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Effect of Selenium, Sulphur and their Interaction on Yield, Contents and Uptake by Onion (*Allium cepa* L.)

A. Jessie Rebecca*

Department of Soil Science and Agricultural Chemistry, College of Agriculture Rajendranagar, Hyderabad

*Corresponding Author E-mail: jessierebecca.jr@gmail.com

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ABSTRACT

The present investigation was carried out during 2015-16 at Agricultural Research Institute, PJTSAU, Rajendranagar. Four levels of soil applied sulphur (0, 15, 30 and 45 kg S ha^{-1}) in combination with four levels of foliar sprayed selenium concentration (0, 25, 50 and 100 ppm) was tried on onion to know their effect on yield, sulphur and selenium contents and their uptakes. The onion crop responded to sulphur application in the range of 10 to 31 percent. Onion bulb yield increased with selenium application only up to 50 ppm spray and subsequently, the yield decreased. Sulphur content in onion bulbs ranged from 0.35 to 0.52 percent due to increase in levels of sulphur application. The selenium content in onion bulb ranged from 5.10 to 15.84 mg kg^{-1}. Antagonistic relationship of sulphur and selenium was observed due to highest sulphur dosage applied to soil (45 kg S ha^{-1}) in combination with highest foliar concentrated spray (100 ppm).

Key words: *Selenium, Sulphur, Onion, yield, Selenium content, Selenium uptake, Sulphur content and Sulphur uptake.*

INTRODUCTION

Selenium (Se) is an important trace element in animal and human nutrition but known as a non-essential element for plants, though its beneficial roles have been reported in the plants capable of accumulating large amount of the element[24]. It plays an important role in body antioxidation system; it is considered as an individual antioxidant that can cooperate with other antioxidants such as vitamins C and E and in the processes protecting the cells from free radicals.

Selenium acts as a cofactor in cellular detoxification of peroxidase. Low Se status in humans may increase the risk of cardiovascular diseases (CVD), cancer and other diseases like Alzheimers, which are caused by free radicals[4].Selenium participates in thyroid hormone metabolism, immune system, inhibits virulence, and slows down the development of AIDS through reducing the speed of HIV development.

In India, onion is grown in an area of 1.17 m ha with a production of 18.77 m tons and ranks second in global onion production[11]. Bulb onion (*Allium cepa* L.) is one of the major sources of dietary flavonoids in several countries[6].

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Due to the substantial consumption and ability to accumulate Se, bulb onion could be one of the best vegetables for Se enrichment. Several studies have been performed to enrich onions with Se, but most of them have been conducted in hydroponic conditions[10].

MATERIAL AND METHODS

Experimental location

A pot experiment was conducted in a net house on *Alfisol* of Rangareddy district, Telangana state during *rabi* of 2015 to study the performance of onion under different sulphur and selenium treatments (Table 1). Sixteen treatments were taken with combinations of four levels of soil applied sulphur (made at the beginning of the crop @ 0, 15, 30 and 45 kg S ha^{-1}) and four levels of foliar sprayed selenium given at 30th day of the crop (0, 25, 50 and 100 ppm Se). The net house in Rajendranagar is geographically situated at an altitude of 531 m above mean sea level (MSL) on 17^0 19.443' N latitude and 78^0 23.956' E longitude. It is located in the southern agro-climatic zone of Telangana state.

Table 1: Treatmental details

Factor I		**Factor II**	
Sulphur (kg ha^{-1})		**Selenium (ppm)**	
Soil application		**Foliar application at 30 DAP**	
S_0	0	Se_0	0
S_{15}	15	Se_{25}	25
S_{30}	30	Se_{50}	50
S_{45}	45	Se_{100}	100

