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Solanke GN
M.Sc. Scholar, Department of Soil Science, College of Agriculture, Latur, VNMKV, Parbhani, Maharashtra, India

Dr. Puri AN
Assistant Professor, College of Agriculture, Latur, VNMKV, Parbhani, Maharashtra, India

Adsul PB
Assistant Professor, College of Agriculture, Latur, VNMKV, Parbhani, Maharashtra, India

Gaikwad GK
Assistant Professor, College of Agriculture, Ambajogai, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
Solanke GN
M.Sc. Scholar, Department of Soil Science, College of Agriculture, Latur, VNMKV, Parbhani, Maharashtra, India

Effect of micronutrient application on growth and yield in green gram (*Vigna radiata* L.)

Solanke GN, Puri AN, Adsul PB and Gaikwad GK

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Abstract
The present investigation entitled "Micronutrient Management in Green Gram (*Vigna radiata* L.)" during *Kharif* season of the year, 2023-2024 at a field experiment was conducted at experimental field College of Agriculture Latur. The experiment was layout in RBD with three replications and a recommended variety of green gram BM 2003-2 as a test crop along with ten treatments.
The results in a nutshell indicated that the growth and yield were significantly influenced by the application of iron and zinc with RDF of green gram. The growth parameters *viz.*, plant height, number of branches, leaf area, dry matter content and number of nodules significantly increased with application of RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ + 10 Kg Borax and was found at par with treatment T_8 RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$, T_4 RDF + S.A. Grade-I micro-nutrient @ 25 kg ha^{-1} + F.A. Grade-II micro-nutrient @ 0.5% at 25 and 40 DAS and treatment T_2 RDF + S.A. Grade- I micro-nutrient @ 25 kg ha^{-1}.
A significantly higher number of seed yield ha^{-1} and straw yield ha^{-1} with application of RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$ + 10 Kg Borax (T_9) and was found at par with treatments T_8 RDF + 25 kg ha^{-1} $FeSO_4$ + 25 kg ha^{-1} $ZnSO_4$, T_4 (RDF + S.A. Grade- I micro-nutrient @ 25 kg ha^{-1} + F.A. Grade- II micro-nutrient @ 0.5% at 25 and 40 DAS) and treatment T_2 (RDF + S.A. Grade- I micro-nutrient @ 25 kg ha^{-1}).

Keywords: Green gram, $FeSO_4$, $ZnSO_4$, Grade II, Soil nutrient status

Introduction

The well-known domesticated legume crop known as green gram (*Vigna radiata* L.) is farmed all over the world. In affluent countries, it is a high-value commodity crop with excellent nutritional value, and in underdeveloped countries, it provides a significant economic boost for marginal farmers. The genus Vigna, species radiata, subfamily *Papilionaceae*, and family Fabaceae are home to green grams. With over 650 genera and 20,000 species, this family is widely distributed and ranks third among all flowering plant families (Doyle, 1994) [3]. Other names for green gram include mung bean, haricot mungo, mash bean, and golden gram. It is a deep-rooted, annual herbaceous plant that can grow up to 100 cm tall and is semi-upright to erect or occasionally twining. The primary growing regions of green gram in India include Andhra Pradesh, Maharashtra, Orissa, Rajasthan, Gujarat, Punjab, Uttar Pradesh, etc. India ranks first in both area and production of all important pulses grown in the world. Pulses are grown on about 30.4 million ha. Area in India with production of 14.77 million tonnes and productivity pulses is 617 kg ha^{-1}. The total area under pulses in Maharashtra is 32.69 lakh ha, with a total production of 21.44 lakh tones and productivity of 217 kg ha^{-1}. Green gram ranks third among all the pulses in India after chickpea and pigeon pea. India accounts for almost 65 percent area and 54 percent production of world mung bean. Green gram grown on about 3.57 million ha. Area in India with a total production of 17.89 metric tonnes and productivity of green gram is 500 kg ha^{-1} (Anonymous, 2021) [2].

