Biological Forum – An International Journal 16(7): 318-323(2024)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Enhancing Production Potential of Mungbean and Improves Soil Fertility Status of Soil through Soil and Foliar fertilization of Micronutrients

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(Received: 03 May 2024; Revised: 22 May 2024; Accepted: 19 June 2024; Published: 15 July 2024)
(Published by Research Trend)

ABSTRACT: A field experiment entitled "Effect of soil and foliar application of micronutrients on growth, yield and quality of mungbean (*Vigna radiata* L.)" was conducted at Agronomy farm, S.K.N College of Agriculture, Jobner during *Rabi*, 2013-14. The experiment included 16 treatment combinations comprising 4 levels of soil application (control, ferrous sulphate @ 50 kg/ha, zinc sulphate @ 25 kg/ha and borex @ 1.5 kg/ha) and four level of foliar spray (control, ferrous sulphate @ 0.5%, zinc sulphate @ 0.5 % and borex @ 0.2%). These were evaluated under Randomized block design with three replications. The result indicate that among the treatments applied as soil, application of zinc sulphate @ 25 kg/ha being at par with ferrous sulphate @ 50 kg/ha recorded significantly seed, straw, biological and protein yield of mungbean over control and when foliar application significantly maximum increase grain, straw, biological and protein yield were recorded with foliar spray of zinc sulphate @ 0.5 % over control. The soil application of micronutrients results revealed that The significantly highest organic carbon (20.9 g/kg) and availanle-N (152.65 kh/ha) in soil was recorded with soil application of zinc sulphate @ 25 kg/ha (T_2) followed by ferrous sulphate @ 50 kg/ha(T_1), respectively. The available P and available K were found non-significant with soil application of micronutrients. The significantly highest ferrous content recorded with the application of 50 kg/ha $FeSO_4$ and the borex content was significantly increased with the application of borex @ 1.5 kg/ha. When foliar application of micronutrients available N, P and K content in soil were found non-significant and DTPA-Zn, Fe and B were found significantly.

Keywords: Production potential, Biological yield, soil nutrients, mungbean.

INTRODUCTION

Greengram (*Vigna radiata* L.), is a plant species in the legume family and is commonly called mung bean or moong in India. Mung bean is an excellent source of high-quality protein and contains about 22-25% protein, 1.0-1.5% oil, 3.5-4.5% fibre, 4.8% ash and 62-65% carbohydrates on dry weight basis. India is its primary origin and is mainly cultivated in East Asia, South East Asia and the Indian subcontinent. It is the third important pulse crop in the country, which occupies nearly 16 per cent of the total pulse area in India. According to the Directorate of Pulses Development Report 2022-2023 mungbean area in India 55.47 lack hectare, production 36.76 lack ton and productivity 663 kg per hectare in the Rajasthan area, production and productivity is 23.32 lack hectare, 11.79 lack tons and 505 kg per hectare respectively.

The global issue to adoption the strategies for sustainable crop production in the degrading soil health and environment is losses of major as well as micronutrient (Ram *et al.,* 2022). Global food production and distribution have been severely strained by booming population, climate variability, industrial emissions, and growing fuel and power demands. According to the Food and Agriculture Organization (FAO, 2017), around 2050, the population of the planet would have surpassed 10 billion, resulting in a 50 percent increase in food requirement, predominantly in developing countries. Worldwide, micronutrient deficiencies impact approximately 38% of pregnant mothers and 43% of preschool-aged children. According to reports, over 30% of people on the planet are anemic and experiencing hidden hunger (Stevens *et al*., 2013; Dogra *et al.,* 2024). The present research is emphasis on the research need micronutrient deficiency caused the reduction in yield of crop (Bashir *et al.,* 2022). Micronutrient deficiencies in soil and crop plants are widespread because of increased micronutrient demand from intensive cropping practices and adaptation of high-yielding crop cultivars, enhanced crop production on marginal soils that contain low levels of essential micronutrients, increased use of high analysis fertilizers with low amounts of micronutrients. Boradkar *et al.* (2022) reported that as much as 48, 12, 5, 4, 33, 13, and 41 percent of soils in India are affected by deficiency of Zn, Fe, Mn, Cu, B, Mo, and S, respectively. Farmers generally applied only major nutrients and not the micronutrients are lacking. Micronutrients like Iron, Zinc, Manganese, Copper, Molybdenum, and Boron are important in increasing legume yield through their effect on the plant itself, nitrogen-fixing symbiotic process, and effective use of major and secondary nutrients. However, they are used in lower amounts as compared to macronutrients. They have a major role in cell division, development of meristematic tissues, photosynthesis, respiration, and acceleration of plant maturity. Nowadays micronutrient deficiencies are found limiting factors for crop growth and optimum yield. 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 in leaves (Nasiri *et al*., 2010).

