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ONION PLANT GROWTH AND YIELD AS AFFECTED BY NITROGEN, POTASSIUM AND SULPHUR COMBINATIONS UNDER EL-ARISH REGION CONDITIONS

Ayatullah E. El-Morsy*, A.A.I. El-Kassas[1] and E.M. El-Tantawy[1]

1. Plant Prod. Dept., Fac. Environ. Agric. Sci., Arish Univ., Egypt

ABSTRACT

A field experiment was carried out at The Experimental Farm of Fac. Environ. Agric. Sci., Arish University, North Sinai, Egypt, during the winter seasons of 2014-2015 and 2015-2016 to study the effect of different combinations among nitrogen, potassium and sulphur levels on growth, yield, and pungency of onion (*Allium cepa* L.) cv. "White Sweet Spanish" compared to control (recommended doses of N, K and S). The results indicated that application of 150% N+ 75% K_2O+ 200% S of recommended dose was the best treatment wherein increased fresh weight of leaves, bulbs and total fresh weight as well as the dry weight of the same previous parameters and photosynthetic pigments in the 1st season. Concerning yield and its components, application of 150% N+ 75% K_2O+200% S was the best treatment for increasing the total yield and its components compared to the recommendation treatment and the other treatments. The previous treatment recorded increases of total relative yield by 131.42% and 115.77% in 1stand 2nd seasons, respectively compared to control treatment (recommended dose); increment in marketable yield by 130.95% and 112.08% in 1st and 2nd seasons, respectively; increase in relative yield of both 1st and 2nd grades which increased by 131.04% , 115.22% for the 1st grade in both seasons, respectively, and by 127.89 and 111.77% for the sum of 1st + 2nd grades in the 1st and 2nd seasons, respectively, while application of 150% N+ 75%K_2O + 100% S recorded the lowest value of bulb pungency.

Key words: Onion, nitrogen, potassium, sulphur and yield.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the important vegetable crops in Egypt, and used both in the raw and mature bulb stages as a vegetable and spice. The area cultivated in Egypt in 2015 was 192.000 fed. which produced 2.889 million ton with average of 15.5 ton/fed. (Minist. Agric., Egypt, 2016 Dept. Agric. Static.). It is the member of the genus *Allium* of the family Alliaceae. Nitrogen is an essential constituent of various enzymes. The protein content of vegetative plant organs as well as storage tissue may be influenced by N supply. It conceders the principal plant nutrient required in much greater quantities, the level of N that should be applied to a crop depends largely on particular crop species and on the prevalent soil conditions. In general, for poor soils which are low in N, the N application rate should be in excesses of the total amount of N uptake.

Un sufficient nitrogen supply may make shortage in plant growth in earlier stage.

This early senescens probably relates to the effect of the N supply on the synthesis and translocation of cytokinins. Many efforts studied the effect of N on onion plant growth, dry weight, photosynthetic pigments **(Khan *et al.*, 2002; Al-Fraihat, 2009; El-Tantawy and El-Beik, 2009;**

Corresponding author: Tel.: +201212180186
E-mail address: ayaelmorsy49@ yahoo.com

Rizk, Fatma *et al.*, 2012; Kolota *et al.*, 2013; Simon *et al.*, 2014; Biru, 2015; El-Sagan and Abd El Baset; 2015; Gessesew *et al*., 2015). Abd El-Kader *et al.* (2007) found that application of N increased pungency in onion bulbs with application up to 100 kg $Nfed^{-1}$., and it decreased with high amount of N (120 kg $Nfed^{-1}$).

Potassium is one of three major nutrients taken up by plant in large quantities, among the major nutrients, potassium plays a vital role in plant metabolism such as photosynthesis, translocation of photosynthetic substrates, regulation of plant pores, activation of plant catalysts and resistance against pests and diseases. It is also considered as a quality element as it improves quality parameters of many crops including onion. Potassium improves color, glossiness and dry matter accumulation besides improving bulb quality of onion. Application of K resulted in increments in onion plant growth and yield as recorded by **El-Bassiony (2006), Islam *et al.* (2008), Siddiquee *et al.* (2008), Verma and Singh (2012), Shafeek *et al.* (2013) and Behairy *et al*. (2015).**

Sulphur has a direct effect on soil properties which greatly decreased pH values. The positive effect of sulphur on reducing soil pH values may be attributed to the oxidation of sulphur to sulphoric acid by many species of soil microorganisms. The decrease of soil pH improves the availability of microelements such as Fe, Zn, Mn, and Cu and improves the chemical properties of sandy soil, as well as it conceders 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 (**Mengel and Kirkby, 1978**). 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.

Onion is an important sulphur-loving crop and it is required for proper growth and yield of onion. Sulphur has been found not only to increase the bulb yield but also it improves its quality especially flavors and pungency. Sulphur containing secondary compounds is of importance for nutritive value and flavors as well as for resistance against pests and diseases and consequently increased plant growth and yield (**Kil *et al.*, 2006; Al-Fraihat, 2009; El-Tantawy and El-Beik, 2009; Lee *et al.*, 2009; Rizk, Fatma *et al.*, 2012; Mishu *et al.*, 2013; de Souza *et al*., 2015).** So, this work aimed to study the effect of N, K, and S in different combinations on productivity and quality of onion (*Allium cepa* L.) cv. White Sweet Spanish under El Arish region conditions.

MATERIALS AND METHODS

A field experiment was carried out at The Experimental Farm of Fac. Environ. Agric. Sci., Arish Univ., North Sinai, Egypt, during the winter seasons of 2014-2015 and 2015-2016. The main object of this work was to study the effect of nitrogen, potassium and sulphur combinations on growth, yield, and pungency of onion (*Allium cepa* L.) cv. "White Sweet Spanish".

White Sweet Spanish' produces a large and globed shaped white onion. A medium to fair storage onion. Onions are mild, sweet and have a white skin. Soil received 30 m^3 compost (Table 1c).

Plants were transplanted on 24th February in both seasons. Drip irrigation system was used. Double dripper lines were used, the distance between the centers of the double dripper lines was 75cm and 20 cm between the two dripper lines in each double dripper line. The transplants were transplanted in one row on each side of the dripper line at 10 cm between plants in the

Table (1a.): The physical and chemical properties of the experimental soil*

Property	1st season (2014/2015)	2nd season (2015/2016)
Physical properties		
Texture	**sandy**	**sandy**
Chemical properties		
pH	7.8	7.9
EC (dSm^{-1})	1.3	0.98
Total N (ppm)	16.22	15.83
Total P (ppm)	0.33	0.34
Total K (ppm)	0.79	0.63

* Soil samples were taken from the 25 cm of the soil surface.

