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Effect of Silicon and iron on yield, yield attributes and economic of green gram (*Vigna radiata* L.)

Nazim Khan, Dr. Virendra Singh, Ram Prakash and Madan Gopal

Nazim Khan
Department of Agronomy, School of Agricultural Sciences & Engineering IFTM University, Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Dr. Virendra Singh
Assistant Professor, (Department of Agronomy) School of Agricultural Sciences & Engineering IFTM University, Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Ram Prakash
Ph.D Scholar, (Department of Agronomy) Acharya Narendra Deva University of Agriculture and Technology, Kumarganj Ayodhya, Uttar Pradesh, India

Madan Gopal
Ph.D, (Department of Agronomy) School of Agricultural Sciences & Engineering IFTM University, Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Corresponding Author:
Nazim Khan
Department of Agronomy, School of Agricultural Sciences & Engineering IFTM University, Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Abstract

Green gram is an important pulse crop which is utilized as for feeding and as raw material in processing industry. However, yield losses are prominent due to the different micro nutrient deficiency and biotic stress. Hence, the study was carried out entitled "Effect of Silicon and iron on yield, yield attributes and economic of green gram (*Vigna radiata* L)." Results revealed that all the treatments significantly increasing in all growth attributes, yield attributes and yield of green gram. Application of T_8– (1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS) was significantly affected to plant height (8.73, 24.60, 24.93 cm), number of leaves (11.60, 35.33, 36.07), number of branches plant^{-1} (2.60 and 2.97) fresh weight (21.94, 24.34 and 39.07) and dry weight (1.27,7.25 and 13.36 g plant^{-1}), number of root nodules (56.33 and 121.33), dry weight of root (0.19 and 1.39 g plant^{-1}), number of pod plant^{-1} (17.40), no. of grains pod^{-1} (9.47), length of pod (7.31cm), test weight (46.69 g), grain, straw and biological yield (12.94, 24.86 and 37.80 q ha^{-1}) at 20,30 & 40 DAS. Maximum net returns (72775.2 Rs. ha^{-1})

Keywords: Silicon, iron, yield, economic and green gram

Introduction

Green gram (*Vigna radiata* L.) is an important legume crop of Asian origin, and is widely cultivated in the continent of Asia, Australia and Africa (Yang *et al.*, 2008) [10]. The genus *Vigna* is pan tropical and includes about 170 species, 120 from Africa, 22 from the Indian continent and Southeast Asia, and the rest from other parts of the world. Moongbean, also known as green gram, belongs to the subgenus *Ceratotropis* and is an important crop among legumes. Green gram is diploid with 2n=22 and it has a small genome size of 0.60 pg/1C (579 Mbp). Green gram 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]. It is an important pulse crop ranked as the second most drought resistant crop after soybean. Green gram has more protein contents and better digestibility than any other pulse crop (Tabassum *et al*., 2010) [9]. Green gram (*Vigna radiate* L.) ranks fourth among grain legumes in India after chickpea, pigeon pea and black gram. It is cultivated during *kharif* as well as zaid season over. A wide range of agro-climatic conditions in India. However, productivity of moong bean is very low in Rajasthan (99 kg/ha) compared to its genetic potential (FAI, 2001) [4]. Importance of Fe in realizing the productivity potential of pulses received increasing attention during past few years (Marschner and Romheld, 1994) [7]. Pulses are the main source of protein particularly for vegetarians and contribute about 14 per cent of the total protein of an Indian average diet. Pulse crop, Green gram [*Vigna radiata* (L.) Wilczek] every 100 g of edible portion of Green gram seed contains 75 mg calcium, 4.5 mg phosphorus, 24.5 g protein and 348 K Cal energy. At global level India share prime position in Green gram production. In India, it is cultivated over a wide range of climatic conditions in the states of Maharashtra, Andhra Pradesh, Rajasthan, Odisha and Bihar. Rajasthan is one of the major Green gram growing states of the country. Whereas, potential yield level of available improved varieties of Green gram varied between 1200 to 1600 kg /ha. This indicates a wide gap between the potential yield and average yield being harvested at cultivator's fields. There may be several possible reasons for low yield harvested by the farmers. Lack of optimum mineral nutrition particularly sulphur and micronutrients management may be one of them, limiting higher productivity of pulses in general and Green gram crop in particular. Farmers usually apply nitrogenous and phosphatic fertilizers but sulphur fertilization is lacking in their fertilizer schedule. Further, micronutrients, *viz.* zinc and iron deficiencies, now a day's becoming major limiting factor in harvesting higher yields of crops. Hence, optimum mineral nutrient management including sulphur and micronutrient (iron) is a basic requirement to realize potential yield of major crops and Green gram as well. Pulses not only have high sulphur requirements but also have the potentiality to remove sulphur from soil nutrient pool *vis-* fertilizer applied, as is evident from the radio sulphur investigations. Sulphur uptake by several crops revealed that the highest sulphur requirement (12 kg/tonne of yield) has been attributed to oilseeds followed by pulses (8 kg/tonne), millets (5-8 kg/tonne) and cereals (3-4 kg/tonne) (Tandon, 1986). It is general consideration among the growers that role of Si in plant growth is non-obligatory. Silicon effects on yield are related to the deposition of the element under the leaf epidermis which results a physical mechanism of defense, production of phenols which stimulates phytoalexin production, reduces lodging, decreases transpiration losses and increases photosynthesis capacity of crop plants. Plant tissue analysis has revealed the optimum amount of silicon is necessary for plant development (Liang *et al.*, 2006) [5].