Iron and zinc deficiency and malnutrition in animal kingdom are one of the major public health concerns for the developing countries (Zargar *et al.,* 2015). According to Stoltzfus *et al.* (2004) estimated 2 billion populations across the world as globally affected by iron deficiency. Estimation around 60-70% the world's total population has iron deficiency. Iron deficiency mainly results in anaemia, leading to functional impairments of the human body (Cappellini *et al.,* 2020). The recommended daily allowance of iron is 13 mg per day for children, 17 mg per day for adult. Micronutrient malnutrition is one of the attention-drawing problems in the developing world. Zinc deficiency is currently listed as a major risk factor for human health and cause of death globally (Cakmak *et al*., 1998; Jat *et al.,* 2022). The deficiencies iron and Zinc micronutrients drastically affect the growth and development, metabolism and reproductive phase in plants, animal and human beings (Rattan *et al*., 2009). In India, about 230 million people are estimated to be undernourished, accounting for more than 27 % of the world's undernourished population (Chakraborti *et al*., 2011). A study by Hossain *et al.* (2019) reported that the application of micronutrients improved the quality of soil organic matter, which led to improved soil structure and increased soil nutrient availability. A study by Kaur and Singh (2020) investigated the impact of micronutrients on soil microbial communities and found that the application of micronutrients increased soil microbial diversity and activity, which improved soil nutrient cycling and contributed to environmental sustainability. Furthermore, a study by Ali *et al.* (2020) investigated the impact of micronutrients on soil microbial communities and found that the application of micronutrients, such as zinc and manganese, increased soil microbial diversity and activity, leading to improved soil nutrient cycling and environmental sustainability.

MATERIAL AND METHODS

A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner-Jaipur. Geographically, Jobner is situated at 75° 28′ East longitude and 26°08′ North latitude and 427 m above mean sea level. This area falls under Agro-climatic zone – IIIa (Semi-Arid Eastern Plain) of Rajasthan. The experiment included 16 treatment combinations comprising four levels of soil application (control, ferrous sulphate @ 50 kg/ha, zinc sulphate @ 25 kg/ha and borex @ 1.5 kg/ha) and four level of foliar spray (control, ferrous sulphate @ 0.5%, zinc sulphate @ 0.5 % and borex @ 0.2%). These were evaluated under Randomized Block Design with three replications. The soil of experimental field was loamy sand in texture having soil pH 8.4, low in available nitrogen (143 kg/ha) available phosphrous (18.43 kg/ha) and in organic carbon (16.0 g kg^{-1}) medium available potassium (168.5 kg/ha).

Mungbean crop (RMG-268) was sown on July 13, 2014 in furrows at a row spacing of 30 cm apart. Seed @ 20 kg/ha was treated with carbandaz in @ 3.0g/kg seed. Crop was fertilized uniform basal dose of 25 kg N ha-1 was applied through DAP and urea to the soil phosphorus through 40 kg P_2O_5 ha^{-1} and the quantity of NPK was applied as basal in furrow below the seed uniformly in all treatments. Zinc (25 kg $ZnSo_4$/ha), boron (1.5 kg borex /ha) and iron (50 kg $FeSo_4$/ha), were applied prior to sowing through broadcasting and mixed thoroughly in the soil and foliar application of iron sulphate (0.5 % $FeSo_4.7H_2O$), zinc sulphate (0.5 % $ZnSo_4.7H_2O$) and boron (0.2 % Borex) was done at flower initiation and pod initiation separately and both the stages with water, respectively. Plant spacing of 10 cm was maintained by thinning operation. Crop was raised under *rainfed* condition, which was received 400 to 500 mm rainfall during cropping period out of an annual rainfall condition of 660 mm. The production potential parameters were observed as seed yield, straw yield, biological yield and protein yield of mungbean at harvest the crop. Protein yield was calculated by seed yield and protein content in seed (Kumar *et al.,* 2017). Initial soil samples were collected from surface soil (0-15 cm depth) and analyzed for physicochemical properties (Table 1). The rhizospheric soil collected from surrounding of cabbage plant roots from each plot at harvesting of crop and brought to laboratory. Air dried soil samples were ground to pass through 2 mm mesh sieve. The soil properties were analyzed by standard methods as given in Table 1. The data gathered in each observation were statistically analyzed using analysis of variance technique and significant differences among treatments mean were tested using least significant difference (LSD) test at 5% probability (Gomez and Gomez 1984).

