Effect of Foliar Spraying with Humic Acid, Salicylic Acid and Copper on Vegetative Growth and Bulbs Yield and Its Componentsof Onion Plants (*Allium cepa* L.)

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ABSTRACT

Two field experiments were imposed during the winter seasons of 2012 and 2013 to study the main and interaction effects of spraying humic acid (0, 500, 1000 and 1500 ppm), Salicylic acid (0, 500 and 1000 ppm) and copper (0, 200 and 400 ppm) on vegetative growth and bulbs yield and its components of onion plants cv. Giza 20. The experiments were carried out in the Experimental Station Farm at Abeis, Faculty of Agriculture, Alexandria University. The main effect of spraying humic acid, salicylic acid and copper, irrespective of the concentration used, significantly, increased number of leaves plant^{-1} and plant height relative to the untreated control. The highest concentration of humic acid, salicylic acid and copper, positively and significantly, increased marketable and total bulbs yield. The second order interaction of humic acid, salicylic acid and copper at the highest concentration was the most effective treatment which gave the best vegetative growth and highest total and marketable bulbs yield.

Key words: Humic acid – Salicylic acid – Copper – Onion – Giza 20.

INTRODUCTION

Onion (*Allium cepa* L.) is a high-value cash crop and one of the most important vegetable crops in Egypt due to its multifarious use in local consumption, food processing and exportation. Egypt ranks 7th among the leading world countries in onion production after China, India, United States, Pakistan, Turkey and Iran(FAO, 2010). The cultivated area in Egypt was 152953 fed produced 2,304,210 tons (FAO, 2011).

Soil health is one of the key factors, which decides the yield of crop. Organic manures are indispensable factor in vegetable production and monitoring soil health. Humic substances classified into three general categories; humic acid, fulvic acid and humin (Solange and Rezende, 2008). The effects of humic acid on plant growth can be grouped into direct effect on physiological and biochemical processes of plants and indirect effect on physical, chemical and biological properties of the soil. Regarding the direct effect, previous studies showed that, humic acid can be used as a growth regulator to regulate hormonal level in plants, enhance stress tolerance, increase essential nutrients uptake, maintaining vitamins and amino acids level, stimulate growth root and whole plant (Piccolo *et al.*, 1992 and Nardi *et al.*, 1996). The indirect effect of humic acid; promote the activity of useful micro-organisms in soil (El-Gizy 1994; Suresh *et al.*, 2004; Remesh, 2008), enhance nutrients availability (Varanini and Pinton, 1995), a source of essential nutrients for plant growth (Yildirim, 2007) and increase leaf N content and solubility of insoluble phosphorus compounds (Le Chang *et al.*, 2012 and Tan, 2003). Several studies have been reported that, humic acid improved not only vegetative growth but, also, yield and quality of onion. For instance, El-Desuki (2004) reported that increasing humic acid application from 0 to 6 kg fed^{-1}, gradually and significantly, increased onion bulbs yield. He, also, added that the combined application of humic acid at 20 kg ha^{-1} together with the recommended dose of NPK recorded higher bulbs yield over the recommended NPK by 12%.

Salicylic acid is classified under the group of plant hormones (Raskin, 1992). Salicylic acid is a natural product of phenyl propanoid metabolism and is a phenolic derivative distributed in a wide range of plant. Salicylic acid plays multifarious roles in the metabolism of plants; flower induction, uptake of ions and control of seed germination, stomata functions, gravity sensing and pathogenesis (Raskin, 1992; Murphy *et al.*, 1999; Alvarez, 2000; Lucas and Lee, 2004). Khadr (2015) clarified that, spraying garlic plants with salicylic acid at 50 ppm after 45, 60, and 75 days of seed sowing gave the highest mean values of plant height, total fresh and dry weights, fresh weight and number of leaves and leaf area plant^{-1}. In addition, the highest mean values of total marketable and exportable bulbs yield, average fresh and dry bulb weight, N, P, K, Ca, chlorophyll a, b, total (a+b) and carotenoid contents were attained.

Copper have been found to be responsive for many plants especially onion. Copper is a constituent of several enzyme systems involved in building and converting amino acids into proteins, metabolism of carbohydrate, formation of lignin, flavor, storage-ability and sugar content of fruits. Under high soil pH, solubility of Cu in soil decreased causing plant physiological disorders (Srivastava and Gupta, 1996). El-Fouly (1983) reported that foliar application of microelements is highly recommended under Egyptian soil conditions. In view of this fact, the Egyptian soil pH exceeds 7.5 and sometimes even 8.5 and some areas show high $CaCO_3$ content which makes application of micronutrients more necessary.

