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Relationship Between Growth, Yield and Storability of Onion (*Allium Cepa* L.) With Fertilization of Nitrogen, Sulphur and Copper under Calcareous Soil Conditions

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Abstract: This work was carried out during the winter seasons of 2005/2006 and 2006/2007 at The Experimental Farm of Environ. Agric. Sci. Fac., El-Arish, North Sinai, to study the effect of nitrogen levels (N), sulphur (S) and copper (Cu) on growth, yield and weight loss (%) of onion (*Allium cepa* L.). The data revealed that application of high dose of nitrogen (120kg N/fed.) increased plant height ,number of leaves /plant, dry weight of different onion plant organs (roots,leaves, bulbs and total dry weight), yield of 1st grade ,total yield ,marketable yield and exportable yield as well as the bulbs weight loss,but it decreased the bulbing ratio. Application of 200 kgS/fed. with spray of Cu at 30 ppm was the the superior treatment for increasing onion vegetative growth, dry weight of different plant organs, 1st grade, total yield, marketable yield, exportable yield, and storability of onion bulbs. Moreover, application of 120kg N/fed.+ 200 kgS/fed. in combinaion with spray of Cu at 30 ppm outdid the other treatments which significantly increased the vegetative growth, dry weight of different plant organs as well as total dry weight per plant, and yield components, but application of 120kg N/fed. alone (control treatment) significantly increased the weight loss of bulbs.

Key words: Onion, nitrogen,sulphur, vegetative growth, dry weight, bulbing ratio, marketable yield, exportable yield and weight loss.

INTRODUCTION

Onion (*Allium cepa* L.) is considered one of the most important crops in Egypt. The area cultivated in Egypt in 2006year was 110,253 fed. and its production was 1,346,983 ton (Agric. Static. Depart., Ministry of Agric., Egypt) as well as it is one of the major exportable vegetable crops. Although onion used as seasoning vegetables, bulbs make an important contribution to human's diet, having vitamins, flavonoids, macro and micro elements[13].

Nitrogen is a growth limiting factor for most crop species (other than legumes) grown in alkaline soil. Total amount of nitrogen and its availability closely related to the soil environment such as soil pH which the minor factor for the level and turnover of nitrogen in alkaline soil[19]. Under alkaline or calcareous soils (such as North Sinai soils), nitrogen conversion from NH_4^+ to NO_3 (nitrification) by soil bacteria is most rapid in soil which moves freely with soil water. So, the decreasing of soil pH is very important to increase the availability and use efficiency of nitrogen and other nutrients. Sulphur has a direct effect on soil properties which greatly decreased pH values[1]. The positive effect of sulphur on reducing soil pH values may be attribute to the oxidation of sulphur to sulphoric acid by many species of soil microorganisms[14,10]. The decrease of soil pH improve the availability of microelements such as Fe, Zn, Mn, and Cu[12] and improving the chemical properties of alkaline soilas well as improving the productinity of yield and its related characterisitics[16]. Additionally ,sulphur is essential for beulding up sulphur contaninig amino acids and also for good vegetative and bulb development in onion[4]. Copper is a constituent of several enzymes such as phenolases. Phenolases are responsible for the biosynthesis of lignin and in the production of infection resistance chemicals (quinones, tannins and melanin) in plants[29]. Copper is important to the formation of lignin in plant cell walls which contributes to the structural strength of the cells and plants and also affect the storage ability of fruits. In addition copper play an important role in photosynthesis process. Copper is a constituent of plastocyanin protein which is present in chloroplast and helps in transport of e^- from photosystem II to photosystem I[25]. Under high soil pH, the solubility of Cu in soil decreased causing plant physiological impaired[29].

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Thus the aim of this work was study the effect of combination between nitrogen levels and application of soil amendments in sulphur form with spraying of copper on growth ,yield and storability of onion under North Sinai conditions.

MATERIALS AND METHODS

Two field experiments were carried out during the winter seasons of 2005/2006 and 2006/2007 at The Experimental Farm of Environ. Agric. Sci. Fac., El-Arish, North Sinai, Egypt. The main object of this work was to study the effect of nitrogen levels, sulphur and copper on growth, yield and weight (loss) % of onion (*Allium cepa* L.) *cv*. Giza 20. The soil properties are sandy loam in texture, pH 7.7,7.9; EC(dSm^{-1})0.695,0.595;organic matter 0.05, 0.07; $CaCO_3$ 9.10, 10.2%; total N (ppm)16.22, 16.83; total P (ppm) 45, 48; and total K (ppm)92, 91in the 1st and 2nd seasons, respectively. This experiment included 18 treatments which were the combination between two factors: Factor A was nitrogen levels (80 and 120 kg/fed.). Factor B was application of sulphur (100 and 200 kg/fed.) and spraying with copper (15 and 30 ppm) as well as the combination between S and Cu. Treatments were randomly arranged in a split plot design with three replications. Treatments of factor A were randomly arranged in the main plots, and treatments of factor B were randomly arranged in the sub- plots. plot area was 17.5 m^2(17.5m in length and 1 m in width; 8.5m^2 for vegetative parameters and 8.5 m^2 for yield).Plants received 30 m^3 FYM, 60 kg P_2O_5 and 100kg K_2O. Plants were transplanted on December 30th in both seasons. Plants were transplanted at 7 cm distance in double dripper lines.The distance between the centers of the double dripper lines was 100 cm and 40 cm between the two dripper lines in each double dripper line. The transplants were transplanted in 4 rows on each side of the dripper line (plant density 114 plants/m^2) in the 1st season, but the plant density was 57 plants/m^2 in the 2 nd season. One third of nirogen and Sulphur were added to the soil during the soil preparation, while the other two thirds were added after 15 dayes from transplanting. The plants were sprayed with Cu four times at 10 days intervals beginning after 30 days from transplanting.