RESULT AND DISCUSSION

A. Effect on production potential

Soil application and foliar spray of ferrous sulphate, zinc sulphate and borex significantly increased the seed yield of mungbean over control (Table 2). The highest increase in seed yield recorded with the soil application of 25 kg zinc sulphate/ha (T_2) was 27.93 per cent higher over control, whereas, foliar spray of 0.5% zinc sulphate (F_2) registered 22.04 per cent higher over control. The data of seed yield was ranged 981 kg/ha to 1255 kg/ha with soil application of ferrous sulphate, zinc sulphate and borex, whereas foliar application of ferrous sulphate, zinc sulphate and borex were ranged from 1016 kg/ha to 1240 kg/ha seed yield. The treatment T_1,T_2, and F_1,F_2 were remained statistically at par with each other. Soil as well as foliar application of ferrous sulphate, zinc sulphate and borex significantly increased the straw yield of mungbean over control. The straw yield ranged from 2481 kg/ha to 3129 kg/ha under soil application of ferrous sulphate, zinc sulphate and borex, whereas, straw yield with the foliar spray of ferrous sulphate, zinc sulphate and borex (F_0 to F_3) ranged between 2626 kg/ha to 3035 kg/ha. The highest increase in straw yield was recorded as 26.11 % higher over control with the soil application of zinc sulphate @ 25 kg/ha (T_2) whereas highest 15.57 % increase in straw yield was recorded with the treatment F_2 (foliar spray of zinc sulphate @ 0.5%). The treatment T_1,T_2, and F_1,F_2 were remained statistically at par with each other. Similar results were finding of biological and protein yield.

A positive correlation between grain yield and available soil Zn and Fe was also observed by Habib (2012); Jat *et al.* (2022). Similar results showed that foliar fertilization of NPK with Fe, Zn and Mn reflected increases in vegetative growth, yield component and nutrient concentrations by cowpea plant (Ali *et al.,* 2014; Mona and Azab 2016). The addition of zinc and ferrous to the soil might have also caused higher activation of micronutrients mainly due to its beneficial effects in mobilizing the native nutrients to increase their availability besides addition of zinc and ferrous to the soil to provide better nutrition over longer time and synergistic effect of both nutrients on yield component (Gaffar *et al*., 2011). Similar results were also reported with soil application of zinc by Singh and Gupta (1996) in chickpea and Mondal *et al.* (2012) in mungbean. The foliar application of micro elements might have increased the plant height, leaf area index, 1000-grain weight, chlorophyll (a), chlorophyll (b) and total chlorophyll, grain protein percentage, proline accumulation and with and without stress condition (Amirani and Kasraei 2015). The significant increase in yield and yield attributes due to foliar application of ferrous sulphate, zinc sulphate and borex might be due to increased leaf area (Kumar *et al*., 2002; Kumawat *et al*., 2006; Ali *et al*., 2008). The effect of micronutrient play important role to increase plant height (cm), number of productive branches, number of leaves, leaf area (cm^2), fresh weight (g), dry weight (g), number of pod per plant, seed yield per plant and 1000-seed weight of mungbean (Malik *et al.*, 2015). Such enhancement effect might be also attributed to the favorable influence of these nutrients on metabolism and biological activity and stimulatory effect on photosynthetic pigments and enzymatic activity which in turn increase vegetative growth of plants (Thalooth *et al.*, 2006). The increase in ferrous supply may also result in enhanced synthesis of carbohydrates. The similar findings were also observed by Mundra and Bhati(1994) in chick pea, (Kumawat *et al*., 2006) in mungbean, Bhat *et al.* (2023); Dogra *et al.* (2024). The increase in yield attributes and yield with foliar application of zinc sulphate were also reported by Kumar *et al*. (2002) in mungbean and ferrous sulphate by Manohar (1979) in mungbean and combined application by Kalidasu *et al*. (2008) in coriander, Ravi *et al.*(2008) ; Habib (2012) in wheat and Sanjay-Swami (2021) in mustard. The increase in protein content a may also be resulted due to increase in photosynthetic rates and chlorophyll content in leaves of the plants and ultimately increase in growth and development of the crop (Shahrokhi *et al*., 2012). Zn deficiency is one of the most common widespread disorders in plants and soils of different regions of India. Importance of Zn as a micronutrient in crop production has increased in recent years, hence considered to be the most yield-limiting micronutrient (Anita *et al.,* 2012). Application of Fe fertilizer also enhanced the quality as well as chickpea yield (Pingoliya *et al*., 2014) and work confirmed by Porkodi *et al.* (2023); Dogra *et al.* (2024).