Information's concerning the effects of optimum humic, salicylic acid and copper concentrations on growth and yield are scant. Accordingly, the scope of the present study is to investigate the effects of humic acid, salicylic acid and copper on growth, bulb yield and its components of onion plants.

MATERIALS AND METHODS

Two field experiments were carried out during the winter seasons of 2012 and 2013 to investigate the main and interaction effects of foliar spraying with humic acid, Salicylic acid and copper at various concentrations on vegetative growth, bulbs yield and yield components of onion plants cv. Giza 20. The experiments were conducted in the Experimental Station Farm at Abeis, Faculty of Agriculture, Alexandria University, using surface irrigation system.

Preceding the initiation of each experiment, soil samples to 25 cm depth were collected and analyzed for some physical and chemical properties according to the standard published procedures (Klute, 1986; Cottenie *et al.*, 1982; Page *et al.*, 1982; Olesen *et al.*, 1954; Bremner, 1965; Jackson, 1967). Results of soil samples analyses are presented in Table 1.

Four concentrations of humic acid (Lele Company, China); 0, 500, 1000 and 1500 ppm, three concentrations of salicylic acid (El-Nasser Pharmaceutical Chemicals Company); 0, 500 and 1000 ppm and three concentrations of copper; 0, 200 and 400 ppm were prepared and used. Copper solute was in the form of cupric sulphate "Copper (ll) sulphate 5-hydrate" (98.5% cu). There were 36 treatments in total. Each treatment was foliar sprayed to run-off three times using a hand sprayer. Foliar application of humic concentrations was practiced after 6, 8 and 10 weeks of transplanting while, spraying salicylic acid concentrations were done after 7 and 11 weeks of transplanting and at the early stage of bulb initiation meanwhile, copper concentrations foliar sprayed; 9, 13 and 17 weeks after transplanting. The untreated control plants were sprayed with tap water.

The experimental layout was a split- split- plots system in a Randomized Complete Blocks Design with three replications. The concentrations of humic acid, salicylic acid and copper were randomly distributed in the main, sub- and sub-sub plots, orderly. Each sub- sub- plot contained two rows of 4 m length and 0.60 m width. Onion transplants were cultivated on both sides of row at in-row spacing of 7 -10 cm on January 18 and 3 in 2012 and 2013, consecutively. Each two adjacent experimental units were separated by one guard row to protect against side effects.

All experimental units received identical doses of nitrogen, phosphorus and potassium at rates of 120, 75 and 48 kg fed^{-1}, orderly. Ammonium sulphate (20.5% N), Calcium super phosphate (15.5 % P_2O_5) and potassium sulphate (48% K_2O) were the respective forms of fertilizers.

Table 1: Soil's physical and chemical properties of the two experimental sites*, in the two growing seasons of 2006/2007 and 2007/2008.

Properties	2012	2013
Physical:		
- Sand %	22.1	22.4
- Silt %	37.8	36.4
- Clay %	40.1	41.2
- Texture	Clay loam	Clay loam
Chemical:		
- EC (dsm^{-1})	3.18	3.12
- PH	8.02	7.90
- Organic matter (%)	0.72	0.76
- N (%)	0.12	0.10
- P (ppm)	141	152
- K ($meql^{-1}$)	0.082	0.085
- Calcium carbonate (%)	5.7-6.5	5.9-6.1
- Na^+ ($meql^{-1}$)	28.90	22.30
- Ca^{++} ($meql^{-1}$)	15.30	16.80
- Mg^{++} ($meql^{-1}$)	20.00	18.00
- Cl^- ($meql^{-1}$)	6.5	4.5

* These analyses were carried out at the central laboratory, Faculty of Agriculture, Alexandria University.

Nitrogen fertilizer was banded at three applications; 3, 7 and 10 weeks after transplanting. Phosphorus fertilizer was broadcasted during soil preparation. Potassium fertilizer was banded at two equal portions; 11 and 14 weeks after transplanting. All other agro-managements practices such as irrigation, cultivation, diseases and pest control were carried out whenever it was necessary and as recommended for the commercial production of onion.

After 130 days of transplanting, in both seasons, bulbs were harvested and cured for complete drying.

Data Recorded

Morphological characters

In each experimental unit, after 115 days of transplanting, randomly five plants were selected to measure the following morphological characters; plant height (cm) starting from the adventitious roots up to top tip of plant and number of leaves plant^{-1} were counted.

