# “ Sulfur Synergy: Improving Black Soybean *(Glycine max* (L.)Merrill) Yields with Varied Sources and levels ”

## Introduction

Sulphur is an essential nutrient for plant growth and development, playing a crucial role in various physiological processes in crops like black soybeans. The availability of sulphur in the soil directly impacts the yield of black soybeans, making it vital to understand the effects of different sources and levels of sulphur on crop productivity. In recent years, research has focused on optimizing sulphur management practices to maximize yields while ensuring sustainable agricultural production(Singh*et al.*, 2018).

The introduction of different sources and levels of sulphur can significantly influence the yield of black soybeans. Sulphur is involved in the synthesis of amino acids and proteins, critical components for plant growth and reproductive processes. Insufficient sulphur levels can lead to reduced chlorophyll production, poor nitrogen utilization, and decreased photosynthetic efficiency, ultimately affecting the overall yield potential of black soybeans. Therefore, the proper management of sulphur is essential for ensuring optimal crop performance and achieving high yields (Layek *et al.*, 2014).

The choice of sulphur sources, such as elemental sulphur, sulphate-based fertilizers, or organic amendments, can impact the availability and uptake of sulphur by black soybeans. Each source has unique characteristics that influence its solubility, release rate, and interaction with soil microbes. Understanding the dynamics of sulphur sources is crucial for designing effective fertilization strategies that meet the nutritional requirements of black soybeans throughout the growing season (Lakshman *et al.*, 2015).

Additionally, the levels of sulphur applied to black soybeans can have varying effects on plant growth and yield. While sulphur is considered a secondary nutrient, its importance in optimizing crop productivity should not be overlooked. Excessive sulphur application can lead to nutrient imbalances and potential toxicity, negatively impacting the physiological processes of black soybeans. Conversely, inadequate sulphur levels can result in nutrient deficiencies and limit the ability of plants to reach their full yield potential (Kumar *et al.*,1992)

By exploring the effects of different sulphur sources and levels on the yield of black soybeans, researchers and farmers can gain valuable insights into optimizing sulphur management practices for sustainable crop production. This introduction sets the stage for a comprehensive analysis of the interactions between sulphur availability, plant nutrition, and yield outcomes in black soybeans. Understanding the complexities of sulphur dynamics in agricultural systems is essential for enhancing crop performance, improving resource efficiency, and meeting the demands of global food security (Sharma *et al.*, 2019)

## Materials and Methods

A field experiment was conducted during the kharif season of 2023 at Jollang, Himalayan University27.14 'N latitude, 93.62 ' E longitude and 320 meters above sea level. Temperature during the cropping period ranged between 15 to 26 $^{o}$ C, the humidity 70 % to 89 % with 8.0 hours day length and a moderate to high rainfall. The soil of the experimental site was silty clay loam in texture with pH 4.2, organic carbon 1.59 %, total nitrogen 613 (kg/ha), available phosphorus 4.86 kg/ha, sulphur 5.25 kg/ha and potassium 218 kg/ha.Three levels viz., $S_1$=15 kg S/ha, $S_2$=30 kg S/ha, $S_3$=45 kg S/ha and 4 sources of sulphur viz., 1. Gypsum ($CaSO_4.2H_2O$) (18.62% S), 2.Iron Pyrite ($FeS_2$) (53.3 % S) 3. Epsom Salt ($MgSO_4$) (13% S) 4. Sphalerite (Zn, Fe)(33.06 % S )and recommended practice are evaluated in FRBD with three replications. VL Bhat a variety of black soybean was sown in lines with a spacing of row to row 45 cm and plant to plant 5 to 7.5 cm. Recommended doses of N, P and K, in the form of urea, DAP and MOP, were applied. All other recommended agronomic practices were followed during the period of crop growth. The crop was harvested from a net plot of size 9 $m^2$ on 22 Nov., 2023. The data on yield parameters were recorded periodically and analyzed statistically to find out the treatment difference and the mean differences were compared using CD values (Gomez and Gomez 1984).

