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ORIGINAL ARTICLES

Effect of Different Nitrogen Plus Phosphorus and Sulphur Fertilizer Levels on Growth, Yield and Quality of Onion (*AIlium cepa* L.)

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ABSTRACT

Field experiments were carried out for two consecutive seasons of 2009/2010 and 2010/2011 at the Experimental Station of National Research Centre in Nubaria region, El-Behira Governorate, Egypt, to find out the response of onion plants cv. Giza 20 to different fertilizer levels of nitrogen plus phosphorus (60 + 30 and 90 + 45 units/fed.) and three levels of sulphur (control, 200 and 400 kg S/fed.) on growth, yield and quality as well as uptake nutrients using an experimental design of split plot with three replications for each treatment. The obtained results revealed that all vegetative growth parameters and harvested bulb attributes as well as mineral and protein contents of onion significantly recorded the highest values, when supplied with nitrogen plus phosphorus at a higher rate of 90 + 45 units/fed. in both seasons of study, except for plant length, bulb diameter and harvested bulb length in the first season, in addition to harvested bulb length and diameter in the second season. Sulphur application at a rate of 400 kg S/fed. markedly enhanced all measured parameters of vegetative growth in the first season only except bulb diameter. While in the second season, there no clear trend was realized, where the highest values for vegetative growth parameters were fluctuated between sulphur application at rate of 200 and 400 kg S/fed. The highest values of the average weight of harvested bulb and bulb yield as well as bulb and neck dimensions (length and diameter) and Fe content in bulb tissues were significantly recorded when onion plant supplied by sulphur at rate of 400 kg S/fed. compared to all other treatments in both seasons, as well as K content in the second season only. The interaction between the two levels of nitrogen plus phosphorus fertilizer and three levels of sulphur had a significant difference effect on bulb diameter, leaves fresh weight and bulb and whole plant dry weight in the first season. As well as on fresh and dry weights of whole plant and its organs except neck dry weight and neck length and diameter in the second season. In the same respect, there was no significant interaction effect of nitrogen plus phosphorus and sulphur treatments on bulb yield, harvested bulb attributes and nutrient contents in both seasons except for length of bulb and neck in the first season and bulb dimensions (length and diameter) as well as K, Fe and Mn contents in the second season.

Key words: Onion, Nitrogen, phosphorus, Sulphur, Plant growth, Bulb yield, quality and Nutrient contents.

Introduction

Onion the "Queen of the Kitchen" is by far one of the most important and commercially valuable vegetable crops grown in Egypt for local consumption and exportation. It is essential in the daily Egyptian diet and all the plant parts are edible, although the bulbs are widely used as a seasoning or a vegetable in various dishes. During 2009 season about 87.2 thousands fed., were planted and more than 1147.6 thousands tons of bulbs were obtained with an average yield of 13.12 tons/fed. according to Ministry of Agriculture Statistics.

Nitrogen (N) and phosphorus (P) are often referred to as the primary macronutrients because of the large quantities taken up by plants from the soil relative to other essential nutrients (Marschner, 1995). Nitrogen comprises 7% of total dry matter of plants and is a constituent of many fundamental cell components (Bungard *et al.,* 1999). Phosphorus is making up about 0.2% of a plant's dry weight and it is essential for root development. Also it is a vital component of nucleic acids (DNA and RNA), energy molecules (AMP, ADP and ATP) and phospholipids. In onions, P deficiencies reduce root and leaf growth, bulb size and yield and can also delay maturation (Brewester, 1994).

Nutrients play a significant role in improving productivity and quality of vegetable crops. Therefore, increasing the productivity of onion with a good quality is an important target for producers. The beneficial effect of nitrogen application on onion yield was noted by Tiwori *et al.* (2002) and Abdel-Mawgoud *et al.* (2005). Lee-Jongatae *et al.* (2003) found that the highest values for plant height and bulb diameter were obtained at rates of 180 and 240 kg N/ha, respectively. However, the highest marketable yield was obtained at rate of 120 kg N/ha. Increasing nitrogen application rates significantly enhanced plant height, number of green leaves/plant and weight of plant and bulb at different stages of onion growth. Total yield, marketable yield,

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percentage of marketable, doubles and bolters as well as total soluble solids were also increased (Nasreen *et al.,* 2007 and Al-Fraihat, 2009). Abdissa *et al.* (2011) concluded that the number of leaves increased by about 8% in response to the application of 92 kg N/ha over the control whereas, leaf diameter and bulb length were not influenced by N fertilization rates. Regardless of the rate of application, N fertilization increased bulb diameter and average weight of bulb by about 12 and 21.5%, respectively, over the control. While P fertilization did not show significant effects on all of the parameters studied. On the contrary, increasing N application rates generally increased all vegetative growth parameters of onion plant (Rizk, 1997) and significantly affect the yield attributes of onion bulbs (Nasreen *et al.,* 2007). Nitrogen and sulphur fertilization was found to increase nutrients availability in the soil and uptake by the plant. This may be due to synergistic effect and/or reduction of soil pH (Nasreen *et al.,* 2007).

