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Effect of micro nutrient application in soybean grown on zinc, iron and boron deficient soil of Renapur tahsil, Latur

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Abstract
The field experiment was carried out on "Effect of Micro Nutrient Application in Soybean Grown on Zinc, Iron and Boron Deficient Soil of Renapur Tahsil, Latur" during *Kharif* season of year, 2023-24 at farmer's field having zinc, iron and boron deficient soils of shri. Prabhakar Ramrao Nagargoje R/O. Dawangaon Tal. Renapur Dist. Latur. The experiment was laidout in RBD with three replications and recommended variety of soybean KDS-753 as a test crop along with ten treatments.
The results indicated that the growth and yield were significantly influenced by application of micronutrient sources in soybean. The growth parameters *viz.*, plant height, number of branches, number of nodules, leaf area and dry matter yield were significantly increased with application of RDF + S.A. Grade-I @ 25 kgha^{-1} + F.A. Grade-II @ 0.5% at 30 and 45 DAS (T_4) but found at par with treatment T_2 (RDF + S.A. Grade-I micro-nutrient @ 25 kgha^{-1}) and T_9 (RDF + S. A. $FeSO_4$ @25 kg ha^{-1}+ $ZnSO_4$ @25 kg ha^{-1}+ Borax @10 kg ha^{-1}).
Significantly higher seed yield and straw yield were recorded with application of RDF + S.A. Grade-I @ 25 kgha^{-1} + F.A. Grade-II @ 0.5% at 30 and 45 DAS (T_4) and it was at par with treatment T_2 (RDF + S.A. Grade-I micro-nutrient @ 25 kgha^{-1}), T_9 (RDF + S. A. $FeSO_4$ @25 kg ha^{-1}+ $ZnSO_4$ @25 kg ha^{-1}+ Borax @10 kg ha^{-1}) and T_8 (RDF + S.A. $FeSO_4$ @ 25 kgha^{-1} + S.A. $ZnSO_4$ @ 25 kgha^{-1}).

Keywords: Soybean, borax, iron, zinc and boron deficient soil

Introduction
Glycine max (L.) is a self-pollinated crop belonging to the *Leguminoceae* family and subfamily *Papilionaceae* genus glycine. Normally, the plant is diploid, with 2n=40 Chromosomes. It is originated in China. Soybean is an important oil seed crop with a high protein content (40-42%), high lysine content and oil (20-22%) rich in vital fatty acids. It also contains isoflavones, which protect the human body from cancer, diabetes, osteoporosis, high blood pressure and heart disease, among other things. Soybean is the most common source of oil in the world and De Oiled Cake (DOC) is utilised in animal feed and as a food processing unit for new food product development. Because of its many uses, soybean is aptly referred to as the "Golden Bean" or "Miracle Crop" of the twentieth century. The growing demand for soya highlights the importance of locating and developing high-quality sources. Soybean protein is rich in valuable amino acid lysine (5%) which is deficient in most of the cereals. It also contains 60% polyunsaturated fatty acids (52.8% linolenic acid + 7.2% Linoleic acid). It has high caloric value releasing 432 calories from 100 gm edible protein as compared to 350 calories from cereals of same quantity. Soybean is an global crop that is known as poor man's meat.
Nutrient interaction is one of the component of balanced nutrition, apart from nitrogen and phosphorus, some of the secondary and micronutrients are considered necessary for increasing grain yield of Soybean. There is fairly good adoption and awareness among the farmers for the use of major nutrients but it is lacking for the use of micronutrients. It has been reported that Zn and Fe increases the unsaturated fatty acids (linoleic, linolenic, oleic) ratios, and decreases the saturated fatty acids (stearic, palmitic) ratios in soybean.
Micronutrients plays many complex roles in plant nutrition and plant production. While, most of the micronutrients participate in the functioning of enzyme systems, there is considerable

variation in the specific functions of the various micronutrients in plant and microbial growth processes. For example, copper, iron, and molybdenum are capable of acting as electron carriers in the enzyme systems that brings about oxidation-reduction reaction in plants. Such reactions are essential in photosynthesis and many other metabolic processes. Zinc and manganese function in many plants enzyme system as bridges to connect the enzyme with the substrate upon which it is meant to act. Micronutrient grade-I fertilizer contains iron, copper, manganese, boron and zinc which can be applied through soil and provide multinutrients to the crop. Grade-II fertilizer contains zinc, iron, boron, manganese, copper and molybdenum which can be used through foliar application and provide multi-micronutrients to crop for growth and development.

