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Original Research Article

Study on Growth and Yield of Soybean (*Glycine max* L.) Crop as Influenced by Micronutrient Application

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Soybean, Micronutrient, Growth and Yield

A B S T R A C T

The field investigation entitled "Effect of micronutrient application on growth, yield of soybean (*Glycine max* L.)" was conducted at experimental farm, Department of Agronomy, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2014.The experiment was laid out in a Randomized block design with twelve treatments and 3 replications. Application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} recorded significantly higher growth attributes, yield attributes, seed yield contributing characters followed by application of RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3 (35&60DAS) (T_5) and T_5 was significantly superior over the rest of the all treatments. The significantly lower growth attributes, yield attributes and seed yield of soybean was observed in 75 % RDF (T_7).

Introduction

Soybean, a wonder legume has high nutritive value and has manifold uses in Agriculture, medicine and industrial sector. Soybean (*Glycine max* L.) belongs to family Leguminoaceae. It is originated in China and was introduced in India in 1985. It is economically profitable as compared to cereals and other oilseed crops. It is highly remunerative crop with comparatively less input demand. Due to its short duration (85 to 95 days) fits well as an intercrop and photo insensitiveness of crops made it as suitable crop in double cropping system. Being a leguminous crop, capable of fixing atmospheric nitrogen to an extent of 65 to 100 kg ha^{-1} and help to improve the soil fertility. Nutrient interaction is one of the components of balanced nutrition, apart from nitrogen, phosphorus and some of the secondary and micronutrients are considered necessary for increase in seed yield of soybean. Among which, imbalanced nutrition especially, the micronutrient play a special role in improving the productivity of the crop. 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. Farmers are also in confusion about method of application of micronutrients.

In case of Marathwada region more than 35% soils were found deficient in sulphur, 27% in zinc and therefore it has become necessary to address this situation. Generally farmers do not pay attention unless and until they come across some deficiency symptoms in respect of micronutrients deficiency. Also there is no regular habit of soil testing among farmers. Again there are various ways to add nutrients like soil application and foliar application etc. Therefore, it has become the great need of time to suggest the most efficient and economical source of application of micronutrients for the crop like soybean.

Materials and Methods

The experiment was conducted during *kharif*, 2014 at Experimental Farm, Department of Agronomy, College of Agriculture, VNMKV, Parbhani. The topography of experimental field was uniform and levelled. The results of the soil revealed that the soil of the experimental plot was clayey in texture, low in available nitrogen (219.75), medium in available phosphorus (18.73), high in available potassium (612.76) and slightly alkaline in reaction. The temperature data revealed that thermal condition of crop environment during crop life were within physiological cardinal limits. In general, maximum temperature ranged between 40.2^0C and 31.3^0C and minimum temperature ranged between 25.7^0C and 13.9^0C. The total precipitation received during crop period was only 414.7 mm with 30 rainy days.

The crop was sown at 45cm x 05cm spacing. The net plot size 4.8 x 3.6 m2.The recommended dose (RDF) 30N: 60P: 30K kgha^{-1} was applied as basal dose. The treatment were laid out in RBD in three replications with twelve treatments viz., T_1: RDF(30:60:30kgha^{-1}); T_2: RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1}; T_3: RDF + soil application of $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1}; T_4: RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax (35 & 60 DAS); T_5: RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3 (35 & 60 DAS); T_6: RDF + foliar application of 1.0% KNO_3 (35 & 60 DAS); T_7:75% RDF; T_8:75% RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1}; T_9:75% RDF + soil application of $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1}; T_{10}:75% RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax (35 & 60 DAS); T_{11}:75% RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3(35 & 60 DAS) and T_{12}:75% RDF + foliar application of 1.0% KNO_3 (35 & 60 DAS).

The observation like Plant height (cm) Number of branches area plant^{-1}, Number of functional leaves area plant^{-1}, Leaf area plant^{-1} (dm^2), Total dry matter plant^{-1} (g), Number of pods plant-1,Weight of pods plant-1 (g), Weight of seed plant^{-1} (g), Number of seed plant^{-1},Seed yield (kg ha^{-1}), Straw yield (kg ha^{-1}), Biological yield (kg ha^{-1}), Test weight (g) were recorded at 30,45,60,75 DAS and at harvest.

