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Effect of iron and sulphur fertilization on growth and yield of greengram [*Vigna radiata* L.]

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Abstract
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, dry weight (24.75gm) at 60 DAS, crop growth rate (1.00 g m^{-2} day^{-1}) at 60 DAS, harvest index (36.32%) 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: Sulphur fertilization, *Vigna radiata* L., randomized block design

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) [13]. Like other pulses it offers a cheap source of protien. 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. 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) [2]. A balanced fertilization of macro and micro nutrients is very important for high yield and high quality products (Sawan *et al*., 2001) [9]. 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) [6]. Foliar feeding is a new and controversal technique of feeding plants by applying liquid fertilizer directly to their leaves (Bernal *et al*., 2007) [4] and (Baloch *et al*., 2008) [3]. 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) [12]. 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) [8] 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 ferrodoxin. 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 250 24' 42" N latitude and 810 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/ 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, and dry weight/plant were recorded. Post harvest observation *viz.* 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 nodules/plant, dry weight, CGR, harvest index, grain yield and straw yield increased significantly in treatment T5 (40 kg S/ha as gypsum+ 0.5% FeSO4 foliar spray 25 DAS). The maximum plant height (76.40cm) at 60 DAS, number of nodules (78.33) at 30 DAS, dry weight (24.75gm) at 60 DAS, crop growth rate (1.00 g m^{-2} day^{-1}) at 60 DAS, harvest index (36.32%) grain yield (716.67kg/ha) and stover yield (1372.67kg/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 T_5. 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. 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) [10].

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, dry weight, CGR, harvest index, grain yield and straw yield. 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) at 60 DAS, number of nodules (78.33) at 30 DAS, dry weight (24.75gm) at 60 DAS, crop growth rate (1.00 g m^{-2} day^{-1}) at 60 DAS, harvest index (36.32%) 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 rhizobiun 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) [5]. 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 capasity) and the leaf area (photosynthate production efficiency as well as pod size). Similar results have been reported by Singh and Aggarwal (1998) [10].

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 cholorophyll and plant growth regulator (Jin *et al*., 2008) [7]. 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) [1].

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.

Table 1: Effect of sulphur and iron fertilization on plant height (cm), no of nodules, dry weight (g) and CGR of greengram.

Treatments		Plant height at 60 DAS	No of nodules at 30 DAS	Dry weight at 60 DAS	Crop growth rate at 45-60 DAS
T_1	No Sulphur + No $FeSO_4$	71.73	56.25	15.99	0.35
T_2	No Sulphur + 0.5% $FeSO_4$ foliar spray at 25 DAS	72.20	58.92	16.44	0.37
T_3	No Sulphur + 0.5% $FeSO_4$ foliar spray at 45 DAS	73.27	59.82	17.11	0.40
T_4	40 kg S/ha as gypsum + No $FeSO_4$	73.73	61.08	19.89	0.52
T_5	40 kg S/ha as gypsum + 0.5% $FeSO_4$ foliar spray at 25 DAS	76.40	78.33	24.75	1.00
T_6	40 kg S/ha as gypsum + 0.5% $FeSO_4$ foliar spray at 45 DAS	75.40	72.50	17.55	0.47
T_7	40 kg S/ha as single super phosphate + No $FeSO_4$	73.27	61.92	19.00	0.43
T_8	40 kg S/ha as single super phosphate + 0.5% $FeSO_4$ foliar spray at 25 DAS	75.47	77.42	20.66	0.64
T_9	40 kg S/ha as single super phosphate + 0.5% $FeSO_4$ foliar spray at 45 DAS	75.27	63.67	18.00	0.49
T_{10}	20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + No $FeSO_4$	73.47	62.50	18.44	0.43
T_{11}	20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + 0.5% $FeSO_4$ foliar spray at 25 DAS	75.13	65.83	19.75	0.47
T_{12}	20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + 0.5% $FeSO_4$ foliar spray at 45 DAS	74.40	65.75	18.55	0.45
F- test		S	S	NS	NS
S. Ed. (±)		1.27	6.57	2.90	0.214
C. D. (P = 0.05)		2.63	13.56	_	_

Table 2: Effect of sulphur and iron fertilization on harvest index, grainyield and stover of greengram.

Treatments		Harvest index (%)	Grain yield (kg/ha)	Stover yield (kg/ha)
T_1	No Sulphur + No $FeSO_4$	32.31	433.33	830.62
T_2	No Sulphur + 0.5% $FeSO_4$ foliar spray at 25 DAS	33.43	456.67	872.40
T_3	No Sulphur + 0.5% $FeSO_4$ foliar spray at 45 DAS	33.92	500.00	924.40
T_4	40 kg S/ha as gypsum + No $FeSO_4$	34.07	506.67	967.67
T_5	40 kg S/ha as gypsum + 0.5% $FeSO_4$ foliar spray at 25 DAS	36.32	716.67	1372.67
T_6	40 kg S/ha as gypsum + 0.5% $FeSO_4$ foliar spray at 45 DAS	34.13	570.00	1009.03
T_7	40 kg S/ha as single super phosphate + No $FeSO_4$	34.83	543.33	989.80
T_8	40 kg S/ha as single super phosphate + 0.5% $FeSO_4$ foliar spray at 25 DAS	35.68	670.00	1292.73
T_9	40 kg S/ha as single super phosphate + 0.5% $FeSO_4$ foliar spray at 45 DAS	35.14	580.00	1176.43
T_{10}	20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + No $FeSO_4$	34.23	506.67	1012.53
T_{11}	20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + 0.5% $FeSO_4$ foliar spray at 25 DAS	34.86	640.00	1052.77
T_{12}	20 kg S/ha as gypsum + 20 kg S/ha as single super phosphate (1:1) + 0.5% $FeSO_4$ foliar spray at 45 DAS	34.56	563.33	1024.37
F- test		NS	S	S
S. Ed. (±)		3.68	77.43	33.82
C. D. (P = 0.05)		_	156.83	69.82

Table 3: Effect of different benefit cost ratio (B:C) of different treatment combination with greengram.

Treatment	Cost of Cultivation	Yield		Sale (`)		Gross return (`)	Net Return (`)	B:C ratio
		Grain (kg/ha)	Stover (kg/ha)	Grains (`)	Stover (`)			
T_1	26,335	433.33	830.62	43514.99	14951.16	58466.2	32131.2	1.22
T_2	26,907	456.67	872.40	45858.80	15703.20	61562	34655	1.28
T_3	26,907	500.00	924.40	50210.00	16639.20	66849.2	39942.2	1.48
T_4	26,797	506.67	967.67	50879.80	17418.06	68297.9	41500.9	1.54
T_5	26,912	716.67	1372.67	71968.00	24708.06	96676.1	69764.1	2.59
T_6	26,912	570.00	1009.03	57239.40	18162.54	72723.7	45811.7	1.70
T_7	27,914	543.33	989.80	54561.19	17816.40	75055.8	47141.8	1.68
T_8	28,029	670.00	1292.73	67281.40	23269.14	90550.5	62521.5	2.23
T_9	28,029	580.00	1176.43	58243.60	21175.74	79419.3	51390.3	1.83
T_{10}	27,083	506.67	1012.53	50879.80	18225.54	69105.3	42022.3	1.55
T_{11}	27,198	640.00	1052.77	64268.80	18949.86	83218.7	56020.7	2.05
T_{12}	27,198	563.33	1024.37	56569.59	18438.66	75008.3	47810.3	1.75

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