

## Response of Mung Bean Crop to Different Levels of Applied Iron and Zinc

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**Keywords:** Mung bean, Nodules, Fe, Zn.

**Abstract.** Fertilization of Mung bean (*Vigna radiata* L.) is one of the most crucial management technique which effects crop growth and yield. Therefore the present study was carried out at Agricultural Research Station Kohat under rain fed conditions during spring 2017, to assess the response of mung bean (*Vigna radiata* L.) to three levels of iron (0, 2 and 5 kg ha<sup>-1</sup>) and three levels of zinc (0, 5 and 10 kg ha<sup>-1</sup>). The experiment was laid out in randomized complete design with split plot arrangement and replicated three times. The results revealed that application of Fe at the rate 5 kg ha<sup>-1</sup> and Zn at the rate 10 kg ha<sup>-1</sup> significantly increased biological yield, grain yield, straw yield, nodule numbers and weight by 5624 kg ha<sup>-1</sup>, 968 kg ha<sup>-1</sup>, 4655 kg ha<sup>-1</sup>, 35 and 0.67g respectively whereas the interaction was found non-significant. The nitrogen content in grains and straw was also significantly increased by 2.22% and 3.56% respectively with application of Fe at 5 kg ha<sup>-1</sup> and Zn at 10 kg ha<sup>-1</sup>, however their interaction was also found non-significant. Similarly, the plant nitrogen uptake was also significantly increased by 323.33 kg ha<sup>-1</sup> with application of Fe at 5 kg ha<sup>-1</sup> and Zn at 10 kg ha<sup>-1</sup>. It was concluded that Fe and Zn enhanced mung bean productivity.

### Introduction

Mung bean (*Vigna radiata* L.) belongs to family Fabaceae and a well known crop of Pakistan enriched in proteins, fibers and in vitamin A [1], Pakistan produced about 93 thousands t/ha of mung bean [2]. In Pakistan, mung bean is grown during July to October and March to June seasons. Although it is grown in different crop rotations, about 75% cultivation follows mung bean - wheat crop rotation. Punjab is the major mung bean growing province that alone accounted for 88% area and 85% of the total mung bean production. [3], however the distinctive feature of mung bean is the root nodules containing nitrogen fixing bacteria *Rizobium* which in turn improve soil fertility [4], and required lesser irrigation as compared with other field crops [5]. On average annually mung bean can fix about 300 kg ha<sup>-1</sup> atmospheric nitrogen [6]. Despite of its importance mung bean got little attention in Pakistan and yet there is a lot of work to do in improving the quality and quantity of mung bean crop.

A balance fertilization of both macro and micro nutrients are equally important for achieving profitable yield of crops [7]. Iron is an essential nutrient for crop growth involved in chlorophyll synthesis and chloroplast development [8]. Although iron content both in soil and plants are high than S content and even P, yet its availability is low for plants and hence Fe deficiency is a common problem [9]. So far the role of iron in nodulation and symbiotic nitrogen fixation is not clear, however many investigator reported poor nodulation in absence of Fe [10, 11], but these reports failed to explain the initiation of nodules and development. Iron is a key part of several key proteins like nitrogenase, leghaemoglobin and ferredoxin [12]. Deficiency of iron reduced the initiation as well as development of nodules in legumes [13]. Therefore, the deficiency of iron in legumes is a clear sign of nitrogen deficiency too.

Zinc is a basic micro nutrient and performs several key roles in plant nutrition as well as in human nutrition and its deficiency has an adverse effect on reproductive system [14]. Zn has a dominant role in metabolism of plant hormone called auxin hence promote plant nutrition [15, 16]. Mung beans are very sensitive to Zn deficiency in alkaline soil like Pakistan [17]. Many investigators reported Zn deficiency in Pakistani soils [18-20].

The importance of Zn for nodulation and yield of mung bean was also reported by various researchers [21-24]. Similarly, [25] also reported more weight of nodules with application of Zn. Maximum nodulation was reported in lentil at application of 9 kg ha<sup>-1</sup>Zn [26].

Therefore, keeping in view, the nutritional importance of iron and zinc for mung bean crop, a field experiment was carried out at Kohat Research Station, to evaluate the effect of different levels of Zn and Fe on mung bean crop.

