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Integrated Management of Nitrogen and Sulfur Sources in Combination with Amino acids Amelioration for Onion Plants Production under Alluvial Soil Condition

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ABSTRACT

Two field experiments were carried out as split-split plot design at Experimental Farm of Tag El-Ezz, Agricultural Research Station (30º59\ N latitude, 31º58\ E longitude´), Dakahlia Governorate, Egypt, during winter seasons of 2018-19 and 2019-20 to study the integration managements of N and S fertilizers as three nitrogen sources in main plots as (urea(Ur), ammonium nitrate(AN) and ammonium sulfate(AS)), two elemental sulfur(ES) treatments (without and with sulfur as a soil application) in sub plots as well as in addition to three amino acids(AA) treatments (control, L-methionine and L-cysteine) as foliar application in the sub-sub plots on growth, yield and its components of onion plants (*Allium cepa L.*) cv.Giza Red(GR) were studied. Available elements N,P,K and S in the experimental soil were determined before cultivation and after harvesting. The obtained results could be summarized as follow: AN fertilizer give the highest effective vegetative growth values, quality parameters, yield and its components compared to other nitrogen sources. Soil application of ES has a significant effect on all studied parameters, while L-methionine is more effective than L-cysteine. Interaction of AN and foliar application of methionine in integration with ES application achieve the highest values of vegetative growth criteria, quality parameters, yield and its components of the onion plants. Highest residual NPK concentration in the soil were recorded with the interaction of AS and without ES and AA application, while the highest values of residual S are obtained by the interaction of AS and methionine foliar application in presence of ES application.

Keywords: Onion, Nitrogen sources, Elemental sulfur, L-methionine and L-cysteine.

INTRODUCTION

Onion *(Allium cepa* L.) is one of the most popular consumed vegetables, not only for its nutritional values where, it contains vitamin A, vitamin C, iron and calcium, but also, for its medicinal values such as reduced blood sugar, act as anticancer agent and antioxidants (Hafez and Geries, 2009). Nutrients have a significant effect on improving the yield and productivity of crops. Therefore, increasing yield, bulb weight, quality and productivity of onion are important purposes for the local market (Krishnamuthy and Sharanappa, 2005). Nitrogen and sulfur are two important macronutrients for growth and productivity of onion (Devi *et al.*, 2003). Application of nitrogen fertilizer affects significantly on vegetative growth parameters such as plant height, number of green leaves plant^{-1} and weight of plant. Moreover, it increases total yield, marketable yield and total soluble solids (Qotob, 2017). Sulfur fertilizer improves soil properties where its application reduces pH value soil, improves soil water relation and increases nutrients availability as P, Fe, Mn and Zn (Al- Fraihat, 2009). Amino acids play an important role within plant where it contains both acidic and basic groups which help amino acids act as a buffer that can maintain pH value within cell (Shafeek and Helmy, 2012). The effect on physiological activities of plant as stimulation of the cell growth (Rai, 2002), regulation of nitrogen uptake (Miller *et al.*, 2007), root development and antioxidants metabolism (Weiland *et al.*, 2015). Cysteine is a sulfur amino acid naturally occurs in plant, plays a role in providing metabolic sulfur donor for a generation many secondary metabolites as methionine, glutathione and iron-sulfur clusters (Bonner *et al.*, 2005). Methionine acts as methyl group donor, precursor of ethylene and growth factors as espermine (Singh, 1999). Moreover, it plays a role in the biosynthesis of growth regulating substances as cytokinins and auxin in plants (Maxwell and Kieber, 2004).

The objective of the present work is to study the effect of applying different sources of N-fertilization under elemental sulfur soil addition and foliar application of some amino acids on onion plants grown on clay soil.

MATERIALS AND METHODS

Two field experiments were carried out to investigate the integrated management of nitrogen and sulfur sources in combination with amino acids amelioration for onion plants growth, productivity and soil fertility sustainability under alluvial soil conditions of Nile Delta in Egypt.

Experimental Site:

Two field experiments were carried out on alluvial soil at the farm of Tag El-Ezz, Dakahlia governorate (located at 30º 59\ N latitude, 31º 58\ E longitude´), Agricultural Research Center (ARC), Egypt, during two successive growing seasons, (*i.e.* 2018-19 and 2019-20) on onion plant (*Allium cepa*) (var. Giza Red). Random disturbed soil samples from 0-30 cm surface layer of the soil were collected before planting. Soil physical, chemical, and nutrients status of the experimental sites were determined according to Page *et al.*, (1982) and Klute (1986) as shown in Table (1). At harvesting time surface soil samples (0-30 cm) from each experimental plot were collected to determine the available N, P, K and S (µg g^{-1}) to estimate the effect of integrated N and S management on macronutrients sustainability.

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Table 1. Average of Physical, chemical, and nutritional properties of the experimental field during the two growing seasons 2018/19 and 2019/20 before planting.