Bulbs yield and its components

In each experimental unit, after 130 days of transplanting, all bulbs were harvested, weighed (Kg plot^{-1}) and converted into tones fed^{-1}. Harvested bulbs were sorted into two classes; marketable and non-marketable bulbs (less than 3 cm in diameter, bolters, dual, rotted and crack), weighed and converted into tones fed^{-1}.

RESULTS AND DISCUSSION

Morphological characters

Results of Table 2 displayed that, spraying of humic acid, salicylic acid and copper concentrations, irrespective of the used concentration, significantly, increased number of leaves plant^{-1} and plant height, relative to the un-treated control, in both seasons. Raising humid acid (from 500 to 1000 or 1500 ppm), salicylic acid (from 500 to 1000 ppm), and copper (from 200 to 400 ppm) concentrations were associated with significant corresponding increases on both studied vegetative growth characters, in the two growing seasons. The highest significant mean values of number of leaves plant^{-1} and plant height were obtained from the application of 1500 ppm humid acid, 1000 ppm salicylic acid, and 400 ppm copper.

The influence of 1st order interaction between any two studied factors on number of leaves plant^{-1} and plant height was significant, in both seasons (Table 3). Comparisons among the various means value of different 1st order interaction showed that, when any two studied factors at the highest concentration (1500 humic acid, 1000 ppm salicylic acid and 400 ppm cu) coupled together, significantly, attained the highest mean values for number of leaves plant^{-1} and plant height, in both years. The only exception was found in plant height, in 2012.

The impact of 2nd order interaction among the three studied factors on number of leaves plant^{-1} and plant height was true, in both seasons (Table 4). Obtained results indicated that, the combined treatment of humic acid (1500 ppm), salicylic acid (1000 ppm) and copper (400 ppm), significantly, recorded the highest mean value for number of leaves plant^{-1} and plant height, in both years. The only exception was found in number of leaves plant^{-1}, in 2012.

The enhancing impact of spraying humic acid at 1500 ppm on number of leaves plant^{-1} and plant height may be related to its action on increasing cell permeability, hormonal growth responses (Poapst *et al*., 1971; Vaughan, 1974),

Table 2: Number of leaves plant^{-1} and plant height of onion plants as affected by humic acid, salicylic acid and copper concentrations in the two winter seasons of 2012 and 2013.

Seasons	2012		2013	
Treatments	No. leaves plant^{-1}	Plant height (cm)	No. leaves plant^{-1}	Plant height (cm)
Humic acid (ppm)				
0	8.30 C*	64.73 B	8.32 B	65.10 C
500	8.74 BC	69.62 B	8.73 AB	73.06 B
1000	9.15 AB	75.26 A	9.05 AB	75.43 AB
1500	9.43 A	79.44 A	9.49 A	80.12 A
Salicylic acid (ppm)				
0	8.72 B	70.80 B	8.73 B	71.62 B
500	8.92 AB	72.41 AB	8.82 AB	73.99 AB
1000	9.08 A	73.58 A	9.15 A	74.67 A
Copper (ppm)				
0	8.68 B	71.06 B	8.76 B	72.44 B
200	8.93 AB	72.25 AB	8.91 AB	73.27 B
400	9.12 A	73.48 A	9.03 A	74.56 A

* Values having the same alphabetical letter (s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D. test at 0.05 level.

Table 3: Number of leaves plant^{-1} and plant height of onion as affected by the 1st order interaction of humic acid, salicylic acid and copper concentrations in the two winter seasons of 2012 and 2013.

