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Response of Okra *(Hibiscus esculantus)* Growth and Productivity to Cobalt and Humic Acid Rates

Nadia Gad, Abdel- Moez, M.R. and Hala Kandil

Plant Nutrition Department, National Research Center, El-Bohooth st., Dokki, Cairo, Egypt.

Abstract: Two field experiments were carried out to study the effect of cobalt and humic acid levels on okra plants. Okra *(Hibiscus Esculantus)* seeds grown in the Research and Production Station, National Research Centre, El-Nubaria site, El- Beheara Governorate, Delta Egypt, under drip irrigation system during 2012 and 2013 seasons. Seedlings (at third truly leaf) were irrigated with cobalt sulphate once with different concentration : 0.0, 2.5, 5.0, 7.5, 10.0 and 12.5 ppm cobalt and humic acid at three levels (5%, 10% and 15%) as soil drench. All the plants received natural practices whenever they needed.

The obtained results could be summarized in the following:

Humic acid has a significant increase in the growth and yield compared with control plants. Humic acid at 10% gave the highest figures followed by 15% rate while the level of 5% has the lowest ones.

Applying cobalt suitable concentration gave a significant promotive effect on okra growth, yield quantity and quality compared to untreated plants. Cobalt at 7.5 ppm resulted the greatest values will all studied levels of humic acid.

The combination between 7.5 ppm cobalt and 10% humic acid resulted the soperior growth, yield parameters as well as mineral composition (N, P, K, Mn, Zn and Cu) and chemical constituents (total proteins, total soluble solids, total carbohydrates, vitamin "C" and vitamin "A" of okra pods.

Finally, humic acid decreases soil pH and increases the availability of cobalt and micronutrients.

Key words: Okra, Cobalt, Humic acid, Organic matter.

Introduction:

Okra is a nutritional, medical proven to fight the human papilloma virus. Okra, also known as "lady's finger" or "Bamia" is one of the popular nutritious-Research suggesrs that consumption of foods rich in vitamin "C" helps human. Okra has a gummy texture, tastes somewhat similar eggplant and it can add nutritional benefits for human diet. Okra whole seeds and their kernels were analyzed for their nutrients consumption[1].

Humic acid is one of the most important components of bio-liquid complex. Because of its molecular structure, it provides numerous to crop production. It helps break up clay compacted soils, assists in transferring micronutrients from the soil to the plant, enhance water retention, increases seed germination rates, improves water, air and roots penetration and stimulates development of microflora population in soils[2]. Humic acid essentially helps the movement of micronutrients from soil to plant, Stumpe et al.,[3] stated that the positive effect of humic acid on the yield capacity of soil consists of many components. Moreover, some researchers showed that the foliar spray of humic acid enhanced nutrient uptake, plant growth, yield and quality in a number of plant species[4,5] at least partially through increasing nutrient uptake, serving as a source of mineral plant nutrient uptake and regulator of their release[6]. Likewise, humic substances have been shown to stimulate shoot and root growth and nutrient uptake of vegetable crops[7]**.** The humic substances in the soil might have both direct and indirect effects on plant growth[8]**.** Indirect effect involved improvement of soil properties such as aggregation, aeration, permeability, water holding capacity, ions transport and availability through pH buffering[9]**.** Direct effect are those, the uptake of humic substances into the plant tissue resulting in various biochemical effects through elevate uptake and maintaining vitamins and amino acids level in plant tissues. Geries[10] stated that foliar spraying of onion plants with humic acid at the rate of 2 kg fed^{-1} at 60, 80 and 100 days after transplanting markedly increased vegetative growth (plant hight, number of leaves/plant, bulb diameter, fresh and dry weights of whole plant) bulb yield and its components (average bulb weight, marketable bulbs yield, culls bulb weight and total bulbs yield), onion quality (bulb diameter total soluble solids (%) and dry matter content) and chemical composition in both seasons. The application of humic acid at the rate of 2 kg fed^{-1} showed improve N, P and K content of onion bulb tissues. Hala Kandil[11] found that increasing humic acid levels from 0.0 to 10% significant increased the growth and yield parameters of pea plants. Humic acid at 10% gave the highest ones.