Silicon, the second most abundant element in the earth's crust, has not yet received the title of essential nutrient for higher plants, as its role in plant biology is poorly understood (Epstein, 1999) [3]. However, various studies have demonstrated that Si application increased plant growth significantly (Alvarez and Datnoff, 2001) [1]. Silicon application is reported to enhance leaf water potential under water stress conditions (Matoh *et al*., 1991) [6]. Since the positive effects of Si amendment on plant growth were established, the influences of Si on the development of rice plants have been extensively studied (Mitani *et al*. 2005) [8].

Materials and Methods

The experiment was conducted during summer season of 2018-19 at Agriculture Farm of IFTM University, Lodhipur Rajput, Moradabad (U.P.) situated at the banks of Ram-Ganga River having alluvial soil and lies between 28°.81° North latitude and 78. 64° East longitudes above mean sea level of 193.23 meters. The climate of this place is tropical to sub-tropical of slightly semi-arid in nature and is characterized by very dry summer, moderate rainfall and very cold winter. December and January are usually the coldest months where the mean temperature normally falls as low as 8.2 °C whereas; April and May are the hottest months, having the maximum average temperature of 40 °C. The normal rainfall is about 1407 mm (10 year average) which is unimodel type mostly precipitating during middle of June to middle of October, where potential evaporation transpiration is lower than the precipitation. The fields were fairly levelled and had good drainage having assured irrigation facility. The soil samples were collected randomly from different spots on the experimental site at the depth of 0-15cm before conduct of experiment and a composite soil sample was prepared after proper during, mixing and sieving. The composite soil sample were analyzed for different physical-chemical Characteristics of the soil. The soil of the experimental site was sandy loam in texture, having pH 7.3, EC 0.90dsm^{-1} and low Nitrogen, Phosphorus, Potassium, Sulphur, Zinc, Boron with (0.39%) percent of organic carbon.

Yield and yield attribute

The number of branches excluding main axis was recorded from the selected plants at an interval of 40 days from at harvesting stage. The number of pods per plant at harvest was recorded from five observational plants selected for recording biometric observations at harvest and mean was worked out to obtain mean number of pods per plant Length of five ran. domly selected pod from each plot was measured and average was worked out to get the length of pod in cm. Total grains of five randomly selected pods from each plot were counted after shelling and averaged to get number of grains. After the threshing of crop 1000-seeds were count from the produce of each plot weighed and values are taken (g).Biological yield was calculated by taking bundle weight per plot and then converted into q/ha. After harvesting they were put for sun drying for 2 to 3 days, after that threshing is completed and finally seeds can measure by weighing balance. After picking of pods the remaining stover is measure by weighing balance. Harvest index is the ratio of the grain yield to total biological produce expressed in percentage. It was calculated with the help of following equation:

$$\text{Harvest index (\%)} = \frac{\text{Economical yield}}{\text{Biological yield}} \times 10$$

Economics

Cost of cultivation is the total expenditure incurred for raising the crop for production (Table 3.2 & Table 3.3). Gross return i.e. the total monetary value of economic produce obtained was calculated based on the market price. Net return was obtained by subtracting cost of cultivation from gross return to cost of cultivation. Formula and calculation used for working out economics of cultivation are given below.

Total cost of cultivation: cost of cultivation of control plot (fixed cost) + different treatment wise cost (variable cost)

Gross return: Gross income was worked out by multiplying grain and straw yield separately under various treatment combinations with their added together in order in archives gross income (R ha^{-1})

Gross income =Total income from grain and straw yield

Net return: Net income was calculated by subtracting the cost of cultivation from the gross return of the individual treatments combination.