Table (1b): The physical and chemical analyses of irrigation water

pH	EC (ppm)	Soluble ions ($meq.L^{-1}$)							
		Cations					Anions		
		Mg^{-1}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}
7.03	3513	4499	16.33	17.60	35.87	0.27	42.26	6.13	21.41

Table (1c): Analysis of organic fertilizer compost for both seasons.

Organic fertilization Content	Values
OM (%)	36.56
pH (1:10)	8.6
Total N (%)	1.24
Total P (%)	0.58
Total K (%)	1.15
Organic Carbon (%)	20.84
C/N ratio	1:16.8
Fe (%)	1.26
Mn (ppm)	578
Cu (ppm)	136
Zn (ppm)	130

Source: Center Laboratory of Organic Agriculture, Agric. Res. Center, Ministry of Agriculture.

same row. All Sulphur, and one third of nitrogen, were added to the soil during the soil preparation, while the other two thirds of N, and all doses of P and K were divided into 28 doses which were added two times weekly beginning 15 days after transplanting. N, P and K were added as ammonium sulphate, phosphoric acid and potassium sulphate, respectively.

Soil and Water Analysis

Mechanical and chemical analyses for the experimental soil as well as, analysis of irrigation water are tabulated in Tables 1a and 1b.

The study included nine treatments as follows:

1. 100% of recommended nitrogen dose (130 kg N added as NH_3 SO_4) + 100% of K_2O (150kg K_2O added as K_2SO_4) + 100% of Sulphur (200kg S) as the control treatment),
2. 75% of recommended N dose +75% of K_2O +100% S,
3. 75% of recommended N dose + 75% of K_2O +200% S,
4. 75% of recommended N dose + 150% K_2O + 100% S,
5. 75% of recommended N dose + 150% of K_2O + 200% S,
6. 150% of recommended N dose + 75% of K_2O + 100% S,
7. 150% of recommended N dose + 75% of K_2O + 200% S,
8. 150% of recommended N dose + 150% of K_2O + 100% S, and
9. 150% of recommended N dose + 150% of K_2O + 200% S.

These Nine treatments were randomly arranged in a randomized complete block design, with three replicates.

Data Recorded

Vegetative growth parameters

Samples of 3 plants of each replicate were randomly taken at 45 and 75 days after transplanting to study the vegetative growth of plants. Plant height (cm), number of leaves/plant, leaf area (cm^2)/plant (which was calculated according **Ackley, 1964**), leafe fresh weight/plant (g), bulb fresh weight/ plant (g), root fresh weight/plant(g), and total fresh weight/plant (g) were determined.

Dry weight

The plant samples were oven dried at 70^o C until the constant weight and the dry weights of root, bulb and leaves were used for calculating the total dry weight. The following traits were estimated: Leaf dry weight/plant (g), bulb dry weight/plant (g), root dry weight/plant (g), and total dry weight/ plant (g).

Photosynthetic pigments content (mg/g fresh weight)

Disks from 10 mature fresh leaves per plant were taken from each experimental unit, washed with distilled water to remove any residue, then, chlorophyll A, B and Carotene contents were determined as mg/g fresh weight using the method of **Wettestein (1957).**

Yield and its component**s**

Plants were harvested when 50% of leaves bent. Bulbs were weighed after curing and the following data were recorded: Grading**:** It was determined according to the specification of **Ministry of Agriculture and Soil Reclamation for Onion Exportation (1963).**

- Marketable yield of bulbs (ton $fed.^{-1}$): weight of grade 1 + grade 2+ grade 3,
- Unmarketable yield of bulbs (ton $fed.^{-1}$): weight of grade4+ rotted bulbs + decay bulbs.
- Total yield (ton $fed.^{-1}$). It included the marketable yield fed^{-1}. +unmarketable yield fed^{-1}
- First grade as% of total yield: (weight of 1^{st} grad / total yield)X100

- Bulb average weight of 1st grade: weight of 1st grade/ number of bulbs of 1st grad,
- Second grade as (%) of total yield: (weight of 2nd grad/total yield tonfed.$^{-1}$) X 100.
- Bulb average weight of 2ndgrade: weight of 2nd grade/ number of bulbs of 2nd grad.
- 1stand Second grad as (%) of total yield: (weight of 1st + 2nd grades)/ total yield (ton fed.$^{-1}$) X100.
- Bulb average weight of 3rd grade: weight of 3rd grade/ number of bulbs of 3rd grad.
- Bulb average weight of 4th grade: weight of 4th grade/ number of bulbs of 4th grad.
- Rotted as (%) of total yield: (weight of rotted/total yield ton fed.$^{-1}$)X 100.
- Bulb average weight: total weight of bulbs/ total number of bulbs.

Pungency analysis (pyruvic acid)

It was determined by using the method of **Schwimmer and Weston (1961)**.

Statistical Analysis

The obtained data were subjected to statistical analysis of variance according to **Snedecor and Cochran (1980),** and means separation was done according to **Duncan's multiple range test (1955)**.

RESULTS AND DISCUSSION

Effect of Treatments on Plant Growth

Plant height, number of leaves, and leaf area

Results in Table 2 show significant effects for the combinations among N, K, and S on some vegetative growth traits of onion; *viz*, number of leaves/plant, plant height, and leaf area/plant. The highest plant height was recorded with application of 150% N + 75% K_2O+ 200% S at 45 days after transplanting in both seasons, without significant differences with application of 150% N+ 150% K_2O + 200% S which recorded the highest plant height at 75 days after transplanting.

The same data show a slight significant differences among the treatments on number of leaves/plant, wherein application of high amount of nutrients increased plant height followed by the treatment of recommendation dose (control treatment). Concerning leaf area/plant the same data illustrate that application of 150% N+ 75% K_2O + 200% S was the best treatment for increasing leaf area/plant at 45 and 75 day of transplanting in both seasons without significant difference with application of 150% N+ 150% K_2O + 200% S at 75 days in 1st season.

Plant fresh weight

Data presented in Table 3 illustrate that fertilizing onion plant with 150% N + 75% K_2O + 200% S of recommended dose significantly increased fresh weight of leaves at the both periods of plant growth (45 and 75 days DAT) in both seasons without significant difference with application of 150% N + 150% K_2O + 200% S of the recommended dose at 75 days in the 1st season.

Regarding fresh weight of bulbs, data revealed that the same previous treatment for fresh weight was true for bulb fresh weight in the 1st season without significant differences between application of 150%N+ 150%K_2O +200%S. In the 2nd season, the superior treatment for the same parameter was 75% N+ 150% K_2O +200%S at 45 and 75 DAT without significant difference than application of 150% N+ 150% K_2O + 100% S at 45 DAT. On the same trend, application of 150% N+ 75% K_2O + 200% S was the best treatment which achieved the highest fresh weight of roots in the 1st season, while application of 75% N + 150% K_2O + 100% S increased fresh weight of roots at 45 and 75 DAT without significant differences than application of 75% N+ 75% K_2O + 200% S or with 150% N + 75% K_2O + 100%S at 45 DAT.