## Materials and Methods

The experiment was carried out at Agricultural Research Station Kohat under rain fed conditions during spring 2017, to study the effect of iron and zinc on the yield, nodulation and nitrogen uptake by mung bean (*Vigna radiate* L). Mung bean cultivar KM<sup>-1</sup> was used as a test crop. The mung bean seeds were sown in randomized complete design with split plot arrangement and replicated three times. Size of the plot was 3 x 5 m<sup>2</sup>. Each plot was comprised of 10 rows containing row to row distance of 30 cm and plant to plant distance was of 20 cm. Different levels of iron at the rate of 0, 2 and 5 kg ha<sup>-1</sup> and zinc at the rate of 0, 5 and 10 kg ha<sup>-1</sup> were applied in the form of iron sulfate and zinc sulfate, respectively. A basal dose of 25 N, 60 P<sub>2</sub>O<sub>5</sub> and 60K<sub>2</sub>O kg ha<sup>-1</sup> was also applied in the form of urea, di-ammonium phosphate and potassium sulfate before sowing. These fertilizer doses were calculated according to [2, 26, 32 and 33] with some little modification. Before fertilizer application a composite soil sample was collected for the determination of physio-chemical characteristics and desired nutrients status for the test soil. All the agronomic and culture practices were performed. Data on nodules number and nodules weight was recorded at appropriate time (between maximum plant biomass and flowering stage). Five plants were selected randomly from each treatment and carefully uprooted along with soil to avoid damage the roots. Then it was placed in plastic bucket containing water and washed carefully the roots. After washing nodule number was counted on each plant roots. After those nodules were removed from plant roots and weighed by an electronic analytical balance (A balance weighs up to 200 g i.e. 4 decimal places in g, and reads to 0.1 mg). At maturity stage the plants were harvested to determined biological yield and grain yield. The total-N concentration in straw and grain was determined by Kjeldhal apparatus as described by [27]. The Nitrogen uptake in grain or straw was determined by multiplying their percent concentrations with the corresponding yield. The total nitrogen uptake was obtained by adding up their respective uptake in grain and straw and was expressed in kilogram per hectare. All the data obtained were subjected to Statistix 8.1 software. After that LSD test of significance was used to compare the treatment differences at P<0.05 level of probability.

## Results and Discussions

The physio-chemical attributes of the soil revealed that soil was sandy loam in texture, alkaline in reaction; low in organic matter, calcareous in nature, the zinc and iron content were found low to optimum level (Table 1).

**Table 1.** Physico-chemical characteristics of soil before mung bean sowing

Physico-chemical properties	Units	Values
Sand	%	55
Silt	%	25
Clay	%	20
Textural Class		Sandy loam
Organic matter	%	0.72
pH	-	7.75
Lime	%	6.2
EC	m mhos	260
Total nitrogen	%	0.04
Iron	ug g <sup>-1</sup>	1.51
Zinc	ug g <sup>-1</sup>	0.59

### Nodules number

Number of nodules as influenced by different levels of Fe and Zn are presented in table 2. Both Fe and Zn applied levels significantly increased the no of nodules. Based on result the maximum no of nodules plant<sup>-1</sup> of 32 were noticed at application of Fe at 5 kg ha<sup>-1</sup>, similarly Zn application also improved the no of nodules plant<sup>-1</sup> linearly from 24 at 0 kg ha<sup>-1</sup> to 30 at 10 kg ha<sup>-1</sup>. The interaction effect of Fe and Zn was not significantly affecting the number of nodules in mung bean plants. The maximum, 35 nodules plant<sup>-1</sup> was observed at plot receiving Fe and Zn 5 kg ha<sup>-1</sup> and 10 kg ha<sup>-1</sup> respectively and 20 nodules plant<sup>-1</sup> at control. Our results was in lined with the published literature it has an established criterion that Fe has dominant effect on nodule formation which ultimately increased the no of nodules plant<sup>-1</sup>. [13] Reported that iron deficiency reduced initiation and development of nodules, similarly [28] also reported positive effect of iron and zinc on number of nodules. Poor nodulation in *Lupinus albus* L was also reported by [29] in Fe deficient soil. Application of micronutrients (Zn, Fe & Mo) along with *Rhizobium* improved nodulation and yield of mung bean [2]. As nodules are the residing place for nitrogen fixing bacteria so it enhances nitrogen fixation in legumes crops.