Cobalt, a border element, is a beneficial element for higher plants growth. Cobalt is an essential for the synthesis of vitamin B_{12} which is required for human and animals nutrition[12]**.** Cobalt dose not accumulate in human body, as the other heavy metals with the increase in age. The daily cobalt requirements for human nutrition could reach 8 ppm depending on cobalt levels in the local supply of drinking water without health hazard[13]**.** Cobalt is an essential component of several enzymes and co-enzymes. It has been shown to effect growth and metabolism of plants, in different degrees, depending on the concentration and status of cobalt in rhizoshere and soil. Cobalt increase cytoplasmic osmotic pressure, leaf resistance to dehydration and decreased the wiltting coefficient of potato plants[14].

Soils of Egypt are poor in organic matter rarely exceeding 2%[15]. To conserve their low level of organic matter. Egyptian soils showed receive about 82 million tons annually[16]**.** Recently, with increasing the cost of mineral fertilizers and questions as their future availability, there is renewed interest in organic recycling to improve soil fertility and productivity. So, organic compost wastes may be utilized in the soil as source of nutrients for crop production[17]. Increasing compost application in the newly reclaimed soils significantly increased both the dry matter production and yield of Roselle[18]. Sowicki[19] showed that organic compost addition significantly increased sunflower plant dry weight, seed yield, oil content, carbohydrates and major elements (N, P and K) as well as seed contents of Fe, Mn, Zn, Co and Ni. Bibak[20] found that while treatment of the winter wheat plants grown on a sandy loam soil supplied with nitrogen increased cobalt uptake by plants, responses were higher when receiving farmyard manure than in the fields not given one. Laila Helmy and Nadia Gad[21] showed that cobalt at 25 mg kg-1 soil significantly increased parseley growth expressed as plant high, leaf number per plant, leaf fresh and dry weights as well as root fresh and dry weights. Cobalt fertilization also significantly increased essential oil yield. The main aroma constituent, 1,3,8- menthatriene which forms about (76%) of leaves essential oil, showed about (10%) increase over than of control with 50 mg kg^{-1} soil. Abd El-Moez and Nadia Gad[22] stated that organic cotton wastes compost at 15 ton fed^{-1} gave the synergetic synergistic effect on cowpea fresh and dry weights of both shoot and root. Supplementing plant media with 8 ppm cobalt with 10 ton fed^{-1} organic cotton wastes compost resulted cowpea shoot and root at the same growth with 20 ton fed^{-1} organic cotton compost alone. Nadia Gad[23] pointed that cobalt is an promising element in the newly reclaimed soils. Organic fertilizer increased the availability of native cobalt affected by high pH under Egyptian soil condition. Cobalt had a significant promotive effect on olive plants endogenous hormones, growth and yield parameters, fruits quantity and quality (oil content, nutritional status) compared with control plants especially with organic fertilization. Cobalt at 22.5 ppm gave the superior values.

Eman Aziz et al.,[24] showed that all pervious cobalt treatments significantly increased all growth and yield parameters of lemongrass compared with control. Cobalt at 22.5 ppm gave the highest values of fresh and dry herb yields (8.97 and 2.66 ton) as well as recorded the greatest increase in the essential oil yield (63.07 Lh^{-1}). Nadia Gad[25] stated that studies organic fertilizer sources significantly increased Roselle growth and yield parameters were obtained by control (minerals fertilizer alone). Applications of cobalt at 20 ppm with fertilized Roselle plants were more effective in increasing growth and yield quantity and quality such as anthocyanin, flavonoids and mineral composition. Nada Gad and Nagwa Hassan[26] found that cobalt with studied organic fertilizer enhancing tomato growth, yield, nutrients status and chemical constituents as well as tomato fruits quality. The superior tomato growth and yield parameters were recorded by plants which supplied with cobalt at 7.5 ppm.

The aim of the present experiments to investigate the effect of cobalt and humic acid on okra growth, yield quantity and quality.

