Original Research Article

Effect of Iron Nutrition on Growth, Quality and Yield of Soybean (*Glycine Max*. L.) Grown on Problematic Inceptisol.

ABSTRACT

Aims: To study the effect of soil and foliar application of iron on growth parameters, yield and quality of soybean (Glycine max.L.).

Study ~~of~~ design: The experiment was laid out in ~~randomizsed~~ randomised block design with three replications.

Place and duration of the study: Agricultural Research Station, Kasbe Digraj, Dist: Sangli (MS) India. The study was conducted during ~~kharif~~ Kharif 2018-19.

Methodology applied: At present in research, the eight treatment consist of absolute control, general recommended dose of fertilizer (GRDF), GRDF + soil application of $FeSO_4$ @ 10 and 20 kg ha^{-1} with and without two foliar sprays of chelated Fe @ 0.2 per cent at 30 and 50 days after sowing (DAS) , GRDF + soil application of $FeSO_4$ @ 20 kg ha^{-1}, GRDF + $FeSO_4$ @ 10 kg ha^{-1} + cow dung slurry @ 500 litre ha^{-1}.

Results. The basal application of $FeSO_4$ @ 10 or 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2 per cent at 30 and 50 days after sowing improved growth parameters of soybean viz; chlorophyll content, average number of days to 50 per cent flowering, plant height, number of branches, number of pods and effective root nodules as compare to only soil application or foliar spray of iron. Significantly higher grain yield~~-~~, straw yield, ~~100-~~ 100-grain weight- oil and crude protein yield of soybean were obtained in ~~soil~~ soil-applied of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% at 30 and 50 days after sowing.

Conclusion: Integrated approach of iron nutrition in soybean both as soil and foliar application could result in better growth and the enhanced yield of soybean.

Keywords: Iron Growth, Quality, Soil and Foliar ~~fertilization~~fertilisation, Soybean, Yield.

1.INTRODUCTION

Soybean (*Glycine max* L.) is a leguminous crop, and it belongs to family papillionaceae, sub family of leguminoaceae, originally a crop of China. Soybean ~~is~~ has been cultivated for more than 3000 years in South-Eastern Asia [1]. Soybean stands first in the world as edible oil and occupies an important place in the economy. Globally legumes play a vital role in human nutrition as these are rich sources of protein, calories, certain minerals and vitamins. Among legumes, soybean is the largest source of protein and vegetable oil with poly-unsaturated fatty acids especially Omega 6 and Omega 3 [2].

Soybean is cultivated ~~on~~ in 124 million ha area in the world. India ranks fifth in area and production after USA, Brazil, China and Argentina. All world estimated area and production of soybean in *Kharif*- 2017 was 10.60 million ha and 8.00 million MT, respectively [3]. The area under soybean cultivation is increasing due to ~~some~~ reason such as soybean is a short duration crop (90-110 days), good market price with its higher productivity as compared to other pulses. It can be processed easily for different