Sulphur is recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium in crops. It is a constituent of sulphur containing amino acids (cysteine and methionine), which are building blocks for essential proteins in the plant. Moreover, it is essential for a good vegetative growth and bulb development in onion and it has a strong influence on onion flavor and pungency through involvement in the volatile S-compounds (Anwar *et al.,* 2001 and Forney *et al.,* 2010).

Onion is an important sulphur-loving crop and it is required for proper growth and yield of onion (Kumar and Singh, 1995). Sulphur has been found not only to increase the bulb yield but also improves its quality especially flavors and pungency (Jaggi and Dixit, 1999). In the same respect, Bell (1981) reported that sulphur containing secondary compounds was importance for nutritive value and flavors as well as for resistance against pests and diseases.

In recent years, there has been an increased concern about the role of sulphur application as a soil amendment and as a factor of increasing fertilizer efficiency. Sulphur has a positive effect on onion and other crops (Bloem *et al.,* 2004). Application of sulphur to the soil has several effects such as reducing pH, improving soil water relation and increasing availability of nutrients (Marschner, 1995). The highest plant height, number of green leaves, bulb diameter, weight of bulbs and yield were obtained by using sulphur (Dabhi *et al.,* 2004; Jaggi, 2005; Nasreen and Imamul Huq, 2005 and Nasreen *et al.,* 2007). The yield of onion bulbs was also increased by the increment of sulphur rate application (Attia, 2001 and El-Shafie and El-Gamaily, 2002). Application of sulphur as Sulfer-95 or gypsum up to 40 kg/ha significantly increased bulb yield and S uptake of onion and garlic plants. Afterwards, the yield and S uptake were reduced at higher level of applied S 60 kg/ha (Singh, 2008). Also Sharma *et al.* (2002) found a linear increment of plant growth, bulb diameter and yield with increasing sulphur application rate from 15 to 60 kg/ha. Sulphur supply influences bulb yield, plant dry matter, bulb pungency and flavor intensity in *Allium* crops (Lancaster and Randle, 2002) but had a little effect on onion storage-life (Forney *et al.,* 2010). Sulphur application significantly increased the uptake of N, P, K and S by onion plants when received 45 kg S/ha (Sankaran *et al.,* 2005). In contrast Dabhi *et al.* (2004) reported that the higher content and uptake of P, K, Mg, S, Zn and Cu in onion bulb were observed with 30 kg S/ha followed by 20 kg S/ha.

The present study was undertaken to investigate the effect of different fertilizer levels of nitrogen plus phosphorus and three levels of sulphur on growth, yield and quality as well as uptake nutrients of onion plant grown under newly reclaimed sandy soil conditions.

Materials and Methods

Two field experiments were carried out during two consecutive winter growing seasons of 2009/2010 and 2010/2011 under newly reclaimed sandy soil conditions at Experimental Station of National Research Centre, El-Nubaria region, El-Behera Governorate, Egypt, to study the effect of different fertilizer levels of nitrogen plus phosphorus with sulphur on vegetative growth, yield, quality and nutrient contents of onion plant cv. Giza 20. The experiment considered of two levels of nitrogen plus phosphorus (60 + 30 and 90 + 45 units/fed.) in the forms of ammonium sulphate (20.6% N) and calcium super-phosphate (16.0% P_2O_5) and three levels of sulphur (control, 200 and 400 kg S/fed.) as agriculture sulphur KZ (98% w/w). The full amounts of sulphur and phosphorus as well as the 1/3rd dose of nitrogen were applied at the time of final land preparation. The remaining nitrogen was side-dressed in two equal portions 45 and 90 days after transplanting date. Uniform onion seedlings at 4 to 5 green true leaf stage or 20 cm height, were transplanted in the experimental field on the third week of December in both seasons of 2009/2010 and 2010/2011. Seedlings were planted on drip irrigated ridges of 70 cm width, 10.0 m length and 10 cm apart on both sides of ridge. Each experimental plot included 6 ridges with a net area of 42.0 m^2. All agricultural practices for onion crop production in the growing area were carried out as recommended by Ministry of Agriculture. The physical and chemical properties of the experimental soil samples (Table 1) were conducted according to the procedures indicated by **Jackson (1967)**.

