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Research Article

Biochemical Assessment and Yield of Mungbean as Influenced By Zinc and Iron Fertilization

Navratan Gahlot[1]*, Ummed Singh[1], Moola Ram[2], M. L. Mehriya[2], Hitesh Borana[1] and Mukesh Mandiwal[1]

[1]Department of Agronomy, College of Agriculture, Mandor, Jodhpur, India
[2]Agricultural Research Station, Mandor, Agriculture University, Jodhpur, India

Abstract

The experiment was conducted at Agricultural Research Station, Mandor, Agriculture University, Jodhpur during *kharif* (rainy) season of 2018 on sandy loam soil of low nitrogen, phosphorus, zinc, iron and medium potassium content with 7.8 pH. Among ten treatments, soil application of zinc sulphate @ 25 kg ha^{-1} combined with its foliar spray of 0.5% at 35 DAS (T_4) recorded significantly higher zinc content in mungbean grains and stover (29.24 ppm and 14.3 ppm), respectively over control (21.77 ppm). Similarly, soil application of ferrous sulphate @ 25 kg ha^{-1} combined with its foliar spray (0.5%) at 35 DAS (T_7) resulted in maximum iron content in mungbean grains and stover (152.2 ppm and 96.5 ppm) over control (135.1 ppm). The significant maximum nitrogen and protein content (4.09 and 25.6%) of mungbean grains was recorded when soil application of both zinc sulphate and iron sulphate were applied each @ 25 kg ha^{-1} along with foliar application of iron sulphate @ 0.5% at 35 DAS (T_{10}). The treatment T_{10} also recorded significantly maximum grain, stover and biological yield (1357, 2492 and 3849 kg ha^{-1}, respectively) over control. Therefore it was concluded that mungbean protein, nutrient content and uptake and yield can be increased substantially due to soil application of zinc sulphate and ferrous sulphate each @ 25 kg ha^{-1} followed by foliar application of ferrous sulphate @ 0.5% at 35 DAS in western Rajasthan conditions.

Keywords: Mungbean Protein, Nutrient Content, Nutrient Uptake, Zinc Sulphate, Ferrous Sulphate, Soil and Foliar Application

***Correspondence**
Author: Navratan Gahlot
Email: gahlotnavratan51@gmail.com

Introduction

Mungbean [*Vigna radiata* (L.) Wilczek] accounts for 1.92 million hectares area with the production of 1.24 million tonnes in Rajasthan out of 4.25 million hectares area with 2.41 million tonnes production in India (Anonymous, 2019) [1]. This signifies the important of mungbean in the state. It finds third place among pulses in terms of importance in India after chick pea and pigeon pea. It is mostly grown in Rajasthan, Uttar Pradesh, Orissa, Maharashtra, Karnataka and Bihar. In Rajasthan it is mainly cultivated in arid and semi-arid districts of the state including Nagaur, Jaipur, Jodhpur, Sikar, Pali, Jhunjhunu and Ajmer. Although Rajasthan contributes about 45% of total mungbean area in India, the average productivity in the state is not quite better. Besides vagaries of monsoon, the majority of soils of Rajasthan are desertic, calcareous, coarse textured with high pH and very low in organic carbon. Crop grown under such soil conditions would suffer multi-nutrient deficiency including iron and zinc which are becoming a major limiting factor for getting higher yield of crops [2]. Singh (2008) [3] reported that Indian soils are deficient in Zn and Fe by 48% and 12%, respectively. The role of iron and zinc has been very crucial in plant system because both micronutrients have involvement in the various courses of plant growth and development [4, 5]. The beneficial effects of micronutrients (Zn and Fe) application on growth attributes and productivity potential of pulses in different soil and agro-climatic conditions had been reported by many workers [6-9]. In view of this, an attempt was made to enhance productivity of mungbean through zinc and iron application in conditions of western Rajasthan.

