

Assess the Zinc, Boron and Rhizobium inoculation on growth and yield of Kharif Mungbean (*Vigna radiata* L.)

ABSTRACTS

The present experiment entitled “Assess the Zinc, Boron and Rhizobium inoculation on growth and yield of Kharif Mungbean (*Vigna radiata* L.)” was carried out during *kharif* season of 2021 and 2022 at Instructional farm, Kamla Nehru Institute of Physical and Social Sciences Sultanpur, U.P. India. Four levels of zinc (0, 2.5, 5.0 and 7.5 Kg Zn ha⁻¹), three levels of boron (0, 0.5 and 1.0 Kg B ha⁻¹) and two levels of rhizobium *i.e.* Uninoculated (Control) and inoculated. A split-split plot design with three replications was used. Zinc levels were allocated to the main plots, boron levels in the sub-plot, while Rhizobium inoculation in the sub-sub plot. Results revealed that plant height, number of branches per plant, dry weight, number of nodules and seed and stover yield was observed that Rhizobium inoculation with application of zinc 7.5 kg ha⁻¹ and Application of boron 1.0 kg ha⁻¹.

Keywords: Boron, Growth, Inoculation, Rhizobium, Zinc.

INTRODUCTION:

For vegetarian population, pulses are the main source of dietary protein. Production of pulses in the country is below the requirement to meet even the minimum level of per capita consumption.

Mungbean (*Vigna radiata* L.) is a diploid, self-pollinated legume crop species with 22 chromosomes ($2n=2x=22$). It's also known as green gram or moong bean, and belongs to the Fabaceae botanical family and the genus *Vigna*. Mungbean is a warm-season crop that's fast-growing, with a short life cycle of 60–75 days, relative tolerance to drought, and ability to improve soil fertility through atmospheric nitrogen (N_2) fixation in symbiosis with *Rhizobium* and *Bradyrhizobium* bacteria in the soil (Yimram *et al.*, 2009). Hence, it plays an important role in crop diversification and sustainable agricultural intensification in Asia. It's mainly cultivated in South, East, and Southeast Asia for its edible seeds and sprouts, and is an inexpensive source of protein, carbohydrates, iron, and folic acid. Mungbean is also a low-input

crop that can be used as livestock feed and green manure.

The Zn essentially is being employed in functional and structural component of several enzymes, such as carbonic anhydrase, alcohol dehydrase, alkaline phosphatase, phospholipase, carboxypeptidase (Coleman, J.E. 1991) and RNA polymerase (Romheld, V. and Marschner, H. 1991). Further, plants emerging from seeds with lower Zn could be highly sensitive to biotic and abiotic stresses (Obata et al., 1999). Zn enriched seeds performs better with respect to seed germination, seedling growth and yield of crops (Cakmak et al., 1996).

MATERIALS AND METHODS

A field experiment was conducted during two consecutive seasons of *kharif* 2020 and 2021 at Instructional farm, Kamla Nehru Institute of Physical and Social Sciences Sultanpur, U.P. (India). The experimental site falls under sub-tropical conditions with remarkable humidity and lies between 26.2927⁰ North latitude and 82.1278⁰ East longitude with an altitude of about 95 m from mean sea level. The experimental field was well levelled having good irrigation and drainage facilities. The source of irrigation was tube well. Four levels of zinc (0, 2.5, 5.0 and 7.5 Kg Zn ha⁻¹), three levels of boron (0, 0.5 and 1.0 Kg B ha⁻¹) and two levels of rhizobium *i.e.* Uninoculated (Control) and inoculated. A split-split plot design with three replications was used. Zinc levels were allocated to the main plots, boron levels in the sub-plot, while Rhizobium inoculation in the sub-sub plot. Soil was sampled before sowing/transplanting and after harvest of the crop to know the fertility status of the experiment field. The growth and yield analysis was done as per standard procedures.

RESULTS AND DISCUSSION

Growth parameters

1. Plant height

Data revealed that zinc levels had significant effect on plant height at all growth stages except 30 DAS (Table -1). Plant height increased successively with increasing the zinc levels up to 7.5 kg ha⁻¹. Maximum plant height was recorded under 7.5 kg Zn ha⁻¹, which was at par with 5 kg Zn ha⁻¹ and significantly superior over control and 2.5 kg Zn ha⁻¹ at all the crop growth stages.

