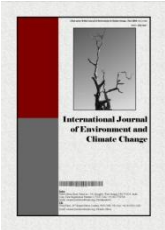

International Journal of Environment and Climate Change

12(9): 119-124, 2022; Article no.IJECC.85762
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Impact of Fertilization of Sulphur and Iron on Yield Attributes and Economics of Greengram (*Vigna radiata* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i930744

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/85762

Original Research Article

Received 29 January 2022
Accepted 09 April 2022
Published 14 April 2022

ABSTRACT

At Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, UP (India), a field experimentation was undertaken in *zaid* 2021. The experimental plot's soil texture was sandy loam. At the same time pH, low organic carbon, available N, available P and available K were (7.4), (0.32%), (188.3 kg/ha), (34.5 kg/ha) and (87.5 kg/ha) respectively. The experiment was set up in a Randomized Block Design (RBD) with 12 treatments and three replica. The results showed that treatment 5 with application of 20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application was recorded maximum no. of pods per plant (36.07), no. of seeds per pod (12.07), test weight (37.03 g), seed yield (1421.00 kg/ha), stover yield (3306.00 kg/ha), harvest index (30.06%), gross return (1,31,196.00 INR/ha), net return (87,806.00 INR/ha) and benefit cost ratio (2.02) as compared to other treatments.

Keywords: Greengram; sulphur; iron; yield attributes and economics.

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1. INTODUCTION

Greengram [*Vigna radiata* (L.) Wilczek.] is a significant Asian originated leguminous crop that is widely grown in nations across Asia, Africa and Australia [1]. Greengram, also known as mungbean or goldengram, is one of India's most widely grown short-duration pulse crops. Pulses have 22-24 percent protein on average, whereas grains contain 8-10 percent. The pulses contain a significant amount of lysine. Greengram, a member of the Leguminosae family, contributes 20-25 kg nitrogen per hectare to atmospheric nitrogen fixation and soil fertility improvement [2]. After chickpea and pigeonpea, greengram is the third most popular pulse in India. Pulses have roughly three times the quantity of high-quality protein than cereals. Greengram is a self-pollinated legume crop that is pivotal produce in tropical regions. Pulses are an essential aspect of economic agriculture because they provide a low-cost source of protein for a significant portion of the population [3]. Edible parts of greengram seeds comprise 24.5 g protein, 75 mg calcium, 4.5 mg phosphorus, and 348 K Cal energy per 100 g. [4]. Pulse protein is less expensive, more readily digested, and has more biological value. Pulses are known as "poor man's protein" because of their lysine-rich protein, which is thought to offset the lack of this amino acid in grain diets [5]. Greengram crop residue improves soil fertility and is used as animal feed. India is the world's greatest producer and consumer of pulses, with 25% of worldwide output and 50% of global consumption [6]. Greengram is grown on around 30.53 lakh hectares of land in India and contributes 15.09 lakh tonnes to the production of pulses [7].

Sulphur is determined as the fourth and major key nutrient in increasing agricultural crop production after nitrogen, phosphorus and potassium (NPK) because of its vital role in synthesis of proteins, vitamins, enzyme and flavoursome chemicals (in plant). Sulphur is present in form of amino acids such as cysteine (27% S), cysteine (26% S), and methionine (21% S) in plants [8]. Sulphur is crucial for pulse crops because it helps to increase chlorophyll constitution and aids photosynthesis. Sulphur also improves the nutritional content of seeds, which improves their quality. Through metabolic and enzymatic effects, sulphur fertilisation is regarded crucial for seed production, protein synthesis, and quality enhancement of economic products in legumes [9]. In pulse crops, gypsum has been shown to be superior to or equivalent to other sulphur-containing fertilisers [10]. Single super phosphate, a multi-nutrient fertiliser comprising 7% P, 12% S, and 21% Ca, accounts for over half of the total S added through major fertilisers in India [11].

Iron (Fe) is one of the key nutritional elements for plant enhancement and reproduction is iron (Fe) [12]. Iron was the first nutrient recognised to be required for plant survival. Iron is involved in a number of metabolic functions in plants, including respiratory enzymes and different photosynthetic events. In legumes, such as greengram, iron is required for nodule development and nitrogen fixation. Because any shortage in the plant system causes foliar chlorosis, iron has long been thought to be linked to chlorophyll production [13]. One of the most often utilised approaches for treating deficiency of Fe in numerous crops is foliar spraying of Fe solutions. This form of treatment typically avoids the issues that come with applying iron to the soil [14].