Table (2):Effect of N, K and S treatments on plant height, number of leaves, and leaf area/plant in 2014/2015 and 2015/ 2016 seasons.

Treatments	Plant height (cm)		Number of leaves/plant		Leaf area/plant (cm^2)	
	Days after transplanting					
	45	75	45	75	45	75
			First season (2014/2015)			
100%N +100% K_2O +100% S	47.33 c	76.78 ab	6.111 ab	10.44 a	209.4 c	878.8 abc
75% N + 75% K_2O +100% S	45.44 d	70.22 d	6.000abc	9.445 bc	209.5 c	746.5 de
75% N + 75% K_2O +200% S	36.89 g	63.89 e	5.556 c	9.222 c	176.7 d	618.7 f
75% N + 150% K_2O +100% S	44.22 e	75.11 bc	6.444 a	9.555 abc	238.2 b	800.8 cd
75% N + 150% K_2O +200% S	43.44 e	70.89 d	5.667 bc	9.111 c	217.7 c	689.1 ef
150% N + 75% K_2O +100% S	47.00 c	76.89 ab	6.222 a	9.445 bc	251.0 b	840.9 bcd
150%N + 75% K_2O +200% S	57.44 a	78.44 ab	6.333 a	10.00 abc	277.0 a	925.8 ab
150% N+150% K_2O +100% S	41.11 f	77.56 ab	6.333 a	9.555 abc	184.2 d	817.8 cd
150% N+ 150% K_2O+200% S	51.00 b	79.11 a	6.445 a	10.33 ab	214.4 c	968.2 a
			Second Season (2015/2016)			
100%N +100% K_2O +100% S	50.22 bc	79.33 ab	6.444 ab	9.556 a	264.2 bc	1023 b
75% N + 75% K_2O +100% S	48.00 d	75.00 c	5.889 c	9.222 ab	187.6 e	864.8 de
75% N + 75% K_2O +200% S	50.67 bc	79.22 a	6.556 a	8.778 bc	239.6 cd	960.3 bcd
75% N + 150% K_2O +100% S	49.78 cd	75.44 bc	6.333 abc	9.000 abc	224.8 d	909.0 cde
75% N + 150% K_2O +200% S	50.33 bc	76.11 bc	6.000 bc	8.556 c	249.1cd	833.9 e
150% N + 75% K_2O +100% S	49.78 cd	76.00 bc	6.000 bc	8.667 bc	282.3 b	883.7 cde
150%N + 75% K_2O +200% S	56.33 a	82.78 a	6.556 a	9.444 a	327.9 a	1228 a
150% N+150% K_2O +100% S	48.33 d	73.56 c	5.889 c	9.444 a	243.1 cd	986.0 bc
150% N+ 150% K_2O+200% S	51.89 b	80.33 a	6.444ab	9.222 ab	261.0 bc	913.3 cde

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 N, K and S combination treatments on fresh weight of leaves, bulb, root, and total fresh weight of onion plant.

Treatments	F.W of leaves (g)		F.W of bulb (g)		F.W of root (g)		Total F.W. of plant (g)	
	Days after transplanting							
	45	75	45	75	45	75	45	75
				First season (2014/2015)				
100%N +100% K_2O +100% S	13.89 bc	99.80 ab	3.233 e	58.02b	1.244 b	3.378 a	18.49 c	161.2 b
75% N + 75% K_2O +100% S	12.68 cd	78.33 de	4.144 bc	35.30 e	1.122 bc	2.600 b	18.02 c	116.2 e
75% N + 75% K_2O +200% S	9.533 e	67.31 f	4.522 b	42.12 d	0.711 d	2.300 bc	14.77 e	111.7 e
75% N + 150% K_2O +100% S	14.37 b	92.37 bc	4.078 bcd	47.40 c	0.633 d	1.844 bc	19.08 bc	141.6 d
75% N + 150% K_2O +200% S	13.89 bc	73.91 ef	3.600 cde	34.14 e	1.333 b	1.522 c	19.10 bc	109.6 e
150% N + 75% K_2O +100% S	15.16 b	93.96 b	3.528 de	55.19 b	1.289 b	2.211 bc	20.10 b	151.4 c
150%N + 75% K_2O +200% S	20.32 a	105.2 a	6.445 a	65.59 a	2.000 a	3.578 a	28.76 a	172.6 a
150% N+150% K_2O +100% S	12.33 d	84.94 cd	3.356 e	58.31 b	0.722 d	1.889 bc	16.52 d	145.1 cd
150% N+ 150% K_2O+200% S	15.07 b	105.6 a	4.311 b	63.16 a	0.989 c	2.533 b	20.43 b	171.3 a
				Second season (2015/2016)				
100%N +100% K_2O +100% S	18.18 b	94.47 b	3.489 bc	39.99 d	1.089 a	2.889 cd	22.76 bc	137.3 cd
75% N + 75% K_2O +100% S	13.94 e	84.56 c	2.967 cd	53.28 b	0.644 b	4.400 a	17.56 f	142.2 bcd
75% N + 75% K_2O +200% S	15.91 c	95.31 b	3.244 bc	37.87 d	1.244 a	2.200 e	20.40 e	135.4 d
75% N + 150% K_2O +100% S	14.58 de	84.99 c	2.533 d	38.13 d	1.022 a	4.711 a	18.13 f	127.8 e
75% N + 150% K_2O +200% S	16.38 c	83.63 c	4.833 a	60.39 a	0.622 b	2.322 de	21.83 cd	146.3 b
150% N + 75% K_2O +100% S	16.86 c	87.94 c	3.733 b	44.58 c	1.144 a	3.245 bc	21.73 d	135.8 cd
150%N + 75% K_2O +200% S	21.50 a	109.0 a	3.467bc	53.29 b	0.722 b	2.311 de	25.68 a	164.6 a
150% N+150% K_2O +100% S	15.83 cd	86.83 c	4.544a	48.02 c	0.744 b	3.400 bc	21.12 de	138.3 cd
150% N+ 150% K_2O+200% S	18.72 b	84.58 c	3.433bc	54.53 b	0.989 a	3.545 b	23.14 b	142.7 bc

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

Concerning total fresh weight of onion plant, the same results showed that fertilizing with 150%N + 75%K_2O + 200%S was the superior treatment in both seasons.

Generally, it could be concluded that the best treatment for increasing fresh weight of onion plant was the application of 150%N+ 75%K_2O +200%S of recommended dose. The increment in total fresh weight due to the high amounts of N and S may be owe to the increments in fresh weight of different plant organs; *i.e*., fresh weight of leaves, bulbs, and roots. The relative increasing in total fresh weight due to application of the same previous treatment was 155.45% and 107.07% in the 1st season at 45 and 75 DAT, respectively and 112.82% and 119.88% in the 2nd season at 45 and 75 DAT, respectively. In addition the increment in total fresh weight may be owe directly to the increment in number of leaves and leaf area/plant (Table 2). The increment in plant growth and leaf area as well as fresh weight of onion plant due to application of 150%N+ 75%K_2O + 200%S may be owe to application of high dose of N and S under sandy soils.