Plant height influenced greatly due to application of boron, it increased with the advancement of the crop growth upto harvest stage in all the levels of boron. Significant impact of boron levels was also noted at all the stages of growth except at 30 days after sowing. Application

of 1 kg B ha⁻¹ registered significantly more plant height which was at par with application 0.5 Kg B ha⁻¹. The trend of data was similar during both the years of study.

Rhizobium inoculation had also pronounced effect on plant height at all the stages of plant growth excluding at 30 days after sowing. Rhizobium inoculated treatment exhibited significantly more plant height than that of un inoculated ones.

The interaction effect of different treatments on plant height was found non-significant at all the stages of crop growth.

Table 1. Effect of Zn, Bo and rhizobium inoculation on plant height of *kharif* mungbean at different stages of growth

Treatments	Plant height (cm)							
	30 DAS		45 DAS		60 DAS		At harvest	
	2020	2021	2020	2021	2020	2021	2020	2021
Zinc levels (kg ha⁻¹)								
Z ₀ : 0	27.17	28.28	34.40	35.43	39.86	41.10	43.24	44.57
Z ₁ : 2.5	28.02	28.86	35.87	36.97	41.60	42.80	45.08	46.46
Z ₂ : 5.0	28.88	29.46	37.70	38.80	43.67	45.03	47.38	49.36
Z ₃ : 7.5	29.17	30.04	38.43	39.64	44.52	45.87	48.33	49.73
SEm _±	0.532	0.547	0.624	0.707	0.796	0.793	0.788	0.911
CD (P=0.05)	NS	NS	1.78	2.01	2.27	2.26	2.24	2.59
Boron levels (kg ha⁻¹)								
B ₀ : 0	27.59	28.43	34.77	35.84	40.30	41.50	43.70	45.39
B ₁ : 0.5	28.60	29.45	36.97	38.08	42.82	44.15	46.46	47.92
B ₂ : 1.0	28.74	29.59	38.06	39.22	44.11	45.45	47.86	49.28
SEm _±	0.461	0.474	0.541	0.612	0.690	0.687	0.682	0.789
CD (P=0.05)	NS	NS	1.54	1.74	1.96	1.96	1.94	2.25
Rhizobium inoculation								
I ₁ : Un-inoculated	28.02	28.86	34.40	35.44	39.88	41.08	43.25	44.83
I ₂ : Inoculated	28.60	29.46	38.80	39.98	44.94	46.32	48.76	50.23
SEm _±	0.376	0.387	0.442	0.500	0.563	0.561	0.557	0.644
CD (P=0.05)	NS	NS	1.26	1.42	1.60	1.60	1.59	1.83

2. Number of branches plant⁻¹

A critical examination of data on number of branches at successive stages of growth as affected by different treatments are summarized in Table 2. The number of branches plant⁻¹ increased progressively till the harvest stage, irrespective of treatments.

Application of different levels of zinc significantly enhanced the number of branches plant⁻¹. The magnitude of increase in number of branches plant⁻¹ due to zinc fertilization at 7.5 kg ha⁻¹ was higher by 11.65 and 11.91 per cent over control during first and second years of study at

harvest stage. However, application of zinc at 5 kg ha⁻¹ being on par with 7.5 kg Zn ha⁻¹ at harvest, recorded 9.52 and 9.49 per cent increase in number of branches plant⁻¹ over control during both respective years of investigation.

Significant influence of boron application was also noticed maximum number of plant⁻¹ was noted 11.96 and 12.35 during both the years of study, when 1.0 Kg ha⁻¹ boron was applied, which was on par with application of 0.5 kg B ka⁻¹ and significantly superior to control.

Rhizobium inoculation also registered significant impact of production of branches plant⁻¹. Percent increase in number of branches plant⁻¹ due to inoculation over uninoculated plants was 12.66% and 12.62 % during first and second years of study.

Interactions of different treatments were not significant during both the years of investigation.

Table 2. Effect of Zn, Bo and rhizobium inoculation on number of branches plant⁻¹ at different stages of growth of Moong bean