Materials and Methods:

Soil analysis:

Physical and chemical properties of some samples from El-Nubaria Soil were determined and particle size distributions along with soil moisture were determined as described by Blackmore[27]. Soil pH, EC, cations and anions, organic matter, $CaCO_3$, total nitrogen and available P, K, Fe, Mn, Zn, Cu were run according to Black et al.,[28]. Determination of soluble, available and total cobalt was determined according to method described by Cottenie et al.,[29]. Some physical and chemical properties of El-Nubaria soil are shown in Table (1).

Table 1: Some physical and chemical properties of El-Nubaria soil.

Field capacity (%)	**Particle size distribution**			
	Soil Texture	**Clay(%)**	**Silt(%)**	**Sand(%)**
21.2	Sandy loam	3.5	26.7	69.8

Chemical properties						
Cobalt (ppm)			O.M[c] (%)	$CaCO_3$ (%)	pH[a] (1:2.5)	EC[b] dsm^{-1}
Total	Available	Soluble				
7.66	1.67	0.34	0.02	3.21	7.8	0.13

Soluble anions (meq L^{-1})				Soluble cations (meq L^{-1})			
$SO_4^{=}$	Cl^-	HCO_3^-	CO_3^-	Na^+	K^+	Mg^{++}	Ca^{++}
1.93	0.8	1.60	-	1.09	0.24	1.10	2.0

Available micronutrients (ppm)				Available (mg/100g)		Total N (mg/100g)
Cu	Zn	Mn	Fe	K	P	
3.01	1.78	2.12	7.77	11.0	13.4	16.5

a) Soil pH was measured in 1 : 2.5 soil-water suspension.

b) EC Was Measured as dSm-1in soil paste.

c) Organic Matter

Experimental works:

Two field experiments were conducted at the Research and Production Station, National Research Centre, El-Nubaria location, Beheara Governorate, Delta Egypt, during two successive seasons of 2013 and 2014, to evaluate the effect of different rates of cobalt and humic acid on okra growth, yield, mineral composition and some chemical constituents.

Superphosphate at 100 kg fed^{-1}, 150 kg fed^{-1} Ammonium sulphate were added during soil preparation before sowing. Okra *(Hibiscus Esculantus)* seeds were sowing on 20 and 23 March of 2013 and 2014 seasons, under drip irrigation system. Potassium sulphate at 100 kg fed^{-1} was adding during 30 days from sowing. According to Nadia Gad et al.,[30], seedling (at the third truly leaf) were irrigated with 0.0, 2.5, 5.0, 7.5, 10.0 and 12.5 ppm cobalt once using cobalt sulphate form. Each treatment was represent by 9 plots. Each plot area was 5 * 5 meter, consisting of five rows. Ten plants in each row (50 cm apart) as a replicates. All treatment was treating with three humic acid rates (5, 10 and 15 %) as soil drench.

All plants received natural agricultural practices whenever they needed.

Measurement of plant growth parameters:

At full blooming stage i.e. 60 days from sowing a representative sample of ten plants was taken from each plot. Some growth parameters such as plant hight, number of branch and leaves per plant, shoot and root fresh weight as well as biomass of both shoots and roots per plant, were recorded in the two studied seasons according to FAO[31].

Measurements of pods yield parameters:

At harvest stage (after 90 days from sowing) the mature pods of okra for each experimental plot were collected along the harvesting two seasons, some yield parameters such a pods number per plant, pods length, pods diameter, pods weight per plant and pods yield per Fadden were recorded according to Gabal et al.,[32].

Measurements pods nutritional status:

Macro (N, P and K) and micro (Fe, Mn, Zn and Cu) nutrients along with cobalt content were determined according to Cottenie et al.,[29].

Measurements pods chemical constituents:

Total proteins, total soluble solids, total carbohydrates, vitamin "C" and vitamin "A" were determined according to A.O.A.C.[33].

Statistical analysis:-

All obtained data were statistically analyzed of variance procedure outlined by (SAS,[34]). Computer program and means compared by LSD method according to Snedecor and Cochran[35].