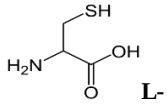
Soil Characteristics	Average of two Growing seasons 2018/19 and 2019/20
I. Physical properties:	
Particle size distribution	
Sand	15.90
Silt	36.70
Clay	47.38
Soil Texture Class	Clay
II. Chemical properties:	
pH, [1:2.5 soil suspension]	7.9
EC, [soil past, dS m^{-1}]*	4.10
Soluble cations, meq 100 g soil $^{-1}$)	
Ca^{2+}	0.65
Mg^{2+}	0.52
Na^{+}	2.26
K^{+}	0.012
Soluble anions, meq 100 g soil $^{-1}$)	
CO_3^{2-}	-
HCO_3^{-}	0.28
Cl^{-}	2.26
SO_4^{2-}	0.86
$CaCO_3$, %	4.84
OM, %	1.72
III. Nutritional properties:	
KCl extractable N, mg kg^{-1}	47.42
$NaHCO_3$ Extractable P, mg kg^{-1}	9.01
Amm. Acetate Extractable K, mg kg^{-1}	225.72

*** Soil Electrical Conductivity (EC) and soluble ions were determined in saturated soil paste extract.**

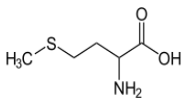
Experiment Description:

The experimental design was split-split plot design system. The experiments included 18 treatments which were the combinations of different nitrogen fertilizers (urea (Ur), ammonium nitrate (AN) and ammonium sulfate (AS)) as main plots, with or without elemental sulfur (ES) soil application as sub plot and three foliar application of some amino acids (Control, L- methionine and L- cysteine) as sub - sub plots on onion (Allium cepa L. var. Giza Red) plants growth, yield, its components and chemical constituents. Each treatment was replicated three times and distributed randomly. The experimental area consisted of 54 plots was an area 14 m^2 (3.5 m×4 m).

The treatments were as the following: urea (Ur) (46.5% N ($(NH_2)_2CO$)), ammonium nitrate (AN) (33.5% N (NH_4NO_3)) and Ammonium Sulfate (AS) (21.5% N, 24% S ($(NH_4)_2SO_4$)). All previous nitrogen sources were applied at the recommended rate for onion plant (90 Kg N fed^{-1}), where nitrogen sources were added after 30 and 60 days from transplanting. .Elemental sulfur (98 % S) was applied into two rates (0 and 100 Kg Fed^{-1}) during land preparation . Mono calcium phosphate (12.5 % P_2O_5) was applied during soil preparation at a rate of 300 Kg Fed^{-1}. Potassium sulfate (48% K_2O) was added at rate of 50 Kg Fed^{-1} with the second dose of N fertilizers. Onion plants were sprayed with amino acids (Control, L- methionine, and L-cysteine) at the rate of 150 mg L^{-1} after 30 and 60 days after transplanting. All other cultural practices and irrigation were done as recommended according to the recommended practices.



L- cysteine



L- methionine

Data Recorded:

a) Growth characters: A random sample of five onion plants was taken from each sub- sub plot, 90 days after transplanting, to determine the following estimates: plant fresh weight, plant dry weight, bulb weight, No. of leaves $plant^{-1}$, bulb length and shoot length.

b) Chemical analysis: the same sample was used for determination of leaf chlorophyll a, b and total chlorophyll (mg g fresh $weight^{-1}$ of leaf), according to the method of Nayek *et al.*, (2014), as well as Total nitrogen (TN) content in dry leaves using the method based on digestion of plant material in sulfuric-salicylic acid mixture (Buresh *et al.*, 1982). Protein content was calculated by multiplication N% x 5.75 according to A.O.A.C., (1990). Phosphorus, potassium and sulfur were determined in dried leaves as described by Chapman and Pratt (1961).

c)Yield and bulb characteristics: these were determined at the harvesting time (150 days after transplanting) including the following:

- Total yield of bulb (ton fed^{-1}).
- bulb weight (g).
- Bulb diameter (cm).
- Bulb length (cm).
- In fresh bulbs (juice), the total soluble solids (TSS) were estimated using handle refractometer according to Snedecor and Cochran (1980).
- N, P, K and S in bulb were determined according to Page *et al.*, (1982).
- Pyruvic acid (Pungency determination) analysis was performed according to Anthon and Barrett (2003) on onion bulbs.

Statistical Analysis: All data were subjected to statistical analysis according to Snedecor and Cochran (1980) and the means were compared using least significant difference at 5% level were carried out. Appropriate analyses of variance were performed for the two experiments according to Steel and Torrie (1984).

RESULTS AND DISCUSSION

1- Vegetative Growth Parameters.

The average data tabulated in Table (2) show the effect of N fertilizer sources, ES application and foliar application of some amino acids as well as their interactions on onion plants vegetative growth parameters (plant fresh weight (PFW) (g), plant dry weight (PDW) (g), bulb weight (BW)(g), No. of leaves $plant^{-1}$, bulb length (BL) (cm) and shoot length (SL) (cm). The data indicate that all treatments have a significant effect on all onion plants studied parameters, except number of leaves $plant^{-1}$ values which were non-significant in individual effect of sub main treatment (ES application) as well as interactions.

Ammonium nitrate (AN) is a superior treatment followed by AS and lately Ur for all studied vegetative growth parameters. This result is in matching with that recorded by Abbes *et al.*, (1995) who found that onion grows better when treated with ammonium at the seedling stage.

Ahmed *et al.*, (2015) concluded that the vigor of vegetative growth of plants achieved with the application of AN rather than Ur, and this may be attributed to plants prefer NO_3-N followed by NO_3 + NH_4 and least with NH_4-N. In addition, urea contains neither NO_3-N nor NH_4-N. Nitrogen fertilizer is a source of major macronutrients (N) which is important for a meristematic activity that increase number of

cells and cell elongation leading to increasing vegetative growth Rizk *et al.*, (2012), and Abd El-Mawgoud *et al*., (2005).