Data Recorded: Sampels of 5 plants from each plot at 80 days from transplanting were randomly taken to determine the follwing data:

1. Vegetative growth(plant height(cm), number of leaves, neck diametr(ND) (cm), bulb diameter (BD) (cm), and bulbing ratio (BD /ND) according to Brewster and butler[6].
2. Dry wight of different plant organs; roots, leaves, bulb as well as total dry weight/plant (gm).
3. Yield and its components: Plants were harvested after 75% of bent leaves and the bulbs were weighed after curing and the following data were recorded:

A. Bulb grades ,namely grade 1 (bulbs with diameter more than 6 cm) , grade 2 (bulbs with diameter between 4.5-6cm) , grade 3(bulbs with diameter between 3.5- 4.5cm) ,and grade 4 (bulbs with diameter less than 3.5cm) were recorded according to the specification of The Ministry of Economic for onion exportation (1963).

B. Marketable yield of bulbs (ton /fed.): weight of grade 1 + grade 2 + grade 3.

C. Exportable yield of bulbs (ton /fed.): weight of grade 1 + grade 2 + grade 4.

D. Total yield (ton /fed.): weight of grade 1 + grade 2 + grade 3 + grade 4.

4. Storability: it was measured as weight loss (%) and decay in bulbs.Bulbs of each treatment were weighed at 30 days intervals. Bulbs which decayed were also avoided and then the cumulative weight loss percentage was calculated as one parameter.
5. Statistical analysis: Statistical analysis of the obtained data was carried out according to statistical analysis of variance according to Snedecor and Cochran[28]. Duncan's multiple range tests was used for comparison among means[8].

RESULTS AND DISCUSSION

Vegetative Growth:

-Effect of Nitrogen: It is clear from the data presented in Table (1) that application of 120 kg N/fed. significantly increased the vegetative growth (plant height ,number of leaves/plant), dry weight of onion plant expressed as dry weight of roots, leaves, bulls and total dry weight /plant. The increment in vegetative growth and consequently in dry weight of onion plants due to application of high rate of nitrogen (120 kg N/fed.) may be attribute to the pronounced role of nitrogen in plant metabolism. Nitrogen is a constituent of proteins, enzymes, hormones, vitamins alkaloids, chlorophyll and photosynthesis [25] which led to an increment in plant metabolism and vegetative growth expressed as plant heights, number of leaves/plant, both length and diameter of leaves[17], leaf area[6,3] and crop growth rate[11,2] as well as dry weight of plant. The same treatment reduced the bulbing ratio in spite of both neck and bulb diameters were not statistically affected. This may be owe to the decrease in bulb diameter and increase in neck diameter with adverse of application of 80 kg N /fed. which increased the bulb

Table 1: Effect of nitrogen rates,and sulphur and coper application on vegetative growth, dry weigh and bulb character of onion plant.

Treatments	Vegetative growth			Dry weight /plant (g)			Bulb charecters		
	Plant heighet (cm)	No.leaves /plant	Roots	leaves	bulbs	Total dry weight	Bulb diameter (cm)	Neck diameter (cm)	Bulbing ratio
Nitrogen rates(kg/fed.)				First season(2005/2006)					
80	58.38b	7.94b	0.57b	6.36b	16.94b	23.88b	6.46a	2.02a	3.19a
120	64.96a	8.85a	0.61a	8.57a	17.19a	26.38a	6.13a	2.16a	2.83b
				Second season (2006/2007)					
80.	62.44b	7.80b	0.56 b	6.48b	16.98b	24.02b	6.35a	2.00a	3.17a
120	66.63a	8.66a	0.60 a	7.99a	17.47a	26.06a	6.16a	2.14a	2.87b
Sulphur and copper application				First season(2005/2006)					
Control	54.69c	7.58b	0.39c	5.58b	13.35d	19.32d	5.78c	1.82b	3.17b
100kg S /fed.	60.83abc	9.00a	0.58bc	6.47b	16.05bcd	23.10bcd	6.24b	2.12ab	2.94bcd
200kg S /fed	63.41ab	9.08a	0.60bc	6.67ab	18.21bc	25.49bc	7.24a	2.00ab	3.62a
15ppm Cu	58.16bc	8.25ab	0.49bc	6.51b	15.16cd	22.17cd	6.10bc	2.14ab	2.85cd
30ppm Cu	59.25bc	8.16ab	0.49bc	7.43ab	15.97bcd	23.90bcd	6.10bc	2.34a	2.60d
100kgS/fed.+15ppm Cu	62.91abc	8.58ab	0.59bc	7.82ab	16.54bcd	24.96bc	6.40b	2.05ab	3.12bc
200kg S/fed+15ppm Cu	64.38ab	8.08ab	0.62abc	8.32ab	17.90bcd	26.85bc	6.20b	2.16ab	1.48e
100kg S/fed+30ppm Cu	66.13a	8.33 ab	0.67ab	8.63ab	18.49b	27.80ab	6.40b	2.13ab	3.00bc
200kg S/fed+30ppm Cu	65.30a	8.50ab	0.85a	9.76a	21.98a	32.59a	6.20b	2.09ab	2.96bc
				Second season (2006/2007)					
Control	58.48c	7.53a	0.44c	5.74b	13.57c	19.76d	5.82e	1.82b	3.19ab
100kg S/fed.	63.90abc	8.41a	0.54abc	7.41ab	15.47c	23.43bc	6.40b	1.98ab	3.23a
200kg S/fed	64.44ab	9.01a	0.55abc	7.48ab	17.68ab	25.73a-c	6.91a	2.17ab	3.18ab
15ppm Cu	61.51bc	8.44a	0.50bc	6.52b	15.74bc	22.76cd	5.97de	2.21a	2.70d
30ppm Cu	63.28abc	8.03a	0.51abc	7.04ab	16.32bc	23.88 bc	6.26bc	2.19ab	2.85cd
100kgS/fed.+15ppm Cu	66.03ab	7.87a	0.60ab	7.55ab	17.77ab	25.92a-c	6.06c-e	2.12ab	2.85cd
200kg S/fed+15ppm Cu	66.89ab	7.92a	0.61ab	7.66ab	18.32ab	26.60ab	6.32bc	1.97ab	3.20ab
100kg S/fed+30ppm Cu	68.22a	7.78a	0.66ab	7.34ab	20.21a	28.22a	6.24b-d	2.03ab	3.07abc
200kg S/fed+30ppm Cu	68.10a	9.08a	0.81a	8.34a	19.94a	29.10a	6.30bc	2.17ab	2.90bcd