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products such *viz*., soy cheese, soy milk, soy protein, soy yoghurt, soybean oil, soy nut. Soybean is also used for making ~~the~~ soy ink, soy paint and soy molasses. It is a potential crop that can boost the food-processing industry in rural areas. Soybean production is affected by many factors such as climatic and edaphic factors, which severely affect ~~its~~ production; According to Turner 1991, the performance of this crop is highly ~~affected~~ influenced by the availability of trace elements such as Molybdenum and Iron. Besides, iron deficiency of Mn and Zn can also affect the production of soybean crops [4]. Deficiency of micronutrients and low availability of other essential nutrients or imbalance use of ~~fertilizsers~~ fertilisers emerged as the important constraint in soybean production. Hence a balanced nutrient application is a must to increase the productivity of the soybean crop. Among micronutrients, iron plays a vital role in a structural component of porphyrin molecules, cytochromes, heams, hematin, ferrichrome and leghaemoglobin. These substances are involved in oxidation-reduction reactions in respiration and photosynthesis. It is also an important part of the enzymes, including amino levlinic acid synthetase and co-proporphyrin ogenoxidase, which is essential for nitrogen fixation in ~~nitrogen~~ nitrogen-fixing microorganisms. Iron in chloroplasts reflects the presence of cytochromes for performing various photosynthetic reduction processes and of ferrodoxin as an electron acceptor. The ferrodoxins are Fe-S proteins and are the first stable redox compound of the photosynthetic electron transport chain. Iron deficiency is usually observed in soybean grown in calcareous or alkaline soils. In calcareous soil, iron availability is restricted due to conversion of ferrous to ferric and showed deficiency of Fe manifest into yellowish inter-venal paling of younger leaves (commonly referred to as iron chlorosis) and soil conditions such as high soil pH found in large areas of the Great Plains may decrease the plant availability of some macro and micronutrients. This may be corrected through initially application at the time of sowing and foliar ~~fertilizser~~ fertiliser application of a combination of starter and booster dose of ~~fertilizer~~fertiliser. Supplementary foliar application of N, P, K and micronutrients for deficient soils can help to enhance the crop yields under these conditions. Foliar application of micronutrients in high pH saline soils is more beneficial in terms of growth and yield of the crop [4]. Foliar application of micronutrients is more beneficial as compared to soil application as the application rate of the nutrient is comparatively lesser, nutrient absorption is more moreover~~,~~ when roots cannot provide necessary nutrients, foliar application is always a compatible alternative [5]. There is an increasing interest from producers about the potential benefits of foliar application of nutrients as a compliment of their ~~fertilizsation~~ fertilisation programs to ~~maximizse~~ maximise yields. ~~Keeping this in view~~In view of this, the present investigation was undertaken to study the effect of soil and foliar application of iron on nutrient availability, uptake, yield and quality of soybean (*Glycine max.* L.).

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2.MATERIAL AND METHODS

3.1 Experimental site and soil

The field experiment was conducted at Agricultural Research Station, Kasbe Digraj, Dist: Sangli Maharashtra, India during *kharif* season of the year 2018. This study area is located in Deccan plateau, hot ~~semi~~ semi-arid eco región, in the western Maharashtra plane zone (Zone VI) and is situated at $16^{0}08'$ North latitude~~,~~ $74^{0}08'$ East longitude and at an altitude of 580 m above mean sea level (MSL). The experimental soil (0-15 cm soil depth) had alkaline pH, electrical conductivity (EC) 0.18 dS m^{-1}, calcium carbonate ($CaCO_3$) 6.80 g kg^{-1}, clayey in texture, bulk density (BD) 1.25 Mg m^{-3} and organic carbon 4.50

g kg^{-1}. The soil available nitrogen, and potassium contents were 170, 7.50, 433 kg ha^{-1}~~.~~ respectively, and soil DTPA iron, zinc, copper and manganese contents were 4.05, 0.35, 0.40 and 2.52 ppm, respectively.

3.2 Experimental details

The experiment was laid out in ~~randomizsed~~ randomised block design with eight treatments and three replications in *kharif*, 2018. The treatments were absolute control (T_1), general recommended dose of fertilizer (GRDF) *i.e.*50:75:45 kg ha^{-1} N:P_2O_5:K_2O + 10 t ha^{-1} FYM (T_2), GRDF + soil application of $FeSO_4$ @ 10 kg ha^{-1} (T_3), GRDF + soil application of $FeSO_4$ @ 20 kg ha^{-1} (T_4), GRDF + $FeSO_4$ @ 10 kg ha^{-1} + cow dung slurry @ 500 liters ha^{-1} (T_5), GRDF + two foliar sprays of chelated Fe @ 0.2% at 30 and 50 days after sowing (DAS) (T_6), GRDF + soil application of $FeSO_4$ @ 10 kg ha^{-1} + two foliar sprays of chelated Fe @ 0.2% at 30 and 50 DAS (T_7) and GRDF + soil application of $FeSO_4$ @ 20 kg ha^{-1} + two foliar sprays of chelated Fe @ 0.2% at 30 and 50 DAS (T_8) . The soybean crop was ~~fertilizsed~~ fertilised with 50 kg N, 75 kg P_2O_5 ha^{-1}and 45 K_2O for treatment GRDF as a basal dose of N, P_2O_5 and K_2O was applied through urea, single super phosphate and muriate of potash to treatment T_2 to T_8 at the time of sowing. The treatment~~s~~ wise quantity of ferrous sulfate was incubated in well decomposed FYM for four days and then applied to treatment $T_{3,}$ $T_{4,}$ T_7 and T_8 at the time of sowing. The foliar sprays of chelated Fe at the rate of 0.2 per cent at 30 and 50 DAS as were applied to treatments $T_{3,}$ $T_{4,}$ $T_{6,}$ T_7 and $T_{8.}$ The cow dung slurry (125 kg cow dung + 500 liters water) with $FeSO_4$ @ 10 kg ha^{-1} were incubated for one week and applied to the treatment T_5 during first irrigation. The seeds of soybean variety *Phule Sangam* (KDS 726) were inoculated with *Rhizobium* and phosphate ~~solubilizsing~~ solubilising bacteria @ 250 g per 10 kg of seeds and used for sowing. The three irrigations were given during the crop growth period. The soybean crop was sown in monsoon (*kharif*) season with 30 cm row spacing.

