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Effect of iron and zinc application on growth, yield and quality of green gram (*Vigna radiata* L.) in inceptisol.

Boradkar SG, Adsul PB, Shelke MS and Khule YR

Abstract
The present investigation entitled “Effect of iron and zinc application on soil properties, nutrient uptake and yield of green gram (*Vigna radiata* L.) in Inceptisol” during Kharif season of year, 2021-2022 at Research farm Department of Soil Science and Agricultural Chemistry, College of Agriculture, Latur. The experiment was laidout in RBD with three replications and recommended variety of green gram BM-2003-2 as a test crop along with nine treatments. The results in nutshell indicated that the growth, yield, quality, nutrient availability, nutrient uptake and soil nutrient balance were significantly influenced by application of iron and zinc with RDF of green gram. The growth parameters viz., plant height, number of leaves plant^{-1}, number of branches plant^{-1}, dry matter content, chlorophyll – a, chlorophyll – b and total chlorophyll content, number of nodules, fresh weight of nodules plant^{-1} and dry weight of nodules plant^{-1} significantly increased with application of RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ and was found at par with treatment T_9 (RDF+ Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS) and treatment T_4 (RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS).

Keywords: Iron, zinc, growth, yield, quality, green gram

Introduction
Pulses are an important part of profitable agriculture because a large section of population relies on them as they are low priced source of proteins (Usman *et al*. 2014) [11]. Green gram (*Vigna radiata* L.) originated in Indo-Burma and area of South-East Asia. It is a high protein 23-24% legume, occupies 14 percent of total pulses area and 7 percent of total pulse production in India. It is also called as Golden gram. It belongs to family Leguminaceae and sub family Papilionaceae. Pulses are the most favoured crops in semi-arid tropics on account of their less input requirement, intrinsic capacity of biological nitrogen fixation, less water requirement deep rooting-system and high temperature tolerance. Since prehistoric times, green gram (*Vigna radiata* L.) has been an important short season grain legume and staple diet of humans and livestock throughout S.E. Asia. Vigna radiata, commonly known as green gram or mung bean is the most widely distributed species among the six Asiatic Vigna species. It has diploid chromosomes no 2n=22. It is known differently in different Indian languages. It is a rich source of calcium 68 mg 100^{-1} g seeds and phosphorous 300 mg 100^{-1}g seed and iron 7 mg 100^{-1}g seed. It is also rich in vitamin C and riboflavin. It is one of the predominant sources of protein and certain essential amino acids like lysine and tryptophan in vegetarian diets. It also provides 334-344 Kcal Energy (Srivastava and Ali, 2004) [9]. In general farmer applied only major nutrients fertilizer like nitrogenous, potassic and phosphatic fertilizers in their fertilizer schedule but micronutrients are lacking. Micronutrients like iron, zinc, manganese, copper, molybdenum, cobalt and boron play an important role in increasing legumes yield through their effect on the plant itself, nitrogen fixing symbiotic process and effective use of major and secondary nutrients. However, they are used in lower amounts as compared to macronutrients such as N, P and K. They have a major role in cell division, development of meristematic tissues, photosynthesis, respiration and acceleration of plant maturity. Now a days micronutrients viz. zinc and iron deficiencies and limiting factor for crop growth and optimum yield. Hence, optimum yield potential attain nutrient management including micronutrient iron and zinc is a basic requirement for major crops and mungbean.

Materials and Methods
Field experiment entitled “Effect of iron and zinc application on soil properties, nutrient

uptake and yield of green gram (*Vigna radiata* L.) in Inceptisol" was conducted at Soil Science and Agricultural Chemistry Departmental Research Farm, College of Agriculture, Latur during kharif season 2021 on green gram variety BM-2003-2. The topography of experimental field was uniform and levelled. The experimental soil was slightly alkaline in nature. The total geographical area of Latur district is 7.37 mha. Geographically Latur district comes under Maharashtra state which is located between 180 05' to 180 75' North. The soils of Latur district belongs to order Vertisols, Inceptisol and Entisol derived from Deccan trap. RDF (25:50:25 kg NPK ha^{-1}) supplied through Urea, SSP, MOP. The experimental soil was clayey in texture, calcareous in nature, moderately alkaline reaction, low in content of organic carbon (3.96 g kg^{-1}), available nitrogen (232.55 kg ha^{-1}), available phosphorous (13.98 kg ha^{-1}), high in available potassium (416.45 kg ha^{-1}), DTPA zinc (0.51 ppm) and DTPA iron (2.18 ppm).The experiment was laid out in randomized block design with nine treatments and three replications, respectively.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads.