Results and Discussion

Plant height (cm)

The application of RDF + soil application of S @ 17 kg ha-1 + FeSO4 @ 20 kg ha-1 + ZnSO4 @ 20 kg ha-1 + Borax @ 05 kg ha-1 (T2) produced more vegetative growth in early period of crop growth. It was observed from the data that the height was found to be increased progressively at every stage of crop growth. The increase in height was rapid during 30-60 DAS and thereafter it increased marginally till maturity. The effect of different treatments on plant height was found to be significant and the higher plant height was recorded by the application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T2) (38.10 cm) as compared to other treatments. It was followed by T5 RDF+ foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3 (35 & 60 DAS).

The increase in growth attributes may be due to better translocation of plant nutrients to growing plants. The balanced nutrition for crop since its early growth stage upto maturity may have favoured growth and development as a strong base for further reproductive and growth final output in term of yield. Similar kind of observations was recorded by Nagaraja and Mohankumar (2010) and Kobraee *et al.,* (2011).

Number of branches area plant^{-1}

Number of branches $plant^{-1}$ it was revealed that the number of branches $plant^{-1}$ increased up to 75 DAS and remained constant at harvest. The rate of increase was high up to 30-60 days, moderate from 60-75 days and remained same thereafter at harvest. Mean significantly higher number of branches were influenced significantly by various treatments under study and application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2) recorded maximum number of branches than the application of 75% recommended dose of fertilizer ha^{-1} and no application of S, Zn, Fe and B. The overall favoured growth might have supported for more number of branches in given treatment. Results were in confirmedly with Dash *et al.,* (2005).

Number of functional leaves plant^{-1}

Number of trifoliate functional leaves $plant^{-1}$ and leaf area per plant revealed that these increased rapidly up to 45 DAS and between 45-60 DAS and decreased thereafter towards maturity due to senescence of leaves.

The application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2) recorded higher mean number of functional leaves $plant^{-1}$ (20.78) and leaf area $plant^{-1}$ (8.41 dm^2) and it was at par with the application of RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3 (35&60DAS) (T_5) at every stage of the crop growth. The balanced nutrition i.e. major nutrients (NPK) along with micronutrients like S, Fe, Zn, and B favoured the crop growth and created base for more chlorophyll formation and enhancement of enzymatic activities.

Thus the application of micronutrient *viz*., S, Zn, Fe and B resulted in increased growth rate which might have contributed towards more photosynthesis which in turn promoted more number of leaves and leaf area. Nagaraja and Mohankumar (2010) also reported similar increased growth parameter and overall increased growth rate.

Leaf area plant^{-1} (dm^2)

The mean leaf area index was low at initial stage of crop growth and it was highest at 60 DAS (4.10) and thereafter it decreased towards maturity of crop due to senescence. The application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2) recorded highest mean leaf area index (4.78) at 60 DAS as compared to the rest of the t favoured growth of the crop in terms of number of leaves and leaf area.

Table.1 Growth attributing characters as influenced by micronutrient treatments

Treatments		Growth attributes					
		Plant height (cm) At harvest	Number of branches area plant^{-1} At 75 DAS	Number of functional leaves area plant^{-1} At 75DAS	Leaf area plant^{-1} (dm^2) At 75 DAS	Total dry matter plant^{-1} (g) At harvest	Number of pods plant-1
T_1	RDF (30:60:30 kg ha^{-1})	30.25	4.86	17.00	7.09	14.30	20.42
T_2	RDF + soil application of S + $FeSO_4$+ $ZnSO_4$ + Borax	38.10	6.18	20.78	8.41	17.87	30.49
T_3	RDF + soil application of $FeSO_4$ + $ZnSO_4$ + Borax	31.76	5.13	17.15	7.36	15.07	24.93
T_4	RDF + foliar application of $FeSO_4$ + $ZnSO_4$ + Borax (35 & 60 DAS)	30.88	5.09	17.10	7.32	14.99	24.67
T_5	RDF + foliar application of $FeSO_4$ + $ZnSO_4$ + Borax + KNO_3 (35 & 60 DAS)	36.57	6.10	20.20	8.33	17.77	29.58
T_6	RDF + foliar application of KNO_3 (35 & 60 DAS)	30.58	5.06	17.05	7.29	14.42	21.20
T_7	75% RDF	24.46	4.20	14.86	5.93	11.19	18.73
T_8	75% RDF + soil application of S + $FeSO_4$ + $ZnSO_4$ + Borax	29.30	4.72	16.21	6.95	13.88	20.61
T_9	75% RDF + soil application of $FeSO_4$+ $ZnSO_4$ + Borax	28.36	4.61	15.50	6.58	13.61	19.31
T_{10}	75% RDF + foliar application of $FeSO_4$ + $ZnSO_4$ + Borax (35 & 60 DAS)	28.20	4.53	15.45	6.53	13.57	19.09
T_{11}	75% RDF + foliar application of $FeSO_4$ + $ZnSO_4$+ Borax + KNO_3 (35 & 60 DAS)	29.09	4.67	15.65	6.90	13.73	20.35
T_{12}	75% RDF+ foliar application of KNO_3 (35 & 60 DAS)	28.11	4.28	15.35	6.44	13.48	18.93
S.Em$\pm$		**1.30**	**0.32**	**0.69**	**0.32**	**0.87**	**1.23**
C.D. at 5%		**3.90**	**0.96**	**2.07**	**0.93**	**2.60**	**3.66**
General mean		**30.47**	**4.95**	**16.86**	**7.10**	**14.49**	**22.36**