Micronutrient deficiencies in soil and crop plants are widespread because of increased micronutrient demand from intensive cropping practices and adaptation of high-yielding crop cultivars, enhanced crop production on marginal soils that contain low levels of essential micronutrients, increased use of high analysis fertilizers with low amounts of micronutrients, decreased use of animal manures, composts, and crop residues, use of soils low in micronutrient reserves, use of liming in acid soils, involvement of natural and anthropogenic factors that limit adequate supplies and create elemental imbalance in soil. Tribhuwan *et al.* (2024) [8] reported that as much as 48, 12, 5, 4, 33, 13, and 41 percent of soils in India are affected by deficiency of Zn, Fe, Mn, Cu, B, Mo, and S, respectively.

Materials and Methods

A field experiment was conducted at Departmental research farm of Soil Science, College of Agriculture, and Latur during *Kharif* 2023-2024 on green gram (variety BM-2003-2). The experimental soil was clayey in texture, slightly alkaline in reaction, low in available nitrogen, available phosphorous, high in available potassium and deficient in DTPA-Fe and Zn.

Latur district of Maharashtra state is situated between 18°05'-18°75' North latitude and between 76°25' to 77°25' East longitude on the Balaghat plateau with mean sea level height 633.85 meters and derived from Deccan trap rock, basaltic rich in Magnesium and dominated by smectite mineral. This area falls under the assured rainfall zone. The annual average precipitation is 750 to 800 mm. Most of the rains are received during July to October from the South-West monsoon. The rainfall pattern and temperature and humidity variation during the period of experimentation.

Table 1: Treatment details

Sr. No	Symbol	Treatment
1	T_1	RDF (25 kg N:50 kg P_2O_5:25 kg K_2O)
2	T_2	RDF + Soil application Grade-I micro-nutrient @ 25 kg ha^{-1}.
3	T_3	RDF + Foliar application Grade-II micro-nutrient @ 0.5% at 25 and 40 DAS.
4	T_4	RDF + Soil application Grade-I micro-nutrient @ 25 kg ha^{-1} + Foliar application Grade-II micro-nutrient @ 0.5% at 25 and 40 DAS
5	T_5	RDF + Soil application $FeSO_4$ @ 25kg ha^{-1}
6	T_6	RDF + Soil application $ZnSO_4$ @ 25kg ha^{-1}
7	T_7	RDF + Soil application Borax @ 10kg ha^{-1}
8	T_8	RDF + Soil application $FeSO_4$ + $ZnSO_4$ @ 25kg ha^{-1}
9	T_9	RDF + Soil application $FeSO_4$ + $ZnSO_4$ @ 25kg ha^{-1} + Borax @ 10kg ha^{-1}
10	T_{10}	RDF + Foliar application $FeSO_4$ + $ZnSO_4$ @ 0.5% + Borax 0.2% at 25 to 40 DAS.

3. Result and Discussion

3.1 Growth Parameters

3.1.1 Plant height

Data presented in Table 2 and Fig 1 revealed that the plant height of green gram was significantly increased due to soil application of micronutrients in combination. The highest plant height 50.39 cm at harvest was recorded with treatment T_9 (RDF + Soil application $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1}). Which was found at par with treatment T_8, T_4 and T_2. The results found were significantly superior over rest of the treatments. The treatment T_1 (RDF) recorded the lowest plant 36.81 cm at harvest.

Application of micronutrients as soil application along with foliar application might have enhanced the availability of nutrients. Activation of nutrient availability the vegetative growth and higher chlorophyll content in the respective treatment that would help to increase the plant height. Similar results were recorded by Gidaganti *et al.* (2019) [5] who reported that the highest plant height was observed with the application of RDF + Zn @ 25 kg ha^{-1} + Fe @ 20 kg ha^{-1} in green gram.

Table 2: Effect of micronutrient application on growth parameter of green gram.

