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Influence of boron and zinc application on quality and nutrient uptake of Indian mustard (*Brassica juncea*)

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Abstract

A field experiment was conducted during the *Rabi* season of 2019-20 at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, on clayey and slightly alkaline soil to evaluate the “Response of Indian Mustard (*Brassica juncea*) to Boron and Zinc Fertilization”. The experiment was laid out in a Randomized Block Design (RBD) with three replications using the variety GDM-4 of Indian mustard. A total of nine treatment combinations were tested, comprising: T₁: RDF, T₂: RDF + 1 kg B/ha, T₃: RDF + 2 kg B/ha, T₄: RDF + 4 kg Zn/ha, T₅: RDF + 8 kg Zn/ha, T₆: RDF + 1 kg B + 4 kg Zn/ha, T₇: RDF + 2 kg B + 4 kg Zn/ha, T₈: RDF + 1 kg B + 8 kg Zn/ha, and T₉: RDF + 2 kg B + 8 kg Zn/ha. Application of boron and zinc significantly influenced seed quality and nutrient uptake in Indian mustard. Treatment T₉ (RDF + 2 kg B ha⁻¹ + 8 kg Zn ha⁻¹) recorded the highest protein (25.91%) and oil content (44.08%), followed by T₈, T₇, and T₆. Nitrogen content in seed was significantly higher under T₉, while P₂O₅ and K₂O contents remained non-significant. Maximum uptake of N, P₂O₅, and K₂O by seed (40.29, 14.82, and 19.88 kg ha⁻¹, respectively) as well as Zn and B uptake (47.39 and 38.19 mg ha⁻¹, respectively) was observed under T₉ and was at par with T₈, T₇, and T₆. Post-harvest soil available N, P₂O₅, and K₂O were not significantly affected by boron and zinc fertilization. The results of the study indicated that higher and more profitable yield of *rabi* Indian mustard can be achieved with the application of RDF + 2 kg B ha⁻¹ + 8 kg Zn ha⁻¹, which proved superior to both sole and other combined applications of boron and zinc. Combined application of zinc and boron also enhanced seed quality by significantly increasing protein and oil content.

Keywords: Indian mustard, protein content, nutrient uptake, boron, zinc

Introduction

India is the fourth-largest producer of oilseed crops globally, after the USA, China, and Brazil. Oilseeds play a crucial role in the production of edible oils, while whole oilseeds are valuable sources of energy, protein, and fibre; the oil cakes derived from them are extensively used as feed for livestock. Among oilseed crops, Indian mustard (*Brassica juncea* L.) occupies a prominent position in India, contributing substantially to the nation's edible oil supply and supporting the rural economy. India ranks among the leading countries in rapeseed-mustard cultivation, with an area of 86.29 lakh hectares, production of 126.06 lakh tonnes, and an average productivity of 1,461 kg ha⁻¹ during the 2024-25 crop year (July-June) (Anonymous a). At the state level, Rajasthan is the largest producer of rapeseed-mustard, recording a production of 5.76 million tonnes, followed by Uttar Pradesh (1.96 million tonnes) and Madhya Pradesh (1.92 million tonnes) (Economic Survey 2024-25). Despite its economic importance, mustard productivity in India is often limited by soil nutrient constraints, particularly deficiencies of micronutrients such as zinc (Zn) and boron (B). Zinc is vital for enzymatic activity, protein synthesis, and auxin metabolism, while boron plays a key role in cell wall formation, pollen tube growth, and reproductive development. Deficiency of these nutrients results in stunted growth, chlorosis, poor seed set, and reduced yield and quality. Boron deficiency, in particular, causes sterility manifested as fewer pods and seeds per pod, leading to low seed yield, whereas boron application has been reported to improve oil and protein content in mustard seed (Choudhary and Bhagal, 2017) [2].

Research has shown that supplementation of Zn and B, either alone or in combination with recommended doses of NPK fertilizers, can significantly enhance growth attributes, seed

yield, oil content, and nutrient uptake in Indian mustard. (Pandey *et al.*, 2018) ^[9]. The combined application of these micronutrients has often outperformed sole applications in terms of productivity and seed quality, highlighting the importance of balanced fertilization for improving both yield and economic returns in mustard production systems.