2. MATERIALS AND METHODS

The experimentation transpired at the Crop Research Farm of Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, UP, India, which is pinpointed at 25^{o} 24' 33" N latitude, 81^{O} 51' 11" E longitude and 98 m above mean sea level. During the *zaid* season of 2021, on sandy loam soil, with approximately neutral soil reaction, organic carbon, available nitrogen, available phosphorus and available potassium (pH 7.4, 0.32%, 188.30 kg/ha, 34.5 kg/ha and 87 kg/ha respectively). The region has a semi-arid subtropical climate. Treatments comprised of T_1 - Control (No Sulphur + No Iron), T_2 - No Sulphur + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS, T_3 - No Sulphur + 25kg/ha $FeSO_4$ as basal dose application, T_4 - 20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS, T_5 - 20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application, T_6 - 20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + No (0) $FeSO_4$ (Distilled water spraying), T_7 - 40kg/ha Sulphur as Single Super Phosphate + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS, T_8 - 40kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application, T_9 - 40kg/ha Sulphur as Single Super Phosphate + No (0) $FeSO_4$ (Distilled water spraying), T_{10} - 40kg/ha Sulphur as Gypsum +

0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS, T_{11} - 40kg/ha Sulphur as Gypsum + 25kg/ha $FeSO_4$ as basal dose application and T_{12} - 40kg/ha Sulphur as Gypsum + No (0) $FeSO_4$ (Distilled water spraying). The experiment was investigated under three replication by using Randomized Block Design. no. of pods per plant, no. of seeds per pod, test weight, seed yield, stover yield, and Harvest Index were all reported as post-harvest observations. Aside from post-harvest observations, the economics of different treatments were investigated to determine the optimal treatment combination for highest yield, maximum net return, and maximum Benefit Cost Ratio (B:C Ratio) of greengram.

3. RESULTS AND DISCUSSION

3.1 Yield Attributes

Yield attributes *viz.* no. of pods per plant, no. of seeds per pod, seed yield, stover yield and harvest index increased significantly in treatment 5 with application of 20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application. However, test weight (37.03) was found to be non-significant in treatment 5 with application of 20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application. The maximum no. of pods per plant (36.07), maximum no. of seeds per pod (12.07), seed yield (1421.00 kg/ha), stover yield (3306.00 kg/ha) and maximum harvest index (30.06%) was resulted under treatment 5 with application of 20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application. As given in Table No. 1. and Table No. 2.

These results obtained from Table No. 1. and Table No. 2. might be due the vital function of sulphur in energy transfiguration, incentive of a number of enzymes and carbohydrate metabolism. These investigated results in close

Table 1. Impact of fertilization of sulphur and iron on yield attributes of greengram

S. no.	Treatment combinations	No. of pods per plant	No of seeds per pod	Test weight (g)
1.	Control (No Sulphur + No Iron)	27.73	9.87	33.40
2.	No Sulphur + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	29.07	10.13	34.43
3.	No Sulphur + 25kg/ha $FeSO_4$ as basal dose application	29.87	10.27	34.87
4.	20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	34.93	11.73	36.37
5.	20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application	36.07	12.07	37.03
6.	20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + No (0) $FeSO_4$ (Distilled water spraying)	32.87	10.93	35.40
7.	40kg/ha Sulphur as Single Super Phosphate + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	33.47	11.13	35.73
8.	40kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application	34.27	11.53	36.57
9.	40kg/ha Sulphur as Single Super Phosphate + No (0) $FeSO_4$ (Distilled water spraying)	32.20	10.87	35.27
10.	40kg/ha Sulphur as Gypsum + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	33.87	11.20	36.40
11.	40kg/ha Sulphur as Gypsum + 25kg/ha $FeSO_4$ as basal dose application.	35.93	11.93	36.83
12.	40kg/ha Sulphur as Gypsum + No (0) $FeSO_4$ (Distilled water spraying)	31.27	10.53	35.07
	F-test	S	S	NS
	SEm±	0.70	0.23	0.10
	CD (P= 0.05)	2.04	0.68	-

Table 2. Impact of fertilization of sulphur and iron on seed yield, stover yield and harvest index of greengram

