

Original Research Article

<https://doi.org/10.20546/ijcmas.2019.806.298>

Effect of Zinc and Boron on Nutrient Uptake, Yield and Quality of Mustard under Rainfed Condition

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ABSTRACT

Keywords

Zinc, Boron,
Mustard, Yield, Oil
content, Uptake

Article Info

Accepted:

18 May 2019

Available Online:

10 June 2019

A field experiment was conducted to study the effect of zinc and boron levels on yield, quality and nutrient uptake in mustard under Northern transition zone of Karnataka during *rabi*, 2017 at MARS, UAS, Dharwad with 10 treatments. The treatment comprised of two levels of zinc (10 kg ha⁻¹ and 20 kg ha⁻¹) and two levels of boron (1 kg ha⁻¹ and 2 kg ha⁻¹) and their combinations. These treatments were compared with RDF + FYM @ 5 t ha⁻¹ and RDF (60:50:40 N: P₂O₅: K₂O) alone. The treatments were replicated thrice in a randomized block design. The experimental soil being deficient in zinc and boron, good response of crop to the applied zinc and boron was noticed. Application of ZnSO₄ @ 20 kg ha⁻¹ along with borax @ 2 kg ha⁻¹ recorded higher seed yield (1973 kg ha⁻¹), oil content (37.08 %), oil yield (731 kg ha⁻¹), uptake of zinc (242 g ha⁻¹) and boron (76 g ha⁻¹) were noticed over RDF + FYM alone. However which was on par with application of RDF + ZnSO₄ @ 20 kg ha⁻¹ + Borax @ 1 kg ha⁻¹ and RDF + ZnSO₄ @ 10 kg ha⁻¹ + Borax @ 2 kg ha⁻¹

Introduction

Mustard (*Brassica juncea* L.) is an important edible oilseed crop in India. Area, production and productivity of mustard is 5.74 million hectares, 6.28 million tonnes and 1,183 kg ha⁻¹ respectively. In Karnataka area, production and productivity of mustard is 0.02 million hectares, 1.00 million tonnes and 500 kg ha⁻¹ respectively (Anon., 2017). The Karnataka productivity is quite lower than national average. The gap between production and demand of oilseeds is progressively widening, therefore, the production of oilseeds is to be

increased for self-sufficiency. The total nutrients absorbed by a crop producing 4.5 tonnes of seed per hectare are of the order (in kilograms): N 300–350, P₂O₅ 120–140, K₂O 300–400, Zn- 100 g and B-36 g. Available zinc status in black and red soils was deficient in the major portion of the northern transition zone of Karnataka (Pulakeshi *et al.*, 2012). Since, the soils are alkaline and rich in CaCO₃, zinc may be precipitated as hydroxides and carbonates under alkaline pH range. Therefore, their solubility and mobility may be decreased resulting in reduced availability.

Micronutrients are as important to plant nutrition as primary and secondary nutrients, though plants don't require as much of them. Lack of any one of the micronutrients in the soil can limit growth, even when all other nutrients are present in adequate amounts. High yielding mustard crop removes more micronutrients from the soil which cannot be replenished from the use of high analysis NPK fertilizers containing lower quantities of micronutrient contaminants. So, there is need for micronutrients application in order to achieve balanced nutrition. Thus, there is an urgent need for stepping up the use of micronutrients in growing field crops.

Every micronutrient has specific role to play in plant physiology and its presence in optimum concentration in plant to complete its life cycle. The deficiencies of micronutrients *viz.*, Zn and B were increased day to day due to imbalance application of nutrients. The research information on response of mustard to zinc and boron application is lacking especially in northern transition zone of Karnataka. In this context the present investigation entitled with "Effect of zinc and boron levels on nutrient uptake, yield and quality of mustard".