Treatments	Plant Height	Number of Branches (Plant^{-1})	Dry Matter Content (g plant^{-1})	Root nodules at flowering stage (plant^{-1})
T_1 : RDF	36.81	7.32	6.30	15.17
T_2: RDF + S.A. Grade-I micro-nutrient @ 25 kg ha^{-1}.	48.14	9.43	8.04	19.43
T_3: RDF + F.A. Grade-II micro-nutrient @ 0.5% at 25 and 40 DAS.	45.93	8.77	7.30	16.55
T_4 : RDF + S.A. Grade-I micro-nutrient @ 25 kg ha^{-1} + F.A. Grade-II micro-nutrient @ 0.5% at 25 and 40 DAS	49.36	9.52	8.42	19.73
T_5: RDF + S.A. $FeSO_4$ @ 25 kg ha^{-1}	45.87	8.98	7.67	18.00
T_6: RDF + S.A. $ZnSO_4$ @ 25 kg ha^{-1}	44.68	8.84	7.53	17.70
T_7: RDF + S.A. Borax @ 10 kg ha^{-1}	42.26	8.60	7.13	16.63
T_8: RDF + S.A. $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1}	49.58	9.52	8.52	19.70
T_9: RDF + S.A. $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10kg ha^{-1}	50.39	9.99	8.65	19.83
T_{10}: RDF + F.A. $FeSO_4$ + $ZnSO_4$ @ 0.5% + Borax 0.2% at 25 to 40 DAS	44.47	8.58	7.41	16.53
SE (m) ±	0.87	0.23	0.21	0.39
CD at 5%	2.60	0.68	0.62	1.15