Pot experiment

The experiment was conducted in completely randomized design with four replications. The initial properties of the soil are given in table 2. The required quantity of *Agrifond Light Red* variety seed was taken and sown in nursery tubs, filled with 4 kgs of 2:1 soil and vermicompost mixture. The seeds were sown in lines with 3 inches gap between the rows on well prepared, leveled and raised seed bed. The seedlings were transplanted @ 4 hills per pot and two seedlings per hill at age of 30 days. The RDF for onion is 150:60:60 of N:P:K kg ha^{-1}. Nitrogen and Potassium was given in 2 splits, once at transplanting and the remaining at 30 DAP (Ist leaf fall stage) while phosphorus was given only once at transplanting in the form of single super phosphate. Potassium was given to the crop in the form of muriate of potash. Nitrogen was supplied as ammonium sulphate and urea. Sulphur was given only once at transplanting using ammonium sulphate for 15, 30 and 45 kg sulphur treatments. Selenium was given in the form of foliar spray at 30 DAP (Ist leaf fall stage) using sodium selenite (Na_2SeO_3) for 25, 50 and 100 ppm of selenium. Prophylactic plant protection measures were carried out by employing spray application of fipronil @ 2 ml/l at vegetative and bulb development stage to control thrips damage.

Table 2: Initial characteristics of the soil collected for the net house experiment

S. No	**Parameters**		**Method**
I.	**Physical properties**		
1	Mechanical composition (%)		Bouyoucos hydrometer method (Piper, 1966)
	Sand (%)	64	
	Silt (%)	20	
	Clay (%)	16	
	Soil textural class	Sandy loam	

II	**Physico-chemical properties**		
2	pH (1:2.5 soil water suspension)	7.75	Glass electrode - Elico LI 127 (Jackson, 1973)
3	Electrical Conductivity (dS m^{-1})	0.29	Conductivity meter - Elico CM 180 (Jackson, 1973)
4	Organic Carbon (%)	0.66	Chromic acid wet digestion method (Walkley and Black, 1934)
III	**Chemical properties**		
5	Available Nitrogen (kg ha^{-1})	188	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
6	Available P_2O_5 (kg ha^{-1})	58	0.5M $NaHCO_3$ (pH 8.5) method using colorimeter ECIL GS 5701 SS (Olsen *et al*., 1954)
7	Available K_2O (kg ha^{-1})	286	Neutral normal ammonium acetate method (Mervin and Peech, 1951)
10	Available Sulphur (mg kg^{-1})	9	Turbedimetric method (Chesnin and Yien, 1950)
11	Total Selenium (mg kg^{-1})	2.71	Azure B colorimetric method (Mathew and Narayana, 2006)

Plant sampling and analytical methods

The crop was harvested at 90 DAT (neck fall stage). The plants were uprooted and harvested separately according to treatments. The bulbs were separated from the leaves and shade dried for 3 days. Dry weights of bulbs were recorded using electronic weighing balance. The onion bulbs collected were then oven dried at 65°C. The dried samples were powdered and the finely ground material were used for estimation of sulphur and selenium contents. The samples employed for estimation of sulphur was digested with di-acid mixture of HNO_3-$HClO_4$ (9:4) as per the procedure of Shaw[19]. Blank was prepared in the same way without plant material. Sulphur in digested plant samples was determined by barium sulphate turbidimetry method using spectrophotometer at 420 nm (Model ECIL GS 5701) as described by Chesnin and Yien[1]. It is expressed in percentage.

Selenium content determination in plants

The method outlined by Levesque and Vendette[7]. was employed for determining the Se content in plants. For this, plant samples of 0.2 to 0.5g were placed in kjeldahl flasks to which 5ml of concentrated HNO_3 and few glass beads were added. After 60 minutes, at room temperature, 2ml of $HClO_4$ (72%) was added. The flasks were put on electro thermal furnace and kept at low heat for 20 minutes. Then the heat was increased so that maximum oxidation conditions were reached some 10 minutes later, when fumes of $HClO_4$ started to evolve. The digestion was considered to be complete when the condensed acid forms a ring at the top of the neck after 15 min. This digested sample is used for determination of total selenium by using Azure B as a chromogenic reagent as outlined by Mathew and Narayana[8]. using spectrophotometer (Model ECIL GS 5701 SS) at 644 nm wavelength. It is expressed in mg kg^{-1}.

