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Effect of iron and zinc on quality and nutrient uptake of French bean in iron and zinc deficient inceptisol soil

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Abstract
A field experiment was conducted at National Agriculture Research Project, Ganeshkhind, Pune (M. S.) on french bean (*cv. Phule Suyash*) to study the effect of iron and zinc on quality and nutrient uptake of french bean on iron and zinc deficient inceptisol with eleven treatments and three replications. Among the various treatments the application of GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} significantly increased quality parameters *viz.* total chlorophyll, protein content and nutrient uptake by french bean. It was closely followed by GRDF + three foliar sprays of each chelated iron + chelated zinc @ 0.2 % at 25, 40 and 55 days after sowing.

Keywords: French bean, iron, zinc, protein, chlorophyll, nutrient uptake

Introduction

Micronutrient deficiency of iron and zinc is increasing in most of the annual crops because of intensive cropping systems, use of modern high yielding cultivars, loss of topsoil organic matter content by erosion, burning crop residues and use of inadequate rates of micronutrients in most cropping systems. Iron is an essential nutrient element for plant growth and development and is involved in chlorophyll and thylakoid synthesis and chloroplast development. Micronutrients, such as iron (Fe) and zinc (Zn) play an important role in human growth, development, and maintenance of the immune system (Shenkin, 2006) [10]. Iron (Fe) and zinc (Zn) are most important micronutrients and approximately 2 billion people suffer from Fe and Zn deficiency worldwide, which has often been claimed to be the predominant cause of anemia (Welch and Graham, 1999) [13].

French bean (*Phaseolus vulgaris* L.) is a member of family Leguminaceae which is self-pollinated annual plant (Cobley, *et al*., 1976) [4]. It is a short season crop having a range 65-110 days from emergence to physiological maturity (Buruchara, 2007) [3]. French bean is good source of energy; it contains high protein content, dietary fiber, complex carbohydrates and also provides folic acid (Edje *et al*., 1980) [5].

Singh *et al.* (1995) [11] reported that the uptake of N by french bean crop increased with increasing application of iron up to 5 kg ha^{-1} but uptake of P remained unaffected. Sahu *et al.* (2008) reported that the application of $FeSO_4$ @ 2 kg ha^{-1} along with biofertilizers inoculation gave the highest grain yield (1473 kg ha^{-1}) and nutrient uptake with *Rhizobium* + PSB inoculation compared to control in chickpea. Malewar *et al.* (1990) [7] observed that increasing zinc rates up to 15 kg ha^{-1} increased the seed N, protein, carbohydrates, Zn, Fe and K content in mungbean (*Vigna radiata*) grown on a zinc deficient soil.

Yield potential of legumes can be achieved by adequate supply of micronutrients. Therefore, experiment was conducted to study the response of french bean to iron and zinc application. The demand for increasing pulses production will require a thorough knowledge on the relationship between nutrients and crop growth. The available information regarding the impact of micronutrients on pulse crops is scanty. Based on this background, the present study was undertaken to study the influence of iron and zinc on nutrient uptake and quality of french bean.

Material and Methods

A field experiment was conducted at National Agriculture Research Project, Ganeshkhind, Pune on french bean during *kharif* 2017 to study the effect of iron and zinc on nutrient uptake and quality of french bean on iron and zinc deficient Inceptisol with eleven treatments and three replications. The treatments comprised of T_1: Absolute control, T_2: GRDF + water spray, T_3: GRDF + foliar spray of chelated iron (0.1%), T_4: GRDF + foliar spray of chelated iron

(0.2%), T_5: GRDF + foliar spray of chelated zinc (0.1%), T_6: GRDF + foliar spray of chelated zinc (0.2 %), T_7: GRDF + foliar spray of chelated iron (0.1 %) + foliar spray of chelated zinc (0.1 %), T_8: GRDF + foliar spray of chelated iron (0.2 %) + foliar spray of chelated zinc (0.2%), T_9: GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1}, T_{10}: GRDF + soil application of $ZnSO_4$ @ 10 kg ha^{-1} and T_{11}: GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1}. The GRDF i.e. general recommended dose of fertilizers of $N:P_2O_5:K_2O$ (50:110:110 kg ha^{-1}) + FYM were applied to french bean.

Soil samples were collected before sowing of french bean and analyzed as per standard methods (Jackson, 1973) [6]. The experimental soil was clay loam in texture had a pH (7.3) slightly alkaline in reaction, low in soluble salts (EC 0.27 dS m^{-1}), medium in organic carbon (0.67%), low in available N (188 kg ha^{-1}), high in available P (31.3 kg ha^{-1}) and available K (318 kg ha^{-1}). The soil was deficient in iron (4.17 mg kg^{-1}) and zinc (0.51 mg kg^{-1}) content. The plant and pod samples were analyzed as per standard methods (Jackson, 1973) [6]. The data on various parameters recorded during the period of investigation were tabulated and statistically analyzed (Panse and Sukhatme, 1967) [8].