Materials and Methods

A field experiment was conducted to study the effect of zinc and boron levels on yield, quality and nutrient uptake in mustard under Northern transition zone of Karnataka during *rabi*, 2017 at MARS, UAS, Dharwad with 10 treatments. The treatment comprised of two levels of zinc (10 kg ha⁻¹ and 20 kg ha⁻¹) and two levels of boron (1 kg ha⁻¹ and 2 kg ha⁻¹) and their combinations. These treatments were compared with RDF + FYM @ 5 t ha⁻¹ and RDF alone. The treatments were replicated thrice in a randomized block design. The concentration of zinc in the digested plant samples was determined after

proper dilution using atomic absorption spectrophotometer (Jackson, 1973). The boron in plant sample was estimated by dry ashing which was extracted with 0.5 M HCl. The boron in the aliquot was determined by Azomethine-H method using spectrophotometer at 420 nm (Singh *et al.*, 2010). The oil content of seed estimated in twelve grams of dried seeds of mustard drawn from the net plot of each treatment were used for estimation of oil content by Nuclear Magnetic Resonance (NMR) method and expressed in percentage. The instrument used is Nuclear Magnetic Resonance Spectrometry. The NMR technique measures the resonance of energy absorbed by the hydrogen atoms in the sample. Usually oil contents are expressed based on specific moisture content basis (%). Using the NMR in measuring oil content is referenced by ISO 10565: 1998 Oilseeds.

Results and Discussion

Seed, stalk yield and harvest index of mustard

Seed yield, stalk yield and harvest index of mustard were significantly influenced by zinc and boron levels on mustard (Table 1). Among the different micronutrient levels, seed yield (1973 kg ha⁻¹) was significantly higher with the application of RDF + FYM + ZnSO₄ @ 20 kg ha⁻¹ + Borax @ 2 kg ha⁻¹ which was on par with RDF + FYM + ZnSO₄ @ 20 kg ha⁻¹ + Borax @ 1 kg ha⁻¹ (1940 kg ha⁻¹) and RDF + FYM + ZnSO₄ @ 10 kg ha⁻¹ + Borax @ 2 kg ha⁻¹ (1929 kg ha⁻¹) compared to RDF alone (1473 kg ha⁻¹). The higher seed yield recorded with application of ZnSO₄ and borax might have met the crop demand for zinc and boron at right time when pollen tubes were to be developed, which may result in increased pollen germination and pollen viability and translocation of photosynthates towards sink that due improved the seed setting percentage in the siliqua of mustard.

Table.1 Seed yield, stalk yield and harvest index of mustard as influenced by levels of zinc and boron

Treatment	Seed yield (kg ha ⁻¹)	Stalk yield (kg ha ⁻¹)	Harvest index (%)
T ₁ : RDF only	1,473	4,415	25.03
T ₂ : RDF + FYM	1,543	4,552	25.30
T ₃ : RDF + FYM + Borax @ 1 kg ha ⁻¹	1,655	4,801	25.63
T ₄ : RDF + FYM + Borax @ 2 kg ha ⁻¹	1,757	4,903	26.39
T ₅ : RDF + FYM + ZnSO ₄ @ 10 kg ha ⁻¹	1,766	4,918	26.39
T ₆ : RDF + FYM + ZnSO ₄ @ 20 kg ha ⁻¹	1,834	4,986	26.91
T ₇ : RDF + FYM + ZnSO ₄ @ 10 kg ha ⁻¹ + Borax @ 1 kg ha ⁻¹	1,847	5,000	26.97
T ₈ : RDF + FYM + ZnSO ₄ @ 10 kg ha ⁻¹ + Borax @ 2 kg ha ⁻¹	1,929	5,081	27.49
T ₉ : RDF + FYM + ZnSO ₄ @ 20 kg ha ⁻¹ + Borax @ 1 kg ha ⁻¹	1,940	5,092	27.61
T ₁₀ : RDF + FYM + ZnSO ₄ @ 20 kg ha ⁻¹ + Borax @ 2 kg ha ⁻¹	1,973	5,125	27.78
S.Em.±	34.07	119.29	0.49
C.D. (p=0.05)	101.23	354.44	1.47

* Note: RDF 60:50:40 N: P₂O₅: K₂O kg ha⁻¹ along with FYM (5 t ha⁻¹) was applied to all the treatments except T₁, DAS- Days after sowing.