Treatments	Number of branches plant ⁻¹							
	30 DAS		45 DAS		60 DAS		At harvest	
	2020	2021	2020	2021	2020	2021	2020	2021
Zinc levels (kg ha⁻¹)								
Z ₀ : 0	5.83	6.00	7.99	8.20	9.78	10.08	10.82	11.17
Z ₁ : 2.5	6.08	6.33	8.33	8.63	10.19	10.53	11.28	11.60
Z ₂ : 5.0	6.39	6.55	8.76	9.07	10.71	11.07	11.85	12.23
Z ₃ : 7.5	6.51	6.73	8.93	9.23	10.92	11.29	12.08	12.50
SEm _±	0.110	0.068	0.160	0.126	0.155	0.202	0.213	0.194
CD (P=0.05)	0.31	0.19	0.46	0.36	0.44	0.58	0.60	0.55
Boron levels (kg ha⁻¹)								
B ₀ : 0	5.89	6.06	8.08	8.38	9.88	10.20	10.93	11.30
B ₁ : 0.5	6.26	6.48	8.59	8.88	10.50	10.87	11.62	11.98
B ₂ : 1.0	6.45	6.68	8.84	9.10	10.82	11.16	11.96	12.35
SEm _±	0.095	0.059	0.139	0.109	0.134	0.175	0.184	0.168
CD (P=0.05)	0.27	0.17	0.40	0.31	0.38	0.50	0.52	0.48
Rhizobium inoculation								
I ₁ : Un-inoculated	5.83	6.03	7.99	8.25	9.78	10.11	10.82	11.17
I ₂ : Inoculated	6.57	6.78	9.01	9.32	11.02	11.38	12.19	12.58
SEm _±	0.077	0.048	0.113	0.089	0.109	0.143	0.150	0.137
CD (P=0.05)	0.22	0.14	0.32	0.25	0.31	0.40	0.43	0.39

3. Dry weight (g) plant⁻¹

Data pertaining to dry weight of plant as influenced by different levels of zinc, boron and rhizobium inoculation have been presented in Table 3.

A perusal of data clearly indicated that marked variations in dry matter of mungbean was recorded due to varying levels of zinc. Application of zinc at 7.5 kg/ha being on par with 5 kg/ha recorded significantly higher dry matter accumulation (3.57 and 3.68), (8.51 and 8.77), (12.18 and 12.57) and (13.02 and 13.43) g plant⁻¹ at 30, 45, 60 days after sowing and harvest stage during first and second years of study, respectively. Percentage increase in dry matter production due to application of zinc at the rate of 2.5, 5, 7.5 kg/ha was 4.20, 9.52 and 11.66% during first year and 4.50, 9.75 and 11.92% during second year at harvest stage.

Dry matter accumulation was recorded highest under application of 1 kg B ha⁻¹ which was non-significantly followed by 5 kg B ha⁻¹ and significantly superior to control at all stages of growth. The trend of data was similar during both the years of investigation. Rhizobium inoculation showed marked impact on dry matter accumulation of mungbean at all stages of growth. Significantly more dry matter was noted under rhizobium inoculated plants as compared to uninoculated ones during both respective years of experimentation.

Interactions of different treatments were not significant during both the years of investigation.

Table 3. Effect of Zn, Bo and rhizobium inoculation on dry weight plant⁻¹ of mung- bean at different stages of growth

Treatments	Dry weight (g plant ⁻¹)							
	30 DAS		45 DAS		60 DAS		At harvest	
	2020	2021	2020	2021	2020	2021	2020	2021
Zinc levels (kg ha⁻¹)								
Z ₀ : 0	3.20	3.29	7.61	7.85	10.90	11.23	11.66	12.00
Z ₁ : 2.5	3.33	3.45	7.94	8.18	11.37	11.72	12.15	12.54
Z ₂ : 5.0	3.50	3.62	8.34	8.60	11.95	12.32	12.77	13.17
Z ₃ : 7.5	3.57	3.68	8.51	8.77	12.18	12.57	13.02	13.43
SEm _±	0.064	0.066	0.147	0.128	0.221	0.177	0.179	0.227
CD (P=0.05)	0.182	0.188	0.418	0.364	0.629	0.503	0.508	0.647
Boron levels (kg ha⁻¹)								
B ₀ : 0	3.23	3.33	7.70	7.93	11.02	11.35	11.78	12.15
B ₁ : 0.5	3.43	3.55	8.18	8.43	11.72	12.08	12.52	12.93
B ₂ : 1.0	3.54	3.65	8.42	8.69	12.06	12.44	12.90	13.28
SEm _±	0.055	0.057	0.127	0.111	0.191	0.153	0.155	0.197
CD (P=0.05)	0.157	0.163	0.362	0.316	0.545	0.435	0.440	0.560
Rhizobium inoculation								
I ₁ : Un-inoculated	3.33	3.30	7.61	7.85	10.91	11.25	11.66	12.04
I ₂ : Inoculated	3.50	3.72	8.59	8.85	12.30	12.66	13.14	13.53
SEm _±	3.57	0.047	0.104	0.091	0.156	0.125	0.126	0.161

