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RESPONSE OF INDIAN MUSTARD (*BRASSICA JUNCEA*) TO SOLE AND COMBINED FOLIAR APPLICATION OF ZINC AND BORON

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ABSTRACT

In order to evaluate the role of foliar application of Zn and B in improving mustard growth, yield and quality under new alluvial zone of West Bengal, an experiment was conducted at Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Vishwavidyalaya during *rabi* (November-March) season of 2020-21. Seven treatment combinations were tried in the experiment which was laid out in randomized block design with three replications. All the plots were fertilized with a recommended dose of chemical fertilizer along with sole and combined foliar application of 0.1% Zn-EDTA and 0.2% Solubor respectively. Results revealed that mustard plot fertilized with 0.1% Zn-EDTA + 0.2% Solubor at 30 and 50 DAS recorded the highest plant height, dry matter accumulation, number of branches plant^{-1}, number of siliqua plant^{-1} and number of seeds siliqua^{-1}. The maximum seed yield was recorded as 1864.2 kg ha^{-1} with 0.1% Zinc-EDTA + 0.2% Solubor at 30 and 50 DAS followed by 0.1% Zinc-EDTA + 0.2% Solubor at 30 DAS obtaining seed yield of 1726.2kg ha^{-1}. The highest oil content (43.2%) was recorded with 0.1 % Zinc-EDTA + 0.2% Solubor at 30 and 50 DAS followed by 0.1% Zinc-EDTA + 0.2% Solubor at 30 DAS (41.1% oil content). Further, combined application of zinc and boron at 30 and 50 DAS influenced higher grain yield but no significant difference was observed in grain yield of mustard with single spray of these nutrients at 30 DAS. Thus at least one combined foliar spray of Zn and B at 30 DAS may be recommended not only for ensuring increased productivity, nutrient (Zn and B) and oil content in grains but also for higher income.

***Key words*: Oilseed, Foliar fertilization, Micronutrient, Productivity, Quality assessment**

Introduction

Rapeseed and mustard are the main oilseed crops grown in the rabi season in India (Kumar *et al.*, 2014). Indian mustard (*Brassica juncea*) is a significantly important oilseed crop in eastern India including West Bengal as it can be grown in post rainy dry season with residual soil moisture with minimal resources (Banerjee *et al*., 2018). Globally, India accounts for 12-15% of oilseeds area and 7-8% of production (Jha *et al.*, 2012). From an area of 0.61 mha, Bengal contributed 1.21 t/ha mustard during 2018-19 (GOI, 2019). However, recent climatic abnormalities and age-old agronomic practices with negligible concern resulting poor productivity than national average. Moreover, intensive fertilization to produce more yields ultimately accelerates the micronutrient mining from soil. Zinc (Zn) plays a vital role in cell expansion, cell division, protein synthesis, carbohydrates metabolism, nucleic acid and lipid metabolism (Khan *et al.*, 2016). Zinc deficiency cause biochemical changes in membranes and also cause reduction in growth and yield. On the other hand, Indian mustard is highly sensitive to boron (B), nitrogen (N), and sulfur (S) deficiency, thereby resulting in a decreased growth, yield, and productivity of the crop (Vanisha et *al.*, 2013; Sanwal *et al.*, 2016). It plays a key role in a diverse range of functions including cell wall formation and stability, maintenance of structural and functional integrity of biological membranes, movement of sugar or energy into growing parts of plants, pollination and seed set (George *et al*., 2012). Boron deficiency is one of the major constraints to crop production (Dhaliwal *et al*., 2022). Its deficiency has been realized as the second most important micronutrient constraint in crops on the global scale (Ahmad *et al*., 2012). About one-third of the cultivated soils in India are deficient in B (Gupta *et al*., 2008). The mustard crop is very much responsive to B (Mengel and Kirkby, 2001). Till now, various methods including soil, foliar, and seed treatment of B to crops have been reported to alleviate their deficiency. Foliar application is the greatest strategy to increase the micronutrient content in crops among different biofortification techniques because nutrients are supplied to the leaves at the appropriate growth stages (Poblaciones and Rengel, 2017; Doolette *et al*., 2018; Kandil *et al*., 2022).