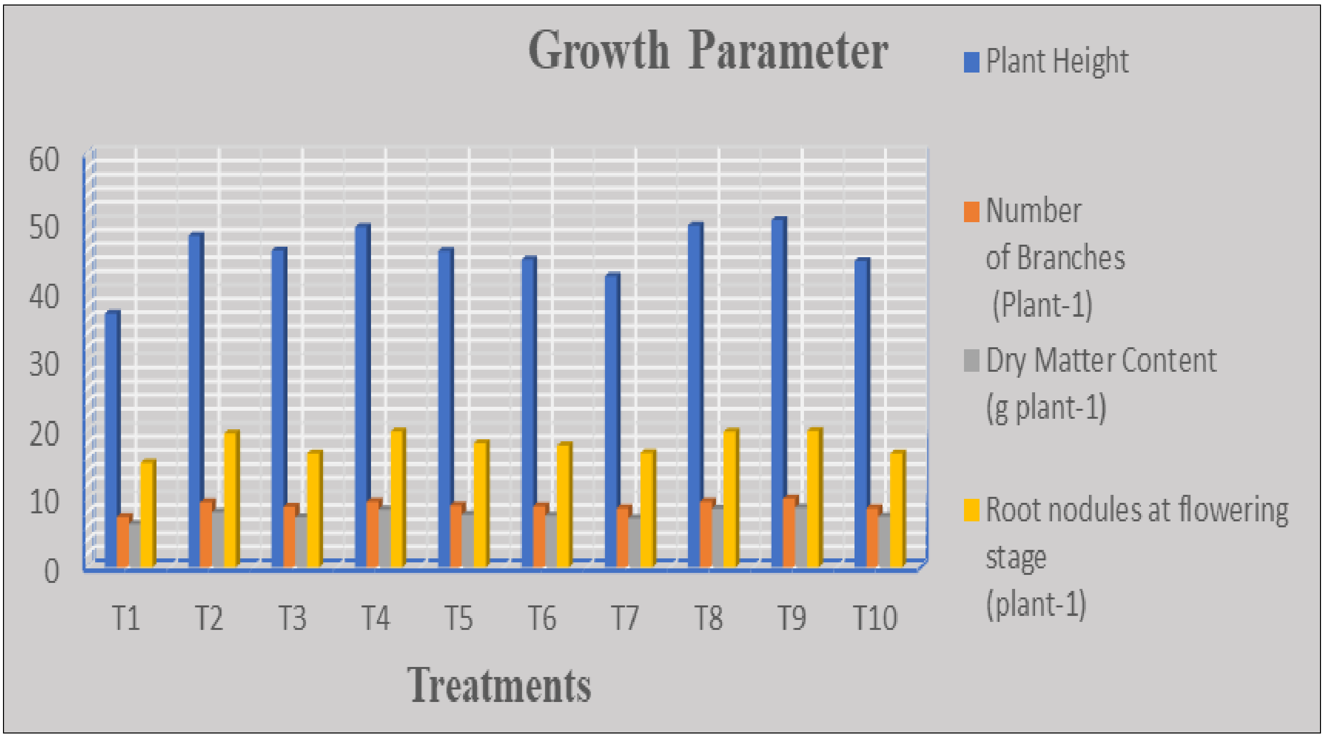

Fig 1: Effect of micronutrient application on Growth Parameter green gram.

3.1.2 Number of branches per plant

The data regarding the number of branches plant^{-1} of green gram as affected by application of micronutrient was recorded during three growth stages at harvest has presented in table 2 and depicted in fig. 1.

Branching is a crucial aspect of crop growth, bearing the plant's pods and ultimately increasing crop yield. The findings showed that the application of micronutrients might have a significant impact on the number of branches plant^{-1} in green gram. The maximum number of branches plant^{-1} 9.99 at harvest were observed in the treatment T_9 (RDF + Soil application $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1}). Which was found at par with treatment T_8, T_4, T_2 and significantly superior over rest of the treatments. A minimum number of branches plant^{-1} 7.32 at harvest respectively were observed in treatment T_1 (RDF).

This might be due to the superiority of iron and zinc sulphate in maintaining higher iron and zinc concentrations in the rhizosphere. The beneficial role of synthesis of IAA, metabolism of auxin, biological activity, stimulating effect on photosynthetic pigments and enzyme activity in turn encourage vegetative growth of plants. Similar results were reported by Almad *et al.* (2020) [1] in pigeon pea.

3.1.3 Leaf area

The data regarding leaf area of green gram as affected by application of micronutrient was recorded during 30, 45 DAS which has presented in table 3 and depicted in fig. 2.

The highest leaf area 509.40 and 530.63 cm^2 plant^{-1} at 30 and 45 DAS respectively was recorded with treatment T_9 (RDF + Soil application $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1}). Which was found at par with treatment T_8, T_4, T_2 and significantly superior over rest of the treatments. The lowest leaf area 384.73 and 401.08 cm^2 plant^{-1} at 30 and 45 DAS respectively was recorded with treatment T_1 (RDF).

This might be due to the highest metabolic activity by the increased supply of nutrients. More dry matter accumulation in leaves helped the photosynthetic area to remain active for a longer period. Similar kinds of results were noticed by Almad *et al.* (2020) [1] in pigeon pea.

Table 3: Effect of micronutrient application on Leaf Area of green gram.

Treatments	Leaf Area (cm^2 plant^{-1})	
	30 DAS	45 DAS
T_1: RDF	384.73	401.08
T_2: RDF + S.A. Grade-I micro-nutrient @ 25 kg ha^{-1}.	492.03	509.90
T_3: RDF + F.A. Grade-II micro-nutrient @ 0.5% at 25 and 40 DAS.	412.50	429.00
T_4: RDF + S.A. Grade-I micro-nutrient @ 25 kg ha^{-1} + F.A. Grade-II micro-nutrient @ 0.5% at 25 and 40 DAS	499.77	510.12
T_5: RDF + S.A. $FeSO_4$ @ 25 kg ha^{-1}	485.60	499.00
T_6: RDF + S.A. $ZnSO_4$ @ 25 kg ha^{-1}	417.63	430.87
T_7: RDF + S.A. Borax @ 10 kg ha^{-1}	404.03	423.32
T_8: RDF + S.A. $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1}	503.10	514.93
T_9: RDF + S.A. $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10kg ha^{-1}	509.40	530.63
T_{10}: RDF + F.A. $FeSO_4$ + $ZnSO_4$ @ 0.5% + Borax 0.2% at 25 to 40 DAS.	436.10	452.82
SE (m) ±	6.52	7.16
CD at 5%	19.37	21.27

