Raising of the quantity and quality of onion crop by foliar application of phosphorus and sulphur

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ABSTRACT

Two field trials were conducted at Kafr El-Akram village, Quessna region, Menoufiya governorate during two successive winter seasons of 2004 and 2005. Response of onion bulbs yield, its quality, mineral content and storability to different levels of applied P_2O_5 and S foliar spraying singly or in dual combination was the main target of the present investigation. Data obtained showed that onion bulbs quantitative and qualitative characteristics significantly enhanced as increasing the foliar application level of P_2O_5 and S up to 2% and 0.2%, respectively. Spraying the onion plants with 2% P_2O_5 and 0.2% S simultaneously achieved the superiority impact compared with the other treatments.

INTRODUCTION

Egyptian onion (*Allium cepa* L.) is considered the most important cash crop after rice. Increasing its yield with consequent economic return is the major goal of all farmers. Moreover, the successful fertilization strategy aims to supply the growing crop with its need of nutrients at suitable time, place and dose. So, foliar fertilization with soluble salts or chelates of both macro-and micronutrients is more efficient and economic than soil fertilization, especially for vegetable crops. Alexander (1986) summarized the advantages of foliar spraying in low application rate, uniform distribution, quick and immediate response and solve of soil fertilization problems.

Numerous studies show that phosphorus and sulphur nutrition affect onion growth, yield, chemical constituents and storability characteristics. In this concern. Pankov and Pavlova (1985) and Abu-Grab and Kandeel (1992) also stated that P-deficiency limit onion growth and productivity. Chemical constituents of onion as affected by P-application were also studied by many investigators (Abu-Grab and Kandeel, 1992 and Nassar *et al.* 2005). An explanation of the role of P in plant was mentioned by Pankov and Pavlova (1985), Shaheen *et al.* (1988) and Marschner (1998) who concluded that P as a constituent of ATP, is considered a part of molecular structure of several vitally important compounds, notably nuclic acids and carbohydrate construction. Moreover, P plays indispensable role in photosynthetic and respiration reactions. It is also necessary for cell division and development of meristematic tissues.

Sulphur as a macronutrient has a favourable effect on onion and other crops (Singh *et al* 1998; El-Shafie and El-Gamaily, 2002 and Fathi *et al.*

2003). This in fact due to that S is essential for the synthesis of certain amino acids and vitamins. S is also presented in some coenzymes including biotin, thiamin and coenzyme A, which are essential for metabolism (Russell, 1988 and Mohammed and Kandeel, 1998).

Therefore, the present study was done to investigate the impact of different levels of phosphorus, sulphur and their dual combinations on the yield and its components, some quality parameters (total soluble solids, pungency and storability) and minerals content of onion bulbs.

MATERIALS AND METHODS

Two field experiments were conducted at Kafr El-Akram village, Quessna region, Menoufiya governorate during 2003/2004 and 2004/2005 winter growing seasons. Representative surface soil samples (0-30 cm depth) were taken before performance of the experiments to determine their physical characteristics (Black, 1965) and chemical ones (Page *et al.*, 1982), as shown in Table (1).

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	2.28	1.66	0.6	12.1	35.2	52.1	Clayey
2004/05	2.25	2.31	1.3	13.0	34.8	50.9	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
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	CO_3^{2-}			
2003/04	7.75	1.05	3.2	2.8	4.5	0.25	1.75	5.13	3.87	-	70.8	10.5	225.1
2004/05	7.60	0.89	2.65	2.3	3.8	0.30	1.50	4.25	3.30	-	81.5	12.7	226.4

Seeds of onion (*Allium cepa* L.) cv. Giza 20 were sown in the nursery on the 13th and 18th of October for the first and second seasons, respectively. After 60 days, uniform transplants were planted at 10 cm apart on both sides of the ridges. The experimental plot area was 10.5 m^2 which included 5 rows, each of 3.5 m in length and 60 cm in width.

