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# Effect of Selenium, Sulphur and Their Interaction on Yield, Contents and Uptake by Sunflower (*Helianthus annus* L.)

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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 sunflower to know their effect on yield and their contents. The sunflower crop showed > 25% response to sulphur application. Sunflower seed yield increased with selenium application only up to 50 ppm spray and subsequently, the yield decreased. Sulphur content in sunflower seeds ranged from 0.15 to 0.33% due to increase in levels of sulphur application. The selenium content in sunflower seed ranged from 9.12 to 20.12 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, Sunflower, 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[23]. 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[3]. Selenium participates in thyroid hormone metabolism, immune system, inhibits virulence, and slows down the development of AIDS through reducing the speed of HIV development. Sunflower (*Helianthus annuus L.*) is an important oilseed crop. It occupies fourth place among oilseed crops in terms of acreage and production in India[6]. It is grown in an area of 0.73 m ha and has production of 0.52 million tonnes in India.

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Sunflower seeds are one of the incredible sources of health benefiting nutrients, minerals, antioxidants and vitamins. Sunflower seeds are rich in selenium having about 79.3 µg Se in 100 g and come in top 10 foods containing selenium[21].

## 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 sunflower 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 30$^{th}$ 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 DAS** | |
| $S_0$ | 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 *DRSH-1* variety seed was taken and sown in pots containing 10 kgs of soil. Each pot was sown with 8 seeds @ 2 seeds for each hill. The RDF for sunflower is 75:90:30 of N:P:K kg $ha^{-1}$. Nitrogen was given in 3 splits i.e., 50% at the time of sowing, 25% at 30 DAS (vegetative stage) and 25% at 50 DAS. Phosphorus and potassium was given only once at sowing in the form of single super phosphate and muriate of potash, respectively. Nitrogen was supplied as ammonium sulphate and urea. Sulphur was given only once at the time of sowing using ammonium sulphate for 15, 30 and 45 kg sulphur treatments. Selenium was given in the form of foliar spray at 30 DAS (vegetative 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 saaf (carbendazim+mancozeb) @ 2 g/l at vegetative, head forming and flowering stage to control leaf spot disease.

**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 DAS (head drop stage). The plants were uprooted and harvested separately according to treatments. The heads were separated from the whole plant and kept for shade drying for 3 days. Dry weights of seeds were recorded using electronic weighing balance. The sunflower seeds 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[16]. 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. Sunflower seed yield**

The results are presented in table 3 for sunflower crop.

**Effect of varying levels of sulphur**: It was observed that there was significant difference in seed yield of sunflower due to application of sulphur. With the increase in sulphur levels from 0 to 45 kg S $ha^{-1}$, the seed yield increased from 3.8 to 6.04 g $pot^{-1}$.The increase in yield of sunflower seed was more than 25 percent over control.

Similar results were reported by Syed *et al*.[19]. in sunflower. They have reported that increase in sulphur levels from 0 to 60 kg $ha^{-1}$, increased the seed yield from 8.14 to 10.04 q $ha^{-1}$. Shamima Nasreen and Imamul Huq[15], also reported similar results in sunflower crop. They have reported that the seed yield increased from 1.80 to 3.68 t $ha^{-1}$ with the application of sulphur @ 0 to 60 kg $ha^{-1}$.

**Effect of varying levels of selenium**: The seed yield of sunflower increased with application of selenium up to 50 ppm. Subsequently, the weight decreased as foliar spray concentration was increased to 100 ppm. The sunflower seed yield increased from 4.46 to 5.65 g $pot^{-1}$ with the increase in selenium

levels from 0 to 50 ppm and then it decreased due to $Se_{100}$ level of foliar spray. Thus, foliar spray of selenium at 30 DAS enhanced the yield in sunflower crop upto 50ppm but was not found to be beneficial at higher levels of foliar spray.

Petr Skarpa[11], found that application of Se at 50 g $ha^{-1}$, increased the achenes yield by 3.1% and application of Se at 150 g $ha^{-1}$, and decreased the yield by 6.8%. Hu *et al.*[4], reported similar results in alfalfa where $Se_{50}$ recorded highest yield of 1121 kg $ha^{-1}$ compared to $Se_0$ treatment.

**Interaction of S x Se levels**: There was significant difference in sunflower seed yield due to interaction of sulphur and selenium levels. Sunflower seed yield was highest in $S_{45}$ x $Se_{50}$ (7.41 g $pot^{-1}$) followed by $S_{45}$ x $Se_{25}$ (6.12 g $pot^{-1}$) and least in $S_0$ x $Se_0$ (3.45 g $pot^{-1}$) treatments, respectively. The seed yield in $S_{45}$ x $Se_{50}$ is 17.4% higher when compared to $S_{45}$ x $Se_{25}$ treatment.

In the interaction effect, 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.