B. Effect on Soil properties

The organic carbon in soil was significantly influenced with soil and foliar application of zinc sulphate, ferrous sulphate and borex (Table 3). The maximum organic carbon in soil 20.90 g/kg was recorded due to soil application of 25 kg zinc sulphate/ha (T_2). The foliar spray of 0.5% zinc sulphate (F_2), gave 10.58 per cent increase in organic carbon content over control. The treatment T_1,T_2, and F_2, F_3 were remained statistically at par with each other. The highest available nitrogen content (152.65 kg/ha) in soil was recorded under soil application of 25 kg/ha zinc sulphate which was registered 8.83% higher over control in available nitrogen content. The treatment T_1 remained at par with T_2. Foliar application of ferrous sulphate, zinc sulphate and borex treatment were found statistically non-significant in available nitrogen content of the soil. The available phosphorus and potassium content in soil at harvest of the crop revealed that soil application as well as foliar spray of ferrous sulphate, zinc sulphate and borex had non-significant effect on available phosphorus content of soil. Data pertaining to available iron revealed that the soil application of ferrous sulphate as well as foliar application had significant effect on available iron content in soil at harvest of the crop. Available iron content was ranged from 4.89 mg/kg to 6.15 mg/kg and foliar application of ferrous sulphate was ranged from 4.79 mg/kg to 6.08 mg/kg, respectively. The increase in available iron content of soil and foliar application was recorded as 21.39% and 22.27% higher over control, respectively. The values of soil application of available zinc were ranged from 0.502 mg/kg to 0.591 mg/kg and T_2, and foliar application of zinc sulphate was ranged from 0.502 mg/kg to 0.596 mg/kg., respectively. The increase in available zinc content of soil and foliar application was recorded as 17.72% and 19.12% higher over control, respectively. The values of soil application of available boron were ranged from 0.51 mg/kg to 0.76 mg/kg and foliar application of borex was ranged from 0.54 mg/kg to 0.76 mg/kg, respectively. The increase in available boron content in soil and foliar application was recorded as 16.55% and 14.28% higher over control, respectively. The experimental soil being low in available ferrous and zinc might have resulted increased available zinc and ferrous with the increase in the level of zinc sulphate and ferrous sulphate application. The increase in available status of Zn and Fe may also be due to higher amount depletion of Zn and Fe resulted due to low nutrient use efficiency of the crop with applied micronutrient fertilizer. The available-P content of the soil after the harvest of the mungbean crop was non- significant with the increase in the level of zinc sulphate application 25 kg/ ha. The increase in the available phosphorus due to increasing level of zinc and ferrous could be ascribed to the established fact that phosphorus have antagonistic relationship with zinc and ferrous which might have worked in the present case. Research works of Gupta (1994); Gour (1994); (2005) Jat *et al.* (2022) ; Porkodi *et al.* (2023) also support the experimental findings under the present study.

Table 1: Initial Physical and chemical properties of experimental soil.

Sr. No.	Characteristic	Value	Method followed with reference
A.	**Physical properties**		
1.	Mechanical composition		International pipette method Piper (1950)
i.	Coarse sand (%)	25.5	
ii.	Fine sand (%)	58.2	
iii.	Silt (%)	8.7	
iv.	Clay (%)	6.8	
	Textural class	Loamy sand	
2.	Bulk density	1.52	Pycnometer method USDA Hand Book No. 60 (Richards,1954)
4.	Saturated hydraulic conductivity (cm hr^{-1})	10.20	Constant head method using undisturbed core (Majumdar and Singh 2000)
5.	Basic infiltration rate (cm hr^{-1})	22.46	Using double ring infiltrometer (Majumdar and Singh 2000)
B.	**Chemical properties**		
1.	Available nitrogen (kg ha^{-1})	143	Alkaline permanganate method (Subbiah and Ashija 1956)
2.	Available phosphorus (kg ha^{-1})	18.8	0.5 M $NaHCO_3$ (pH 8.5) extractable P_2O_5 (Olsen *et al.*, 1956)
3.	Available potassium (kg ha^{-1})	168.46	Neutral 1N ammonium acetate K using flame photometer (Metson, 1956)
4.	Available zinc (mg kg^{-1})	0.532	DTPA-extractable using atomic absorption spectro-photometer (Lindsay and Norvell 1978)
5.	Available Fe (mg kg^{-1})	4.80	
6.	Available boron (mg kg^{-1})	0.56	Hot water extractable (Berger and Truog 1939)
7.	Organic carbon (g kg^{-1})	16.0	Rapid titration method (Walkely and Black's 1934)
8.	EC_2 at 25°C (dSm^{-1})	0.17	EC meter using 1:2 soil water suspension (Piper, 1950)
9.	pH_2	8.4	pH meter using glass electrode (Piper, 1950)