Each experiment involved twelve treatments i.e., three levels of phosphorus (0, 1 and 2% P_2O_5) and four levels of sulphur (0.0, 0.1 0.15 and 0.2%) which were used in the liquid forms and sprayed twice, after 60 and 75 days from transplanting (400 L/fed).

The experimental design was split plot in randomized complete blocks, with four replicates. Phosphorus treatments were arranged as the main plots, whereas sulphur levels were randomly assigned in sub plots. The other usual cultural processes of onion plants were practiced.

At the harvesting time (150 days from transplanting), a random sample of 20 bulbs were chosen from every plot to determine the average of bulb and neck diameter (cm), bulb weight (g/plant) and the percentage of dry matter content. Bulbs yield of each plot (kg) was weighted, then it was estimated as ton/fed. The total soluble solids (T.S.S.) in juice samples were also determined using carlzeiss referactometer. Pyruvic acid as indicator for pungency was colorimetrically determined at 420 nm as described by Schwimmer and Weston (1961). N, P and K contents in onion bulbs were determined on the basis of dry matter yield according to Chapman and Rratt (1978).

Storability evaluation: A sample of 5 kg cured uniform bulbs was taken from each plot and packed in conventional mesh bags. Bulbs were stored at room temperature (20-30°C and 60-70% RH) for 5 monthes. Monthly, bulbs were inspected, the rotted and sprouted bulbs were discarded and the remaining ones were weighted. Weight loss of bulbs was estimated as percentage of the original weight.

The obtained results were statistically analyzed using the combined analysis of the two growing seasons according to Gomez and Gomez (1984). L.S.D. test at 5% level of significance was used for comparison between the means of different treatments.

RESULTS

Data attained herein show the effect of foliarly added P- or/and S-levels on the yield and its components, some quality characteristics and minerals contents of onion bulbs.

I-Effect on onion bulbs yield and its components:

Data shown in Table (2) reveal that components of onion bulbs yield investigated herein i.e. bulb and neck diameter (cm) and bulb weight (g/plant) as well as total onion bulbs yield (ton/fed) were significantly enhanced as raising the levels of P_2O_5 and S foliar spraying up to 2 and 0.2%, respectively. The relative increases due to 2% P_2O_5 spraying compared with the untreated treatment were 41.4, 21.0, 80.9 and 13.8%, for the bulb diameter, neck diameter, bulb weight/ plant and total bulbs yield/ fed. Whereas, the corresponding increases induced by foliar addition of 0.2% S were 14.5, 10.4, 29.9 and 6.9%. This mean that foliar application of P is more effective on onion yield and its components than S foliar addition. On the other hand, all parameters mentioned before were non-

significantly affected by foliar spraying of both P and S simultaneously. This mean that the action of each factor was independent of the other.

Table (2): Effect of phosphorus and sulphur foliar spraying on onion bulbs yield and its components (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)
P_2O_5 levels (%)	S levels (%)				
	0.0	5.38	2.10	55.82	16.84
0	0.1	6.09	2.29	58.03	18.25
	0.15	6.13	2.37	59.96	18.51
	0.2	6.42	2.41	62.72	18.58
Mean		6.01	2.29	59.13	18.04
	0.0	6.75	2.49	63.76	19.17
1	0.1	7.05	2.52	67.04	19.07
	0.15	7.12	2.63	71.67	19.59
	0.2	7.55	2.65	79.68	20.11
Mean		7.12	2.58	70.54	19.49
	0.0	8.12	2.62	87.24	19.80
2	0.1	8.31	2.76	99.51	20.48
	0.15	8.34	2.80	114.84	20.86
	0.2	9.21	2.88	126.18	20.95
Mean		8.50	2.77	106.94	20.53
Means of S levels:					
0.0		6.75	2.40	68.94	18.60
0.1		7.15	2.53	74.86	19.27
0.15		7.19	2.60	82.16	19.65
0.2		7.73	2.65	89.52	19.88
L.S.D. at 5% for :					
P_2O_5		0.11	0.15	0.26	0.70
S		0.08	0.13	0.06	0.44
P_2O_5 x S		N.S	N.S	N.S	N.S

II-Effect on some quality parameters of onion bulbs:

1-Effect on total soluble solids (T.S.S.) and pungency:

Total soluble solids (T.S.S.) in onion bulbs were markedly increased by foliar spraying of P, S and their dual combinations, Table (3). In this connection, the highest values were obtained when foliar application of 2%

P_2O_5 and 0.2% S was performed simultaneously. Pungency values after the first and second months took also the same previous trend with the addition of P_2O_5 and S singly or in dual combination.