Seasons		2012		2013	
Treatments		No. of leaves plant^{-1}	Plant height (cm)	No. of leaves plant^{-1}	Plant height (cm)
Humic acid (ppm)	Salicylic acid (ppm)				
	0	63.20 g*	7.91 f	64.23 d	8.64 c-f
0	500	65.40 fg	8.36 ef	65.40 d	7.96 f
	1000	65.58 fg	8.64 de	65.67 d	8.36 def
	0	70.11 de	8.80 cde	72.53 c	8.24 ef
500	500	68.91 ef	8.49 ef	73.04 c	8.98 b-e
	1000	69.84 e	8.93 b-e	73.60 c	8.98 b-e
	0	74.29 cd	8.96 b-e	73.64 c	8.89 b-e
1000	500	76.29 cd	9.18 a-d	77.31 bc	8.89 b-e
	1000	75.20 bc	9.31 abc	75.33 bc	9.38 abc
	0	75.60 bc	9.20 a-d	76.07 bc	9.13 a-d
1500	500	79.02 b	9.64 a	80.22 ab	9.44 ab
	1000	83.71 a	9.44 ab	84.07 a	9.89 a
Humic acid (ppm)	Copper (ppm)				
	0	62.89 g	8.16 e	63.38 f	8.22 f
0	200	65.07 fg	8.29 de	64.89 ef	8.36 ef
	400	66.22 f	8.47 cde	67.03 e	8.38 ef
	0	68.82 e	8.47 cde	72.71 d	8.53 def
500	200	69.20 e	8.84 bcd	72.87 d	8.73 c-f
	400	70.84 e	8.91 bc	73.60 cd	8.93 bcd
	0	74.80 d	8.93 bc	74.96 cd	8.78 cde
1000	200	74.98 d	9.36 ab	75.40 c	9.11 abc
	400	76.00 cd	9.16 b	75.93 c	9.27 abc
	0	77.71 bc	9.18 b	78.73 b	9.49 a
1500	200	79.76 ab	9.22 b	79.93 ab	9.42 ab
	400	80.87 a	9.89 a	81.69 a	9.56 a
Salicylic acid (ppm)	Copper (ppm)				
	0	69.18 c	8.73 bc	70.47 d	8.73 bc
0	200	71.20 bc	8.73 bc	72.33 cd	8.73 bc
	400	72.02 b	8.68 bc	72.06 cd	8.72 bc
	0	71.23 bc	8.55 c	73.27 bc	8.53 c
500	200	72.85 b	9.10 ab	73.72 bc	9.03 ab
	400	73.13 ab	9.10 ab	75.00 ab	8.88 bc
	0	72.75 b	8.77 bc	73.60 bc	9.00 bc
1000	200	72.70 b	8.95 bc	73.77 bc	8.95 bc
	400	75.30 a	9.53 a	76.63 a	9.50 a

* Values having the same alphabetical letter (s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D. test at 0.05 level.

Also, application of humic caused improvement of soil physical, chemical and biological conditions as well as some plant hormone- like substances seems to be present in the humic acids, thus stimulate growth and development of chlorophyll and proliferation of desirable micro-organisms in soil (Liu *et al.*, 1998).

The positive effect of salicylic acid at 1000 ppm on number of leaves plant^{-1} and plant height might be attributed to the efficient water use, distinguished carboxylation process and augmentation rate of photosynthesis (Fariduddin *et al.*, 2003). Similar results on various crops coincided our results such as Bardisi (2004 a) on garlic, Jayakumar *et al.* (2006) on tomato, El-Tantawy and El-Beik (2009) on onion and Khadr (2015) on garlic. Amin *et al*. (2007), working on onion plants, reported that, spraying the foliage with salicylic acid caused, significant, increase in growth characters and photosynthetic pigments content of leaves.

500 0 0 8.80 c-j 69.13 m-r 8.27 j-n 72.87 h-k

		200				
		400				
		0	8.20 h-k	67.27 n-s	8.93 b-m	72.27 ijk
	500	200	8.73 d-j	69.07 m-r	9.33 a-h	71.80 jk
		400	8.53 e-k	70.40 k-o	8.67 c-m	75.07 e-j
		0	8.40 g-k	70.07 k-p	8.40 h-n	73.00 g-k
	1000	200	8.87 b-i	67.00 o-s	8.87 c-m	72.67 h-k
		400	9.53 a-e	72.47 i-m	9.67 a-e	75.13 e-j
		0	9.40 a-g	73.33 g-m	9.00 b-l	72.73 h-k
	0	200	9.07 a-h	73.07 h-m	8.87 f-m	75.00 f-j
		400	8.40 g-k	76.47 d-i	8.80 d-m	73.20 g-k
		0	8.73 d-j	75.07 e-j	8.20 k-n	77.53 c-f
1000	500	200	9.53 a-e	77.60 c-g	9.27 a-i	77.60 c-f
		400	9.27 a-g	76.20 d-i	9.20 a-j	76.80 d-h
		0	8.67 d-k	76.00 d-i	9.13 a-k	74.60 f-k
	1000	200	9.47 a-f	74.27 f-k	9.20 a-j	73.60 f-k
		400	9.80 abc	75.33 e-j	9.80 abc	77.80 c-f
		0	8.67 d-k	73.73 f-l	9.07 b-k	74.73 f-k
	0	200	9.27 a-g	76.20 d-i	9.33 a-h	76.33 d-i
		400	9.67 a-d	76.87 d-h	9.00 b-l	77.13 d-g
		0	9.47 a-f	78.07 c-f	9.53 a-g	79.27 b-e
1500	500	200	9.40 a-g	78.93 cde	9.20 a-j	80.00 bcd
		400	10.07 a	80.07 bcd	9.60 a-f	81.40 bc
		0	9.40 a-g	81.33 abc	9.87 ab	82.20 b
	1000	200	9.00 b-i	84.13 ab	9.73 a-d	83.47 ab
		400	9.93 ab	85.67 a	10.07 a	86.53 a

Table 4: Number of leaves plant^{-1} and plant height of onion as affected by the 2nd order interaction of umic acid, salicylic acid and copper concentrations in the two winter seasons of 2012 and 2013.

