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Effect of different methods of micronutrients mixture application on growth and yield of mungbean in Cauvery command area

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Abstract
The aim of the experiment was to study the effect of different methods of micronutrients application on growth and yield of mungbean in red soil. A field experiment was conducted during early *Kharif* 2015 on sandy loam soil at University of agricultural Sciences, Bengaluru. The experiment was laid out in Completely Randomized Block Design with Twelve treatments including control, RDF alone, RDF+ water spray and soil, foliar and seed treatment with micronutrients (Fe, Mn, Zn, Cu, B and Mo and deficient micronutrients). The treatment receiving RDF +foliar application of MM at 30 and 45 DAS recorded significantly superior yield of 1140.84 kg ha^{-1} which increased about 7.16 , 38.39 and 56.13 per cent over soil application of MM (Fe+Mn+Zn+Cu+B) along with RDF, RDF alone and control respectively. However, grain yield with RDF +foliar application of MM at 30 and 45 DAS and RDF +Soil application of MM treatments were statistically non-significant. Suggesting that supplementation of MM as basal enhances the early vigour thus helps in better yield. Similarly foliar application at later stages is responsible for translocation of assimilates to sink thus resulting in higher yield. Significantly higher stover yield of 2483.86 kg ha^{-1} was recorded due to soil application of RDF +micronutrients mixture followed by 2386.63 kg ha^{-1} due to RDF + soil application of deficient micronutrients (only Zn and Boron).The grain yield obtained with seed treatment or with application of only deficient micronutrients was lower than that obtained with the soil or foliar application of micronutrients. The higher yield obtained might be attributed to improvement in growth and yield attributing parameters with the foliar or soil application of micronutrients mixture. Thus foliar application of micronutrients mixture at two growth stages or soil application of RDF +MM is beneficial for enhancing higher grain and stover yield.

Keywords: Greengram, micronutrients mixture, foliar application, soil application, seed treatment

Introduction
Pulses in India have long been considered as the poor man's only source of protein, grown on 22-23 million hectares of area with an annual production of 13-15 mt. India accounts for 33 per cent of the world area and 22 per cent of the world production of pulses. More popular among these are chickpea, pigeonpea, mungbean, urdbean and lentil (FAO, 2009) [6]. However, due to population explosion and low productivity of pulse crops, per capita availability of pulses has come down from 60 g day^{-1} person^{-1} in 1951 to 31 g day^{-1} person^{-1} in 2008 (Indian Council of Medical Research recommends 65 g day^{-1}capita^{-1}) (Amarendar Reddy, 2009) [1].
Greengram [*Vigna radiata* (L.) Wilczek] also known as mungbean is an important pulse crop of India. It is also considered as “Golden Bean” because of its nutritional value (Its seed contains 24.2% protein, 1.3% fat and 60.4% carbohydrate) and suitability for increasing the soil fertility by way of addition of nitrogen (30 kg ha^{-1} annum^{-1}). Among all pulses grown in India, greengram ranks third after chickpea and pigeon pea, with a production of 1.49 mt. from 3.53 m ha area (Anon., 2012) [2].
Application of micronutrients in small quantities (0.5 to 2 kg ha^{-1}) has resulted in 40-120 per cent increase in grain yield, indicating that it is not the single nutrient deficiency is limiting the productivity of pulses rather multi micronutrients deficiencies are quite often the reasons for low productivity. The multi-micronutrients mixture facilitate the application of the wide range of plant nutrients in the proportion and to suit the specific requirements of a crop in different stages of growth, and are more relevant under specific nutrient management practices (Hegde, 2007) [8].

Materials and method
A field experiment was conducted during early *Kharif* 2015 on sandy loam soil at College of Agriculture, V.C. Farm, Mandya, University of agricultural Sciences, Bengaluru, Karnataka to

study the effect of different methods of micronutrients mixture application on yield, nutrient uptake and economics of mung bean in Southern Dry Zone (Zone 6) of Karnataka. The twelve treatments combinations including control, RDF alone, RDF +water spray / soil / foliar / seed treatment with MM (Fe, Mn, Zn, Cu, B, Mo and deficient micronutrients). All twelve treatments combination were replicated three times in randomized block design.