During last 3-4 years, it has been observed that the soybean crop in Renapur tahsil of Latur district showed symptoms as yellowing of younger leaves and stunted growth. Therefore, an experiment was proposed on Zn, Fe and B deficient soil with the aim to evaluate the effect of sources of micronutrients on growth, nodulation, uptake, yield and quality of soybean.

Materials and Methods

The present investigation entitled "Effect of micronutrient application in soybean grown on zinc, iron and boron deficient soil of Renapur Tahsil, Dist. Latur" was conducted during *kharif* season of the year 2023-2024. Experimental soil was Inceptisol with deep black in colour having pH (8.29), low in available nitrogen (152.34 kg ha^{-1}), low in available phosphorus (8.11 kg ha^{-1}), medium in available potassium (445 kg ha^{-1}) and field topography was uniform levelled, well drained and favorable for optimum crop growth. This data indicated that mean maximum temperature during crop growth period is 32.34 °C while the mean minimum temperature is 20.10 °C. The mean humidity during morning is 83.69% while mean humidity during evening is 34.09%.

The experiment was laid out in randomized block design with three replications and ten treatments. The treatment includes T_1 - RDF, T_2 - (RDF + S.A. Grade-I micro-nutrient @ 25 kg ha^{-1}), T_3 - (RDF + F.A. Grade-II micro-nutrient @ 0.5% at 30 and 45 DAS.), T_4 - (RDF + S.A. Grade-I @ 25 kg ha^{-1}+ F.A. Grade-II micro-nutrient @ 0.5% at 30 and 45 DAS.), T_5 - (RDF + S.A. FeSO4 @ 25 kg ha^{-1}), T_6 - (RDF + S.A. $ZnSO_4$ @ 25 kg ha^{-1}), T_7 - (RDF + S.A. Borax @ 10 kg ha^{-1}), T_8 - (RDF + S. A. $FeSO_4$ @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}), T_9 - (RDF + S. A. $FeSO_4$ @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @10 kg ha^{-1}), T_{10} - (RDF + F. A. $FeSO_4$ @ 0.5% + $ZnSO_4$ @ 0.5% + Borax @ 0.2% at 30 and 45 DAS.)

The plot size of each experimental unit was 4.05 m x 4 m. Sowing was done by drilling method on 07^{th} July 2023 at spacing of 45 x 5 cm. The recommended cultural practices and plant protection measures were undertaken. The recommended dose of fertilizer 30:60:30:20 kg N:P2O5:K2O:S ha^{-1} was applied as per treatments. The foliar application of Grade-II. The crop was harvested on 23^{th} October 2023.

Results and Discussion

Growth Parameters

Plant height

Table 1 and Figure 1 display the data that were periodically recorded during the crop growth phases, illustrating the effects of different treatments on plant height. The average plant height of soybean at harvest, it was found to be 93.2 cm, respectively. Plant height increased fastly between 30 and 60 DAS, after which it was increased at a slower rate. Based on the data shown in Table 1, it can be concluded that the plant height was increased gradually throughout the crop's growth stages until maturity. Due to the application of various nutrients through soil and foliar application, it was discovered that the effects of diverse treatments on soybean height were substantial. Application of RDF + S.A. Grade-I @ 25 $kgha^{-1}$+ F.A. Grade-II micro - nutrient @ 0.5% at 30 and 45 DAS (T_4) recorded significantly higher plant height of crop but it was at par with treatment (T_2) RDF + S.A. Grade-I micro-nutrient @25 $kgha^{-1}$, (T_9) RDF + S. A. $FeSO_4$ @ 25 $kgha^{-1}$+ $ZnSO_4$ @ 25 $kgha^{-1}$ + Borax @10 $kgha^{-1}$and (T_8) RDF + S. A. $FeSO_4$ @ 25 $kgha^{-1}$+ $ZnSO_4$ @ 25 $kgha^{-1}$. The treatment RDF (30 kg N: 60 kg P2O5: 30 kg K2O: 20 kg S ha^{-1}) *i.e.* (T_1) noticed significantly lowest plant height at harvest stage (80.4 cm) of soybean. Further individual application of micronutrient did not affect significantly on plant height of soybean.

The results are confirmative with the finding of Shinde *et al.* (2015) [1] and Chavan *et al* (2020) [2].