3.3.Growth parameters

Five plants of soybean were selected randomly from each net plot by using random numbers. The selected plants were marked by fixing pegs. All the observations were recorded on these plants. The days were counted required for soybean to attain 50 % flowering. The plant height of five plants ~~were~~ was measured from the ground level up to the growing point of the plant and the average height of the plant was expressed in centimetres. The number of branches plant^{-1} ~~were~~ was recorded at the pod filling stage. Randomly selected five plants used for counting the number of pods plant^{-1} at harvest. Then pods from each plant were removed, separated, counted and recorded under the respective treatments, and then the mean was computed. The two plants were randomly selected used for counting the number of effective nodules and ~~non~~ non-effective plant^{-1} and counted the nodule on the root.

3.4. Chlorophyll content

The chlorophyll content was obtained by 30 DAS and 50 DAS of green plant samples. Chlorophyll of fresh plant leaves (4th leaf) at flowering stage was extracted in 85 per cent acetone and the absorbance values at 660 nm and 642.5 nm wavelength were recorded on spectro photometer [6].

3.5. Harvesting

The soybean crop was harvested at physiological maturity when the pods turned yellow colour with matured seeds. The border~~-~~line plants were removed first to eliminate the border effect. The crop from the net plot was cut close to the ground and kept in respective plots for ~~sun~~ drying.~~-~~ The plot wise threshing of soybean was carried out~~done.~~ The grains were separated from the plant by a mechanical thresher. The straw yield and soybean grain yield were recorded by weighing as per ~~the~~ treatments. One hundred

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3.7. Quality parameters:

The protein content in the seeds was ~~analyzsed~~ analysed by indirect method. First, the per cent nitrogen content of the sample was estimated by microkjeldahl method [7]. Then the nitrogen value was multiplied by a factor 5.71 to get the protein content of the sample and expressed in percentage [8]. Oil percentage of grain was determined by Soxhlet extractor using petroleum ether as a solvent.

3.8 Statistical Analysis

The experimental data were analysed statistically by applying the ~~technique of "Analysis of variance"~~ "Analysis of variance" technique and significance was tested by variance ratio i.e. F value at 5 per cent level of significance [9]. Standard error of the mean (S.Em.) and critical difference (CD) was worked out to evaluate differences between treatment means.

3 Results and Discussion

3.1 Chlorophyll content at 30 and 50 DAS

Chlorophyll content in leaves differed significantly due to soil application of iron and foliar sprays treatments. The soil application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% (T_8) had recorded ~~significantly the highest chlorophyll content~~the highest chlorophyll content significantly at 30 and 50 DAS (20.28 mg g^{-1}) and (21.95 mg g^{-1}) respectively, over the rest of treatments however, it was at par with soil application $FeSO_4$ @ 10 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% at 30 DAS (19.49 mg g^{-1}) and 50 DAS (21.15 mg g^{-1}) and soil application of $FeSO_4$ @ 20 kg ha^{-1}. The soil application of $FeSO_4$ @ 10 or 20 kg ha^{-1} and foliar application of chelated Fe 0.2% ~~were found~~exhibit higher chlorophyll content at 30 and 50 DAS as compare to GRDF (T_2) and absolute control (T_1).This might be due to the beneficial effect of $FeSO_4$ application to the soil along with foliar spray increased iron availability in soil, and ferrous iron (Fe^{2+}) uptake by plant leaves in foliar resulting in better absorption and translocation of iron. Which, in turn, might have helped the cellular activity and also directly or indirectly participated in the formation of chlorophyll and thus increasing photosynthesis. The results are in agreement with that of Kandoliya *et al* [10], who reported an increase in total chlorophyll content due to iron nutrition in wheat crops.