CD (P=0.05)	0.064	0.133	0.296	0.258	0.445	0.355	0.359	0.457
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4. Number of nodule plant⁻¹

Data on account of number of nodules plant⁻¹ as influenced by various doses of zinc, boron and rhizobium inoculation have been presented in Table 4. Increasing trend in number of nodules was noted with each increment of zinc dose. Maximum number of nodules were noted when 7.5 kg Z ha⁻¹ was applied and it was significantly more than that of 0.5 kg Z ha⁻¹ and control. However, the differences among values of nodules plant⁻¹ under 7.5 kg Z ha⁻¹ and 5 kg Z ha⁻¹ were not significant. It is observed that data was similar during both the years of study.

Data revealed that application of 1kg B ha⁻¹ significantly affected number of nodules plant⁻¹ in mungbean. A significant increase of 6.36 and 9.45 per cent during first year and 6.44 and 9.59 per cent during second year, respectively, over control was noted at application of 0.5 kg B ha⁻¹ and 1 kg B ha⁻¹ respectively.

Rhizobium inoculation exhibited marked impact on number of nodules plant⁻¹ in mungbean. Significantly more number of nodules plant⁻¹ was noted under rhizobium inoculated plants as compared to uninoculated ones during both the years of experimentation.

Interactions of different treatments were not significant during both the years of investigation.

Table 4. Effect of Zn, Bo and rhizobium inoculation on number and weight of nodule plant⁻¹ of mung- bean at different stages of growth

Treatments	No. of nodule plant ⁻¹		Fresh wt. of nodule plant ⁻¹		Dry wt. of nodule plant ⁻¹	
	2020	2021	2020	2021	2020	2021
Zinc levels (kg ha⁻¹)						
Z ₀ : 0	45.14	46.43	158.82	163.08	84.83	88.22
Z ₁ : 2.5	47.04	48.43	165.58	170.10	88.44	92.02
Z ₂ : 5.0	49.44	50.93	174.03	178.78	92.95	96.77
Z ₃ : 7.5	50.40	51.93	177.41	182.29	94.81	98.67
SEm ₊	0.795	0.701	2.713	3.255	1.536	1.591
CD (P=0.05)	2.26	1.99	7.72	9.27	4.37	4.53
Boron levels (kg ha⁻¹)						
B ₀ : 0	45.60	46.93	160.51	164.71	85.73	89.16
B ₁ : 0.5	48.50	49.95	170.65	175.40	91.18	94.91
B ₂ : 1.0	49.92	51.43	175.72	180.58	93.85	97.71
SEm ₊	0.688	0.607	2.349	2.819	1.330	1.378
CD (P=0.05)	1.96	1.73	6.69	8.03	3.79	3.92
Rhizobium inoculation						

I ₁ : Un-inoculated	45.13	46.47	158.82	163.10	84.83	88.29
I ₂ : Inoculated	50.88	52.40	179.10	184.02	95.68	99.56
SEm ₊	0.562	0.496	1.918	2.302	1.086	1.125
CD (P=0.05)	1.60	1.41	5.46	6.55	3.09	3.20

5. Seed yield (q ha⁻¹)

Seed yield is an important parameter which decides the efficiency and superiority of a particular treatment over other treatments. Data pertaining to seed yield plant⁻¹ as influenced by zinc, boron and rhizobium inoculation are presented in Table 5.

It is clear from data, yield of mungbean was improved significantly with every increasing level of zinc upto 7.5 kg ha⁻¹. It attained the yield of (8.53 and 8.79) q ha⁻¹ with a remarkable increase of 10.64 and 10.71 per cent over control during 2019-20 and 2020-21 respectively. Whereas, (9.60 and 9.70) and (5.32 and 5.42) per cent increments in yield were obtained under 5 and 2.5 kg zinc/ha over control, respectively. Likewise, application of zinc to mungbean at 7.5 kg/ha enhanced grain yield by 0.82, 0.41, 0.08 and 0.85, 0.42, 0.08 q/ha over control, 2.5 and 5 kg Zn/ha during 2019-20 and 2020-21, respectively.

A further reference to data revealed that increasing levels of boron significantly increased the seed yield of mungbean. Application of 1kg B ha⁻¹ recorded an increase of 8.47 per cent over control during both years of study.

Rhizobium inoculation also registered significant impact on yield q ha⁻¹ of mungbean. Percent increase in seed yield due to inoculation over uninoculated plants was 8.39% and 8.25 % during first and second years of study.