Table.2 Zinc and boron uptake as influenced by levels of zinc and boron

Treatment	Zinc (g ha ⁻¹)			Boron (g ha ⁻¹)		
	Seed	Stalk	Total	Seed	Stalk	Total
T ₁ : RDF only	50.44	88.92	139.35	15.35	24.62	39.98
T ₂ : RDF + FYM	58.44	107.20	165.64	20.74	31.88	52.62
T ₃ : RDF + FYM + Borax @ 1 kg ha ⁻¹	61.35	116.18	177.53	22.58	40.32	62.90
T ₄ : RDF + FYM + Borax @ 2 kg ha ⁻¹	67.10	121.56	188.66	23.87	44.45	68.32
T ₅ : RDF + FYM + ZnSO ₄ @ 10 kg ha ⁻¹	68.41	123.19	191.60	24.05	44.66	68.71
T ₆ : RDF + FYM + ZnSO ₄ @ 20 kg ha ⁻¹	71.23	152.96	224.19	25.07	46.18	71.25
T ₇ : RDF + FYM + ZnSO ₄ @ 10 kg ha ⁻¹ + Borax @ 1 kg ha ⁻¹	72.58	155.58	228.16	25.28	46.38	71.66
T ₈ : RDF + FYM + ZnSO ₄ @ 10 kg ha ⁻¹ + Borax @ 2 kg ha ⁻¹	76.07	159.84	235.91	28.15	47.20	75.35
T ₉ : RDF + FYM + ZnSO ₄ @ 20 kg ha ⁻¹ + Borax @ 1 kg ha ⁻¹	76.06	161.68	237.74	28.64	47.41	76.05
T ₁₀ : RDF + FYM + ZnSO ₄ @ 20 kg ha ⁻¹ + Borax @ 2 kg ha ⁻¹	77.30	165.41	242.71	29.04	47.69	76.74
S.Em.±	2.36	6.76	8.11	0.56	1.41	1.50
C.D. (p=0.05)	7.01	20.07	24.08	1.67	4.20	4.45

* Note: RDF 60:50:40 N: P₂O₅: K₂O kg ha⁻¹ along with FYM (5 t ha⁻¹) was applied to all the treatments except T₁, DAS- Days after sowing.

Table.3 Oil content and oil yield of mustard as influenced by levels of zinc and boron

Treatment	Oil content (%)	Oil yield (kg ha ⁻¹)
T ₁ : RDF only	35.56	524
T ₂ : RDF + FYM	35.63	550
T ₃ : RDF + FYM + Borax @ 1 kg ha ⁻¹	35.65	589
T ₄ : RDF + FYM + Borax @ 2 kg ha ⁻¹	35.66	627
T ₅ : RDF + FYM + ZnSO ₄ @ 10 kg ha ⁻¹	35.83	632
T ₆ : RDF + FYM + ZnSO ₄ @ 20 kg ha ⁻¹	35.84	657
T ₇ : RDF + FYM + ZnSO ₄ @ 10 kg ha ⁻¹ + Borax @ 1 kg ha ⁻¹	36.73	678
T ₈ : RDF + FYM + ZnSO ₄ @ 10 kg ha ⁻¹ + Borax @ 2 kg ha ⁻¹	37.03	714
T ₉ : RDF + FYM + ZnSO ₄ @ 20 kg ha ⁻¹ + Borax @ 1 kg ha ⁻¹	37.06	718
T ₁₀ : RDF + FYM + ZnSO ₄ @ 20 kg ha ⁻¹ + Borax @ 2 kg ha ⁻¹	37.08	731
S.Em.±	0.37	12
C.D. (p=0.05)	1.11	35

* Note: RDF 60:50:40 N: P₂O₅: K₂O kg ha⁻¹ along with FYM (5 t ha⁻¹) was applied to all the treatments except T₁, DAS- Days after sowing.

Similar types of results were found by Rani and Reddy (1993) and Tamak *et al.*, (1997) in mustard. The stalk yield of mustard was also significantly influenced by zinc and boron levels (Table 1). Among different treatments, application RDF + FYM + ZnSO₄ @ 20 kg ha⁻¹ + Borax @ 2 kg ha⁻¹ at harvest recorded significantly higher stalk yield (5125 kg ha⁻¹) which was on par with application of RDF + FYM + ZnSO₄ @ 20 kg ha⁻¹ + Borax @ 1 kg ha⁻¹ (5092 kg ha⁻¹), RDF + FYM + ZnSO₄ @ 10 kg ha⁻¹ + Borax @ 2 kg ha⁻¹ (5081 kg ha⁻¹) and RDF + FYM + ZnSO₄ @ 10 kg ha⁻¹ + Borax @ 1 kg ha⁻¹ (5000 kg ha⁻¹) at harvest. This was mainly due to zinc and boron role in increasing photosynthesis which resulted in higher growth and development. Same results were also reported by Shaker and Mohammed (2011) in mustard.