Table 2. Mean effect of different nitrogen fertilizer sources, with or without ES and some amino acids foliar application on vegetative growth parameters of onion.

Treatments			Weight (g plant^{-1})			No. of leaves plant^{-1}	Length (cm)	
			Fresh	Dry	Bulb		Bulb	Shoot
Nitrogen Fertilizer sources								
Urea (Ur)			89.37	6.44	31.43	9.16	8.25	69.17
Ammonium Nitrate(AN)			118.37	7.89	32.85	10.16	9.50	72.59
Ammonium Sulfate(AS)			109.63	7.51	32.23	9.60	9.00	69.70
F. significance			***	***	***	*	***	***
LSD at 5%			0.217	0.199	0.208	0.739	1.08	0.316
Sulfur Fertilizer rates								
Without ES (ES0)			103.19	6.11	32.10	9.50	8.61	70.23
With ES (ES1)			108.60	8.45	32.23	9.70	9.22	70.98
F. significance			***	***	***	NS	***	***
LSD at 5%			0.139	0.197	0.185	0.54	2.60	0.175
Foliar Applications								
Non foliar			96.68	5.13	27.95	8.50	7.83	67.17
Methionine			114.10	9.00	36.43	11.16	9.90	72.96
Cysteine			107.00	7.71	32.12	9.30	9.00	71.70
F. significance			***	***	***	***	***	***
LSD at 5%			0.182	0.173	0.155	0.628	1.74	0.126
Interaction								
Urea (Ur)	ES0	No foliar	75.47	5.23	23.46	8.10	8.15	71.50
		Methionine	78.64	6.36	37.43	10.13	10.00	74.33
		Cysteine	77.30	5.55	35.26	9.16	9.50	73.50
	ES1	No foliar	95.34	3.60	29.43	8.00	8.00	69.43
		Methionine	107.46	7.43	32.63	11.01	10.20	74.30
		Cysteine	104.43	6.50	30.36	9.20	9.32	73.33
Ammonium Nitrate (AN)	ES0	No foliar	120.50	6.23	31.70	9.52	7.25	62.33
		Methionine	127.30	11.40	36.36	12.00	8.50	72.56
		Cysteine	123.30	10.36	34.33	10.14	8.15	71.00
	ES1	No foliar	98.70	5.26	29.76	9.36	7.72	64.36
		Methionine	130.70	13.36	38.30	11.12	11.00	75.66
		Cysteine	109.50	11.23	30.63	10.14	9.85	70.46
Ammonium Sulfate (AS)	ES0	No foliar	86.70	5.96	25.63	8.50	8.16	65.56
		Methionine	130.50	12.10	37.36	11.10	10.95	75.56
		Cysteine	113.70	10.10	27.40	9.62	9.50	69.43
	ES1	No foliar	103.20	5.53	30.73	9.15	9.22	69.83
		Methionine	124.70	8.30	35.50	11.00	10.69	70.36
		Cysteine	113.70	6.50	33.70	9.60	10.54	72.46
F. significance			***	***	***	NS	***	***
LSD 5%			0.447	0.424	0.381	1.53	4.28	0.296

ES= elemental sulfur

Also, ES soil fertilization treatment (ES1) gives the highest values of plant fresh weight (g), plant dry weight (g), bulb weight (g), No. of leaves plant^{-1}, bulb length (cm) and shoot length (cm) comparing with zero ES application. Similar results were obtained by Al-Fraihat (2009) who studied the influence of different sulfur fertilizer level on onion growth and found that sulfur increase vegetative growth comparing with treatment without sulfur where, sufficient supply of sulfur for plants in the early stages of development is important for the production of sulfur amino acids which effect on growth Losak *et al*., (2010). On the other hand, it's obvious that amino acid L-methionine followed by L-cysteine was achieved a significant effect on all vegetative growth parameters comparing with control treatment, El-Awadi and Abd El-wahed (2012) recorded the same result. Shafeek and Helmy, (2012) reported that AA have significant role in growth and productivity of plant especially methionine which not only acts as a precursor of growth regulators as cytokine and auxin that increasing rooting, but also, it contributes to synthesis ethylene plant hormone that enhances cell division and enlargement.

Also, data recorded of interaction indicated that ES application interaction with AN and methionine foliar application achieved the highest values of most vegetative studied parameters while in absence of ES application the most highest values obtained by the interaction of AS and methionine foliar application.

2- Chlorophyll Content.

It is evident from Table (3) that the average chlorophyll content (*Chl*. a, *Chl*. b and total *Chl*.) are significantly increased under fertilization with AN as Abd El-Hafez *et al*., (2016) recorded, and in case of ES application where sulfur is necessary for chlorophyll formation Tisdale *et al.*, (1984). ES application influences the chlorophyll formation when compared with control (i.e. zero ES) this may be due to the important role of sulphur in forming enzymes and vitamins which are necessary for chlorophyll formation Qotob (2017).

Table 3. Mean effect of different nitrogen fertilizer sources, with or without ES and some amino acids foliar application on chlorophyll content (mg g FW^{-1}) of onion.