The soil was sandy loam in texture with 75.03, 18.2, and 6.77 per cent sand, silt and clay, respectively and bulk density of 1.5 Mg cm^{-3}. The soil was neutral in reaction (pH 7.21) and low in soluble salts (0.16 dS m^{-1}). The soil was low in organic carbon (4.8 g kg^{-1}), available nitrogen (151.2 kg ha^{-1}) and available P_2O_5 (9.64 kg ha^{-1}), while it was medium in K_2O (202.944 kg ha $^{-1}$) and high in sulphur (15.67 mg kg^{-1}). The exchangeable calcium and magnesium content of soil was 3.4 and 2.5 meq 100 g^{-1}, respectively. The DTPA extractable micronutrient content *viz.,* zinc, iron, copper manganese and boron were 0.52, 7.82, 0.41, 8.62 and 0.46 mg kg^{-1}, respectively. Zn and B content were below the critical limit. Mungbean variety KKM-3 was sown at 30cm row and 10 cm plant to plant apart.

Recommended dose of NPK for greengram is 20:50:50 kg ha^{-1} was supplied with urea, single super phosphate and murate of potash respectively and micronutrients like Fe, Mn, Zn, Cu, B and Mo was applied in the form of Iron sulphate, Manganese sulphate, Zinc sulphate, Copper sulphate, Borax and Ammonium molybdate respectively. Micronutrient mixture for foliar spray was prepared by dissolving the appropriate quantity of all the micronutrient salts in distilled water. Then the pH of the solution was adjusted to 6.5 using KOH solution. This solution was used for foliar spraying at 30 and 45 days after sowing as per the treatment plan. To reduce weed infestation one hand weeding was done at 25 days after sowing. In all 4 irrigations were given at different stages of crop growth to fulfill the water requirement. To control the whitefly (*Bemisia tobaci*), Roger 30 EC @ 1.0 litre ha^{-1} was uniformly sprayed at vegetative growth stage of the crop. Crop was harvested at proper maturity. Periodical and quantitative observations were taken in order to assess the effect of micronutrients mixture on growth, yield, nutrient uptake and economics of mungbean. Mature pods were harvested manually by five hand picking. The grain was separated by manual threshing Powdered plant sample of 1.0 g were pre-digested with conc. HNO_3 overnight and then digested with di-acid mixture containing HNO_3 and $HClO_4$ in the proportion of 9:4 till a snow white residue was obtained. The volume of the digest was made to 100 ml with distilled water and used for total elemental analysis Except N. Micronutrient content of mungbean seed was analyzed in atomic absorption spectrophotometer after digesting sample using di-acid mixture. Soil available micronutrients (Fe, Mn, Cu and Zn) were determined by Lindsay and Norvell (1978) [14] method. Hot water soluble B was estimated using azomethine- H in spectrophotometer (Berger and Truog 1939) [4].

Results and Discussion

Results and discussion

Effect of micronutrients mixture on growth and yield of greengram

Plant height in control was 20.42 cm which increased significantly to 28.11 cm due to application of RDF + soil application of MM followed by 27.66 cm with the application of RDF + foliar application of MM at 30DAS. The maximum number of leaves per plant (18.43) was recorded due to application of RDF + soil application of MM these were significantly higher than that recorded in control (14.11), T_2 RDF(15.23).The higher chlorophyll content of 48.81 was recorded due to application of RDF + soil application of micronutrients mixture (Table1).

