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Effect of foliar spray of zinc, iron and seed priming with molybdenum on growth and yield attributes and quality of soybean in the rainfed condition of Vertisol

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Abstract
Field experiment was conducted to assess the effect of micronutrients on growth traits, yield and quality of soybean grown under rainfed condition of North Maharashtra at Agricultural Research Station, College of Agriculture, Dhule in 2012-2013. The experiment was laid out in randomized block design with nine treatments and three replications viz. T_1: Control (RDF 50:75:00), T_2: Water spray, T_3: $FeSO_4$ spray (0.5%), T_4: $ZnSO_4$ spray (0.5%), T_5: Seed fortification with Mo, T_6:$FeSO_4$ spray (0.5%) + $ZnSO_4$ spray (0.5%), T_7: $FeSO_4$ spray (0.5%) + Mo, T_8:$ZnSO_4$ spray (0.5%)+ Mo and T_9:$FeSO_4$ spray (0.5%) + $ZnSO_4$ spray (0.5%)+Mo. The result revealed that the highest number of branches (16.83 plant^{-1}) observed in the treatment receiving combined application of zinc and iron with seed fortification of molybdenum. The higher number of (44.66) nodules was recorded in treatment seed fortification of molybdenum. The higher values of chlorophyll content at 20 DAS (19.90 mg 100 g^{-1}), 60 DAS (18.14 mg 100 g^{-1}) and 80 DAS (10.14 mg 100 g^{-1}) of soybean was recorded with T_9 (foliar application of zinc and iron with seed fortification of molybdenum). However, the higher chlorophyll content at 40 DAS (28.06 mg 100 g^{-1}) of soybean was observed under treatment T_6 receiving foliar application of zinc and iron. The highest grain (22.65 q ha^{-1}) and straw yield (19.66 q ha^{-1}) were observed in T_6 which receives foliar spray of zinc and iron. The lowest grain (16.62 q ha^{-1}) and straw (11.18 q ha^{-1}) yield were recorded in T_1 (control). Application of zinc and iron with molybdenum significantly increased oil (21.20%) and protein (42.99%) content of soybean while, the lowest oil (18.20%) and protein (40.76%) content were recorded (18.20%) in treatment control.

Keywords: Zinc, iron, molybdenum, foliar application, seed priming

Introduction

In India soybean occupies an area of 9.3 million hectares with total annual production of 101.28 lakh MT with productivity of 10.89 q ha^{-1}. In Maharashtra, the area under this crop is about 2.6 million hectares with annual production of 27.54 lakh MT with the productivity 10.58 q ha^{-1}. (Anonymous, 2010) [1].

One of the limiting factors for low yield was found to be imbalance and indiscriminate use of fertilizers and emergence of micronutrients deficiencies. The increasing cost of fertilizer nutrients have leaded to search for alternative practices of managing the fertilizer nutrients more judiciously, efficiently and in balance proportions. Such approach would reduce the depletion of macro and micronutrients from soil. Among the nutrients, macro-nutrients have been given the priority and little attention has been towards micronutrients. In the absence of micronutrients, plant shows physiological disorders which eventually lead to low crop yield and fair quality. Foliar spraying is a new method for crop feeding in which micronutrients in the form of liquid are used into leaves (Nasiri *et al.*, 2010) [1]. Foliar application of micronutrient is more beneficial than soil application. Since, application rates are lesser as compared to soil application, same quantity of nutrient application could be supplied easily and crop reacts to nutrient application immediately. Undoubtedly higher yield and quality especially oil will be obtained by micronutrient foliar spraying. Foliar spraying of micronutrient is very helpful when the roots cannot provide necessary nutrients. Moreover, soil pollution would be a major problem by soil application of micronutrients. As people are concerned about the environment and uptake nutrients through plant leaves is better than soil application, foliar spraying was advised (Bozorgi *et al.*, 2011) [3].

Crop roots are unable to absorb some important nutrients such as zinc, because of soil properties, such as high pH, lime or heavy texture, and in this situation, foliar spraying is better as compared to soil application. It has been found that micronutrient foliar application is in the same level and even more influential as compared to soil application. It was suggested that micronutrients could be applied successfully to compensate shortage of those elements. Foliar spraying could be effective 6 to 20 times as compared to soil application. Resistance to different stresses will be increased by foliar application of micronutrients. Since, in field situation, soil features and environmental factors which affect nutrients absorption are extremely changeable, foliar application could be an advantage for crop growth. Also, effectiveness of foliar spraying is higher and the cost of foliar application is lower as compared to soil application.