3.2 Days to 50% flowering

Days to 50 per cent flowering also differed significantly due to different treatment applications of iron through the soil and foliar.~~-~~ The significantly higher average number of days to 50 per cent flowering (44.33) was noticed in soil application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% at 30 and 50 DAS (44.33) over the rest of the other treatments. The T_8 was at par with T_7 at 30 and 50 DAS (43.66). The treatments T_2 to T_7 were at par with each other for average number of days to 50 per cent flowering. The application of Fe ~~fertilizser~~ fertiliser with FYM took longer period for average number of days to 50 per cent flowering. This might be due to the $FeSO_4$ along with FYM treatments enhances the growth by ~~mineralizsation~~ mineralisation and availability of essential nutrients to soybean and increases the uptake of nutrients and more vegetative growth of soybean. The findings of Maheswari and Karthik [11] also confirmed the results of present study.

3.3 Plant height

The plant height of the soybean crop was significantly influenced by iron application through the soil and foliar treatments. The treatment T_2 recorded significantly higher plant height as compared to control. The application of chemical ~~fertilizsers~~ fertilisers along with FYM resulted in the increase in growth attributes~~t~~. This may be due to better uptake and translocation of plant nutrients to growing plants and more photosynthesis, which in turn promoted more number of leaves, leaf area and dry matter production and found to have a more beneficial effect on plant height of soybean. The soil application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% at 30 and 50 DAS (T_8) was ~~noticed~~ shown to have ~~the~~ a significantly higher plant height (86.33 cm) than the rest of the treatments. The treatment T_8 was on par with T_7 for plant height (85.00 cm), T_4 (83.33 cm) and T_6 (84.00 cm). It clearly indicated that GRDF along with soil application of $FeSO_4$ @ 10 and 20 kg ha^{-1} with two sprays of chelated Fe 0.2 % treatments were found higher plant height. The application of Fe resulted in the increase in chlorophyll content and more photosynthesis also FYM had more beneficial and significant effect on plant height. Similar results were also reported by Balachander *et al*. [12].

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3.4 Number of branches per plant

The number of branches per plant of soybean was influenced by various ~~the~~ treatments and was found to be statistically significant. The significant highest number of branches (11.0 $plant^{-1}$) was recorded in soil application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% over the rest of the treatments. The treatments T_8, T_7, T_4, T_6 and T_5 were at par ~~with each other for more number of~~ for more branches per plant. The higher number of branches in soybean exhibited by treatment receiving soil application of $FeSO_4$ @ 10 or 20 kg ha^{-1} and two sprays of chelated Fe @ 0.2% might be due to the combined application of Fe with recommended dose of other major nutrients which in turn might have increased uptake of nutrients in the plants leading to enhanced chlorophyll content and carbohydrate synthesis and thus helped in increased number of branches per plant of soybean. Similar results were also noticed by Kumar *et al.* [13] and Kunjammal and Sukumar [14].

3.5 Number of pods per plant

The number of pods per plant differed significantly due to iron application through the soil and foliar sprays. The soil application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% (T_8) obtained the significantly more number of pods (44.0 $plant^{-1}$) over the rest of treatments. The treatment T_8 was at par with T_7 (43.33 $plant^{-1}$) and T_4 (41.33 $plant^{-1}$) for number of pods. The highest pods $plant^{-1}$ ~~was produced due to foliar application could be attributed to significant effect iron~~ produced due to the foliar application could be attributed to iron's significant effect on reproductive organs, such as stamens and pollens [15]. The increase in the number of ~~pods of soybean was confirmation of~~ soybean pods confirmed the translocation of photosynthates to the productive sink. Application of Fe increases the number of pods per plant in moth bean [16].

3.6 Root nodules per plant

~~Significantly~~ A significantly more number of effective root nodules (44.33) was noticed in soil application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% treatment than the rest of the remaining treatments. Iron is required for the synthesis of Fe containing proteins in the host, including leghaemoglobin and in bacteriods for nitrogenase and cytochromes of electron transport chain.~~-~~ Similar results were also observed by Shukla and Shukla [17]. The soil application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% was found to have non-significant effect with soil application $FeSO_4$ @ 10 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% at 30 and 50 DAS (T_7) and soil

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application of $FeSO_4$ @ 20 kg ha^{-1} (T_4). It ~~clearly~~ indicated that basal application $FeSO_4$ @ 10 or 20 kg ha^{-1} were increased the nodule count. The soil application of $FeSO_4$ @ 10 or 20 kg ha^{-1} and foliar application of chelated Fe 0.2% at 30 and 50 DAS treatments were found to have a higher number of effective root nodules at 30 and 50 DAS as compared to GRDF (T_2) and absolute control (T_1). The soil application of ferrous sulphate at 25 kg ha^{-1} to soybean crop increased nodulation, and nodules dry weight per plant as compared to control [18]. The reverse trend was observed in respect of non-effective root nodules per plant of soybean.

