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Effect of efficient sulfur fertilization on *summer* mungbean (*Vigna radiata* L.)

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Abstract

The present investigation, entitled "Effect of Efficient Sulfur Fertilization on *Summer* Mungbean (*Vigna radiata* L.)", was conducted during the *summer* season of 2025 at the Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh. The experiment was laid out in a Randomized Block Design with nine treatments replicated thrice, viz., T₁ - Control (no sulfur), T₂ - Recommended sulfur @ 20 kg ha⁻¹, T₃ - Nano Sulfur @ 10 kg ha⁻¹, T₄ - Nano Sulfur @ 100 ppm, T₅ - Nano sulfur coated urea @ 100 ppm, T₆ - RDS @ 10 kg ha⁻¹ + spray @ 2 g/L at pre-flowering, T₇ - Nano S @ 5 kg ha⁻¹ + spray @ 2.5 mg/L at pre-flowering, T₈ - Multiplex liquid S @ 2.5 ml/L at seed dressing + at pre-flowering, and T₉ - RDS @ 10 kg ha⁻¹ + multiplex S spray @ 2.5 ml/L at pre-flowering.

The results revealed that sulfur fertilization significantly influenced the growth parameters and yield-attributing characters, viz., number of pods plant⁻¹, number of grains pod⁻¹, grain yield plant⁻¹ and test weight. The application of Nano S @ 5 kg ha⁻¹ as basal application along with foliar spray @ 2.5 mg/L at pre-flowering recorded the highest dry matter accumulation at harvest, which was 21.3% higher than the control (12.2 g plant⁻¹). The treatment T₇ also recorded the highest grain yield (1326 kg ha⁻¹) and net returns (₹86,267 ha⁻¹), representing an increase of 313 kg ha⁻¹ in grain yield and ₹28,896 ha⁻¹ in net returns over the control, respectively. Sulfur application also improved nodulation, quality attributes, nutrient content and uptake and soil fertility status. The next best treatments were RDS @ 10 kg ha⁻¹ + Multiplex S spray @ 2.5 ml/L at pre-flowering and RDS @ 10 kg ha⁻¹ + foliar spray @ 2 g/L at pre-flowering. In contrast, the control treatment recorded the lowest values for grain yield, net returns, benefit: cost ratio, nodulation and yield-attributing characters.

Keywords: Sulfur, nano sulfur, coated sulfur, multiplex liquid sulfur

1. Introduction

Pulses are considered as the second major constituent of Indian diet after cereals. On an average, pulses contain 22-24% proteins as against 8-10% in cereals. A good amount of lysine is also present in the pulses. Globally, pulses occupy about 96.8 million hectares with an annual production of approximately 101.4 mt, resulting in an average productivity of about 1050 kg ha⁻¹. India is the largest producer and consumer of pulses, contributing nearly 29% of global production, followed by Canada, China and the European Union (FAO, 2025) [2]. India is the world's largest producer and consumer of pulses. During 2024-25, pulses were cultivated over 27.72 million hectares, producing 25.68 mt with an average productivity of 926 kg ha⁻¹ (Anonymous, 2024-25). Mungbean (*Vigna radiata* L.) belongs to the family fabaceae or leguminaceae. Being a short duration crop and having wider adaptability, it can be grown in *kharif* as well as in *summer* season. Moreover, it is drought resistant that can withstand adverse environmental conditions and hence successfully be grown in rainfed areas (Nair and Schreinemachers 2020) [3]. It is grown principally for its protein-rich (25%) edible seeds (Jain et al., 2020) [4] and have good amount of lysine content (460 mg g⁻¹) and tryptophan (60 mg g⁻¹). Sulfur is considered to be the fourth major plant nutrient and hence important as nitrogen, phosphorus and potassium. In India sulfur responses have been obtained from pastures, pulses and oilseeds. Sulfur has an important role in stimulation of cell division and photosynthetic process. It also promotes the root nodulation in legumes which ensure its availability during vegetative growth period and development of plant occurs. It is involved in protein synthesis, chlorophyll formation and is considered indispensable for the synthesis of cysteine, cystine and methionine.

It also promotes the root nodules in legumes which cause the more sulfur available during vegetative growth period and development of plant occurs (Meena *et al.*, 2013 and Das, 2017 and Krishna *et al.*, 2020) [6, 16, 5]. Nano-sulfur has generated interest due to its antibacterial and insecticidal properties. Cao *et al.*, (2021) [7] showed that sulfur nanoparticles of 30 nm and 100 nm were effective in controlling *Fusarium* wilt compared to the application of bulk sulfur granules and sulfate. Research has shown that nano-sulfur acts as a plant growth promoter, enhancing plant stress resistance and improving the nutritional quality of plants.