Net return (Rs. ha^{-1}) = Gross return (Rs. ha^{-1}) – Cost of cultivation (Rs. ha^{-1})

Benefit: cost ratio: The cost of cultivation was worked out by considering all the expenses gross return was worked out by multiplying grain and straw yield by its price prevailing in the market on per hectare basis under various treatments. The money value of grain and straw yields was added together. Net returns were calculated by subtracting the cost of cultivation from the gross return of the treatment.

Benefit: cost ratio= Net return /Total cost of cultivation

Results and Discussion

No. of grains pod^{-1}

Number of grains pod^{-1} was recorded at the harvest of the crop and data are summarized in table 4.8 and fig. 8. Number of grains pod^{-1} was showed significantly with the application of 1.5 % $FeSo_4$ spray at 20,30 & 40 DAS over the control treatment. The highest Number of grains pod^{-1}was recorded with application of 1.5 % $FeSo_4$ spray at 20,30 & 40 DAS

(9.47) at 20 and 40 DAS followed byT_7 -1.0 % $FeSo_4$ spray at 20, 30 & 40 DAS (9.27) and lowest in T_1 (8.47) at 20 and 40 DAS.

Pod length (cm)

Pod size plant^{-1} was recorded at harvest stage of the crop and data are summarized in table 4.9 and fig. 9. Pod size was significantly influenced with the application of Iron over the control treatment. The highest pod size (7.31) was record in T_8 (1.5 % $FeSo_4$ spray at 20,30 & 40 DAS) at harvesting stage followed byT_7 -1.0 % $FeSo_4$ spray at 20, 30 & 40 DAS (6.76) and lowest in T_1 (6.25) at harvesting stage.

Number of pods plant^{-1}

Number of pods plant^{-1} was recorded at harvest of the crop and data are summarized in table 4.10 and fig. 10. Number of pods (17.40) was significantly increased with the application of T_8 (1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS) over the control treatment followed by T_7 -1.0 % $FeSo_4$ spray at 20, 30 & 40 DAS (17.13). While lowest pods recorded under T_1 (9.93) at harvesting stage.

Test weight (g)

Test weight was recorded at harvest of the crop and data are summarized in table 4.11 and fig. 11. The non-significantly highest test weight was recorded with the application of 1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS over the control treatment. The highest test weight was record in treatment T_8 (46.69 g) followed by T_7 -1.0 % $FeSo_4$ spray at 20, 30 & 40 DAS (45.26) and lowest in T_1 –Control (44.37 g) at harvesting stage.

The maximum number of branches plant^{-1} are recorded in 40 DAS and at harvest. The number of branches plant^{-1} recorded in T_8- 1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS (2.66 and 2.97). The increasing of number of branches will lead to an increase in the photosynthesis area, eventually enhancing photosynthesis efficiency and carbohydrates translocation to reproductive meristems all mentioned reports are supporting findings here that Fe has increased number of branches which eventually leads to an increase in yield. The similar findings were collaborated by Hung *et al.*, (2002). Number of pods plant^{-1} was recorded at harvest. Number of pods was significantly increased with the application of 1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS Pod size plant^{-1} was recorded at harvest stage of the crop. Pod size (cm) was significantly influenced with the application of T_8- 1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS (7.31). Number of grains pod^{-1} was recorded at the harvest of the crop. Number of grains pod^{-1} was showed significantly with the application of T_8- 1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS (9.47) over the control treatment. Due to sample amount of Iron availability. The harvest index was found significantly with the application of Iron over the control treatment. The maximum harvest index was obtained in in T_6- (0.5 % $FeSo_4$ spray at 20, 30 & 40 DAS), reported same trend in yield attributes. Arif Hussain *et al*. (2012) reported same trend in yield attributes.