Materials and Methods

Present study was conducted during the *rabi* season of 2020–21 at Central Research Farm, BCKV, Nadia, India (22.98°N latitude, 88.49°E longitude, and 17 m above MSL). The negligible amount of rainfall was recorded throughout the crop period. Moderate fertility with good internal drainage and neutral pH are the key characteristic of the experimented soil. Maximum and minimum temperature was varied in between 29.6°C and 24.8°C, and 17.5°C and 11.5°C, respectively. Maximum and minimum relative humidity ranged from 43.5 to 52.0% and 91.3 to 89.1%, respectively. The experiment was laid out in randomized block design (RBD) with three replications comprising of seven foliar fertilizations *viz.* T_1 - no foliar spray (control); T_2 - 0.1 % Zinc-EDTA at 30 DAS; T_3 - 0.2% Solubor at 30 DAS; T_4 - 0.1 % Zinc-EDTA+ 0.2% Solubor at 30 DAS; T_5 - 0.1 % Zinc-EDTA at 30 and 50 DAS; T_6 - 0.2% Solubor at 30 and 50 DAS; T_7 - 0.1 % Zinc-EDTA+ 0.2% Solubor at 30 and 50 DAS. The mustard hybrid (*cv.* PM-28) was sown at 30 cm × 10 cm. Uniform dose of nitrogen, phosphorous and potassium (80 kg N, 40 kg P_2O_5, and 40 kg K_2O) was supplied to each plot. Foliar fertilization of Zn and B was given at 30 DAS and 50 DAS as par treatment. Observations on growth (plant height, dry matter accumulation, crop growth rate), yield components (number of branches plants^{-1}, number of siliqua plants^{-1}, number of seeds siliqua^{-1}, test weight), seed yield, stover yield, harvest index (%), qualitative traits (oil %, Zn and B content) in mustard and finally, economics was calculated as par standard procedure (Banerjee *et al*., 2018). The STAR Software version 2.0.1 was used for analyzing recorded data on selected parameters. The treatment means were separated using the least significant difference (LSD) at the 5% level of significance.

Results and Discussions

Growth attributes

Plant height exhibited an increasing trend upto maturity irrespective of different foliar nutrition and it was significantly influenced by application of Zn and B (Table 1). Among the different foliar application schedules, application of 0.1 % Zinc-EDTA + 0.2% Solubor at 30 and 50 DAS produced significantly taller plant than others, while the shortest plant was recorded in control treatment (RDF only). Dry matter accumulation increased steadily for all treatments upto 95 DAS. Among the treatments, highest dry matter accumulation was recorded in T_7 (665.6g m^{-2} at 65 DAS, 825.6 g m^{-2} at 85 DAS and 893.6 g m^{-2} at 95 DAS) and the lowest was recorded in control plots at all growth stages (Table 1). The rate of growth for mustard (var. PM-28), as measured by calculating crop growth rate (CGR), reached at top level during 85 DAS, and beyond that it showed a