The experiment constituted of 9 treatment combinations was laid out in Factorial Randomized block design.The details of treatments are given below:

**A: Sources**

$S_1$ = Gypsum / Calcium Sulphate

$S_2$ = Iron Pyrite / Ferrous Sulfide

$S_3$ = Epsomite+ Sphalerite

**B: Levels**

$L_1$ = 15 kg Sulphur $ha^{-1}$

$L_2$ = 30 kg Sulphur $ha^{-1}$

$L_3$ = 45 kg Sulphur $ha^{-1}$

## TreatmentCombination: ( 3×3=9)

| Treatment | TreatmentCombination |
|---|---|
| $T_1(S_1L_1)$ | Gypsumat15kgSha$^{-1}$ |
| $T_2(S_1L_2)$ | Gypsumat30kgSha$^{-}$ 1 |
| $T_3(S_1L_3)$ | Gypsumat45kgSha$^{-1}$ |
| $T_4(S_2L_1)$ | IronPyriteat15kgSha$^{-1}$ |
| $T_5(S_2L_2)$ | IronPyriteat30kgSha$^{-1}$ |
| $T_6(S_2L_3)$ | IronPyriteat45kgSha$^{-1}$ |
| $T_7(S_3L_1)$ | Epsomite+ Sphalerite at15kg S ha$^{-1}$ |
| $T_8(S_3L_2)$ | Epsomite+ Sphalerite at30kg S ha$^{-1}$ |
| $T_9(S_3L_3)$ | Epsomite+Sphaleriteat45kg S ha$^{-1}$ |

## Results and Discussion :

### Yield Attributes

The growth of the crop was appeared to be reflected in the yield attributes of soybean. Levels of sulphur brought about significance variation in all the yield attributes of soybean. Like growth parameters yield attributes viz. number of pods per plant , number of seeds per pod , 100 seed weight, seed yield , straw yield , biological yield and harvest index increased with

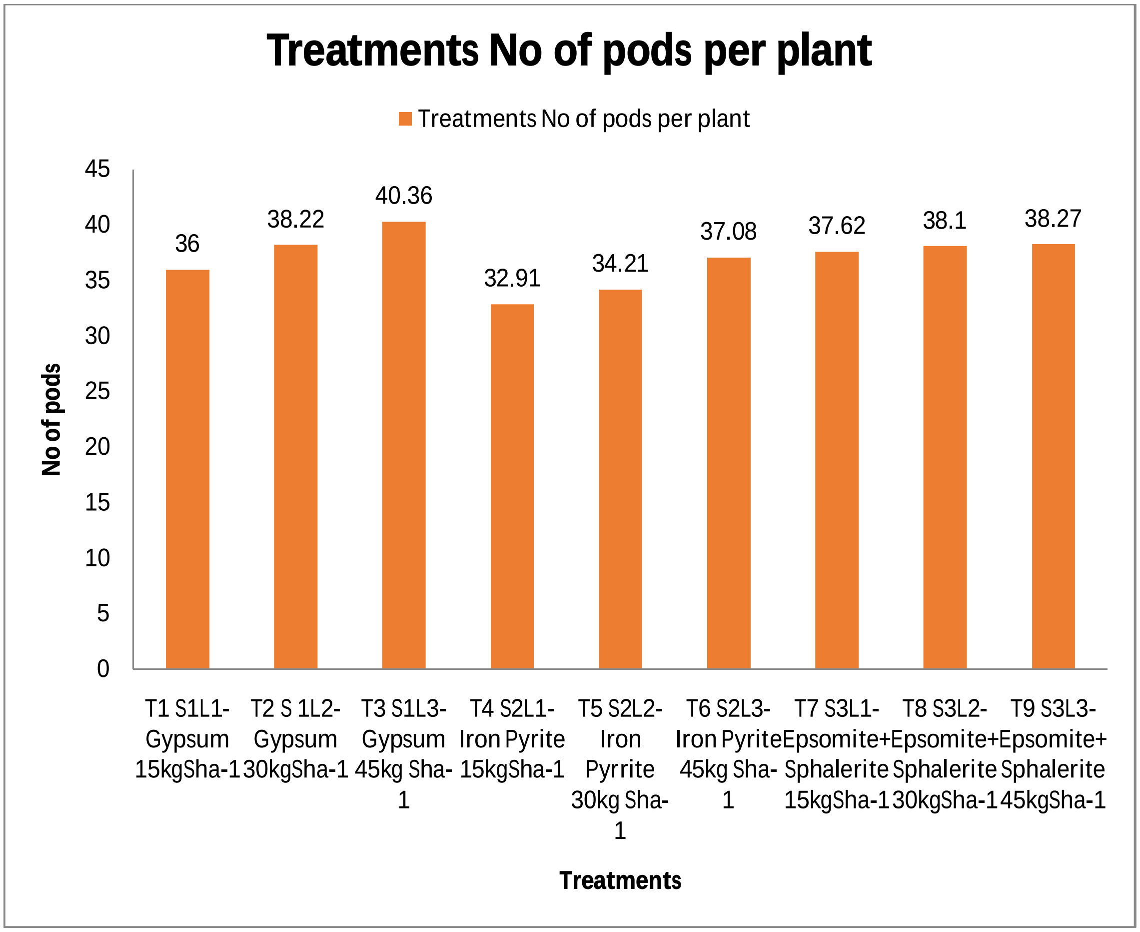
| **Treatments** | **Number of pods** | **Number of seeds** | **100 Seed** | **Seed yield** | **Straw yield** | **Biological yield (t/ha)** | **Harvest index** |
|---|---|---|---|---|---|---|---|

