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Micronutrient (Cu, Zn, Fe and Mn) Uptake in Soybean [*Glycine max* (L.) Merill] Growing Soils of Dharwad Taluk (Karnataka)

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The present investigation was carried out to study the uptake of micronutrients in soybean growing soils of Dharwad taluk during 2015-16 *kharif* season. For this purpose 51 representative soybean growing soils of Dharwad taluk were selected. Based on the average grain yields in 51 fields, the entire group was divided into below average and above average yield categories. Mean yield of 51 fields was 14.67 q ha^{-1}. Crop cutting experiment from the selected farmers' fields were carried out for recording yield data. The study revealed that micronutrient uptake in below average yield category ranged from 45.01 to 68.44 g ha^{-1} with a mean value of 55.90 g ha^{-1}, 84.28 to 108.05 g ha^{-1} with a mean value of 99.49 g ha^{-1}, 490.72 to 690.61 g ha^{-1} with a mean value of 643.28 g ha^{-1} and 91.26 to 140.74 g ha^{-1} with a mean value of 118.67 g ha^{-1} of Cu, Zn, Fe and Mn respectively. The micronutrient uptake in above average yield category ranged from 56.24 to 78.85 g ha^{-1} with a mean value of 68.72 g ha^{-1}, 113.45 to 141.14 g ha^{-1} with a mean value of 128.68 g ha^{-1}, 718.33 to 874.25 g ha^{-1} with a mean value of 795.61 g ha^{-1} and 104.14 to 162.16 g ha^{-1} with a mean value of 134.25 g ha^{-1} of Cu, Zn, Fe and Mn respectively. Among micro nutrients, available zinc and iron were found to be positively and significantly correlated with dry matter production in both below average and above average yield categories.

Introduction

Soybean [*Glycine max* (L.) Merill], being the "Golden Bean", of the 20th century is a species of legume, native to East Asia, widely grown for its edible bean which has numerous uses. Soybean is described variously as a "miracle bean", "crop of the planet", "God sent golden bean" and "greater bean," etc. The plant is classed as an oilseed rather than a legume by the Food and Agricultural

Organization (FAO). Soybean is one of the nature's most versatile and fascinating crop in the present farming system of Indian agriculture. An increase in population pressure increased the demand of edible oil greatly in last decade. As a result there is an increase in the area of oil seed crops in the country. Among the oil seed crops, Soybean is largely popularized in recent years in the

country as well as in Karnataka. It also enriches the soil through symbiotic N-fixation and its residual nitrogen is about 30-40 kg N per hectare for succeeding crops (Apeji, 1988). The soybean contains high protein (40-43 %), oil content (24-26 %) and also consists of high percentage of amino acids which are essential in human nutrition. Its oil content belongs to the linolenic unsaturated fatty acid group without cholesterol. Fat-free (defatted) soybean meal is a significant and cheap source of protein for animal feeds and many pre-packaged meals. In addition to this, soybean protein has five per cent lysine, which is deficient in most of the cereals and enriching the cereal flour with soybean improves the nutritive quality.

In India, major soybean producing states are Madhya Pradesh, Uttar Pradesh, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh and Karnataka. Karnataka is one of the major soybean growing state occupying about 2.470 lakh ha with an annual production of 3.001 lakh MT with the productivity of 1215 kg ha^{-1} (Anonymous, 2014).

Being an easy care crop, it is widely acceptable by majority of farmers and it gets its preference for all type of soils (Jagdish and Hajare, 1992). Introduction of soybean has led to a shift in the cropping system from fallow–wheat/ chickpea to soybean–wheat/chickpea system (Jagdish and Singh, 1997). Soybean being oilseed legume besides phosphorus and sulphur some of the micronutrients like Zn, Fe, Mn and Cu are required to improve and sustain performance of the soybean crop. Zinc promotes growth hormones, starch formation, seed maturation and production of plant whereas, iron helps in the absorption of other nutrient, Fe and Mn play an important role in chlorophyll formation and copper has some indirect effect on nodule formation.

