Effect of phosphorus and copper foliar spraying on the yield, mineral content and quality of onion plants

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ABSTRACT

Two field experiments were carried out during the winter seasons of 2004 and 2005 at Kafr El-Akram village, Quessna region, Menoufiya governorate to study the effect of different levels of P_2O_5 and Cu added by foliar spraying, singly or in dual combinations on the growth and some quantitative and qualitative characteristics of onion bulbs (Giza 20 cv.).Data obtained show that :1- Spraying the onion plants with P or Cu enhanced all growth characters, yield and its components, quality and mineral contents of onion bulbs. The highest values for all previous parameters were recorded with foliar addition of 2% P_2O_5 and 0.03% Cu simultaneously.2- Raising phosphorus foliar application up to 2% P_2O_5 significantly increased both macro-and micronutrients contents in onion bulbs. On the other hand, foliar addition of Cu raised NPK and Cu contents but there were negative relationships between the addition of Cu and the uptake of Fe, Zn and Mn.3- Foliar spraying with 2% P_2O_5 or 0.03% Cu mostly induced significant decreases in the total weight loss of onion bulbs during the five monthes of investigation. As a result, the storability value of these bulbs increases. So, it could be concluded that spraying the onion plants twice, after 60 and 75 days from transplanting with 2% P_2O_5 and 0.03% Cu together elevates the efficiency of the added fertilizers which finally improves yield, quality, mineral content and storability value of onion bulbs.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important vegetable crops in Egypt for local consumption and export. Fertilization is considered one of the main practices that increase the productivity and improve the quality of onion bulbs. In this concern, technique of foliar spraying with different nutrients offers great opportunities for raising their effectiveness, saving cost and reducing environmental pollution, while assuring high yields.

P-fertilization plays an indispensable role in cell division and development of meristematic tissues, stimulates photosynthesis, respiration, energy and nucleotide transfer reactions and hastens the plant maturity (Abu-Grab and Kandeel, 1992 and Marschner, 1998). For onion crop, Henriksen (1987) found that supplying onion plants with P-fertilizer gave rapid growth, high yield and good bulb maturity. P-fertilization also markedly increased the number of leaves as well as length, diameter, fresh and dry weights of onion bulbs.

Although micronutrients are needed in relatively very small quantities for adequate plant growth and production, their deficiencies induce a great disturbance in the different physiological and metabolic processes inside the plant. Copper is considered an essential micronutrient for plant growth as a component of the phenolase, lactase and ascorbic acid oxidase enzymes (Brown and Clark, 1977). Moreover, most of Cu functions are based on the participation of enzymatically bound Cu in redox reactions. Cu also affects the formation and chemical composition of cell wall (Marschner, 1998). Furthermore, El-Aref and Hamada (1998) showed that Cu stress reduced some enzymatic bonds of alcohol dehydrogenase and esterase and the content of soluble carbohydrates during the vegetative growth.

Therefore, the current investigation aimed to evaluate the impact of foliar spraying with different levels of P and Cu on the growth and yield as well as the quality, mineral content and storability of onion bulbs.

MATERIALS AND METHODS

Two field experiments were performed at Kafr El-Akram village, Quessna region, Menoufiya governorate during the two successive winter seasons of 2004 and 2005. Some physical and chemical properties of the two investigated soil locations are determined according to Black (1965) and Page *et al.* (1982), respectively and presented in Table (1). Effect of different foliarly added levels of P and Cu on the growth and some quantitative and qualitative characteristics of onion bulbs was the main target of the present investigation.