**Table 3: Effect of sulphur and selenium on yield (g $pot^{-1}$) of sunflower (seed)**

| Se (ppm) / S (kg $ha^{-1}$) | Sunflower | | | | |
|---|---|---|---|---|---|
| | **$Se_0$** | **$Se_{25}$** | **$Se_{50}$** | **$Se_{100}$** | **Mean** |
| **$S_0$** | 3.45 | 3.70 | 4.23 | 3.82 | **3.80** |
| **$S_{15}$** | 3.98 | 4.46 | 5.23 | 5.32 | **4.75** |
| **$S_{30}$** | 5.05 | 5.42 | 5.74 | 5.83 | **5.51** |
| **$S_{45}$** | 5.35 | 6.12 | 7.41 | 5.30 | **6.04** |
| **Mean** | **4.46** | **4.93** | **5.65** | **5.07** | |

| **Factors** | **Sunflower** | |
|---|---|---|
| | **SE(m)±** | **C.D at 5%** |
| **Sulphur (S)** | 0.15 | 0.43 |
| **Selenium (Se)** | 0.15 | 0.43 |
| **S × Se** | 0.29 | 0.86 |

There has been considerable work on interaction of sulphur and selenium in various crops. The earlier studies were mostly in solution cultures[12,24].

**B. Sulphur content and uptake by Sunflower seed**

The sulphur content and uptake by sunflower seeds presented in table 4 showed that they increased with increased levels of sulphur to crop. The increase in sulphur content and uptake was statistically significant. The highest sulphur content (0.29%) and uptake (1.73 mg $pot^{-1}$) of sunflower seeds was due to application of sulphur to the soil at 45 kg S $ha^{-1}$. In contrast, the sulphur content in the sunflower seeds was highest (0.29%) due to no selenium application and was lowest (0.21%) when 100 ppm concentration of selenium spray was given to crop. The sulphur uptake by sunflower seed increased with enhanced selenium concentration of 50 ppm foliar sprays. However, after Se50 dose, the sulphur uptake by the seed decreased significantly to 1.07 mg $pot^{-1}$ (Fig 1). The sulphur content and uptake was higher when lower concentration of selenium was in combination with sulphur than when selenium was at higher dose and in combination with sulphur levels.

Increased sulphur uptake with increasing levels of its application was also reported by several workers for several crops[20,17], and the results of present investigation also corroborated the same.

**Table 4: Effect of sulphur and selenium on sulphur content (%) of sunflower seed**

| Se (ppm) / S (kg ha$^{-1}$) | Sulphur Content | | | | |
|---|---|---|---|---|---|
| | **$Se_0$** | **$Se_{25}$** | **$Se_{50}$** | **$Se_{100}$** | **Mean** |
| **$S_0$** | 0.25 | 0.23 | 0.18 | 0.15 | **0.20** |
| **$S_{15}$** | 0.28 | 0.24 | 0.22 | 0.19 | **0.23** |
| **$S_{30}$** | 0.29 | 0.25 | 0.24 | 0.23 | **0.25** |
| **$S_{45}$** | 0.33 | 0.28 | 0.28 | 0.26 | **0.29** |
| **Mean** | **0.29** | **0.25** | **0.23** | **0.21** | |

| Factors | Sulphur Content | |
|---|---|---|
| | **SE(m)±** | **C.D at 5%** |
| **Sulphur (S)** | 0.0088 | 0.024 |
| **Selenium (Se)** | 0.0088 | 0.024 |
| **S × Se** | 0.0176 | 0.048 |