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

diameter but the neck diameter was decreased at the same time. The slight increment in neck diameter and decrease in bulb diameter due application of 120 kg N/fed. may be owe to the high vegetative growth and delay the bulb filling. These results are in harmony with those reported by Brewster and butler[6] who studied the effect of N on bulb ratio and found that bulb diameter was higher with low N level than in high N treatments, but the reverse was true at the later harvest. Similar result was found by Khan *et al.*[15] who illustrated that excessive highly doses of N delay in bulb maturity. Abd El-Kader *et al.*[1] found that application of 120 kg N/fed. increased onion neck diameter, bulb diameter, and both bulb fresh and dry weight.

- Effect of Sulphur and Copper: Plant height and dry weight of different plant organs (roots, leaves, bulbs, and total dry weight of plant) were significantly increased with spraying onion plants with the high concentration of Cu (30 ppm) with the two rates of sulphur (100 and 200 kg/fed.) followed by spraying with 15 ppm Cu as foliar spray with 100 or 200 kg S /fed. (Table 1). Regarding bulb characters, the previous

data show that application of 200 kg S/fed. and 100 kg S/fed. in the 1st and 2nd seasons , respectively recorded the highest value of bulbing ratio as a result of increase the bulb diameter. In contrast, spraying onion plants with 15 ppm Cu alone or with application of 200 kg S/fed. in the 2nd and 1st seasons , respectively recorded the highest value of neck diameter, and consequently the bulbing ratio was decreased. Control treatment recorded the lowest value of all previous parameters except the bulbing ratio in the 2nd season. The increment in vegetative growth and dry weight of plant organs due to the combination between sulphur and copper may be attributed to the direct effect of sulphur on soil properties which greatly decreased pH values from 8.35 to 7.68 and it was also found to improve plant metabolism, increased photosynthetic rate, and free amino acids[1] which led to an increase in vegetative characters. The positive effect of sulphur on reducing soil pH values may be attributed the oxidation of sulphur to sulfuric acid by many species of soil micro-organisms[14,10]. Nasreen *et al.*[21] found that the highest dry matter, CGR, RGR and bulb characters (horizontal diameter and vertical diameter) were recorded with application of 45 and 60 kg S/ha. They added that the increment in total dry matter might be due to the increase in photosynthetic rates which was most favorably influenced by sulphur fertilizer. Mahmoud and Hafez [18] showed that vegetative growth of okra was gradually and significantly increased by increasing the level of sulphur from 0.0 up to 200 kg/fed. on both seasons. They added that the increase in vegetative growth due to the role of sulphur on reducing soil pH and increasing the availability of P and some microelements (Fe, Mn, Zn and Cu) as reported by Hetter [12]. In addition copper play an important role in photosynthesis process. Copper is a constituent of plastocyanin protein which is present in chloroplast and helps in transport of e^- from photosystem II to photosystem I[25].

- Effect of Interaction Between Nitrogen Levels and Sulphur and Copper Application: Concerning the interaction between nitrogen levels and sulphur and copper application, data in Table 2 reveal that the combination between 120 kg N/fed. with fertilization of 200 kg S/fed.+ spraying with 30ppm Cu was the best interaction treatment which enhanced the plant growth and dry weight of different onion plant organs and total dry weight of onion plant. These results in may be owe to the progressive effect of sulphur on soil properties which decreased soil pH and increased CEC of soil character which led to increase the availability of nutrients for plants[1]. Nasreen *et al.*[21] found the highest dry matter, CGR ,RGR and bulb characters (horizontal diameter and vertical diameter) were recorded with the combination between 45 kg S /ha and 120 kg N/ha. Likewise, the vital role of nitrogen and copper in plant metabolism and their progressive effects on photosynthesis process owe to increase in plant growth expressed in increments in vegetative growth and plant dry weight.