Results and Discussion

Vegetative growth:

Table (2) show the effect of cobalt and humic acid on okra growth parameters such as plant hight, number of branches and leaves per plant, fresh weight of both shoot and root along with shoot and root biomass.

Table (2): Okra growth parameters as affected by cobalt and humic acid rates (mean of two seasons).

Humic acid (%)	Cobalt treatments (ppm)	Plant hight (cm)	Number plant^{-1}		Fresh weight (g plant^{-1})		Dry weight (g plant^{-1})	
			Branches	Leaves	Shoot	Root	Shoot	Root
5%	Control	79.17	3.89	18.23	197.5	16.31	36.31	4.55
	2.5	82.06	4.15	20.56	224.6	17.18	41.78	4.81
	5.0	86.11	4.33	22.81	259.9	18.71	46.62	5.22
	7.5	89.51	4.67	25.21	287.7	20.13	54.56	5.61
	10.0	88.32	4.59	23.05	264.8	19.02	54.21	5.58
	12.5	86.08	4.40	21.87	258.4	18.86	53.12	5.22
Mean		85.21	4.34	21.96	248.8	18.37	47.77	5.17
LSD 5%		0.34	0.08	0.21	4.31	0.15	0.21	0.04
10%	Control	93.15	3.96	20.87	215.7	19.40	39.52	4.91
	2.5	97.86	4.19	21.46	236.1	20.11	42.85	5.15
	5.0	106.2	4.63	23.67	269.8	21.32	51.76	5.49
	7.5	113.5	4.84	26.58	324.5	27.21	58.19	7.02
	10.0	108.4	4.76	25.60	312.6	27.02	57.77	6.95
	12.5	103.0	4.71	24.89	297.7	26.57	57.23	6.82
Mean		103.69	4.52	23.85	276.1	19.87	51.22	7.27
LSD 5%		0.41	0.07	0.18	3.84	0.18	0.23	0.05
15%	Control	84.77	3.91	20.04	208.6	17.28	37.89	4.76
	2.5	87.61	4.04	22.60	232.1	19.19	41.90	5.28
	5.0	91.81	4.19	23.98	267.9	19.78	47.62	5.47
	7.5	95.06	4.56	25.78	286.2	20.30	55.71	5.66
	10.0	93.14	4.39	24.60	281.1	20.11	55.23	5.58
	12.5	91.11	4.28	23.88	277.7	19.23	54.69	5.31
Mean		90.58	4.23	23.48	258.9	19.32	48.89	5.34
LSD 5%		0.38	0.05	0.23	4.53	0.12	0.22	0.03

Humic acid rates can be arranged in decreasing order as follows: 10 % > 15 % > 5 %. All humic acid treatments significantly increase okra growth parameters compared with control. The lowest values of okra growth parameters were obtained by 5 % rate. These data are in harmony with those obtained by Mackowiak et al.,[2] who found that humic acid enhance water retention, increase seed germination rates, improves plant growth. Confirm these results Cimrin and Yilmaz[7] who stated that humic substances have been shown stimulate shoot and root growth and nutrient uptake of vegetable crops. Table (2) also indicates that all cobalt treatments gave a significant beneficial effect on all studied growth parameters with different humic acid levels compared with control plants (humic acid alone).

Cobalt at 7.5 ppm resulted the greatest values of growth parameters with different humic acid rates. Increasing cobalt addition in plant media above 7.5 ppm reduce the beneficial effect. These results are in harmony with those obtained by Nadia Gad et al.,[36] who found that cobalt is an promising element in the newly reclaimed soils. Organic fertilizer increased the availability of native cobalt affected by high pH under Egyptian soils condition. Cobalt had a significant promotive effect on olive plants endogenous hormones, growth and yield parameters, fruits quantity and quality (oil content, nutritional status) compared with control plants especially with organic fertilization. Cobalt at 22.5 ppm gave the greatest values. Confirm these data Biabak[20] who stated that, when treatment of the winter wheat plants grown on a sandy loam soil supplied with farmyard manure, cobalt uptake by plants was increased and hence plant growth and yield compared with fields not given one.