Materials and Methods

The experiment was conducted in 2012 at Agriculture Research Station, College of Agriculture, Dhule. Experiment was conducted to asses the effect of different micronutrient application on yield, nutrient uptake and quality of soybean. The experiment was laid out in Randomized Block Design with nine treatments replicated thrice, each treatment consisted of 10 rows (4 meters long) with row to row spacing of 30 cm. The soil had pH=7.9 and EC 0.38 ds m-1 and clayey texture. NPK fertilizer application (50:75:00) and other agronomic practices were carried out uniformly according to the recommendations in all the treatments. Seed fortification of molybdenum @ 0.66 g kg-1(Source: Sodium molybdate) at the time of sowing and foliar application of ZnSO4 (0.5%) and FeSO4 (0.5%) at 30, 50, 70 DAS was given. At harvest time, soybean plants were collected from each plots and the grain and straw yield, uptake of nutrients and oil and protein percentage were estimated. The nutrient (N, P and K) and micronutrient (Fe, Zn and Mo) uptake at harvest was calculated by multiplying its per cent concentration with dry matter. Total nitrogen content in plant and grain was determined using the digestion method described by Parkinson and Allen (1975) [12]. Protein content was estimated by multiplying N content with 5.71. Oil content in soybean seed was estimated by using Soxhlet ether extraction method (Ranganna, 1994) [14]. Petroleum ether was used as extractant. Whereas, total Zn and Fe were determined by DTPA extraction method (Lindsay and Norvell, 1978) [7] and total Mo was determined by spectrophotometric method as described by Purvis and Peterson (1956) [13].

Result and Discussion

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

Growth Attributes

Number of branches

The highest number of branches (16.83 plant^{-1}) observed in the treatment receiving combined application of zinc, iron and molybdenum (T_9). This was at par with T_6, T_7 and T_8 respectively. The lowest branch (10.43 plant^{-1}) was recorded in control and was at par with T_2, T_3, T_4 and T_5 as shown in Fig 1. The branching in soybean was increased due to combined application of Fe, Zn and Mo compared with their individual application.

It might be due to the deficiency of Zn and Fe in soil and interaction effect of Fe and Zn with or without molybdenum on metabolic activities like synthesis of IAA, metabolism of auxins and synthesis of nitrate reductase enzyme in the leguminous crop of soybean. Similar nature of observations was also recorded by Ravi *et al.* (2008) [15] for mustard with application of S (soil), Fe and Zn (Foliar).

Number of nodules

The significantly highest number of nodules (44.66) were recorded in treatment T_5. which received molybdenum and was at par with T_9 and T_6? The lowest number of nodules found in T_1 (control) which receives RDF alone and it was at par with T_2 T_3, T_4 and T_7 as shown in Fig. 2. It might be due to role of Mo for improving nitrogen fixation symbiotically in legumes and in the roots of non-legumes when improved the nodule number plant^{-1}. These results confirmed with findings of Togay *et al.* (2008) [16].

Chlorophyll content

The effect of various treatments on chlorophyll content of leaf were recorded at 20, 40, 60 and 80 DAS of soybean and results are depicted in Table 2. The result indicates that in general, the higher amount of chlorophyll was recorded at 40 DAS compared to 20 DAS, 60 DAS and 80 DAS indicating gradual decline in chlorophyll content at 80 DAS. The higher amount of chlorophyll content at all stages was recorded in treatment T9 receiving zinc, iron and molybdenum. The chlorophyll content at 40 DAS ranged from 15.8 to 28.0 mg 100 g-1. The highest amount of chlorophyll was recorded (28.0 mg 100 g-1) in treatment T9 receiving foliar application of zinc and iron with seed fortification of molybdenum. The chlorophyll content at 80 DAS ranged from 6.43 to 10.14 mg 100 g-^{1} and found lower as compared to other stages. The results indicate that the higher value of chlorophyll content was also noted in T6 receiving foliar application of iron and zinc. It may be due to zinc and iron take part in chlorophyll synthesis and imparts dark green color to the plants. Similar results were found by Babaein *et al*. (2011) [2] and in sunflower crop and Galavi *et al*. (2011) [5] in safflower with application of iron and zinc.

Yield of Soybean

Grain yield: Data depicted in Fig. 3. that significant differences between increases in grain yield were observed. The highest grain yield was observed (22.66 q ha^{-1}) in T_6 which receives foliar spray of zinc and iron in combination. Treatment T_6 was at par with T_9, T_7, T_8 and T_3 and superior over rest of the treatment. The lowest grain yield was observed in control (16.62 q ha^{-1}).

This result might be due to enhancement of enzymatic activity in microelement which effectively increased photosynthesis and ultimately translocation of assimilates to the seed. The available soil zinc and iron status (0.4 mg Zn kg^{-1}) and (1.2 mg Fe kg^{-1}) is below critical level, hence there is significant response in terms of grain yield observed in the treatment received zinc and iron. Similar results found by Ravi *et al.* (2008) [15], Galavi *et al.* (2011) [5] in safflower and Mostafavi (2012) [8] due to micronutrient application.