Regarding bulbing characters, it is clear from the same data that application of 120 kg N+200kg S/fed. and application of 80 kg N combined with 200 kg S/fed. +spraying with 15 ppm Cu in 1st and 2nd seasons, respectively recorded the first rank of bulbing ratio. This may be attributed to the increment in bulb diameter and reduction in neck diameter. These results may be owe to the direct effect of N and Cu on increasing of vegetative growth and consequently delay the bulb filling. Coolong *et al.*[7] reported that plant growth, bulb fresh and dry weight were affected by N and S levels.

Yield and its Components:

- Effect of Nitrogen: Data presented in Table (3) show that the first grade of onion bulbs was significantly increased with increasing N level up to 120 kg/fed., while the third grade was decreased resulting in the increment in 1st grade. In the meantime, the 2nd and 4th grades were not significantly affected. It is also clear that total yield , marketable yield and exportable yield were increased by 10.26 %, 11.82 %; 10.60 %,11.95 % and 11.07 %, 12.27 % due to application of 120 kg N /fed. compared to application of 80 kg N /fed. in both seasons, respectively. The increment in total yields due to application of 120 kg N /fed. Could be attributed to the increment of vegetative growth and rising photosynthesis production which associated with increment in bulb size and single bulb weight as recorded by Khan *et al.*[15] and Nasreen *et al.*[22]. The increment in marketable and exportable yields owe to the increment in first grade yield as a result of increasing in 1st grade yield. The increment in total yield is in agreement with those reported by Baloch *et al.*[5], Al-Moshileh[3] and Aliyu *et al.*[2] who found that increasing N application increased onion bulb yield. In addition, Nasreen *et al.*[22] illustrated that application of N from 0.0 to 120 kg/ha. resulted in progressive increase in bulb yield of onion and thereafter decreased with 160 kg N /hectare.

-Effect of Sulphur and Copper: Data presented in Table (3) illustrate that application of sulphur at a rate of 200 kg/fed. + spraying with Cu at 15 ppm as well as application of 100 or 200 kg S /fed. +30 ppm Cu in the 1st season and application of the highest rate of S (200 kg/fed.) + the highest concentration of Cu (30 ppm) in the second season increased the yield of 1st grade and total yield of onion bulbs. The same

Table 2: Effect of interaction between nitrogen rates and sulphur and copper application on vegetative growth, dry weigh and bulb characters of onion plant.

Nitrogen rates (kg/fed.)	Treatments	Vegetative growth			Dry weight /plant (g)			Bulb charecters		
		Plant heighet (cm)	No.leaves /plant	Roots	leaves	bulbs	Total dry weight	Bulb diameter (cm)	Neck diameter (cm)	Bulbing ratio
		First season(2005/2006)								
80	Control	53.50f	7.16 b	0.42de	4.52e	12.70 c	17.65d	5.95bc	1.70a	3.50ab
	100kg S/fed.	58.17def	8.50ab	0.51b-e	6.14de	15.47bc	22.13b-d	6.34bc	1.96a	3.23bc
	200kg S/fed	62.17cde	8.66ab	0.51b-e	6.38c-e	18.56a-c	25.46bc	7.50a	2.16a	3.47ab
	15ppm Cu	55.50f	7.50ab	0.45c-e	5.89de	15.78bc	22.12b-d	5.85c	2.08a	2.81def
	30ppm Cu	56.00ef	7.66ab	0.52b-e	6.13de	16.46bc	23.12b-d	6.45bc	2.13a	3.02de
	100kg S/fed.+15ppm Cu	59.33def	8.66ab	0.60b-e	6.72c-e	16.37bc	23.69b-d	6.66a-c	1.95a	3.41bc
	200kg S/fed+15ppm Cu	61.60cde	7.66ab	0.60b-e	7.03b-e	18.53a-c	26.17bc	6.66a-c	2.28a	2.92def
	100kg S/fed+30ppm Cu	61.43cde	7.33ab	0.72a-c	7.01b-e	18.81a-c	26.54bc	6.45bc	1.92a	3.35bc
	200kg S/fed+30ppm Cu	57.77def	8.33ab	0.77ab	7.43b-e	19.82ab	28.03bc	6.33bc	2.03a	3.11cd
120	Control	55.89f	8.00ab	0.35e	6.64c-e	13.99bc	20.99cd	5.61c	1.95a	2.87def
	100kg S/fed.	63.50cd	9.50a	0.65b-d	6.79c-e	16.63bc	24.08b-d	6.15bc	2.28a	2.69f
	200kg S/fed	64.67bcd	9.50a	0.68a-d	6.97b-e	17.86a-c	25.51bc	6.98ab	1.85a	3.77a
	15ppm Cu	60.83cde	9.00ab	0.54b-e	7.13b-e	14.55bc	22.22b-d	6.36bc	2.20a	2.89def
	30ppm Cu	62.50cde	8.66ab	0.46c-e	8.74b-d	15.47bc	24.68b-d	5.76c	2.55a	2.25g
	100kg S/fed.+15ppm Cu	66.50abc	8.50ab	0.58b-e	8.93a-d	16.72bc	26.23bc	6.15bc	2.15a	2.86def
	200kg S/fed+15ppm Cu	67.17abc	8.50ab	0.64b-d	9.62a-c	17.26bc	27.53bc	5.73c	2.05a	2.79ef
	100kg S/fed+30ppm Cu	70.83ab	9.33ab	0.63b-d	10.26ab	18.16a-c	29.06b	6.35bc	2.34a	2.71f
	200kg S/fed+30ppm Cu	72.83a	8.66ab	0.92a	12.08a	24.14a	37.15a	6.08bc	2.15a	2.82def
		Second season (2006/2007)								
80	Control	57.19g	7.23c	0.45d	5.68d	13.94cd	20.08de	6.14d-g	1.99a-c	3.08a-e
	100kg S/fed.	62.53d-g	7.72bc	0.51cd	6.25b-d	14.29cd	21.07c-e	6.52b-d	1.97a-c	3.30ab
	200kg S/fed	62.05d-g	8.14bc	0.54b-d	6.70a-d	17.70a-d	24.95b-e	6.82ab	2.09a-c	3.26abc
	15ppm Cu	59.72fg	7.89bc	0.51cd	5.89cd	17.28a-d	23.68b-e	6.00e-g	2.04a-c	2.94de
	30ppm Cu	60.17e-g	7.53bc	0.49cd	6.31b-d	16.57b-d	23.38b-e	6.43b-e	2.04a-c	3.15a-d
	100kg S/fed.+15ppm Cu	63.96b-f	7.44bc	0.62b-d	7.00a-d	17.35a-d	24.98b-e	6.36c-f	2.02a-c	3.14a-d
	200kg S/fed+15ppm Cu	64.44a-f	7.73bc	0.59b-d	6.49a-d	19.10a-c	26.18a-c	6.61bc	1.96a-c	3.37a
	100kg S/fed+30ppm Cu	65.83a-f	7.46bc	0.62b-d	6.41a-d	18.06a-d	25.11b-d	6.17c-g	1.86bc	3.31ab
	200kg S/fed+30ppm Cu	66.10a-f	9.05ab	0.73ab	7.57a-d	18.52a-c	26.83ab	6.11d-g	2.04a-c	2.99cde