Table.2 Yield attributing characters as influenced by micronutrient treatments

Treatments		Yield attributes						
		Weight of pods plant-1 (g)	Weight of seed plant^{-1} (g)	Number of seed plant^{-1}	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Test weight (g)
T_1	RDF (30:60:30 kg ha^{-1})	6.04	3.37	42.26	1126	1918	3044	79.65
T_2	RDF + soil application of S + $FeSO_4$+ $ZnSO_4$ + Borax	7.60	5.30	65.45	1362	2190	3553	80.91
T_3	RDF + soil application of $FeSO_4$ + $ZnSO_4$ + Borax	6.15	4.23	52.42	1154	1947	3101	80.75
T_4	RDF + foliar application of $FeSO_4$ + $ZnSO_4$ + Borax (35 & 60 DAS)	6.12	4.14	51.48	1148	1940	3089	80.49
T_5	RDF + foliar application of $FeSO_4$ + $ZnSO_4$ + Borax + KNO_3 (35 & 60 DAS)	7.40	5.05	62.51	1351	2176	3527	80.85
T_6	RDF + foliar application of KNO_3 (35 & 60 DAS)	6.06	3.54	44.19	1132	1925	3057	79.93
T_7	75% RDF	5.21	2.96	37.34	961	1691	2652	79.24
T_8	75% RDF + soil application of S + $FeSO_4$ + $ZnSO_4$ + Borax	6.02	3.34	42.31	1090	1863	2954	79.61
T_9	75% RDF + soil application of $FeSO_4$+ $ZnSO_4$ + Borax	5.54	3.11	39.04	1011	1735	2746	79.57
T_{10}	75% RDF + foliar application of $FeSO_4$ + $ZnSO_4$ + Borax (35 & 60 DAS)	5.45	3.06	38.51	988	1705	2693	79.55
T_{11}	75% RDF + foliar application of $FeSO_4$ + $ZnSO_4$+ Borax + KNO_3 (35 & 60 DAS)	6.01	3.32	41.79	1068	1833	2902	79.59
T_{12}	75% RDF+ foliar application of KNO_3 (35 & 60 DAS)	5.27	3.02	38.04	983	1697	2680	79.35
S.Em$\pm$		**0.42**	**0.20**	**2.52**	**65.28**	**69.19**	**114.85**	**0.42**
C.D. at 5%		**1.23**	**0.58**	**7.52**	**193.84**	**203.93**	**336.86**	**NS**
General mean		**6.07**	**3.70**	**46.28**	**1115**	**1885**	**3000**	**79.96**

Total dry matter plant^{-1} (g)

Total dry matter accumulation plant^{-1}(g) was found to be increased continuously with advancement in the age of the crop till harvest. The rate of increase in dry matter accumulation was faster between 30 to 75 DAS and thereafter it increased with till decreasing rate at harvest stage. The application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2) recorded the higher dry matter accumulation at harvest (17.87 g) along with the application of RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3 (35&60DAS) (T_5)(17.77 g). The least dry matter plant^{-1} was recorded by the application of 75% recommended dose of fertilizer ha^{-1} (11.19 g) at all the crop growth stages. It may be due to better utilization of available resources with combination of S, Zn, Fe and B as soil application which resulted in more photosynthesis and hence more dry matter was produced. Similar kinds of results were reported by Mondal and Poi (2006).