Materials and Methods

The experiment was conducted at Agricultural Research Station-Mandor, Agriculture University, Jodhpur during *kharif* season of 2018 on sandy loam soil of low nitrogen, phosphorus, zinc, iron and medium potassium content with 7.8 pH. The mean daily maximum and minimum temperature fluctuated between 31.6 to 39.7^{0} C and 23.9 to 29.5^{0} C, respectively during the crop growing season. There was total 227.2 mm of rainfall received in 15 rainy days during the *kharif* season (26th MW, 2018 to 38th MW, 2018). The experiment was laid out in Randomized Block Design with ten treatments and three replications. The treatments comprised of T_1- RDF (common to all treatments), T_2- Soil application of zinc sulphate @ 25 kg ha^{-1}, T_3- Foliar application of zinc sulphate @ 0.5% at 35 DAS, T_4- T_2+T_3, T_5- Soil application of ferrous sulphate @ 25 kg ha^{-1}, T_6- Foliar application of ferrous sulphate @ 0.5% at 35 DAS, T_7- T_5 + T_6, T_8- Soil application of zinc sulphate and ferrous sulphate each @ 25 kg ha^{-1}, T_9- T_8 + T_3, T_{10}- T_8 + T_6. A basal dose of 15 kg nitrogen and 30 kg phosphorus/ha (RDF) were applied through urea and diammonium phosphate in all plots. Zinc and iron were applied through zinc sulphate heptahydrate and iron sulphate heptahydrate, respectively in individual plot as per treatments through broadcasting at the time of sowing and mixed thoroughly in the soil. Foliar application of zinc sulphate and iron sulphate was given at 35 DAS @ 5 g $liter^{-1}$ of water after cleaning the weeds from crop at 30 DAS. Crop variety GM 4 was sown on 5th July, 2018. One irrigation was applied at pre-flowering (25 DAS) for proper growth and development of crop during the growing season. The observations of yield and yield attributes were recorded at harvest. Harvest index (H.I.) was calculated by dividing economical yield (seed yield) by the biological yield (seed + stover) and represented in percentage and it was calculated as per formula advocated by Donald and Hamblin (1976) [10].

The samples for seed and stover were drawn from the lot of net plot yields. These samples were ground to a fine powder and were analyses for N content from seed, Zn and Fe content from seed and stover samples as per method given in **Table 1**. The uptake of Zn and Fe at harvest in grain and stover was estimated g ha^{-1} by using the following formula:

$$\text{Nutrient (Zn \& Fe) Uptake g ha}^{-1} = \frac{\text{Nutrient content in seed/stover (ppm)} \times \text{seed/stover yield (kg ha}^{-1})}{1000}$$

The protein content in grain was obtained by multiplying the per cent nitrogen content by 6.25[11].

Table 1 Reference and method adopted for nutrients analysis in plant sample

Plant analysis	**Reference and method of analysis**
N content (%)	N analyser fully automatic by Kelplus Classic DX-VA unit using kjeldahl method
Zn content	By wet digestion of plant samples with diacid (nitric and perchloric acid in ratio of 9:1) mixture. The aliquot of digested material was analyses with the help of AAS [12]
Fe content	By wet digestion of plant samples with diacid (nitric and perchloric acid in ratio of 9:1) mixture. The aliquot of digested material was analyses with the help of AAS [12]
Protein content	By multiplying %N in seed with a factor 6.25 [11]

Experimental data recorded in various observations were statistically analyzed in accordance with the 'Analysis of Variance' technique as described by [13]. The critical difference (CD) for the treatment comparisons were worked out where ever the variance ratio (F test) was found significant at 5% level of probability.

Results and Discussion

Nutrient content, uptake and quality attributes

Zinc content in grains

Soil application of zinc sulphate @ 25 kg ha^{-1} followed by its foliar spray of 0.5% at 35 DAS (T_4) recorded significantly higher zinc content in mungbean grains (29.24 ppm) over control (21.77 ppm). The zinc content increased when soil application of both zinc sulphate and iron sulphate were applied each @ 25 kg ha^{-1} along with foliar application of zinc sulphate @ 0.5% at 35 DAS (T_9) which recorded 37.6% higher zinc content over control **(Table 2)**. But T_9 was statistically at par with T_4. This was due to the role of zinc to increasing the cation exchange capacity of roots might have led to more absorption of nutrients from soil and further more translocation to different vegetative and reproductive parts which ultimately led to higher content in the grains as well as in the stover of the mungbean. Similar results were also reported with soil application of zinc in fenugreek by Sammuria (2007) [14] and Saini (2003) [15] in mothbean. Soil application of zinc fertilizer resulted in higher zinc enrichment in mungbean grains were also reported by Haider *et al*. 2018 [16].

