g/plant) (B)									
	0.00	2.00	4.00	6.00	Mean	0.00	2.00	4.00	6.00	Mean
	1st season					2nd season				
	Flower dry weight (g)									
0.00	2.23	2.38	2.45	2.48	2.39	2.15	2.35	2.48	2.58	2.39
0.50	2.27	2.58	2.66	2.89	2.60	2.25	2.59	2.74	2.86	2.61
1.00	2.39	2.73	2.97	3.28	2.84	2.36	2.83	2.97	3.30	2.87
1.50	2.26	2.58	2.85	3.00	2.67	2.23	2.64	2.88	2.98	2.68
Mean	2.29	2.57	2.73	2.91		2.25	2.60	2.77	2.92	
$LSD_{0.05}$	A= 0.08		B= 0.05	A×B= 0.09		A= 10.26		B= 0.05	A×B= 0.09	
	Flower stem diameter (mm)									
0.00	4.49	4.76	5.21	5.69	5.04	4.46	4.90	5.38	5.79	5.13
0.50	4.96	5.86	7.28	7.91	6.50	4.99	5.83	7.30	7.89	6.50
1.00	5.20	7.52	9.40	9.56	7.92	5.21	7.56	9.37	9.50	7.91
1.50	5.16	7.36	8.87	9.63	7.76	5.26	7.41	8.98	9.17	7.71
Mean	4.95	6.38	7.69	8.20		4.98	6.41	7.76	8.09	
$LSD_{0.05}$	A= 0.39		B= 0.41	A×B= 0.82		A= 0.22		B= 0.47	A×B= 0.95	
	Total chlorophyll (mg/100 g F.W.)									
0.00	168.80	179.62	187.39	183.78	179.90	170.95	178.52	191.72	189.01	182.55
0.50	176.55	194.32	211.22	209.39	197.87	178.52	198.81	215.62	213.51	201.62
1.00	193.18	221.28	257.80	266.32	234.65	196.76	222.67	259.38	257.92	234.18
1.50	190.82	216.72	240.74	246.87	223.78	190.93	215.80	243.59	248.79	224.55
Mean	182.34	202.99	179.43	226.59		187.60	204.70	227.33	228.06	
$LSD_{0.05}$	A= 1.13		B= 2.41	A×B= 3.58		A= 1.97		B= 2.28	A×B= 3.46	

2. Carbohydrates content:

Data in Table (5) show a significant increment in total carbohydrates (mg/g D.W.) in the dried leaves of *Rosa hybrida* L. cv. Santrix plants treated with humic acid (HA) and foliar NPK fertilizer application compared to the untreated plants. Supplying the plants with the highest rate of humic acid increased total carbohydrates in the dried leaves than that produced by the other treatments (Table, 5). Concerning NPK-fertilizer treatments, a gradual increase was observed in total carbohydrates with increasing the concentration of NPK fertilizer to 1.0% compared to the other treatments. For the interaction, organic fertilizer (humic acid) in combination with different concentrations of NPK fertilizer treatments (foliar application) resulted in the highest content of the total carbohydrate in the dried leaves. It could be concluded from the tabulated data, the great influence of supplying the plants with humic acid at 6.0 g/plant combined with 1.0% NPK fertilizer. Such treatment increased total carbohydrate content to 250.82 and 251.88 mg/g D.W. against 184.70 and 188.25 mg/g D.W. resulting from the control treatment. The significant increments in carbohydrate contents due to all fertilizer rates of humic application with NPK-fertilizer could be attributed to the impact of HA, and mineral nutrition in enhancing leaf production, which probably had higher chlorophylls (a+b) content and, consequently more carbohydrates production. The results are in accordance with those obtained by Manoly (1989) on tuberose and Hassan *et al*. (2016) on gladiolus plants.