**Table 2.** Number of Nodules per plant of mung bean as affected by different levels of Iron and Zinc

Zn Levels (kg ha <sup>-1</sup> )	-----Fe Levels (kg ha <sup>-1</sup> )-----			Mean
	0	2	5	
0	20	23	29	24 c
5	23	27	33	28 b
10	25	30	35	30 a
Mean	23 c	27 b	32 a	

LSD<sub>(0.05)</sub> of Nodules plant<sup>-1</sup> for Fe= 394.98

LSD<sub>(0.05)</sub> of Nodules plant<sup>-1</sup> for Zn= 655.19

LSD<sub>(0.05)</sub> of Nodules plant<sup>-1</sup> for Fe\*Zn= 1134.8

### Weight of nodules (gm)

The weight of nodules increased simultaneously with the application of both Fe and Zn levels (Table3). Maximum weight of 0.61 gm was recorded at 5 kg ha<sup>-1</sup> Fe application and 0.57gm at 10 kg ha<sup>-1</sup> Zn application. As in table 2, it was cleared that Fe application speed up the nodule formation which on other hand also increased its weight which is not strange. Our results was also supported by many researchers [30] also resulted increased in weight of nodules with the application of Zn. More nodules formation is associated with micro nutrients application [2]. It is an established criterion that Fe deficient crop appeared nitrogen deficiency. The interaction of Fe and Zn levels was also significantly increases the weight of nodules. The maximum weight of 0.67 gm was at full dose of Fe and Zn 0.31 gm was observed in control (Table3). Our results were in lined with published literature, [28] stated that Zn application significantly increased the nodules number and ultimately weight. [10] Reported that Fe application significantly increased the number and weight of nodules. [31] Conformed that Zn application enhance nodulation which ultimately improve nodules biomass.

**Table 3.** Weight of Nodules (in grams) of mung bean as affected by different levels of Iron and Zinc

Zn Levels (kg ha <sup>-1</sup> )	-----Fe Levels (kg ha <sup>-1</sup> )-----			Mean
	0	2	5	
0	20	23	29	24 c
5	23	27	33	28 b
10	25	30	35	30 a
Mean	23 c	27 b	32 a	

LSD<sub>(0.05)</sub> of weight of Nodules for Fe= 0.0235

LSD<sub>(0.05)</sub> of weight of Nodules for Zn= 0.0311

LSD<sub>(0.05)</sub> of weight of Nodules for Fe\*Zn= 0.053

## Biological yield

Results revealed that both the Fe and Zn levels significantly increased the biological yield of mung bean crop over control (Table 4). Iron applied at the rate of 5 kg ha<sup>-1</sup> attributed the maximum biological yield of 4533 kg ha<sup>-1</sup> whereas the minimum of 3541 kg ha<sup>-1</sup> was observed in control. When averaged across the Fe levels, maximum biological yield of 4997 kg ha<sup>-1</sup> was observed in the plots treated with 10 kg Zn ha<sup>-1</sup> while the minimum biological yield of 3192 kg ha<sup>-1</sup> was noted in untreated plots. The interactive effect of Fe and Zn was observed non-significant. The maximum biological yield of 5624 kg ha<sup>-1</sup> was noted in the plots receiving 5 and 10 kg ha<sup>-1</sup> Fe and Zn respectively whereas the lowest yield of 2823 kg ha<sup>-1</sup> was observed in control (Table 4). Many researchers reported significant increase in yield with the application of different levels of Fe. [11, 32] also reported an increase in biomass with the application of micro nutrients (Zn, B, Mo, Fe) different levels. [33] Concluded the same results in mung bean. [34] Stated that micronutrients play important role in growth and yield of legumes. [35] Reported that applied levels of (Fe + Zn) combine and zinc alone significantly increased the crop yield.