Table (3): Effect of phosphorus and sulphur foliar spraying on some quality characteristics of onion bulbs (Combined analysis of 2003/2004 and 2004/2005 growing seasons).

Treatments		T.S.S	Pungency		Weight loss (%)				
P_2O_5 levels (%)	S levels (%)		1st month	2nd month	After a month	After two months	After three months	After four months	After five months
0	0.0	10.41	0.166	0.241	2.34	4.29	8.61	13.22	15.92
	0.1	11.53	0.207	0.263	2.34	4.22	8.53	13.14	15.95
	0.15	11.70	0.228	0.291	2.50	4.17	8.49	13.07	15.80
	0.2	12.70	0.233	0.298	2.39	4.12	8.43	12.91	15.71
Mean		11.59	0.209	0.274	2.39	4.20	8.52	13.09	15.85
1	0.0	11.65	0.185	0.246	2.39	4.09	7.92	12.06	14.66
	0.1	12.94	0.195	0.270	2.34	4.04	7.87	11.94	14.57
	0.15	13.00	0.230	0.297	2.33	3.99	7.71	11.79	14.50
	0.2	13.02	0.247	0.307	2.29	3.97	7.64	11.54	14.39
Mean		12.65	0.214	0.280	2.34	4.02	7.79	11.83	14.53
2	0.0	11.75	0.159	0.242	2.31	3.95	7.64	11.67	14.35
	0.1	12.86	0.198	0.283	2.27	3.88	7.56	11.25	14.17
	0.15	13.01	0.250	0.320	2.26	3.85	7.48	11.00	14.01
	0.2	12.92	0.267	0.325	2.20	3.80	7.37	10.93	13.83
Mean		12.64	0.219	0.293	2.26	3.87	7.51	11.21	14.09
Means of S levels:									
0.0		11.27	0.170	0.243	2.35	4.11	8.06	12.31	14.98
0.1		12.45	0.200	0.272	2.32	4.05	7.99	12.11	14.90
0.15		12.57	0.236	0.303	2.37	4.00	7.88	11.96	14.77
0.2		12.88	0.249	0.310	2.30	3.96	7.81	11.79	14.64
L.S.D. at 5% for :									
P_2O_5		0.02	0.005	0.013	0.11	0.12	0.18	0.10	0.11
S		0.03	0.006	0.009	0.08	0.11	0.12	0.12	0.08
P_2O_5 x S		0.05	0.01	N.S	N.S	N.S	N.S	0.20	N.S

2-Effect on storability:

The effect of different levels of P and S foliar spraying on bulb weight loss percentage are demonstrated in Table (3). Generally, single treatments of P_2O_5 and S, significantly reduced weight loss percentage of bulbs stored under room temperature condition, along all investigated periods, except that detected after a month in case of the addition of 1% P_2O_5 , where there was non-significant difference between it and the

untreated treatment. The relative decreases in total weight loss percentage of onion bulbs induced by 2% P_2O_5 compared with 0% P_2O_5 were 5.4, 7.9, 11.9, 14.4 and 11.1%, after 1st , 2nd , 3rd , 4th and 5th months. While, the corresponding decreases observed for 0.2% S spraying were 2.1, 3.6, 3.1, 4.2 and 2.3%. On the other hand, bulb weight loss percentage didn't significantly respond to the dual application of P_2O_5 and S, except the observation after the fourth month.