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Experimental design and statistical analysis:

The experimental design was a split plot with three replicates. The two levels of nitrogen plus phosphorus were distributed in the main plots, while the three levels of sulphur were randomly arranged within the sub-plots. The obtained data were tabulated and subjected to statistical analysis and mean separation was done using the least significant differences (LSD) test at $P<0.05$ level of probability according to the method described by Snedecor and Cochran (1980).

Table 1: Physical and chemical properties of the experimental soil.

Physical properties												
Sand%			Clay%			Silt%			Soil texture			
89.76			4.10			6.14			Sandy			
Chemical properties												
EC	pH	OM	$CaCO_3$	Cations (Meq./L)					Anions (Meq./L)			
(ds/m)		(%)	(%)	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	P^{+++}	CO_3	HCO_3	Cl	SO_4
1.32	8.34	0.43	7.85	1.3	0.25	0.84	0.44	0.11	Nil	1.05	1.1	0.6

Measured parameters:

Vegetative growth parameters:

A random sample of 12 onion plants were taken from each experimental sub-plot at 100 days after transplanting date and transferred to the laboratory to determine the following parameters:
1- Plant length (cm);
2- Number of leaves/plant;
3- Bulb length and diameter (cm);
4- Neck length and diameter (cm);
5- Fresh and dry weights of leaves, neck and bulb as well as whole plant (g/plant).

Yield and physical properties of bulbs:

At harvesting time, 160 days after transplanting date, 30 bulbs from each sub-plot were randomly chosen to determine the following parameters:
1- Bulb length and diameter (cm);
2- Neck length and diameter (cm);
3- The average weight of bulb (g);
4- Average yield of bulb determined by weighing the harvested bulbs from each experimental sub-plot and total yield was calculated as ton/fed.

Macro and micro-nutrient contents:

Bulb tissues were oven dried at $70^{o}C$ for 72 hours, then fine grinded and used to determine ion contents on a dry weight basis. Bulb dried samples were wet digested as described by Wolf (1982). Total nitrogen and phosphorus were determined using the modified micro Kjeldah method and colorimetric method using spectrophotometer (SPECTRONIC 20D, Milton Roy Co. Ltd., USA), respectively, according to the procedure described by Cottenie *et al.* (1982). Potassium content was measured using flame photometer method (JENWAY, PFP-7, ELE Instrument Co. Ltd., UK) as described by Chapman and Pratt (1982). Also Fe, Zn, Mn and Cu were determined using Atomic-absorption (Analyst 200, Perkin Elmer, Inc., MA, USA), as described by Chapman and Pratt (1982). In addition, protein percentages in bulbs were calculated by multiplying nitrogen content by 6.25.

Results and Discussion

A- Plant growth parameters:

Data presented in Tables (2 and 3) clearly showed that addition of N plus P fertilizer at rates of 90 + 45 units/fed. for onion plants caused an enhancement in plant growth expressed as plant length, number of green leaves/plant, bulb and neck dimensions (length and diameter) and fresh and dry weights of whole plant and its different organs (leaves, neck and bulb) at 100 days after transplanting date. There was a significant difference between the two levels of nitrogen plus phosphorus fertilizer in all measured parameters. It is clear that the higher level of N plus P fertilizer (90 + 45 units/fed.) significantly increased plant length, number of green

leaves/plant, bulb and neck dimensions and fresh and dry weights of whole plant and its different organs as compared with the lower level (60 + 30 units/fed.) in both seasons of study except for plant length and bulb diameter in the first season only. Moreover, the application of N plus P fertilizer at a higher rate increased total fresh and dry weights of onion plant by 7.9, 10.4% and 19.7, 14.7% in the first and second seasons, respectively.