increase in level of sulphur up to 45 kg S/ha. Improvement in pods/plant ,seeds/pod and 100-seed weight with the application of S have been also reported (Shivran *et al*. 2012; Devi *et al*. 2012) . Source of sulphur also significantly influenced number of pods/plant, seeds/pod and 100-seed weight. Among the source of sulphur, ($T_3$ $S_1L_3$- Gypsum 45 kg S $ha^{-1}$) excelled all the other in terms of pods/plant, seeds/pod and 100- seed weight, seed yield ,straw yield , biological yield and harvest index . The superiority of gypsum in influencing yield attributes in soybean (Mamatha*et al*., 2018) and other legumes (Yatheesh *et al*., 2013) have been amply documented. However, ($T_9S_3L_3$Epsomite+ Sphalerite45 kg S $ha^{-1}$)was statistically at par with gypsum in influencing pods/plant , seeds/pod, 100-seed weight, seed yield , straw yield , biological yield and harvest index. Sphalerite , Epsom salt and Iron pyrite were comparable to each other in influencing the seeds/pod and 100-seed weight. The overall effects of sulphur application were found to be significantly superior .Sulphur applications increased pods/plant, seeds/pod ,100-seed weight, seed yield , straw yield, biological yield and harvest index by about 40.36 , 3.07, 10.35 g,1.90 t/ha, 3.59 t/ha , 5.49 t/ha , 34.62 % respectively.