Season			2012		2013	
Treatments			No. of leaves plant^{-1}	Plant height (cm)	No. of leaves plant^{-1}	Plant height (cm)
Humic acid (ppm)	Salicylic acid (ppm)	Copper (ppm)				
		0	8.07 h-k*	60.53 t	8.60 g-m	61.53 n
	0	200	7.67 k	64.00 st	8.73 e-m	63.87 mn
		400	8 00 ijk	65.07 rs	8.60 g-m	67.30 mn
		0	7.80 jk	64.53 st	7.47 n	64.00 mn
0	500	200	8.73 d-j	65.80 p-s	8.33 i-n	65.47 mn
		400	8.53 e-k	65.87 p-s	8.07 lmn	66.73 mn
		0	8.60 e-k	63.60 st	8.60 g-m	64.60 lm
	1000	200	8.47 f-k	65.40 qrs	8.00 mn	65.33 lm
		400	8.87 c-i	67.73 n-s	8.47 h-m	67.07 lm

* Values having the same alphabetical letter (s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D. test at 0.05 level.

The beneficial effects of spraying copper at 400 ppm on morphological studied phenomena may be due its vital contribution in several metabolic processes related to growth in plant, (Marschner, 1995). Similar result was reported by El-Tantawy and El-Beik (2009) who exhibited that foliar application of onion plants with 30 ppm cu, significantly, increased plant stature followed by 15 ppm cu.

The promoting effect of 1stand 2nd order interactions on umber of leaves plant^{-1} and plant height may be related to the beneficial individual effect of the studied factors at the highest concentration which coupled together to enhance absorption of nutrients and activate photosynthesis to go forward (Amin *et al*., 2007).

Bulbs yield and its components

Foliar application of humic acid, salicylic acid and copper, irrespective of the concentration used, gradually and significantly, increased total bulbs yield compared to control, in both seasons (Table 5). The exception was in 2013 where difference between control and 200 ppm copper in total bulbs yield was not significant. Marketable bulbs yield, positively and significantly, responded to the concentrations of 500, 1000 and 1500 ppm humic acid, 500 and 1000 ppm salicylic acid and 400 ppm copper, in both seasons. Response of non-marketable bulbs yield varied, statistically, between the two seasons. In 2012, foliar Application of 1000 and 1500 ppm humic acid as well as 1000 ppm salicylic acid, significantly, augmented non-marketable bulbs yield while, foliar application of 400 ppm copper, significantly, decreased non-marketable yield relative to control. In 2013, differences among the concentrations of humic acid, salicylic acid and copper in non-marketable bulbs yield were too small to be significant.

Comparisons among the mean values of 1st order interactions (Table 6) displayed that, the interaction between humic acid × salicylic acid, humic acid × copper and salicylic acid × copper at the highest concentration, significantly, gave the highest mean values of total and marketable bulbs yield, in both seasons. Non-marketable bulbs yield was, significantly, the lowest when the combined treatments of humic acid (0 ppm) × salicylic acid (500 ppm), humic acid (0 and/or 500 ppm) × copper (400 ppm) and salicylic acid (0 ppm) × copper (400 ppm) were foliar sprayed, in both seasons.

The 2nd order interaction among the three factors under study at the highest concentration was pioneer and, significantly, attained the best total and marketable bulbs yield, in both years. The lowest non-marketable bulbs yield was obtained as a result of interactive treatment of humic acid (1000 and/or 1500 ppm) × salicylic acid (0 ppm) × copper (400 ppm), in both seasons (Table 7).

Improving of humic acid, salicylic acid and copper and their interactions, up to the highest concentration, on total, marketable and non-marketable bulbs yield may be discussed on the ground that, application of humic acid capable to regulate hormonal level in plants, increased essential nutrients uptake and stimulate growth root and whole plant(Piccolo *et al.*, 1992 and Nardi *et al*., 1996). Also, salicylic acid application augmented uptake of ions, control stomata functions and gravity sensing and pathogenesis (Alvarez, 2000 and Lucas and Lee, 2004). Moreover, foliar application of copper is important in metabolism of carbohydrate, formation of lignin especially under Egyptian soil conditions.