Yield characteristics:-

Data in Table (3) clearly indicate that all studied humic acid rates significant increased okra yield parameters such as pods number per plant, pods length, pods diameter, pods weight per plant and pods yield (ton fed^{-1}).

Table (3): Okra yield parameters as affected by cobalt and humic acid rates (mean of two seasons).

Pods yield (Ton fed^{-1})	Pods weight plant^{-1} (g)	Pods diameter (cm)	Pods length (cm)	Pods number plant^{-1}	Cobalt treatments (ppm)	Humic acid (%)
1.299	225.17	1.76	3.15	69.12	Control	5%
1.326	229.61	1.79	3.22	71.91	2.5	
1.863	336.22	1.83	3.31	79.72	5.0	
2.110	364.19	1.87	3.80	83.19	7.5	
1.994	346.22	1.73	3.69	83.08	10.0	
1.954	339.14	1.73	3.65	81.62	12.5	
1.758	306.76	1.79	3.47	77.94	Mean	
0.01	6.22	0.02	0.09	0.38	LSD 5%	
1.960	314.59	2.24	3.89	87.22	Control	10%
2.169	366.12	2.28	3.92	95.81	2.5	
2.631	415.23	2.33	3.97	103.62	5.0	
3.301	558.61	2.41	4.22	112.59	7.5	
2.802	484.40	2.37	4.08	110.01	10.0	
2.421	418.36	2.35	4.03	110.01	12.5	
2.547	426.22	2.33	4.02	103.21	Mean	
0.02	5.14	0.01	0.07	0.36	LSD 5%	
1.802	278.60	1.87	3.41	75.32	Control	15%
1.921	295.50	1.91	3.46	79.63	2.5	
2.137	326.70	1.94	3.53	86.92	5.0	
2.681	389.30	1.98	3.81	93.77	7.5	
2.335	361.41	1.96	3.76	93.11	10.0	
2.269	351.23	1.96	3.64	91.87	12.5	
2.191	333.79	1.94	3.60	71.14	Mean	
0.01	6.41	0.02	0.06	0.33	LSD 5%	

The rate of 10 % humic acid gave the highest okra yield compared other rates while the rate of 5 % resulted the lowest one, these data are agree with those obtained by Dorer and Peacock[37] who reported that humic acid is widely used for production of most crops, as it provides soil microbes with energy, improves nutrients retention in the soil and enhances the water holding capacity. Confirm these results Pilanal and Kaplan[38] who reported that humic acid increased plant hight, leaf area, plant dry weight and fruit number of strawberry. Data in Table (3) also indicate that cobalt treatments gave a significant promotive effect with different humic acid rates compared with control (humic acid alone). Cobalt at 7.5 ppm has the greatest yield parameters. Cobalt at 7.5 ppm with humic acid at 10 % resulted the superior pod yield. Cobalt at 7.5 ppm with 10 % humic acid increased okra yield about 68.42 %. These results are good agreement with those obtained by Karakurt et al.,[4] who found that humic acid enhanced nutrient uptake, plant growth, yield and quality in a number of plant species. Nadia Gad et al.,[36] added that organic fertilizers increased the availability of native cobalt affected by high pH under Egyptian soil condition. Cobalt had a significant promotive effect on olive yield, fruits oil, fruit macro and micro-nutrients, fruit quality and endogenous hormones especially with organic fertilization.

Nutritional Status:-

Data in Table (4) show the effect of humic acid rate on mineral composition of okra pods. All humic acid treatments can be arranged in decreasing order as follows: 10% > 15%> 5%. The highest nutrients content of okra pods were obtained by the rate at 10% while the level of 5% gave the lowest ones. The observations are in consistent with previous reports obtained by El-Nemr et al.,[5] who found that humic acid enhanced nutrient uptake. Plant growth, yield and quality in a number of plant species. Confirm these results Stumpe et al.,[3] who stated that humic acid essentially helps the movement of micronutrients from soil to plant. Data in Table (4) also indicate that, all cobalt treatments have a significant positive effect on okra pod minerals concentration compared with control (humic acid alone). Cobalt at 7.5 ppm gave the greatest values of macro (N, P and K) and micro (Mn, Zn and Cu) nutrients. These data in harmony with those obtained by Boureto et al.,[39] who showed that cobalt at 2.5 ppm in sand culture found to promote the effects on N, P and K of tomato plants.