III- Effect on minerals contents of onion bulbs:

Data shown in Table (4) elucidate that spraying of the onion plants with P or/and S significantly increased N, P and K contents in onion bulbs. The maximum values were achieved in case of foliar addition of 2% P_2O_5 and 0.2% S simultaneously. At this treatment, the relative increases compared with the untreated plants(didn't receive P or S)were 60.4,119.8 and 152.6% for N, P and K contents, respectively. Moreover, N-content in onion bulbs was non-significantly promoted by the dual application of both P and S.

Table (4): Effect of phosphorus and sulphur foliar spraying on mineral contents of onion bulbs, kg/fed (Combined analysis of 2003/2004 and 2004/2005 growing seasons).

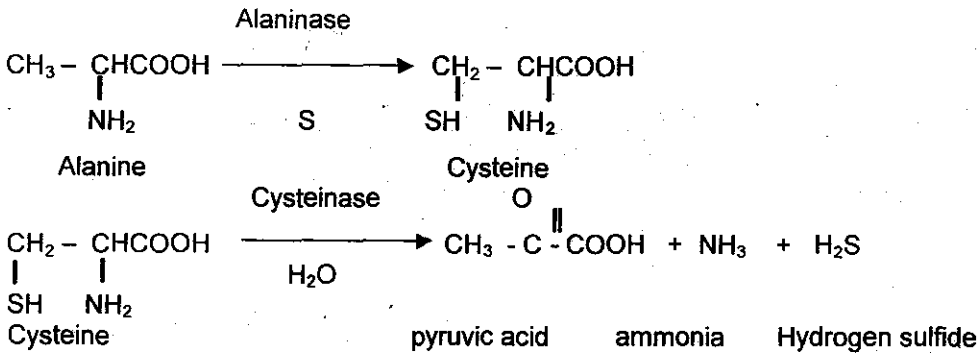
Treatments		N	P	K
P_2O_5 levels (%)	S levels (%)			
	0.0	51.3	6.40	13.3
0	0.1	58.0	8.71	15.1
	0.15	60.4	10.35	17.7
	0.2	62.3	10.41	18.4
Mean		58.0	8.97	16.1
	0.0	65.4	11.58	16.9
1	0.1	66.7	11.99	19.1
	0.15	71.6	12.60	33.3
	0.2	77.3	12.96	34.2
Mean		70.3	12.28	25.9
	0.0	77.0	13.25	31.2
2	0.1	80.8	13.85	32.2
	0.15	85.0	14.11	35.4
	0.2	86.3	15.08	35.8
Mean		82.3	14.07	33.6
Means of S levels:				
0.0		64.6	10.41	20.5
0.1		68.5	11.51	22.2
0.15		72.3	12.36	28.8
0.2		75.3	12.82	29.5
L.S.D. at 5% for :				
P_2O_5		5.7	0.53	1.1
S		1.9	0.20	0.9
P_2O_5 x S		N.S	0.34	1.6

DISCUSSION AND CONCLUSION:

From the abovementioned results, it could be threw more light on the following important view points:

I- Foliar spraying of onion plants with phosphorus or sulphur has significant impacts on its yield and yield components. P stimulative effect may be due to its fundamental role in raising the efficiency of plants to photosynthetic metabolic (Marschner, 1998), activating large number of enzymatic reactions depending on phosphorylation (Mohammed, 1998 and Nassar *et al.* 2005) and increasing the plant meristematic tissues which take much of P in the early stages. As a result, root development as well as macro-and micronutrients uptake by the plants were increased producing increases in plant quantity and quality (El-Koumy *et al.* 1993). On the other hand, the promoting influence of S on the yield of onion could be explained on the basis that S lowers the pH inside the plant and thereby enhances the metabolic activities within plant. S is also required with greater supplies for onion and garlic than other crops (Schultz *et al.* 1966). Likewise, S is necessary for synthesis of certain amino acids, vitamins, enzymes and hormones essential for protein elaboration and the formation of chlorophyll and certain disulphide linkages associated with structural characteristics of plant protoplasm (Marschner, 1998). Hence, S helps to have a good vegetative growth leading to have a high yield (Tisdale and Nelson, 1985 and El-Shafie and El-Gamaily, 2002).