Table 2: Continue

120	Control	59.77fg	7.84bc	0.43d	5.81cd	13.21d	19.45e	5.50h	1.65c	3.33ab
	100kg S/fed.	65.27a-f	9.11ab	0.56b-d	8.57a-c	16.66b-d	25.79bc	6.29c-f	1.98a-c	3.17a-d
	200kg S/fed	66.82ad	9.89a	0.57b-d	8.27a-d	17.66a-d	26.51a-c	7.01a	2.25ab	3.11a-e
	15ppm Cu	63.30c-g	9.00ab	0.49cd	7.15a-d	14.20cd	21.85b-e	5.93fg	2.39a	2.48h
	30ppm Cu	66.39a-e	8.53a-c	0.54b-d	7.78a-d	16.06cd	24.38b-e	6.10d-g	2.35a	2.59gh
	100kg S/fed.+15ppm Cu	68.10a-d	8.30a-c	0.57b-d	8.09a-d	18.19a-d	26.86ab	5.76gh	2.22ab	2.59gh
	200kg S/fed+15ppm Cu	69.33a-c	8.11bc	0.62b-d	8.84ab	17.54a-d	27.01ab	6.03e-g	1.97a-c	3.06b-e
	100kg S/fed+30ppm Cu	70.60a	8.10bc	0.70a-c	8.27a-d	22.36a	31.33a	6.31c-f	2.19ab	2.88ef
	200kg S/fed+30ppm Cu	70.10ab	9.12ab	0.89a	9.11a	21.37ab	31.37a	6.48b-d	2.30ab	2.81ef

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

Table 3: Effect of nitrogen rates,and sulphur and coper application on yield and its components of onion plants.

Treatments	Yield and its components (ton/fed.)						
	First grade	Second grade	Third grade	Fourth grade	Total Yield	Marketable Yield	Exportable Yield
Nitrogen rates(kg/fed.)			First season(2005/2006)				
80.	4.86b	5.37a	2.58a	0.61a	13.43b	12.82b	10.24b
120	6.34a	5.01a	2.25a	0.67a	14.27a	13.60a	11.34a
			Second season (2006/2007)				
80.	7.63b	2.38a	0.85a	0.31a	11.17b	10.85b	10.00b
120	9.65a	2.61a	0.69b	0.35a	13.21a	12.97a	12.27a
Sulphur and copper application			First season(2005/2006)				
Control	4.43b	4.97a	2.27a	0.57a	12.27c	11.69c	9.42c
100kg S/fed.	4.96b	4.85a	2.30a	0.76a	12.93c	12.17bc	9.78c
200kg S/fed	5.20ab	5.09a	2.39a	0.51a	13.20bc	12.69bc	10.29bc
15ppm Cu	5.67ab	5.40a	2.53a	0.60a	14.25ab	13.62ab	11.08ab
30ppm Cu	5.66ab	5.33a	2.56a	0.64a	14.20ab	13.56ab	10.99b
100kgS/fed.+15ppm Cu	5.65ab	5.35a	2.14a	0.62a	13.77abc	13.15abc	11.00b
200kg S/fed+15ppm Cu	6.13a	5.31a	2.75a	0.69a	14.90a	14.20a	11.45a
100kg S/fed+30ppm Cu	6.46a	5.10a	2.17a	0.62a	14.37ab	13.74ab	11.56a
200kg S/fed+30ppm Cu	6.24a	5.29a	2.53a	0.70a	14.78a	14.07a	11.54a
			Second season (2006/2007)				
Control	6.87c	2.85a	0.74a	0.31a	10.75c	10.44c	9.69c
100kg S/fed.	8.50a-c	2.16a	0.96a	0.77a	11.90bc	11.63abc	10.67bc
200kg S/fed	8.34bc	2.49a	0.90a	0.27a	12.01abc	11.74abc	10.83bc
15ppm Cu	7.75 bc	2.47a	0.73a	0.27a	11.24bc	10.97bc	10.23bc
30ppm Cu	8.53a-c	2.09a	0.79a	0.26a	11.69bc	11.41abc	10.62bc
100kgS/fed.+15ppm Cu	8.79a-c	2.67a	0.62a	0.28a	12.38abc	12.09abc	11.46abc
200kg S/fed+15ppm Cu	8.92a-c	2.34a	0.76a	0.28a	12.32abc	12.03abc	11.26abc
100kg S/fed+30ppm Cu	9.54ab	2.94a	0.73a	0.25a	13.47ab	13.22ab	12.48ab
200kg S/fed+30ppm Cu	10.51a	2.47a	0.70a	0.28a	13.97a	13.69a	12.98a