Table (4): Okra nutritional status as affected by cobalt and humic acid rates (mean of two seasons).

Cobalt	Micronutrients (ppm)				Macronutrients (%)			Cobalt treatments (ppm)	Humic acid (%)
(ppm)	Fe	Cu	Zn	Mn	K	P	N		
0.85	146	28.5	33.6	40.51	0.886	0.232	o.652	Control	5%
1.25	143	31.6	36.1	43.0	0.890	0.236	0.659	2.5	
3.61	140	34.5	39.0	45.8	0.893	0.241	0.671	5.0	
4.96	136	38.0	42.7	49.6	0.898	0.248	0.698	7.5	
6.84	131	36.1	40.2	47.1	0.896	0.248	0.695	10.0	
8.48	128	33.5	38.0	44.3	0.892	0.245	0.689	12.5	
4.33	137	33.7	38.27	45.1	0.893	0.242	0.677	Mean	
0.11	0.68	0.19	0.21	0.23	0.034	0.022	0.038	LSD 5%	
0.96	156	30.2	38.1	44.5	0.956	0.341	0.770	Control	10%
1.41	153	32.5	41.3	46.8	0.959	0.346	0.793	2.5	
3.98	149	35.0	44.6	49.5	0.963	0.352	0.808	5.0	
5.09	145	37.8	48.4	53.8	0.970	0.358	0.841	7.5	
7.11	141	36.0	46.7	51.3	0.970	0.356	0.839	10.0	
8.77	138	34.2	43.9	49.1	0.967	0.351	0.834	12.5	
4.55	147	34.3	43.8	49.2	0.964	0.351	0.814	Mean	
0.13	0.83	0.15	0.23	0.21	0.031	0.019	0.036	LSD 5%	
0.91	151	29.9	36.2	42.6	o.911	0.314	0.718	Control	15%
1.31	148	31.5	38.6	43.9	o.923	0.317	0.731	2.5	
3.97	145	34.3	40.2	46.4	o.937	0.321	0.769	5.0	
4.88	141	37.6	42.8	48.8	0.941	0.326	0.814	7.5	
7.06	137	35.2	40.5	52.1	0.940	0.324	0.786	10.0	
8.78	133	32.7	38.1	54.0	0.937	0.321	0.781	12.5	
4.49	142	33.5	39.4	47.9	0.932	0.321	0.767	Mean	
0.15	0.74	0.16	0.20	0.21	0.029	0.017	0.039	LSD 5%	

Confirm these data Nadia Gad and Nagwa Hassan[26] who added that the addition of cobalt with organic matter (chicken or farmyard manure) had a synergistic effect on both macro (N, P and K) and micro (Mn, Zn and Cu) nutrients of tomato fruits compared with control. Data in Table (4) also show that, increasing cobalt addition in okra growing media above 7.5 ppm was significantly reducing Fe content for two seasons. This may be explained on the basis of the obtained results by Blaylock[40] who showed certain antagonistic relationships between the two elements (cobalt and iron), and revealed that the relative response of Fe to the control indicated continues decrease of this element as a result of cobalt addition. Also data in Table (4) clearly indicate that increasing cobalt levels in growing okra media from 2.5 ppm to 12.5 ppm increased cobalt content in okra pods which grown for two seasons compared with untreated plants. These results show that cobalt content goes along with the concentration of added cobalt. These results may explain on the basis of the obtained results by Nadia Gad et al.,[30]. Young[13] reported the daily requirements for human nutrition could reach 8 ppm without health hazard. Level of 5.09 ppm in the cobalt treatment with 7.5 ppm level, since the daily consumption of okra pods does not exceed a few grams.