Table (1): Mechanical and chemical characteristics of the studied soils during the two investigated seasons.

a) Mechanical analysis:

Season	Total $CaCO_3$ (%)	Organic matter (%)	Particle size distribution (%)				Texture class
			Coarse sand	Fine sand	Silt	Clay	
2003/04	2.36	1.60	0.7	15.1	34.8	49.4	Clayey
2004/05	2.29	2.22	1.4	13.5	37.7	47.4	Clayey

b) Chemical analysis:

Season	pH (1:2.5 Soil Susp.)	EC (dSm^{-1})	Soluble ions (m.e./100 g soil)								Available nutrients (μgg^{-1})			
			Cations				Anions				N	P	K	Cu
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	CO_3^{2-}				
2003/04	7.80	1.10	3.30	2.85	4.68	0.31	1.87	5.37	3.90	-	77.30	11.24	238.0	0.83
2004/05	7.67	0.91	2.73	2.36	3.87	0.26	1.55	4.44	3.23	-	83.74	13.01	272.4	1.24

Onion seeds (Giza 20 cv.) were sown in the nursery on October 15th and 20th while transplanting took place on January 1st and 5th for the first and second seasons, respectively. The design of the two experiments was split plots with four replicates, where P-levels were randomly assigned in the main plots, while the treatments of Cu were randomly arranged in the sub plots. The experimental plot area was 10.5 m^2 (3.5 m in length and 3.0 m in width). Phosphorus and copper were used in the liquid forms at levels of 0, 1 and 2% P_2O_5 and 0.00, 0.01, 0.02 and 0.03% Cu. Different spraying treatments were performed twice, after 60 and 75 days from transplanting. The other usual agronomic processes of onion plants were practiced.

At harvesting, a sample of fifteen plants were randomly taken from every treatment to estimate the weight of bulbs (g/plant), bulb and neck diameter (cm) and total onion yield (ton/fed). Total soluble solids (T.S.S.) in juice samples were also determined. N, P, K, Fe, Zn, Mn and Cu contents in bulbs were determined on the basis of dry matter yield according to Chapman and Pratt (1978).

From each plot, some bulbs were weighted and placed in common burlap bags. Then, they were kept under room temperature. The total weight loss percentage was calculated and recorded monthly until the fifth month after harvesting.

Results of the two investigated seasons gave nearly the same trends. So, data attained for all studied parameters was statistically analyzed using the combined analysis of the two growing seasons, according to Gomez and Gomez (1984). The differences among means were tested using the least significant difference (L.S.D.) at the 5% level of significance.

RESULTS AND DISCUSSION

1-Bulbs yield and its components:

Data presented in Table (2) show that raising the spraying level of phosphorus or copper markedly increased onion yield and its components, namely bulb and neck diameter (cm), bulb weight (g/plant) and total bulbs yield (ton/fed). For all abovementioned parameters, the highest values were observed for foliar spraying of 2% P_2O_5 and 0.03% Cu, simultaneously, compared with the other treatments and control one. Total soluble solids percentages (T.S.S.%) showed also the same previous trend. This mean that foliar application of P_2O_5 and Cu together enhances both onion yield and its components rather than their application singly and each nutrient activates the action of the other. Moreover, the stimulative impacts of P and Cu foliar spraying on onion yield may be due to the great importance of these nutrients in the physiological processes induced within the plant and their defected amounts in the studied soils (Table, 1). In this respect,

Marschner (1998) indicated that in plants grown in P-deficient soils, foliar application of P after anthesis can delay senescence of the leaves and thus, increase the leaves area duration. Yet, P is recognized as a constituent of important organic and energy storage and transfer compounds necessary for metabolic processes. P also has a fundmental role in raising the efficiency of plants to photosynthetic metabolites (Marschner, 1998), activating large number of enzymatic reactions depending on phosphorylation (Nassar *et al.* 2005) and increasing the plant meristematic tissues and root development. These results are in agreement with those obtained by Negm *et al.* (1992) on safflower and Nassar *et al.* (2005) on faba bean.

Table (2): Effect of phosporus and copper foliar spraying on the yield of onion bulbs, its component and T.S.S.% (Combined analysis of 2003/2004 and 2004/2005 growing seasons).