Plant height

The data regarding plant height was recorded at 30, 45 DAS and at harvest of crop are presented in table 1. It was evident from the results that the plant height was influenced due to application of iron and zinc nutrients at critical growth stages of crop. The highest plant height was recorded with treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) at 30 DAS (44.84 cm), 45 DAS (46.92 cm) and at harvest (53.95 cm) and was found at par with treatment T_9 (RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS) and treatment T_4 (RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS) and significantly superior over rest of the treatments. The increase in plant height might be due to iron and zinc application along with RDF in green gram crop which helps in various enzymes that are responsible for driving many metabolic activities in crop and involved in the synthesis of chlorophyll and it is essential for the maintenance of chloroplast structure and function which helps in increasing plant growth. Similar results were recorded by Gidaganti *et al*. (2019) [3] reported that the highest plant height (54.10 cm) was found with application of RDF + Zn @ 25 kg ha^{-1}+ Fe @ 20 kg ha^{-1} in green gram.

Table 1: Effect of iron and zinc application on plant height (cm) of green gram at 30, 45 DAS and at harvest.

Treatments	30 DAS	45 DAS	At harvest
T_1: RDF (25 kg N:50 kg P_2O_5:25 kg K_2O ha^{-1})	28.76	31.45	45.22
T_2: RDF + 0.5 % Foliar spray of $FeSO_4$ at 30 and 45 DAS	35.72	40.68	47.52
T_3: RDF + 0.5 % Foliar spray of $ZnSO_4$ at 30 and 45 DAS	31.58	32.40	47.43
T_4: RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS	43.94	45.97	53.22
T_5: RDF + 25 kg ha^{-1} $FeSO_4$	33.52	34.53	47.42
T_6: RDF + 25 kg ha^{-1} $ZnSO_4$	37.78	41.95	48.20
T_7: RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$	44.84	46.92	53.95
T_8: RDF + Grade I micronutrients formulation @ 25 kg ha^{-1}	40.22	44.22	48.25
T_9: RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS	44.29	46.90	53.58
SE (m) ±	0.48	0.94	0.68
CD at 5%	1.45	2.83	2.05

Number of leaves (plant^{-1})

The data regarding number of leaves plant^{-1} of green gram as influenced by soil application of micronutrient fertilizers was recorded during growth stages presented in table 2. The highest number of leaves plant^{-1} at 30 DAS (18.72), 45 DAS (30.26) and at harvest (15.67) reported due to treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) and was found at par with treatment T_9 (RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS) and treatment T_4 (RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS) and significantly superior over rest of the treatments. The lowest number of leaves plant^{-1} at 30 DAS (11.32), 45 DAS (20.70) and at harvest (10.52) of green gram crop were recorded in the treatment T_1 (RDF). Increased number of leaves plant^{-1} might be due to proper nutrition to green gram crop through application of iron and zinc nutrition which required for plant growth, development and it is involved in photosynthesis and chlorophyll synthesis. The results were in confirmatory with the findings of Gidaganti *et al.* (2019) [3].

Table 2: Effect of iron and zinc application on number of leaves (plant^{-1}) of green gram at 30, 45 DAS and at harvest.

Treatments	30 DAS	45 DAS	At harvest
T_1: RDF (25 kg N:50 kg P_2O_5:25 kg K_2O ha^{-1})	11.32	20.70	10.52
T_2: RDF + 0.5 % Foliar spray of $FeSO_4$ at 30 and 45 DAS	17.24	25.32	13.94
T_3: RDF + 0.5 % Foliar spray of $ZnSO_4$ at 30 and 45 DAS	12.90	23.75	10.36
T_4: RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS	18.12	29.42	15.05
T_5: RDF + 25 kg ha^{-1} $FeSO_4$	13.51	24.36	10.64
T_6: RDF + 25 kg ha^{-1} $ZnSO_4$	17.62	26.96	14.20
T_7: RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$	18.72	30.26	15.67
T_8: RDF + Grade I micronutrients formulation @ 25 kg ha^{-1}	17.76	27.53	14.84
T_9: RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS	18.40	29.66	15.30
SE (m) ±	0.35	0.45	0.26
CD at 5%	1.05	1.37	0.79