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

treatments increased the marketable and exportable yield as a result of increase in the 1st grade yield. The same data reveal that the other grades of yield (2nd, 3rd, 4th grades) were not significantly affected. These results attribute to the increment in vegetative growth (Table 1) which turn on yield especially 1st grade and hence the increment in total, marketable and exportable yields. In this connection El-Desuki[9] found that application of sulphur caused increase in NPK uptake, which reflected on yield[18,23]. Nasreen *et al.* [22] found that yield of onion significantly increased with increasing S up to 40 kg /ha. and therefore decreased, while Skwierawska *et al.*[27] found that the most beneficial effect on onion yield was produced by the rates of 40 and 80 kg S/hectare.

- Effect of Interaction Between Nitrogen Levels with Sulphur and Copper Application: It is clear from the date shown in Table 4 that the interaction between the highest level of N (120 kg/fed.) with the two rates of sulphur (100 and 200 kg /fed.) and copper (15 or 30 ppm) in the 1st season and the combination between 120 kg N / fed. with 200kg S/fed. + 30 ppm Cu in the second one was the best combinations for increasing the yield of 1st grade.

Concerning the second grade, the same data reveal that application of 80 kg N with 100or 200 kg S/fed. + spray with 30 ppm Cu in the first season and application of 120 kg N/ fed. Only (control treatment), in the second season, recorded the highest values. On the other hand, the combination between 120 kg N/ fed. with 200 kg S/ fed. + 30 ppm Cu recorded the first rank of 4th grade, but this position was reversed in the second season wherein recorded the lowest value. The difference between the two seasons yield grades owe to the difference in plant density/ m^2.

It could be concluded that application of 120kg N/fed. with 200kg S/fed. +foliar spray with 30ppm Cu was the best combination treatment for increasing total, marketable and exportable yields. These results may be due to the increment in the yield of the 1st and 3rd grades in the first season and the increment in the 1st grade yield in the second season as a result of the vital role of S, N and Cu on soil properties and plant metabolism which increased plant growth (Table 2) and consequently increased the previous yield components. In this trend, Nasreen *et al.*[22] found that the combined application of N up to 120 kg and 40 kg S/ha showed a significant synergistic effect on the bulb yield of onion.

Storability:

- Effect of Nitrogen: It is obvious from Table (5) that application of 120 kg N/fed. significantly increased weight loss of onion bulbs. The weight loss rate reached at the end of storage season to 25.6% and 9.42% in the 1st and 2nd season, respectively. The Decrease in the storability of onion due to application of high rate of nitrogen may be owed to the high content of moisture in bulbs. It also may be owe to the deficit of Cu uptake as a result of application of high dose of nitrogen[13] which play a principle role for increasing plant cells resistance to pathogenic reasons. Similar results were found with Rodriguez and Valenzuela[26] who found that application of N increased weight losses of stored bulbs.

- Effect of Sulphur and Copper: Weight loss percentage was significantly decreased with application of sulphur or Cu and their combination compared to control treatment. Spraying onion plants by Cu at a concentration of 30 ppm with application of 100 or 200 kg S/fed. recorded the highest ability to storage wherein recorded the lowest value of bulbs weight (%) approximately in both seasons (Table 5). The high ability of onion bulbs due to application of sulphur and copper may be owe to:

- Application of sulphur increased the availability of some microelements such as Cu[12] which increased the storability of onion.
- Copper is a constituent of several enzymes such as phenolases. Phenolases are responsible for the biosynthesis of lignin and in the production of infection resistance chemicals (quinones, tannins and melanin) in plants[29].
- Copper is important to the formation of lignin in plant cell walls which contributes to the structural strength of the cells and plants and also affect the storage ability of fruits.
- Copper is essential for lignifications, a process that form, stabilizes and strengths cell walls and membranes. A copper deficiency weakness cell walls and reduces skin strength and thickness. In this connection, Quareshia and Lawandek[24] found that storage losses of onion bulb were reduced by 10.4 % over a period of 6 months storage due to application of 45 kg S ha/ in comparison to only NPK. It is also makes both the plant and bulb more susceptible for disease and copper improved storage life of onion.