Table 4.8: Pod length (cm), No. of pods/plant, Test weight, No. of grains pod^{-1}

Treatments	Pod length(cm)	No. of pods/plant	Test weight	No. of grains/pod
T_1-Control	6.25	9.93	44.37	8.47
T_2-0.5 ml Si spray at 20, 30 & 40 DAS	6.54	11.07	44.52	8.60
T_3-1.0 ml Si spray at 20, 30 & 40 DAS	6.65	12.27	44.66	8.87
T_4-1.5 ml Si spray at 20, 30 & 40 DAS	6.66	13.13	44.74	8.87
T_5 -2.0 ml Si spray at 20, 30 & 40 DAS	6.69	13.87	44.94	9.00
T_6-0.5 % $FeSo_4$ spray at 20, 30 & 40 DAS	6.75	15.67	45.17	9.40
T_7-1.0 % $FeSo_4$ spray at 20, 30 & 40 DAS	6.76	17.13	45.26	9.27
T_8-1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS	7.31	17.40	46.69	9.47
S.Em (±)	0.169	0.432	0.705	0.218
CD at 5%	0.516	1.322	NS	0.667

Grain Yield (kgha^{-1})

Grain yield was recorded at the harvest of crop and data are summarized in table 4.12 and fig. 12. Grain yield was significantly with the application of 1.5 % $FeSo_4$ over the control treatment T_8 Maximum grain yield (1294.2kgha^{-1}) was obtained in response to applied T_8 (1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS) followed by T_7 -1.0 % $FeSo_4$ spray at 20, 30 & 40 DAS (1264kg ha^{-1}) and lowest yield (723.9kg ha^{-1}) obtained from T_1 (Control).

Stover Yield (kgha^{-1})

The Stover yield which was recorded after harvesting of the crop and data are summarized in table 4.13 and fig. 13. The Stover yield was found significantly superior with the application of Iron over the control treatment. The maximum Stover yield (2486kg ha^{-1}) was obtained in T_8 (1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS) followed by T_7 -1.0 % $FeSo_4$ spray at 20,30 & 40 DAS (2360 kg ha^{-1}) and lowest in T_1[(control) (1540kg ha^{-1})].

Grain and Stover yield was significantly with the application of Iron over the control treatment (T_8) Maximum grain yield (12.94 q ha^{-1}) was obtained in response to applied 1.5 % $FeSo_4$ spray at 20,30 & 40 DAS. The application of iron sulphate plays an important role in synthesis of cholorophyll and plant growth regulator. Iron also improves photosynthesis and assimilates transportation to sinks and finally increases seed and stover yield. This may include increase in carbohydrate synthesis. Atul Kumar Saini (2017) were reported same result.

Table 4.9: Grain Yield and Stover yield (kgha^{-1}) as influenced by Si and Iron application

Treatments	Grain Yield (kg ha^{-1})	Stover Yield (kg ha^{-1})	Biological yield (kgha^{-1})	Harvest Index %
T_1- Control	723.9	1540.0	2263.9	32.18
T_2- 0.5 ml Si spray at 20, 30 & 40 DAS	1038.6	2043.7	3082.3	33.71
T_3- 1.0 ml Si spray at 20, 30 & 40 DAS	1061.1	2124.7	3185.8	33.34
T_4- 1.5 ml Si spray at 20, 30 & 40 DAS	1091.7	2144.7	3236.3	33.80
T_5- 2.0 ml Si spray at 20, 30 & 40 DAS	1164.8	2189.0	3374.5	34.64
T_6- 0.5 % $FeSo_4$ spray at 20, 30 & 40 DAS	1236.1	2209.7	3425.1	36.31
T_7- 1.0 % $FeSo_4$ spray at 20, 30 & 40 DAS	1264.0	2360.0	3624.0	35.10
T_8- 1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS	1294.2	2486.0	3780.2	34.20
S.Em (±)	46.138	117.101	111.569	1.740
CD at 5%	141.302	358.630	341.688	N.S.

Biological yield (kg ha^{-1})

Biological yield was recorded at the harvest of crop and data are summarized in table 4.14 and fig. 14. Grain yield was recorded significantly with the application of T_8 (1.5 % $FeSo_4$) over the control treatment. Maximum biological yield (3780.2kg ha^{-1}) was obtained in response to applied T_8 (1.5 % $FeSo_4$ spray at 20,30 & 40 DAS) followed by T_7 -1.0 % $FeSo_4$ spray at 20,30 & 40 DAS (3624kg ha^{-1}) and lowest yield obtained from T_1-Control (2263.9kg ha^{-1}).

Harvest index

The harvest index which was recorded after harvesting of the crop and data are summarized in table 4.15 and fig. 15. The harvest index was found significantly with the application of Iron over the control treatment. The maximum harvest index was obtained in in T_6-0.5 % $FeSo_4$ spray at 20, 30 & 40 DAS(36.31) followed by T_7 -1.0 % $FeSo_4$ spray at 20,30 & 40 DAS (35.10)and lowest in T_1 (Control) 32.18.