Plant dry weight

The results in Table 4 show that application of 150% N+ 75% K_2O +200%S has significant effect on dry weight of leaves in both seasons at 45 and 75 DAT without significant differences with application of 150%N+ 150%K_2O + 200%S at 75 and 45 DAT in the 1st and 2nd season, respectively. The same previous treatment was the superior treatment for dry weight of bulb in the 1st season, but the treatment of 75% N+ 150% K_2O + 200% S was the best one in the 2nd season at 45 and 75 DAT, without significant difference than 150% N + 150% K_2O + 200% S at 45 days and with application of 150%N+ 75% K_2O + 200%S or 150% N+ 150% K_2O+ 200% S at 75 DAT.

Concerning dry weight of roots, the same data indicated that, application of 75% N+ 150% K_2O + 100% S increased the dry weight of roots at 45 and 75 DAT in the 1st season without significant difference than recommended dose (control) at 75 days. The same treatment recorded the highest value in the 2nd season at 75 days, while application of 75% N+ 75% K_2O + 200% S was the best one at 45 DAT.

In addition, total dry weight of onion plant at 45 and 75 DAT in both seasons was significantly increased with application of 150% N+ 75% K_2O + 200%S. The relative increases in total dry weight compared to control treatment were 122.73% and 121.50%, 114.85% and 102.77% in 1st and 2nd seasons at 45 and 75 DAT, respectively. The increment in dry weight of onion plant may be owe to the increment in fresh weight of plant (Table 3).

Effect of treatments on onion photosynthetic pigments

The results in Table 5 reveal that application of 150%N+ 75%K_2O + 200%S was the best treatment which increased Chl. a, Chl. b, and caroten at 45 and 75 DAT in the 1st season. On the other hand, the treatments did not have a constant direction in the 2nd season where they fluctuated mainly among the same previous treatments and other treatments. However, it could be said that application of 150% N+ 75% K_2O + 200% S increased photo-assimilation pigments of onion plant in the 1st season particularly.

These results may be owed to the roles of N and S in assimilation of photosynthetic pigments. In this connection, **Kolota *et al.* (2013)** found increments in photosynthetic pigments (chl. a+ b, and carotene) in onion plants. So, it could be said that, the increment in plant growth expressed in number of leaves/plant, leaf area, both of fresh and dry weight as well as photosynthetic pigments as shown in Tables 2, 3, 4, 5 due to application of 150% N+ 75% K_2O + 200% S may be related to fertilization with high amounts of N and S under poor soils (sandy and calcareous soils).

Table (4): Effect of N, K and S combination treatments on dry weight of leaves, bulb, root, and total dry weight of plant onion.

Treatments	D.W of leaves (g)		D.W of bulb (g)		D.W of root (g)		Total Dry weight of plant (g)	
	Days after transplanting							
	45	75	45	75	45	75	45	75
	First season (2014/2015)							
100%N +100% K_2O +100% S	1.368 b	7.533 cd	0.2557 h	4.356 bc	0.2677 b	0.6223 a	1.891 b	12.51 bc
75% N + 75% K_2O +100% S	1.054 d	6.100 ef	0.3823 b	3.100 de	0.2043 g	0.4300 abc	1.640 c	9.630 d
75% N + 75% K_2O +200% S	0.835 e	5.155 f	0.2723 g	3.611 cd	0.1580 h	0.3123 bc	1.265 d	9.079 d
75% N + 150% K_2O +100% S	1.267 bc	6.922 de	0.3567 d	3.867 bcd	0.3073 a	0.5057 ab	1.931 b	11.29 c
75% N + 150% K_2O +200% S	1.110 cd	9.944 b	0.3143 e	2.456 e	0.2313 d	0.2223 c	1.656 c	11.13 c
150% N + 75% K_2O +100% S	1.431 b	7.533 cd	0.2810 f	4.478 b	0.2067 f	0.3267 bc	1.919 b	12.34 bc
150%N + 75% K_2O +200% S	1.779 a	10.55 ab	0.4077 a	5.489 a	0.1343 i	0.2857 c	2.321 a	15.20 a
150% N+150% K_2O +100% S	1.134 cd	8.400 c	0.2857 f	4.422 bc	0.2287 e	0.2733 c	1.649 c	13.10 b
150% N+ 150% K_2O+200% S	1.364 b	11.33 a	0.3737 c	3.600 cd	0.2553 c	0.3357 bc	1.994 b	15.27 a
	Second season (2015/2016)							
100%N +100% K_2O +100% S	1.587 b	8.111 d	0.3123 b	4.533 b	0.2280 b	0.4867 c	2.127cd	15.11 a
75% N + 75% K_2O +100% S	1.313 c	9.318 b	0.2910 b	4.667 b	0.1800 h	0.5833 b	1.784 f	14.56 c
75% N + 75% K_2O +200% S	1.489 b	9.011 b	0.3190 b	3.587 e	0.2847 a	0.2943 i	2.092cde	12.89 e
75% N + 150% K_2O +100% S	1.516 b	6.833 e	0.2263 c	3.267 f	0.2200 c	0.6567 a	1.962 e	10.75 i
75% N + 150% K_2O +200% S	1.444 bc	5.922 f	0.4643 a	5.070 a	0.1443 i	0.3557 g	2.052 de	11.34 g
150% N + 75% K_2O +100% S	1.552 b	6.833 e	0.3133 b	3.911 d	0.2157 d	0.3647 f	2.081 de	11.11 h
150%N + 75% K_2O +200% S	1.928 a	10.11 a	0.3033 b	4.933 a	0.2120 e	0.3200 h	2.443 a	15.53 a
150% N+150% K_2O +100% S	1.566 b	7.973 d	0.4590 a	4.222 c	0.2057 f	0.4420 d	2.230 bc	12.64 f
150% N+ 150% K_2O+200% S	1.812 a	8.589 c	0.2863 b	4.889 a	0.1957 g	0.4100 e	2.294 b	13.89 d

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 N, K and S combination treatments on onion photosynthetic pigments.

