Original Research Article

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Effect of Sulphur and Iron Fertilization on Growth and Yield of Greengram [Vigna radiata L.]

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A B S T R A C T

A field experiment was conducted during kharif season of 2016 at Crop Research Farm, Department of Agronomy, SHUATS, Allahabad (U.P.). The soil of experimental plot was sandy loam in texture, neutral in soil reaction (pH 7.5), low in organic carbon (0.35%), available N (230 kg/ha), available P (20 kg/ha) and available K (98kg/ha). The treatments comprised of 4 levels of sulphur viz. S₀ (No Sulphur), S₁ (40 kg as gypsum), S₂ (40 kg/ha as single super phosphate) and S₃ (20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate) and three levels of iron viz. F₀ (No iron), F₁ (0.5% FeSO₄, foliar spray at 25 DAS) and F₂ (0.5% FeSO₄, foliar spray at 45 DAS). There were 12 treatments each replicated thrice. The experiment was laid out in Randomized Block Design. The result showed that maximum plant height (76.40cm) at 60 DAS, number of nodules (78.33) at 30 DAS, number of branches/plant (7.67) at 60 DAS, number of grains/pod (12.17), test weight (39.67gm), grain yield (716.67kg/ha) and stover yield (1372.67kg/ha) were recorded under treatment T₅ (40 kg S/ha as gypsum+ 0.5% FeSO₄ foliar spray 25 DAS). Maximum net return of Rs 69764.1 and B.C. ratio 2.59 was also recorded in treatment T₅ (40 kg S/ha as gypsum+ 0.5% FeSO₄ foliar spray 25 DAS).

Keywords
Greengram, Sulphur levels, Sources of sulphur, Iron levels, Growth and yield.

Introduction

Greengram (Vigna radiata L.) is an important legume crop of Asian origin, and is widely cultivated in the countries of Asia, Australia and Africa continents (Yang et al., 2008). Like other pulses it offers a cheap source of protein. It is an important pulse crop ranked as the second most drought resistant crop after soybean. Mung bean has more protein contents and better digestibility than any other pulse crop (Tabassum et al., 2010). Mung bean grains contain 51% carbohydrates, 26% protein, 10% moisture and 3% vitamins. The residue of green gram is also used as feed for animals and enhances the soil fertility (Asaduzzaman, 2008). A balanced fertilization of macro and micro nutrients is very important for high yield and high quality products (Sawan et al., 2001). Mung bean is considered as poor man’s meat as it contains approximately triple amount of protein as compared to rice. It synthesizes nitrogen in symbiosis with rhizobia and increases soil fertility and biomass of soil. Iron (Fe) is an essential nutrient for plant growth and development and it is involved in chlorophyll and thylakoid synthesis and chloroplast development. Although, total iron content of soils is much higher than requirement of plant but its bioavailability is limited (Guerinot and Yi, 1994). Foliar feeding is a new and
controversial technique of feeding plants by applying liquid fertilizer directly to their leaves (Bernal et al., 2007 and Baloch et al., 2008). Sulphur has been recognised as an essential major nutrient for plant and it ranks 4th macronutrient after N, P and K because of its role is synthesis of proteins, vitamins, enzyme and flavoured compounds in plant. About 90% of plant sulphur is present in amino acid viz. Methionine, cystine and Cysteine (Tandon and Messiet, 2002). These amino acids are the building blocks of protein. It is also involved in the formation of chlorophyll and activation of enzymes (Mengel and Krikby, 1987) and due to this sulphur is crucial for pulse crops. Sulphur is also a constituent of vitamin biotine and thiamine and also of iron-sulphur protein ferredoxin. Sulphur also enhances quality of grains by increasing its nutritional values. Thus, an experiment was conducted to study the effect of sulphur and iron fertilization on growth and yield of green gram.

**Materials and Methods**

A field experiment was conducted during kharif season of 2016 at Crop Research Farm, Department of Agronomy, SUATS, Allahabad (U.P.) which lies between 25° 24’ 42” N latitude and 81° 50’ 56” E latitude and at an altitude of 98m above mean sea level. The soil of experimental plot was sandy loam in texture, neutral in soil reaction (pH 7.5), low in organic carbon (0.35%), available N (230 kg/ha), available P (20 kg/ha) and available K (98 kg/ha). The treatments comprised of 4 levels of sulphur viz. S0 (No Sulphur), S1 (40 kg/ha as gypsum), S2 (40 kg/ha as single super phosphate) and S3 (20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate) and three levels of iron viz. F0 (No iron), F1 (0.5% FeSO4, foliar spray at 25 DAS) and F2 (0.5% FeSO4, foliar spray at 45 DAS). There were 12 treatments and each replicated thrice. The experiment was laid out in Randomized Block Design. Pre-harvest observation viz. Plant height, number of nodules/plant, CGR, number of branch/plant and dry weight/plant were recorded. Post harvest observation viz. Number of pods/plant, no. of grains/pod, test weight, harvest index, grain and stover yield were also recorded. In addition to pre and post harvest observation, economics of treatments was also studied to find out the best treatment combination for higher yield, maximum net return and highest B:C ratio of mungbean.