- Effect of Interaction Between Nitrogen Levels with Sulphur and Copper Application: It could be concluded from the data showed in Table (6) that application of 120 kg N/fed. alone (control treatment) decreased the storability of onions which expressed as weight loss(%)[26] while application of the low rate of N (80 kg/fed.) recorded the lowest value of weight loss% when combined with 100 kg S/fed. and spraying with 30 ppm Cu. These results may be owe to the

Table 4: Effect of interaction between nitrogen rates and sulphur and copper application on yield and its components of onion.

Nitrogen rates (kg/fed)	Treatments Sulphur and copper application	Yield and its components (ton/fed.) First grade	Second grade	Third grade	Fourth grade	Total Yield	Marketable Yield	Exportable Yield
		First season(2005/2006)						
80	Control	3.95c	4.04b	3.12ab	0.61a	11.72c	11.16b	8.03b
	100kg S/fed.	4.08bc	4.79ab	3.37ab	0.70a	12.95abc	12.25ab	8.8b
	200kg S/fed	4.21bc	4.96ab	2.75ab	0.40a	12.34bc	11.93ab	9.17ab
	15ppm Cu	4.80bc	5.59ab	2.77ab	0.57a	13.75ab	13.17ab	10.40ab
	30ppm Cu	4.57bc	5.67ab	3.15ab	0.63a	14.03ab	13.40ab	10.25ab
	100kgS/fed.+15ppm Cu	4.92bc	5.7ab	1.96b	0.50a	13.13ab	12.63ab	10.66ab
	200kg S/fed+15ppm Cu	5.42abc	5.70ab	3.00ab	0.71a	14.84ab	14.13ab	11.13ab
	100kg S/fed+30ppm Cu	6.18ab	5.80a	1.43b	0.62a	14.04ab	13.42ab	11.98ab
	200kg S/fed+30ppm Cu	5.62ab	6.04a	1.64b	0.70a	14.01ab	13.31abb	11.66ab
120	Control	4.90abc	5.90a	1.41b	0.52a	12.76bc	12.23ab	10.81ab
	100kg S/fed.	5.8abc	4.91ab	1.40b	0.81a	12.91abc	12.09ab	10.69ab
	200kg S/fed	6.18ab	5.23ab	2.02ab	0.62a	14.0ab	13.44ab	11.41ab
	15ppm Cu	6.54ab	5.21ab	2.30ab	0.68a	14.74ab	14.06ab	11.76a
	30ppm Cu	6.74ab	4.99ab	1.96b	0.65a	14.37ab	13.71ab	11.74ab
	100kgS/fed.+15ppm Cu	6.37a	4.97ab	2.32ab	0.74a	14.41ab	13.67ab	11.34ab
	200kg S/fed+15ppm Cu	6.84a	4.92ab	2.51ab	0.67a	14.95ab	14.28ab	11.76a
	100kg S/fed+30ppm Cu	6.74ab	4.40ab	2.91ab	0.63a	14.69ab	14.06ab	11.14ab
	200kg S/fed+30ppm Cu	6.87a	4.55ab	3.42a	0.71a	15.55a	14.84a	11.42ab
		Second season (2006/2007)						
80	Control	6.44e	2.56a-d	0.86a-c	0.34b	10.13e	9.78e	8.92e
	100kg S/fed.	7.69c-e	2.01cd	0.90a-c	0.39b	11.00c-e	10.61c-e	9.70de
	200kg S/fed	7.30c-e	2.27a-d	1.09a	0.31b	10.98c-e	10.66c-e	9.57de
	15ppm Cu	6.64de	2.55a-d	0.79a-c	0.28b	10.27de	9.98de	9.19e
	30ppm Cu	7.89c-e	1.77d	0.91a-c	0.29b	10.87c-e	10.57c-e	9.66de
	100kgS/fed.+15ppm Cu	7.68c-e	2.52a-d	0.59bc	0.30b	11.10c-e	10.79c-e	10.20c-e
	200kg S/fed+15ppm Cu	8.03c-e	2.12b-d	0.80a-c	0.31b	11.28c-e	10.95c-e	10.14c-e
	100kg S/fed+30ppm Cu	8.14c-e	2.96ab	0.80a-c	0.26b	12.18b-e	11.91b-e	11.10c-e
	200kg S/fed+30ppm Cu	8.87b-e	2.66a-d	0.89a-c	0.28b	12.72a-e	12.43a-e	11.54b-e

Table 4: Continue

120	Control	7.31c-e	3.14a	0.63a-c	0.27b	11.37c-e	11.09c-d	10.45c-e
	100kg S/fed.	9.32b-d	2.31a-d	1.01ab	1.15a	12.81a-e	12.65a-e	11.63b-e
	200kg S/fed	9.39b-d	2.71a-c	0.71a-c	0.22b	13.04a-d	12.81a-d	12.10a-d
	15ppm Cu	8.87b-e	2.39 a-d	0.68a-c	0.26b	12.21b-e	11.95b-e	11.27b-e
	30ppm Cu	9.16b-e	2.42a-d	0.67a-c	0.23b	12.50a-e	12.26a-e	11.59b-e
	100kgS/fed.+15ppm Cu	9.91a-c	2.82a-c	0.65a-c	0.26b	13.65a-c	13.38a-c	12.73a-c
	200kg S/fed+15ppm Cu	9.82a-c	2.55a-d	0.73a-c	0.25b	13.37a-c	13.11a-c	12.38a-d
	100kg S/fed+30ppm Cu	10.95ab	2.91a-c	0.66a-c	0.23b	14.77ab	14.53ab	13.87ab
	200kg S/fed+30ppm Cu	12.15a	2.28a-d	0.52c	0.28b	15.23a	14.94a	14.42a

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

Table 5: Effect of nitrogen rates and sulphur and copper application on onion bulbs weight loss (%).