3. Leaf macro-elements content:

Results of chemical composition of *Rosa hybrida* L. cv. Santrix leaves for their N, P

Table 5. Effect of humic acid and mineral nutrion on carbohydrates content, N, P and K% of *Rosa hybrida* L. cv. Santrix.

NPK % (A)	Humic acid (HA) (g/ plant) (B)									
	0.00	2.00	4.00	6.00	Mean	0.00	2.00	4.00	6.00	Mean
	1st season					2nd season				
	Carbohydrates (mg/g D.W.)									
0.00	163.57	206.28	215.94	223.83	202.40	165.76	213.34	217.45	229.82	206.59
0.50	179.54	217.83	230.12	242.71	217.55	176.79	218.95	245.87	243.59	221.30
1.00	215.48	231.29	239.27	252.33	234.59	212.09	233.11	249.54	256.83	236.40
1.50	212.61	217.90	223.94	229.57	221.00	214.87	220.96	225.65	227.91	222.35
Mean	192.80	218.32	227.32	237.11		192.38	221.59	234.63	239.54	
$LSD_{0.05}$	A= 1.84		B= 1.84	A×B= 3.19		A= 1.63		B= 1.63	A×B= 2.79	
	N %									
0.00	2.02	2.22	2.41	2.44	2.27	2.22	2.44	2.66	2.69	2.50
0.50	2.40	2.64	2.88	2.91	2.71	2.64	2.91	3.17	3.20	2.98
1.00	2.59	3.33	3.05	3.58	3.14	2.80	3.28	3.57	3.59	3.31
1.50	2.41	3.19	3.24	3.53	3.09	2.59	3.20	3.36	3.51	3.17
Mean	2.36	2.84	2.89	3.11		2.84	2.96	3.19	3.25	
$LSD_{0.05}$	A= 0.09		B= 0.10	A×B= 0.12		A= 0.09		B= 0.11	A×B= 0.14	
	P %									
0.00	0.17	0.24	0.39	0.33	0.28	0.15	0.24	0.37	0.32	0.27
0.50	0.21	0.29	0.44	0.38	0.33	0.22	0.28	0.45	0.38	0.33
1.00	0.27	0.45	0.58	0.52	0.46	0.28	0.43	0.61	0.57	0.47
1.50	0.21	0.37	0.53	0.50	0.40	0.33	0.39	0.59	0.52	0.46
Mean	0.22	0.34	0.49	0.43		0.25	0.34	0.51	0.45	
$LSD_{0.05}$	A= 0.03		B= 0.03	A×B= 0.06		A= 0.02		B= 0.03	A×B= 0.06	
	K %									
0.00	2.16	2.35	2.61	2.63	2.44	2.28	2.59	2.87	2.89	2.66
0.50	2.58	2.80	3.11	3.14	2.91	2.84	3.08	3.42	3.46	3.20
1.00	2.98	3.17	3.53	3.65	3.33	3.00	3.27	3.84	3.69	3.45
1.50	2.91	2.97	3.50	3.54	3.23	2.96	3.08	3.55	3.60	3.30
Mean	2.66	2.88	3.19	3.24		2.77	3.01	3.42	3.41	
$LSD_{0.05}$	A= 0.05		B= 0.06	A×B= 0.07		A= 0.04		B= 0.04	A×B= 0.06	

