International Journal of Plant & Soil Science

Volume 34, Issue 24, Page 990-995, 2022; Article no.IJPSS.96158
ISSN: 2320-7035

Productivity and Nutrient Uptake Influenced by Zinc and Iron on Summer Mungbean

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i242728

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/96158

Original Research Article

Received: 19/10/2022
Accepted: 30/12/2022
Published: 31/12/2022

ABSTRACT

Nutrient management is one of the most significant strategies that have an impact on mungbean (*Vigna radiata* L.) growth and development. Therefore, the field trial was carried out at RRTTSS, Kirei, Sundargarh during summer season 2021. Experiment consists of eight treatment including T_1- control (RDF: 20-40-20 kg/ha and FYM 5 tha^{-1}), T_2 - T_1+ 0.5% $ZnSO_4$ FI, T_3 - T_1+ 0.5% $ZnSO_4$ FI & PI, T_4 - T_1+ 0.5% $FeSO_4$ FI, T_5 - T_1+ 0.5% $FeSO_4$ FI & PI, T_6 - T_1+ 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ FI, T_7 - T_1+ 25 kgha^{-1} $ZnSO_4$ soil application, T_8 - T_1+ 50 kg ha^{-1} $FeSO_4$ soil application and replicated thrice with RBD. The results of the experiment revealed that yield attributes *viz.* pods per plant (15.63), seeds per pod (10.50), Seed yield (521 kg ha^{-1}) and stover yield (1307 kg ha^{-1}), total uptake of N (36.47 kg ha^{-1}), P (4.60 kg ha^{-1}), K (27.95 kg ha^{-1}), Zn (47.99 g ha^{-1}) and Fe (156.98 g ha^{-1}) were recorded significantly highest under the treatment of 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at flower initiation stage along with RDF and FYM. The highest N, P and K uptake was found with application of 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ at flower initiation stage (20.09 kg ha^{-1}), (2.17 kg ha^{-1}) and (3.37 kg ha^{-1}) in seed & stover (16.38 kg ha^{-1}), (2.43 kg ha^{-1}) and (24.58 kg ha^{-1}), respectively.

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Keywords: Zinc; iron; foliar application; mungbean; growth; yield and nutrient uptake.

1. INTRODUCTION

"Pulses are an important part of Indian agriculture after grains and oilseeds. It is more important in our country since they provide significantly more nutrients in Indian diets than they do in Asia or the rest of the world. In India pulses is grown on an area of about 283.4 lakh ha with the production of 23.15 million tons and productivity of 817 kg ha^{-1} [1]. For mankind, pulses are a vital source of nutritional protein, energy, minerals, and vitamins. Pulses meet 25% of the protein needs of the mostly vegetarian population. Pulses' lysine-rich protein is used to compensate lysine shortage in cereal diets.

Mungbean is an essential legume crop that is grown in the country's arid and semi-arid regions. It is India's third most significant pulse crop in terms of cultivated area and production Singh et al. [2]. "In comparison to experimental fields, mungbean productivity is poor in farmer fields. The potential yield of mungbean is limited by a variety of biotic and abiotic variables. Micronutrients such as iron and zinc, in addition to the primary plant nutrients, are vital for increasing mungbean productivity. The scarcity of these micronutrients has an impact on seed quality as well. Spraying micronutrients on mungbean improves their growth and quality. Many enzymes, including Tryptophan synthetase, superoxide dismutase, and dehydrogenases, require zinc to function. Zinc shortage affects the synthesis of RNA and protein. As a result, the zinc-deficient plant has a low protein content" [3]. Foliar spraying of Fe solutions in several crops, particularly legumes, is one of the most commonly used ways to treat Fe deficiency. In plants, iron plays a vital role in a variety of physiological and metabolic pathways. With these considerations in mind, the current study was designed to assess the effects of zinc and iron application on mungbean productivity and nutrient uptake.