Treatments		Bulb diameter (cm)	Neck diameter (cm)	Bulb weight (g/plant)	Total yield (ton/fed)	T.S.S. (%)
P_2O_5 levels (%)	Cu levels (%)					
	0.00	4.38	1.27	55.81	17.39	13.69
0	0.01	5.20	1.63	60.20	18.32	13.85
	0.02	5.27	1.69	62.94	20.59	14.10
	0.03	5.79	1.76	68.79	21.43	14.00
Mean		5.16	1.59	61.94	19.43	13.91
	0.00	6.25	1.97	79.81	19.09	13.40
1	0.01	6.68	2.02	82.42	19.85	13.77
	0.02	6.99	2.06	82.55	21.99	13.97
	0.03	7.52	2.17	83.80	23.39	13.98
Mean		6.86	2.06	82.15	21.08	13.78
	0.00	7.63	2.06	91.28	20.51	13.48
2	0.01	8.03	2.45	94.11	22.41	14.16
	0.02	8.06	2.51	96.38	23.74	14.39
	0.03	8.74	2.96	100.56	24.37	14.47
Mean		8.11	2.50	95.58	22.76	14.12
Means of Cu levels:						
0.00		6.09	1.77	75.63	19.00	13.52
0.01		6.64	2.03	78.91	20.19	13.93
0.02		6.78	2.09	80.62	22.11	14.15
0.03		7.35	2.30	84.38	23.06	14.15
L.S.D. at 5% for :						
P_2O_5		0.06	0.05	0.55	0.87	0.03
Cu		0.05	0.06	0.60	0.46	0.03
P_2O_5 x Cu		0.07	0.1	1.10	0.42	0.06

On the other hand, the stimulative effect of Cu spraying could be explained on the basis that Cu is considered a component of various enzymes. Cu functions are mainly related to its enzymatic bond in redox reactions (Mengel and Kirkby, 1987). The rate of photosynthesis can also be related to the role of Cu in chloroplast. Furthermore, Cu has a marked effect on the formation and chemical composition of cell wall (Marschner, 1998). Data presented herein are in harmony with those attained by Abd El-Fattah and Sorial (1998); Allam (1999) and El-Shafie and El-Gamaily (2002).

2- Macro- and micronutrients content:

Data in Table (3) show the effect of Cu foliar application levels under the three levels of P_2O_5 on both macro- (N, P and K) and micronutrients (Fe, Zn, Mn and Cu) contents in onion bulbs. NPK contents in onion bulbs were significantly enhanced by foliar addition of either P or Cu and the maximum values were recorded when the plants were sprayed with a mixture of 2% P_2O_5 and 0.03% Cu together. At this treatment, the relative increases over the control were 155.9, 172.2 and 91.8% for N, P and K contents, respectively. Bulbs micronutrients contents took trends similar to those attained with macronutrients as affected by P foliar spraying. The positive effect of P on the contents of both macro- and micronutrients in onion bulbs may be due to:

1- The close relationship between K-uptake and ATP-ase activity which increases by P application (Marschner, 1998).
2- Contribution of macro- and micronutrients in vital plant processes such as protein and carbohydrate construction, cell division and expansion, protein and nucleic acids synthesis as well as respiration and photosynthesis (Dwivedi and Chaubey, 1995).
3- Contribution of P and the investigated micronutrients (Fe, Zn, Mn and Cu) in assimilation processes of organic and inorganic phosphatic compounds, i.e. phosphoproteins, phospholipids and phosphocarbohydrates (Nassar *et al.* 2005).
4- Increasing the corresponding values of onion bulbs yield as indicated in Table (2).

Moreover, the favourable impact of Cu on macronutrients contents of onion bulbs may be due to its effect to form vegetative plant material, which in turn increase the uptake of NPK by plants. Similar results were attained by Negm (1998) on wheat, El-Shafie and El-Gamaily (2002) on onion and Nassar *et al.* (2005) on faba bean. Concerning the effect of Cu spraying on the content of micronutrients in onion bulbs, data shown in Table (3) reveal that Fe, Mn and Zn contents in onion bulbs were significantly decreased by raising the level of Cu up to 0.03%. These depressing effects may be

attributed to the negative influence of excessive Cu on the availability, absorption, translocation and utilization of the other investigated micronutrients. Cu content showed an opposite trend where it was generally high and proportional to its concentration in the spraying solution.

