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Response of different varieties of mungbean (*Vigna radiata* L.) to zinc, boron and their combined application under Tripura condition

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ABSTRACT

A field experiment was carried out in the experimental farm of College of Agriculture, Tripura to study response of different varieties of Mungbean (*Vigna radiata* L.) to zinc, boron and their combined application, during summer season of 2022. The experiment was laid out in split plot design with three replications. In main plot there were six varieties (V_1:MEHA-IPM-99-125, V_2:Samrat, V_3: Bireswar, V_4:Virat, V_5:TMB – 37,V_6: TM-2000-2) and four micronutrients (M_0:Control, M_1:Zinc- 0.1%, M_2:Boron- 0.2%,M_3: Zinc- 0.1% + Boron- 0.2%) in subplots. Plot size was 6 m^2 (3m×2m) and spacing was 30 cm × 15 cm. Recommended fertilizers (20- 40- 40 Kg, N, P_2O_5, K_2O ha^{-1}) were applied as basal. Zinc @ 0.1 %, Boron @ 0.2 % and combined solution (Zinc @ 0.1 % + Boron @ 0.2 %) were applied at 30 DAS on selected plots as per field lay out. The results of the experiment showed that different varieties of mungbean crop significantly responded to micronutrients Zn and B as well as their combined application. The crop growth attributes such as number of branches per plant, nodules per plant, plant dry matter accumulation, Crop Growth Rate were all significantly influenced by different varieties and micronutrient application. Application of Zinc- 0.1% + Boron- 0.2% (M_3) with variety Virat (V_4) recorded the maximum seed yield as well as stover yield and harvest index. Virat (V_4) variety performed best among all six varieties in respect of yield attributes and yield.

1. Introduction

Mung bean (*Vigna radiata* L.) is one of the most important pulse crops cultivated in India. It has an advantage over the other pulse crops owing to its high nutritive value. The mungbean grains are easily digestible having more protein content (24.20 %) as compared to other pulse crops (Tabasum *et al*., 2010) and 50% carbohydrates, 3% fat, 4-5% ash, 3-4.5% fibers (Faruque *et al.*, 2000). The seed also contains significant elements such as calcium (Ca) 118 mg and phosphorus (P) 340 mg per 100 g of seed (Imran *et al.,* 2015). Mungbean / greengram grains are used as dal, soup and preparing many sweet items. It is short duration legume crop (Ahamed *et al*., 2011) grown mostly as a fallow crop in rotation with rice. In India, the important states growing this crop with a total area of about 30 lakh hectares are Orissa, Madhya Pradesh, Gujarat, Rajasthan, U.P and Bihar. Similar to the leguminous pulses, green gram, enriches soil nitrogen content and used as green manuring crop. It also helps in preventing soil erosion. Mung bean can be used as feed for cattle (Asaduzzaman *et al.,* 2008) after harvesting the pods, green plant are uprooted or cut from ground level and chopped into small pieces and feed to the cattle. The husk of the seed can be soaked in water and used as cattle feeds.

Indian farmers are more interested to grow cereal crops to meet up the basic demand of food and for more profit. For this reason, farmers do not want to use their fertile land in pulse cultivation. The productivity of the pulse crop is very low because of its cultivation on marginal and sub-marginal lands of low soil fertility, where little attention is paying to adequate fertilization (Saravanan *et al*., 2013). Sufficient supply of micronutrient is necessary for normal growth and yield of crops, and their scarcity in soil is a prevailing issue in the developed countries (Singh, 2009). The micronutrients including Zn and B are the most

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important nutrients to maintain proper and optimal plant growth. The presence of Zn and B in the soil helps plant to uptake adequate amount of NPK properly to maintain crop plant growth and production (Shojaei and Makariian, 2015).

Zn plays a major role in plant growth, development and finally on yield. Zinc is involved in photosynthetic activity, plant metabolism and synthesis of auxins, carbohydrate, phosphate and nucleic acid. Zinc influences the capacity of water uptake in plant and transports and reduces the adverse effects of short periods of heat stress or of salt stress. Zinc deficiency depressed root and shoot growth and chlorophyll concentration. Zinc enriched seeds can perform better with respect to seed germination, seedling health, crop growth and finally yield advantage (Cakmak *et al.,* 1996). Boron is one of the mineral nutrients required for normal plant growth (Reddy and Singh, 2021) and also essential for cell division, cell wall biosynthesis, pods and seed formation. Its deficiency causes decrease in pollen grain count, pollen germination etc. It also influences growth parameters and filling up of seeds.