3.7 100 grain weight

The findings regarding ~~100~~ 100-grain weight revealed that the treatments receiving iron nutrition either through soil, foliar or a combination of both recorded higher grain weight. Soil application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% showed significantly higher ~~100~~ 100-grain weight (19.20 g) over GRDF (T_2) and control (T_1); however, this value was at par with all the other treatments of iron nutrition. The reason for the increased of the 100 grain weight could be attributed to enhanced photosynthetic activity due to increased chlorophyll content in leaves due to iron application. This might have resulted in the production and accumulation of carbohydrates in ~~100~~ 100-grain weight development. Similar results were also recorded by Mohammad *et al.* [19] foliar spray of micronutrient had a significant effect on 1000 seed weight safflower. Rubens *et al.*,[20] reported an increased in soybean grain weight due to micronutrient ~~fertilization~~fertilisation.

3.8 Grain yield

The significantly higher grain yield (24.93 q ha^{-1}) was observed with treatment receiving soil application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% (T_8) over the rest of the treatments, which was estimated to be 14 per cent higher compared to T_2 and 81 per cent over T_1. Treatments receiving iron nutrition irrespective of the method of application demonstrated increment in soybean grain yield as compared treatments without iron supplement could be due to quicker availability of iron to plants, ~~soil~~ soil-applied $FeSO_4$ and FYM might have resulted in increased concentration of plant available iron and formation of metalo-organic complexes of higher extractability and helped in the continuous supply of iron and this ~~in turn~~, in turn, increases chlorophyll content and accumulate more carbohydrates, which seems to be associated with an increase in flowering and pod development ultimately increasing grain yield of soybean. While foliar application of iron might have resulted in direct absorption of the foliage sprayed with Fe solution. The results ~~are in conformity~~conform ~~to that of Sale *et al.* [21] who observed increased in~~ to that of Sale et al. [21], who observed increased soybean yields due to foliar nutrition of Fe and Zn. Similarly, Moosavi and Ronaghi [22] also reported a substantial increase in soybean yield in response to foliar and soil iron nutrition.

3.9 Oil content and oil yield

The oil content in seed was not influenced significantly due to various treatments. Nevertheless, treatment receiving iron ~~fertilizsation~~ fertilisation along with major nutrients revealed slight increase in oil content. Significantly difference was noticed in the case of oil yield, application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% (T_8) recorded the significantly higher oil content (19.46%) and oil yield (485 kg ha^{-1}) over the rest of treatments. The soil application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% was at par with soil application of $FeSO_4$ @ 10 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% at 30 and 50 DAS for oil yield (T_7 446 kg ha^{-1}) and soil application of $FeSO_4$ @ 20 kg ha^{-1} (T_4 444 kg ha^{-1}). The soil application of $FeSO_4$ @ 10 or 20 kg ha^{-1}

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and foliar application of chelated Fe 0.2% at 30 and 50 DAS and GRDF treatments recorded higher oil yield over the control. It ~~clearly~~ indicated that the application of iron through the soil and foliar was beneficial for increasing ~~oil yield of soybean~~soybean oil yield. Ferrous sulphate also contains sulphur in addition to iron. Sulphur is one of the important secondary nutrients required by the crops, sulphur a~~long with iron might have helped to~~nd iron might have helped obtain a higher oil yield of soybean. Higher oil yield may be due to higher iron availability in alkaline soils, which ensured better biosynthesis of oil in groundnut [23].