2. MATERIALS AND METHODS

The field experiment was conducted during summer of 2021 on sandy loam soil at the field of Regional Research and Technology Transfer Sub Station (RRTTSS), Kirei, Sundargarh, Odisha to investigate the influence of zinc and iron on growth, yield and nutrient uptake of mungbean. The eight treatments combinations including T_1- control (RDF: 20-40-20 kg/ha and FYM 5 tha^{-1}), T_2 - T_1+ 0.5% $ZnSO_4$ FI, T_3 - T_1+ 0.5% $ZnSO_4$ FI & PI, T_4 - T_1+ 0.5% $FeSO_4$ FI, T_5 - T_1+ 0.5% $FeSO_4$ FI & PI, T_6 - T_1+ 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ FI, T_7 - T_1+ 25 $kgha^{-1}$ $ZnSO_4$ soil application, T_8 - T_1+ 50 $kgha^{-1}$ $FeSO_4$ soil application. All the eight treatments combinations were replicated thrice in randomized block design (RBD). The soil in the experimental field had a sandy loam texture, was acidic in response (pH 5.7), had low available nitrogen (145.41 kg ha^{-1}), medium available phosphorus (35.13 kg ha^{-1}), low available potassium (71.68 kg ha^{-1}), and low zinc and iron concentration (0.53 and 4.23 ppm, respectively).

Mungbean, IPM 02-14 variety was sown on 9^{th} February, 2021 in furrows at a spacing of 30×10 cm. Before sowing, seed @20 $kgha^{-1}$ was treated with Vitavax power @2 g kg^{-1} of seed. Five plants were chosen at random from each plot to record individual plant nutrient content and uptake in the leaves, shoot, root, and seed using various analyses. Standard procedures were used to conduct the soil analysis. At flower initiation and pod initiation, zinc sulphate and iron sulphate were applied as a 0.5 percent foliar treatment at both stages. Hand weeding and hoeing were performed after 20- and 35- days following seeding. Irrigation was started before the land was prepared, and it was repeated every 15 days after that. At the right time, important observations were recorded.

The N, P, K, Zn and Fe content was expressed as per cent and its uptake in kg/ha was calculated by using following formula

$$\text{Nutrient uptake (N, P and K kg/ha)} = \frac{\text{Nutrient content in seed \& stover (\%)} \times \text{Seed yield \& stover yield (kg/ha)}}{100}$$

$$\text{Nutrient uptake (Zn and Fe g/ha)} = \frac{\text{Nutrient content in seed \& stover (\%)} \times \text{Seed yield \& stover yield (kg/ha)}}{1000}$$

3. RESULTS AND DISCUSSION

3.1 Yield Attributes and Yield

Foliar spray of Zinc and iron treatment effect on yield attributes like pod length, harvest index was statistically similar. Yield attributes viz. pods per plant (15.63), seeds per pod (10.50), Seed yield (521 kg ha^{-1}) and stover yield (1307 kg ha^{-1}) were observed significantly higher in foliar spray of zinc and iron sulphate i.e., 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ at flower initiation stage. These results attributed to stimulatory effect of zinc and iron on most of the physiological and metabolic processes and nitrogen metabolism, synthesis of chlorophyll, plant growth regulator, improves photosynthesis and assimilates transportation to sink resulted enhanced seed yield of mungbean. The foliar application of zinc sulphate and iron sulphate at flower initiation and bud initiation stage are responsible for efficient translocation of photosynthate from source to sink, this causes' higher number of pod formation and higher test weight. These results are in accordance with Awlad, H.M. et al. [4] and Teixeira, I.R. et al. [5], Kumawat, R.N. et al. [6] and Soni and Kushwaha [7].

Seed yield (521 kg ha^{-1}) and stover yield (1307 kg ha^{-1}) was found to be higher with application of 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ at flower initiation stage, that might be due to significant effect on yield attributing characters like number of pods bearing branches per plant, pods per plant and 1000-seeds weight. Similarly higher yield attributes and yield were noticed with the combined foliar spray of micro nutrients with zinc attributed to optimum availability of nutrients for luxurious crop growth and efficient partitioning of assimilates from source to sink. "Higher stover yield of mungbean might be due to direct influence of zinc on auxin production which in turn enhanced the elongation processes of plant development" Prasanna, K.L. et al. [8] and Choudhary, P. et al. [9].