In Tripura, mungbean is one of the most important pulse crop consumed by local people but production level is very low due to various reasons like lack of suitable and available varieties, lack of improved processing units, lack of knowledge about improved production techniques etc. Farmers are using N, P, K fertilizers but not micronutrients though Tripura soil is deficient in micronutrient content. So keeping these points in view the present experiment was under taken to study the effect of Zinc and Boron micronutrients on growth and yield attributes of different mungbean varieties.

2. Materials and Methods

A field experiment was carried out in the experimental farm of College of Agriculture, Tripura, during summer season of 2022 to study the response of different varieties of mungbean to zinc, boron and their combined application. The field was situated at an altitude of 52 meters above mean sea level with the geographical location at 23°54′25" North latitude and 91°18′44" East longitude. The soil of the experimental field was sandy loam in texture having pH 5.2, low in available nitrogen (265.4 kg ha^{-1}) and phosphorus (4.2 kg ha^{-1}), potassium (132.37 kg ha^{-1}), organic carbon (0.65 %), zinc (0.89 ppm) boron (0.2 ppm). The experiment was laid out in split plot design with three replications. In main plot there were six varieties (V_1: MEHA-IPM-99-125, V_2: Samrat, V_3: Bireswar, V_4: Virat, V_5: TMB – 37, V_6: TM-2000-2) and four micronutrients (M_0: Control, M_1: Zinc- 0.1%, M_2: Boron- 0.2%, M_3: Zinc- 0.1% + Boron- 0.2%) in subplots. There were 24 treatment combinations and the plot size was 6 m^2 (3m×2m). Mungbean crop was sown at 30 cm plant to plant and 15 cm row to row spacing. Seeds @ 20 kg ha^{-1} were treated with rhizobium culture before sowing. Entire quantity of NPK (20-40-40 kg ha^{-1}) fertilizers was applied as basal uniformly in all treatments. Zinc @ 0.1 % solution and Boron @ 0.2 % solution were applied separately at 30 DAS on selected plots and combined application of both (Zinc @ 0.1 % solution + Boron @ 0.2 % solution) also was done at 30 DAS on selected plots as per field lay out. Imidachlorprid @ 2ml $litre^{-1}$ of water was applied for insect control. Temperature range during experimental period was 30^0C- 13^0C and total 47mm rain fall received. All the growth and yield attributes were taken at appropriate time using standard procedure and data were statistically analyzed as procedures given by Gomez and Gomez (1976).

3. Result and discussion

Growth attributes

Data on effect of different varieties of mungbean and Zn and B micronutrients on growth attributes viz. plant height (cm), root length (cm) and number of branches $plant^{-1}$ are presented in Table 1. Data indicates that plant height and root length were not significantly affected due to different varieties of mungbean at all stages of crop growth but numbers of branches significantly differed due to different varieties. The maximum plant height (44.05 cm at 60 DAS and 58.59 cm at harvest), root length (7.60cm at 30 DAS, 15.08cm at 60 DAS, 20.25cm at harvest), number of branches $plant^{-1}$ (5.48 $plant^{-1}$) were recorded by V_4 (Virat) variety and minimum plant height, root length and branches $plant^{-1}$ were recorded by V_6 (TM-2000-2) respectively. Variety, V_4 (Virat) was superior in respect of plant height, root length and number of branches per plant among six tested varieties of mungbean and followed by V_3 (Bireswar), V_2 (Samrat), V_5 (TMB – 37), V_1 (MEHA-IPM-99-125). Variety, V_4 (Virat) and V_3 (Bireswar) are statistically at par in case of number of branches per plant. Singh *et al.* (2022) recorded that different cultivars (including Virat) of mungbean had a significant effect on growth characters viz. plant height, number of branches $plant^{-1}$.