**Table 4.** Biological yield (kg ha<sup>-1</sup>) of mung bean as affected by different levels of Iron and Zinc

Zn Levels (kg ha <sup>-1</sup> )	-----Fe Levels (kg ha <sup>-1</sup> )-----			Mean
	0	2	5	
0	2823	3010	3743	3192 c
5	3634	3944	4233	3937 b
10	4167	5200	5624	4997 a
Mean	3541 c	4051 b	4533 a	

LSD<sub>(0.05)</sub> of BY for Fe= 406.47

LSD<sub>(0.05)</sub> of BY for Zn= 646.13

LSD<sub>(0.05)</sub> of BY for Fe\*Zn= 1119.1

## Grain yield

Grain yield was significantly increased with increasing levels of Fe and Zn (Table 5). On average maximum grain yield of 636 kg ha<sup>-1</sup> was obtained from the plots treated with high dose 5 kg ha<sup>-1</sup> of Fe which was significantly higher than control. Results regarding Zn levels showed a significant increased in grain yield with each increment. On average, maximum grain yield of 743 kg ha<sup>-1</sup> was observed in the plots treated with 10 kg ha<sup>-1</sup> Zn. The interactive effect of Fe and Zn was also significant. On average, the maximum grain yield of 968 kg ha<sup>-1</sup> was obtained for the treatment receiving Fe at 5 kg ha<sup>-1</sup> and Zn 10 kg ha<sup>-1</sup> (Table 5 and Fig.1). Many published literatures confirmed the results. [36] Reported an increase of 28.1% of mung bean grain yield with Zn fertilization as compared with control. Zn application improves the growth and quality parameters in mung bean [22, 37]. Increased in grain yield of mung bean with application of Zn and Mg was also reported by [38]. Foliar application of iron significantly increased the grain yield of mung bean [39]. Iron and zinc application increased the grain yield either applied to soil or applied as foliar spray [40, 41].

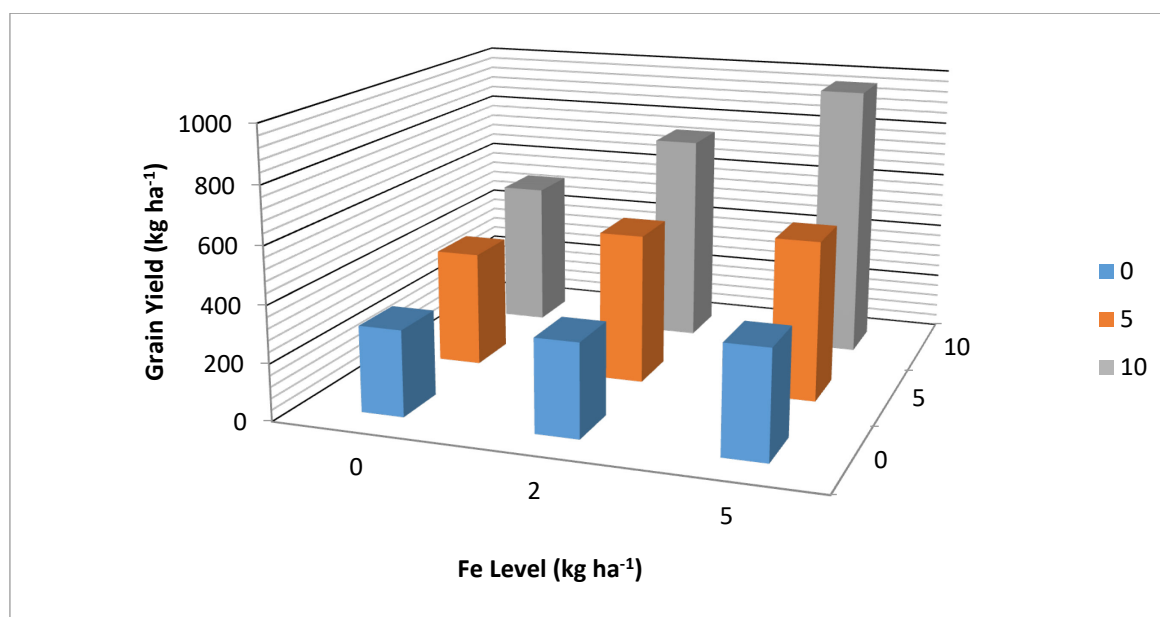
**Table 5.** Grain yield as (kg ha<sup>-1</sup>) of mung bean as affected by different levels of Iron and Zinc

Zn Levels (kg ha <sup>-1</sup> )	-----Fe Levels (kg ha <sup>-1</sup> )-----			Mean
	0	2	5	
0	303 e	328 e	378 e	336 c
5	407 de	528 cd	562 c	499 b
10	517 cd	745 b	968 a	743 a
Mean	409 c	534 b	636 a	