Number of branches (plant^{-1})

Branching is a crucial aspect of crop growth, bearing the plants pods and ultimately increasing crop yield. The information regarding effect of iron and zinc application on number of branches plant^{-1} at critical growth stages are shown in table 3. The findings showed that the application of RDF + $FeSO_4$ + $ZnSO_4$ might have significant impact on the number of branches plant^{-1} in green gram. The maximum number of branches plant^{-1} were observed in the treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) at 30 DAS (5.63), 45 DAS (9.46) and at harvest (11.76) and was found at par with treatment T_9 (RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS) and treatment T_4 (RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS) and significantly superior over rest of the treatments. While minimum number of branches plant^{-1} were observed in treatment T_1 (RDF) at 30 DAS (3.06), 45 DAS (5.23) and at harvest (7.96). This might be due to superiority of zinc sulphate in maintaining higher zinc concentration in the rhizosphere and beneficial role of zinc in synthesis of IAA, metabolism of auxin, biological activity, stimulating effect on photosynthetic pigments and enzyme activity which inturn encourage vegetative growth of plants. Similar findings were reported by Sudhanshu *et al.* (2022) [10].

Table 3: Effect of iron and zinc application on number of branches (plant^{-1}) of green gram at 30, 45 DAS and at harvest.

Treatments	30 DAS	45 DAS	At harvest
T_1: RDF (25 kg N:50 kg P_2O_5:25 kg K_2O ha^{-1})	3.06	5.23	7.96
T_2: RDF + 0.5 % Foliar spray of $FeSO_4$ at 30 and 45 DAS	3.66	8.16	9.13
T_3: RDF + 0.5 % Foliar spray of $ZnSO_4$ at 30 and 45 DAS	3.36	7.23	8.43
T_4: RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS	5.16	9.23	11.16
T_5: RDF + 25 kg ha^{-1} $FeSO_4$	3.13	7.13	8.06
T_6: RDF + 25 kg ha^{-1} $ZnSO_4$	4.36	8.26	9.46
T_7: RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$	5.63	9.46	11.76
T_8: RDF+ Grade I micronutrients formulation @ 25 kg ha^{-1}	4.46	8.36	9.83
T_9: RDF+ Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS	5.36	9.26	11.23
SE (m) ±	0.30	0.30	0.38
CD at 5%	0.92	0.91	1.14

Dry matter content (g plant^{-1})

The data regarding dry matter content g plant^{-1} was recorded at different growth stages of green gram is presented in table 4. The higher dry matter was observed with the treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) at 30 DAS (4.77 g plant^{-1}), at 45 DAS (7.25 g plant^{-1}) and at harvest (11.79 g plant^{-1}) and was found at par with treatment T_9 (RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS) and treatment T_4 (RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS) and significantly superior over rest of the treatments. Further data revealed that, the treatment T_1 (RDF) produced lower dry matter content g plant^{-1} at 30 DAS (2.93), at 45 DAS (5.38) and at harvest (9.15) in green gram. This might be due to superiority of zinc sulphate in maintaining higher zinc concentration in the rhizosphere and beneficial role of zinc in synthesis of IAA, metabolism of auxin, biological activity, stimulating effect on photosynthetic pigments and enzyme activity which inturn encourage vegetative growth of plants. Similar findings were reported by Kareti and George (2017) [4] found that maximum number of branches plant^{-1} (19.5) was recorded from those plots that had received from 70 kg P_2O_5 + 20 kg $ZnSO_4$ ha^{-1} in chickpea.

Table 4: Effect of iron and zinc application on dry matter content (g plant^{-1}) of green gram at 30, 45 DAS and at harvest.