Metals such as Zinc, iron and manganese have vital roles in plant's life cycle and very important for normal growth plants (Fageria, 2007). Zinc is considered as the most limiting factor in producing crops in different parts of the world (Mandal *et al.,* 2000; Fageria and Baligar, 2005). Zn is an essential catalytic component of over 300 enzymes, including alkaline phosphatase, alcohol dehydrogenase, Cu-Zn superoxide dismutase, and carbonic anhydrase (Fox and Guerinot, 1998). Zinc plays an important role in synthesizing proteins, RNA, DNA and precursor of auxin which is essential for cell elongation (Welch, 2001; Awlad *et al.,* 2003).

Iron plays an important role in nitrogen fixation and photosynthesis (Bennett, 1993). Synthesis of chlorophyll, thylakoid, and many ferrous proteins is dependent on this element (Imsande, 1998). Iron deficiency in plants is caused by factors that either inhibit its absorption and translocation or impair its utilization in metabolic processes (Fontes and Cox, 1998).

Manganese is an essential element for plants growth and is identified a co- factor for nitrogen catabolism in leaves and a major factor for stabilizing nitrogen within roots and its transfer to shoots in soybean (Izaguirre–Mayoral and Sinclair, 2005). Mn plays an important role in stabilization of structural protein, the ultra-structural of chloroplasts' and photosynthesis (Popelkova *et al.,* 2003).

Materials and Methods

Location of the study area

The study area is Dharwad *taluk* in Dharwad district, Karnataka. The study area lies between 15^0 21' to 15^0 31' N latitude and 74^0 48' to 75^0 9' E longitude. The location of study the area is presented in figure 1. The study area is situated in Northern Transitional

Zone (Zone-8) of North Karnataka. The location of soil samples in selected villages of Dharwad taluk are presented in figure 2. The area receives a mean annual rainfall of 716.2 mm.

Preparation of plant sample

The five plant samples collected for estimating the dry matter production and nutrient uptake from each field at peak flowering stage (55-60 DAS), samples were thoroughly washed with distilled water and dried in hot air oven at 65 °C. Dried samples were powdered in a Willey mill to considerable fineness before storing them in polythene bags for further analysis.

Digestion of plant samples

Powdered plant samples were treated with concentrated HNO_3 overnight for pre digestion. Then, the pre-digested samples were treated with a di-acid mixture (HNO_3:$HClO_4$) (10:4) and digested on a sand bath till colourless white precipitate was obtained. The residue was dissolved in 6N HCl, filtered and then the content was made to a known volume by using 6N HCl. This digest was used for further nutrient analysis. Zinc, iron, copper and manganese were estimated in the aliquot of di-acid digested plant extract using Atomic Absorption Spectrophotometer (AAS, Shimadzu model) as described by Tandon, 1998.

Nutrient uptake studies

The micro nutrient uptake by soybean at flowering was worked out using the following equation.

Micro nutrientuptake (g ha^{-1}) =

$$\frac{\text{Nutrient content (ppm)} \times \text{Dry matter yield (kg ha}^{-1})}{1000}$$

Crop cutting experiment on the fields of selected farmers

Crop cutting experiment from the selected farmers' fields were carried out. In each of the fields at the time of harvest in area of 3×3 m was selected randomly at three different spots. Plants were uprooted in the selected area and pods were separated from plants, yields were recorded by taking average from all the three spots and expressed in quintals per hectare. Average grain yield of these fifty one fields was calculated. Based on this average grain yield, these fifty one fields were divided into below average yield category and above average yield category.

Results and Discussion

Nutrient uptake studies

Copper (Cu) uptake

The copper uptake by soybean plants in below average yield category ranged from 45.01 to 68.44 g ha^{-1} with a mean value of 55.90 g ha^{-1} and standard deviation of 6.746 (Table 1). In above average yield category it ranged from 56.24 to 78.84 g ha^{-1} with a mean value of 68.72 g ha^{-1} and standard deviation of 6.604 (Table 1). The mean copper uptake by soybean plants in the above average yield category was found to be higher (Table 1) than that of below average yield category (Table 1) despite similar mean available copper contents in soils of both the categories. This difference is explained by higher organic matter content in the soils of above average yield category that enhanced the availability of native micronutrient cations through the transformation of solid phase to soluble metal complexes. Further, the extensive root system enhanced the copper uptake in such soils. Bidari (2000) reported higher copper uptake by plants grown on soils with high organic matter content.