Treatments	Weight loss (%)			Weight loss (%)		
	120 dayes	150 dayes	180 dayes	120 dayes	120 dayes	180 dayes
Nitrogen rates(kg/fed.)	First season(2005/2006)			Second season (2006/2007)		
80.	6.52b	8.05b	10.64b	7.00b	10.11a	10.96b
120.	8.92a	11.79a	14.32a	8.28a	10.78a	12.10a
Sulphur and copper application	First season(2005/2006)			Second season (2006/2007)		
Control	11.13a	13.39a	16.07a	8.38a	11.66a	13.00a
100kg S/fed.	9.39ab	10.70ab	13.13b	8.04a	10.68ab	12.37ab
200kg S/fed	8.25ab	10.48ab	13.32b	7.93a	10.80ab	12.22ab
15ppm Cu	7.65ab	10.28ab	13.25b	7.94a	10.49ab	11.82abc
30ppm Cu	7.25ab	9.99abc	12.04bc	7.78a	10.39ab	11.95abc
100kgS/fed.+15ppm Cu	7.05ab	8.72bc	11.86bc	7.49a	10.29abc	11.04bc
200kg S/fed+15ppm Cu	6.59abc	9.06abc	11.07bc	6.91a	10.11bc	10.76c
100kg S/fed+30ppm Cu	6.62bc	8.57bc	10.70c	7.40a	9.88c	10.41c
200kg S/fed+30ppm Cu	5.57 c	8.12c	10.91c	6.89a	9.78c	10.25c

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

Table 6: Effect of interaction between nitrogen rates and sulphur and copper application on onio bulbs weight loss (%)

	Treatments	Weight loss (%)			Weight loss (%)		
		120 dayes	150 dayes	180 dayes	120 dayes	120 dayes	180 dayes
Nitrogen rates X Sulphur and copper application (kg/fed.)			First season(2005/2006)			Second season (2006/2007)	
80	Control	9.38ab	11.36ab	14.04a-c	7.64ab	10.89b-d	12.09a-d
	100kg S/fed.	8.52ab	8.43ab	11.20bc	7.46ab	10.20b-d	11.43b-e
	200kg S/fed	7.47ab	8.74ab	12.06a-c	7.47ab	10.49b-d	11.45b-e
	15ppm Cu	6.32ab	8.20ab	12.25a-c	7.33ab	10.40b-d	11.44b-e
	30ppm Cu	5.54b	7.84ab	10.27bc	7.25ab	10.23b-d	11.22b-e
	100kgS/fed.+15ppm Cu	6.00ab	6.68b	9.93bc	6.79ab	10.19b-d	10.71de

Table 6: Continue

	200kg S/fed+15ppm Cu	5.61b	8.04ab	8.97bc	6.02b	9.80b-d	10.68de
	100kg S/fed+30ppm Cu	5.54b	6.77b	8.14c	6.96ab	9.47cd	9.87e
	200kg S/fed+30ppm Cu	4.33b	6.43b	8.89bc	6.08b	9.38d	9.80e
120	Control	12.87a	15.41a	18.10a	9.12a	12.43a	13.92a
	100kg S/fed.	10.27ab	12.97ab	15.06ab	8.62ab	11.16ab	13.32ab
	200kg S/fed	9.02ab	12.21ab	14.58ab	8.39ab	11.11a-c	13.00a-c
	15ppm Cu	8.97ab	12.36ab	14.25a-c	8.56ab	10.58b-d	12.20a-d
	30ppm Cu	8.97ab	12.14ab	13.81a-c	8.30ab	10.54b-d	12.69a-d
	100kgS/fed.+15ppm Cu	8.10ab	10.77ab	13.79a-c	8.20ab	10.38b-d	11.37b-e
	200kg S/fed+15ppm Cu	7.56ab	10.10ab	13.17a-c	7.81ab	10.43b-d	10.85c-e
	100kg S/fed+30ppm Cu	7.71ab	10.37ab	13.27a-c	7.83ab	10.30b-d	10.94c-e
	200kg S/fed+30ppm Cu	6.81ab	9.82ab	12.93a-c	7.70ab	10.18b-d	10.70de

Values having the same alphabetical letter(s) did not significantly differ at 0.05 level of significance, according to Duncan's multiple range test.

effect of high level of N on the content of moisture in bulbs and decreasing the availability to storage, as well as the progressive effect of S and Cu for increasing onion bulbs storability. Quareshia and Lawandek[24] found that storage losses of onion bulb were reduced by 10.4 % over a period of six months storage due to the combination of 45 kg S with 100 kg N/ha. compared to NPK only.

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