and K contents are listed in Table (5). Statistical analysis of these results revealed that the interaction between humic acid (HA) treatment and NPK-fertilizer showed significant differences of leaf N, P and K contents in the two seasons of study. The highest values were recorded with 6.0 g/plant of humic acid combined with foliar NPK-fertilizer at 1.0% in the two growing seasons (3.58, 0.52, 3.65 and 3.58, 0.50, 3.69%, respectively). While the following values were obtained by 6.0 g/plant humic acid and NPK-fertilizer at 1.5% for both seasons (3.53, 0.50, 3.54 and 3.51, 0.52, 3.60%, respectively). However, the control treatment gave the lowest values (2.02, 0.17, 2.16 and 2.22, 0.15, 2.28% of leaf N, P and K contents) in both seasons, respectively. Several studies agree with our findings and demonstrate the beneficial influence of humic acid on leaf NPK accumulation in different crops i.e. El-Desuki (2004) on onion, Celik *et al*. (2008) who reported that HA significantly increased mineral-nutrients uptake of Maize. Nikbakht *et al*. (2008) mentioned that humic acid application has a beneficial effect on nutrient uptake in gerbera (*Gerbera jamesonii*), particularly uptake of N, P, K, Mg, Ca, Zn, Fe, and Cu by plants. Also, Mahmoud *et al*. (2011)

mentioned that N, P and K content of soybean plants considerably increased as a result of soil or foliar application of HA. Furthermore, humic substances affect the solubility of many nutrient elements by building complex forms or chelating agents of humic matter with metallic cations. Moreover, the indirect effects of humic acid involve improvement of the soil properties such as aggregation, aeration, permeability, water holding capacity, nutrients transport and availability (Tan, 2003). Spraying foliar nutrition impact of macro elements' contents absorption by the plant surface especially leaves, and hence its accumulation in leaves (Epstein, 1972). El-Naggar (1999) resulted in the same results on gladiolus, Mahgoub *et al.* (2006) on iris and Lolo, (2022) on calendula.

According to the results, and to obtain high-quality *Rosa hybrida* L. cv. Santrix plants for different decorative purposes, it can be recommended to apply humic acid at 6.0 g/plant combined with NPK fertilizer at 1.0% as a foliar spraying.

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تأثير حامض الهيوميك و التغذية المعدنية على النمو و إنتاجية الأزهار و المحتوى الكيماوى للورد

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صممت التجربة بهدف دراسة تأثير حامض الهيوميك عند أربع مستويات صفر، ٢، ٤ ، ٦ جرام لكل نبات و أربع تركيزات من معدلات التسميد بالسماد المعدنى NPK ٠,٠ , ٠,٥ , ١,٠ و ١,٥٪ و تأثيرهم المشترك على النمو والإزهار ومحتوى الأوراق من عناصر النتروجين والفوسفور والبوتاسيوم بالإضافة إلى محتوى الأوراق من الكلوروفيلات والكربوهيدرات الكلية لنباتات الورد *Rosa hybrida* L. cv. Santrix. أوضحت النتائج المتحصل عليها أن إضافة حامض الهيوميك بمعدل ٦ جم/نبات و الرش بالسماد المعدنى المركب NPK بتركيزاته المختلفة بصورة فردية أو متداخلة مع حامض الهيوميك قد أدت إلى زيادة معنوية فى كل من قياسات النمو الخضري والزهري مقارنة بنباتات معاملة المقارنة (الكنترول)، بالإضافة إلى ذلك كان للتأثير المتداخل لكل من حامض الهيوميك والرش الورقى بالسماد المعدنى المركب NPK تأثيرا فعالاً فى إحداث زيادة معنوية لكل من صفات النمو الخضري الإنتاج الزهري. و أوضحت نتائج التحليل الكيماوى زيادة معنوية فى محتوى الأوراق من الكلوروفلات الكلية والكربوهيدرات الكلية والعناصر المعدنية (ن ، فو ، بو) نتيجة للمعاملة بكل من حامض الهيوميك و الرش بالسماد المعدنى المركب NPK مقارنة بنباتات الكنترول. ويمكن القول إجمالاً بأن أفضل النتائج تم التوصل إليها بعد معاملة النباتات بمعدل ٦ جم/نبات من حامض الهيوميك بالإضافة إلى الرش بالسماد المعدني المركب NPK بتركيز ١,٠ أو ١,٥٪ وذلك خلال موسمي النمو، بينما أظهرت نباتات المقارنة (الكنترول) أقل القياسات فى هذا الصدد.