The increase in growth parameters with supplementation of micronutrients mixture might be attributed to the balanced nutrition of the crop. Also, the addition of the micronutrients helps in better utilization of the major nutrients to produce higher biomass production. The hidden deficiencies of micronutrients are overcome due to their supplementation during the growth period, which results in better crop growth and thereby yield. The beneficial effect on use of multi micronutrients mixture have been reported in different crops for good growth; Blackgram (Kannan *et al.,* 2014, Poongothai and Chitdeshwari, 2003) [11, 15] Cowpea (Hemn, 2013) [9] Chickpea (Valenciano *et al.,* 2010) [20] and Mungbean (Quddus *et al.,* 2011) [17].

Table 1: Plant height, number of leaves and chlorophyll content (mg cm^{-2}) as influenced by application of micronutrients mixture.

Treatments	Plant height (cm)	Number of leaves	Chlorophyll content
Absolute control	20.42	14.11	46.93
Only RDF	27.14	15.23	53.98
RDF +water spray	27.61	15.85	53.35
RDF +foliar application of MM at 30 DAS	27.66	17.80	54.69
RDF +foliar application of MM at 45 DAS	24.51	16.55	53.10
RDF +foliar application of MM at 30 & 45DAS	25.18	18.36	56.52
RDF +foliar application of deficient MM at 30 DAS	24.81	15.99	50.82
RDF +Mo seed treatment + foliar application of deficient MM at 30 DAS	25.71	18.37	51.07
RDF +soil application of MM	28.11	18.43	51.44
RDF +soil application of deficient MM	27.36	17.24	51.23
RDF +Mo seed treatment + soil application of deficient MM	23.45	17.48	51.31
RDF +Mo seed treatment + MM seed treatment	26.35	18.07	52.62
CD (p=0.05)	3.64	2.36	4.34

Effect of micronutrients mixture on yield parameters

Application of RDF + micronutrients mixture had significant influence on the number of pods per plant of greengram. The maximum number of pods per plant (24.02) was recorded due to application of RDF + foliar application of micronutrients mixture at 30 and 45 DAS followed by 23.73 with the RDF + soil application of micronutrient mixture (T_9) and these were significantly higher than that recorded in control (19.66), T_5 (21.14) and T_8 (21.67) but they were on par with rest of the treatments.

Pod length did not vary significantly due to application of RDF + micronutrients mixture. However, highest pod length

(8.73 cm) was recorded in RDF + foliar application of MM at 30 and 45 DAS, followed by 8.65 cm in RDF + foliar application of MM at 30 DAS and the least pod length of 7.74 cm was recorded in control.

Application of RDF + micronutrients mixture had significant influence on the number of pods per plant of greengram. The maximum number of pods per plant (24.02) was recorded due to application of RDF + foliar application of micronutrients mixture at 30 and 45 DAS followed by 23.73 with the RDF + soil application of micronutrient mixture (T_9) and these were significantly higher than that recorded in control (19.66), T_5 (21.14) and T_8 (21.67) but they were on par with rest of the treatments.

Among different treatments T_6 (14.00) and T_9 (13.47) recorded significantly higher number of seeds per pod over control (11.27), RDF alone (12.07) and T_8 (11.87).Micronutrients such as Fe, Zn and Mn have a structural role in chlorophyll. Consequently supply of these micronutrients enhances the chlorophyll content. This in turn, leads to an increase in growth parameters and yield attributes in the treatment that received micronutrients mixture.

Table 2: Number of pod bearing auxiliary branches, pod length (cm), number of pods per plant and number of seeds per pod as influenced by application of micronutrients mixture.