Straw yield: Data depicted in Fig. 3 with respect to straw yield shown the effect of micronutrients (zinc and iron) foliar application with or without seed fortification of molybdenum. The highest straw yield observed (19.66 q ha^{-1}) in T_6 which received zinc and iron through foliar application. The treatment T_6 was at par with T_9, T_7 and T_8 and superior over rest of the treatments. The treatment control (11.18 q ha^{-1}) was lowest for straw yield.

This result might be due to enzymatic activity, enhancement microelement effectively increased photosynthesis and translocation of assimilates to the seed. The available soil zinc and iron status (0.4 mg Zn kg^{-1}) and (1.2 mg Fe kg^{-1}) were below critical level hence, there was significant response observed in terms of straw yield in the treatment which received zinc and iron. Generally, micronutrient play a critical role in plant that lead to increase leaf area index and there by increased light absorption and increase the amount of dry matter (straw yield).

Similar results found by Ravi *et al.* (2008) [15] and Kobraee *et al.* (2011) [11] who claimed that zinc and iron application at the same time could be lead to higher dry matter production. Similar results were found by Galavi *et al.* (2012) in safflower.

Grain quality Parameter

Oil content

Application of zinc and iron with molybdenum found significantly highest increase of oil content of soybean (21.20%). This treatment was found at par with T_8, T_6, and T_7 and superior over rest of the treatments. Lowest oil percentage was observed (18.20%) in control (T_1) as shown in Table 3.

Many scientists reported that micronutrient supplied as per plant need lead to increase in seed oil percentage. It might be due to enhancement of enzymatic activity increased photosynthesis and translocation of assimilates to seed. The available soil zinc (0.4 mg Zn kg^{-1}) and iron (1.2 mg Fe kg^{-1}) status was below critical level, hence there was significant response in terms of oil content observed in the treatment receiving zinc and iron. Similar results were found by Ravi *et al.* (2008) [15] in safflower, Ebrahimian *et al.* (2010) [4] in sunflower crop with the application of zinc and iron.

Protein content

Application of zinc, iron and molybdenum significantly increased protein content (42.99%) in treatment T_9. Treatment T_9 was at par with T_8, T_5 and T_6 and superior over rest of the treatments as shown in Table 3. The lowest protein content was observed (40.76%) in treatment T_1 (control) which received RDF alone. Increase in protein content might be due to iron and zinc which are two important elements of structure of enzymes involved in amino acids synthesis ultimately protein synthesis and there by protein content increased with the application of these micronutrients. The available soil zinc (0.4 mg Zn kg^{-1}) and iron (1.2 mg Fe kg^{-1}) status was below critical level, hence there was significant response in terms of protein content observed in the treatment receiving zinc and iron. These results are agreed with the similar findings of Ravi *et al.* (2008) [15] in safflower and Ebrahimian *et al.* (2010) [4] in sunflower.

Table 1: The details of treatment

Treatments	Particulars
T_1	Control
T_2	Water spray
T_3	$FeSO_4$ spray (0.5%)
T_4	$ZnSO_4$ spray (0.5%)
T_5	Seed fortification with MoO_4
T_6	$FeSO_4$ spray (0.5%) + $ZnSO_4$ spray (0.5%)
T_7	$FeSO_4$ spray (0.5%) + MoO_4
T_8	$ZnSO_4$ spray (0.5%)+ MoO_4
T_9	$FeSO_4$ spray (0.5%) + $ZnSO_4$ spray (0.5%)+MoO_4

Table 2: Effect of micronutrient application Chlorophyll content of soybean

Treatments	Total chlorophyll (mg 100 g^{-1})			
	(20 DAS)	(40 DAS)	(60 DAS)	(80 DAS)
T_1 :Control	10.38	15.85	10.19	6.43
T_2: Water	10.58	16.02	11.66	7.45
T_3: $FeSO_4$ (0.5%)	13.40	21.36	12.85	8.25
T_4: $ZnSO_4$ (0.5%)	13.22	19.29	15.11	9.00
T_5: Seed fortification with MoO_4	12.26	17.82	13.90	8.13
T_6: $FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%)	18.22	28.06	17.73	10.09
T_7: $FeSO_4$ (0.5%) + MoO_4	14.42	20.80	15.96	9.33
T_8: $ZnSO_4$ (0.5%) + MoO_4	14.24	24.62	16.10	9.98
T_9:$FeSO_4$(0.5%)+ $ZnSO_4$ (0.5%) + MoO_4	19.90	27.08	18.14	10.14
S.E. ±	1.64	1.03	0.70	0.79
C.D @ 5%	4.92	3.10	2.11	2.39