Treatments	30 DAS	45 DAS	At harvest
T_1: RDF (25 kg N:50 kg P_2O_5:25 kg K_2O ha^{-1})	2.93	5.38	9.15
T_2: RDF + 0.5 % Foliar spray of $FeSO_4$ at 30 and 45 DAS	3.99	6.26	10.18
T_3: RDF + 0.5 % Foliar spray of $ZnSO_4$ at 30 and 45 DAS	3.46	5.62	9.24
T_4: RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS	4.48	7.14	11.40
T_5: RDF + 25 kg ha^{-1} $FeSO_4$	3.24	5.70	9.35
T_6: RDF + 25 kg ha^{-1} $ZnSO_4$	4.36	6.29	10.41
T_7: RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$	4.77	7.25	11.79
T_8: RDF + Grade I micronutrients formulation @ 25 kg ha^{-1}	4.44	6.39	11.14
T_9: RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS	4.57	7.20	11.68
SE (m) ±	0.21	0.18	0.13
CD at 5%	0.65	0.55	0.41

Nodulation

Data tabulated on effect of iron and zinc on number of nodules plant^{-1}, fresh weight and dry weight of nodules g plant^{-1} at flowering stage (45 DAS) of green gram presented in table 5. The maximum number of nodules plant^{-1}, fresh weight and dry weight of nodules g plant^{-1} was obtained under the treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) which was (19.76), (2.66) and (1.68), respectively over control and was found at par with treatment T_8 (RDF + Grade I micronutrients formulation @25 kg ha^{-1}) and treatment T_6 (RDF + 25 kg ha^{-1} $ZnSO_4$) and significantly superior over rest of the treatments. The minimum number of nodules plant^{-1}, fresh weight and dry weight of nodules g plant^{-1} was obtained under the treatment T_1 (RDF) which was (13.33), (1.17) and (0.71), respectively. Increase in number of nodules might be due to increased infection and rhizobial colonization in rhizosphere because of increased availability of iron and also zinc plays a vital role in cellular growth, differentiation and metabolism which results in vigorous growth of plants and extensive root system leading to increased growth parameters.

Similar results also reported by Kumar *et al.* (2020) [5] revealed that higher number of root nodules plant^{-1} in black gram. Sudhanshu *et al.* (2022) [10] observed higher number of nodules plant^{-1} was (30.16) at 45 DAS in green gram.

Table 5: Effect of iron and zinc application on nodulation of green gram at flowering stage (45 DAS).

Treatments	Nodules (plants^{-1})	Fresh weight (g plant^{-1})	Dry weight (g plant^{-1})
T_1: RDF (25 kg N:50 kg P_2O_5:25 kg K_2O ha^{-1})	13.33	1.17	0.71
T_2: RDF + 0.5 % Foliar spray of $FeSO_4$ at 30 and 45 DAS	15.33	1.60	0.76
T_3: RDF + 0.5 % Foliar spray of $ZnSO_4$ at 30 and 45 DAS	14.36	1.54	0.75
T_4: RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS	16.23	1.61	0.79
T_5: RDF + 25 kg ha^{-1} $FeSO_4$	18.13	1.95	0.96
T_6: RDF + 25 kg ha^{-1} $ZnSO_4$	18.76	2.27	1.17
T_7: RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$	19.76	2.66	1.68
T_8: RDF + Grade I micronutrients formulation @ 25 kg ha^{-1}	19.16	2.59	1.56
T_9: RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS	17.46	1.83	0.91
SE (m) ±	0.36	0.26	0.17
CD at 5%	1.09	0.78	0.53

Chlorophyll content

Data on effect of iron and zinc application on chlorophyll content at flowering stage (45 DAS) is presented in table 6. From data observed that the chlorophyll-a, chlorophyll-b and total chlorophyll were found in range of 3.21 to 5.77, 2.37 to 4.69 and 5.59 to 10.47 mg g^{-1}, respectively at flowering stage (45 DAS) among different treatment due to application of $FeSO_4$ and $ZnSO_4$ in green gram. The treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) was found maximum chlorophyll-a (5.77), chlorophyll-b (4.69) and total chlorophyll (10.47) mg g^{-1} over control and followed by treatment T_9 (RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS) and treatment T_4 (RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS) and significantly superior over rest of the treatments. The minimum chlorophyll-a (3.21), chlorophyll-b (2.37) and total chlorophyll (5.59) mg g^{-1} were observed in treatment T_1 (RDF) in green gram. These results might be due to chlorophyll is a green pigment in the chloroplast of the green plants. It helps plants create their own food through photosynthesis. Iron plays a crucial role during electron transport and chlorophyll formation and zinc also play an important role in synthesis of chlorophyll its enzymatic role in starch formation and in protein synthesis. This increase in the availability of zinc to plant might have stimulated the metabolic and enzymatic activities thereby increasing the growth of the crop.