The increment of onion plant vegetative parameters with the addition of higher level of N + P may be attributed to more availability of nutrients, especially N, which enhances the number of leaves by its simulative effect on cell division and cell enlargement that in turn may increase number of leaves and leaf dimensions. Also enhances protein synthesis leading to an increase in building up carbohydrates and this in turn resulted in increases in plant growth characters. In the same respect, more availability of P nutrient where the available P level for plant in Egyptian soil is usually low, since it rapidly converts to unavailable form. Under these conditions, the farmers used to add considerable amount of mineral P fertilizer to face this problem. Phosphorus plays a pivotal role in metabolic processes and it is a main constituent of energy compounds, nucleic acids, phospholipids and co-enzymes. Also it may be attributed to favorable effects of phosphorus on root development and formation of carbohydrates. Bungard *et al.* (1999) stated that N is a constituent of many fundamental cell components and it plays a vital role in all living tissues of the plant. No other element has such an effect on promoting vigorous plant growth. Also the improvement of fresh and dry weight of whole onion plant could be attributed to an increased photosynthetic area in response to N + P fertilization that enhanced assimilates production and partitioning to the plants.

The obtained results are in conformity with the findings of Anwar *et al.* (2001); Tiwori *et al.* (2002); Abdel-Mawgoud *et al.* (2005); Al-Fraihat (2009); Abdissa *et al.* (2011) and Shaheen *et al.* (2011) on onion.

Agriculture sulphur fertilization positively affected all vegetative characters of onion plant. Increasing sulphur levels from 0 to 400 kg S/fed. significantly increased all measured vegetative parameters. The highest values of plant length, number of green leaves/plant, bulb and neck dimensions (length and diameter) and fresh and dry weights of whole plant and its different organs (leaves, neck and bulb) at 100 days after transplanting date were recorded when onion plant supplied the highest rate of sulphur fertilization (400 kg S/fed.) in the first season only except for bulb diameter. While in the second season there no clear trend was realized, where the highest values for vegetative growth parameters were fluctuated between sulphur application at rate of 200 and 400 kg S/fed. without significant differences between them. Moreover, the lowest values for these variables were recorded under sulphur regime of 0 kg S/fed. (control treatment) in both seasons.

Table 2: Effect of nitrogen plus phosphorus and sulphur fertilization at different levels on plant growth of onion plants in first season of 2009/2010.

Treatments		Plant length (cm)	No. of leaves/ plant	Bulb (cm)		Neck (cm)		Fresh weight (g)				Dry weight (g)			
N + P units/fed.	Sulphur kg/fed.			Length	Diameter	Length	Diameter	Leaves	Neck	Bulb	Total	Leaves	Neck	Bulb	Total
N P 60 30	Control	33.48	8.67	5.30	4.00	6.70	1.20	6.63	4.37	62.13	73.13	2.50	2.01	7.70	12.21
	200	36.40	10.33	5.57	9.53	7.23	1.77	7.67	5.17	82.13	94.97	3.53	2.47	10.77	16.77
	400	34.87	10.73	5.73	6.93	8.87	1.83	8.17	6.60	84.20	98.97	3.87	2.97	15.33	22.17
Mean		34.92	9.91	5.53	6.82	7.60	1.60	7.49	5.38	76.15	89.02	3.30	2.48	2.48	17.05
N P 90 45	Control	30.29	9.57	5.40	5.00	8.77	1.50	7.67	5.53	70.20	83.40	2.90	2.00	9.43	14.33
	200	33.33	11.07	5.43	5.73	10.03	1.83	10.77	5.13	78.77	94.67	3.67	3.17	13.63	20.47
	400	35.70	11.33	6.80	6.83	12.00	1.93	11.10	7.83	91.27	110.20	4.30	3.07	14.30	21.67
Mean		33.11	10.65	5.88	5.85	10.27	1.75	9.85	6.16	80.08	96.09	3.62	2.75	2.75	18.82
Average	Control	31.88	9.12	5.35	4.50	7.73	1.35	7.15	4.95	66.17	78.27	2.70	2.01	8.57	13.27
	200	34.87	10.70	5.50	7.63	8.63	1.80	9.22	5.15	80.45	94.82	3.60	2.82	12.20	18.62
	400	35.29	11.03	6.27	6.88	10.44	1.88	9.64	7.22	87.74	104.59	4.09	3.02	14.82	21.92
L.S.D. at 5%	N + P	0.45	0.64	0.23	0.16	0.23	0.14	0.03	0.13	2.10	2.00	0.01	0.26	0.62	0.35
	Sulphur	2.52	N.S.	N.S.	1.14	N.S.	0.41	0.37	1.10	4.89	5.65	0.58	0.43	1.30	1.34
	Interactions	N.S.	N.S.	N.S.	1.62	N.S.	N.S.	0.53	N.S.	N.S.	N.S.	N.S.	N.S.	1.83	1.89

Table 3: Effect of nitrogen plus phosphorus and sulphur fertilization at different levels on plant growth of onion plants in second season of 2010/2011.