LSD<sub>(0.05)</sub> of GY for Fe= 98.152

LSD<sub>(0.05)</sub> of GY for Zn= 59.868

LSD<sub>(0.05)</sub> of GY for Fe\*Zn= 103.69



**Figure 1.** Grain yield as ( $\text{kg ha}^{-1}$ ) of mung bean as affected by different levels of Iron and Zinc

### Straw yield

On average, maximum straw yield of  $3897 \text{ kg ha}^{-1}$  was obtained from the plots treated with high dose of  $5 \text{ kg ha}^{-1}$  of applied Fe that was statistically similar to the plot receiving Fe dose at  $2 \text{ kg ha}^{-1}$  while significantly higher than the control (Table 6). Zinc application at different levels increased the straw yield of mung bean crop significantly. On average, maximum straw yield of  $4253 \text{ kg ha}^{-1}$  was observed in the plots treated with  $10 \text{ kg ha}^{-1}$  Zn and the minimum  $2856 \text{ kg ha}^{-1}$  was without Zn application. However, the interactive effect of Fe and Zn was found non-significant. Maximum straw yield of  $4655 \text{ kg ha}^{-1}$  was recorded from treatment containing Fe at  $5 \text{ kg ha}^{-1}$  and Zn at  $10 \text{ kg ha}^{-1}$  and that was statistically similar for the treatments receiving Fe at  $2 \text{ kg ha}^{-1}$  and Zn  $10 \text{ kg ha}^{-1}$  and the minimum yield of  $2520 \text{ kg ha}^{-1}$  was observed in control (Table 6). The result was corroborated with published values; [42] reported that Fe levels significantly increased the straw yield of cowpea. [33] Concluded that the seed and Stover yield of mung bean significantly increased over control by the application of Fe. Micro nutrients application can increase the straw yield of mung bean [43].

**Table 6.** Straw yields ( $\text{kg ha}^{-1}$ ) of mung bean as affected by different levels of Iron and Zinc

Zn Levels ( $\text{kg ha}^{-1}$ )	-----Fe Levels ( $\text{kg ha}^{-1}$ )-----			Mean
	0	2	5	
0	2520	2682	3365	2856 b
5	3227	3415	3672	3438 b
10	3650	4455	4655	4253 a
Mean	3133 b	3517 ab	3897 a	

LSD<sub>(0.05)</sub> of SY for Fe= 394.98

LSD<sub>(0.05)</sub> of SY for Zn= 655.19

LSD<sub>(0.05)</sub> of SY for Fe\*Zn= 1134.8

### Grain Nitrogen (%)

Both Iron and Zn application significantly increased the nitrogen content in mung bean grain (Table 7). Iron levels significantly affect the nitrogen content. Maximum nitrogen of 3.35 % was recorded at  $5 \text{ kg ha}^{-1}$  Fe application and minimum of 2.95 % was at control. Zn levels showed a significant increase in grain nitrogen with each increment. On average, maximum nitrogen content of 3.35 % was observed in the plots treated with  $10 \text{ kg ha}^{-1}$  and minimum of 2.92 % was at without Zn application. The interaction of applied Fe and Zn was found non-significant effect on grain

nitrogen content of mung bean. The maximum nitrogen of 3.56 % was recorded at 5 and 10 kg ha<sup>-1</sup> applied Fe and Zn respectively and minimum of 2.65 % was at control. Our results were in lined with [22, 44, 45, 23, 46 and 47] who reported increased in grain nitrogen with application of Zn fertilization. Similarly, [2] also confirmed that N content in mung bean increased with micronutrients (Zn, Fe & Mo) application.

**Table 7.** Grain Nitrogen conc (%) of mung bean as affected by different levels of Iron and Zinc

Zn Levels (kg ha <sup>-1</sup> )	-----Fe Levels (kg ha <sup>-1</sup> )-----			Mean
	0	2	5	
0	2.65	2.97	3.13	2.92 b
5	2.99	3.17	3.36	3.17 ab
10	3.20	3.28	3.56	3.35 a
Mean	2.95 b	3.14 ab	3.35 a	