Chemical constituents:-

Data in Table (5) indicate similar responses of okra pods chemical constituents to different rates of humic acid. Cobalt addition to okra grown media significantly increased the chemical constituents such as total proteins, total soluble solids, total carbohydrates, vitamin "C" and vitamin "A". Humic acid at 10% gave the highest values followed by the rate of 15% while the level of 5% resulted the lowest ones. During the two studied seasons. These results are harmony with those obtained by Sebastiano et al.,[41] who stated that humic acid application stimulate growth, yield and its quality of some crops including wheat. Paksoy et al.,[42] added that humic acid and potassium application increased the performance growth and mineral contents of okra plant. Data in Table (5) also show that cobalt significantly increased all studied chemical constituents of okra pods. Cobalt at 7.5 ppm gave the highest figures. The superior values of okra chemical constituents obtained by 7.5 ppm cobalt with 10% humic acid. The relative calculated values as percentage from control. Cobalt at 7.5 ppm with 10% humic acid increased the content of: total proteins 9.2%, total soluble solids 26%, total carbohydrates 13.6%, vitamin "C" 13.2% and vitamin "A" 9.4% respectively as mean of two seasons.

Table (5): Okra chemical constituent as affected by cobalt and humic acid rates (mean of two seasons).

Vitamin "A"	Vitamin "C"	Total carbohydrates	Total soluble solids	Total protein	Cobalt treatments (ppm)	Humic acid (%)
mg/100g F.w		%				
13.19	25.72	12.78	7.46	4.08	Control	5%
33.31	26.94	12.97	7.59	4.12	2.5	
34.49	27.78	13.54	8.66	4.19	5.0	
35.75	29.02	14.32	9.41	4.36	7.5	
35.69	28.69	14.19	9.38	4.34	10.0	
34.08	28.14	13.97	9.33	4.31	12.5	
31.09	27.72	13.63	8.64	4.23	Mean	
0.31	0.23	0.09	0.05	-	LSD 5%	
33.88	26.89	13.08	7.95	4.81	Control	10%
34.29	28.00	13.31	8.19	4.96	2.5	
35.60	29.52	14.08	8.97	5.05	5.0	
37.00	30.45	14.86	10.03	5.26	7.5	
36.81	30.13	14.74	9.95	5.24	10.0	
36.69	29.58	14.56	9.89	5.21	12.5	
35.71	29.09	14.11	9.16	5.09	Mean	
0.33	0.25	0.13	0.07	-	LSD 5%	
33.36	26.22	12.83	7.87	4.49	Control	15%
33.72	26.91	13.02	8.96	4.59	2.5	
34.44	28.11	13.27	9.21	4.81	5.0	
36.08	29.72	13.52	9.89	5.09	7.5	

35.83	28.81	13.50	9.82	4.91	10.0	
34.79	28.43	13.47	9.76	4.88	12.5	
34.70	28.03	13.27	9.25	4.80	Mean	
0.31	0.23	0.11	0.05	-	LSD 5%	

These data are in harmony with those obtained by Nadia Gad and Hala Kandil[43] who revealed that cobalt application significantly increased protein, starch, mono sugars, total soluble solids, total soluble sugars, vitamin "C" as L- Ascorbic acid and vitamin "A" as carotenoids of sweet potato roots compared with untreated plant. Morkova[44] added that soil application of 0.7 kg $CoSo_4$ ha^{-1} before transplanting increased both total soluble solids and total soluble sugars compared with untreated tomato plants. Vitamin "A" is an important antioxidant and is essential to human growth, normal physiological functions, health of the skin as well as muscous membrans. Moreover, vitamin "C" is an antioxidant and is necessary to several metabolic processes and reduced gastric cancer risk[45].

Conclusion:

Humic acid decreases soil pH and increases the availability of cobalt and micronutrients. Cobalt has a significant beneficial effect on okra growth, yield quantity and quality compared with control (humic acid alone). The combination between cobalt at 7.5 ppm and 10% humic acid resulted the superior values.

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