Similar findings were reported by Lokhande (2018) [6] the maximum chlorophyll content chlorophyll-a (0.89), chlorophyll-b (0.23) and total chlorophyll (1.12) mg g^{-1} which was observed in green gram.

Table 6: Effect of iron and zinc application on chlorophyll content (mg g^{-1}) of green gram at flowering stage (45 DAS).

Treatments	Chlorophyll a	Chlorophyll b	Total chlorophyll (mg g^{-1})
T_1: RDF (25 kg N:50 kg P_2O_5:25 kg K_2O ha^{-1})	3.21	2.37	5.59
T_2: RDF + 0.5 % Foliar spray of $FeSO_4$ at 30 and 45 DAS	3.93	3.12	7.05
T_3: RDF + 0.5 % Foliar spray of $ZnSO_4$ at 30 and 45 DAS	3.63	2.87	6.50
T_4: RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS	5.29	4.29	9.58
T_5: RDF + 25 kg ha^{-1} $FeSO_4$	3.58	2.86	6.43
T_6: RDF + 25 kg ha^{-1} $ZnSO_4$	4.76	3.26	8.02
T_7: RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$	5.77	4.69	10.47
T_8: RDF + Grade I micronutrients formulation @ 25 kg ha^{-1}	4.94	4.19	9.13
T_9: RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS	5.48	4.63	10.12
SE (m) ±	0.29	0.33	0.47
CD at 5%	0.89	0.99	1.41

Number of pods (plant^{-1})

The data regarding number of pods plant^{-1} in green gram is presented in table 7. The number of pods plant^{-1} is an important parameter which is directly related to seed yield and production per unit area of green gram. The maximum number of pods plant^{-1} (29.88) recorded in the treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) and was found at par with treatment T_9 (RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS) and T_4 (RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS) and significantly superior over rest of the treatments. The minimum number of pods plant^{-1} (25.03) recorded in the treatment T_1 (RDF). The reason for increasing the number of pods plant^{-1} might be due to availability of nutrients through soil application to the green gram crop which increased number of pods plant^{-1}. Zinc plays a very important role in the metabolism of the plant process by influencing the activity of growth enzymes as well as it is involved in carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis and regulation of auxin synthesis and pollen formation. It also converts ammonia to nitrate in crops which contribute to yield. These results are in confirmatory with Banoth *et al.* (2022) [2] reported that maximum number of pod plant^{-1} in green gram.

Number of grains (pod^{-1})

Data presented in table 7 indicated that the treatments differed significantly in respect to number of seeds pod^{-1} at harvest stage. The maximum number of seeds pod^{-1} observed in treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) which were (13.68) seeds pod^{-1} and was found at par with treatment T_9 (RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS) and treatment T_4 (RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS) and significantly superior over rest of the treatments. The minimum number of seeds pod^{-1} (10.98) was observed in the treatment T_1 (RDF) in green gram. This might be due to application of iron and zinc plays accumulative effect of growth characters and also yield attributes as it contain zinc which involved in IAA synthesis and also different metabolic process in plants. This might be due to the fact that IAA promotes the prevention of pod abscission and cell elongation at suppression of pod abscission of pod was the major determining factor of the seed yield. On the other hand, auxin indirectly controlled the ethylene activity which accelerated the abscission. It also suppressed the cellusase activity, cell degrading enzyme which favoured abscission process.

These results are in line with Gidaganti *et al.* (2019) [3] showed that significantly increased the number of seed pods^{-1} at 60 DAS (9.13) over control. Sudhanshu *et al.* (2022) [10] observed higher number of seeds pod^{-1} (12.07) in green gram.

Table 7: Effect of iron and zinc application on number of pods (plant^{-1}) and number of grains (pod^{-1}) of green gram at harvest.