Number of pods plant^{-1}

It was observed from the data on mean number of pods plant^{-1} increased progressively from 60 days onwards till maturity. The application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2) recorded higher mean number of pods per plant (30.49) but it was at par with the application of RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3 (35&60DAS) (T_5) (29.58). The balanced and timely nutrient favoured crop growth and provided base for overall development of the crop plants. More over these nutrients played significant role in efficient translocation of nutrients prepared food. The increase in number of pods plant^{-1} might be due to translocated reproductive parts and ultimately resulted in improving the number of pods. Results were confirmedly in conforming with Shirpurkar *et al.*, (2006).

Weight of pods plant^{-1} (g)

The mean weight of pod plant^{-1} (g) was significantly influenced by the various treatments. The application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2) recorded significantly higher dry weight of pod plant^{-1} (g) (7.60 g). More pod yield due to application of S, Zn, Fe and B soil application may be reatments. This might be due to cumulative effect of due to more growth and photosynthates which resulted in better translocation of photosynthates and filling of pod hence more pod yield (g) plant^{-1} was obtained. Beneficial effect of sulphur, zinc, iron and Boron on pod yield was also reported by Kobraee *et al.*, (2011) and Gupta *et al.*, (2003).

Weight of seed plant^{-1} (g)

The effect of different treatments on mean weight of seed plant^{-1} (g) was found to be significant. The application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2)recorded significantly higher mean weight of seed plant^{-1} (g) (5.30 g plant^{-1}) but it was at par with the application of RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3 (35&60DAS) (T_5) (5.05 g plant^{-1}). The growth parameters like plant height, number of leaves, have shown the similar trend of response for application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2). Moreover due to micronutrients there may be promotion of growth hormones in reproduction processes and enzymes leading to grain formation due to element like zinc and increased amino acids, proteins and N-uptake due to element like S. Thus treatment might have provided more S, Zn, Fe and B nutrient resulted in increased number of grains by the plant consequently favored yield contributing characters Shirpurkar *et al.,* (2006) also reported similar results.

Number of seed plant^{-1}

The effect of different treatments on mean number of seeds plant^{-1} was found to be significant. The application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2)recorded significantly higher mean number of seeds plant^{-1} (65.45) followed by the application of RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3 (35&60DAS) (T_5) (62.51). More number of seeds plant^{-1} was due to better growth of plant and pod bearing capacity which was enhanced due to different element applied through treatments (Table 1).

Seed yield (kg ha^{-1})

Seed yield Kg ha^{-1} as influenced by different treatments was found to be significant. The application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2) recorded significantly higher mean seed yield (1362 Kg ha^{-1}) and it was at par with the application of RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3 (35&60DAS) (T_5)(1351 Kg ha^{-1}). This might be because of the cumulative effect in favouring growth contributing characters, increase in number of pods plant^{-1} and number of seeds plant^{-1} which have been clearly exhibited on the final produce i.e. seed and straw yield ha^{-1}. The efficient transfer of photosynthates from sources to sink are majorly governed by various micronutrient and therefore all together resulted in higher seed yield of soybean due to micronutrient application.

Straw yield (kg ha^{-1})

Straw yield kg ha^{-1} as influenced by different treatments was found to be significant. The application of RDF + soil application of S @ 17 kg ha^{-1} + $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2) recorded significantly higher mean straw yield (2190 Kg ha^{-1}) but it was at par with the application of RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3 (35&60DAS) (T_5) (2176 Kg ha^{-1}).

Biological yield (kg ha^{-1})

Data on biological yield kg ha^{-1} as influenced by different treatments was found to be significant. The application of RDF + soil application of S @ 17 kg ha^{-1}+ $FeSO_4$ @ 20 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 05 kg ha^{-1} (T_2) recorded significantly higher mean biological yield (3553 Kg ha^{-1}) followed by the application of RDF + foliar application of 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ + 0.2% Borax + 1.0% KNO_3 (35&60DAS) (T_5), (3527 Kg ha^{-1}). Least biological yield was recorded in 75% RDF where S, Zn, Fe and B were not applied. Beneficial effect of sulphur, zinc, iron and Boron on biological yield was also reported by Adkine *et al.*, (2011) and Vaiyapuri *et al.*, (2010) observed similar results (Table 2).

Test weight (g)

The effect of different treatments on means Test weight (1000 seeds) was found to be non-significant. Since seed index is genetically controlled factor, hence the micronutrient applies fraction to include it significantly. Results are in confirming with Gupta *et al.*, (2003).

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