Table 5: Bulbs yield and its components feddan^{-1} (marketable, non-marketable and total yield) of onion plants as affected by humic acid, salicylic acid and copper concentrations in the two winter seasons of 2012 and 2013.

- Values having the same alphabetical letter (s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D. test at 0.05 level.

Seasons	2012			2013		
Treatments	**Marketable bulbs yield (ton fed^{-1})**	**Non-marketable bulbs yield (ton fed^{-1})**	**Total bulbs yield (ton fed^{-1})**	**Marketable bulbs yield (ton fed^{-1})**	**Non-marketable bulbs yield (tonfed^{-1})**	**Total bulbs yield (ton fed^{-1})**
Humic acid (ppm)						
0	7.53 C*	0.52 B	8.05 D	7.07 D	0.55 A	7.61 D
500	9.50 C	0.68 B	10.19 C	9.67 C	0.60 A	10.26 C
1000	12.22 B	0.92 A	13.14 B	12.64 B	0.73 A	13.37 B
1500	14.28 A	1.06 A	15.34 A	15.11 A	0.81 A	15.93 A
Salicylic acid (ppm)						
0	9.86 C	0.69 B	10.55 C	10.00 C	0.56 A	10.56 C
500	10.75 B	0.82 AB	11.57 B	11.25 B	0.70 A	11.95 B
1000	12.17 A	0.89 A	13.06 A	12.27 A	0.77 A	13.03 A
Copper (ppm)						
0	10.25 B	0.88 A	11.13 B	10.19 B	0.77 A	10.96 B
200	11.13 A	0.83 AB	11.96 A	10.95 B	0.68 A	11.63 B
400	11.40 A	0.69 B	12.10 A	12.38 A	0.57 A	12.95 A

Table 6: Bulbs yield and its components feddan^{-1} (marketable, non-marketable and total yield) of onion plants as affected by the 1st order interaction of humic acid, salicylic acid and copper concentrations in the two winter seasons of 2012 and 2013.

Seasons		2012			2013		
Treatments		Marketable bulbs yield (ton fed^{-1})	Non-marketable bulbs yield (ton fed^{-1})	Total bulbs yield (ton fed^{1})	Marketable bulbs yield (ton fed^{-1})	Non-marketable bulbs yield (ton fed^{-1})	Total bulbs yield (ton fed^{-1})
Humic acid (ppm)	Salicylic acid (ppm)						
	0	5.79 h*	0.58 cd	6.37 f	6.03 e	0.49 b	6.52 f
0	500	7.57 g	0.43 d	7.99 e	7.23 e	0.42 b	7.65 ef
	1000	9.45 def	0.56 cd	10.01 cd	8.045 de	0.76 ab	8.80 de
	0	9.05 f	0.64 cd	9.69 d	9.52 cd	0.57 b	10.09 cd
500	500	9.17 ef	0.73 bcd	9.90 cd	10.05 cd	0.48 b	10.53 cd
	1000	10.30 de	0.67 cd	10.97 cd	9.41 cd	0.75 ab	10.16 cd
	0	10.71 d	0.43 d	11.15 c	10.66 c	0.57 b	11.23 c
1000	500	12.60 c	1.43 a	14.04 b	13.27 b	0.77 ab	14.04 b
	1000	13.22 bc	0.91 bc	14.13 b	13.85 b	0.86 ab	14.70 b
	0	13.89 b	1.10 ab	14.99 b	13.78 b	0.61 ab	14.39 b
1500	500	13.68 bc	0.69 cd	14.37 b	14.45 b	1.13 a	15.58 b
	1000	15.29 a	1.39 a	16.68 a	17.11 a	0.71 ab	17.82 a
Humic acid (ppm)	Copper (ppm)						
	0	7.23 f	0.64 cd	7.87 f	6.51 f	0.64 ab	7.15 g
0	200	7.50 f	0.46 d	7.96 f	6.87 f	0.48 b	7.35 g
	400	7.90 ef	0.46 d	8.37 f	7.92 ef	0.51 ab	8.43 fg
	0	9.01 de	0.92 abc	9.92 e	8.94 e	0.58 ab	9.53 ef
500	200	10.02 cd	0.57 d	10.59 e	8.92 e	0.81 b	9.73 ef
	400	9.49 d	0.56 d	10.05 e	11.12 d	0.40 b	11.52 de
	0	11.00 c	0.91 abc	11.91 d	11.22 d	0.83 ab	12.05 d
1000	200	12.68 b	1.15 a	13.83 bc	12.89 cd	0.63 ab	13.52 cd
	400	12.91 b	0.73 bcd	13.63 c	13.69 bc	0.74 ab	14.43 bc
	0	13.77 ab	1.06 a	14.83 ab	14.07 bc	1.04 a	15.10 abc
1500	200	14.32 a	1.13 a	15.45 a	15.14 ab	0.80 ab	15.94 ab
	400	14.77 a	0.99 ab	15.76 a	16.13 a	0.61 ab	16.75 a
Salicylic acid (ppm)	Copper (ppm)						
	0	8.89 c	0.93 a	9.82 d	10.25 d	0.50 a	6.58 d
0	200	10.35 b	0.61 bcd	10.95 c	9.82 d	0.67 a	10.49 d
	400	10.35 b	0.53 d	10.87 c	9.93 d	0.50 a	10.43 d
	0	10.79 b	0.86 ab	11.65 bc	10.04 d	0.93 a	10.97 d
500	200	10.46 b	1.00 a	11.46 bc	10.76 cd	0.67 a	11.43 cd
	400	11.02 b	0.59 cd	11.61 bc	12.94 ab	0.51 a	13.45 ab
	0	11.08 b	0.85 abc	11.93 b	10.27 d	0.89 a	11.15 d
1000	200	12.59 a	0.87 ab	13.45 a	12.28 bc	0.71 a	12.99 bc
	400	12.85 a	0.96 a	13.81 a	14.26 a	0.71 a	14.96 a