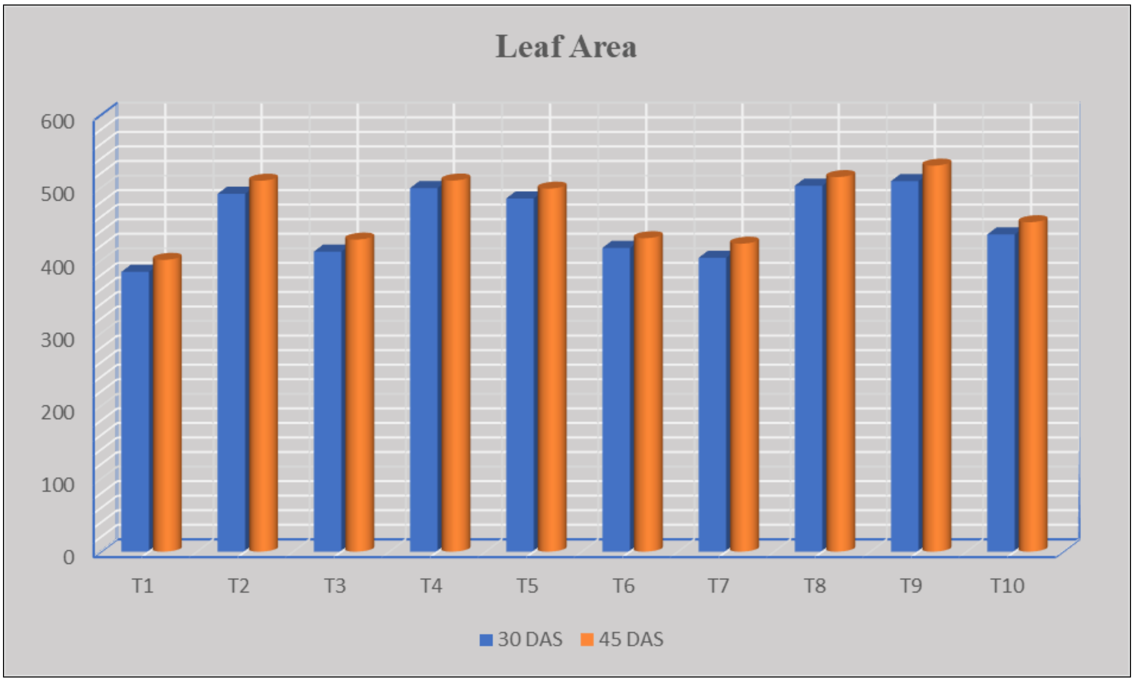

Fig 2: Effect of micronutrient application on Leaf Area of green gram.

3.1.4 Dry matter content

The data on dry matter content g plant^{-1} of green gram as affected by application of micronutrient was recorded during three growth stages at harvest which has presented in table 2 and depicted in fig. 1.

The highest dry matter content 8.65 g plant^{-1} at harvest was observed with the treatment T_9 (RDF + Soil application $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1}). The result found was at par with treatment T_8, T_4, T_2 and significantly superior over rest of the treatments. Further data revealed that the treatment T_1 (RDF) produced lower dry matter content 6.30 g plant^{-1} at harvest respectively.

Higher dry matter production might be due to the increased photosynthetic rate, accelerated nutrient uptake from soil, increased availability of major and micro-nutrients also which increases vegetative growth and plant height. Similar findings were reported by Sudhanshu *et al.* (2022) [7] in green gram.

3.1.5 Nodulation

The data regarding the number of nodules plant^{-1} of green gram as affected by application micronutrient was recorded during the flowering stage and has presented in table 2 and depicted in Figure 1.