S. No.	Treatment combinations	Seed yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1.	Control (No Sulphur + No Iron)	936.67	2493.33	27.30
2.	No Sulphur + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	1020.00	2605.00	28.13
3.	No Sulphur + 25kg/ha $FeSO_4$ as basal dose application	1043.33	2685.00	27.98
4.	20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	1326.67	3176.67	29.45
5.	20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application	1421.00	3306.00	30.06
6.	20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + No (0) $FeSO_4$ (Distilled water spraying)	1171.67	2916.67	28.06
7.	40kg/ha Sulphur as Single Super Phosphate + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	1250.00	2956.00	29.72
8.	40kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application	1311.67	3101.67	29.72
9.	40kg/ha Sulphur as Single Super Phosphate + No (0) $FeSO_4$ (Distilled water spraying)	1093.33	2875.00	27.55
10.	40kg/ha Sulphur as Gypsum + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	1299.00	3050.13	29.87
11.	40kg/ha Sulphur as Gypsum + 25kg/ha $FeSO_4$ as basal dose application.	1348.33	3140.00	30.04
12.	40kg/ha Sulphur as Gypsum + No (0) $FeSO_4$ (Distilled water spraying)	1061.67	2791.67	27.55
	F-test	S	S	S
	SEm±	37.36	55.51	0.38
	CD (P= 0.05)	109.57	162.79	1.12

Table 3. Impact of fertilization of sulphur and iron on economics of greengram

S. No.	Treatment combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio
1.	Control (No Sulphur + No Iron)	42,360.00	86,793.63	44,433.63	1.04
2.	No Sulphur + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	42,495.00	94,405.00	51,910.00	1.22
3.	No Sulphur + 25kg/ha $FeSO_4$ as basal dose application	43,110.00	96,584.70	53,474.70	1.24
4.	20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	42,775.00	1,22,576.97	79,801.97	1.86
5.	20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application	43,390.00	1,31,196.00	87,806.00	2.02
6.	20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + No (0) $FeSO_4$ (Distilled water spraying)	42,990.00	1,08,366.97	65,376.97	1.52

S. No.	Treatment combinations	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio
7.	40kg/ha Sulphur as Single Super Phosphate + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	42,815.00	1,15,456.00	72,641.00	1.70
8.	40kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application	43,430.00	1,21,151.97	77,721.97	1.79
9.	40kg/ha Sulphur as Single Super Phosphate + No (0) $FeSO_4$ (Distilled water spraying)	43,030.00	1,01,274.70	58,244.70	1.35
10.	40kg/ha Sulphur as Gypsum + 0.5% $FeSO_4$ Foliar spray at 25 and 45 DAS	42,735.00	1,19,960.13	77,225.13	1.81
11.	40kg/ha Sulphur as Gypsum + 25kg/ha $FeSO_4$ as basal dose application.	43,350.00	1,24,489.70	81,139.70	1.87
12.	40kg/ha Sulphur as Gypsum + No (0) $FeSO_4$ (Distilled water spraying)	42,950.00	98,341.97	55,391.97	1.29

 # Data not subjected to statistical analysis

agreement with the findings of [15]. These outcome might be ascribe to process of tissue disparity from somatic to progenetive meristematic venture and floral primitive buildout might have expansion with elevated sulphur levels, produce furthermore to a greather extent of flowers (No.) and prolonged pods and elevated productivity of seeds. These results are in agreement with the finding of Singh et al. [16]. Increased iron availability aids in the absorption of nutrients, which are predicted to have a more effective photosynthetic mechanism and be better harnessed for efficient photosynthate translocation from source to sink, resulting in a higher harvest index [14].

3.2 Economics

It is revelated from the data exhibited in Table No. 3. that treatment 5 with application of 20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application recorded maximum gross return (1,31,196.00 INR/ha), net return (87,806.00 INR/ha) and B:C ratio (2.02) followed by treatment 11 with application of 40kg/ha Sulphur as Gypsum + 25kg/ha $FeSO_4$ as basal dose application.

4. CONCLUSION

It is concluded from the experimental finding that the treatment 5 application with 20kg/ha Sulphur as Gypsum + 20kg/ha Sulphur as Single Super Phosphate + 25kg/ha $FeSO_4$ as basal dose application was found more productive and can be implemented by the growers for accquiring highest yield and net return from crop (greengram) as compared to other treatment combinations.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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