3.10 Crude protein content and protein yield

Protein content in seed and protein yield ~~were~~ was significantly influenced by various treatments. The application of Fe either through soil as well as foliar sprays recorded higher values of crude protein content and protein yield of soybean as compare to control. Significantly lower crude protein (27.16%) and crude protein yield (372 kg ha^{-1}) were recorded in without FYM and ~~fertilizsers~~ fertilisers over the rest of treatments. However, the significantly higher crude protein (32.24%) and crude protein yield (807 kg ha^{-1}) ~~noticed in treatment soil application of $FeSO_4$ @ 20 kg ha^{-1} along with~~were noticed in treatment soil application of FeSO4 @ 20 kg ha-1 and two foliar sprays of chelated Fe @ 0.2% as compared to rest of treatments. The treatments T_2 to T_7 were at par ~~with each other~~ for crude protein content in soybean. The treatment T_8 was at par with T_7 (746 kg ha^{-1}) and T_4 (746 kg ha^{-1}) for crude protein yield of soybean. It clearly indicated that the application of iron is beneficial for increasing crude protein content and crude protein yield of soybean~~, t~~. This might be due to iron is essential for nitrogen fixation and better availability of nitrogen and it absorption ultimately increases in protein content in grain of soybean. Similar results were close in conformity with Sale *et al.* [21].

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4. Conclusions

The application of 50:75:45 N:P_2O_5:K_2O kg ha^{-1} + 10 t FYM ha^{-1} and soil application of $FeSO_4$ @ 20 kg ha^{-1} along with two foliar sprays of chelated Fe @ 0.2% at 30 and 50 DAS to soybean in ~~iron~~ iron-deficient soil recorded higher growth parameters, grain and straw yield, quality parameters, nutrient uptake by soybean. The residual soil fertility was improved in treatments received GRDF a~~longwith Fe as~~nd Fe compared to initial soil fertility status.

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Table 1 Effect of soil and foliar application of iron on chlorophyll content and number of days to 50 percent flowering of soybean

Treatments	Chlorophyll content (mg g^{-1})		Days to 50 percent flowering
	30 DAS	50 DAS	
T_1	16.11	16.45	38.68
T_2	17.25	17.26	42.00
T_3	17.62	18.02	42.68
T_4	18.21	18.88	43.00
T_5	17.76	18.26	42.00
T_6	16.92	20.05	41.66
T_7	19.49	21.15	43.66
T_8	20.28	21.95	44.33
SE$\pm$	0.71	0.59	0.54
CD at 5 %	2.17	1.81	1.66

Table 2 Effect of soil and foliar application of iron on growth parameters of soybean

Treatments	Plant height at flowering stage (cm)	Number of branches plant^{-1} at flowering stage	Number of pods plant^{-1} at harvest	Number of root nodules plant^{-1} at flowering	
				Effective	Non-effective
T_1	75.00	8.00	29.33	31.33	16.33
T_2	80.00	8.66	37.66	36.66	15.00
T_3	81.00	9.33	38.66	38.00	13.00
T_4	83.33	10.00	41.33	40.66	12.33
T_5	81.66	9.66	40.66	38.33	11.33
T_6	84.00	10.00	40.66	39.33	12.33
T_7	85.00	10.66	43.33	42.33	7.00
T_8	86.33	11.00	44.00	44.33	8.00
SE$\pm$	0.97	0.54	0.93	1.50	0.82
CD at 5 %	2.95	1.66	2.85	4.55	2.50

Table 3 Effect of soil and foliar application of iron on grain, straw yield and yield contributing parameter of soybean

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	100 grain weight (g)
T_1	13.72	20.70	17.1
T_2	21.80	33.05	17.7
T_3	22.12	34.79	18.2
T_4	23.14	36.33	18.9
T_5	22.37	35.28	18.7
T_6	22.19	35.20	18.3
T_7	23.24	36.38	19.0
T_8	24.93	37.79	19.2
SE±	0.70	1.52	0.40
CD at 5 %	2.12	4.62	1.23

Table 4 Effect of soil and foliar application of iron on quality parameters of soybean

Treatments	Oil (%)	Oil yield (kg ha^{-1})	Crude protein (%)	Crude protein yield (kg ha^{-1})
T_1	18.40	252	27.16	372
T_2	18.83	410	30.78	671
T_3	19.00	420	30.88	684
T_4	19.20	444	32.31	746
T_5	19.40	434	31.38	705
T_6	19.06	422	31.91	707
T_7	19.20	446	32.17	746
T_8	19.46	485	32.24	807
SE±	0.28	15.89	0.80	31.30
CD at 5 %	NS	48.20	2.43	94.94