* Values having the same alphabetical letter (s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D. test at 0.05 level.

Table 7. Bulbs yield and its components feddan^{-1} (marketable, non-marketable and total yield) of onion plants as affected by the 2nd interaction of humic acid, salicylic acid and copper concentrations in the two winter seasons of 2012 and 2013.

Season			2012			2013		
Treatments			**Marketable bulbs yield (ton fed^{-1})**	**Non-marketable bulbs yield (ton fed^{-1})**	**Total bulbs yield (tonfed^{-1})**	**Marketable bulbs yield (ton fed^{-1})**	**Non-marketable bulbs yield (ton fed^{-1})**	**Total bulbs yield (tonfed^{-1})**
Humic acid (ppm)	Salicylic acid (ppm)	Copper (ppm)						
0	0	0	3.91 p*	0.96 c-g	4.87 q	6.61 mno	0.47 abc	7.08 op
		200	6.85 mno	0.37 ij	7.21 op	5.50 o	0.55 abc	6.05 p
		400	6.62 no	0.42 hij	7.04 op	6.00 mno	0.44 abc	6.44 p
	500	0	9.74 h-l	0.38 hij	10.12 j-n	5.58 no	0.60 abc	6.18 p
		200	6.23 o	0.46 f-j	6.69 pq	6.96 k-o	0.36 bc	7.32 nop
		400	6.73 no	0.44 g-j	7.17 op	9.15 g-m	0.30 c	9.45 j-p
	1000	0	8.06 l-o	0.58 e-j	8.63 no	7.34 i-o	0.86 abc	8.21 m-p
		200	9.42 jkl	0.54 f-j	9.96 lmn	8.15 h-o	0.53 abc	8.68 k-p
		400	11.60 e-i	0.56 e-j	12.15 g-j	8.95 g-o	0.94 abc	9.88 i-p
500	0	0	8.90 kl	0.79 d-i	9.69 lmn	10.54 e-i	0.59 abc	11.13 g-m
		200	9.59 i-l	0.45 g-j	10.04 k-n	9.77 f-l	0.62 abc	10.38 i-o
		400	8.65 k-n	0.69 e-j	9.35 mn	8.25 h-o	0.49 abc	8.74 k-p
	500	0	8.70 klm	1.22 bcd	9.92 lmn	9.24 g-m	0.68 abc	9.92 i-o
		200	9.37 jkl	0.48 f-j	9.85 lmn	7.98 h-o	0.47 abc	8.45 l-p
		400	9.43 jkl	0.50 f-j	9.92 lmn	12.93 c-f	0.30 c	13.23 d-i
	1000	0	9.42 jkl	0.74 d-j	10.16 i-n	7.05 j-o	0.47 abc	7.52 nop
		200	11.11 f-j	0.78 d-j	11.89 h-k	9.01 g-n	1.35 a	10.36 i-o
		400	10.37 g-k	0.50 f-j	10.87 j-m	12.18 c-g	0.41 bc	12.59 e-j
1000	0	0	9.48 i-l	0.52 f-j	10.00 k-n	10.38 e-k	0.37 bc	10.74 h-n
		200	10.85 g-j	0.52 f-j	11.37 h-k	10.50 e-j	0.55 abc	11.05 g-m
		400	11.82 efg	0.26 j	12.08 hij	11.11 d-h	0.79 abc	11.90 f-l
	500	0	11.87 efg	0.98 c-f	12.85 f-i	12.21 c-g	1.16 abc	13.37 c-i
		200	12.08 d-g	2.42 a	14.50 b-f	13.14 c-f	0.78 abc	13.92 b-h
		400	13.87 bcd	0.90 d-h	14.77 b-e	14.47 bcd	0.35 bc	14.82 b-f
	1000	0	11.64 e-h	1.24 bcd	12.88 e-i	11.07 d-h	0.96 abc	12.04 f-k
		200	15.10 ab	0.51 f-j	15.62 bc	15.03 bc	0.56 abc	15.59 b-e
		400	13.00 cde	0.95 d-g	13.95 c-g	15.04 bc	0.99 abc	16.04 a-d
1500	0	0	13.27 b-e	1.46 bc	14.73 b-f	13.47 bcd	0.59 abc	14.05 b-h
		200	14.10 abc	1.09 cde	15.19 bcd	13.52 b-e	0.94 abc	14.46 b-g
		400	14.30 abc	0.74 d-j	15.04 bcd	14.36 bcd	0.29 c	14.65 b-f
	500	0	12.85 c-f	0.87 d-i	13.71 d-h	13.15 c-f	1.27 ab	14.41 b-g
		200	14.15 abc	0.67 e-j	14.81 bcd	14.98 bc	1.05 abc	16.03 a-e
		400	14.04 abc	0.54 f-j	14.58 b-f	15.22 bc	1.09 abc	16.31 a-d
	1000	0	15.19 ab	0.85 d-i	16.04 ab	15.59 abc	1.25 ab	16.85 abc
		200	14.71 abc	1.64 b	16.35 ab	16.92 ab	0.40 bc	17.32 ab
		400	15.96 a	1.69 b	17.65 a	18.82 a	0.46 abc	19.28 a