The maximum number of nodules plant^{-1} (19.83) was obtained with the treatment T_9 (RDF + Soil application $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1}). The result was found at par with treatment T_8, T_4, T_2 and significantly superior over rest of the treatments. The minimum number of nodules plant^{-1} (15.17) was obtained with the treatment T_1 (RDF).

The increase in several nodules might be due to increased rhizobial colonization in the rhizosphere because of the increased availability of iron and zinc which plays a vital role in cellular growth, differentiation and metabolism. Which ultimately results in vigorous growth of plants and extensive root system leading to increased growth parameters. Similar results were also reported by Kumar *et al.* (2020) [6] in black gram.

3.2 Yield parameters

The data related to different yield parameters like number of seed yield (kg ha^{-1}) and straw yield (kg ha^{-1}) as influenced by the application of micronutrient sources with certain treatments has shown below.

3.2.1 Seed yield

The data regarding seed yield of green gram as influenced by the application of micronutrients are presented in table 4 and depicted in fig. 3.

The seed yield of green gram ranged between 1027.31 kg ha^{-1} to 1428.36 kg ha^{-1}. The highest seed yield (1428.36 kg ha^{-1}) was recorded with treatment T_9 (RDF + Soil application $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1}) which was at par with treatment T_8, T_4, T_2 and significantly superior over rest of the treatments. Whereas, the lowest seed yield (1027.31 kg ha^{-1}) was recorded with treatment T_1 (RDF).

The increase in yield might be due to fulfillment of the demand for the crop by higher assimilation and translocation of photosynthates from source to sink and better role of iron and zinc during the reproductive phase of crop growth. However, the combined effect of iron and zinc provided sufficient nutrition to the plant and thereby more yield attributes and yield were recorded.

Similar findings were observed by Gidaganti *et al.* (2019) [5] who recorded soil application of RDF + Zn @ 25 kg ha^{-1} + Fe @ 10 kg ha^{-1} in green gram which significantly increased the seed yield.

Table 4: Effect of micronutrient application on seed yield and straw yield of green gram.

Treatments	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1: RDF	1027.31	1411.47
T_2: RDF + S.A. Grade-I micro-nutrient @ 25 kg ha^{-1}.	1255.48	1793.10
T_3: RDF + F.A. Grade-II micro-nutrient @ 0.5% at 25 and 40 DAS.	1069.31	1493.58
T_4: RDF + S.A. Grade-I micro-nutrient @ 25 kg ha^{-1} + F.A. Grade-II micro-nutrient @ 0.5% at 25 and 40 DAS	1312.69	1808.08
T_5: RDF + S.A. $FeSO_4$ @ 25 kg ha^{-1}	1148.47	1665.82
T_6: RDF + S.A. $ZnSO_4$ @ 25 kg ha^{-1}	1102.88	1579.49
T_7: RDF + S.A. Borax @ 10 kg ha^{-1}	1110.26	1493.16
T_8: RDF + S.A. $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1}	1378.33	1847.34
T_9: RDF + S.A. $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10kg ha^{-1}	1428.36	1904.76
T_{10}: RDF + F.A. $FeSO_4$ + $ZnSO_4$ @ 0.5% + Borax 0.2% at 25 to 40 DAS.	1080.71	1479.44
SE (m) ±	74.57	44.84
CD at 5%	216.07	133.23

*S.A.-Soil Application, **F.A.-Foliar Application

3.2.2 Straw yield

The data in respect of straw yield of green gram as influenced by the application of micronutrients has presented in table 4 and depicted in fig. 3.

Straw yield is directly related to an increase in vegetative growth of the plants. Data indicated that the application of iron and zinc markedly influenced the straw yield in the range of 1411.47 kg ha^{-1} to 1904.76 kg ha^{-1}. The maximum straw yield (1904.76 kg ha^{-1}) was recorded with treatment T_9 (RDF + Soil application $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1}) which was found at par with treatment T_8, T_4, T_2 which was significantly superior over rest of the treatments. Whereas, the lowest straw yield (1411.47 kg ha^{-1}) was recorded with the treatment T_1 (RDF).