Table 5. Effect of Zn, Bo and rhizobium inoculation on Seed and stower yield q ha⁻¹ of mungbean

Treatments	Seed yield (q ha ⁻¹)		Stower yield (q ha ⁻¹)	
	2020	2021	2020	2021
Zinc levels (kg ha⁻¹)				
Z ₀ : 0	7.71	7.94	31.04	31.91
Z ₁ : 2.5	8.12	8.37	32.56	33.46
Z ₂ : 5.0	8.45	8.54	33.75	34.02
Z ₃ : 7.5	8.53	8.79	33.98	34.89
SEm ₊	0.140	0.160	0.527	0.564
CD (P=0.05)	0.40	0.46	1.50	1.60
Boron levels (kg ha⁻¹)				
B ₀ : 0	7.79	8.03	31.22	32.11
B ₁ : 0.5	8.37	8.49	33.48	33.90

B ₂ : 1.0	8.45	8.70	33.80	34.70
SEm _±	0.121	0.139	0.457	0.489
CD (P=0.05)	0.35	0.40	1.30	1.39
Rhizobium inoculation				
I ₁ : Un-inoculated	7.87	8.11	31.56	32.44
I ₂ : Inoculated	8.53	8.71	34.10	34.70
SEm _±	0.099	0.113	0.373	0.399
CD (P=0.05)	0.28	0.32	1.06	1.14

5. Stower yield (q ha⁻¹)

Data pertaining to seed yield plant⁻¹ as influenced by zinc, boron and rhizobium inoculation are presented in Table 5.

It is clear from data, stower yield of mungbean was improved significantly with every increasing level of zinc upto 7.5 kg ha⁻¹. It attained the stower yield of (33.98 and 34.89) q ha⁻¹ with a remarkable increase of 9.34 and 9.57 per cent over control during both the years respectively. It was non significantly followed by 5 kg Zn ha⁻¹ and significantly followed by rest levels of zinc. Minimum stower yield of 31.04 and 31.91 q ha⁻¹ was noted under control plots during both years of investigation respectively. Application of boron significantly increased the stower yield of mungbean. Application of 1kg B ha⁻¹ recorded highest stower yield of 33.80 and 34.70 q ha⁻¹ during 2019-20 and 2020-21 respectively and it was statistically superior to control. Minimum stower yield of 31.22 and 32.11 q ha⁻¹ was recorded in control plots. Rhizobium inoculation also registered significant impact on stower yield of mungbean. Significantly more stower yield was noted under inoculated plots than that in uninoculated ones during both respective years of study.

DISCUSSION

The favourable influence of zinc on photosynthetic and enzymatic activities would in turn increase vegetative growth of plants (Thalooth *et al.*, 2006). Such improvement under increased availability of zinc in rhizosphere might be resulted in greater uptake by the plant, consequently leading to a favourable stimulatory effect on physiological and metabolic processes of plant. Thus, the application of zinc in a soil deficient in its content (0.48 mg/kg), improved the overall growth and development of plant. These results are in close conformity with the findings of Haider *et al.* 2018b. The importance of zinc for nodulation was reported that zinc nutrition is essential and paramount for *Rhizobium* activity to fix nitrogen and increase weight of nodules. Upadhyay *et al.*

(2016) also reported increased nodule weight with the application of zinc. More nodules formation is associated with zinc application. Increase in nodulation by zinc could be due to increase in root weight or size, which provided sufficient site for nodulation.

The maximum values of these parameters were recorded with zinc application at 7.5 kg/ha. The effect of zinc nutrition on physiological and metabolic processes of plants, role in more absorption of essential elements due to increased cation exchange capacity of roots and thereby bearing more yield contributing characters are possible basis of more yield. Zinc application at 7.5 kg/ha enhanced grain yield and stover yield significantly, compared with no zinc application. This indicated that mungbean respond better to zinc application even at higher rates without showing the symptoms of zinc toxicity. In an earlier study Jamal *et al.* (2018) reported that mungbean responded upto application of zinc at 10 kg/ha. Zinc also has significant role in primordia initiation, indole-acetic acid synthesis and partitioning of food material from leaves to reproductive parts which ultimately results in good fruiting (Kalyanaraman and Sivagurunath, 1993 and Quah *et al.*, 2004).

CONCLUSIONS

On the basis of results obtained from the present investigation, the following conclusion may be drawn, Rhizobium inoculation of seed with Zinc 7.5 kg ha⁻¹ and Boron 1.0 kg ha⁻¹ have proved its superiority for better plant growth, dry matter, yield and productivity of mungbean.

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