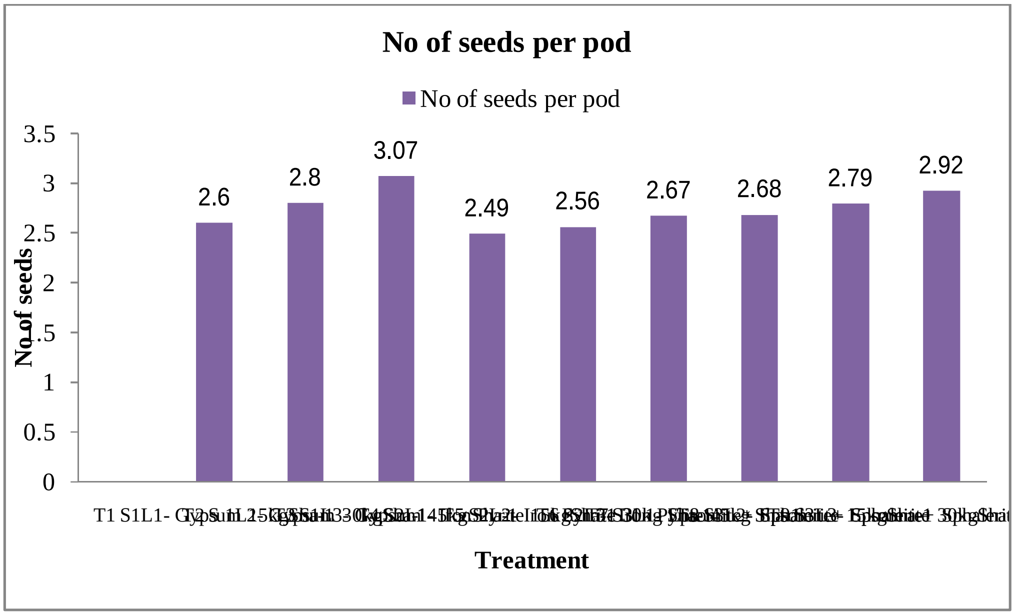
| | per plant | per pod | weight (g) | (t/ha) | (t/ha) | | (%) |
|---|---|---|---|---|---|---|---|
| **$T_1S_1L_1$- Gypsum 15 kg S ha$^{-1}$** | 36.00 | 2.60 | 10.02 | 1.66 | 3.39 | 5.06 | 33.00 |
| **$T_2S_1L_2$- Gypsum 30 kg S ha$^{-1}$** | 38.22 | 2.80 | 10.08 | 1.82 | 3.50 | 5.31 | 34.04 |
| **$T_3$ $S_1L_3$- Gypsum 45 kg S ha$^{-1}$** | 40.36 | 3.07 | 10.35 | 1.90 | 3.59 | 5.494 | 34.62 |
| **$T_4$ $S_2L_1$-Iron Pyrite 15 kg S ha$^{-1}$** | 32.91 | 2.49 | 9.65 | 1.61 | 3.33 | 4.94 | 32.61 |
| **$T_5$ $S_2L_2$- Iron Pyrite 30 kg S ha$^{-1}$** | 34.21 | 2.56 | 9.67 | 1.64 | 3.35 | 4.99 | 32.90 |
| **$T_6$ $S_2L_3$- Iron Pyrite 45 kg S ha$^{-1}$** | 37.08 | 2.67 | 10.03 | 1.72 | 3.41 | 5.14 | 33.57 |
| **$T_7S_3L_1$- Epsomite+ Sphalerite15 kg S ha$^{-1}$** | 37.62 | 2.68 | 10.05 | 1.74 | 3.45 | 5.20 | 33.52 |
| **$T_8$ $S_3L_2$- Epsomite + Sphalerite 30 kg S ha$^{-1}$** | 38.10 | 2.79 | 10.07 | 1.771 | 3.48 | 5.25 | 33.79 |
| **$T_9$ $S_3L_3$- Epsomite+ Sphalerite 45 kg S ha$^{-1}$** | 38.27 | 2.92 | 10.14 | 1.86 | 3.55 | 5.42 | 34.47 |
| **F test** | S | S | S | S | S | S | S |
| **SEm±** | 0.27 | 0.051 | 0.034 | 0.008 | 0.019 | 0.023 | 0.13 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **CD (P=0.05)** | 0.59 | 0.10936 | 0.073 | 0.018 | 0.041 | 0.050 | 0.27 |

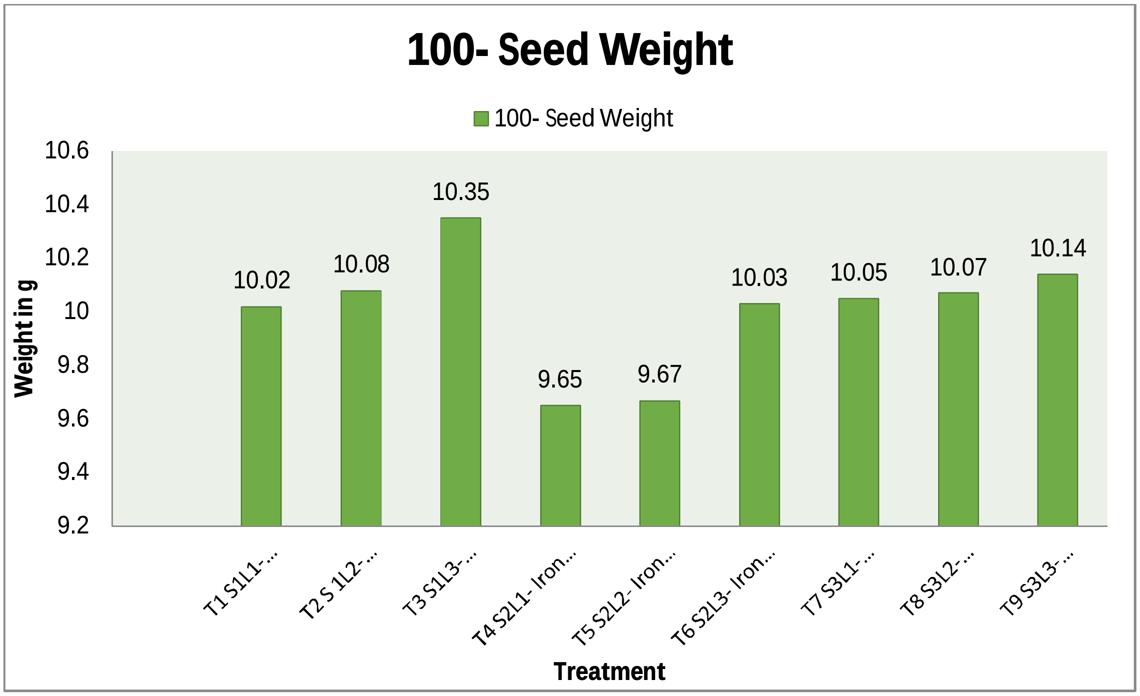
**Table 1** : Effect of levels and sources of sulphur on number of pods per plant , number of seeds per pod , 100 seed weight , seed yield , straw yield , biological yield and harvest index of black soybean.