Materials and Methods

A field trial was conducted in the college farm of N.M College of Agriculture, Navsari Agricultural University, Navsari during the *rabi* season of 2019-20. The study area falls under the heavy rainfall zone of South Gujarat, characterized by deep black clayey soils with medium to poor drainage, good water holding capacity with an initial soil reaction of 7.68 and normal electrical conductivity of 0.38 with low available N (238.6 kg ha⁻¹), medium available P (50.8 kg ha⁻¹) and high available K (356.2 kg ha⁻¹). The trial was laid out in a Randomized Block Design (RBD) with factorial concept in three replications constituting the following treatment combinations of T₁ (RDF), T₂ (1 Kg B/ha), T₃ (2 Kg B/ha), T₄ (4 Kg Zn/ha), T₅ (8 Kg Zn/ha), T₆ (1 Kg B + 4 Kg Zn/ha), T₇ (2 Kg B + 4 Kg Zn/ha), T₈ (1 Kg B + 8 Kg Zn/ha) and T₉ (2 Kg B + 8 Kg Zn/ha). A fine tilth suitable for sowing was achieved through field preparation using a tractor-drawn plough, followed by harrowing and planking. Basal application of organic manures, viz., FYM and bio-compost, along with inorganic fertilizers such as urea, single super phosphate, zinc sulphate, and borax, was carried out as per the respective treatment requirements. Indian mustard (*Brassica juncea* L.) variety GDM-4 was sown on 19 November 2019 using a seed rate of 3.5-4.0 kg ha⁻¹ at a depth of 3-4 cm, maintaining a spacing of 45 × 15 cm. An optimum plant population was ensured through thinning and gap filling at 10 days after sowing (DAS). Weed management was undertaken through two hand weedings, and irrigation was provided as per the crop requirement to ensure normal crop growth. Biometric observations recorded during the experimentation included plant population, plant height, number of branches per plant, days to 50% flowering, number of siliquae/plant, number of seed/siliquae, Siliquae length, Seed and stover yield (kg/ha), Harvest index and test weight (g). Besides these quality parameters, such as protein content and oil content, and biochemical parameters like N, P, K, B, and Zn content and uptake by mustard, soil N, P, and K levels were calculated before and after harvest. The crop was harvested during the

first week of March 2020. After adequate drying, the total biological yield was recorded, and plot-wise threshing was carried out manually by beating with sticks, followed by winnowing and cleaning of the grains.

The cost of cultivation was computed for each treatment by accounting for all field operations from preparatory tillage to threshing, based on prevailing local market rates. Gross returns (₹ ha⁻¹) were calculated from seed and straw yields using the respective market prices, while net returns were estimated by subtracting the total cost of cultivation from the gross returns. The benefit-cost (B: C) ratio was calculated as the ratio of gross returns to the total cost of cultivation. Data pertaining to growth, yield, and yield-attributing characters were subjected to analysis of variance (ANOVA) appropriate for a randomized block design, following the procedure described by Fisher (1950) ^[11]. Treatment means were compared using the critical difference (CD) at the 5% level of significance wherever the F-test indicated significant differences among treatments.

Results and Discussion

Protein content (%)

The protein content in Indian mustard improved significantly with boron and zinc fertilization. The highest protein content was obtained in the T₉ (25.91%) treatment which remained statistically at par with treatments T₈, T₇ and T₆ over control. The application of 2 Kg B + 8 Kg Zn/ha increased the protein content of Indian mustard by 32.12% over control.

Oil Content (%)

Significantly higher oil content was recorded under treatment T₉ (44.08%), which was statistically at par with treatments T₈, T₇, and T₆. In contrast, the lowest oil content was observed under control (T₁). The increase in oil content under T₉ was 13.19% over the control. The enhanced oil content may be attributed to improved metabolic activity associated with the biosynthesis of carbohydrates, organic acids, amino acids, and other biochemical constituents (Sethupathi, 2019) ^[10]. Zinc plays a crucial role in the activation and synthesis of several enzymes, thereby facilitating oil biosynthesis in mustard seeds. Furthermore, the individual and interactive effects of boron and zinc on oil content were significant (Kumar *et al.*, 2014) ^[6]. The present findings are in close agreement with earlier reports by Hallur (2011) ^[5] and Nadaf and Chandranath (2019) ^[7].

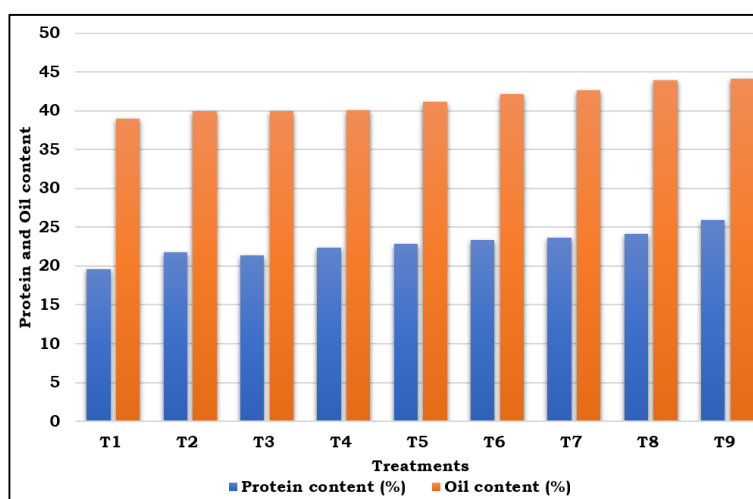


Fig 1: Protein and Oil Content of Indian Mustard as influenced by Zinc and Boron fertilization