Treatments	No. of pod bearing auxiliary branches	Pod length (cm)	No. of pods per plant	No. of seeds per pod
T_1	2.47	7.74	19.66	11.27
T_2	2.93	8.08	22.37	12.07
T_3	2.93	8.36	22.60	12.27
T_4	3.27	8.65	23.37	12.73
T_5	3.24	8.48	21.14	12.40
T_6	3.23	8.73	24.02	14.00
T_7	3.27	8.22	23.23	12.73
T_8	3.13	8.22	21.67	11.87
T_9	3.33	8.64	23.73	13.47
T_{10}	3.20	8.49	23.50	12.33
T_{11}	3.07	8.53	22.22	12.67
T_{12}	3.07	8.25	22.13	12.33
SEm±	0.11	0.24	0.75	0.42
CD (p=0.05)	0.32	NS	2.24	1.24

Effect of micronutrients mixture application on grain and stover yield

The effect of treatments on the test weight at both the picking was non-significant. However, application of RDF + foliar application of micronutrients mixture at 30 and 45 DAS recorded highest test weight at first (4.49 g) and second picking (4.28 g) followed by T_8 (4.35 and 4.18 g, respectively).Significantly superior yield of 1140.84 kg ha^{-1} was registered in RDF + foliar application of micronutrients mixture at 30 and 45 DAS followed by 1064.56 kg ha^{-1} with the application of RDF + soil application of micronutrients mixture.

Significantly higher stover yield of 2483.86 kg ha^{-1} was recorded due to soil application of RDF+MM followed by 2386.63 and 2333.13 kg ha^{-1} due to (RDF + soil application of deficient micronutrients) and T_6 (RDF + foliar application of MM at 30 and 45 DAS) respectively compared to control (1831.97 kg ha^{-1}), RDF only (1962.31 kg ha^{-1}), RDF + Water spray (1957.18 kg ha^{-1}) and RDF + MM seed treatment (2062.27 kg ha^{-1}).

Application of (Fe, Mn, Cu, Zn and B) maintained early crop vigour and growth, dry matter production by augmenting photosynthetic process and higher production of photosynthatase as some of these acts as co-factor in enzyme involved in electron transport process of photosynthesis and respiration and in chloroplast synthesis, which might have helped in better growth (Hazra *et al.*, 1987) [7].

Table 3: Test weight (100 grain weight in g), grain yield and stover yield (kg ha^{-1}) as influenced by application of micronutrients mixture.

Treatments	Test weight (g)		Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
	First picking	Second picking		
T_1	4.14	4.06	730.70	1831.97
T_2	4.20	4.10	821.01	1962.31
T_3	4.21	4.11	825.37	1957.18
T_4	4.32	4.16	1023.58	2290.10
T_5	4.14	3.90	1018.07	2278.11
T_6	4.49	4.28	1140.84	2333.13
T_7	4.25	4.13	985.24	2281.53
T_8	4.35	4.18	1020.85	2296.90
T_9	4.28	4.13	1064.56	2483.86
T_{10}	4.25	4.08	1036.74	2386.63
T_{11}	4.25	4.10	986.85	2269.18
T_{12}	4.34	4.11	1024.31	2062.27
CD (p=0.05)	NS	NS	95.86	203.16

Effect of application of micronutrients mixture on grain protein content of greengram

The protein content in control was 34.45 per cent which increased to 38.08 per cent with the application of RDF alone. Application of micronutrients further increased the protein content. Thus the highest protein content of 48.67 per cent was recorded with the foliar application of MM at 30 and 45 DAS followed by soil application of MM along with RDF.

The increase in the percentage of protein by microelements application is reported by other researchers (Babhulkar *et al*., 2000; Sawan *et al.*, 2001) [3, 18]. Hemn (2013) [9] they reported that application of micronutrients iron, zinc and manganese has increased on average two percentage seed protein in bean. The highest protein percentage was obtained when greengram was treated with micronutrients mixtures. As these micronutrients are applied when plant was established helped in the translocation of N to grain. Besides, the increases may also be related to the role of Fe in chlorophyll formation, respiration, photosynthesis and symbiotic N fixation in plant (Hemn, 2013) [9] while Zn is required as structural and catalytic components of protein and enzymes for normal growth and development (Broadley *et al.*, 2007) [5], thus application of micronutrients increased the crude protein content of greengram grain. Krishna (1995) [12] also reported a significant positive effect of zinc treatment on crude protein content in the seeds of mungbean. Iqtidar and Rahman (1984) [10] found that essential amino acid increased with increasing B supply. Thus inclusion of B in the treatment had a positive role on protein synthesis (Raj, 1985) [16]. Therefore, applications of micronutrients in addition