Number of branches

Branching is a crucial feature of crops that produces pods $plant^{-1}$ and ultimately increases crop yield. Table 1 and Figure 1 provide information on the impact of micronutrient sources on the mean number of branches per plant during the growth stages of soybean crop. The outcome made it evident that the effect of micronutrient sources had significant impact on the number of branches $plant^{-1}$ in soybeans. Treatment T_4 (RDF + S.A. Grade-I @ 25 $kgha^{-1}$ + F.A. Grade-II @ 0.5% at 30 and 45 DAS) produced significantly greater number of branches $plant^{-1}$ at harvest stage (17.8). However, it was at par with the treatments T_2 and T_9 harvest stage. Lowest number of branches $plant^{-1}$ were observed in control treatment T_1 (RDF) at harvesting (12.9). The substantial roles that iron and zinc play in balancing nutrient management along with recommended dose of fertilizer (RDF) may be the cause of the increase in branches $plant^{-1}$ in soybean.

The preceding findings are agreed with Singh *et al.* (2017) [3].

Number of nodulations at flowering

Table 1 and Figure 1 illustrate how the number of root nodules $plant^{-1}$ at the early flowering stage was impacted by the sources of micronutrients. Sources of micronutrients in soybeans considerably enhanced the number of nodules $plant^{-1}$.

The treatment T_4 (RDF + S.A. Grade-I @ 25 $kgha^{-1}$+ F.A. Grade-II @ 0.5% at 30 and 45 DAS) exhibited the greatest number of root nodules $plant^{-1}$ as compared to the other treatments at the flowering stage (44.7). Among the different treatments T_4, T_2 and T_9 were at par with each other. However, significantly lowest root nodules were observed in control treatment T_1 (33) then the all other treatment except T_{10} which was at par with it at flowering stage in soybean. Similar result was evaluated by Chavan *et al.* (2022) [2].

Leaf area

Use of micronutrient sources in soybean had a considerable impact on leaf area, as shown by the results in Table 2 and Fig. 2.

The results indicated that, in comparison to the other treatments, treatment T_4 (RDF + S.A. Grade-I @ 25 $kgha^{-1}$+ F.A. Grade-II @ 0.5% at 30 and 45 DAS) had the significantly highest leaf area, with values recorded at 60 DAS (1056.9 cm^2) DAS over rest of the treatment except T_2 and T_9. Treatment T_1 (control) on the other hand, had the significantly lowest leaf area, with value recorded at 60 DAS (739.4 cm^2) compared to the other treatments. Among the different treatment the result of T_2

followed by T_9. Similar result was evaluated obtained by Chavan *et al*. (2022) [2].

Dry matter Production

The information on soybean dry matter production is given in table 1 and depicted figure 1. The data on dry matter production grew gradually at 45 and 60 DAS, and the different treatments had a significant effect on the results.

The treatment T_4 (RDF + S.A. Grade-I @ 25 kgha^{-1} + F.A. Grade-II @ 0.5% at 30 and 45 DAS) produced the highest amount of dry matter at harvest (44.1 g plant^{-1}) stages, superior to the other treatments by a significant margin. However, at all growth stages treatment T_4 was at par to the treatments T_2 (RDF + S.A. Grade-I micro-nutrient @ 25 kgha^{-1}) and T_9 (RDF + S.A. $FeSO_4$ @ 25 kgha^{-1}+ $ZnSO_4$ @ 25 kgha^{-1}+ Borax @ 10 kgha^{-1}). Additional information revealed that the dry matter yield of treatment T_1 (control) was much lower at harvesting stage which were 35.5 g plant^{-1}.

Similar result was reported obtained by Chavan *et al*. (2022) [2].

Yield and yield attributes

Grain yield (kg ha-1)

The effects of various micronutrient sources on soybean grain yield are shown in Table 3 and Figure 3 Soybean seed yields were varied from 1838.1 kg ha^{-1} to 2876.2 kg ha^{-1} which were influenced by various treatments. T_4 (RDF + S.A. Grade-I @ 25 kgha^{-1} + F.A. Grade-II micro-nutrient @ 0.5% at 30 and 45 DAS) treatment produced significantly highest seed yield (2876.2 kg ha^{-1}), which was at par and comparable to T_2 (RDF + S.A. Grade-I micro-nutrient @ 25 kgha^{-1}) (2807.9 kg ha^{-1}), T_9 (RDF + S. A. $FeSO_4$ @ 25 kgha^{-1} + $ZnSO_4$ @ 25 kgha^{-1} + Borax @ 10 kgha^{-1}) (2779.4 kg ha^{-1}) and T_8 (RDF + S. A. $FeSO_4$ @ 25 kgha^{-1} + $ZnSO_4$ @ 25 kgha^{-1}) (2720.9 kg ha^{-1}). The treatment T_5, T_6 and T_7 were found at par with each other. On the other hand, treatment T_1 (RDF) had the lowest measured seed yield (1838.1 kg ha^{-1}) over the rest of the treatments except T_7.