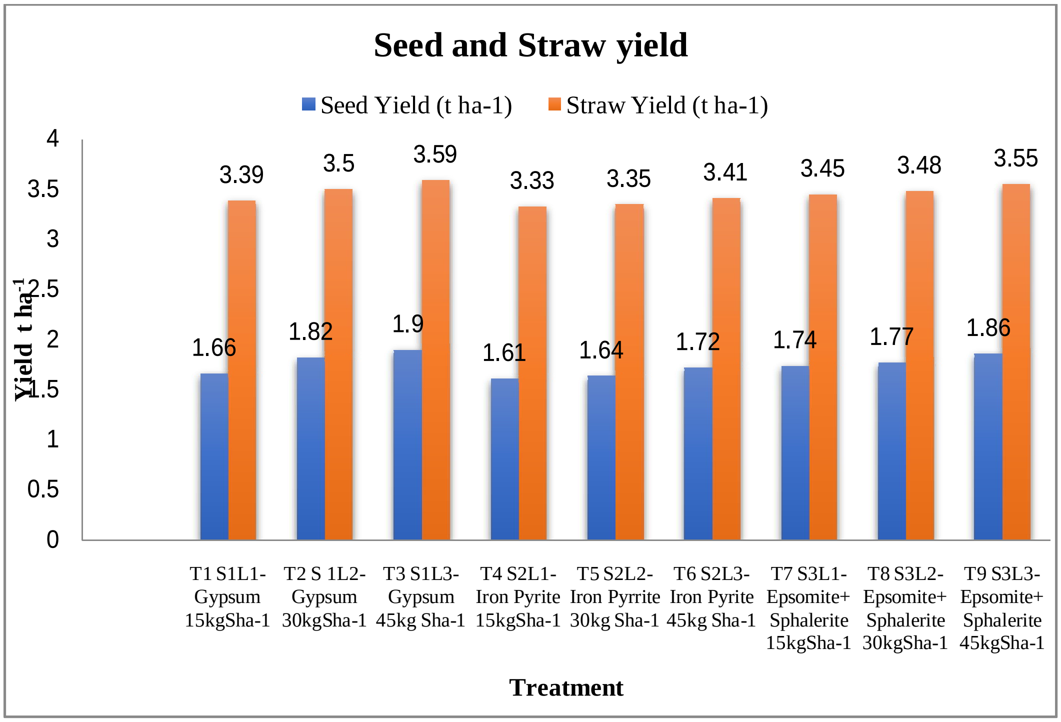
**Graph 1:Effect of different sources and levels of sulphur on no. of pods per plant of black soybean**