3.2 Nutrient Uptake

Soil and foliar application of $ZnSO_4$ and $FeSO_4$ significantly increased the N, P, K, Zn uptake by mungbean seed & stover. The highest N, P and K uptake was found with application of 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ at flower initiation stage (20.09 kg ha^{-1}), (2.17 kg ha^{-1}) and (3.37 kg ha^{-1}) in seed & stover (16.38 kg ha^{-1}), (2.43 kg ha^{-1}) and (24.58 kg ha^{-1}), respectively. "This might be due to increasing the cation exchange capacity of roots 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 seeds as well as in the stover of the mungbean. Similar results were also reported with soil application of zinc in fenugreek by Sammuria [10] and Saini [11] in mothbean. Soil application of zinc fertilizer resulted in higher zinc enrichment in mungbean grains" were also reported by Haider et al. [12] and Kudi et al. [13].

Total uptake of Zn (47.99 g ha^{-1}) was observed maximum in 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ spray at flower initiation. The more absorption of zinc and iron through foliar nutrition fulfill the unmet requirement of these nutrients from source to sink and thereby more content and uptake of these nutrients. These results are in line with those reported by Singh et al. [14], Tak et al. [15] and Solanki et al. [16] in mungbean.

"The maximum total uptake of Fe (156.98 g ha^{-1}) was observed under 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ spray at flower initiation. Such increment in content of iron in seed and stover with the application of iron sulphate might be due to more availability in rhizosphere and absorption of iron resulting from application of these micronutrients. The increment in the zinc and iron content with the soil application of iron sulphate + zinc sulphate" were noted by Bhamare et al. [17].

Foliar application of $FeSO_4$ enhanced the Fe contents in mungbean grains, which significantly increased the seed quality. This might be due to increased availability of physiologically active iron (Fe^{2+}) in the plant system which in turns affects various physiological functions of plants favorably. Since uptake is directly related to seed and stover yield and their nutrient concentration, the significant improvement in concentration of these nutrients coupled with seed and straw yield, increased the uptake of N, P, Zn and Fe significantly. Increased concentration of N, P, Zn and Fe with the application of iron fertilizer has also been reported by several researchers Kumawat et al. [6].

Table 1. Effect of application of zinc and iron on yield and yield attributes of summer mungbean

Treatments	At Harvest					
	Pods/plant	Pod length (cm)	Seeds/pod	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
T_1 - Control (RDF: 20-40-20 kg/ha and FYM 5 tha^{-1})	9.87	6.17	8.00	402.3	1074.7	27.24
T_2 - T_1+ 0.5% $ZnSO_4$ FI	14.77	6.60	10.10	502.3	1274.7	28.27
T_3 - T_1+ 0.5% $ZnSO_4$ FI & PI	15.03	7.03	10.30	511.3	1296.0	28.29
T_4 - T_1+ 0.5% $FeSO_4$ FI	12.97	6.57	9.33	456.0	1178.7	27.90
T_5 - T_1+ 0.5% $FeSO_4$ FI & PI	13.77	6.63	10.00	450.3	1169.0	27.81
T_6 - T_1+ 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ FI	15.63	7.03	10.50	521.0	1307.0	28.50
T_7 - T_1+ 25 kg/ha $ZnSO_4$ soil application	12.90	6.50	9.20	446.7	1195.0	27.21
T_8 - T_1+ 50 kg/ha $FeSO_4$ soil application	12.40	6.20	8.33	439.0	1202.7	26.74
SE (m)±	0.38	0.21	0.17	9.6	12.2	0.52
CD (P=0.05)	1.12	N/S	0.52	28.6	36.2	1.53

*RDF: Recommended Dose of Fertilizer, *FI: Flower Initiation, *PI: Pod Initiation, *SEm: Standard Error of the mean*