Treatments			(mg g FW^{-1}) Chlorophyll a	Chlorophyll b	Total chlorophyll
Nitrogen Fertilizer sources					
Urea (Ur)			0.616	0.262	0.838
Ammonium Nitrate (AN)			0.630	0.266	0.892
Ammonium Sulfate (AS)			0.571	0.265	0.881
F. significance			***	***	***
LSD at 5%			0.043	0.002	0.042
Sulfur Fertilizer rates					
Without ES (ES0)			0.596	0.263	0.860
With ES (ES1)			0.615	0.270	0.881
F. significance			***	***	***
LSD at 5%			0.0410	0.004	0.039
Foliar Applications					
Non foliar			0.528	0.256	0.796
Methionine			0.649	0.269	0.910
Cysteine			0.639	0.267	0.906
F. significance			***	***	***
LSD at 5%			0.040	0.005	0.040
Interaction					
Urea (Ur)	ES0	No foliar	0.680	0.250	0.933
		Methionine	0.683	0.281	0.963
		Cysteine	0.523	0.256	0.780
	ES1	No foliar	0.626	0.250	0.876
		Methionine	0.636	0.276	0.913
		Cysteine	0.630	0.260	0.886
Ammonium Nitrate (AN)	ES0	No foliar	0.670	0.255	0.926
		Methionine	0.683	0.250	0.933
		Cysteine	0.403	0.290	0.693
	ES1	No foliar	0.620	0.260	0.880
		Methionine	0.683	0.283	0.996
		Cysteine	0.636	0.266	0.890
Ammonium Sulfate (AS)	ES0	No foliar	0.660	0.261	0.920
		Methionine	0.670	0.279	0.956
		Cysteine	0.643	0.266	0.923
	ES1	No foliar	0.572	0.264	0.837
		Methionine	0.626	0.265	0.891
		Cysteine	0.336	0.262	0.599
F. significance			***	***	***
LSD 5%			0.099	0.013	0.098

ES= elemental sulfur

While, methionine foliar application recorded the highest values of chlorophyll content than cysteine and this

result is the same to be recorded by Khan *et al*., (2019). Both Tripathy *et al*., (2013), and Qotob (2017) showed that sulfur plays an important role in chlorophyll synthesis as well as production of sulfur amino acids which act as a factor in terms of photosynthesis. In addition to that, methionine plays a role in chlorophyll synthesis Khan *et al*., (2019).

Also, it appears that interaction between AN, ES application and methionine foliar application gave the highest values of total chlorophyll content (0.996 mg g FW^{-1}).

3- Nutrients Concentration by Vegetative Plant.

It is obvious from the average results in Table (4) that, AN as a source of nitrogen fertilizer increase NPK concentration at vegetative growth stage, while; AS records the highest value of S concentration. Abo EL-Dahab *et al*., (2016) obtained that, although the required amount of N at seedling stage are small, the nitrate concentration in the soil should be high to achieve optimum N uptake by root .

Table 4. Mean effect of different nitrogen fertilizer sources, with or without ES and some amino acids foliar application on nutrient concentration (%) at maximum vegetative growth stage.

Treatments			(%)			
			N	P	K	S
Nitrogen Fertilizer sources						
Urea (Ur)			3.55	0.28	2.61	0.44
Ammonium Nitrate (AN)			3.91	0.32	2.92	0.36
Ammonium Sulfate (AS)			3.70	0.29	2.75	0.59
F. significance			***	***	***	***
LSD at 5%			0.031	0.002	0.017	0.017
Sulfur Fertilizer rates						
Without ES (ES0)			3.28	0.282	2.53	0.328
With ES (ES1)			3.81	0.319	2.99	0.611
F. significance			***	***	***	***
LSD at 5%			0.013	0.002	0.021	0.016
Foliar Applications						
Non foliar			3.27	0.28	2.53	0.25
Methionine			3.72	0.31	2.91	0.60
Cysteine			3.64	0.30	2.84	0.55
F. significance			***	***	***	***
LSD at 5%			0.023	0.002	0.022	0.017
Interaction						
Urea (Ur)	ES0	No foliar	2.96	0.24	2.22	0.15
		Methionine	3.24	0.26	2.49	0.42
		Cysteine	3.17	0.26	2.42	0.37
	ES1	No foliar	3.32	0.27	2.52	0.21
		Methionine	3.86	0.32	2.97	0.78
		Cysteine	3.77	0.31	2.65	0.72
Ammonium Nitrate (AN)	ES0	No foliar	3.08	0.25	2.52	0.12
		Methionine	3.65	0.30	2.84	0.32
		Cysteine	3.57	0.29	2.78	0.27
	ES1	No foliar	3.71	0.31	2.89	0.17
		Methionine	4.13	0.35	3.20	0.68
		Cysteine	4.07	0.34	2.30	0.62
Ammonium Sulfate (AS)	ES0	No foliar	3.02	0.25	2.50	0.25
		Methionine	3.94	0.28	3.02	0.54
		Cysteine	3.37	0.27	2.7	0.47
	ES1	No foliar	3.52	0.29	2.72	0.57
		Methionine	4.00	0.33	3.16	0.87
		Cysteine	3.92	0.32	3.11	0.83
F. significance			***	***	***	***
LSD 5%			0.055	1.89	0.053	0.044

ES= elemental sulfur

Elemental sulfur (ES) application give the highest values of NPK and S concentration compared to the ES0 treatment as shown in tabulated results in table 4. This may be due to ES application decrease pH soil and this led to increases the availability of some nutrients in the soil leading to increase nutrients plant uptake. Similar results obtained by Al-Fraihat, (2009). Osman and Rady (2014) showed that the sulphur addition stimulates bacterial activity to produce some hormones, which encourage the root and root hairs proliferation that increase nutrient uptake surfaces. Also, Qotob (2017) reported that sulfur application (100 kg fed^{-1}) had a significant increase in macronutrients uptake of onion.