Nutrient Content and Uptake by Indian mustard: The highest nitrogen content in seed was recorded under treatment T₉ and was statistically at par with treatments T₈, T₇, T₆, and T₅, whereas the lowest value was observed under the control (T₁). Seed P₂O₅ and K₂O contents were not significantly influenced by the treatments; however, maximum P₂O₅ (0.59%) and K₂O (0.79%) contents were noted under T₉, while minimum values occurred under T₁. Nitrogen uptake by seed was significantly highest under T₉ (40.29 kg ha⁻¹) and remained at par with T₈, T₇, and T₆. Similarly, P₂O₅ uptake was highest under T₉ (14.82 kg ha⁻¹) but was statistically comparable with T₈, T₇, T₆, and T₅. The

highest K₂O uptake by seed was recorded under T₉ (19.88 kg ha⁻¹), remaining at par with T₈, T₇, and T₆. Significantly lower uptake of N, P₂O₅, and K₂O was recorded under the control (T₁).

Enhanced nutrient uptake under boron and zinc fertilization may be attributed to improved seed setting, seed quality, and nitrogen absorption (Nandi *et al.*, 2020) [8]. The superior nutrient uptake recorded under treatment T₉ could further be ascribed to enhanced vegetative growth and better root development, leading to increased absorption of N, P, and K from the soil and improved metabolic activity within the plant (Nandi *et al.*, 2020) [8].

Table 1: N, P and K content and uptake in seed of Indian mustard as influenced by zinc and boron fertilization.

Treatments		N, P, K content in seed (%)			N, P, K uptake by seed (kg/ha)		
		N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
T ₁	RDF	0.55	0.67	0.67	26.68	10.66	12.97
T ₂	1 Kg B/ha	0.57	0.67	0.67	27.35	11.03	13.13
T ₃	2 Kg B/ha	0.57	0.70	0.70	28.59	11.46	14.09
T ₄	4 Kg Zn/ha	0.57	0.71	0.71	29.92	11.86	14.62
T ₅	8 Kg Zn/ha	0.57	0.74	0.74	31.27	12.34	15.82
T ₆	1 Kg B + 4 Kg Zn/ha	0.58	0.76	0.76	33.52	13.06	17.40
T ₇	2 Kg B + 4 Kg Zn/ha	0.58	0.78	0.78	38.94	14.54	19.26
T ₈	1 Kg B + 8 Kg Zn/ha	0.58	0.78	0.78	39.89	14.63	19.42
T ₉	2 Kg B + 8 Kg Zn/ha	0.59	0.79	0.79	40.29	14.82	19.88
	S.E.m. ±	0.01	0.04	0.04	2.59	0.85	1.30
	C.D at 5%	NS	NS	NS	7.78	2.56	3.92
	C.V.%	3.83	10.73	10.73	13.64	11.64	13.91

Zn and B content and uptake by Indian mustard

Significantly highest Zn content in seed was recorded with treatment T₉ (18.73 ppm) which remained statistically at par with T₈, T₅, T₇, T₆ and T₄. The highest B content was recorded with treatment T₉ (15.12 ppm) and remained statistically at par with treatments T₇, T₃, T₈, T₆ and T₂. The lowest Zn and B content in seed was registered under control (T₁).

Considerably highest Zn uptake by seed was recorded with treatment T₉ (47.39 mg/ha) which remained at par with treatments T₈, T₇, T₅ and T₆ and B uptake by seed was significantly highest under treatment T₉ (38.19 mg/ha), which remained statistically at par with treatments T₇, T₈ and T₆. The lowest uptake by seed was observed under treatment T₁ for both the nutrients Zn and B. The suggested

fertilization of Zn and B nutrients will increase the concentration of both nutrients in the plant tissue (Debnath *et al.*, 2015) [3].