Results and Discussion

Quality parameters

Chlorophyll content

The results on chlorophyll content (Table 1) showed that the application of $FeSO_4$ @ 15 kg ha^{-1}+ $ZnSO_4$ @ 10 kg ha^{-1} along with GRDF recorded significantly higher total chlorophyll content (1.22 mg g^{-1} of fresh weight). However, it was on par with GRDF + foliar application of each chelated iron and chelated zinc @ 0.2 %, GRDF + foliar spray of each chelated iron and chelated zinc @ 0.1% and application of $ZnSO_4$@ 10 kg ha^{-1} along with GRDF. While it was lowest in absolute control (T_1). The increased in total chlorophyll content in leaves could be attributed to the functional role of iron and zinc in setting up some chlorophyll biosynthesis pathway enzymes and some antioxidants enzymes such as ascorbate peroxidase and glutatheon reductase have a fundamental role and prevent the chlorophyll degradation by reactive oxidation process. The results are in conformity with the findings of Zayed *et al.* (2011) [14] and Ayad *et al*. (2011) [1].

Protein content

The protein content (Table 1) was significantly increased due to different treatments. The application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} along with GRDF recorded significantly higher protein content (23.56 per cent) and it was closely followed by GRDF + foliar application of each chelated iron and chelated zinc @ 0.2 % (T_8). Both treatments were significantly superior over rest of the treatments. While no application of fertilizer (absolute control) recorded lowest protein content i.e. 18.69 per cent. The increase in protein content might be due to iron and zinc are two important elements in enzyme structure involved in amino acid biosynthesis and because amino acids are base of protein synthesis and thereby protein content increases in case of these micronutrients (Baybordy and Mamedov, 2010) [2]. Similarly, Thalooth *et al.* (2006) [12] showed that the using of $ZnSO_4$ increased grain protein content of mung bean. In addition iron is involved in metabolism of nitrogen and increased leaf area and has direct impact on process of protein production.

Protein yield

The protein yield (Table 1) was significantly increased due to different treatments. The maximum protein yield (1038.4 kg ha^{-1}) was recorded due to application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} along with GRDF and it was closely followed by GRDF + foliar application of each chelated iron and chelated zinc @ 0.2 % (T_8). Both the treatments were significantly superior over rest of the treatments. The increased in protein yield either through foliar or soil application might be attributed to enzyme substrate involved in amino acid biosynthesis and because of the amino acids are base of protein synthesis and thereby increased in protein yield. (Baybordy and Mamedov, 2010) [2].

Table 1: Effect of iron and zinc application on quality parameters of french bean

Tr. No.	Treatments	Total chlorophyll content (mg g^{-1} fresh wt.)	Protein (%)	Protein yield (kg ha^{-1})
T_1	Absolute control	0.88	18.69	518.1
T_2	GRDF + water spray	0.93	18.75	731.4
T_3	GRDF + foliar spray of chelated iron (0.1%).	0.95	19.38	800.5
T_4	GRDF + foliar spray of chelated iron (0.2%).	1.04	19.69	823.8
T_5	GRDF + foliar spray of chelated zinc (0.1%).	0.95	19.48	807.7
T_6	GRDF + foliar spray of chelated zinc (0.2 %)	1.07	20.31	853.3
T_7	GRDF + foliar spray of chelated iron (0.1 %) + foliar spray of chelated zinc (0.1 %)	1.18	22.19	944.5
T_8	GRDF + foliar spray of chelated iron (0.2 %) + foliar spray of chelated zinc (0.2%)	1.21	23.19	1019.5
T_9	GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1}	0.98	21.94	911.6
T_{10}	GRDF + soil application of $ZnSO_4$ @ 10 kg ha^{-1}	1.15	20.81	878.2
T_{11}	GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1}	1.22	23.56	1038.4
SE($\pm$)		0.02	0.17	20.34
CD (0.05)		0.07	0.51	60.02

Macronutrient uptake

Nitrogen

The data on macronutrient uptake (Table 2) showed significant effect on total nitrogen uptake by french bean. Among the treatments T_{11} i.e. soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$@ 10 kg ha^{-1} along with GRDF registered significantly higher N uptake (186 kg ha^{-1}). It was at par with T_5 i.e. GRDF + Foliar spray of chelated zinc (0.1%), T_6 i.e. GRDF + Foliar spray of chelated zinc (0.2 %) and T_8 i.e. foliar sprays of each chelated iron + chelated zinc @ 0.2% along with GRDF. T_8 i.e. GRDF + foliar spray of chelated iron (0.2%) + foliar spray of chelated zinc (0.2%) was next best treatment followed by soil application of iron and zinc treatment (T_{11}).