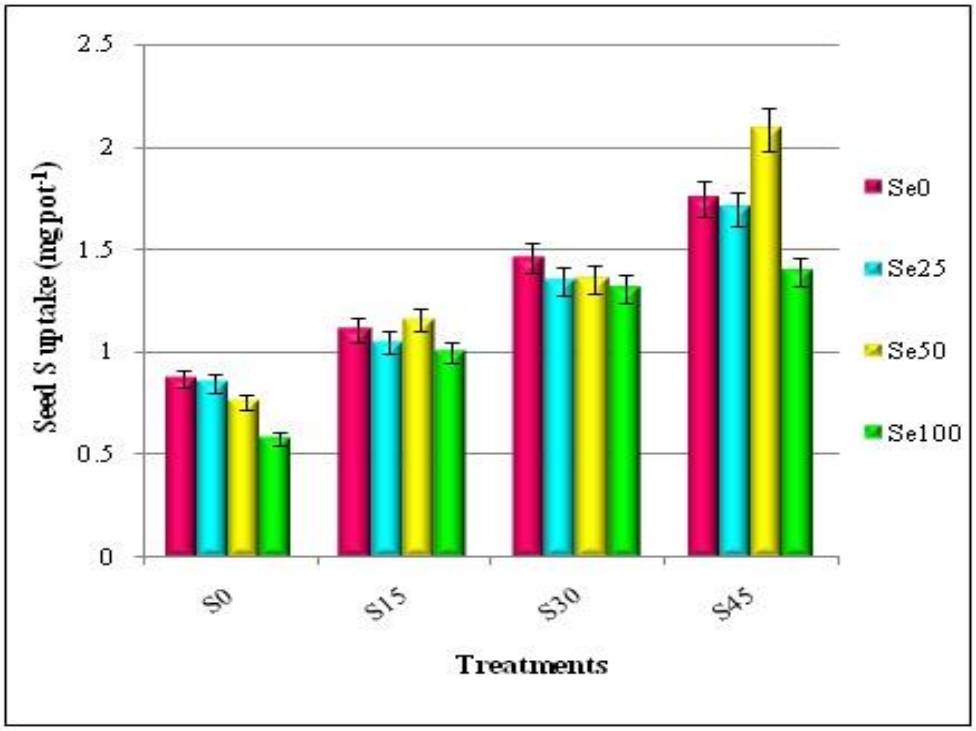


**Fig. 1: Effect of sulphur and selenium on sulphur uptake (mg pot$^{-1}$) by sunflower seed**

**C. Selenium content and uptake by Sunflower seed**

The selenium content in sunflower seed (Table 5) significantly increased with increased concentrations of foliar sprays of selenium given to crop at 30$^{th}$ day after sowing. The highest selenium concentration (17.96 µg g$^{-1}$) and uptake (90.09 µg pot$^{-1}$) in sunflower seed was recorded in $Se_{100}$ treatment. The selenium content decreased significantly in sunflower seeds due to soil application of sulphur made at the time of sowing. Least selenium content (12.88 µg g$^{-1}$) was observed at $S_{45}$ level. The selenium uptake by sunflower seed increased from 61.15 to 78.45 µg pot$^{-1}$ with increasing sulphur levels made to soil (Fig 2).

The interaction effect of foliar sprayed selenium and soil applied sulphur on selenium content in sunflower 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[11,14]. Phillip and Goldman[12]. 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* [24],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* [2].

**Table 5: Effect of sulphur and selenium on selenium content (µg $g^{-1}$) of sunflower seed**

| Se (ppm) / S (kg $ha^{-1}$) | Selenium Content | | | | |
|---|---|---|---|---|---|
| | **$Se_0$** | **$Se_{25}$** | **$Se_{50}$** | **$Se_{100}$** | **Mean** |
| **$S_0$** | 10.45 | 15.42 | 17.64 | 20.12 | **15.91** |
| **$S_{15}$** | 10.06 | 14.58 | 16.34 | 18.76 | **14.93** |
| **$S_{30}$** | 9.58 | 13.62 | 15.21 | 17.11 | **13.88** |
| **$S_{45}$** | 9.12 | 12.27 | 14.30 | 15.84 | **12.88** |
| **Mean** | **9.80** | **13.97** | **15.87** | **17.96** | |

| **Factors** | **Selenium Content** | |
|---|---|---|
| | **SE(m)±** | **C.D at 5%** |
| **Sulphur (S)** | 0.32 | 0.94 |
| **Selenium (Se)** | 0.32 | 0.94 |
| **S × Se** | 0.64 | 1.88 |

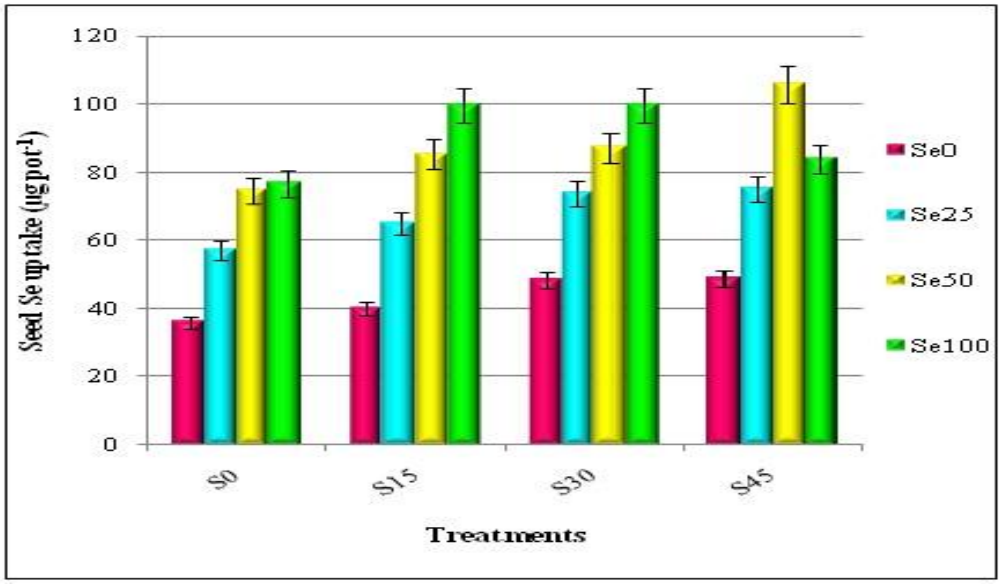


**Fig. 2: Effect of sulphur and selenium on selenium uptake (µg $pot^{-1}$) by sunflower seed**

## CONCLUSIONS

It was found that with the increase in sulphur levels, the 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 sunflower crops.

An antagonistic interaction was observed between sulphur and selenium in sunflower crop. 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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