L-methionine as well as L-cysteine recorded a significant effect on NPK and S concentration. While L-methionine was more effective than L-cysteine. Amino acids (AA) act as a source of nitrogen which responsible for the building block of protein El-Awadi and Abd El-Wahed, (2012).

On the other hand, it appears that the interaction of AN, ES application and methionine foliar application give the highest values of N, P and K concentration at the maximum vegetative growth stage. But, in case of S concentration the highest values were obtained with the interaction of AS, ES application (ES1) and methionine foliar application.

4- Yield and Its Parameters.

The data presented in Table 5 and Fig 1 indicate the average of yield (ton fed^{-1}) and yield parameters [i.e. bulb weight (g), bulb diameter (cm), and bulb length (cm)]. It records that AN gave the highest yield and yield parameters as well as ES application treatment and also, methionine foliar application. The same results were obtained by Fomey *et al*., (2010). Nitrogen fertilizer is a constituent of amino acids, nucleic acids, and enzymes which important for physiological processes in the plant that consequently increasing yield Geries (2013). While, Sulfur is the fourth most abundant element in the plant after nitrogen, phosphorus, and potassium. Onion as all bulbous vegetable crops required sulfur for growth and yield (Fomey *et al.*, 2010). It plays an important role in several processes in the plant as synthesis of sulfur- amino acids, co enzyme A, and secondary sulfur compounds (Tripathy *et al.*, 2013 and Qotob 2017).

Methionine plays important role in plant metabolism, protein assimilation(Khan *et al.*, 2019), on the other hand, Cysteine is the first organic reduced sulfur compound, and act as sulfide donor for synthesis of vitamins, co-factors and antioxidants such as glutathione which involved in the synthesis of many defense compounds (Grudkowska and Zagdańska, 2004; and Losak *et al*., 2010).

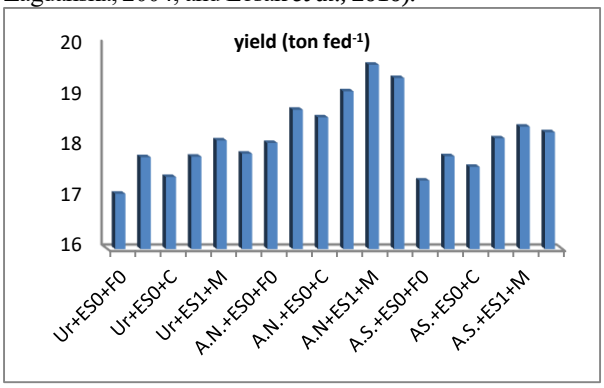


Fig. 1. Mean interaction effect of different nitrogen fertilizers sources, ES application and some amino acids on onion yield (ton fed^{-1})

It's obvious from data that the highest yield and yield parameters values were obtained by the interaction of AN, ES

application, and methionine foliar application. In case of ES application, AS with L- methionine and L- cysteine foliar application gave the lowest values of yield and yield parameters comparing with that recorded by Ur or AN with L-methionine and L- cysteine foliage. This result in matching with that recorded by (Liu *et al.,* 2012). This may attributed to the over-fertilization with sulfur can depress growth and yield of onion and this result in matching with that recorded by (Qotob 2017).

Table 5. Mean effect of different nitrogen fertilizer sources, with or without sulfur and some amino acids foliar application on yield and yield parameters.

Treatments			(g plant^{-1}) Bulb weight	(cm) Bulb diameter	Bulb length	(ton fed^{-1}) Yield
Nitrogen Fertilizer sources						
Urea (Ur)			97.03	4.82	4.65	17.69
Ammonium Nitrate (AN)			99.90	5.38	4.93	18.92
Ammonium Sulfate (AS)			99.60	5.01	4.66	17.95
F. significance			***	***	**	***
LSD at 5%			0.541	0.073	0.157	0.077
Sulfur Fertilizer rates						
Without ES (ES0)			97.60	5.03	4.64	17.84
With ES (ES1)			100.11	5.11	4.85	18.53
F. significance			***	*	***	***
LSD at 5%			0.321	0.067	0.0845	0.176
Foliar Applications						
Non foliar			90.68	4.83	4.39	17.94
Methionine			105.76	5.36	5.16	18.42
Cysteine			100.12	5.02	4.68	18.19
F. significance			***	***	***	***
LSD at 5%			0.362	0.068	0.098	0.216
Interaction						
Urea (Ur)	ES0	No foliar	86.50	4.40	4.51	17.09
		Methionine	100.00	5.22	5.12	17.81
		Cysteine	90.63	4.71	4.90	17.42
	ES1	No foliar	93.23	4.65	4.62	17.82
		Methionine	110.46	5.10	5.35	18.41
		Cysteine	101.36	4.91	4.91	18.30
Ammonium Nitrate (AN)	ES0	No foliar	82.26	5.10	4.10	18.09
		Methionine	97.26	5.62	4.66	18.74
		Cysteine	89.23	5.23	4.35	18.59
	ES1	No foliar	96.30	5.11	4.66	19.10
		Methionine	118.23	5.83	5.69	19.62
		Cysteine	14.33	5.50	5.13	19.36
Ammonium Sulfate (AS)	ES0	No foliar	99.16	5.12	4.30	17.35
		Methionine	118.20	5.55	5.67	17.83
		Cysteine	115.16	5.00	4.62	17.62
	ES1	No foliar	86.66	4.72	4.21	18.18
		Methionine	90.43	4.96	5.10	18.14
		Cysteine	90.03	4.71	4.33	17.88
F. significance			***	*	**	**
LSD 5%			0.888	0.166	0.177	0.530