Plant height was not significantly affected by zinc, boron and their combined application at 30 DAS, 60 DAS and at harvest. Highest plant height (41.68 cm, 55.51 cm) was recorded by M_3 (Zinc- 0.1% + Boron- 0.2%) treatment at 60 DAS and at harvest respectively and lowest height was recorded under M_0 i.e. control or water spray condition. Application of zinc and boron increased plant height over control condition as these micronutrients improve germination, cell division and seedling growth. Mubeen *et al.* (2020) also recorded same results that combined application of zinc and boron has positive effect on plant height. Zinc, boron and their combined application significantly affects root length of mungbean plants at 60 DAS and at harvest

though there was no significant effect on root length at 30 DAS. Highest root length (7.30 cm, 14.95 cm, 19.61 cm) was recorded by M_3 (Zinc- 0.1% + Boron- 0.2%) treatment and smallest root length was recorded under M_0 i.e. control condition. Application of zinc [M_1 (Zinc- 0.1%)] and boron [M_2 (Boron- 0.2%)] give higher root length over control as it improves root growth and development (Kanwal *et al.,* 2020 and Qamar *et al*., 2015). Number of branches per plant of mungbean significantly increased with Zinc, boron and their combined applications over control or water spray. Highest number of branches (4.78 per plant) were recorded by M_3 (Zinc- 0.1% + Boron- 0.2%) treatment (Islam *et al*., 2017). M_3 (Zinc- 0.1% + Boron- 0.2%) treatment significantly increased no. of branches over other treatments but treatment [M_1 (Zinc- 0.1%)] and M_2 (Boron- 0.2%) were statistically at par. Higher number of branches were recorded by application of zinc [M_1 (Zinc- 0.1%)] foliar spray over control or water spray and the same was recorded by Malik *et al*. (2015). Application of B showed significant effect on zaid mungbean and showed higher plant height and number of branches (Singh *et al.,* 2018).

The interaction of different varieties of mungbean and micronutrients (Zn and B) application did not show any significant effects on plant height, root length and number of branches.

Dry matter accumulation and Crop growth rate

Data presented in Table 2 showed that different varieties have significant effects on dry matter accumulation and crop growth rate at all stages of growth. The maximum dry matter accumulation (51.04 g^{m-2}, 174.90 g^{m-2}, 305.66 g^{m-2}) and crop growth rate (4.12, 4.35 g m^{-2} day^{-1}) were recorded by V_4 (Virat) at all stages of growth followed by V_3 (Bireswar), V_2 (Samrat), V_5 (TMB – 37), V_1 (MEHA-IPM-99-125) respectively and minimum dry matter accumulation (32.77 g^{m-2}, 61.12 g^{m-2}, 98.61 g^{m-2}) and crop growth rate (0.94, 1.24 g m^{-2} day^{-1}) were recorded by V_6 (TM-2000-2).

Dry matter accumulation (**g^{m-2}**) and crop growth rate (g m^{-2} day^{-1}) of mungbean plants were significantly differ due to Zinc, boron and their combined application on mungbean plants at mid period of growth and at harvest though there was no significant effect on dry matter accumulation and crop growth rate at early stage of growth i.e. upto 30 DAS. Highest dry matter (40.20 g, 128.32 g, 225.78 g) was recorded by M_3 (Zinc- 0.1% + Boron- 0.2%) treatment at 60 DAS and at harvest and lowest dry weight per plant was recorded under M_0 i.e. control condition or water spray. Higher dry matter accumulation (Srikanth *et al*., 2021) and Crop growth rate (Praveena *et al.,* 2018) were recorded by application of zinc [M_1 (Zinc- 0.1%)] foliar spray over control or water spray. From the table it is also observed that Boron [M_2(Boron- 0.2%)] also gives higher dry weight (Ram *et al.*, 2017) and crop growth rate (Reddy *et al.*, 2021) over control as it improves plant height, number of leaves, number of branches. Combined application of Zn and B gives highest dry matter accumulation (Praveena *et al.,* 2018) and crop growth rate (Krishna *et al.,* 2022) than sole application of Zn and B.

The interaction of different varieties of mungbean and micronutrients (Zn and B) application did not show any significant effects on dry matter accumulation (g m^{-2}) and crop growth rate (g m^{-2} day^{-1}) at all growth stages.