These results are in line with the results reported by Kumbhar *et al*. (2018) [4] and Chavan *et al*. (2022). [2]

Straw yield (kg ha^{-1})

Data on soybean straw yield as affected by zinc, iron and boron applications are shown in table 3 and illustrated in fig. 3.

The straw yield of soybean ranged between 1823.4 kg ha^{-1} to 2838.5 kg ha^{-1}. Significantly highest straw yield (2838.5 kg ha^{-1}) was recorded in treatment T_4 (RDF + S.A. Grade-I @ 25 kg ha^{-1} + F.A. Grade-II micro nutrient @ 0.5% at 30 and 45 DAS) which was at par with treatment T_2 (RDF + S.A. Grade-I micro-nutrient @ 25 kg ha^{-1}) (2688.6 kg ha^{-1}) and T_9 (RDF + S. A. $FeSO_4$ @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @10 kg ha^{-1}) (2650.6 kg ha^{-1}) and T_8 (RDF + S. A. $FeSO_4$ @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}) (2555.7 kg ha^{-1}). However, treatment T_1 (RDF) had the lowest straw yield (1823.4 kg ha^{-1}). The increase in yield may be the result of micronutrients working together to boost growth-contributing characteristics like dry matter content and leaf count, which are clearly seen in the final product or straw yield ha^{-1}.

The results explained above are in close conformity with the findings of Raghuwanshi *et al*. (2017) [5] and Dikey *et al*. (2019) [6].

Table 1: Effect of micronutrient application on growth attributes at harvest stage of soybean.

Treatments	Plant height (cm)	No. of branches (plant^{-1})	Root nodules	Dry matter
T_1: RDF (Control)	80.4	12.9	33	35.5
T_2: RDF + S.A. Grade-I micro - nutrient @ 25 kg ha^{-1}.	92.9	17.1	44.1	43.4
T_3: RDF + F.A. Grade-II micro - nutrient @ 0.5% at 30 and 45 DAS.	87.2	14.4	37.6	39.9
T_4: RDF + S.A. Grade-I @ 25 kg/ha + F.A. Grade-II micro - nutrient @ 0.5% at 30 and 45 DAS	93.2	17.8	44.7	44.1
T_5: RDF + S.A. $FeSO_4$ @ 25 kg ha^{-1}	91.8	15.5	40.6	42.8
T_6: RDF + S.A. $ZnSO_4$ @ 25 kg ha^{-1}	91.7	15.1	39	42.2
T_7: RDF + S.A. Borax @ 10kg ha^{-1}	91.5	14.7	38.3	40.7
T_8: RDF + S. A. $FeSO_4$ @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}.	92.2	16.3	40.8	42.8
T_9: RDF + S. A. $FeSO_4$ @ 25 kg ha^{-1} $ZnSO_4$ @ 25 kg ha^{-1}+ Borax @10 kg ha^{-1}.	92.3	16.8	43.6	43.4
T_{10}: RDF + F. A. $FeSO_4$ @ 0.5% + $ZnSO_4$ @ 0.5% + Borax @ 0.2% at 30 and 45 DAS.	86.6	14.3	36.5	39.8
SE±	0.45	0.48	1.2	0.3
CD at 5%	1.36	1.41	3.5	0.9