Treatments	No. of pods (plant^{-1})	No. of grains (pod^{-1})
T_1: RDF (25 kg N:50 kg P_2O_5:25 kg K_2O ha^{-1})	25.03	10.98
T_2: RDF + 0.5 % Foliar spray of $FeSO_4$ at 30 and 45 DAS	26.83	12.16
T_3: RDF + 0.5 % Foliar spray of $ZnSO_4$ at 30 and 45 DAS	25.85	11.86
T_4: RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS	29.15	13.28
T_5: RDF + 25 kg ha^{-1} $FeSO_4$	25.41	11.37
T_6: RDF + 25 kg ha^{-1} $ZnSO_4$	28.01	12.60
T_7: RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$	29.88	13.68
T_8: RDF + Grade I micronutrients formulation @ 25 kg ha^{-1}	28.24	12.39
T_9: RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS	29.48	13.42
SE (m) ±	0.24	0.25
CD at 5%	0.74	0.75

Test weight (g)

Data regarding effect of iron and zinc on test weight was tabulated in table 8 indicated that the application of iron and zinc markedly influence the test weight in the range of (30.59 to 35.88 g). Test weight significantly influenced by application of iron and zinc and maximum test weight (35.91 g) was found under the treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) which was found at par with treatment T_9 (RDF+ Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS) i. e. test weight (35.88 g) and treatment T_4 (RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS) test weight (34.94 g) and significantly superior over rest of the treatments. Whereas, the lowest test weight (30.59 g) was recorded in the treatment T_1 (RDF) in green gram.

Increase in test weight due to greater mobilization of photosynthes to the developing seeds by application of micronutrients might be the reason for increase in seed weight. Increase in this attribute by soil application might be due to the involvement of the iron and zinc in enzyme activation, membrane integrity, chlorophyll formation, stomatal balance and starch utilization at early stages which enhanced accumulation of assimilate in the grains resulting in heavier grains.

Similar findings were recorded by Misal (2018) [8] observed that maximum test weight (42.61 g) in green gram. Gidaganti *et al.* (2019) [3] observed that significantly increased the test weight (36.6) over control.

Protein content (%) and Protein yield (kg ha^{-1})

The data on protein content (%) as influenced by different treatments is presented in table 8. The mean protein content was (22.72%). The mean protein content was not affected significantly due to different treatments. The numerically higher protein content (22.72 %) recorded with treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) followed by treatment T_9 (22.68 %), T_4 (22.65 %), T_8 (22.62 %), T_3 (22.56 %), T_2 (21.90 %) significantly superior over rest of the treatments. While, minimum protein content (21.12 %) was recorded at treatment T_1 (RDF) in green gram.

Table 8: Effect of iron and zinc application on test weight (g), protein content (%) and protein yield (kg ha^{-1}) of green gram.

Treatments	Test weight (g)	Protein content (%)	Protein yield (kg ha^{-1})
T_1: RDF (25 kg N:50 kg P_2O_5:25 kg K_2O ha^{-1})	30.59	21.12	189.45
T_2: RDF + 0.5 % Foliar spray of $FeSO_4$ at 30 and 45 DAS	33.35	21.90	273.37
T_3: RDF + 0.5 % Foliar spray of $ZnSO_4$ at 30 and 45 DAS	33.73	22.56	319.48
T_4: RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS	34.94	22.65	303.55
T_5: RDF + 25 kg ha^{-1} $FeSO_4$	34.72	21.27	239.95
T_6: RDF + 25 kg ha^{-1} $ZnSO_4$	34.98	21.19	268.07
T_7: RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$	35.91	22.72	333.33
T_8: RDF + Grade I micronutrients formulation @ 25 kg ha^{-1}	35.81	22.62	289.61
T_9: RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS	35.88	22.68	326.06
SE (m) ±	0.78	0.55	8.05
CD at 5%	2.33	NS	24.15

Similar findings was observed with Misal (2018) [8] recorded higher protein content (22.72 %) in green gram. Mane *et al.* (2021) [7] recorded that highest protein content (20.71 %) in pigeon pea.