Zinc content in stover

Zinc content in stover of mungbean was recorded significantly maximum (14.4 ppm) when soil application of both zinc sulphate and iron sulphate were applied each @ 25 kg ha^{-1} along with foliar application of zinc sulphate @ 0.5% at 35 DAS (T_9). However soil application of zinc sulphate @ 25 kg ha^{-1} combined with foliar application of zinc sulphate @ 0.5% at 35 DAS (T_4) recorded 14.3 ppm zinc content in stover which was statistically at par with T_9. The more absorption of zinc and iron through foliar nutrition to fulfill the unmet requirement of these nutrients from source to sink and thereby more content and uptake of these nutrients were recorded in the foliar treatment supplemented with soil application. These results of showing increment in quality parameters are in line with those earlier reported by Singh *et al*. (2013) [8] and Tak *et al*. (2014) [17] in mungbean due to foliar application of zinc sulphate. In this study the rest of the treatments did not significantly influence zinc content in mungbean stover except T_2, T_8 and T_{10} over control **(Table 2)**.

Table 2 Effect of zinc and iron application on zinc and iron content in grains, stover and total zinc and iron uptake by mungbean

Treatments	Zn content (ppm)		Total Zn uptake	Fe content (ppm)		Total Fe uptake
	Grains	Stover	(g ha^{-1})	Grains	Stover	(g ha^{-1})
T_1	21.77	11.72	43.07	135.10	87.47	294.98
T_2	27.26	13.50	64.10	135.11	87.47	364.25
T_3	22.85	12.80	48.06	135.12	87.48	307.44
T_4	29.24	14.28	70.18	135.12	87.49	373.71
T_5	21.78	11.74	46.36	144.60	92.40	335.73
T_6	21.77	11.72	46.48	148.20	93.07	342.98
T_7	21.78	11.73	48.57	152.17	96.53	368.43
T_8	27.27	13.55	68.83	144.67	92.42	414.58
T_9	29.45	14.82	75.33	146.00	93.77	423.26
T_{10}	27.28	13.58	70.80	153.37	98.88	453.45
SEm±	0.72	0.37	1.74	1.64	1.63	10.28
CD (P=0.05)	2.15	1.10	5.19	4.87	4.84	30.57

Total zinc uptake

The total zinc uptake of mungbean was significantly increased due to soil application of zinc sulphate alone and in combination with foliar application. The significantly maximum zinc uptake 75.33 g ha^{-1} was recorded due to soil application of 25 kg zinc sulphate ha^{-1} + 25 kg iron sulphate ha^{-1} + foliar application of 0.5% zinc sulphate at 35 DAS (T_9), which was followed by T_{10} (70.80 g ha^{-1}) and T_4 (70.18 g ha^{-1}), respectively over control **(Table 2)**. The alone soil application of 25 kg zinc sulphate ha^{-1} (T_2) was significantly better than its foliar application @ 0.5% at 35 DAS (T_3) with respect to zinc uptake. However combined application of T_2 + T_3 i.e. T_4 recorded significantly higher zinc uptake over T_3 as well as over control (T_1). The uptake of zinc largely depends on increment in the grain and stover yield of mungbean under all treatments since uptake is a calculated from their content and yields. Zinc has many beneficial roles in plant such as auxin formation, activation of dehydrogenase enzymes; stabilization of ribosomal fractions increasing the cation exchange capacity of roots, help in chlorophyll formation, regulating the auxin concentration and its stimulatory effect on most of the physiological and metabolic processes of the plant, production of photosynthates and their translocation to different plant parts including seed that might have ultimately led to absorption of more amount of these nutrients from soil and higher content and uptake of these nutrients in the seed and stover of mungbean. Similar results were also reported with soil application of zinc in fenugreek by Sammuria (2007) [14] and Saini (2003) [15] in mothbean.