Yield Attributes

Six different types of varieties of mungbean are used in this experiment and from the result depicted in the Table 3 it is observed that different varieties have significant effects on number of pods per plant and number of seeds per pod. The maximum pods (18.26) and number of seeds per pod (10.47) were recorded by V_4 (Virat) which was significantly superior from other varieties followed by V_3 (Bireswar), V_2 (Samrat), V_5 (TMB – 37), V_1 (MEHA-IPM-99-125) and minimum number of pods (12.04) and number of seeds per pod (7.60) was recorded by V_6 (TM-2000-2) respectively.
From the data presented in the Table 3 it is observed that number of pods per plant and numbers of seeds per pod were significantly increased by zinc, boron and their combined treatments over control. Highest number of pods (18.02) and seeds per pod (9.8) were recorded by M_3 (Zinc- 0.1% + Boron- 0.2%) and lowest numbers were recorded under M_0 i.e. control condition or water spray. M_3 (Zinc- 0.1% + Boron- 0.2%) treatment was significantly superior than the other treatments but M_2 (Boron- 0.2%) and M_1 (Zinc- 0.1%) treatments are statistically at par in both number of pods per plant and numbers of seeds per pod. M_3 (Zinc- 0.1% + Boron- 0.2%) treatment increased 50 % number of pods in mungbean plant over control. Application of zinc [M_1(Zinc- 0.1%)] shows significant effects on number of pods per plant and increase pod numbers (25 %) over control which is inconformity with the result reported by Malik *et al.* (2015). Number of seeds per pod was increased due to zinc application as it improves pod growth and development (Movalia *et al*., 2018 and Bhadru *et al.,* 2019). According to Maqbool *et al. (*2018) final seed yield was significantly increased by boron application mainly due to increased number of pods bearing branches, number of pods per plant, number of seeds per pod and 1000-grain weight. Combined application of Zn and B increased number of pods per plant (Verma *et al.,* 2020) and numbers of seeds per pod (Praveena *et al.,* 2018) and highest number of pods per plant was obtained from M_3(Zinc- 0.1% + Boron- 0.2%) treatment.

The interaction of different varieties of mungbean and micronutrients (Zn and B) application did not show any significant effects on number of pods per plant but number of

seeds per pod was significantly influenced by varieties and micronutrients. Variety, V_4 (Virat) gave highest result in interaction with M_3 (Zinc- 0.1% + Boron- 0.2%).

Yield and harvest index

In the present experiment six numbers of different mungbean varieties are used which have different yield capacity. From the result depicted in the Table 3 it is observed that seed yield and stover yield significantly differ for different varieties of mungbean. Highest seed yield (1054.40 kg/ha) and highest stover yield (2347.39 kg/ha) were recorded by V_4 (Virat) variety followed by V_3 (Bireswar), V_2 (Samrat), V_5 (TMB – 37), V_1 (MEHA-IPM-99-125) and lowest seed yield (760.90 kg ha^{-1}) and stover yield (1861.77 kg ha^{-1}) were recorded by V_6 (TM-2000-2) respectively. Variety V_4 (Virat) is significantly superior than rest four varieties but seed yield of V_4 (Virat) and V_3 (Bireswar) were statistically at par. From the result presented in the Table 3**,** it is observed that different varieties have no significant effects on harvest index of mungbean though highest harvest index (30.95 %) was recorded by variety V_4 (Virat).