Cost of cultivation

The cost of cultivation of green gram was recorded at harvest. The data depicted in table no. 4.16and Fig.16. The data recorded at harvest clearly indicate that the maximum cost of cultivation at harvest was recorded from T_8 (₹28080). The minimum cost of cultivation was recorded from control treatment T_1 (₹16870).

Gross return

The gross return of green gram was recorded at harvest which is clearly indicated that gross return of green gram is significantly influenced by varying the levels of Iron.The data depicted in table no. 4.16and Fig.16. The maximum gross return at harvest was recorded from T_8 (₹100484.04).The minimum Gross return was recorded from control treatment T_1 (₹56876.11).

Net return

The net returns of green gram was recorded at harvest which is clearly indicate that net return of green gram is significantly influenced by varying in the Iron. The data depicted in table no. 4.16and Fig.16.The maximum net return at harvest was recorded from T_8(₹72404.04) and minimum net return was recorded from control treatment T_1 (₹40006.11).

B:C ratio

The benefit-cost ratio of green gram was recorded at harvest. The data depicted in table no.4.16 and Fig.16.which is clearly indicate that benefit-cost ratio of green gram is significantly influenced by Iron. The maximum benefit-cost ratio was recorded in T_6 (3.13) and minimum in T_1 (2.37).

Cost of cultivation, gross return, net return and benefit cost ratio is was attributed to greater increase in grain and straw yield as compared to cost of cultivation with increasing levels of Iron. This might be due to increase in seed yield in diminishing manner under the increasing levels of Iron. This increase in the net return due to application of increasing levels of Iron. These results are in conformity with those observed by Atul Kumar Saini (2017).

Table 4.11: Cost of cultivation, Gross return, Net return and B: C ratio as influenced by Si and Iron application

Treatments	Cost of cultivation(₹ha^{-1})	Gross return(₹ ha^{-1})	Net return (₹ ha^{-1})	B: C ratio
T_1- Control	16870	56876.11	40006.11	2.37
T_2- 0.5 ml Si spray at 20, 30 & 40 DAS	22041	80861.51	58820.51	2.67
T_3- 1.0 ml Si spray at 20, 30 & 40 DAS	23499	82777.36	59278.36	2.52
T_4- 1.5 ml Si spray at 20, 30 & 40 DAS	24957	84975.54	60018.54	2.40
T_5 - 2.0 ml Si spray at 20, 30 & 40 DAS	26415	90222.62	63807.62	2.42
T_6- 0.5 % $FeSo_4$ spray at 20, 30 & 40 DAS	23082	95234.63	72152.63	3.13
T_7- 1.0 % $FeSo_4$ spray at 20, 30 & 40 DAS	25581	97835.77	72254.77	2.82
T_8- 1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS	28080	100484.04	72404.04	2.58

Conclusions

- The result indicated gradual increase in plant height (cm) at 20 DAS, 40 DAS and at harvest stage. (8.73, 24.60 and 24.93), the maximum fresh weight of plant (g.) at 20 DAS, 40 DAS, harvest stage (21.94, 24.34 and 39.07), the maximum dry weight of plant(g) at 20 DAS, 40 DAS, harvest stage (1.27, 7.25 and 13.36), number of nodules at 20DAS and 40 DAS(56.33 and 121.33), dry weight of root(g.) at 20 DAS, 40 DAS, harvest stage(0.19 and 1.39), number of branches plant^{-1} at 40 DAS and harvest stage (2.60 and 2.97), number of leaves plant^{-1} at 20 DAS,40 DAS and harvest stage (11.60,35.33 and 36.07), number of pods plant^{-1} (17.40), pod size(7.31), number of grain pod^{-1} (9.47), test weight (46.69g).
- Maximum grain yield (1294.2kgha^{-1}), stover yield (2486 kgha^{-1}) and biological yield (3780.2 kg ha^{-1}) were found in T_8 -1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS.
- Maximum harvest index (36.31%) were found in T_6-0.5

% $FeSo_4$ spray at 20, 30 & 40 DAS.

- Maximum gradual increase in cost of cultivation (27410₹ ha^{-1}), gross return (100211.66 ₹ ha^{-1}), net return (72801.66 ₹ ha^{-1}) were found in T_8-1.5 % $FeSo_4$ spray at 20, 30 & 40 DAS.
- Benefit cost ratio (3.24) were found in T_6-0.5 % $FeSo_4$ spray at 20, 30 & 40 DAS.

On the basis of above findings following conclusions are drawn

It may be concluded on the basis of above findings that 1.5 percent foliar application of Iron at 20, 30 and 40 days after sowing of green gram was observed best treatment for higher yield and net returns during summer season.

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