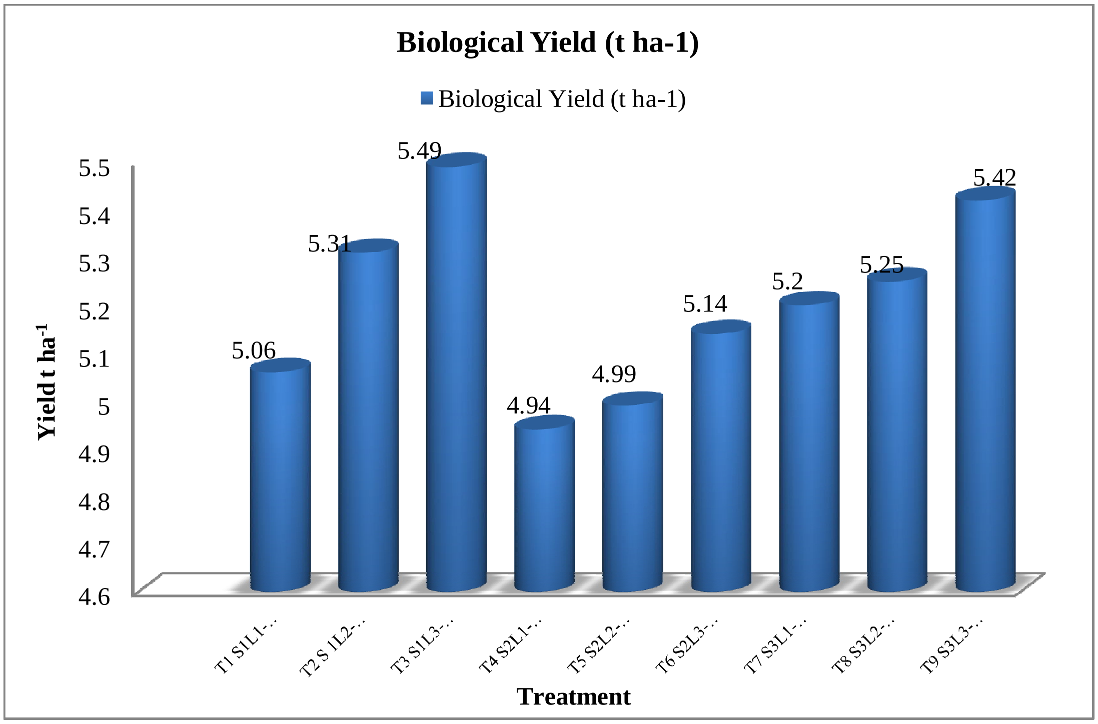
Graph 2: Effect of different sources and levels of sulphur on no. of seed per pod of black soybean



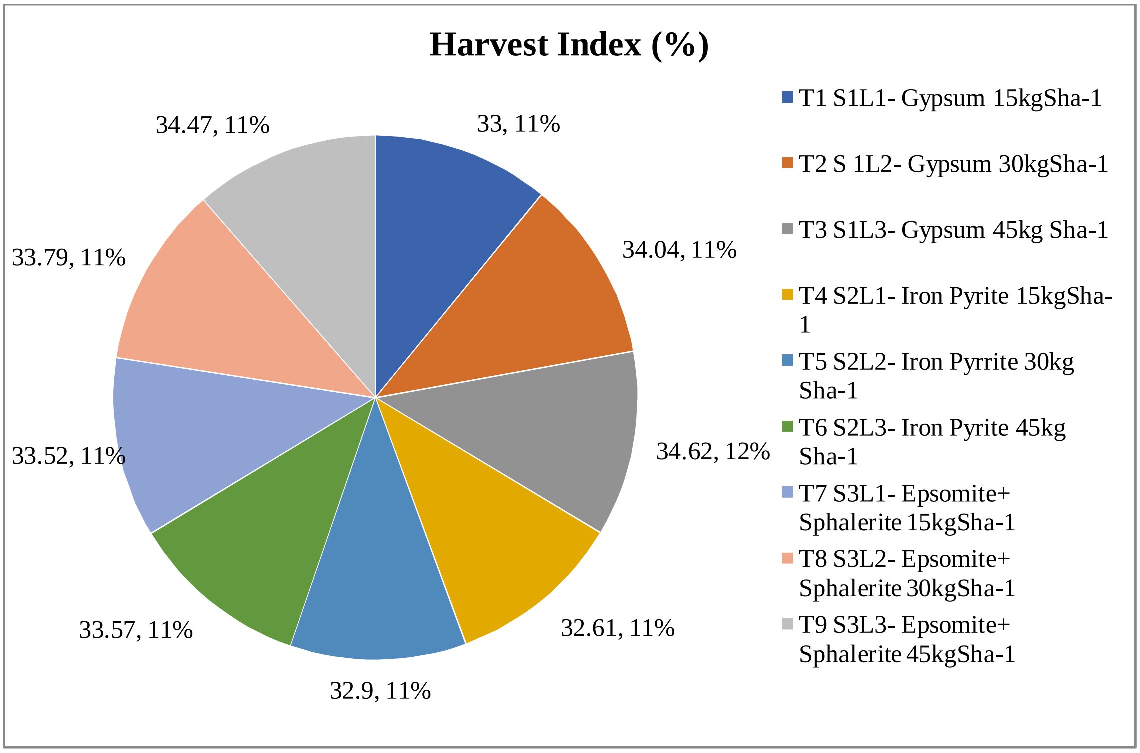
Graph 3 : Effect of different sources and levels of sulphur on seed weight of black soybean