Treatments	Chl. a (mg/g F.W.)		Chl. b (mg/g F.W.)		Caroten (mg/g F.W.)	
	Days after transplanting					
	45	75	45	75	45	75
	First season (20114/2015)					
100%N +100% K_2O +100% S	1.830f	1.480b	1.838 c	1.485cd	1.831c	2.062bc
75% N + 75% K_2O +100% S	1.940e	1.458b	1.784 c	1.375d	1.795cd	1.686e
75% N + 75% K_2O +200% S	1.745f	1.867a	1.66 c	1.817ab	1.618d	1.995c
75% N + 150% K_2O +100% S	2.219cd	1.848a	2.281a	1.848ab	1.975bc	2.154b
75% N + 150% K_2O +200% S	2.164d	1.578b	2.245 a	1.567c	1.923bc	2.034bc
150% N + 75% K_2O +100% S	2.338b	1.790a	2.021b	1.754b	1.942bc	2.157b
150%N + 75% K_2O +200% S	2.466a	1.786a	2.322a	1.894a	2.352a	2.407a
150% N+150% K_2O +100% S	2.304bc	1.598b	2.166ab	1.551c	2.060b	1.823de
150% N+ 150% K_2O+200% S	2.254bcd	1.561b	2.220a	1.543c	1.987bc	1.847d
	Second season (20115/2016)					
100%N +100% K_2O +100% S	1.924bc	2.423a	1.654d	1.852c	1.750 bc	2.196a
75% N + 75% K_2O +100% S	1.653d	1.962b	2.016ab	2.013b	1.772b	2.311a
75% N + 75% K_2O +200% S	2.015bc	1.800bcd	1.720d	1.680c	1.958a	2.026b
75% N + 150% K_2O +100% S	1.860c	1.776cd	1.941bc	1.799c	1.630c	1.871bc
75% N + 150% K_2O +200% S	1.977bc	1.748d	1.94bc	1.792c	1.883ab	2.031b
150% N + 75% K_2O +100% S	1.619d	2.024ab	1.641d	1.928c	1.625c	2.229a
150%N + 75% K_2O +200% S	2.333a	2.200ab	2.140 a	2.462a	1.839ab	1.771c
150% N+150% K_2O +100% S	2.105b	2.032ab	2.102a	2.237b	1.801b	2.019b
150% N+ 150% K_2O+200% S	2.428a	2.222ab	1.863c	1.858c	1.805b	1.910bc

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

It is well known that nitrogen has a vital factor in plants grown in alkaline soils which have high pH. Total amount of N and its availability related to soil environment such as soil pH. Under alkaline or calcareous soils, nitrogen converted from NH_4 to NO_3 through nitrification process by soil bacteria and is most rapid in soil and moves freely with soil water. So, soil pH is very important to increase the availability and use efficiency of nitrogen and other nutrients. Under these conditions, application of sulphur has a benefit role which greatly decreased pH values **(Abd El-Kader *et al.*, 2007)** through oxidation of sulphur to sulphoric acide by micro-organisms. **Khafagi and Abd El-Hadi (1990) and El-Eweddy *et al.* (2005)** who added that EC values of soil was clearly decreased as affected by sulphur application rates.

Adding sulphur to soil had a favorable effect on reducing soil pH, and increasing the availability of certain plant nutrients in the soil **(El-Galla *et al.*, 1989).**

The obtained results due to application of high rate of S (150 kg K_2Ofed^{-1}.) are in coincide with those reported by **Shafeek *et al.* (2013)** who found that the highest onion plant growth values were recorded with application of 300 Kg S Fed^{-1}. Also results are in accordance with those of **Abd El-Aal *et al.* (2005), El-Bassiony (2006) and El-Desuki *et al.* (2006)**.

Sulphur has a positive effect on reducing soil salinity that may be due to an increment in the solubility of ions as a result of S oxidation to sulphuric acid. Therefore, more soluble salts may be laced out and move with free soil water. The decrease of soil pH improves the availability of microelements as Fe, Zn, Mn and Cu **(Hetter, 1985)** and improve the chemical properties of alkaline soil. Nitrogen had a pronounce role in plant metabolism. It`s a constituent of proteins, enzymes, hormones, vitamins, chlorophyll **(Reddy and Reddi, 2002)** and leaf area/ plant (Table 1) leading to high rate of photo-assimilation and consequently increases in plant growth expressed in fresh and dry weight of plant.

Likewise, application of sulphur increase plant growth through decreasing pH and increase cation exchange capacity (CEC) and releasing micronutrients as Fe and Cu which lead to an increment in photosynthesis. In addition sulphur plays an important role in plant metabolism. It had a main function in proteins or polypeptides formation. Participate to the formation of enzymes proteins and enzyme reactions as reported by **Mengel and Kirkby (1978)**.

They added that sulphur is a constituent of CoA of the vitamins biotin and thiamine (sulphur is an essential element in thiazole ring which is a component of thiamine) which associated (Biotin) with CO_2 fixation and decarboxylation reactions.

In this connection **El-Tantawy and El-Beik (2009)** found that application of N at a rate of 120 Kg N/fed., increased the vegetative growth and dry weight of onion plant significantly under the same region of this study and their results were due to application of S at a rate of 200 Kg fed^{-1}., compared to control. In this connection, the increase in onion plant height, number of leaves/plant, length and diameter of leaves, leaf area and crop growth rate due to application of N were found by **Brewster and Butler (1989), Kumar *et al.* (1998), and Islam *et al.*(1999).** In addition **Nasreen *et al.* (2003)** found that the combination between 45 Kg S ha^{-1} and 120 Kg N ha^{-1} increased crop growth rate (CGR) and relative growth rate (RGR) of onion.

Additionally, **Al-Fraihat (2009)** found that the highest level of N (200 Kg Nha^{-1}) increased plant height and number of green leaves/plant as compared with control (100 Kg Nha^{-1}) he indicated that the increment in plant growth due to the addition of nitrogen to the high level that enhanced 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. He added that addition sulphur to onion plants increased plant height and number of green leaves up to 100 Kg S ha^{-1} without significant differences with 50 kg S ha^{-1}. The lowest plant height was obtained with the interaction between 100 kg N+ 0.0 kg S ha^{-1}., while, the highest plant height was with 200 kg N ha^{-1}+ 50 kg S ha^{-1}.

Rizk Fatma*et al.* (2012), Simon *et al.* (2014) and Gessesew *et al.* (2015) found that increment in plant growth was due to increase in N fertilization. On the other hand, **Khan *et al.* (2002)** found an increase in onion plant hight and number of leaves/ plant with application of moderate dose of N (100 kg ha^{-1}.), while increasing the doses of nitrogen decreased onion plant height. Likewise, the increment due to addition of N and S may be attributed to the role of N in building up protoplasm and proteins, which induce cell division and meristematic activity resulting in more plant cells which increase plant growth **(Devlin, 1979).**

Many investigators reported that application of high rates of N and S resulted in higher plant height, maximum number of leaves, higher fresh and dry weight of onion plant **(Mozumder *et al.,* 2007; Rizk Fatma *et al.,* 2012)**. They owed their results to application of sulphur which helps in the availability of other nutrients resulting in better growth and increased uptake of all the nutrients at higher levels of sulphur. Application of S at a moderate dose (40 kg ha^{-1}) increased leaf area compared to low (0.0, 20 kg S ha^{-1}) or high levels of S (60, 80 kg S ha^{-1}) as showed by **Mishu *et al.* (2013).**

Effect of treatments on yield and its component

Results in Tables 6 and 7 illustrate that combination among N, K and S as 150% N+ 75% K_2O + 200% S increased yields of 1st and 2nd grades in both seasons. Application of 150% N+150% K_2O + 200% S increased avg. bulb weight of 1st, 2nd, 3rd and 4th, grade in both seasons. The increment in average bulb weight of 1st and 2nd grades led to the increment in yield of the same grades. The decrease of 3rd and 4th grades may be owe to the increment in yields of 1st and 2nd grades.