Zinc (Zn) uptake

The zinc uptake by soybean plants in below average yield category ranged from 84.27 to 108.04 g ha^{-1} with a mean value of 99.49 g ha^{-1} and standard deviation of 6.463 (Table 1). In above average yield category, it ranged from 113.44 to 141.14 g ha^{-1} with a mean value of 128.68 g ha^{-1} and standard deviation of 7.240

(Table 1). The mean zinc uptake by soybean plants in the below average yield category was found to be lower (Table 1) than that of above average yield category (Table 1). Similar findings were reported by Prasad *et al.,* (1982). However, it was noticed that there was higher uptake of iron by soybean of above average yield category.

Table.1 Uptake (g ha^{-1}) of micronutrients by soybean crop at flowering stage in Below and above average yield category

	Copper	Zinc	Iron	Manganese
Below average yield category				
Minimum	45.01	84.28	490.72	91.26
Maximum	68.44	108.05	690.61	140.74
Mean	55.90	99.49	643.28	118.67
Standard deviation	6.746	6.463	58.046	15.288
Above average yield category				
Minimum	56.24	113.45	718.33	104.14
Maximum	78.85	141.14	874.25	162.16
Mean	68.72	128.68	795.61	134.25
Standard deviation	6.604	7.240	43.949	19.552

Note: Average yield - 14.67 q ha^{-1}

Table.2 Correlation coefficients between soil properties and nutrient status with Soybean dry matter production (g plant^{-1})

	Dry matter	pH	EC	OC	CaCO$_3$	Cu	Zn	Fe	Mn
Dry matter	1								
pH	-0.128	1							
EC	-0.010	0.303*	1						
OC	0.808**	-0.146	-0.109	1					
CaCO$_3$	-0.203	0.908**	0.425**	-0.226	1				
Cu	0.001	-0.031	0.334*	-0.141	-0.010	1			
Zn	0.729**	-0.254	-0.001	0.664**	-0.258	-0.018	1		
Fe	0.370**	0.264	0.197	0.375**	0.233	-0.074	0.140	1	
Mn	0.015	0.150	-0.215	-0.002	0.064	-0.111	-0.054	0.089	1