Treatments		Plant length (cm)	No. of leaves / plant	Bulb (cm)		Neck (cm)		Fresh weight (g.)				Dry weight (g.)			
N + P units/fed.	Sulphur kg/fed.			Length	Diameter	Length	Diameter	Leaves	Neck	Bulb	Total	Leaves	Neck	Bulb	Total
N P 60 30	Control	62.23	9.00	5.24	3.40	9.17	0.83	12.87	28.53	10.83	52.23	6.25	4.04	14.43	24.72
	200	65.83	9.67	5.83	3.87	8.97	1.13	14.43	36.40	12.87	63.70	7.00	4.83	12.87	24.70
	400	70.93	11.33	5.77	3.89	9.87	1.23	13.47	37.97	13.80	65.24	7.95	5.15	13.47	26.57
Mean		66.33	10.00	5.61	3.72	9.34	1.06	13.59	34.30	12.50	60.39	7.07	4.67	13.59	25.33
N P 90 45	Control	62.30	9.75	5.87	4.01	8.53	0.94	13.23	44.10	9.91	67.24	7.23	4.62	16.43	28.28
	200	69.93	10.67	6.27	4.50	10.40	1.40	18.60	46.57	18.60	83.77	8.52	5.69	18.60	32.81
	400	74.10	11.67	6.23	4.67	10.93	1.03	16.47	36.13	13.23	65.83	7.58	5.29	13.23	26.10
Mean		68.78	10.70	6.12	4.39	9.95	1.12	16.10	42.27	13.91	72.28	7.78	5.20	16.09	29.06
Average	Control	62.27	9.38	5.55	3.70	8.85	0.89	13.05	36.32	10.37	59.73	6.74	4.33	15.43	26.50
	200	67.88	10.17	6.05	4.19	9.69	1.27	16.52	41.49	15.74	73.74	7.76	5.26	15.74	28.76
	400	72.52	11.50	6.00	4.28	10.40	1.13	14.97	37.05	13.52	65.54	7.77	5.22	13.35	26.34
L.S.D. at 5%	N + P	N.S.	0.44	0.24	0.20	0.41	0.03	0.11	2.78	0.19	2.48	0.13	0.25	0.20	0.14
	Sulphur	N.S.	1.43	N.S.	0.43	0.65	0.13	0.20	4.21	1.48	4.44	0.51	N.S.	0.47	1.38
	Interactions	N.S.	N.S.	N.S.	N.S.	0.92	0.19	0.29	5.96	2.10	6.28	0.72	N.S.	0.66	1.95

Generally, it could be stated that application of sulphur fertilization for onion plant gained a superior plant growth and the highest sulphur rate (400 kg S/fed.) resulted the best plant growth. These results may be due to

that application of sulphur helps in the availability of other nutrients resulting in better growth and increased uptake of all the nutrients at higher levels of sulphur. Similar results have also been reported by Dabhi *et al.* (2004); Jaggi (2005) and Nasreen *et al.* (2007). In this respect, Sharma *et al.* (2002) found a linear increment of plant growth, bulb diameter and yield with increasing sulphur application rate from 15 to 60 kg/ha. In contrast, Hamilton *et al.* (1998) indicated that additional sulphur nutrition did not affect plant growth significantly.

The interaction between nitrogen plus phosphorus and sulphur fertilizers had a significant effect on bulb diameter, leaves fresh weight and dry weight of bulb and whole onion plant only in the first season. As well as on neck length and diameter, fresh and dry weights of whole plant and its organs (leaves, neck and bulb) except neck dry weight in the second season.

Data presented in Tables (2 and 3) showed clearly that the highest values of vegetative growth of onion plants were obtained by the combination between 90 + 45 unit/fed. N + P fertilizer and 200 - 400 kg S/fed. sulphur. Whereas, the lowest values were obtained by the combination between 60 + 30 unit/fed. N + P fertilizer and 0 kg S/fed. sulphur (control treatment). The combined application of nitrogen plus phosphorus and sulphur up to 90 + 45 unit/fed. and 200 - 400 kg S/fed showed a significant synergistic effect on the vigor onion plant growth in both seasons.

B- Onion bulb yield and its physical properties:

Data shown in Table (4) revealed that bulb and neck dimensions (length and diameter), the average weight of harvested bulb and bulb yield were significantly increased with increasing nitrogen plus phosphorus fertilizer up to 90 + 45 unit/fed. at 160 days after transplanting date. The maximum values of bulb and neck dimensions (length and diameter), the heavier weight of bulb and bulb yield were obtained in case of using the higher level of nitrogen plus phosphorus fertilizer. These finding were completely true in both seasons, except for bulb length and bulb length and diameter, in the first and second seasons, respectively.