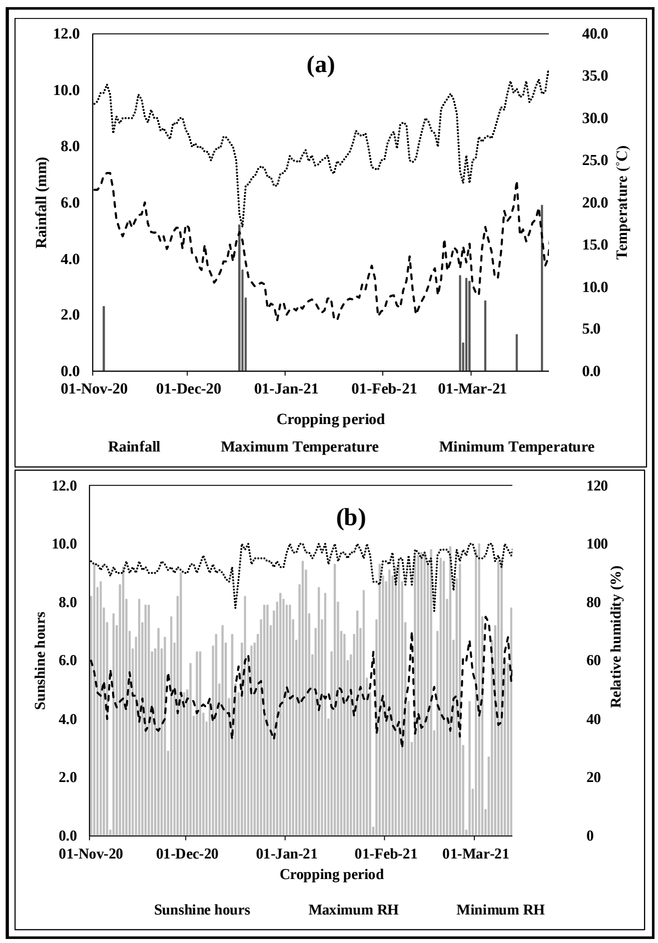

Fig. 1: Meteorological observations on rainfall and temperature; **(a)** sunshine hours and relative humidity; **(b)** during the experimental period.

Table 1: Growth attributes and yield components of Indian mustard (*cv.* PM-28) as influenced by foliar application of Zn and B.

Treatments	Growth attributes									Yield attributes			
	Plant height (cm)			DMA (g m^{-2})			CGR (g m^{-2} day^{-1})			No. of branches plant^{-1}	No. of siliqua plant^{-1}	No. of seeds siliqua^{-1}	1000 -grain weight (g)
	65 DAS	85 DAS	95 DAS	65 DAS	85 DAS	95 DAS	45-65 DAS	65-85 DAS	85-95 DAS				
Control (RDF)	134	139	148	426	549	590	6.5	6.12	4.1	4.6	61.5	11.9	4.59
0.1 % Zinc-EDTA at 30 DAS	144	149	159	560	668	714	8.6	5.4	4.6	5.1	111.3	13.6	4.72
0.2% Solubor at 30 DAS	139	147	155	541	643	686	8.3	5.1	4.3	4.6	98.0	13.3	4.63
0.1 % Zinc-EDTA + 0.2% Solubor at 30 DAS	153	163	169	621	779	842	9.5	7.9	6.3	5.6	125.6	14.6	4.88
0.1 % Zinc-EDTA at 30 and 50 DAS	149	151	175	615	771	832	9.4	7.8	6.1	5.6	119.1	13.9	4.85
0.2% Solubor at 30 and 50 DAS	147	150	165	600	716	770	9.2	5.8	5.4	5.3	116.6	13.7	4.76
0.1 % Zinc-EDTA + 0.2% Solubor at 30 and 50 DAS	155	170	185	665	826	894	10.2	8.0	6.8	6.0	126.3	15.0	5.02
LSD ($P \leq 0.05$)	9.06	6.64	11.55	79.60	97.54	108.10	1.22	1.30	1.89	0.72	0.72	2.75	ns

RDF recommended dose of fertilizer DAS- days after sowing; DMA- dry matter accumulation; CGR- crop growth rate; LSD least significant difference; ns- non significant

decreasing trend towards maturity. The CGR of the tested mustard cultivar was significantly influenced by the different types of foliar nutrition (Table 1). Highest CGR was recorded with the crop receiving 0.1 % Zinc-EDTA + 0.2% Solubor at 30 and 50 DAS and the lowest CGR was recorded in plants of control plot at all growth stages. Zinc produced higher impact on CGR as compared to boron both in single and double applications though the differences were significant in case of double application. Better growth traits from supplemental micronutrient application were the consequence of higher oxygen biosynthesis, more efficiency of phosphor enol pyruvate carboxylase and ribulose biphosphate carboxylase, less sodium concentration in plant tissues and increased inefficiency of primary macronutrients (Yadav *et al*., 2016).