Table 2: Effect of iron and zinc application on macronutrient uptake by French bean

Treatment No.	Treatments	Nitrogen	Phosphorus	Potassium
		(kg ha^{-1})		
T_1	Absolute control	102.5	13.4	36.4
T_2	GRDF + water spray	141.4	18.7	42.6
T_3	GRDF + foliar spray of chelated iron (0.1%).	150.5	20	45.3
T_4	GRDF + foliar spray of chelated iron (0.2%).	163	21.5	47.8
T_5	GRDF + foliar spray of chelated zinc (0.1%).	168.5	20	45.6
T_6	GRDF + foliar spray of chelated zinc (0.2 %)	168.4	21.5	49.4
T_7	GRDF + foliar spray of chelated iron (0.1 %) + foliar spray of chelated zinc (0.1 %)	163.7	21.4	51.7
T_8	GRDF + foliar spray of chelated iron (0.2 %) + foliar spray of chelated zinc (0.2%)	168.4	24.6	54.9
T_9	GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1}	162.5	20.9	48.5
T_{10}	GRDF + soil application of $ZnSO_4$ @ 10 kg ha^{-1}	170.8	22.7	51.8
T_{11}	GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1}	186	25	57.3
SE$\pm$		7.1	0.4	0.6
CD (0.05)		20.9	1.3	1.7

Phosphorus
Effect of different treatments on phosphorus uptake by French bean was significant (Table 2). The treatment T_{11} i.e. GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} recorded significantly higher phosphorus uptake (25 kg ha^{-1}) and closely followed by treatment T_8 i.e. GRDF + foliar spray of chelated iron (0.2 %) + foliar spray of chelated zinc (0.2 %). Treatment T_{11} was at par with treatment T_8 and both treatments were superior over rest of the treatments.

Potassium
Among the various treatments T_{11} i.e. GRDF + Soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} recorded significantly higher K uptake (57.3 kg ha^{-1}) which was superior over rest of the treatments (Table 2). While lowest K uptake was recorded in absolute control.

Micronutrient uptake
Iron
The micronutrient uptake (Table 3) showed the total uptake of iron by French bean was differed significantly due to different treatments. In general the total iron uptake ranged from 271 to 510.6 g ha^{-1}. The iron uptake was increased significantly with application of iron either through foliar or soil application over no application of iron. Similarly, increased levels of iron also increased in total iron uptake by French bean. Among the treatments T_{11} i.e. GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} recorded significantly higher total iron uptake (510.6 g ha^{-1}) which was at par with T_8 i.e. GRDF + foliar spray of chelated iron (0.2 %) + foliar spray of chelated zinc (0.2 %).

Zinc
Zinc uptake was affected significantly by different treatments (Table 3). The total zinc uptake was increased significantly with application of iron and zinc either through foliar or soil application over no application of fertilizers. It was ranged from 75.2 to 165.8 g ha^{-1} by French bean. The treatment T_{11} i.e. GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} recorded significantly highest zinc uptake (165.8 g ha^{-1}) and closely followed by T_8 i.e. GRDF + foliar spray of chelated iron (0.2 %) + foliar spray of chelated zinc (0.2 %) treatments. Both these treatments were at par with each other.

Manganese
The data pertaining to total manganese uptake by French bean was affected by different treatments presented in Table 3. It was ranged from 77 to 192 g ha^{-1}. The total Mn uptake (192 g ha^{-1}) was found highest in T_{11} i.e. GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} treatment. It was closely followed by treatment T_8 i.e. GRDF + foliar spray of chelated iron (0.2 %) + foliar spray of chelated zinc (0.2 %).

Table 3: Effect of iron and zinc application on micronutrient uptake by French bean

Treat. No.	Treatments	Fe	Zn	Mn	Cu
		(g ha^{-1})			
T_1	Absolute control	271	75.2	77	11.1
T_2	GRDF + Water spray	390.4	112.2	117.6	19.1
T_3	GRDF + foliar spray of chelated iron (0.1%).	417.8	123.6	131.4	24.7
T_4	GRDF + foliar spray of chelated iron (0.2%).	448.3	139	152.7	32.9
T_5	GRDF + foliar spray of chelated zinc (0.1%).	425.9	127	138.1	30.3
T_6	GRDF + foliar spray of chelated zinc (0.2 %)	460.5	139.6	161.8	27.7
T_7	GRDF + foliar spray of chelated iron (0.1 %) + foliar spray of chelated zinc (0.1 %)	482.4	152	176.4	37.6
T_8	GRDF + foliar spray of chelated iron (0.2 %) + foliar spray of chelated zinc (0.2%)	507.8	159.2	184.3	40.8
T_9	GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1}	439.3	132.7	144.4	30.6
T_{10}	GRDF + soil application of $ZnSO_4$ @ 10 kg ha^{-1}	469.1	146.7	171	31.7
T11	GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1}	510.6	165.8	192	42.7
SE$\pm$		7.2	6.9	2.1	2.8
CD (0.05)		21.4	20.3	6.2	8.1

Copper
Among the various treatments the soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} along with GRDF recorded significantly higher Cu uptake (42.7 g ha^{-1}) which was on par with foliar application of each chelated iron and chelated zinc @ 0.2% along with GRDF (Table 3). Both the treatments were significantly superior over rest of the treatments.

Conclusion

From the results it concluded that either the application of GRDF + soil application of $FeSO_4$ @ 15 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} or three foliar sprays of each chelated iron + chelated zinc @ 0.2 % at 25, 40 and 55 days after sowing found beneficial for improving the quality and nutrient uptake of french bean.

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