The higher protein yield (333.33 kg ha^{-1}) was observed with treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) which was found at par with treatment T_9 (326.06 kg ha^{-1}), T_4 (303.55 kg ha^{-1}), T_8 (289.61 kg ha^{-1}), T_2 (273.37 kg ha^{-1}) and T_6 (268.07 kg ha^{-1}) and significantly superior over rest of the treatments. Whereas, lower protein yield (189.45 %) was recorded in treatment T_1 (RDF) in green gram. The increase in protein content might be due to iron and zinc which are two important elements in enzymes structure involved in amino acids are the base of protein synthesis, protein content increased with the application of iron and zinc.

Similar findings was observed by Misal (2018) [8] recorded higher protein yield (277.02 kg ha^{-1}) in green gram. Lokhande (2018) [6] reported that maximum protein yield (328.55 kg ha^{-1}) in green gram.

Grain yield (kg ha^{-1})

The data on seed yield of green gram as influenced by application of iron and zinc fertilizers are presented in table 9. The seed yield of green gram ranged between 897.02 kg ha^{-1} to 1467.13 kg ha^{-1}. The highest seed yield (1467.13 kg ha^{-1}) was recorded in treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) which was at par with treatment T_9 RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS (1437.92 kg ha^{-1}) and treatment T_4 RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS (1415.79 kg ha^{-1}) and significantly superior over rest of the treatments. Whereas, the lowest seed yield (897.02 kg ha^{-1}) was recorded in the treatment T_1 (RDF) in green gram. The increase in yield might be due to fulfillment of the demand of crop by higher assimilation and translocation of photosynthates from source to sink and better role of iron and zinc during reproductive phase of crop growth. However, combined effect of iron and zinc provided sufficient nutrition to the plant and thereby more yield attributes and yield was recorded.

Similar findings were observed by Gidaganti *et al.* (2019) [3] recorded that significantly increased the seed yield (32.37 q ha^{-1}) over control.

Straw yield

The data on straw yield of green gram as influenced by application of iron and zinc are tabulated in table 9. Straw yield is directly related with increase in vegetative growth of the plants. Data indicated that the application of iron and zinc markedly influence the straw yield in the range of (1762.97 kg ha^{-1} to 2934.26 kg ha^{-1}).

The maximum straw yield (2934.26 kg ha^{-1}) was recorded in the treatment T_7 (RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ kg ha^{-1}) which was found at par with treatment T_9 (RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS) i.e. straw yield (2861.46 kg ha^{-1}) and treatment T_4 (RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS) i.e. straw yield (2859.03 kg ha^{-1}) and significantly superior over rest of the treatments. Whereas, the lowest straw yield (1762.97 kg ha^{-1}) was recorded in the treatment T_1 (RDF). The higher straw yield might be due to improved vegetative growth and growth parameters through adequate availability of major and micronutrient in soil, which in turn, favorably influenced physiological process and buildup of photosynthates. Similar findings showed by Misal (2018) [8] recorded that maximum straw yield (1783 kg ha^{-1}) in green gram. Almad *et al.* (2020) [1] noticed that in pigeon pea higher straw yield (4761 kg ha^{-1}).

Table 9: Effect of iron and zinc on grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of green gram.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1: RDF (25 kg N:50 kg P_2O_5:25 kg K_2O ha^{-1})	897.02	1762.97
T_2: RDF + 0.5 % Foliar spray of $FeSO_4$ at 30 and 45 DAS	1248.76	2371.12
T_3: RDF + 0.5 % Foliar spray of $ZnSO_4$ at 30 and 45 DAS	1340.06	2360.15
T_4: RDF + 0.5% each Foliar spray of $FeSO_4$ and $ZnSO_4$ at 30 and 45 DAS	1415.79	2859.03
T_5: RDF + 25 kg ha^{-1} $FeSO_4$	1130.18	2069.26
T_6: RDF + 25 kg ha^{-1} $ZnSO_4$	1265.51	2445.34
T_7: RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$	1467.13	2934.26
T_8: RDF + Grade I micronutrients formulation @ 25 kg ha^{-1}	1280.28	2591.14
T_9: RDF + Grade II micronutrients formulation @ 0.5% Foliar spray at 30 and 45 DAS	1437.92	2861.46
SE (m) ±	21.08	40.21
CD at 5%	63.20	120.57

Conclusion

Green gram crop fertilized with application of RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ found significantly superior in growth, yield and quality of crop and was found at par with treatment RDF + Grade II micronutrients formulation @ 0.5% F.S. at 30 and 45 DAS.

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