ES= elemental sulfur

5- Yield Components.

Data presented in Table 6, Figs 2 and 3 show that the average effect of different nitrogen fertilizer sources, with or without elemental sulfur soil application and some amino acids foliar application on yield components. AN as a source of nitrogen give the highest values of NPK and protein concentration, while the highest values of S, TSS, and pyruvic acid content were recorded by AS fertilizer; the same results were reported by Qotob (2017).

ES application (ES1) has the highest significant effect in all studied yield components comparing with zero ES (ES0) treatment. Khodadadi (2012) mentioned that the highest pyruvic acid contents obtained when applied sulphur at a rate of 100 Kg S fed^{-1}. An increase in the pyruvic acid content of bulb was due to increased uptake of sulphur by crop due to its application to soil resulting in the increased synthesis of volatile sulphur compounds and the production of more pungency in onion. Similar results were obtained by (Chattopadhyay *et al*., 2015).

While, L-methionine foliar application was more effective than L- cysteine. These results are in agreement with those obtained by Tripathy *et al.,* (2013), and Osman and Rady (2014). On the other hand, the interaction of AN, ES application and methionine foliar application achieved the highest significant values of NPK and protein concentration in onion yield, while, AS interaction with ES application and methionine foliar application gave highest values of S, TSS and pyruvic content in yield.

Table 6. Mean effect of different nitrogen fertilizer sources, with or without ES and some amino acids foliar application on yield components

Treatments			(%) N	P	K	S	Protein	TSS	(µmol gFW^{-1}) PYRUVIC
Nitrogen Fertilizer sources									
Urea (Ur)			2.65	0.22	2.13	0.69	15.25	10.82	5.71
Ammonium Nitrate (AN)			2.90	0.25	2.41	0.62	16.71	11.04	5.34
Ammonium Sulfate (AS)			2.77	0.24	2.27	0.83	15.96	11.51	6.42
F. significance			***	***	***	***	***	***	***
LSD at 5%			0.031	0.003	0.025	0.023	0.183	0.033	0.038
Sulfur Fertilizer rates									
Without ES (ES0)			2.56	0.22	2.04	0.59	14.73	10.69	5.14
With ES (ES1)			2.99	0.26	2.49	0.84	17.21	11.56	6.50
F. significance			***	***	***	***	***	***	***
LSD at 5%			0.02	0.001	0.021	0.021	0.115	0.071	0.031
Foliar Applications									
Non foliar			2.55	0.21	2.03	0.49	14.71	10.36	4.70
Methionine			2.91	0.25	2.42	0.85	16.76	11.78	6.50
Cysteine			2.86	0.25	2.35	0.80	16.44	11.23	6.28
F. significance			***	***	***	***	***	***	***
LSD at 5%			0.021	0.002	0.017	0.023	0.121	0.010	0.038
Interaction									
Urea (Ur)	ES0	No foliar	2.34	0.19	1.75	0.40	13.45	8.10	4.12
		Methionine	2.52	0.21	2.02	0.75	14.50	11.80	5.71
		Cysteine	2.44	0.21	1.95	0.62	14.06	10.90	5.46
	ES1	No foliar	2.57	0.22	2.07	0.45	14.81	11.10	4.59
		Methionine	3.05	0.26	2.52	0.99	17.53	11.60	7.32
		Cysteine	2.98	0.26	2.47	0.94	17.13	11.40	7.08
Ammonium Nitrate (AN)	ES0	No foliar	2.41	0.20	1.91	0.35	13.87	11.00	3.91
		Methionine	2.70	0.23	2.17	0.61	16.44	11.80	5.25
		Cysteine	2.62	0.23	2.12	0.55	16.15	11.40	5.02
	ES1	No foliar	2.92	0.25	2.42	0.42	16.80	11.00	4.36
		Methionine	3.24	0.29	2.77	0.90	18.66	12.10	6.86
		Cysteine	3.18	0.28	2.70	0.91	18.32	11.80	6.65
Ammonium Sulfate (AS)	ES0	No foliar	2.34	0.19	1.82	0.51	13.47	9.90	4.8
		Methionine	2.86	0.25	2.35	0.79	15.56	11.00	6.14
		Cysteine	2.81	0.24	2.29	0.74	15.10	10.30	5.91
	ES1	No foliar	2.76	0.24	2.24	0.83	15.87	11.10	6.40
		Methionine	3.11	0.28	2.66	1.06	17.89	12.30	7.76
		Cysteine	3.11	0.27	2.59	1.03	17.88	11.60	7.54
F. significance			***	***	***	***	***	***	***
LSD 5%			0.051	0.005	0.041	0.065	0.297	0.175	0.092