Table (3): Effect of phosporus and copper foliar spraying on macro- and micronutrients contents of onion bulbs.

Treatments		Macronutrients (kg/fed)			Micronutrients (g/fed)			
P_2O_5 levels (%)	Cu levels (%)	Nitrogen	Phosphorus	Potassium	Iron	Zinc	Manganese	Copper
	0.00	32.2	5.62	20.7	448.4	115.3	39.8	11.8
0	0.01	38.6	6.60	23.2	446.3	104.9	39.5	16.8
	0.02	47.2	7.72	26.8	294.7	89.0	33.9	21.6
	0.03	53.4	8.64	31.6	263.5	64.9	29.8	24.1
Mean		42.8	7.15	25.6	363.2	93.5	35.8	18.6
	0.00	37.7	8.43	22.7	463.6	123.1	41.1	13.8
1	0.01	45.9	9.36	25.3	449.8	108.6	39.6	17.9
	0.02	56.5	10.92	29.1	395.1	89.8	38.8	22.0
	0.03	66.9	12.61	34.3	266.4	81.9	31.6	25.4
Mean		51.8	10.33	27.9	393.7	100.8	37.8	19.7
	0.00	62.0	11.81	25.3	475.7	121.0	41.7	15.7
2	0.01	69.8	13.38	30.1	453.3	108.9	39.6	18.0
	0.02	76.1	14.50	32.7	417.6	96.2	38.7	22.7
	0.03	82.4	15.30	39.7	292.4	85.1	32.9	25.8
Mean		72.6	13.75	32.0	409.8	102.8	38.2	20.5
Means of Cu levels:								
0.00		44.0	8.62	22.9	462.6	119.8	40.9	13.8
0.01		51.4	9.78	26.2	449.8	107.5	39.6	17.6
0.02		59.9	11.05	29.5	369.2	91.7	37.1	22.1
0.03		67.6	12.18	35.2	274.1	77.3	31.5	25.1
L.S.D. at 5% for :								
P_2O_5		1.9	0.3	1.2	11.4	2.5	0.7	0.8
Cu		1.1	0.19	0.6	6.9	2.8	0.9	0.6
P_2O_5 x Cu		1.9	0.25	1.1	11.8	4.7	1.5	1.0

3-Storability:

The effect of different levels of P and Cu as well as their combinations on the total weight loss percentage of onion bulbs are demonstrated in Table (4). It's obvious that P foliar spraying significantly reduced weight loss of bulbs stored at room temperature condition after all investigated periods, except that observed after a month, under the addition of 1% P_2O_5 where there was non-significant difference between it and 0% P_2O_5 . The total weight loss percentages of onion bulbs induced by 2% P_2O_5 foliar spraying compared with the plants which didn't receive phosphatic spraying were 12.2, 7.4, 4.6, 5.9 and 4.9% after 1st , 2nd, 3rd, 4th and 5th monthes. These

decreases in bulbs weight loss may be interpreted on the basis that bulbs produced from plants sprayed with 2% P_2O_5 achieved the highest dry matter yield (Table, 2) compared with those produced from the other levels. These results are in accordance with those attained by Petkov *et al.* (1976).

Table (4): Effect of phosporus and copper foliar spraying on the total weight loss percentage of onion bulbs during different storage periods (Combined analysis of 2003/2004 and 2004/2005 growing seasons).