Debnath *et al.* (2015) [3] reported that the combined application of Zn and B tended to enhance B uptake by mustard grown in the alluvial soils of Kanpur, Uttar Pradesh. Increased B uptake was observed at all levels of B application with increasing Zn supply, indicating that adequate Zn availability facilitates B accumulation in mustard grain, seed, and stalk. Furthermore, higher B supply under elevated Zn application rates resulted in improved Zn uptake, suggesting a synergistic interaction between B and Zn. This implies that B application can enhance Zn uptake when Zn is supplied at adequate levels (Kumar *et al.*, 2014) [6].

Table 2: Zn and B content and uptake by seed of Indian mustard as influenced by zinc and boron fertilization.

Treatments		Zn and B content and uptake by seed			
		Zn and B content (ppm)		Zn and B uptake (mg/ha)	
		Zn	B	Zn	B
T ₁	RDF	16.18	13.27	31.19	25.52
T ₂	1 Kg B/ha	16.37	14.70	31.87	28.68
T ₃	2 Kg B/ha	16.40	15.00	33.09	30.27
T ₄	4 Kg Zn/ha	17.25	13.27	35.78	27.48
T ₅	8 Kg Zn/ha	18.42	13.43	39.54	28.90
T ₆	1 Kg B + 4 Kg Zn/ha	17.50	14.78	39.47	33.33
T ₇	2 Kg B + 4 Kg Zn/ha	17.57	15.07	43.83	37.45
T ₈	1 Kg B + 8 Kg Zn/ha	18.50	14.87	46.62	37.43
T ₉	2 Kg B + 8 Kg Zn/ha	18.73	15.12	47.39	38.19
	S.E.m. ±	0.60	0.49	3.01	2.31
	C.D at 5%	1.80	1.49	9.03	6.93
	C.V.%	5.97	5.98	13.46	12.54

NPK status of soil before and after crop harvest

Soil samples were collected from 0-15 cm depth before and after harvest of the Indian mustard crop. The status of

available N, P and K before the crop sowing was in the order of 238.9, 51.1 and 356.4 kg/ha, respectively. N content in soil after harvest was found to be non-significant.

The highest N content in soil after harvest was recorded in treatment T₈ (249.58 kg/ha) while lowest registered in treatment T₂ (246.93 kg/ha). Non-significant effect of zinc and boron fertilization treatments on available phosphorus (P₂O₅ kg/ha) of soil after harvest of crop was recorded and the highest P₂O₅ content in soil after harvest was recorded in treatment T₇ (53.86 kg/ha) while lowest registered in treatment T₁ (51.93 kg/ha). Non-significantly the highest available K₂O of soil after harvest of the crop was recorded from treatment T₉ (350.51 kg/ha) while lowest registered in treatment T₄ (346.26 kg/ha). The results revealed that differences among Zn and B fertilization treatments in available N, P₂O₅ and K₂O in the soil after harvest of crop were found non-significant. It means there was no adverse effect of treatments of Zn and B fertilization on Indian mustard crop.

Table 3: NPK content in soil after harvest of Indian mustard as influenced by zinc and boron fertilization.

Treatments	NPK content in soil after harvest (kg/ha)		
	N	P ₂ O ₅	K ₂ O
T ₁ RDF	247.90	51.93	346.99
T ₂ 1 Kg B/ha	246.93	53.21	348.99
T ₃ 2 Kg B/ha	248.40	53.70	347.14
T ₄ 4 Kg Zn/ha	247.90	52.97	346.26
T ₅ 8 Kg Zn/ha	249.27	53.64	350.03
T ₆ 1 Kg B + 4 Kg Zn/ha	249.40	52.37	349.88
T ₇ 2 Kg B + 4 Kg Zn/ha	249.30	53.86	350.26
T ₈ 1 Kg B + 8 Kg Zn/ha	249.58	53.71	350.09
T ₉ 2 Kg B + 8 Kg Zn/ha	249.38	53.82	350.51
S.E.m. ±	17.14	1.66	19.00
C.D at 5%	NS	NS	NS
C.V.%	11.94	5.43	9.43

Conclusion

From the results of the experiment, it can be inferred that the combined application of RDF + 2 Kg B + 8 Kg Zn/ha over other combinations as well as sole Zn and B fertilization significantly improved protein and oil content. Significantly highest N content in seed was registered under 2 Kg B + 8 Kg Zn/ha treatment T₉ which was at par with T₈, T₇, T₆, and T₅. The P₂O₅ and K₂O content in seed was found non-significant. Considerably the highest Zn and B content in seed were observed with 2 Kg B + 8 Kg Zn/ha fertilization. Significantly highest uptake of N, P, K, Zn and B was recorded in T₉ (2 Kg B + 8 Kg Zn/ha). The different treatments of B and Zn fertilization practices did not cause significant influence on N, P₂O₅ and K₂O content in soil after harvest of Indian mustard.

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