Application of N plus P fertilizers at a higher rate (90 + 45 units/fed.) resulted the heavier significant bulb yield (15.99 and 16.36 tons/fed., respectively, in the first and second seasons) if compared to the application of the lower rate (60 + 30 units/fed.). This superiority amounted by 0.97 and 1.0 ton/fed. in the first and second seasons, respectively. This increase was found to be due to the increment of bulb size and weight.

This might be due to applying nitrogen plus phosphorus improving the vegetative growth and accelerating the photosynthesis in storage organs of bulbs and increased allocation to the bulbs resulting in an increased diameter and weight of the bulb. These results are in agreement with those of Lee-Jongatae *et al.* (2003); Al-Fraihat (2009) and Abdissa *et al.* (2011).

Nasreen *et al.* (2007) reported a significant increase in the diameter of bulbs due to the application of N up to 120 kg/ha. Similar results also reported by Yadav *et al.* (2003) who found that N at 150 kg/ha, enhanced the formation of bulbs with larger diameters.

Increasing the addition rates of agriculture sulphur to onion soil from 0 to 400 kg S/fed. markedly enhanced the average weight of harvested bulb and bulb yield as well as bulb and neck dimensions (length and diameter). The highest values of bulb yield and bulb attributes were significantly recorded when onion plant supplied by sulphur at rate of 400 kg S/fed. compared to all other treatments in both seasons of study.

Data presented in Table (4) showed that application of sulphur fertilizer at rate of 400 kg S/fed. achieved the biggest bulb and neck dimensions length and diameter 8.12, 7.64 and 8.15, 0.76 cm and 8.42, 7.92 and 6.82, 0.72 cm; the heaviest weight of bulb 164.64 and 166.33 g/bulb and the highest total yield of bulb 17.24 and 17.46 tons/fed. in the first and second seasons, respectively. Moreover, the supplement of 400 kg S/fed. led to increase total bulb yield over control treatment by 4.24 and 4.29 tons/fed. in the first and second seasons, respectively.

These results might be attributed to the favorable effect of sulphur on reducing soil pH, increasing soil particles flocculation, thereby improving soil structure and increasing the availability of certain plant nutrients in the soil. Another possibility could be due either to the fact that sulphur is required with greater supplies for onion than other crops or for the synthesis of co-enzyme and amino acid for protein elaboration and for the formation of certain disulphide linkages that have been associated with structural characteristics of plant protoplasm (Marschner, 1995). The influence of S on the yield of onion could be attributed to an important role of sulphur in plant protein and some hormones formation, also sulphur is necessary for enzymatic action, chlorophyll formation, synthesis of certain amino acids and vitamins, hence it help to have a good vegetative growth leading to get high yield (El-Shafie and El-Gamaily, 2002). In addition, the increment of onion bulb yield with 400 kg S/fed. might be due to increase the formation of vegetative structures for nutrient absorption and photosynthesis and increase production of assimilates to fill the sinks, resulting in increased bulb yield.

Similar results in increase of average weight of bulb, bulb yields and dimensions of onion bulb with sulphur fertilization have been reported (Attia, 2001; Dabhi *et al.*, 2004; Jaggi, 2005 and Nasreen *et al.*, 2007). The obtained results also suggested that sulphur deficiency has adverse effect on growth and yield of onion. Increasing sulphur availability has been associated with increasing bulb weight (Lancaster *et al.*, 2001). In the

same regard, Hariyappa (2003) recorded a significant increase in yield and yield attributes (bulb diameter and bulb length) at higher levels of S application.

There were no significant differences effect concerning the interaction between nitrogen plus phosphorus and sulphur levels for bulb yield, average weight of bulb and bulb dimensions in both seasons of study except for bulb length and neck length in the first season and bulb length and diameter in the second season as shown in Table (4). The highest values of bulb yield, average weight of bulb and bulb dimensions in seasons of 2009/2010 and 2010/2011 were obtained from those onion plants fertilized with the higher level of nitrogen plus phosphorus (90 + 45 unit/fed.) and sulphur (400 kg S/fed.) during both seasons.

Table 4: Effect of nitrogen plus phosphorus and sulphur fertilization at different levels on bulbs yield of onion in both seasons of 2009/2010 and 2010/2011.