2. Materials and Methods

This chapter provides a description of the materials and methodology used in the study Effect of Efficient Sulfur Fertilization on Summer Mungbean (*Vigna radiata* L.). At a latitude of 29.081833 North, longitude of 77.700589 East, and elevation of 237 meters above mean sea level, the field experiment was conducted at the Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.). Meerut has a subtropical climate and is located in the center of Western Uttar Pradesh. The geography of the trial field was uniform, and the drainage system was effective. The experimental field's soil had a sandy loam texture, low levels of accessible nitrogen and organic carbon, medium levels of

available phosphorus, potassium and sulfur, and a reaction that was almost neutral. Pant Mung-5 was sown on 25 March 2025. The experiment was laid out in a Randomized Block Design (RBD) with 9 treatments with 3 replications. Nine plots of gross plot size (5 m × 4.5 m) and net plot size (4 m × 3.3 m) were included in each replication.

3. Results and Discussion

3.1 Yield attributing characters

3.1.1 Number of pods plant⁻¹

The sulfur fertilization in mungbean had significant effect on number of pods plant⁻¹. Significantly highest number of pods plant⁻¹ were obtained with Nano S @5kg ha⁻¹ + spray @2.5 mg/L at pre flowering (25.2) which was statistically *at par* with T₆ (23.50), T₉ (23.00), T₂ and T₅ (21.5) but superior to rest of the treatments. Further, the per cent increase in number of pods plant⁻¹ was 29.2% as compared to T₄.

3.1.2 Number of grains pod⁻¹

The sulfur fertilized treatments had significant effect on number of grains pod⁻¹. Spray with Nano S @5kg ha⁻¹ + spray @2.5 mg/L at pre flowering resulted into the highest (9.8) grains pod⁻¹ followed by T₉ and T₆ treatments. Though, the minimum number of grains pod⁻¹ was recorded in control (6.8).

Table 1: Effect of efficient sulfur fertilization on yield attributes in mungbean

Treatment	Yield attributes			
	No. of pods plant ⁻¹	No. of grains pod ⁻¹	Grain yield plant ⁻¹ (g)	Test weight (g)
T ₁ - Control (no sulfur)	18.5	6.8	3.8	32.2
T ₂ - Recommended sulfur @20 kg ha ⁻¹	22.5	8.6	4.5	35.0
T ₃ - Nano Sulfur @10 kg ha ⁻¹	21.0	8.0	4.2	34.2
T ₄ - Nano Sulfur @100 ppm	19.5	7.2	3.8	32.8
T ₅ - Nano sulfur coated urea @100 ppm	21.5	8.2	4.3	34.5
T ₆ - RDS @10 kg ha ⁻¹ + spray @2g/L at pre flowering	23.5	9.0	4.6	35.2
T ₇ - Nano S @5kg ha ⁻¹ + spray @2.5 mg/L at pre flowering	25.2	9.8	4.8	35.8
T ₈ - Multiplex liquid S @2.5 ml/L at seed dressing + at pre flowering	20.0	7.5	4.0	33.5
T ₉ - RDS @10 kg ha ⁻¹ + multiplex S spray @2.5 ml/L at pre flowering	23.0	9.4	4.7	35.5
S.E.m.±	1.3	0.5	0.2	0.7
C.D. (p=0.05)	3.9	1.5	0.5	2.2

3.1.3 Grain yield plant⁻¹ (g)

Grain yield plant⁻¹ (g) in mungbean varied significantly due to sulfur treatments. Maximum grain yield plant⁻¹ (4.8g) was recorded T₇ (Nano S @5kg ha⁻¹ + spray @2.5 mg/L at pre flowering) treatment, which remained *at par* with T₆ (4.6g) and T₉ (4.7g) while significantly superior over all other treatments. The lowest grain yield plant⁻¹ was recorded in control (3.8g). Moreover under T₇, T₉ and T₆ the pace of increment was to the tune of 20, 17.5 and 15%, respectively over T₈.

3.1.4 Test weight (g)

The perusal of the data showed that test weight varied significantly due to sulfur application in mungbean. However, the highest test weight (35.8 g) was recorded in treatment receiving Nano S @5kg ha⁻¹ + spray @2.5 mg/L at pre flowering (T₇) and lowest test weight under control treatment (32.2 g). The next in the order were T₉, T₆ and T₂.