LSD<sub>(0.05)</sub> of Gain N for Fe= 0.3532

LSD<sub>(0.05)</sub> of Gain N for Zn= 0.2664

LSD<sub>(0.05)</sub> of Gain N for Fe\*Zn= 0.4614

### Straw nitrogen concentration (%)

Straw Nitrogen content as affected by different levels of Fe and Zn are presented in table 13. Both Iron and Zn application significantly increased the mung bean straw nitrogen. Iron levels significantly affect the nitrogen content. Maximum % Nitrogen of 1.82 % was recorded 5 kg ha<sup>-1</sup> Fe application and minimum of 1.51 % was at control. Results regarding Zn levels showed a significant increase in straw nitrogen with each increment. On average, maximum nitrogen content of 1.89 % was observed in the plots treated with 10 kg ha<sup>-1</sup> and minimum was at without Zn application. The interaction of applied Fe and Zn was found non-significant. The maximum % nitrogen of 2.22 % was recorded at 5 and 10 kg ha<sup>-1</sup> applied Fe and Zn respectively and minimum of 1.35 % was at control. Published literature revealed that iron application increased the N content of plants. [2] Reported that N content in mung bean plant increased by micronutrients (Zn, Fe & Mo) application. Zn application reduced the P content however it increased crop nitrogen content [23].

**Table 8.** Straw Nitrogen (%) concentrations of mung bean as affected by different levels of Iron and Zinc

Zn Levels (kg ha <sup>-1</sup> )	-----Fe Levels (kg ha <sup>-1</sup> )-----			Mean
	0	2	5	
0	1.35	1.51	1.55	1.47 c
5	1.52	1.66	1.72	1.63 b
10	1.66	1.82	2.22	1.89 a
Mean	1.51 b	1.66 ab	1.82 a	

LSD<sub>(0.05)</sub> of straw N for Fe= 1.7988

LSD<sub>(0.05)</sub> of straw N for Zn= 3.2957

LSD<sub>(0.05)</sub> of straw N for Fe\*Zn= 5.7084

### Total nitrogen (Straw+Grain) uptake

Both Iron and Zn application significantly increased the nitrogen uptake in mung bean crop. Iron levels significantly affect the nitrogen uptake. Maximum nitrogen uptake of 238.06 kg ha<sup>-1</sup> was recorded 5 kg ha<sup>-1</sup> Fe application and minimum of 160.34 kg ha<sup>-1</sup> was at control (Table 9). Results regarding Zn levels showed a significant increase in nitrogen uptake with each increment. On average, maximum nitrogen content of 263.99 kg ha<sup>-1</sup> was observed in the plots treated with 10 kg ha<sup>-1</sup> and minimum of 141.58 kg ha<sup>-1</sup> was at 0 kg ha<sup>-1</sup> applied Zn. The interaction effect of applied Fe and Zn was found non-significant. The maximum nitrogen uptake of 323.33 kg ha<sup>-1</sup> was recorded at 5 and 10 kg ha<sup>-1</sup> applied Fe and Zn respectively and minimum of 141.58 kg ha<sup>-1</sup> was at control. Published literature revealed that iron application increased the N uptake of plants .Our result was similar to the findings of [48, 49].

**Table 9.** Plant Nitrogen (Straw+Grain) uptake as ( $\text{kg ha}^{-1}$ ) of mung bean as affected by different levels of Iron and Zinc

Zn Levels ( $\text{kg ha}^{-1}$ )	-----Fe Levels ( $\text{kg ha}^{-1}$ )-----			Mean
	0	2	5	
0	113.72	135.02	176.01	141.58 c
5	164.00	190.39	214.82	189.74 b
10	203.30	265.33	323.33	263.99 a
Mean	160.34 c	196.91 b	238.06 a	

LSD<sub>(0.05)</sub> of plant N for Fe= 23.168

LSD<sub>(0.05)</sub> of plant N for Zn= 32.809

LSD<sub>(0.05)</sub> of plant N for Fe\*Zn= 56.826

## Conclusions

From the investigation it was concluded that application of Fe and Zn at the rate of 5 and 10  $\text{kg ha}^{-1}$  respectively significantly enhanced the biological, grain, straw yields, number and weight of nodules of mung bean. Maximum uptake of nitrogen by the plants straw and grain was also observed in the plots where Fe and Zn were applied at higher rate of 5  $\text{kg ha}^{-1}$  and 10  $\text{kg ha}^{-1}$  respectively. Such studies are suggested to evaluate the effect of iron and zinc for various leguminous crops under different agro-ecological zones to improve the nitrogen fixation.

## Conflict of Interest

The authors declare that there is no conflict of interest.

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