* Values having the same alphabetical letter (s) in common, within a particular group of means in each character, do not significantly differ, using Revised L.S.D. test at 0.05 level.

Therefore, absorption and uptake of nutrients, photosynthetic pigments and plant growth are activated with an eventual improves of total, marketable and non-marketable bulbs yield.

Conclusively, foliar application of 1500 ppm humic acid + 1000 ppm salicylic acid + 400 ppm copper was the most efficient combination treatment which gave the best results for vegetative growth and bulbs yield and its components of onion plants.

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الملخص العربى

تأثير الرش الورقي باستخدام حمض الهيوميك وحمض السلسليك والنحاس علي النمو الخضري والمحصول ومكوناته لنباتات البصل صنف "جيزة ٢٠"

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اجريت تجربتان حقليتان خلال موسمي شتاء ٢٠١٢ و٢٠١٣، لدراسة تأثير الرش بكل من حمض الهيوميك (صفر، ٥٠٠، ١٠٠٠، ١٥٠٠ جزء في المليون)، وحمض السلسليك(صفر، ٥٠٠، ١٠٠٠ جزء في المليون) والنحاس(صفر، ٢٠٠، ٤٠٠ جزء في المليون) بالاضافه إلي التداخل بينهم علي صفات النمو الخضري والمحصول ومكوناته لنباتات البصل صنف جيزة ٢٠. تم اجراء التجربة في مزرعة كلية الزراعة(في أبيس)– جامعة الاسكندرية، باستخدام نظام الري السطحي.

أظهرت النتائج أن الرش بالتركيزات المختلفة لكل من الهيوميكوالسلسليك والنحاس– كل علي حدة– أدي إلي زيادة معنوية في عدد الأوراق وإرتفاع النباتات مقارنة بالكنترول في كلا الموسمين. كما أظهرت زيادة معنوية ملحوظة في كل من المحصول الكلي للأبصال والأبصال القابلة للتسويق عند الرش باستخدام التركيز المرتفع لكل من حمض الهيوميك(١٥٠٠ جزء في المليون) وحمض السلسليك(١٠٠٠ جزء في المليون) والنحاس(٤٠٠ جزء في المليون).

وفقاً لنتائج هذه الدراسة، فإن الرش الورقي باستخدام التركيزات المرتفعة من الهيوميك والسلسليك والنحاس (١٥٠٠ + ١٠٠٠ + ٤٠٠ جزء في المليون على التوالي) كان التداخل الأكثر فاعلية حيث أظهر أفضل صفات للنمو الخضري بالاضافه إلي المحصول ومكوناته لنباتات البصل صنف جيزة ٢٠.