Table 3: Effect of micronutrient application on grain quality of Soybean

Treatments	Oil (%)	Protein (%)
T_1 :Control	18.20	40.76
T_2: Water	18.79	40.93
T_3: $FeSO_4$ (0.5%)	19.31	42.32
T_4: $ZnSO_4$ (0.5%)	19.69	42.14
T_5: Seed fortification with Mo	19.73	42.77
T_6: $FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%)	20.31	42.43
T_7: $FeSO_4$ (0.5%) + Mo	20.15	41.65
T_8: $ZnSO_4$ (0.5%)+ Mo	20.55	42.78
T_9: $FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%) +MoO_4	21.20	42.99
S.E. ±	0.47	0.24
C.D @ 5%	1.42	0.73

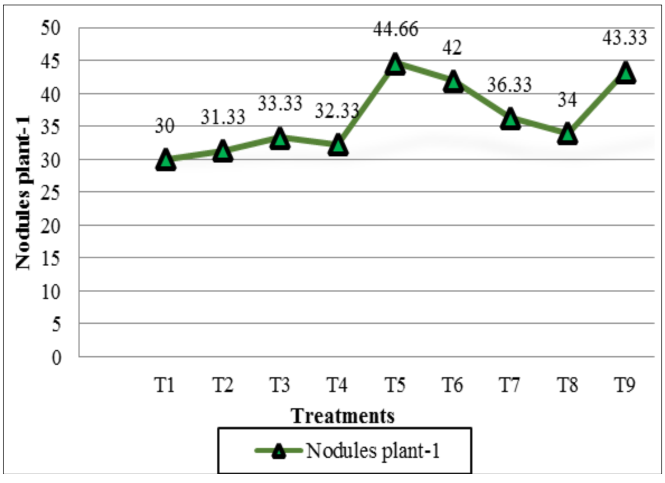

Fig 1: Effect of micronutrient application on nodulation of soybean

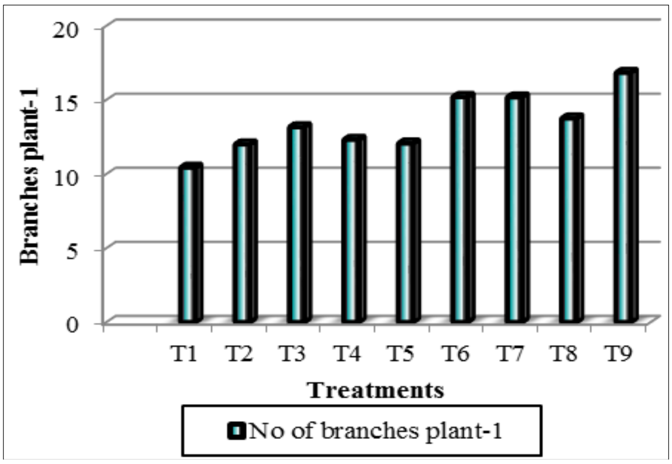

Fig 2: Effect of micronutrient application on branching of soybean

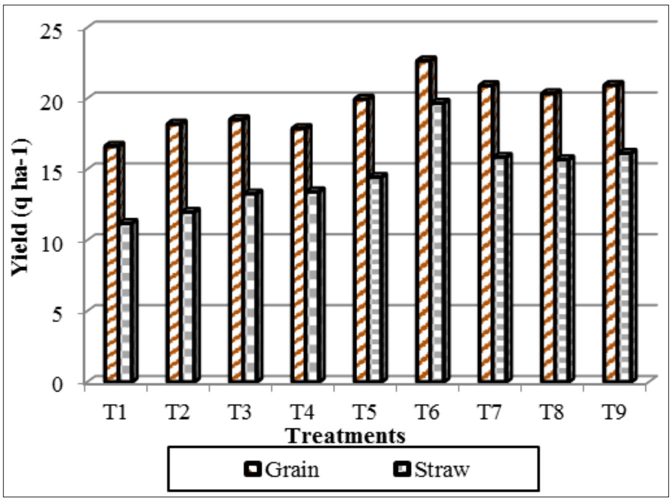

Fig 3: Effect of micronutrient application on staw and grain of soybean

Conclusion

The present study revealed that number of branches, nodule count, chlorophyll content and soybean yield were favorably affected by foliar application and seed fortification with micronutrients. Foliar application of Fe and Zn and the seed fortification with Mo was found best suitable for increasing the soybean yield and maximum oil and protein percentage. It was concluded that that micronutrient had positive effect on grain quality of soybean.

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