Zinc, boron and their combined application, have significant effects on seed and stover yield (kg ha^{-1}) of mungbean and highest seed yield (953.70 kg ha^{-1}) and stover yield (2196.66 kg ha^{-1}) were recorded by M_3 (Zinc- 0.1% + Boron- 0.2%) and lowest yield were recorded under M_0 i.e. control condition or water spray. M_3 (Zinc- 0.1% + Boron- 0.2%) treatment was significantly superior to produce seed yield than other treatments but treatment M_2 (Boron- 0.2%) and M_1 (Zinc- 0.1%) were statistically at par. Application of zinc [M_1 (Zinc- 0.1%)] showed significant effects on seed yield and increased seed yield (6.09 %) over control which is in conformity with the result reported by Singh *et al*., (2013) who conducted one experiment using 12 mungbean varieties and revealed that, application Zn as foliar spray (before flowering) along with recommended dose of fertilizer in mungbean is good for enhancement of production, quality and socio economic status. M_3 (Zinc- 0.1% + Boron- 0.2%) treatment was significantly superior than M_1 (Zinc- 0.1%) and M_0 i.e. control but M_3 (Zinc- 0.1% + Boron- 0.2%) was statistically at par with M_2 (Boron- 0.2%) in case of stover yield. Application of zinc [M_1 (Zinc- 0.1%)] shows significant effects on stover yield and increases stover yield over control (Kumar *et al.,* 2020). Application of boron [M_2 (Boron- 0.2%)] also showed higher seed yield and stover yield over control. Karthik *et al.* (2021) also found that yield attributes viz. number of pods per plant , number of seeds per pod, seed yield, haulm yield were maximum with Boron 0.2% foliar application at 35 DAS. Combined application of Zn and Boron increases seed yield and stover yield over control. Alam *et al.* (2016) also reported that combined application of zinc and boron showed significant increase in yield and yield contributing characters of mungbean in acidic red soil of Northern and Eastern hills Soil. Zinc, boron and their combined application, have no significant effects on harvest index of mungbean and highest harvest index (30.19 %) was recorded by M_3(Zinc- 0.1% + Boron- 0.2%) and lowest harvest index (28.67 %) was recorded under M_0 i.e. control condition or water spray.

The interaction of different varieties of mungbean and micronutrients (Zn and B) did not show significant effects on seed yield, stover yield and harvest index.

4. Conclusion

It can be concluded from the present experiment that combined application of zinc and boron (Zinc- 0.1% + Boron- 0.2%) was observed to have a significant influence on the performance of mungbean growth and yield attributes. Variety, Virat was found more suitable with combined application of zinc and boron for producing higher seed and stover yield than other five varieties Bireswar, Samrat, TMB – 37, MEHA-IPM-99-125 and TM-2000-2 under Tripura condition. Zinc- 0.1% along with Boron- 0.2% was significantly superior to produce higher seed yield than sole application of zinc and boron but sole application of boron (0.2%) and zinc (0.1%) were statistically at par in respect of seed yield.

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Table 1. Effect of different varieties of mungbean and micronutrients (Zn and B) on plant height, root length and number of branches.

Plant height (cm)				**Root length (cm)**			**Number of branch plant^{-1}**
Treatments	**30 DAS**	**60 DAS**	**At Harvest**	**30 DAS**	**60 DAS**	**At Harvest**	**At harvest**
Different varieties							
V_1(MEHA-IPM-99-125)	15.48	35.77	50.55	6.35	12.14	17.08	3.40
V_2(Samrat)	18.52	41.15	54.32	7.17	13.82	17.97	4.02
V_3(Bireswar)	16.17	42.42	56.15	7.28	14.95	19.45	4.87
V_4(Virat)	16.38	44.05	58.59	7.60	15.08	20.25	5.48
V_5 (TMB – 37)	16.87	39.34	52.03	7.08	12.46	17.33	3.78
V_6(TM-2000-2)	15.66	33.93	49.14	6.27	11.41	16.12	2.70
S.Em±	0.92	1.11	1.25	0.24	0.36	0.67	0.21
CD (P=0.05)	NS	3.49	NS	NS	1.14	NS	0.68
Micronutrients (Zn and B)							
M_0(Control- Water spray)	16.39	37.77	51.63	6.69	12.16	16.53	3.31
M_1(Zinc- 0.1%)	16.89	38.57	53.02	6.86	12.97	17.84	3.90
M_2(Boron- 0.2%)	16.46	39.76	53.70	6.98	13.17	18.15	4.18
M_3(Zinc- 0.1% + Boron- 0.2%)	16.32	41.68	55.51	7.30	14.95	19.61	4.78
S.Em±	0.61	0.97	0.74	0.15	0.20	0.31	0.15
CD (P=0.05)	NS	NS	NS	NS	0.59	0.90	0.43

Table 2. Effect of different varieties of mungbean and micronutrients (Zn and B) on dry matter accumulation and crop growth rate.