Concerning the marketable yield, the same data indicate that application of 150% N + 75% K_2O + 200% S was the best treatment for increasing the marketable yield. This increment in marketable yield may be owe to the increase in the yields of 1st and 2nd grades which consists most marketable yield. Regarding decay and rotted yields, the data in Table 7 reveal that application of 75%N+ 150%K_2O + 100% S increased the rotted yield without significant differences with application of 150% N+ 75% K_2O +200% S in the 2nd season. The same previous treatment (75% N+ 150% K_2O + 100% S) increased the decay yield in the 1st season, but it increased in the 2nd season with application of the highest rates of N, K and S (150%N + 150%K_2O + 200% S).

So that, the total of unmarketable yield was increased with application of 75% N+ 150% K_2O + 100% S in both seasons without significant differences with application of 150% N+ 150%K_2O + 200% S in the 2nd season. This increment in unmarketable yield may be mainly owe to the increment in rotted and decay yield.

With regard to total yield, the same data in Table 7 show that fertilizing onion plants with 150% N + 75% K_2O + 200% S was the superior treatment to increase the total yield in both seasons without significant differences with application of 150%N+ 150% K_2O + 200% S and 75% N+ 150% K_2O + 100% S in the second season. The increment on total yield due to application of 150% N+ 75% K_2O + 200% S is mainly due to the increment in bulb weight, the yield of 1st and 2nd grades as well as the increase of yield/m^2. However, the increment

Table (6): Effect of N, K and S combination treatments on yield of 1st, 2nd, 3rd, 4th, and marketable yield of onion in 2014/ 2015 and 2015/ 2016 seasons.

Treatments	1st grade			2nd grade				3rd grade		4th grade		Marketable yield	
	Bulb avg. wt. (g)	ton/ fed.	As(%) of total	Bulb Avg. Wt. (g)	ton/ fed.	as% of total	1st&2nd as (%)	Bulb avg. wt. (g)	ton/fed	Bulb avg. wt. (g)	ton/fed.	ton/fed.	as (%) of total
First season (2014/2015)													
100%N +100% K_2O +100% S	162.3 c	11.37 c	66.53 c	90.64 b	3.494 b	20.44 b	86.97 b	39.85 e	0.857 g	0.000 d	0.000 g	15.54 cd	91.70 b
75% N + 75% K_2O +100% S	180.1 bc	10.79 c	68.16 bc	79.90 cd	2.375 d	15.00 cd	83.16 d	47.08 cd	1.439 b	19.91 b	0.494 d	14.60 de	92.22 b
75% N + 75% K_2O +200% S	160.0 c	5.935 f	60.07 d	73.10 d	1.220 e	12.34 d	72.41 e	42.90 de	1.116 f	16.38 c	0.582 c	8.271 g	83.65 c
75% N + 150% K_2O +100% S	182.5 ab	6.795 e	46.38 f	97.51 ab	2.510 d	17.13 bc	63.51 f	55.63 b	1.222 de	20.81 b	0.292 ef	10.53 f	71.82 d
75% N + 150% K_2O +200% S	186.5 ab	9.126d	61.04 d	92.43 ab	3.661 b	24.48 a	85.52 bc	61.96 a	1.191 ef	28.96 a	0.847 a	13.98 e	93.44 b
150% N + 75% K_2O +100% S	175.2 bc	8.927d	53.07 e	102.6 a	3.433b	20.41 b	73.48 e	45.07 de	1.647 a	23.07 b	0.760 b	14.01 e	83.29 c
150%N + 75% K_2O +200% S	183.8 ab	14.90 a	66.36 cd	94.69 ab	4.112 a	18.31bc	84.67 cd	52.57 bc	1.335 c	30.06 a	0.547 cd	20.35 a	90.60 b
150% N+150% K_2O +100% S	174.9 bc	12.79 b	73.59 ab	88.04 bc	2.741 c	15.77bcd	89.36 a	40.91 de	1.492 b	22.00 b	0.252 f	17.02 b	97.88 a
150% N+ 150% K_2O+200% S	211.9a	12.66 b	74.82 a	102.3 a	2.424 d	14.32 cd	89.14 a	40.08 e	1.290 cd	23.31 b	0.311 e	16.38 bc	96.75 a
Second season (2015/2016)													
100%N +100% K_2O +100% S	188.3 ab	12.94 b	75.06 d	78.41 c	2.241 a	13.01 b	88.07 a	41.58 ab	0.130 a	0.000 d	0.000 f	15.31 abc	88.76 c
75% N + 75% K_2O +100% S	175.3 ab	10.91 c	70.17 e	85.01 b	2.140 a	13.76 a	83.93 c	43.00 ab	0.336 a	0.000 d	0.000 f	13.39 de	86.11 d
75% N + 75% K_2O +200% S	166.9 b	10.27 c	69.74 e	75.79 c	1.571 b	10.67 c	80.41 d	38.50 b	0.490 a	21.44 b	0.033 d	12.33 e	83.71 e
75% N + 150% K_2O +100% S	173.0 ab	13.16 b	73.32 d	85.81b	1.329 c	7.404 f	80.72 d	30.88 c	0.563 a	0.000 d	0.000 f	15.05 bcd	83.72 e
75% N + 150% K_2O +200% S	182.5 ab	12.54 b	81.57 b	65.81d	1.118 c	7.276 f	88.85 a	25.22 d	0.283 a	0.000 d	0.000 f	13.94 cde	90.69 a
150% N + 75% K_2O +100% S	181.2 ab	14.94 a	84.27 a	65.34 d	0.700 d	3.951 g	88.22 a	42.76 ab	0.466 a	22.45 b	0.120 c	16.11 ab	90.94 a
150%N + 75% K_2O +200% S	183.5 ab	14.91 a	74.70 d	89.99 ab	2.058 a	10.31 c	85.01 bc	45.00 a	0.193 a	15.00 c	0.019 e	17.16 a	85.99 d
150% N+150% K_2O +100% S	189.3 ab	13.60 b	77.20 c	85.68 b	1.689 b	9.561 d	86.76 ab	42.56 ab	0.496 a	21.83 b	0.137 b	15.79abc	89.61 b
150% N+ 150% K_2O+200% S	192.2 ab	13.95 b	73.03 d	95.44 a	1.638 b	8.571 e	81.60 d	46.67 a	0.323 a	30.21 a	0.191 a	15.91 ab	83.29 e

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 (7): Effect of N, K and S combination treatments on decay, rotted, unmarketable yield, total yield and bulb average weight of onion in 2014/2015 and 2015/ 2016 seasons.