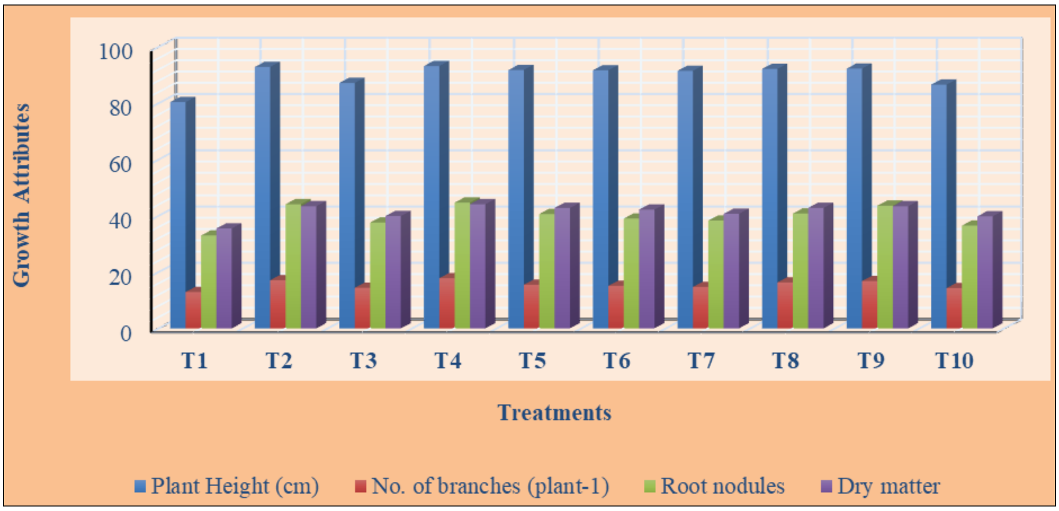

Fig 1: Effect of micronutrient sources on Growth Attributes of soybean

Table 2: Effect of micronutrient application on leaf area (cm^2 $Plant^{-1}$) of soybean.

Treatments	Leaf area
T_1: RDF (Control)	739.4
T_2: RDF + S.A. Grade-I micro-nutrient @ 25 kg ha^{-1}	1053.1
T_3: RDF + F.A. Grade-II micro-nutrient @ 0.5% at 30 and 45 DAS.	861.2
T_4: RDF + S.A. Grade-I @ 25 kg ha^{-1} + F.A. Grade-II micro nutrient @ 0.5% at 30 and 45 DAS	1056.9
T_5: RDF + S.A. $FeSO_4$ @ 25 kg ha^{-1}	979.8
T_6: RDF + S.A. $ZnSO_4$ @ 25 kg ha^{-1}	893.4
T_7: RDF + S.A. Borax @ 10 kg ha^{-1}	865.5
T_8: RDF + S. A. $FeSO_4$ @ 25 kg ha^{-1}+ $ZnSO_4$ @ 25 kg ha^{-1}	998.6
T_9: RDF + S. A. $FeSO_4$ @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}+ Borax @10 kg ha^{-1}.	1052.1
T_{10}: RDF + F. A. $FeSO_4$ @ 0.5% + $ZnSO_4$ @ 0.5% + Borax @ 0.2% at 30 and 45 DAS.	855.1
SE±	14.7
CD at 5%	43.6

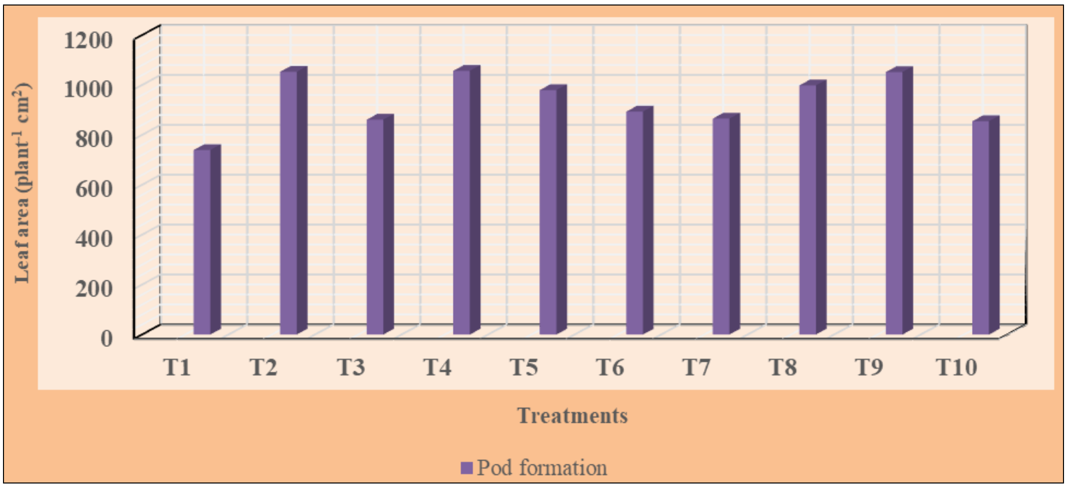

Fig 2: Effect of micronutrient sources on leaf area of soybean.