Iron content in grains

The soil application of iron sulphate @ 25 kg ha^{-1} followed by its foliar spray of 0.5% at 35 DAS (T_7) recorded significantly higher iron content in mungbean grains (152.2 ppm) over control (135.1 ppm). The alone soil application of iron sulphate @ 25 kg ha^{-1} (T_5) and foliar application of iron sulphate @ 0.5% at 35 DAS (T_6) were at par with each other but recorded significantly higher iron content in grains (144.6 and 148.2 ppm), respectively over control **(Table 2)**. The iron content further increased when soil application of both zinc sulphate and iron sulphate were applied each @ 25 kg ha^{-1} along with foliar application of iron sulphate @ 0.5% at 35 DAS (T_{10}) which recorded 13.5% higher iron content over control. But T_{10} was statistically at par with T_7. Such increment in content of iron in seed and stover with the application of iron sulphate might be due to more availability and absorption of iron in rhizosphere resulting from application of these micronutrients to deficient soil. The increment in the zinc and iron content with the soil application of iron sulphate + zinc sulphate were noted by Bhamare *et al*. (2018) [18]. Increased concentration of iron with the soil application of iron fertilizer had also been reported by Kumawat *et al*. (2006) [7] and that of foliar application of iron sulphate by Fang *et al*. (2008) [19] in rice grain, Sohrabi *et al*. (2012) [20] in soybean and Meena *et al*. (2013) [21] in mungbean.

Iron content in stover

Perusal of data in Table 2 stated that iron content in stover of mungbean was recorded significantly maximum (98.9 ppm) when soil application of both zinc sulphate and iron sulphate were applied each @ 25 kg ha^{-1} along with foliar application of iron sulphate @ 0.5% at 35 DAS (T_{10}). However soil application of iron sulphate @ 25 kg ha^{-1} combined with foliar application of iron sulphate @ 0.5% at 35 DAS (T_7) recorded 96.5 ppm iron content in stover which was statistically at par with T_{10}. There was no increment in iron content where zinc sulphate treatment was applied and vice versa. This might be due to decreased concentration of iron resulting from non Fe treatment application leading to insufficient supply and increased concentration of zinc might have caused decreased absorption and translocation of native ferrous from the roots to shoot parts of the plant [22]. The reduced iron content in seed and straw with application of zinc were also observed by Gour (1994) [23] and Gupta (1994) [24] in fennel.

Total iron uptake

The total iron uptake of mungbean was significantly increased due to soil application of ferrous sulphate alone and in combination with foliar application **(Table 2)**. The maximum iron uptake 453.45 g ha^{-1} followed by 423.26 g ha^{-1} were recorded due to soil application of 25 kg zinc sulphate ha^{-1} + 25 kg iron sulphate ha^{-1} + foliar application of iron sulphate @ 0.5% at 35 DAS (T_{10}) and soil application of 25 kg zinc sulphate ha^{-1} + 25 kg iron sulphate ha^{-1} + foliar application of zinc sulphate @ 0.5% at 35 DAS (T_9) respectively, in which T_{10} was at par with T_9 and T_9 was numerically higher (at par) with T_8 (soil application of 25 kg zinc sulphate ha^{-1} + 25 kg iron sulphate ha^{-1}). Meena *et al*. (2013) [21] also recorded significantly higher iron content and uptake over control by foliar spray of iron sulphate in mungbean. The significant increased in iron uptake was noted due to zinc sulphate application and vice versa. This was probably due to increase in seed and stover yield of mungbean as uptake of nutrient is a function of their content and yields and this trend was similar in case of zinc uptake due to application of iron treatments.

Nitrogen and protein content in grains

The application of treatment T_{10} (soil application of both zinc sulphate and iron sulphate each @ 25 kg ha^{-1} along with foliar application of iron sulphate @ 0.5% at 35 DAS) recorded significantly maximum nitrogen and protein content 4.09 and 25.57%, respectively in mungbean grains which was followed by T_9 (4.0 and 24.98%) and T_8 (3.98 and 24.89%) being at par with each other **(Table 3)**. The basis of more protein content in mungbean grain might be enhanced activity of amino acid biosynthesis due to application of zinc and iron because both these micronutrients have involvement in the various courses of plant growth and development [4, 5]. The increased protein content might be due to increased N content [15] as zinc takes part in nitrate conversion to ammonia in plants [25]. The soil application of both micronutrient zinc and iron had increased the nitrogen content in mungbean grains was also reported by Jamal *et al.* 2018 [26]. The role of zinc in indole acetic acid synthesis results in amino acids which in turn makes protein [27]. The increase in protein content may also be due to increase in photosynthetic rates and chlorophyll content in leaves of the plants [28].