**. Correlation is significant at the 0.01 level
*. Correlation is significant at the 0.05 level
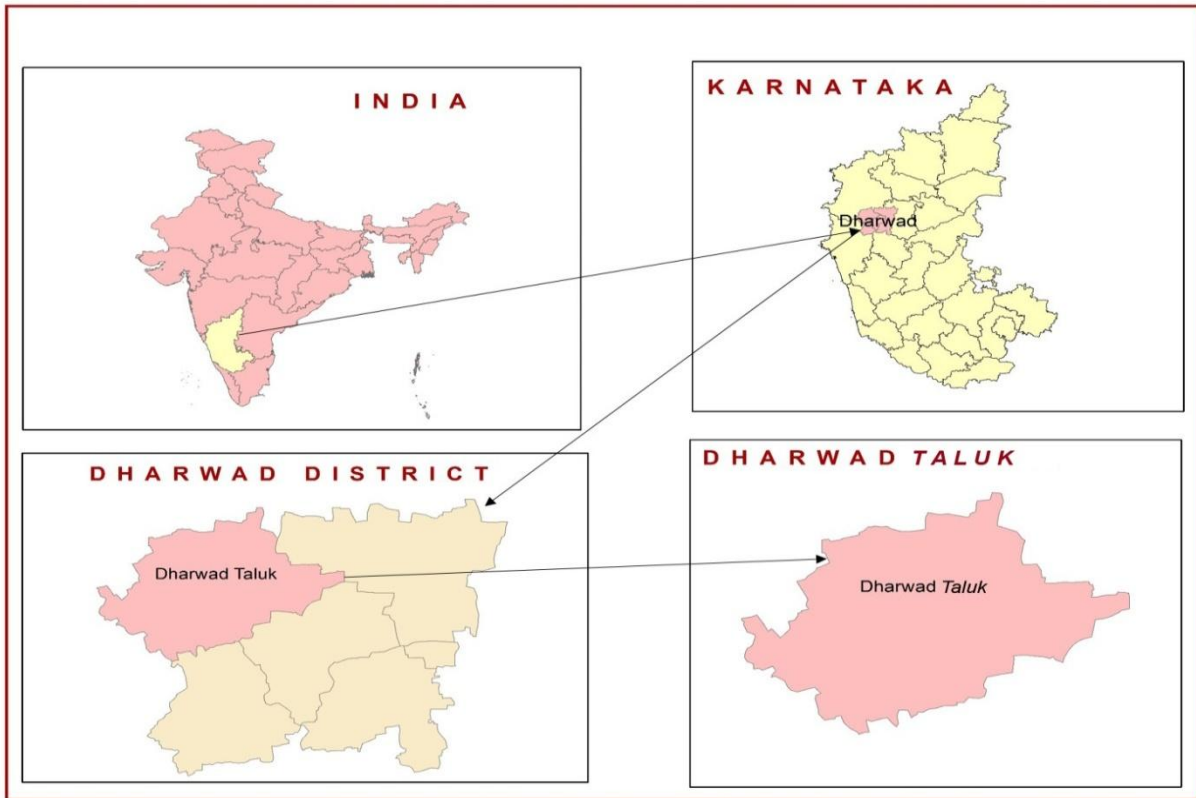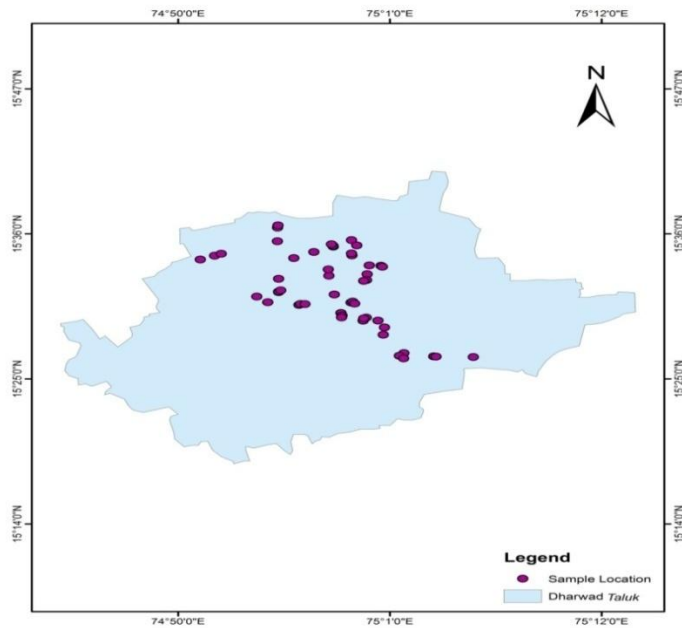
Fig.1 Location of study area

Fig.2 Location of soil samples in Dharwad taluk

Iron (Fe) uptake

The iron uptake by soybean plants in below average yield category ranged from 490.71 to 690.60 g ha^{-1} with a mean value of 643.28 g ha^{-1} and standard deviation of 58.046 (Table 1). In above average yield category it ranged from 718.32 to 874.25 g ha^{-1} with a mean value of 795.61 g ha^{-1} and standard deviation of 43.949 (Table 1). The mean uptake of iron in below average yield category was found to be lower than above average yield category.

Manganese (Mn) uptake

The manganese uptake in below average yield category ranged from 91.26 to 140.73 g ha^{-1} with a mean value of 118.67 g ha^{-1} and standard deviation of 15.288 (Table 1). In above average yield category, it ranged from 104.13 to 162.16 g ha^{-1} with a mean value of 134.25 g ha^{-1} and standard deviation of 19.552 (Table 1). The manganese taken up by soybean did not vary in both the categories. But the mean uptake of Mn above average yield category was found to be higher (Table 1) than that of below average yield category (Table 1). Pradeep *et al.,* (2006) reported that higher uptake of nutrients is also due to higher dry matter production in above average yield category.

Relationship between soil properties and nutrient status with soybean dry matter production

Among chemical properties of soils, organic carbon content showed significant and positive relationship with dry matter production in both below and above average yield categories (Table 2). Among micro nutrients, available zinc and iron were found to be positively and significantly correlated with dry matter production in both below average and above average yield categories (Table 2).

In conclusion, all micronutrient uptake in above average yield category was found to be higher than that of below average yield category it might be due to the higher nutrient status in the soils of above average yield category

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