Table 2: Effect of soil and foliar application of micronutrients on seed, straw, biological and protein yieldof mungbean crop.

Treatments	Seed (kg ha^{-1})	Straw (kg ha^{-1})	Biological yield (kg ha^{-1})	Protein Yield (kg ha^{-1})
Soil application				
T_0- control	981	2481	3463	204.15
T_1- 50 kg $FeSO_4.7H_2O$	1234	3085	4320	279.99
T_2 -25 kg $ZnSO_4.7H_2O$	1255	3129	4385	284.01
T_3- 1.5 kg Borex	1144	2861	4006	245.27
SEm±	24.05	68.39	91.44	11.02
CD (P=0.05)	69.44	197.49	260.93	31.06
Foliar application				
F_0- water spray	1016	2626	3643	199.85
F_1- 0.5% $FeSO_4.7H_2O$	1219	3011	4231	280.49
F_2- 0.5% $ZnSO_4.7H_2O$	1240	3035	4276	283.71
F_3- 0.2% Borex	1139	2884	4024	250.58
SEm±	24.05	68.39	91.44	11.02
CD (P=0.05)	69.44	197.49	260.93	31.06

Table 3: Effect of soil and foliar application of micronutrients on soil properties at harvest of mungbean crop.

Treatments	Organic carbon (g/kg)	Available N content (kg ha^{-1})	Available P_2O_5 content (kg ha^{-1})	Available K_2O content (kg ha^{-1})	Available Fe content (mg/kg)	Available Zn content (mg/kg)	Available B content (mg/kg)
Soil application							
T_0- control	18.9	140.26	17.85	162.55	4.89	0.502	0.51
T_1- 50 kg $FeSO_4.7H_2O$	20.6	152.58	18.35	168.48	6.15	0.588	0.74
T_2 -25 kg $ZnSO_4.7H_2O$	20.9	152.65	16.92	170.65	6.05	0.591	0.72
T_3- 1.5 kg Borex	19.8	147.95	18.10	165.82	5.85	0.583	0.76
SEm±	0.22	3.58	0.37	3.87	0.12	0.009	0.011
CD (P=0.05)	0.64	10.35	NS	NS	0.34	0.026	0.031
Foliar application							
F_0- water spray	19.0	145.63	17.71	161.91	4.79	0.502	0.54
F_1- 0.5% $FeSO_4.7H_2O$	20.4	152.60	18.33	168.16	6.08	0.587	0.70
F_2- 0.5% $ZnSO_4.7H_2O$	20.7	153.37	17.00	171.48	6.05	0.596	0.74
F_3- 0.2% Borex	20.0	152.85	18.19	165.95	6.03	0.579	0.76
SEm±	0.22	3.58	0.37	3.87	0.12	0.009	0.011
CD (P=0.05)	0.64	NS	NS	NS	0.34	0.026	0.031

CONCLUSIONS

The result indicate that among the treatments applied as soil application of zinc sulphate @ 25 kg/ha being at par with ferrous sulphate @ 50 kg/ha recorded significantly seed, straw, biological and protein yield of mungbean over control and when foliar application significantly maximum increase grain, straw, biological and protein yield were recorded with foliar spray of zinc sulphate @ 0.5 % over control. The soil application of micronutrients results revealed that The significantly increased in organic carbon and availanle-N, DTPA-Fe, Zn and extractable-B in soil and available P and available K were found non-significant with soil application of micronutrients. When foliar application of micronutrients available N, P and K content in soil were found non-significant and DTPA-Zn, Fe and B were found significantly.

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How to cite this article: Rajhans Verma, Parvati Deewan, Madhuri Meena, Suresh Kumar Fagodia and Shyopal Jat (2024). Enhancing Production Potential of Mungbean and Improves Soil Fertility Status of Soil through Soil and Foliar fertilization of Micronutrients. *Biological Forum – An International Journal, 16*(7): 318-323.