**Results and Discussion**

**Effect of sulphur**

Growth and yield attributes viz. Plant height, number of branches/plant, number of nodules/plant, number of grains/pod, test weight and grain yield increased significantly in treatment T5 (40 kg S/ha as gypsum+ 0.5% FeSO4 foliar spray 25 DAS). However, Dry Weight, Crop Growth Rate, Number of pods/plant and Harvest Index were found to be non-significant with application of sulphur and 0.5% FeSO4 spray (Table 1). The maximum plant height (76.40cm) at 60 DAS, maximum number of nodules (78.33) at 30 DAS, maximum number of branches/plant (7.67) at 60 DAS, maximum number of branches/plant (7.67) at 60 DAS, number of grains/pod (12.17), test weight (39.67 g), grain yield (716.67 kg/ha) were recorded in treatment T5 followed by treatment T8 (40 kg S/ha as single super phosphate + 0.5% FeSO4 foliar spray 25 DAS) and it was found to be at par to treatment T5 (Table 2). These results obtained might be ascribed to process of tissue differentiation from somatic to reproductive meristematic activity and development of floral primordial might have increased with increasing sulphur levels, resulting in more number of flowers and longer pods and higher grains yield.
Table 1 Effect of sulphur and iron fertilization on dry weight (g), CGR, number of pods/plant and harvest index of greengram

| Treatments                                                                 | Dry Weight (g) at 60 DAS | CGR at 60 DAS | No. of pods/plant | Harvest index (%) |
|----------------------------------------------------------------------------|--------------------------|---------------|-------------------|-------------------|
| T₁  Control                                                                | 15.99                    | 0.35          | 15.75             | 15.75             |
| T₂  S₀ + 0.5% FeSO₄ foliar spray (25 DAS)                                   | 16.44                    | 0.37          | 15.75             | 15.75             |
| T₃  S₀ +0.5% FeSO₄ foliar spray (45 DAS)                                    | 17.11                    | 0.40          | 16.25             | 16.25             |
| T₄  40 kg S/ha as gypsum+ F₀                                                | 19.89                    | 0.52          | 16.58             | 16.58             |
| T₅  40 kg S/ha as gypsum+ 0.5% FeSO₄ foliar spray (25 DAS)                  | 24.75                    | 1.00          | 18.42             | 18.42             |
| T₆  40 kg S/ha as gypsum+0.5% FeSO₄ foliar spray (45 DAS)                   | 17.55                    | 0.47          | 17.25             | 17.25             |
| T₇  40 kg S/ha as single super phosphate+ F₀                                | 19.00                    | 0.43          | 17.17             | 17.17             |
| T₈  40 kg S/ha as single super phosphate+ 0.5% FeSO₄ foliar spray (25 DAS) | 20.66                    | 0.64          | 17.33             | 17.33             |
| T₉  40 kg S/ha as single super phosphate+ 0.5% FeSO₄ foliar spray (45 DAS) | 18.00                    | 0.49          | 17.25             | 17.25             |
| T₁₀ 20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + F₀  | 18.44                    | 0.43          | 16.58             | 16.58             |
| T₁₁ 20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + 0.5% FeSO₄ foliar spray (25 DAS) | 19.75                    | 0.47          | 16.75             | 16.75             |
| T₁₂ 20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + 0.5% FeSO₄ foliar spray (45 DAS) | 18.55                    | 0.45          | 16.75             | 16.75             |

| F- test                      | NS          | NS          | NS     | NS     |
| S. Ed. (±)                   | 2.90        | 0.214       | 0.83   | 0.83   |
| C. D. (P = 0.05)             | _           | _           | _      | _      |
Table 2 Effect of sulphur and iron fertilization on plant height, number of nodules, number of branches/plant and number of grains/pod of greengram