II- Quality characteristics of onion bulbs namely total soluble solids (T.S.S.) and pungency were improved by the foliar addition of either P or S. This may be due to that P encourages much more metabolites to be stored in bulbs as storage organs. S also enhances the photosynthesate accumulation in onion bulbs. These results are in accordance with those obtained by Khalaf and Taha (1988) on garlic and Randle and Bussard (1993) on onion. Since pyruvic acid is considered an indicator of onion odour strength, i.e. pungency. S affects the pungency level through its effect on the concentration of pyruvic acid formed as the following equations:



III- NPK contents in onion bulbs were significantly enhanced by P and S foliar spraying. P promoting effect may be due to one or more of the following reasons:

1. Contribution of N, P and K in vital plant processes such as protein and carbohydrate construction, cell division and expansion, respiration and photosynthesis (Dwivedi and Chaubey, 1995).
2. P encourages the plant to absorb more N to keep the balance between them within the plant. P also increases photosynthesis and activity of succinate, dehydrogenase, nitrogenase and nitrate reductase enzymes necessary for accumulation of amino acids and proteins (Bethlenfalvay *et al.* 1997 and Abd El-Lateef *et al.* 1998).
3. The close relationship between K-content and ATP-ase activity which increases by P application (Marschner, 1998).
4. Increasing the corresponding values of dry matter yield (Table, 2).

The positive impact of foliar S on bulbs NPK contents could be attributed to its important role in plant proteins, hormons, enzymes and chlorophyll formation. S also helps to have good vegetative growth and high yield which absorb high amounts of different nutrients (Marschner, 1998).

IV- Single foliar treatments of P and S significantly reduced weight loss percentage of bulbs stored under room temperature condition, during the most investigated periods. The most effect was observed in case of the addition of 2% P_2O_5 and 0.2% S together. This may be interpreted on the basis that the abovementioned treatment achieved the highest dry matter bulbs yield (Table, 2). In this connection, Gawish (1997) stated that S application for onion plants improved the storability of bulbs.

V- In most cases, the dual application of P and S didn't achieve significant impacts on onion bulbs yield, quality, minerals contents and storability.

Therefore, it could be concluded that foliar application of 2% P_2O_5 and 0.2% S together gives the highest values of bulbs yield and improves its quality and nutritive content as well as raises the storability value of the resultant bulbs.

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الملخص العربى

زيادة محصول البصل كماً ونوعاً بالرش الورقي بمحاليل الفوسفور والكبريت

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أجريت تجربتان حقليتان بقرية كفر الأكرم مركز قو يسنا محافظة المنوفيـــة خـــلال موســـمي الزراعة الشتويين لعامي 2004 ، 2005 بهدف دراسة استجابة محصول البصل كماً ونوعـــاً (النـــسبة المئوية للمواد الصلبة فى العصير والحرافة والقيمة التخزينية) وكذا المحتوى الغذائي للأبـــصال للـــرش الورقي بمستويات مختلفة من محاليل الفوسفور والكبريت .وقد أشارت نتائج الدراسة إلي استجابة جميـــع مقاييس النمو والمحصول الكمي والنوعي للبصل معنوياً للإضافات الورقية لكل من الفوسفور والكبريـــت وتناسبت الاستجابة طردياً مع المعدل المضاف لكلا العنصرين السابقين وسجلت أعلاها عند إضـــافة 2% فوسفات أو 2 0% كبريت مقارنة بباقي مستويات نفس العنصر .. فضلاً عن أن الرش الورقي للفوسفات والكبريت معاً بتركيزي 2% ، 0.2% على التوالي بعد 60 ، 75 يوم من الشتل يحقق الحـــصول علـــى أعلى المقاييس المدروسة ويزيد المحصول الكمي للبصل ويحسن من جودته ويرفع من قيمتـــه الغذائيـــة والتخزينية .