Treatments		Bulb (cm)		Neck (cm)		Average weight of bulb	Yield (ton/ fed.)	Bulb (cm)		Neck (cm)		Average weight of bulb	Yield (ton/ fed.)
N + P units/fed.	Sulphur kg/fed.	Length	Diameter	Length	Diameter			Length	Diameter	Length	Diameter		
		2009/2010						2010/2011					
N P 60 30	Control	7.10	6.30	6.20	0.47	125.10	12.96	6.00	5.84	5.50	0.30	137.12	13.48
	200	7.19	7.21	6.00	0.60	145.11	15.50	7.30	8.00	6.40	0.65	153.78	16.36
	400	8.53	7.28	6.24	0.79	159.73	16.60	8.68	7.64	6.52	0.69	158.63	16.24
Mean		7.61	6.93	6.15	0.62	142.26	15.02	7.33	7.16	6.14	0.62	149.84	15.36
N P 90 45	Control	5.72	6.36	6.74	0.42	127.40	13.03	5.31	6.00	6.33	0.44	120.84	12.86
	200	8.97	7.73	6.07	0.77	163.09	17.06	7.31	6.30	6.83	0.68	168.16	17.53
	400	7.71	8.00	10.05	0.73	169.54	17.88	8.16	8.20	7.12	0.75	174.03	18.68
Mean		7.47	7.36	7.62	0.64	153.34	15.99	6.93	6.83	6.76	0.62	154.34	16.36
Average	Control	6.41	6.33	6.47	0.45	126.25	13.00	5.66	5.92	5.92	0.37	128.98	13.17
	200	8.08	7.47	6.04	0.69	154.10	16.28	7.31	7.15	6.62	0.67	160.97	16.95
	400	8.12	7.64	8.15	0.76	164.64	17.24	8.42	7.92	6.82	0.72	166.33	17.46
L.S.D. at 5%	N + P	N.S.	0.11	0.33	0.00	7.90	0.23	0.08	0.10	0.17	0.07	4.24	0.27
	Sulphur	1.12	0.44	0.90	0.10	16.16	1.25	0.19	0.25	0.52	0.11	17.24	1.18
	Interactions	1.58	N.S.	1.28	N.S.	N.S.	N.S.	0.26	0.35	N.S.	N.S.	N.S.	N.S.

It is of interest to note that the bigger bulbs (diameter, length and weight) resulted when onion plants received the higher N plus P fertilizer rate (90 + 45 units/fed.) and the highest sulphur rate (400 kg S/fed.). Similar results were reported by Coolong *et al.* (2004).

Shortly, it could be stated that the obtained results indicated that each interaction factor might be act individually not independently.

C- Nutritional values of onion bulb yield:

Tables (5 and 6) demonstrated that the nutritional values of onion bulb, i.e. protein, N, P, K, Fe, Mn, Zn and Cu contents were influenced by the application of N plus P fertilizer and sulphur at different rates in both seasons. Results showed that nutrient and protein contents in onion bulb tissues were significantly increased when onion plants received a higher rate of N plus P fertilizer (90 + 45 unit/fed.) when compared with the lower rate (60 + 30 unit/fed.) in both seasons of study.

Application of N plus P fertilizer at rate of 90 + 45 unit/fed. gave significantly the highest values of protein, N, P, K, Fe, Mn, Zn and Cu contents, while, the lowest values were obtained with using N plus P fertilizer at rate of 60 + 30 unit/fed. These findings were completely similar in both seasons.

It could be stated that the higher protein, N, P, K, Fe, Mn, Zn and Cu contents were associated with addition of N plus P fertilizers at rate of 90 plus 45 units/fed. The obtained results are in good accordance with Nasreen *et al*. (2007) and Shaheen *et al.* (2011).

Table 5: Effect of nitrogen plus phosphorus and sulphur fertilization at different levels on chemical properties of onion bulb in first season of 2009/2010.