Significantly higher harvest index (27.78 %) of mustard was recorded with the application of RDF + FYM + ZnSO₄ @ 20 kg ha⁻¹ + Borax @ 2 kg ha⁻¹ at harvest. Significantly lower harvest index (25.03 %) observed with application of RDF only. The increase in harvest index may be attributed to better utilization of photo-assimilates for seed formation. Similar results have been discussed by Venkatakrishnan and Balasubramaniam (1996).

Uptake of zinc and boron by mustard

In the present study, among different treatments, higher uptake of zinc in seed (77 g ha⁻¹) and stalk (165 g ha⁻¹) by mustard crop at harvest was significantly higher with application of RDF + FYM + ZnSO₄ @ 20 kg ha⁻¹ + Borax @ 2 kg ha⁻¹ at harvest which was on par with application of RDF + FYM + ZnSO₄ @ 20 kg ha⁻¹ + Borax @ 1 kg ha⁻¹ (76 and 161 g ha⁻¹ respectively), RDF + FYM + ZnSO₄ @ 10 kg ha⁻¹ + Borax @ 2 kg ha⁻¹ (76 and 159 g ha⁻¹ respectively) and RDF + FYM + ZnSO₄ @ 10 kg ha⁻¹ + Borax @ 1 kg ha⁻¹

(72 and 155 g ha⁻¹ respectively) (Table 2). The higher dry matter production as discussed earlier owing dominant role played by zinc in improving the photosynthetic ability and assimilating capacity of crop by being a component in various enzymatic and other biochemical reactions. This might be due to increase in zinc availability because of availability of macronutrients and micronutrients to the plant. Similar results were also observed by Mankar *et al.*, (2004).

Application of zinc and boron individually or in combination increased the uptake of boron by the crop significantly (Table 2). The highest boron uptake was recorded in the treatment receiving soil application of ZnSO₄ @ 25 kg ha⁻¹ along with borax @ 2 kg ha⁻¹ in seed (29 g ha⁻¹) and stalk (47 g ha⁻¹) which was on par with application of RDF + FYM + ZnSO₄ @ 20 kg ha⁻¹ + Borax @ 1 kg ha⁻¹ (28 and 47 g ha⁻¹ respectively) and RDF + FYM + ZnSO₄ @ 10 kg ha⁻¹ + Borax @ 2 kg ha⁻¹ (28 and 47 g ha⁻¹ respectively) (Table 2) over RDF alone (15 and 24 g ha⁻¹ respectively). This may be probably due to increase in availability and absorption of boron, when boron was applied to deficit soil in the nutrient. The increased uptake might have increased the yield. Several workers have reported increased boron uptake due to boron application (Singh *et al.*, 1994; Singh and Dixit, 1994; Cutcliffe and Gupta, 1980). Further synergistic effect was noticed between boron and zinc with respect to uptake and yield.

Quality of mustard

Among different treatments higher oil yield (731 kg ha⁻¹) was recorded with the application of RDF + FYM + ZnSO₄ @ 20 kg ha⁻¹ + Borax @ 2 kg ha⁻¹ at harvest which was on par with application of RDF + FYM + ZnSO₄ @ 20 kg ha⁻¹ + Borax @ 1 kg ha⁻¹ (718 kg ha⁻¹) and RDF + FYM + ZnSO₄ @ 10 kg

ha⁻¹ + Borax @ 2 kg ha⁻¹ (714 kg ha⁻¹). This was mainly due to higher seed yield (1973 kg ha⁻¹, 1940 kg ha⁻¹, and 1929 kg ha⁻¹, respectively) and oil content (37.08, 37.06 and 37.03 %, respectively). The higher oil content due to synthesis of more glucosides, which produces sulphur rich amino acids like cysteine and methionine, thioglucoside and synthesis of amino acids ultimately increased the oil content in seed. Bhat *et al.*, (2007) and Muhammad *et al.*, (2013) also reported higher oil yield and oil content with application of zinc and boron in mustard (Table 3).

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How to cite this article:

Shanoor Nadaf and Chandranath, H.T. 2019. Effect of Zinc and Boron on Nutrient Uptake, Yield and Quality of Mustard under Rainfed Condition. *Int.J.Curr.Microbiol.App.Sci*. 8(06): 2490-2495. doi: <https://doi.org/10.20546/ijcmas.2019.806.298>