RESULTS AND DISCUSSIONS

A. Onion bulb yield

The results are presented in table 3 for onion crops.

Effect of varying levels of sulphur: It was observed that there was significant difference in bulb yield of onion due to application of sulphur. With the increase in sulphur levels

from 0 to 45 kg S ha^{-1}, the bulb yield increased from 104 to 136 g pot^{-1}. The increase in bulb yield due to sulphur application ranged from 10 to 31 percent.

Shamima Nasreen and Imamul Huq[18]. reported that onion bulb yield increased from 7.29 to 18.06 t/ha with increasing S levels from 0 to 60 kg ha^{-1}. Pradhan *et al*.[17]. found that application of sulphur (S) @ 45 kg ha^{-1} produced highest bulb yield of 251.10 q ha^{-1} followed by S @ 30 kg ha^{-1} (226.07 q ha^{-1}).

Effect of varying levels of selenium: The bulb yield of onion increased with application of selenium up to 50 ppm. Subsequently, the weight decreased as foliar spray concentration was increased to 100 ppm. Thus, foliar sprays of selenium at 30 DAP enhanced the yield in crop up to 50ppm but was not found to be beneficial at higher levels of foliar spray.

Similar results were reported by Poldma Priit *et al.*[16]. They reported that the selenium sprayed @ 50ppm had a notable tendency to increase the yield in onion. On an average, Se_{50} treatment significantly increased the bulb yield and weight (3.6 kg m^{-2} and 81 g) compared to control (3.2 kg m^{-2} and 69 g). The Se_{100} treatment had a tendency to decrease bulb weight (77 g) and yield (3.4 kg m^{-2}).

Interaction of S x Se levels: There was significant difference in bulb yield of onion crop due to interaction of sulphur and selenium levels. Bulb yield was highest with S_{45} x Se_{50} (149 g pot^{-1}) followed by S_{45} x Se_{25} (138 g pot^{-1}) and least in S_0 x Se_0 (101 g pot^{-1}) treatments, respectively. The bulb yield in S_{45} x Se_{50} is 7.38% higher when compared to S_{45} x Se_{25} treatment.

Table 3: Effect of sulphur and selenium on yield (g pot^{-1}) of onion (bulb)

Se (ppm) / S (kg ha^{-1})	Onion (Fresh weight)				
	Se_0	**Se_{25}**	**Se_{50}**	**Se_{100}**	**Mean**
S_0	101	104	105	105	**104**
S_{15}	107	112	119	119	**114**
S_{30}	114	126	137	129	**127**
S_{45}	127	138	149	132	**136**
Mean	**112**	**120**	**128**	**121**	

Factors	**Onion**	
	SE(m)±	**C.D at 5%**
Sulphur (S)	3.84	10.95
Selenium (Se)	3.84	10.95
S × Se	7.69	21.82

There has been considerable work on interaction of sulphur and selenium in various crops. The earlier studies were mostly in solution cultures[14,25].

B. Sulphur content and uptake by Onion bulb

The data presented in table 4 indicated that there was significant difference in sulphur content in the onion bulbs due to sulphur application. With the increase in sulphur levels (0 to 45 kg S ha^{-1}), sulphur content and uptake increased. Sulphur content and uptake in the bulb due to S_{45} treatment was 9.09% and 18.95% higher than that of S_{30} application, respectively. It was observed that sulphur content gradually decreased as the concentration of selenium spray was enhanced and the reduction was significant at the highest level of selenium application. However, the sulphur uptake by onion bulb increased gradually up to 50 ppm of Se foliar spray and decreased to 4.84 mg pot^{-1} by the time foliar spray was deployed at 100 ppm (Fig, 1).