Treatments		After a month	After two months	After three months	After four months	After five months
P_2O_5 levels (%)	Cu levels (%)					
	0.00	2.50	5.05	8.49	12.95	15.63
0	0.01	2.48	4.85	8.37	12.89	15.53
	0.02	2.45	4.76	7.82	12.25	14.69
	0.03	2.42	4.72	7.73	11.99	14.55
Mean		2.46	4.84	8.10	12.52	15.10
	0.00	2.42	4.67	8.24	12.72	15.34
1	0.01	2.37	4.69	8.20	12.50	15.14
	0.02	2.32	4.62	7.45	11.75	14.39
	0.03	2.24	4.59	7.33	11.38	14.30
Mean		2.34	4.64	7.81	12.09	14.79
	0.00	2.35	4.61	8.25	12.65	14.85
2	0.01	2.15	4.55	8.16	11.67	14.75
	0.02	2.11	4.42	7.23	11.47	13.96
	0.03	2.04	4.33	7.29	11.34	13.87
Mean		2.16	4.48	7.73	11.78	14.36
Means of Cu levels:						
0.00		2.42	4.78	8.33	12.77	15.27
0.01		2.33	4.70	8.24	12.36	15.14
0.02		2.29	4.60	7.50	11.82	14.35
0.03		2.24	4.55	7.45	11.57	14.24
L.S.D. at 5% for :						
P_2O_5		0.20	0.15	0.17	0.09	0.08
Cu		0.09	0.12	0.15	0.11	0.08
P_2O_5 x Cu		N.S	N.S	N.S	0.19	N.S

Also, spraying the onion plants with Cu up to 0.03% significantly decreased the weight loss of onion bulbs, in most cases (Table, 4). This may be due to Cu vital role in the synthesis and activity of phenols, lignin, polyphenol oxidase and peroxidase which lead to disease resistance (Badawi *et al.* 1986 and El-Shafie and El-Gamaily, 2002).

Dual foliar additions of both P_2O_5 and Cu caused non-significant impacts on the total weight loss percentage of onion bulbs during all storage periods, except the fourth one.

Finally, it could be concluded that spraying the onion plants with 2% P_2O_5 and 0.03% Cu together, twice, after 60 and 75 days from transplanting, raises the efficiency of the added fertilizers and improves the yield and its characteristics, quality, nutritive content and storability of onion bulbs.

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الملخص العربى

تأثير الرش الورقى بعنصرى الفوسفور والنحاس على المحصول والمحتوى الغذائى وجودة نباتات البصل

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أجريت تجربتان حقليتان بقرية كفر الأكرم مركز قويسنا محافظة المنوفية خلال موسمى الزراعة الشتويين لعامى 2004 ، 2005 لدراسة تأثير الرش بعنصرى الفوسفور والنحاس على النمو والمحصول وصفاته والمحتوى الغذائى وجودة نباتات البصل (صنف جيزة 20) . وقد أشارت النتائج المتحصل عليها إلى الآتى :[1] أدى الرش الورقى لنباتات البصل بمحلول الفوسفات أو النحاس الى تحسين جميع صفات النمو ومحصول البصل ومكوناته وجودته.. وقد سجلت أعلى القيم لجميع المقاييس السابقة عند رش النباتات بتركيز 2% فوسفات + 0.03% نحاس .[2] أدى الرش الورقى بالفوسفور حتى تركيز 2% فوسفات الى الزيادة المعنوية لمحتوى البصل من العناصر الكبرى والصغرى فى حين حققت الإضافة الورقية للنحاس زيادة محتواه ومحتوى البصل من العناصر الكبرى بينما أدت زيادة تركيزه فى محلول الرش إلى إنخفاض محتوى البصل من الحديد والزنك والمنجنيز .[3] الرش الورقى لنباتات البصل بمحلول 2% فوسفات أو 0.03% نحاس خفض معنوياً من الفقد الحادث فى أوزان الأبصال عند تخزينها مما يرفع من قيمتها التخزينية .ومن ثم يمكن القول بأن الرش مرتان (بعد 60 ، 75 يوم من الشتل) يزيد من كفاءة الأسمدة المضافة ويحسن من محصول البصل ومكوناته وجودته ومحتواه الغذائى ويرفع من قيمته التخزينية .