Treatments	Decay	Rooted		Unmarketable yield		Total yield		Avreg.w of bulb (gm)
	ton/fed.	ton/fed.	As(%) of total	ton/ fed.	as (%) of total	ton/ fed.	kg /m^2	
First season (2014/2015)								
100%N +100% K_2O +100% S	1.377 b	0.000 d	0.000 c	1.377 e	8.050 c	17.09 bc	4.026 bc	128.9 bc
75% N + 75% K_2O +100% S	0.737 d	0.000 d	0.000 c	1.231e	7.770 c	15.83 c	3.770 cd	121.5 cd
75% N + 75% K_2O +200% S	1.034 c	0.000d	0.000 c	1.616d	16.35 b	9.890 d	2.354 d	70.63 f
75% N + 150% K_2O +100% S	2.445 a	1.394 a	9.510 a	4.130a	28.19 a	14.66 c	3.490 d	100.3 e
75% N + 150% K_2O +200% S	0.000f	0.133 c	0.880 c	0.981f	6.560 c	14.96 c	3.561 d	110.8 de
150% N + 75% K_2O +100% S	1.287 b	0.771 b	4.580 b	2.818b	16.75 b	16.82 bc	4.004 bc	127.4 bcd
150%N + 75% K_2O +200% S	0.783d	0.778 b	3.460 b	2.110 c	9.390 c	22.46 a	5.347 a	158.4 a
150% N+150% K_2O +100% S	0.116e	0.000 d	0.000 c	0.369h	2.120 d	17.39 b	4.140 b	139.7 b
150% N+ 150% K_2O+200% S	0.151 e	0.088 c	0.520 c	0.550g	3.250 d	16.95 bc	4.031 b	168.7 a
Second season (2015/2016)								
100%N +100% K_2O +100% S	0.2390 h	1.698 b	9.854 d	1.937 de	11.24 c	17.24 bcd	4.106 bcd	153.8 c
75% N + 75% K_2O +100% S	0.4810 c	1.680 b	10.80 c	2.161 cd	13.89 b	15.55 cde	3.703 cde	144.7 d
75% N + 75% K_2O +200% S	0.6110 b	1.755 b	11.92 b	2.399 c	16.29 a	14.73 e	3.507 e	134.8 e
75% N + 150% K_2O +100% S	0.3550 f	2.566 a	14.30 a	2.921 ab	16.28 a	17.97 ab	4.279 ab	151.3 c
75% N + 150% K_2O +200% S	0.2740g	1.157 d	7.530 ef	1.431 f	9.313 e	15.38 de	3.661 de	161.7 b
150% N + 75% K_2O +100% S	0.1420 i	1.345cd	7.586 ef	1.607 ef	9.064 e	17.72 bc	4.219 bc	151.7 c
150%N + 75% K_2O +200% S	0.4430e	2.336 a	11.70 b	2.798 b	14.01 b	19.96 a	4.753 a	176.2 a
150% N+150% K_2O +100% S	0.4520d	1.242cd	7.047 f	1.831 de	10.39 d	17.62 bc	4.195 bc	135.7 e
150% N+ 150% K_2O+200% S	1.484 a	1.529bc	7.945 e	3.204 a	16.71 a	19.11 ab	4.551 ab	168.2 a

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

in total yield duo to application of 75% N+ 150%K_2O + 100% S in the 2nd season may be owe to the increment in unmarketable yield.

Additionally, **El-Tantawy and El-Beik (2009)** found that the best combination treatment between N and S for increasing total, marketable yield and exportable yield of onion was the application of 120 Kg N+ 200 Kg S fed^{-1} plus foliar spray with Cu at a concentration of 30 ppm. **Nasreen *et al.* (2003)** found that the combination between 120 Kg N and 40 Kg S/ ha showed a synergistic effect on onion bulb yield. It could be noticed that application of 150% N + 75% K_2O + 200% S was the best treatment for increasing the total yield and its component compared to the recommendation treatment and other treatments.

The previous treatment recorded increases of relative total yield by 131.42% and 115.77% in 1st and 2nd seasons, respectively compared to control treatment (recommended dose); increment in marketable yield by 130.95% and 112.08% in 1st and 2nd seasons, respectively.

The increment in relative marketable yield due to application of 150% N+ 75%K_2O + 200% S compared to the recommended dose may be owe to the increase in relative yield of both 1st and 2nd grades which increased by 131.04%, 115.22% for the 1st grade in both seasons, respectively, and by 127.89 and 111.77% for the sum of 1st + 2nd grades in the 1st and 2nd seasons, respectively.

The increase of marketable yield and total yield may be attributed to the increments in plant growth, total fresh weight of plant, total dry weight of plant and higher content of photosynthetic pigments (Tables 2, 3, 4 and 5).

These results are coincide with these reported by **El-Tantawy and El-Beik (2009)** who found that the yield of 1st grade of onion was increased with increasing N up to 120 Kg $Nfed.^{-1}$, while the yield of 3rd grade was decreased resulting in an increase in 1st grade, increased the marketable yield, exportable yield and total yield.

They added that increments in yield may be attributed to the best vegetative growth and increase in the photosynthetic production which increased bulb size and bulb weight. Similar results were obtained by **Baloch *et al.* (1991), Al-Moshileh (2002), Khan *et al.* (2002), Nasreen *et al.* (2003) and Aliyu *et al.* (2008).**

Al-Fraihat (2009) found that marketable yield and total yield were increased with increasing the rates of S to 100 kg S/ha and N to 200 kg Nha^{-1}. It was reported that addition of N and sulpur may be attributed to the increment in plant growth due to of N that enhanced accelerating the phytosynthtace in storage organs of bulbs resulting in an increase in bulb weight, as well as to the role of S in protein and hormones formation, enzymatic actions, chlorophyll formation, synthesis of amino acids and vitamins which helps to have good vegetative growth leading to height yield.

High yield was observed with the high rates of N and sulphur this may be attributed to oxidation of S to SO_4^{-2} that increased with increasing rate of N up to 248 kg ha^{-1} **(Awad, Nemat *et al.*, 2011**) and the oxidation was rapid in a field soil with pH 8.0 leading to an enhancement in nutrients availability and increase in plant growth as well as in yield.