| Treatments                                                                 | Plant height at 60 DAS | No. of nodules at 30 DAS | No. of branch/plant at 60 DAS | No. of grains/pod |
|---------------------------------------------------------------------------|------------------------|--------------------------|-------------------------------|------------------|
| T₁ Control                                                                | 71.73                  | 56.25                    | 6.93                          | 10.33            |
| T₂ 40 kg S/ha as gypsum + F₀                                                | 72.20                  | 58.92                    | 7.13                          | 10.42            |
| T₃ 40 kg S/ha as single super phosphate                                       | 73.27                  | 59.82                    | 7.13                          | 10.83            |
| T₄ 40 kg S/ha as gypsum + 0.5% FeSO₄ foliar spray (25 DAS)                 | 73.73                  | 61.08                    | 7.20                          | 11.17            |
| T₅ 40 kg S/ha as single super phosphate + 0.5% FeSO₄ foliar spray (25 DAS) | 76.40                  | 78.33                    | 7.67                          | 12.17            |
| T₆ 40 kg S/ha as single super phosphate + 0.5% FeSO₄ foliar spray (45 DAS) | 75.40                  | 72.50                    | 7.60                          | 11.50            |
| T₇ 40 kg S/ha as single super phosphate + F₀                                     | 73.27                  | 61.92                    | 7.60                          | 11.00            |
| T₈ 40 kg S/ha as single super phosphate + 0.5% FeSO₄ foliar spray (25 DAS) | 75.47                  | 77.42                    | 7.66                          | 12.00            |
| T₉ 40 kg S/ha as single super phosphate + 0.5% FeSO₄ foliar spray (45 DAS) | 75.27                  | 63.67                    | 7.40                          | 11.75            |
| T₁₀ 20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + F₀  | 73.47                  | 62.50                    | 7.27                          | 11.17            |
| T₁₁ 20 kg S/ha as single super phosphate + F₀                               | 75.13                  | 65.83                    | 7.60                          | 11.42            |
| T₁₂ 20 kg S/ha as single super phosphate + 0.5% FeSO₄ foliar spray (45 DAS) | 74.40                  | 65.75                    | 7.60                          | 11.25            |

F- test                          | S         | S         | S        | S        |
S. Ed. (±)                           | 1.27      | 6.57      | 0.15     | 0.52     |
C. D. (P = 0.05)                     | 2.63      | 13.56     | 0.31     | 1.08     |
Table 3 Effect of sulphur and iron fertilization on test weight (gm), grain yield (kg/ha) and stover yield (kg/ha) of greengram

| Treatments | Test weight (gm) | Grain yield (kg/ha) | Stover yield (kg/ha) |
|------------|------------------|--------------------|----------------------|
| T1 Control | 31.00            | 433.33             | 830.62               |
| T2 S₀+ 0.5% FeSO₄ foliar spray (25 DAS) | 32.33 | 456.67 | 872.40 |
| T3 S₀ +0.5% FeSO₄ foliar spray (45 DAS) | 33.67 | 500.00 | 924.40 |
| T4 40 kg S/ha as gypsum+ F₀ | 34.67 | 506.67 | 967.67 |
| T5 40 kg S/ha as gypsum+ 0.5% FeSO₄ foliar spray (25 DAS) | 39.67 | 716.67 | 1372.67 |
| T6 40 kg S/ha as gypsum+0.5% FeSO₄ foliar spray (45 DAS) | 35.33 | 570.00 | 1009.03 |
| T7 40 kg S/ha as single super phosphate+ F₀ | 35.67 | 543.33 | 989.80 |
| T8 40 kg S/ha as single super phosphate+ 0.5% FeSO₄ foliar spray (25 DAS) | 39.00 | 670.00 | 1292.73 |
| T9 40 kg S/ha as single super phosphate+ 0.5% FeSO₄ foliar spray (45 DAS) | 36.67 | 580.00 | 1176.43 |
| T₁₀ 20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + F₀ | 34.67 | 506.67 | 1012.53 |
| T₁₁ 20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + 0.5% FeSO₄ foliar spray (25 DAS) | 36.00 | 640.00 | 1052.77 |
| T₁₂ 20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + 0.5% FeSO₄ foliar spray (45 DAS) | 35.33 | 563.33 | 1024.37 |

F-test
S S S
S. Ed. (±) 2.22 77.43 33.82
C. D. (P = 0.05) 4.60 159.83 69.82
Table 4 Effect of different benefit cost ratio (B:C) of different treatment combination with greengram crop