Dean *et al*[2]. reported that low concentrations of sodium selenate (Na_2SeO_4) significantly enhanced sulphur uptake and accumulation in onion. Increased sulphur uptake with increasing levels of its application was also reported by several workers for several crops[22,20]. and the results of present investigation also corroborated the same.

Table 4: Effect of sulphur and selenium on sulphur content (%) of onion bulb

Se (ppm) / S (kg ha^{-1})	Sulphur Content				
	Se_0	**Se_{25}**	**Se_{50}**	**Se_{100}**	**Mean**
S_0	0.38	0.38	0.37	0.35	**0.37**
S_{15}	0.43	0.42	0.40	0.38	**0.41**
S_{30}	0.47	0.45	0.43	0.41	**0.44**
S_{45}	0.52	0.50	0.47	0.45	**0.48**
Mean	**0.45**	**0.44**	**0.42**	**0.40**	

Factors	**Sulphur Content**	
	SE(m)±	**C.D at 5%**
Sulphur (S)	0.014	0.039
Selenium (Se)	0.014	0.039
S × Se	0.025	0.078

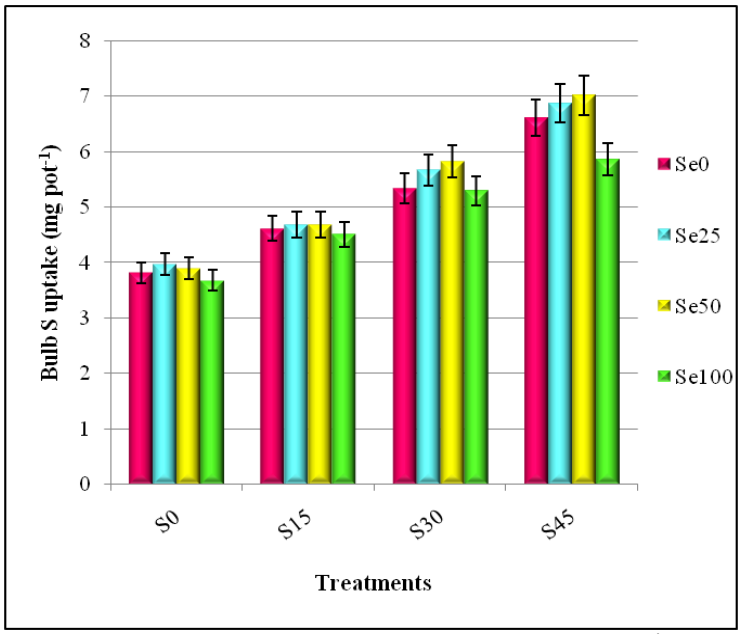

Fig. 1: Effect of sulphur and selenium on sulphur uptake (mg pot^{-1}) by onion bulb

C. Selenium content and uptake by Onion bulb

The selenium content in onion bulbs (Table 5) significantly increased with increased concentrations of foliar sprays of selenium given to crop at 30th day after planting. It reached to the highest concentration of 14.10 µg g^{-1} due to 100 ppm foliar spray of selenium. The Se uptake by onion bulbs also followed similar trend of enhancement like that of

selenium content in onion bulbs due to foliar sprays of selenium (Fig 2). However, the Se content in onion bulbs decreased due to increased levels of soil application of sulphur. Lowest selenium content at (9.28 µg g^{-1}) in onion bulb was noticed when sulphur was applied at 45 kg S ha^{-1}. The interaction effect of foliar sprayed selenium and soil applied sulphur on selenium content in onion bulbs was more pronounced due to combination of Se_{100} and S_{45} treatment.

The interaction effect of foliar sprayed selenium and soil applied sulphur on selenium content in onion crop showed that, for a given level of selenium spray, the selenium content decreased with increasing sulphur application levels. However, the selenium uptake increased due to association of a given selenium level and increased sulphur application.