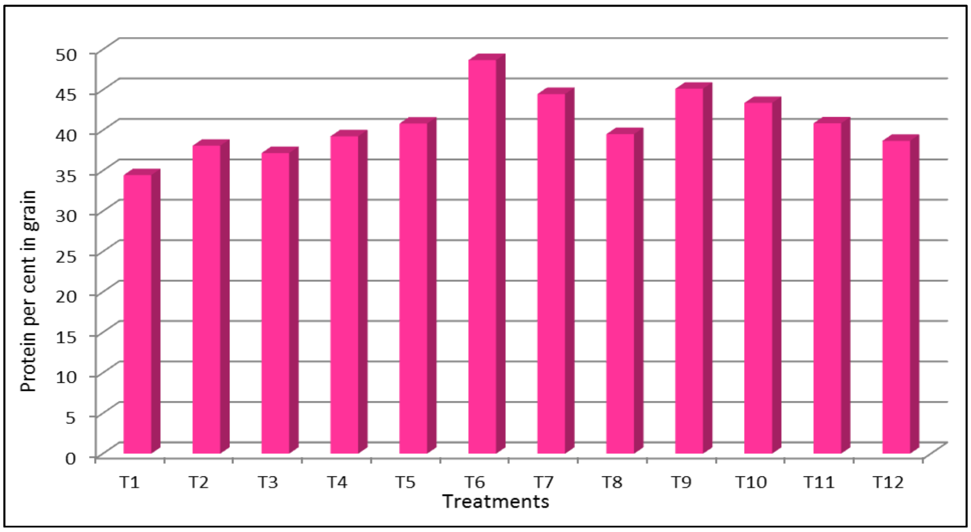

Fig 1: Protein (%) content in grain as influenced by application of micronutrients mixture in greengram at harvest.

Micronutrient status (mg kg^{-1}) of post-harvest soil as influenced by multi-micronutrient mixture.

Available Iron, manganese, zinc, copper and boron status of the soil after harvest of the crop increased significantly due to application of RDF and micronutrients mixture along with RDF (Fig.1 and 2). Highest Iron (9.50 mg kg^{-1}), manganese (8.88 mg kg^{-1}), zinc (1.10 mg kg^{-1}), copper (0.51 mg kg^{-1}) and boron (0.77mg kg^{-1}) content in post-harvest soil was recorded with soil application of RDF+ micronutrients mixture. The lowest fertility status was observed in control (T_1). The higher fertility status observed after the harvest of greengram with the application of RDF and micronutrients might be attributed to supply of these nutrients from external source and also could be due to improved nitrogen fixation. Hemn Othman Salih (2013) [9] noted that soil N content increases with soil or foliar application of micronutrients. The balanced supply of nutrients might have improved the root growth which added root litter to the soil thus increasing the nutrient status in post-harvest soil. Quddus *et al*. (2011) [17] also observed similar increase in both macro and micro nutrients status with the application of Zn and B. Poongothai and Chitdeshwari, (2003) [15] reported that Application of 5.0 kg Zn + 1.5 kg B + 0.5 kg Mo + 40 kg S ha^{-1} to blackgram has significantly enhanced the available nutrient status of the post-harvest soil. These findings are in accordance with those reported by Kannan *et al*. (2014) [11] and Malla Reddy *et al.* (2007) [13]. Singh *et al.*, (2003) [19] reported that inclusion of pulses in intensive agriculture is beneficial in improving the soil fertility.