| Treatment | Cost of Cultivation | Yield | Sale (₹) | Gross return (₹) | Net Return (₹) | B:C ratio |
|-----------|---------------------|-------|----------|------------------|----------------|-----------|
|           |                     | Grain (kg/ha) | Stover (kg/ha) | Grains (₹) | Stover (₹) |            |            |
| T₁        | 26,335              | 433.33 | 830.62   | 43514.99      | 14951.16       | 58466.2   | 32131.2   | 1.22       |
| T₂        | 26,907              | 456.67 | 872.40   | 45858.80      | 15703.20       | 61562     | 34655     | 1.28       |
| T₃        | 26,907              | 500.00 | 924.40   | 50210.00      | 16639.20       | 66849.2   | 39942.2   | 1.48       |
| T₄        | 26,797              | 506.67 | 967.67   | 50879.80      | 17418.06       | 68297.9   | 41500.9   | 1.54       |
| T₅        | 26,912              | 716.67 | 1372.67  | 71968.00      | 24708.06       | 96676.1   | 69764.1   | 2.59       |
| T₆        | 26,912              | 570.00 | 1009.03  | 57239.40      | 18162.54       | 72723.7   | 45811.7   | 1.70       |
| T₇        | 27,914              | 543.33 | 989.80   | 54561.19      | 17816.40       | 75055.8   | 47141.8   | 1.68       |
| T₈        | 28,029              | 670.00 | 1292.73  | 67281.40      | 23269.14       | 90550.5   | 62521.5   | 2.23       |
| T₉        | 28,029              | 580.00 | 1176.43  | 58243.60      | 21175.74       | 79419.3   | 51390.3   | 1.83       |
| T₁₀       | 27,083              | 506.67 | 1012.53  | 50879.80      | 18225.54       | 69105.3   | 42022.3   | 1.55       |
| T₁₁       | 27,198              | 640.00 | 1052.77  | 64268.80      | 18949.86       | 83218.7   | 56020.7   | 2.05       |
| T₁₂       | 27,198              | 563.33 | 1024.37  | 56569.59      | 18438.66       | 75008.3   | 47810.3   | 1.75       |

Selling price of greengram grain 100.41 ₹/kg
Selling price of greengram stover 18 ₹/kg
Increase in growth parameter may be due to cell division, enlargement and elongation resulting in overall improvement in plant organs associated with faster and uniform vegetative growth of the crop under the effect of sulphur application. These results are in agreement with the finding of Singh and Aggarwal (1998).

Effect of sulphur sources

The application of different sources of sulphur differed significantly with respect to growth and yield attributes of mung bean viz. Plant height, number of nodules/plant, number of branches/plant, number of grains/pod, test weight, grain yield and stover yield (Table 3). The parameters increased with increase in application of gypsum followed by single super phosphate at same dose and time of application. Results on the growth parameters indicated that application of gypsum recorded maximum plant height (76.40cm), number of nodules/plant (78.33), number of branches/plant (7.67), number of grains/pod (12.17), test weight (39.67gm), grain yield (716.67kg/ha) and stover yield (1372.67kg/ha) in treatment T5 (40 kg S/ha as gypsum+ 0.5% FeSO4 foliar spray 25 DAS) followed by treatment T8 (40 kg S/ha as single super phosphate+ 0.5% FeSO4 foliar spray 25 DAS). Maximum seed yield might be due to pivotal role of sulphur in regulating the metabolic and enzymatic processes including photosynthesis, respiration and legume rhizobium symbiotic nitrogen fixation which reflected in increased yield. The other reasons may be due to the important role of sulphur in energy transformation, activation of enzymes and also in carbohydrate metabolism. The third reason may be due to optimum availability of available sulphur which consequently resulted in well filled pods resulting in increased seed yield of mung bean. These results are in conformity with those of Ghosh and Sarkar (2000). The increase yield in sulphur applied in the form of gypsum may be due to presence of readily available SO4 sulphur in gypsum as compare to single super phosphate. The other reasons may be due to its ability to mobilize more sulphur to the crop plants and gypsum brought remarkable improvement in the physio-chemical properties of the soil. Gypsum application influences the productivity of the crop by improving basic infrastructural frame (bearing capacity) and the leaf area (photosynthese production efficiency as well as pod size). Similar results have been reported by Singh and Aggarwal (1998).

Effect of FeSO4 foliar spray at 25 and 45 DAS

Influence of single spray of 0.5% FeSO4 at 25 DAS recorded grain yield (716.67kg/ha) and at 45 DAS (570kg/ha) did not differed significantly. However, these treatments increased the grain yield of mung bean by 65.38% and 31.53% respectively, compared to control which recorded minimum grain yield (433.33 kg/ha). The application of iron sulphate plays an important role in synthesis of chlorophyll and plant growth regulator (Jin et al., 2008). Iron also improves photosynthesis and assimilates transportation to sinks and finally increases seed and stover yield. This may include increase in carbohydrate synthesis. Similar effect of foliar spray of iron was observed in cowpea in sandy loam soil of Kerala by Anitha et al., (2005).

Economics

A persual of the table 4 clearly revels that treatment T5 recorded maximum net return of (69764.1), followed by treatment T8 (63638.3) giving a B:C ratio of (2.59) and (2.23) respectively.
In conclusion, from the experimental finding it can be concluded that 40 kg S/ha as gypsum + 0.5% FeSO₄ foliar spray at 25 DAS can be adopted by the farmers for getting maximum yield and returns from greengram crop in eastern U.P.

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