Such increase in selenium content in crops due to foliar spray is in agreement with the earlier reports[13,16]. Phillip and Goldman[14]. reported that at constant selenium level, increasing the sulphur in solution culture reduced selenium concentration and they suggested that sulphur must be applied at lower levels to produce high concentration of selenium. Similarly, Zayed *et al*[25], reported increase in concentration of sulphur, decreases the uptake of selenium in cauliflower and cabbage crops under hydroponics solution. Reduced selenium uptake with increased gypsum application under field condition to wheat crop was also reported by Dhillon *et al*[3].

Table 5: Effect of sulphur and selenium on selenium content (µg g^{-1}) of onion bulb

Se (ppm) / S (kg ha^{-1})	Selenium Content				
	Se_0	**Se_{25}**	**Se_{50}**	**Se_{100}**	**Mean**
S_0	6.97	10.19	14.09	15.84	**11.77**
S_{15}	5.78	9.78	12.43	14.73	**10.68**
S_{30}	5.42	9.06	11.04	13.16	**9.67**
S_{45}	5.10	8.78	10.59	12.65	**9.28**
Mean	**5.82**	**9.45**	**12.04**	**14.10**	

Factors	**Selenium Content**	
	SE(m)±	**C.D at 5%**
Sulphur (S)	0.29	0.85
Selenium (Se)	0.29	0.85
S × Se	0.58	1.70

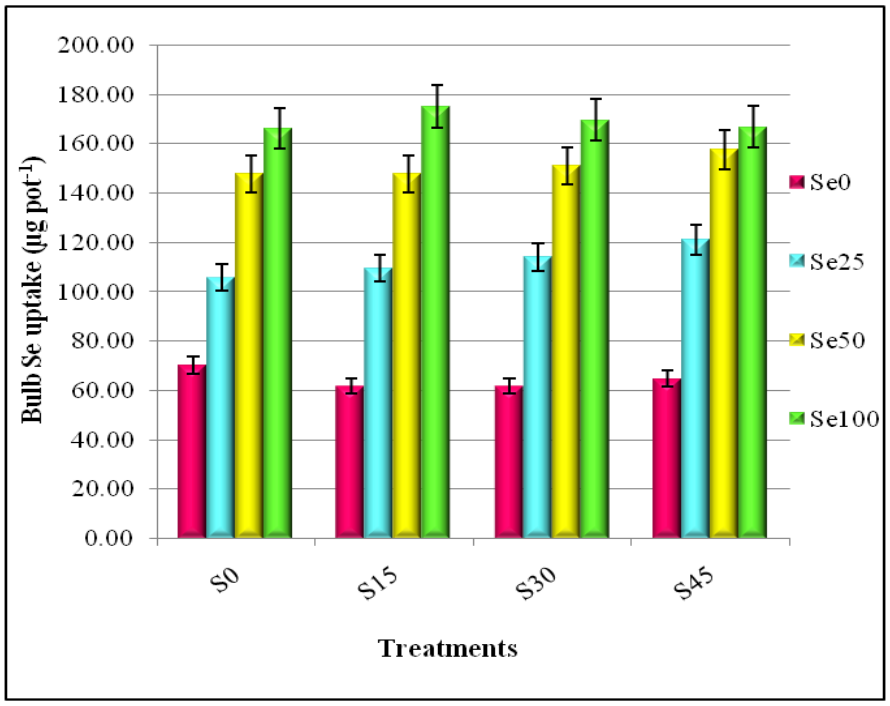

Fig. 2: Effect of sulphur and selenium on selenium uptake (µg pot^{-1}) by onion bulb

CONCLUSIONS

It was found that with the increase in sulphur levels, yield also increased and with the increase in selenium levels, the yield increased till Se_{50} then decreased due to the interaction of soil applied sulphur and foliar sprayed selenium in onion crop.

An antagonistic interaction was observed between sulphur and selenium in onion. Sulphur content at any stage of the crop decreased whenever sulphur is associated with higher selenium levels compared to that of lower selenium levels and vice versa. Among the treatments, S_{45}×Se_{50} was found to result in highest yield and better antioxidant properties.

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