3.2 Yield

3.2.1 Grain yield (kg ha⁻¹)

Grain yield kg ha⁻¹ varied significantly with sulfur nutrition in mungbean. Perusal of data presented in Table 4.11 and depicted in Fig. showed that maximum grain yield (1326 kg ha⁻¹) was

observed with Nano S @5kg ha⁻¹ + spray @2.5 mg/L at pre flowering (T₇) which remained *on par* with treatment T₉ (1238), T₆ (1205) and T₂ (1193), while significantly superior to rest of the treatments. Moreover, the increase in grain yield under T₇ and T₉ was 20.8 and 12.8%, respectively over T₈. However, the minimum grain yield was recorded in treatment receiving no sulfur fertilizer (1013 kg ha⁻¹). These findings corroborate the results of Budhar *et al.* (2001) [10], Dey *et al.* (2004) [11], Kadam *et al.* (2006) [12], Srivastava *et al.* (2006) [15], Singh *et al.* (2015) [14], Arunraj *et al.* (2018) [8], Murshed *et al.* (2021) [13] and Neha and Dawson (2023) of improved yield attributes and yield of mungbean with sulfur fertilization.

3.2.2 Straw yield (kg ha⁻¹)

The data on straw yield of mungbean as summarized in Table 4.11 showed a significantly influence of sulfur fertilizers over control. The straw yield varied between 1902 to 3097 kg ha⁻¹ among different treatments, being highest with Nano S @5kg ha⁻¹ + spray @2.5 mg/L at pre flowering (T₇) followed by T₉. The treatments receiving foliar application over and above sub optimal S (50%) remained *on par* with each other. Further, the increase in yield by T₇, T₉ and T₂ was 1195, 935 and 889 kg ha⁻¹, respectively over control.

3.2.3 Biological yield (kg ha⁻¹)

The data pertaining to biological yield was found to be significant with sulfur in mungbean. The data presented in Table 4.11 revealed that biological yield (kg ha⁻¹) increased significantly with application of sulfur, irrespective of the treatments in comparison to control. However, highest biological yield (3950 kg ha⁻¹) was recorded with Nano S @5kg ha⁻¹ + spray @2.5 mg/L at pre flowering (T₇) which was significantly more over T₄ (3294 kg ha⁻¹) and control, while rest of the treatments were significantly *at par* to each other. Moreover, the increase in

biological yield by T₇ and T₉ was 21.2 and 14.6%, respectively over control (T₁).

3.2.4 Harvest index

The maximum harvest index of 34.6% was recorded in treatment receiving Nano S @5kg ha⁻¹ + spray @2.5 mg/L at pre flowering (T₇), which remained *at par* with treatment T₆ (33.8), T₂ (33.5) and T₉ (34.0%), but significantly superior to rest of the treatments. Although, the minimum harvest index (31.6%) was obtained under control followed by T₄ (31.7%).

Table 2: Effect of efficient sulfur fertilization on yield kg ha⁻¹ in mungbean

Treatment	Yield kg ha ⁻¹			H.I. (%)
	Grain	Straw	Biological	
T ₁ - Control (no sulfur)	1013	1902	3257	31.6
T ₂ - Recommended sulfur @20 kg ha ⁻¹	1193	2791	3633	33.5
T ₃ - Nano Sulfur @10 kg ha ⁻¹	1147	2500	3542	32.3
T ₄ - Nano Sulfur @100 ppm	1037	2091	3294	31.7
T ₅ - Nano sulfur coated urea @100 ppm	1167	2614	3573	33.5
T ₆ - RDS @10 kg ha ⁻¹ + spray @2g/L at pre flowering	1205	2943	3634	33.8
T ₇ - Nano S @5kg ha ⁻¹ + spray @2.5 mg/L at pre flowering	1326	3097	3950	34.8
T ₈ - Multiplex liquid S @2.5 ml/L at seed dressing + at pre flowering	1097	2317	3431	31.9
T ₉ - RDS @10 kg ha ⁻¹ + multiplex S spray @2.5 ml/L at pre flowering	1238	2837	3732	34.0
S.Em.±	48	170	131	0.7
C.D. (p=0.05)	144	509	393	2.0

4. Sulfur contents and uptake

4.1 Sulfur contents (%) in grains and straw

Sulfur fertilization had a significant effect on sulfur content in grain and straw of mungbean. Sulfur content in grain and straw ranged between 0.395 to 0.445 and 0.107 to 0.147% under different sulfur treatments.

The data revealed that sulfur content in grain (0.445) and straw (0.147%) was significantly highest under mungbean with Nano S @5kg ha⁻¹ + spray @2.5 mg/L at pre flowering (T₇) but, the lowest sulfur content in grain (0.395) and straw (0.107%) was recorded in control.