Table 2. Effect of application of zinc and iron on nutrient (N, P and K) uptake of mungbean

Treatments	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total
T_1 - Control (RDF: 20-40-20 kg/ha and FYM 5 tha^{-1})	13.50	6.85	20.35	1.23	1.33	2.55	2.07	13.32	15.39
T_2 - T_1+ 0.5% $ZnSO_4$ FI	19.14	14.00	33.15	1.91	2.12	4.03	3.08	22.04	25.12
T_3 - T_1+ 0.5% $ZnSO_4$ FI & PI	19.61	14.78	34.39	2.13	2.18	4.31	3.22	23.08	26.30
T_4 - T_1+ 0.5% $FeSO_4$ FI	16.25	10.89	27.14	1.65	1.89	3.54	2.48	19.51	21.99
T_5 - T_1+ 0.5% $FeSO_4$ FI & PI	17.72	11.77	29.49	1.73	1.94	3.67	2.84	20.31	23.15
T_6 - T_1+ 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ FI	20.09	16.38	36.47	2.17	2.43	4.60	3.37	24.58	27.95
T_7 - T_1+ 25 kg/ha $ZnSO_4$ soil application	15.22	9.69	24.91	1.53	1.70	3.24	2.40	18.03	20.43
T_8 - T_1+ 50 kg/ha $FeSO_4$ soil application	14.35	8.67	23.02	1.42	1.55	2.97	2.26	16.48	18.74
SE (m)±	0.12	0.38	0.45	0.09	0.03	0.09	0.08	0.13	0.16
CD (P=0.05)	0.35	1.13	1.33	0.26	0.08	0.26	0.23	0.38	0.48

*RDF: Recommended Dose of Fertilizer, *FI: Flower Initiation, *PI: Pod Initiation, *SEm: Standard Error of the mean*

Table 3. Effect of application of zinc and iron on nutrient (Zn and Fe) uptake of mungbean

Treatments	Zn uptake (g/ha)			Fe uptake (g/ha)		
	Seed	Stover	Total	Seed	Stover	Total
T_1 - Control (RDF: 20-40-20 kg/ha and FYM 5 tha^{-1})	11.80	12.28	24.08	29.75	58.26	88.00
T_2 - T_1+ 0.5% $ZnSO_4$ FI	24.72	20.26	44.98	39.78	90.01	129.79
T_3 - T_1+ 0.5% $ZnSO_4$ FI & PI	26.07	21.65	47.72	41.12	95.68	136.79
T_4 - T_1+ 0.5% $FeSO_4$ FI	18.94	18.73	37.67	46.55	95.57	142.11
T_5 - T_1+ 0.5% $FeSO_4$ FI & PI	20.29	19.38	39.67	55.93	99.09	155.02
T_6 - T_1+ 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ FI	25.70	22.29	47.99	54.08	102.90	156.98

Treatments	Zn uptake (g/ha)			Fe uptake (g/ha)		
	Seed	**Stover**	**Total**	**Seed**	**Stover**	**Total**
T_7 - T_1+ 25 kg/ha $ZnSO_4$ soil application	18.25	17.14	35.39	33.99	80.32	114.31
T_8 - T_1+ 50 kg/ha $FeSO_4$ soil application	15.05	15.85	30.90	38.71	70.75	109.46
SE (m)±	0.36	0.20	0.32	1.20	1.83	2.06
CD (P=0.05)	1.06	0.58	0.94	3.58	5.44	6.11

RDF: Recommended Dose of Fertilizer, *FI: Flower Initiation, *PI: Pod Initiation, *SEm: Standard Error of the mean

4. CONCLUSION

It is concluded that application of micronutrient (Zn & Fe) as a foliar spray have improved the yield and nutrient uptake of mungbean that might be due to application of treatment combinations $T_{2,}$ $T_{3,}$ T_5 and $T_{6.}$ So, it is strongly recommended to farmers to apply @ 0.5% $ZnSO_4$ and 0.5% $FeSO_4$ foliar spray at flower initiation stage along with RDF and FYM for better performance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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