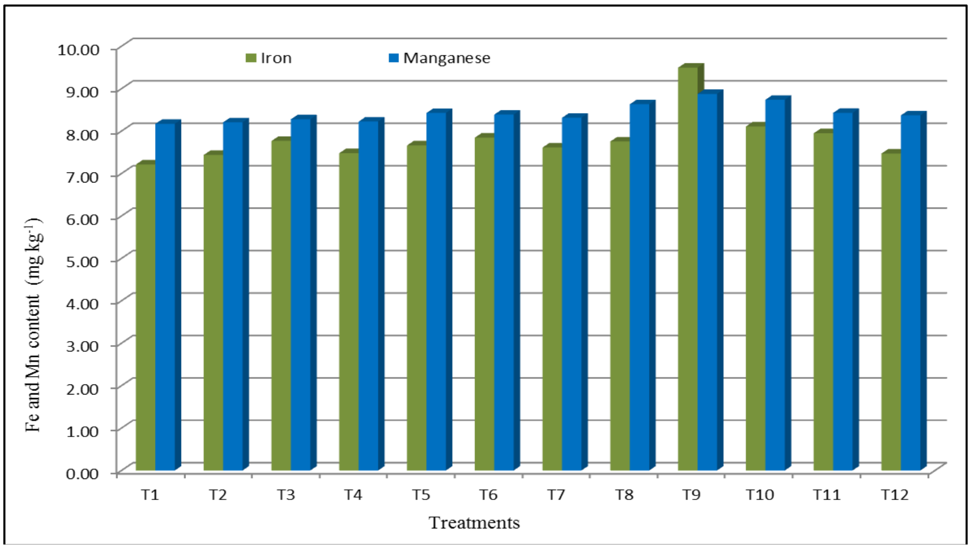

Fig 2: DTPA extractable Fe, Mn, content (mg kg^{-1}) in soil as influenced by application of micronutrients mixture in mungbean at harvest

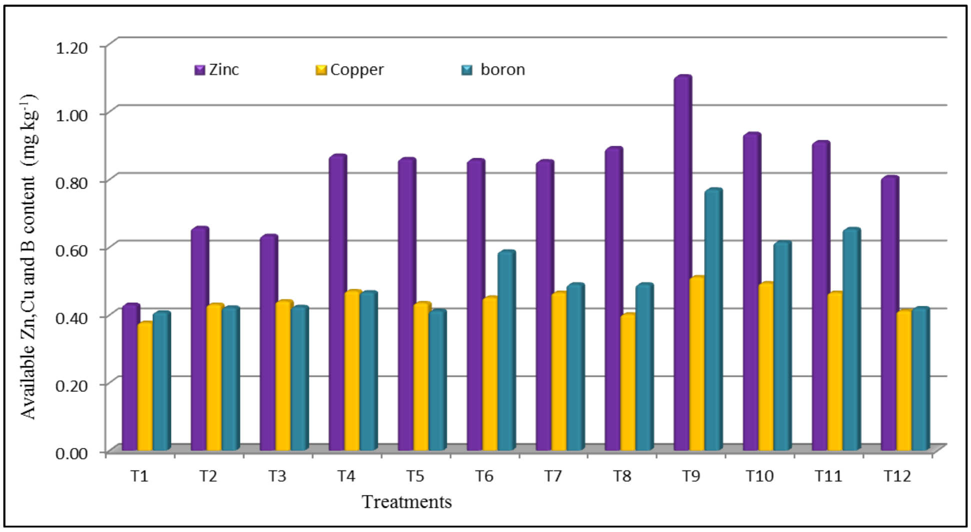

Fig 3: DTPA extractable Fe, Mn, Zn, Cu and hot water soluble B content (mg kg^{-1}) in soil as influenced by application of micronutrients mixture at harvest.

Conclusion

The results indicated that soil or foliar application of micronutrients mixture along with RDF can significantly enhance the growth and yield of greengram. Application of micronutrients mixture ensure the balanced supply of nutrients which in turn helps in improving the nutritional quality of greengram.

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