Treatments		%				ppm			
N + P units/fed.	Sulphur kg/fed.	Protein	N	P	K	Fe	Mn	Zn	Cu
N P 60 30	Control	8.29	1.33	0.253	0.48	252.33	28.00	31.33	10.33
	200	8.73	1.40	0.357	0.59	270.67	29.00	35.67	11.67
	400	9.21	1.47	0.413	0.63	274.67	30.33	36.67	13.33
Mean		8.74	1.40	0.341	0.57	265.89	29.11	34.56	11.78
N P 90 45	Control	8.60	1.38	0.263	0.47	252.00	26.00	33.67	11.00
	200	9.44	1.51	0.387	0.71	306.00	34.00	39.33	14.33
	400	9.54	1.53	0.453	0.77	313.33	36.00	42.00	15.33
Mean		9.19	1.47	0.368	0.65	290.44	32.00	38.33	13.56
Average	Control	8.45	1.35	0.258	0.48	252.17	27.00	32.50	10.67
	200	9.08	1.45	0.372	0.65	288.33	31.50	37.50	13.00
	400	9.38	1.50	0.433	0.70	294.00	33.17	39.33	14.33
L.S.D. at 5%	N + P	0.140	0. 22	0.04	0.04	20. 6	1.28	0.898	1.08
	Sulphur	N.S.	N.S.	N.S.	N.S.	44.97	N.S.	N.S.	N.S.
	Interactions	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 6: Effect of nitrogen plus phosphorus and sulphur fertilization at different levels on chemical properties of onion bulb in second season of 2010/2011.

Treatments		%				ppm			
N + P units/fed.	Sulphur kg/fed.	Protein	N	P	K	Fe	Mn	Zn	Cu
N P 60 30	Control	8.40	1.34	0.253	0.48	252.33	27.67	32.00	10.00
	200	8.98	1.44	0.363	0.61	262.33	31.00	36.00	14.00
	400	9.21	1.47	0.433	0.65	265.00	32.67	38.33	14.33
Mean		8.86	1.42	0.350	0.58	259.89	30.44	35.44	12.78
N P 90 45	Control	8.52	1.36	0.317	0.50	251.00	28.67	35.67	10.67
	200	9.54	1.53	0.443	0.74	275.67	36.00	41.00	15.00
	400	9.77	1.56	0.463	0.79	312.33	37.33	44.33	16.00
Mean		9.28	1.48	0.408	0.67	279.67	34.00	40.33	13.89
Average	Control	8.46	1.35	0.285	0.49	251.67	28.17	33.83	10.33
	200	9.26	1.48	0.403	0.67	269.00	33.50	38.50	14.50
	400	9.49	1.52	0.448	0.72	288.67	35.00	41.33	15.17
L.S.D. at 5%	N + P	0. 77	0. 12	0. 06	0.04	10.05	0.513	0.715	0.257
	Sulphur	N.S.	N.S.	N.S.	0.202	25.18	N.S.	N.S.	N.S.
	Interactions	N.S.	N.S.	N.S.	0.285	35.61	18.30	N.S.	N.S.

The obtained results may be due to that root growth, particularly development of lateral roots and fibrous rootlets which responsible for nutrients uptake from the soil is positively encouraged by phosphorus (Barker and Pilbeam, 2007).

Application of agriculture sulphur to onion soil increased the elements uptake from the soil by onion plant as well as element contents of onion bulb tissues. This observation was clear in both season of study. Data presented in Tables (5 and 6) showed that the highest sulphur level (400 kg S/fed.) led to higher protein, N, P, K, Fe, Mn, Zn and Cu contents in onion bulb tissues compared to other treatments, although there no significant differences among sulphur application were detected in both seasons, except for Fe content in the first and second seasons and K content in the second season only.

These results might be attributed to the favorable effect of sulphur on reducing soil pH, increasing soil particles flocculation, thereby improving soil structure and increasing the availability of certain plant nutrients in the soil (Marschner, 1995). Sulphur application increased the uptake of N, P, K and S which might have influenced the synthesis and translocation of stored materials. These results are in accordance with Dabhi *et al.* (2004); Jaggi (2005) and Sankaran *et al.* (2005).

The interaction between the two levels of nitrogen plus phosphorus fertilizer and three levels of sulphur had a significant difference effect only in the second season on K, Fe and Mn contents. This means that each interaction factor may be affect the nutritional elements independently. Regarding the interaction, the highest values of nutritional values (protein, N, P, K, Fe, Mn, Zn and Cu contents) in onion bulb tissues were obtained from onion plants fertilized with the higher level of nitrogen plus phosphorus (90 + 45 unit/fed.) and the highest level of sulphur (400 kg S/fed.) during the two seasons of 2009/2010 and 2010/2011.

Conclusions:

Under the conditions of this study, application of N + P fertilizer at rate of 90 + 45 unit/fed. and 400 kg S/fed. sulphur, is advisable for better grown of onion plant and to ensure high yield and good quality of onion bulbs in Giza 20 cultivar in newly reclaimed sandy soil.

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