Table 3 Effect of zinc and iron application on nitrogen and protein content in grains, grain and stover yield and harvest index of mungbean

Treatments	N content in grains (%)	Protein content in grains (%)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_1	3.74	23.35	988	1852	2840	34.71
T_2	3.89	24.32	1224	2277	3501	35.03
T_3	3.79	23.66	1028	1927	2955	34.87
T_4	3.92	24.47	1262	2326	3588	35.15
T_5	3.87	24.19	1060	1977	3037	34.92
T_6	3.91	24.42	1070	1985	3056	34.97
T_7	3.92	24.48	1114	2068	3182	35.15
T_8	3.98	24.89	1323	2418	3741	35.37
T_9	4.00	24.98	1333	2441	3774	35.38
T_{10}	4.09	25.57	1357	2492	3849	35.39
SEm±	0.05	0.31	64.94	117.07	119.05	1.87
CD (P=0.05)	0.15	0.93	192.95	347.85	353.74	NS

Grain, stover, biological yield and harvest index

The application of treatment T_{10} (soil application of zinc sulphate and iron sulphate each @ 25 kg ha^{-1} along with foliar application of 0.5% iron sulphate) recorded significantly maximum grain, stover and biological yield (1357, 2492 and 3849 kg ha^{-1}), respectively over control which was followed by T_9 and T_8 being at par with each other **(Table 3)**. Harvest index of mungbean was found to be non significant due to different treatments pertaining to application of zinc sulphate and iron sulphate. The combined effect of zinc and iron provided sufficient nutrition to the plant and thereby more yield attributes and yield was recorded. The soil application of zinc and iron has synergistic effect [29]. The similar results of increased grain and straw yield and biological yield in mungbean with soil application of both zinc sulphate and iron sulphate were found by Jamal et al. (2018) [26] and Singh et al. (2013) [8] with respect to application of iron sulphate as soil+foliar spray in mungbean.

Figure General view of crop under treatment T_{10}

Correlation studies

The strong positive and significant correlation was also documented between zinc and iron uptake by grain and grain yield with the corresponding r values as 0.970 and 0.948, respectively **(Table 4)**. Similarly, high correlation was also noted between zinc and iron uptake by stover and stover yield with r value of 0.972 and 0.943. There was also positive correlation found in case of zinc and iron uptake and protein yield with its r value of 0.947and 0.972, respectively.

Table 4 Correlation coefficient and regression lines showing relationship between independent variables (X) and dependent variables (Y)

Independent variables (X)	Dependent variables (Y)	Correlation coefficient (r)	Regression lines (Y = a + bX)
Zinc uptake (g ha^{-1})	Grain yield (kg ha^{-1})	0.970^{**}	Y = 555.938 + 10.656X
Iron uptake (g ha^{-1})	Grain yield (kg ha^{-1})	0.948^{**}	Y = 220.365 + 2.597X
Zinc uptake (g ha^{-1})	Stover yield (kg ha^{-1})	0.972^{**}	Y = 1107.825 + 18.366X
Iron uptake (g ha^{-1})	Stover yield (kg ha^{-1})	0.943^{**}	Y = 541.177 + 4.445X
Zinc uptake (g ha^{-1})	Protein yield (kg ha^{-1})	0.947^{**}	Y = 110.746 + 3.045X
Iron uptake (g ha^{-1})	Protein yield (kg ha^{-1})	0.972^{**}	Y = 1.119 + 0.780X

**Significant at 1 per cent level of significance.

Conclusion

Indian soils are greatly deficient in zinc and iron micronutrients. Mungbean being an important pulse crop of short duration legume crop, it becomes essential to maintain and further increase the average productivity as well nutrient quality of this crop in the country. The results of this study would be helpful in recommending that mungbean quality and yield can be increased substantially with soil application of zinc sulphate and iron sulphate each @ 25 kg ha^{-1} followed by one foliar application of ferrous sulphate @ 0.5% at 35 days after sowing in western Rajasthan conditions.

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