Table 3: Effect of micronutrient application on grain and straw yield of soybean.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1: RDF (Control)	1838.1	1823.4
T_2: RDF + S.A. Grade-I micro-nutrient @ 25 kg ha^{-1}.	2807.9	2688.6
T_3: RDF + F.A. Grade-II micro-nutrient @ 0.5% at 30 and 45 DAS.	2084	2112.5
T_4: RDF + S.A. Grade-I @ 25 kg ha^{-1}+ F.A. Grade-II micro nutrient @ 0.5% at 30 and 45 DAS	2876.2	2838.5
T_5: RDF + S.A. $FeSO_4$ @ 25 kg ha^{-1}	2427	2458.4
T_6: RDF + S.A. $ZnSO_4$ @ 25 kg ha^{-1}	2308.7	2272.9
T_7: RDF + S.A. Borax @ 10 kg ha^{-1}	2145.4	2201.1
T_8: RDF + S. A. $FeSO_4$ @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}	2720.9	2555.7
T_9: RDF + S. A. $FeSO_4$ @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}+ Borax @10 kg ha^{-1}	2779.4	2650.6
T_{10}: RDF + F. A. $FeSO_4$ @ 0.5% + $ZnSO_4$ @ 0.5% + Borax @ 0.2% at 30 and 45 DAS.	1956.3	2019.6
SE±	123.8	121.4
CD at 5%	367.8	360.8

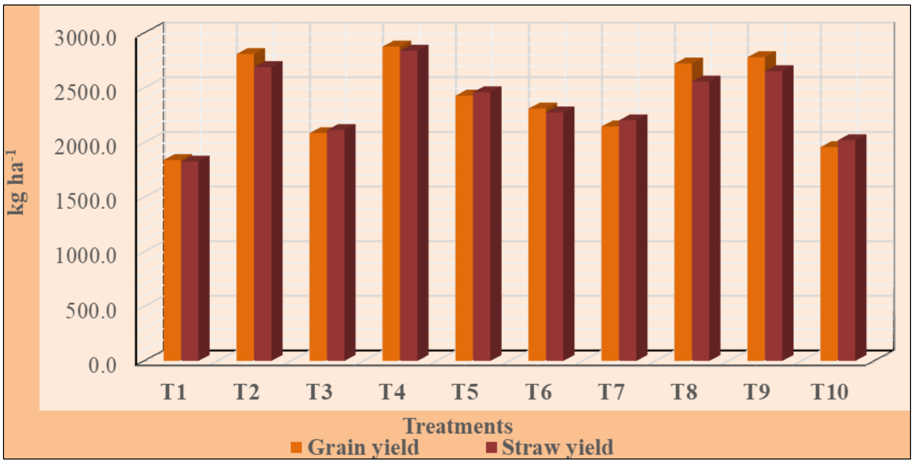

Fig 3: Effect of micronutrient sources on grain yield and straw yield of soybean

Conclusion

1. Application of RDF + S.A. Grade-I @ 25 kgha^{-1} + F.A. Grade-II @ 0.5% at 30 and 45 DAS (T_4) recorded significantly higher plant height (93.2 cm), number of branches plant^{-1} (17.8), nodulation (44.7), leaf area (1056.9 cm^2 plant^{-1}) and dry matter content (44.10 g), and in zinc, iron and boron deficient soil over rest of the treatments in soybean.
2. Significantly maximum seed yield (2876.2 kg ha^{-1}) and straw yield (2838.5 kg ha^{-1}) of soybean was observed due to application of RDF + S.A. Grade-I @ 25 kgha^{-1} + F.A. Grade-II @ 0.5% at 30 and 45 DAS (T_4) than the other treatments. But it was at par with the treatments T_2 (RDF + S.A. Grade-I micro-nutrient @ kgha^{-1}), T_9 (RDF + S. A. $FeSO_4$ @ 25 kgha^{-1} + $ZnSO_4$ @ 25 kgha^{-1} + Borax @10kg/ha) and T_8 (RDF + S. A. $FeSO_4$ @ 25 kgha^{-1} + $ZnSO_4$ @ 25 kgha^{-1}). The lowest seed yield (1838.1 kg ha^{-1}) and straw yield (1823.4 kg ha^{-1}) were recorded with treatment T_1(control)

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