Dry matter accumulation (g m^{-2})				**Crop growth rate (g m^{-2} day^{-1})**	
Treatments	**30 DAS**	**60 DAS**	**At Harvest**	**30 DAS – 60 DAS**	**60 DAS –Harvest**
Different varieties					
V_1(MEHA-IPM-99-125)	33.05	76.19	133.93	1.43	1.92
V_2(Samrat)	39.37	114.15	212.52	2.49	3.28
V_3(Bireswar)	44.35	139.75	254.29	3.17	3.81
V_4(Virat)	51.04	174.90	305.66	4.12	4.35
V_5 (TMB – 37)	38.71	92.21	165.64	1.78	2.44
V_6(TM-2000-2)	32.77	61.12	98.61	0.94	1.24
S.Em±	1.09	5.30	8.44	0.08	0.14
CD (P=0.05)	3.45	16.71	26.60	0.28	0.44

Micronutrients(Zn and B)					
M_0(Control- Water spray)	38.58	89.11	159.65	1.68	2.35
M_1(Zinc- 0.1%)	39.52	105.20	191.01	2.19	2.85
M_2(Boron- 0.2%)	41.22	116.25	203.99	2.49	2.92
M_3(Zinc- 0.1% + Boron- 0.2%)	40.20	128.32	225.78	2.93	3.24
S.Em±	1.51	2.38	3.75	0.06	0.04
CD (P=0.05)	NS	6.83	10.77	0.19	0.13

Table 3.a. Effect of different varieties of mungbean and micronutrients (Zn and B) on number of pods plant^{-1}, number of seeds pod^{-1}, test weight, seed yield, stover yield and harvest index.

Treatments	**Number of pods plant^{-1}**	**Number of seeds pod^{-1}**	**Test weight (g)**	**Seed yield (kg ha^{-1})**	**Stover yield (kg ha^{-1})**	**Harvest index (%)**
Different varieties						
V_1(MEHA-IPM-99-125)	13.33	7.85	35.42	788.20	1957.90	28.64
V_2(Samrat)	15.61	8.89	36.49	884.60	2140.20	29.19
V_3(Bireswar)	16.97	9.35	37.20	961.90	2221.60	30.19
V_4(Virat)	18.26	10.47	39.38	1054.40	2347.40	30.95
V_5 (TMB – 37)	14.32	8.57	35.87	825.80	2066.20	28.51
V_6(TM-2000-2)	12.04	7.60	34.62	760.90	1861.80	28.94
S.Em±	0.30	0.11	0.42	31.85	33.91	0.77
CD (P=0.05)	0.96	0.34	1.34	100.39	106.86	NS
Micronutrients (Zn and B)						
M_0(Control- Water spray)	11.96	7.36	35.64	809.00	2002.40	28.67
M_1(Zinc- 0.1%)	14.95	8.77	36.28	858.30	2071.00	29.20
M_2(Boron- 0.2%)	15.45	9.21	36.61	896.10	2126.60	29.55
M_3(Zinc- 0.1% + Boron- 0.2%)	18.02	9.80	37.45	953.70	2196.70	30.19
S.Em±	0.29	0.08	0.57	13.45	30.03	0.36
CD (P=0.05)	0.84	0.24	NS	38.58	86.14	NS

Table 3.b. Interaction effect of different varieties of mungbean and micronutrients (Zn and B) on number of seeds pod^{-1}

Treatment	**Mungbean Varieties**					
Micronutrients	**V1 (MEHA-IPM-99-125)**	**V2 (Samrat)**	**V3 (Bireswar)**	**V4 (Virat)**	**V5 (TMB – 37)**	**V6 (TM-2000-2)**
M_0(Control- Water spray)	6.38	7.90	7.81	8.37	7.67	6.08
M_1(Zinc- 0.1%)	7.65	8.95	9.56	10.11	8.54	7.85
M_2(Boron- 0.2%)	8.40	9.10	9.61	11.15	8.94	8.10
M_3(Zinc- 0.1% + Boron- 0.2%)	8.97	9.62	10.42	12.27	9.13	8.37
Variety×Micronutrient						
S.Em±	0.21					
CD (P=0.05)	0.58					
Micronutrient×Variety						
S.Em±	0.21					
CD (P=0.05)	0.61					