ES= elemental sulfur

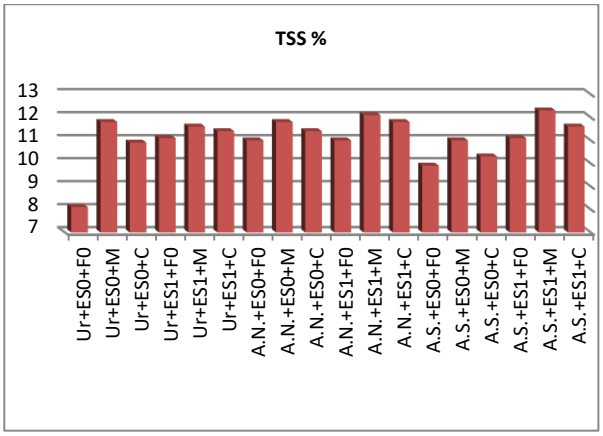


Fig. 2. Mean interaction effect of different nitrogen fertilizers sources, ES addition and some amino acids on TSS %.

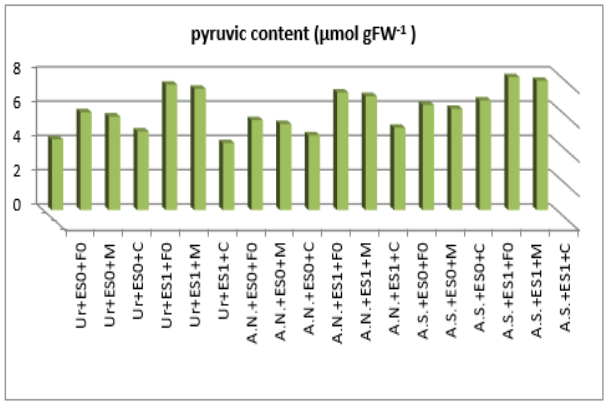


Fig 3. Mean interaction effect of different nitrogen fertilizers sources, ES addition and some amino acids on pyruvic content (µmol gFW^{-1})

6-Soil Available Nitrogen, Phosphorus, Potassium and Sulfur after Harvesting.

Available nitrogen, phosphorus, potassium and sulfur (µg g^{-1}) status at the root zone pronouncedly differs after harvest of onion crop due to N and S nutrients managements as shown in Table 7, where the values are mean of the two successive seasons. At the harvest stage, the highest values of N, P, K and S (µg g^{-1}) of soil is recorded with N-fertilization by AS, while the lowest one is recorded in the case of Ur fertilizer. On the other hand, the values of N, P, K (µg g^{-1}) of soil treated with ES as soil application are less than that untreated. This is due to the positive effect of ES added to the soil on onion plants growth, thus increasing the ability of the plant to uptake the nutrients from the soil. On the contrary, the values of S (µg g^{-1}) of soil treated with ES application are more than that untreated. This is a result of increasing the sulfur content of the soil as a result of the soil application of sulfur. Amino acids (AA) cause decrease average available nitrogen, phosphorus and potassium (µg g^{-1}) in the soil after harvesting compared to control treatment (without AA) due to improvement of plant growth by amino acids, thus the onion plants uptake more N, P and K ,thus the soil content from these elements reduce. While the values of S (µg g^{-1}) of soil increase due to foliar application of amino acids compared to untreated plants.

AS (21.5% N) (24% S) is a favorite fertilizer for alkaline soil where ammonium ion is released and small amounts of acids , decreasing soil pH as well as gave essential nitrogen for plant growth . But, its content of nitrogen is lower than AN (Zapp, 2012).

AN (33.5% N) provides the nitrogen in two forms equally the nitrate and the ammonium form. The nitrate form directed easily to the roots and leashed with irrigation water where it is available for plant uptake. The roots absorb ammonium part or gradually soil microorganisms converted it into nitrate. Many vegetable crops prefer an immediately available nitrate source of plant nutrition (F.A.O., 2000).

Urea (46% N) is the most abundant source of nitrogen in the world because has high nitrogen concentration and usually has an attractive price per unit of nitrogen. Moreover, the application of urea needs especial agricultural practices to avoid losses by evaporation of ammonia. (F.A.O., 2000) .

Table 7. Mean effect of different nitrogen fertilizer sources, with or without ES and some amino acids foliar application on soil after onion harvesting.