Yield components

Application of foliar nutrition enhanced the yield attributes and seed yield of hybrid mustard during winter season, compared to control situation. The number of branches plant^{-1} of mustard was significantly influenced by foliar application of zinc and boron (Table 1). It was observed that combined application of Zn and B twice at 30 and 50 DAS (T_7) produced higher number of branches plant^{-1} (6.0) as compared to application of either Zn or B once (at 30 DAS) or twice (at 30 and 60 DAS) and combined application (Zn + B) at 30 DAS. Under different foliar application protocols, the maximum number of siliqua plant^{-1} was obtained with combined application of Zn + B twice at 30 and 50 DAS (126.3). The lowest number of siliqua plant^{-1} was recorded with no foliar treatment (61.5). Foliar application of Zn and B in combination produced a comparatively higher effect when applied at 30 and 50 DAS as compared to single application at 30 DAS. Highest number of seed siliqua^{-1} (15) was recorded with combined application of Zn + B at 30 and 50 DAS and the effect was at par with other treatments except for control (RDF only). The lowest number of seeds siliqua^{-1} was recorded

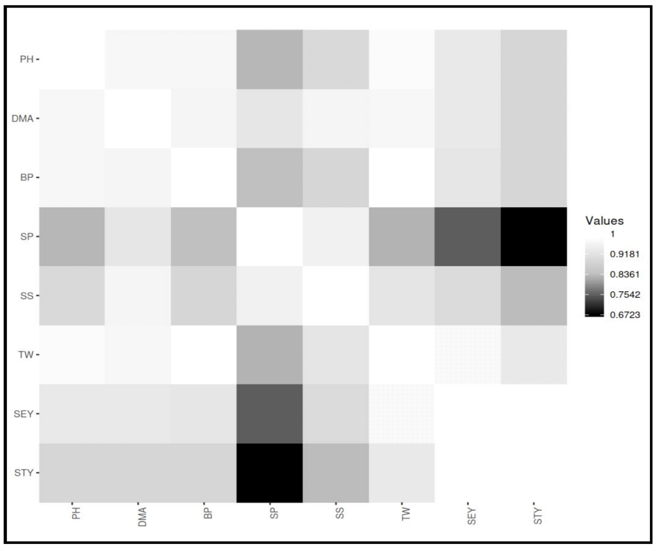

Fig. 2: Correlation heatmap among different observed traits of Indian mustard.

(Notes: PH = plant height at harvest in cm, DM = dry matter at harvest in g m^{-2}, BP = Branches plant^{-1} in nos., SP = Siliqua plant^{-1} in nos., SS = Seeds siliqua^{-1} in nos., TW = Test weight in g, SEY = Seed yield in kg ha^{-1}, STY = Stover yield in kg ha^{-1})

Table 2: Yield, harvest index, economics and quality of Indian mustard (*cv.* PM-28) as influenced by foliar application of Zn and B.

Treatments	Yield			Economics			Quality traits		
	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C	Oil content (%)	Zn content (ppm)	B content (ppm)
Control (RDF)	1320	2679	33.5	52808	22208	1.73	35.0	0.2	0.6
0.1 % Zinc-EDTA at 30 DAS	1409	2698	34.3	56348	23992	1.74	36.7	0.3	0.6
0.2% Solubor at 30 DAS	1399.	2716	34.0	55984	24058	1.75	36.3	0.2	0.7
0.1 % Zinc-EDTA + 0.2% Solubor at 30 DAS	1726	3136	35.5	69048	36122	2.10	41.1	0.3	0.7
0.1 % Zinc-EDTA at 30 and 50 DAS	1615	3013	34.9	64612	30500	1.89	38.8	0.4	0.7
0.2 % Solubor at 30 and 50 DAS	1453	2735	34.7	58140	24888	1.75	37.7	0.2	0.8
0.1 % Zinc-EDTA + 0.2% Solubor at 30 and 50 DAS	1864	3243	36.5	74568	39116	2.10	43.2	0.3	0.7
LSD ($P \leq 0.05$)	169.09	242.92	1.77	-	-	-	2.60	0.06	0.14

RDF recommended dose of fertilizer; B:C - benefit-cost ratio; Zn- zinc; B- boron; LSD least significant difference

in control plots (Table 1). In this experiment, the treatments with and without micronutrients (control, only RDF) had no significant influence on test weight of mustard, which might be because the test weight is a genetic trait of a particular variety. However, highest test weight (5.02g) was recorded with combined application of Zn and B at 30 and 50 DAS and the lowest (4.59 g) recorded with control treatment (RDF only). Yield enhancement from foliar feeding of micronutrient might be due to the better enzymatic activities, acceleration of photosynthesis and better translocation of photosynthates from source to sink (seed) (Afsahi *et al*., 2020).