Similar findings showed by Gahlot *et al.* (2020) [4] reported that the soil application of $ZnSO_4$ and $FeSO_4$ each @ 25 kg ha^{-1} along with foliar application of 0.5% $FeSO_4$ recorded significantly maximum straw yield in mungbean.

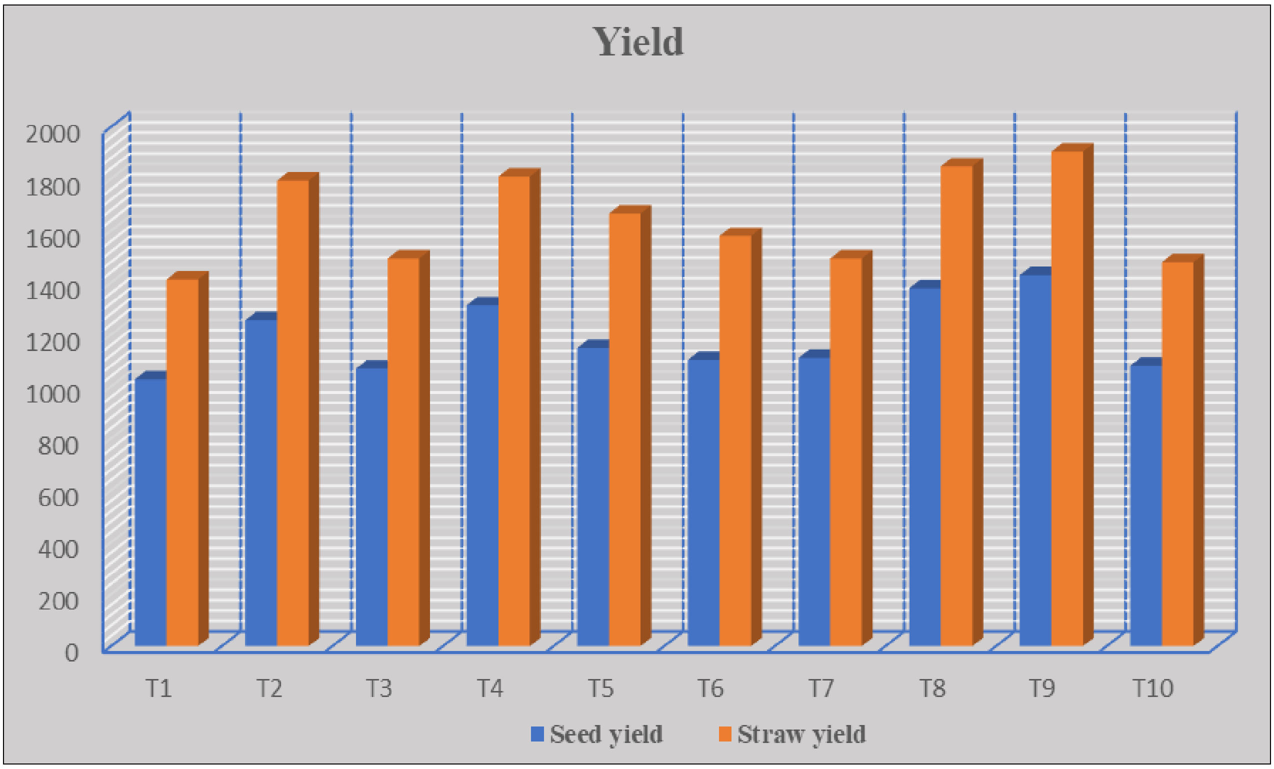

Fig 3: Effect of micronutrient application on seed yield and straw yield of green gram.

Conclusion
1. Green gram crop fertilized with the application of RDF + Soil application $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1} improves growth parameters like plant height, number of branches plant $^{-1}$, leaf area, dry matter content and number of root nodules.
2. Significantly seed yield ha^{-1} and straw yield ha^{-1} with the application of RDF + Soil application $FeSO_4$ + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1}.

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