Many researchers came to similar results that high rates of S increased onion yield **(Mishu *et al.*, 2013; Nasreen and ImamulHuq, 2005)** and high N rates increased onion yield **(Smriti *et al.*, 2002; Mozumder *et al.*, 2007),** and that high N rates which may be owe to the high needs for onion yield where N can easily volatile and leached out of root zones **(Brewster and Bulter, 1989; Marschner, 1995).**

Pungency

Effect of treatments on onion pungency

Concerning the effect of N, K and S combinations on pungency. It was found from Fig.1 that application of 100%N + 100% K_2O + 100%S (recommended dose) recorded the highest value of onion pungency with no significant differences with the next treatments (75% N + 75% K_2O + 100% S, 75% N + 75% K_2O + 200% S, 75% N + 15o% K_2O + 100% S, 75% N + 150% K_2O + 200% S) (Fig.1), while the treatments that had high nitrogen contents it decreased the content of pungency specially application of 150% N + 75% K_2O + 100% S, which recorded the lowest value of pungency without significant differences with the treatments of 150% N + 75% K_2O + 200% S, 150%N + 150% K_2O + 100% S, 150% N+ 150% K_2O + 200% S. Thes results are in agreement with **Abd El-Kader *et al.* (2007)** who found that application of nitrogen increased pungency up to 100 kg $Nfed^{-1}$. and it decreased with high amount of N (120 kg $Nfed^{-1}$).

A close relationship between pyrovic acid development and the sensory evaluation of pungency has been established **(Smittle *et al*., 1979).** Pungency has ben positively correlated with sulphur fertilization rates **(Freeman and Mossadeghi, 1970), while Kil *et al.* (2006)** demonstrated that the pungency levels were not positively correlated with soil sulphur nutrition levels. Therefore, choosing cultivars with low pungency, ideal growing environments and proper sulphur nutrition control, are key factors in producing sweet onion. In this respect, **Lancaster and Boland (1990)** stated that, sulphur fertility is of particular interest because the primary falvor compounds in onions are sulphur based.On the other hand, **Paula *et al.* 2002) and Lee *et al.* (2009)** found no increase in the pungency of onion with increasing S doses, this may be owe to pungency intensity is controlled by genetic and environmental factors with differences between cultivars which pungency does not increase with increasing S doses **(Randle and Bussard, 1993; Randle, 1997; Mccallum *et al.*, 2001).**

Approximately 80% of variation in the level of pungency in onions is explained by genetic factors **(Yoo *et al.*, 2006 and Grangerio *et al.*, 2008).** Onion pungency depended on the amount of pyruvic acid produced after slicing and its genetic characteristics and variety **(Lin *et al.*, 1995).**

An increase level of pyruvate with N application could be explained partly by greater synthesis and accumulation of sulphur containing amino acids that are precursors of flavor compounds and pyruvate **(Randel, 2000)** which represented the amount of enzymatically produced pyruvate with N fertilization.

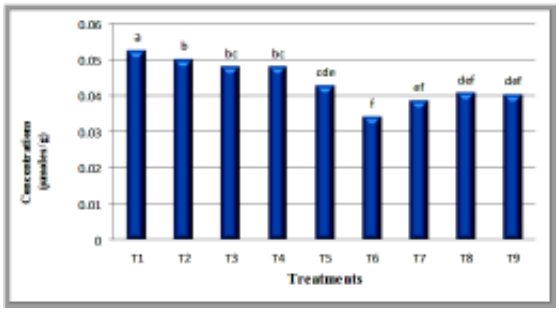

Fig (1): Effect ofN, K and S combination treatments on onion pungency

T_1 (100%N +100%K + 100%S), T_2 (75%N + 75%K + 100%S), T_3 (75%N + 75%K+ 200%S), T_4 (75%N + 150% K + 100%S), T_5 (75%N + 150%K + 200%S), T_6 (150%N + 75%K+ 100%S), T_7 (150%N + 75%K + 200% S), T_8 (150%N + 150%K + 100%S), T_9 (150%N + 150%K+ 100%S).

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الملخص العربى

تأثير التداخل بين النيتروجين، والبوتاسيوم، والكبريت على النمو والمحصول فى البصل

آية الله السيد المرسى، على إبراهيم القصاص[١]، السيد محمد الطنطاوي[١]

١. قسم الإنتاج النباتي، كلية العلوم الزراعية البيئية، جامعة العريش، مصر.

أجريت تجربتان حقليتان في المزرعة البحثية لكلية العلوم الزراعية البيئية - جامعة العريش- شمال سيناء- مصر. خلال الموسمين الشتويين لعامي ٢٠١٤-٢٠١٥، و٢٠١٥-٢٠١٦ لدراسة تأثير تداخلات مستويات مختلفة من النيتروجين، والبوتاسيوم، والكبريت على النمو والمحصول والحرافة فى البصل صنف "هوايت سويت سبانش" بالمقارنة مع الكنترول (الموصى به من النيتروجين والبوتاسيوم والكبريت). وقد أوضحت النتائج أن المعاملة باستخدام ١٥٠% نيتروجين + ٧٥% بوتاسيوم + ٢٠٠ % كبريت من الموصى به كانت أفضل المعاملات حيث أدت الى زيادة الوزن الطازج للاوراق، والأبصال، والوزن الطازج الكلى للنبات، وكذلك الوزن الجاف لنفس القياسات السابقة، وكذلك صبغات التمثيل الضوئي فى الموسم الأول. وقد أدت نفس المعاملة السابقة باستخدام ١٥٠% نيتروجين + ٧٥% بوتاسيوم + ٢٠٠% إلى زيادة المحصول ومكوناته مقارنة بمعاملة الكنترول (الموصى به) والمعاملات الأخرى. كذلك أدت إلى زيادة المحصول الكلى بنسبة ١٣١,٤٢%، ١١٥,٧٧% في الموسمين الأول والثاني على التوالي مقارنة بالكنترول (الموصى به)، وكذلك الزيادة في المحصول القابل للتسويق ب ١٣٠,٩٥% و ١١٢,٠٨% لكلا الموسمين على التوالي. وكانت الزيادة فى الدرجتين الأولى والثانية ب ١٣١,٠٤ و١١٥,٢٢% للدرجة الأولى في كلا الموسمين، وب ١٢٧,٨٩%، و١١١,٧٧% لمجموع الدرجتين الأولى والثانية في كلا الموسمين على التوالي. بينما حققت المعاملة ١٥٠% نيتروجين + ٧٥% بوتاسيوم + ١٠٠% كبريت اقل النتائج فى الحرافة للأبصال.

الكلمات الاسترشادية: البصل، وهوايت سويت سبانش، والنيتروجين، والبوتاسيوم، والكبريت، والمحصول، والحرافة.

المحكمون:

١.أ.د. المهدى إبراهيم على متولى أستاذ الخضر، كلية الزراعة، جامعة كفر الشيخ، مصر.

٢.أ.د. علـــى محمد محمد مسعـود أستاذ الخضر، قسم البساتين، محطة البحوث الزراعية، مصر.