**Graph 4: Effect of different sources and levels of sulphur on seed yield and straw yield of black soybean**



**Grpah 5: Effect of different sources and levels of sulphur on biological yield of black soybean**



**Graph 6: Effect of different sources and level of sulphur on Harvest Index**

## Conclusion

The study investigating the impact of different sources and levels of sulfur on yield parameters of black soybean cultivation, specifically focusing on the $T_1S_1L_1$ treatment (Gypsum 45 kg S ha$^{-1}$), has provided significant insights. The application of gypsum at 45 kg S ha-1 in the $T_1S_1L_1$ treatment demonstrated compelling results across multiple aspects of black soybean production.

Firstly, the increased number of pods observed in the $T_1S_1L_1$ treatment signifies the positive influence of sulfur supplementation on plant reproductive development. Sulfur is essential for flower and pod formation, and the enhanced pod count indicates improved flowering and successful pod setting in black soybean plants under this treatment.

Furthermore, the higher number of pods per plant in the $T_1S_1L_1$ treatment suggests effective utilization of sulfur by the soybean crop, leading to increased pod development on individual plants. This indicates better plant health, nutrient uptake, and overall productivity in the presence of adequate sulfur levels provided by gypsum application.

The significant increase in 100-seed weight associated with the T1S1L1 treatment indicates improved seed filling and quality. Sulfur plays a critical role in protein synthesis and seed development, leading to heavier seeds with superior nutritional value. This observation highlights the positive impact of sulfur supplementation on seed characteristics in black soybean cultivation.

Moreover, the elevated seed yield in the $T_1S_1L_1$ treatment underscores the importance of sulfur in enhancing overall crop productivity. Sulfur is known to stimulate enzyme activity, improve nutrient uptake, and enhance metabolic processes crucial for seed formation. The higher seed yield in this treatment reflects the optimized utilization of sulfur for maximizing soybean production.

The increased straw yield in the $T_1S_1L_1$ treatment further supports the notion that sulfur application positively influences plant biomass production. Sulfur is essential for chlorophyll synthesis, photosynthesis, and overall plant growth. The higher straw yield indicates improved vegetative growth and biomass accumulation, contributing to enhanced crop performance under sulfur-enriched conditions.

Additionally, the rise in biological yield and harvest index associated with the $T_1S_1L_1$ treatment signifies the overall improvement in crop productivity and efficiency. Sulfur availability has a direct impact on plant metabolism, nutrient assimilation, and yield components, leading to increased biological yield and harvest index. This outcome reflects the positive response of black soybean plants to sulfur supplementation through gypsum application.

In conclusion, the $T_1S_1L_1$ treatment involving the application of gypsum at 45 kg S ha$^{-1}$ has demonstrated favorable effects on the number of pods, number of pods per plant, 100-seed weight, seed yield, straw yield, biological yield, and harvest index of black soybean cultivation. The results indicate that sulfur plays a crucial role in enhancing various yield parameters and overall crop performance in black soybean production systems, emphasizing the importance of sulfur management for sustainable and optimized soybean cultivation practices.

## Disclaimer (Artifical intelligence )

Authors hereby decalre that No generative technologies such as Large Language Models and text to image generators have been used during writing or editing of manuscript.

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