4.2 Sulfur uptake in grains, straw and total (kg ha⁻¹)

Sulfur fertilization had a significant influence on sulfur uptake by mungbean in grains, straw and total biomass. Across the different sulfur treatments, sulfur uptake in grains varied from 4.0 to 5.9 kg ha⁻¹, while straw sulfur uptake ranged between 2.0 and 4.5 kg ha⁻¹. Consequently, the total sulfur uptake ranged from

6.0 to 10.4 kg ha⁻¹. These results are in line with the reports of Tripathi *et al.* (2012) ^[18], Das (2016) ^[16], Patel *et al.* (2017) ^[17], Serawat *et al.* (2020) ^[19], Sachan *et al.* (2020) ^[20] at SVPUAT, Meerut, Rajni and Kumawat (2021) ^[21] and Chaudhari *et al.* (2024) of sulfur- nitrogen synergism and enhanced nutrient uptake with sulfur fertilization in greengram and mungbean.

Perusal of the data presented in Table 3 revealed that all sulfur treatments significantly enhanced sulfur uptake in mungbean compared with the control. The highest sulfur uptake by grains (5.9 kg ha⁻¹) and straw (4.5 kg ha⁻¹) was recorded under the application of Nano S @ 5 kg ha⁻¹ + foliar spray @ 2.5 mg/L at the pre-flowering stage (T₇). This treatment was followed by T₉, which recorded grain and straw sulfur uptake of 5.5 and 4.0 kg ha⁻¹, T₆ with 5.2 and 4.1 kg ha⁻¹, respectively. These treatments were statistically *at par* with each other. Under T₇ the total sulfur uptake was 33.3% higher than that recorded under T₃. In contrast, the lowest sulfur uptake by grains, straw and total biomass (4.0, 2.0 and 6.0) was observed in control.

Table 3: Effect of efficient sulfur fertilization on sulfur contents (%) and uptake (kg ha⁻¹) in grains and straw mungbean

Treatment	Sulfur content (%)		Sulfur uptake (kg ha ⁻¹)		Total uptake (kg ha ⁻¹)
	Grains	Straw	Grains	Straw	
T ₁ - Control (no sulfur)	0.395	0.107	4.0	2.0	6.0
T ₂ - Recommended sulfur @20 kg ha ⁻¹	0.425	0.132	5.1	3.7	8.8
T ₃ - Nano Sulfur @10 kg ha ⁻¹	0.416	0.123	4.8	3.1	7.8
T ₄ - Nano Sulfur @100 ppm	0.399	0.114	4.1	2.4	6.6
T ₅ - Nano sulfur coated urea @100 ppm	0.419	0.129	4.9	3.4	8.3
T ₆ - RDS @10 kg ha ⁻¹ + spray @2g/L at pre flowering	0.432	0.138	5.2	4.1	9.3
T ₇ - Nano S @5kg ha ⁻¹ + spray @2.5 mg/L at pre flowering	0.445	0.147	5.9	4.5	10.4
T ₈ - Multiplex liquid S @2.5 ml/L at seed dressing + at pre flowering	0.409	0.119	4.5	2.7	7.2
T ₉ - RDS @10 kg ha ⁻¹ + multiplex S spray @2.5 ml/L at pre flowering	0.439	0.142	5.5	4.0	9.5
S.Em.±	0.010	0.004	0.3	0.2	0.3
C.D. (p=0.05)	0.030	0.013	0.8	0.6	1.0

5. Conclusion

On perusal of the findings, it remains no more obscure that different sources and methods of sulfur fertilization affected the growth, nodulation, yield attributes, yield, quality, nutrient uptake and economics of summer mungbean. Thus, it may be concluded

that combined basal and foliar application of sulfur through Nano S @ 5 kg ha⁻¹ as basal dose along with foliar spray @ 2.5 mg/L at pre-flowering (T₇) led to the highest grain yield (1326 kg ha⁻¹) and fetched the highest net returns (Rs 86,267 ha⁻¹), being higher by 313 kg ha⁻¹ and Rs 28,896 ha⁻¹ than control, respectively, besides

improving nodulation, quality attributes, nutrient content and uptake, and soil fertility status. The next best options were T₉ (RDS @ 10 kg ha⁻¹ + multiplex S spray @ 2.5 ml/L at pre-flowering) and T₆ (RDS @ 10 kg ha⁻¹ + spray @ 2 g/L at pre-flowering). Since the findings are based on a single season of experimentation, there is a need for conducting the experiment for one more season to arrive at a consistent and confirmatory conclusion.

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