Treatments			µg g^{-1}			
			N	P	K	S
Nitrogen Fertilizer sources						
Urea (Ur)			51.64	13.70	234.52	15.30
Ammonium Nitrate (AN)			63.38	14.91	234.52	16.56
Ammonium Sulfate (AS)			67.87	15.18	234.72	17.87
F. significance			**	***	***	***
LSD at 5%			0.42	0.654	0.109	0.048
Sulfur Fertilizer rates						
Without ES (ES0)			64.51	15.14	252.45	14.64
With ES (ES1)			57.42	14.99	216.74	15.35
F. significance			**	***	***	***
LSD at 5%			0.769	0.156	0.041	0.033
Non foliar			62.31	15.59	251.07	16.15
Methionine			59.66	12.64	223.60	17.00
Cysteine			60.93	14.92	229.11	16.58
F. significance			**	***	***	***
LSD at 5%			0.523	0.362	0.071	0.065
Urea (Ur)	ES0	No foliar	56.04	11.0	259.55	14.24
		Methionine	52.77	10.00	256.52	15.04
		Cysteine	54.42	15.18	257.95	14.64
	ES1	No foliar	50.96	12.60	251.73	18.04
		Methionine	46.30	12.80	212.62	18.90
		Cysteine	49.38	14.40	227.30	18.52
Ammonium Nitrate (AN)	ES0	No foliar	68.77	15.60	254.25	12.84
		Methionine	66.38	13.32	239.42	13.84
		Cysteine	67.49	14.95	244.95	13.37
	ES1	No foliar	60.5	11.30	233.22	16.85
		Methionine	57.84	13.14	184.41	17.65
		Cysteine	59.35	10.97	192.46	17.23
Ammonium Sulfate (AS)	ES0	No foliar	73.04	16.82	262.33	15.54
		Methionine	70.06	11.80	247.35	16.36
		Cysteine	71.63	11.50	249.72	15.94
	ES1	No foliar	64.54	12.90	245.37	19.41
		Methionine	64.61	13.80	198.32	20.21
		Cysteine	63.33	16.10	205.21	19.75
F. significance			***	***	***	***
LSD 5%			1.28	0.888	0.122	0.159

ES= elemental sulfur

Nitrogen applied as CO $(NH_2)_2$ (Ur) is converted into NH_4-N by the enzyme urease. These series of reactions increase the lag time between application and uptake by plants and this time may be lengthened or shorten based on several factors

such as soil moisture, soil texture, soil temperature, microbial activity and soil organic matter. (Ahmed *et al.,* 2015).

Sulfur must be oxidized to sulfate by thiobacillus bacteria to provide plant – available sulfur (Vidyalakshmi *et al.,* 2009). Sulfur oxidation process reducing soil pH enhancing soil-water relation by improving aggregation and increasing availability of nutrients as phosphorus, iron, manganese and zinc (Al- Fraihat, 2009).

Interaction of AS and no-foliar application in absence of ES application (ES0) gave the highest values of NPK content in soil, while the highest S content in the soil after harvesting was obtained by the interaction of an AS and methionine foliar application in presence of sulfur addition (ES1).

CONCLUSION

The results indicated that ammonium nitrate (AN) fertilizer is the best nitrogen source in most studied onion plants growth parameters; elemental sulfur fertilizer (ES1) application give the highest significant values compared (ES0) treatment. Regard to amino acids foliar application L-methionine is more effective than L-cysteine. Finally, the interaction of AN and foliar application of methionine in the presence ES achieve the highest growth, yield, and components of the onion plant. But, in case of ES0 treatment highest values are recorded by AS fertilizer and methionine foliar application. Whereas over-fertilization with sulfur (ES1) in case of fertilizing with AS can depress growth and yield of onion. Elemental sulfur application with AN fertilization sustained soils nutrients content as well as fertilization minimize important of ES application under onion planting conditions.

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الإدارة المتكاملة لمصادر النيتروجين والكبريت بالاشتراك مع الاحماض الأمينية لتحسين انتاجية البصل في الأراضي الرسوبية

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اجريت تجربتان حقليتان بتصميم قطع منشقة مرتين فى محطة بحوث تاج العز بمحافظة الدقهلية- مصر فى الموسمين الشتويين لعامي 2018/2019 و 2019/2020 بهدف دراسة الادارة المتكاملة لثلاث مصادر مختلفة من التسميد النيتروجيني (اليوريا و نترات الأمونيوم و سلفات الأمونيوم) في القطع الرئيسية، مع اضافة الكبريت الزراعي للتربة (كنترول و 100 كجم كبريت للفدان) في القطع المنشقة، فى وجود ثلاث معاملات للرش ببعض الاحماض الامينية الكبريتية (كنترول والميثيونين و السيستئين) في القطع تحت المنشقة و والتداخلات بينهم على صفات النمو الخضري ومحتوى الاوراق من الكلوروفيل ومحتوى العناصر المعدنية بالإضافة الى بعض المواد البيوكيماوية مثل المواد الصلبة الذائبة والبروتين الكلى والمحصول وجودته. وكذلك دراسة المتبقي فى التربة من النيتروجين و الفوسفور و البوتاسيوم والكبريت بعد مرحلة الحصاد. ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:- كان سماد نترات الامونيوم هو الافضل فى معظم القياسات الخضرية وفى الانتاجية وجودة المحصول هو مقارنة بالأسمدة النيتروجينية الأخرى. - أدت اضافة سماد الكبريت الزراعي بمعدل 100كجم كبريت للفدان نتائج افضل بالإضافة الى الميثيونين الذي حقق اعلى معنوية فى معاملات الرش. - أظهرت النتائج ان التفاعل بين سماد نترات الامونيوم مع الكبريت والميثونين حقق اعلى نمو و انتاجية فى المحصول بالمقارنة بباقي المعاملات. ايضا حقق سلفات الامونيوم مع الميثونين اعلى معدل انتاجية - فى التربة كانت اعلى قيم للنيتروجين و الفوسفور و البوتاسيوم المتبقي فى معاملات سماد سلفات الأمونيوم وعدم اضافة الكبريت الزراعي و غياب الاحماض الأمينية فى حين كانت اعلى قيم للكبريت المبقى فى التربة فى سلفات الامونيوم واضافة الكبريت والميثونين.