Yield

Mustard yield was significantly influenced by foliar application of Zn and B at different growth stages (Table 2). Highest seed yield was obtained with the application of 0.1 % Zinc-EDTA + 0.2% Solubor at 30 and 50 DAS and the lowest was observed in control plots (no foliar application). Application of both Zn and B was found to be more effective (treatments T_4 and T_7) in enhancing the yield of mustard than application of either Zn or B. Though combined application of these nutrients recorded 7.99% higher yield (1864.2 kg ha^{-1}) when applied at 30 and 50 DAS (T_7) compared to single application at 30 DAS (T_4) (1726.2 kg ha^{-1}), no significant difference was observed between these two treatments. Both these treatments recorded significantly higher yields over control. Effect of micronutrient application in a balanced fertilization schedule has also been found to increase use efficiency of macronutrients in different cropping systems and thus lead to yield improvement. Stover yield was found to be the best (3243.2 kg ha^{-1}) with the application of 0.1 % Zinc-EDTA + 0.2% Solubor at 30 and 50 DAS ((Table 2). The lowest stover yield (2679.3 kg ha^{-1}) was recorded in control plots. Harvest Index (HI) was significantly different among the treatments. The highest harvest index (36.5%) was observed with combined application of Zn and B at 30 DAS and 50 DAS (Table 2). The lowest HI was recorded in control plots (33.5%). The higher values of HI were due to application of micronutrients which might have enhanced the photosynthetic activity and translocation of photosynthates to economic parts because of increased enzymatic and other biological activities. The results conform to the findings of Kour *et al.,* (2017).

Quality parameters

Oil content in mustard was significantly influenced by foliar application of Zn and B (Table 2). Highest oil content (43.2%) was obtained with application of 0.1 % Zinc-EDTA + 0.2% Solubor at 30 and 50 DAS and the effect of this treatment was at par with the application of 0.1% Zinc-EDTA + 0.2% Solubor at 30 DAS (41.1%). Lowest amount of oil content was recorded in control plot (35%). Zinc content in mustard grain was significantly influenced by the foliar application of Zn and B (Table 2). Highest concentration of Zn was observed (0.4 ppm) with foliar application of Zn twice at pre-flowering (30 DAS) and at 50% flowering stage (50 DAS), which was significantly superior to all other treatments. Highest concentration of B (0.8 ppm) was also measured when boron was applied twice at 30 and 50 DAS but remained statistically at par with all treatments except control (RDF only) and foliar application of Zn at 30 DAS (Table 2). The lowest concentrations of Zn and B were recorded in control plots.

Economic analysis

Among the treatments, the combined application of

Zn and B at 30 and 50 DAS resulted in the highest gross and net return per hectare followed by foliar application of both Zn and B only at 30 DAS (Table 2). The lowest gross and net return per hectare was obtained with the treatment with control treatment (no foliar application) because the lowest yield was realized at this treatment. The highest benefit: cost ratio (2.10) was noted with the treatments of 0.1 % Zinc-EDTA+ 0.2% Solubor at 30 DAS and 0.1 % Zinc-EDTA+ 0.2% Solubor at 30 and 50 DAS (Table 2). Less cost of cultivation and comparatively higher yield might have attributed higher B:C ratio with the treatment having single spray of both Zn and B at 30 DAS. The lowest BCR was computed with the control treatment (1.73).

Conclusion

This research quantified mustard productivity and yield-attributing traits and evaluated the seed quality and profitability under differential doses of Zn and B. From aforesaid results and discussion, it may be concluded that in addition to recommended dose of macronutrients, the supplemental application through foliar is earnestly needed not only for more production but also for better oil content and quality. Micronutrient application accounted ~70% more return than control that makes it economically feasible also.

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