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# EFFECTS OF ZINC AND BORON ON YIELD, NUTRIENT UPTAKE AND ECONOMICS OF MUSTARD (*BRASSICA JUNCEA* L.) IN MUSTARD-MAIZE CROPPING SEQUENCE

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**Abstract**

Field experiments were carried out to evaluate the effects of Zn and B on yield, nutrient uptake and economics of mustard (*Brassica juncea* L.) in mustard - maize (*Zea mays* L.) cropping sequence in subtropical soils of Jammu region. Twelve treatments consisting of recommended dose of fertilizers (RDF) i.e., 60 : 30 : 15 : 20 kg/ha N : P : K : S either alone or with addition of different doses of zinc and boron were tested. The application of RDF + 10 kg Zn + 2 kg B/ha though at par with application of RDF + 5 kg Zn/ha resulted in significant increase in yield attributes *viz.* siliquae/plant, seeds/siliquae, test weight, seed and stover yields of mustard crop than recommended dose of fertilizers. However there was no significant residual effect of application of boron and zinc on the grain and stover yield of succeeding maize crop. Maximum B : C ratio for mustard crop was recorded with application of RDF + 5 kg Zn/ha which was higher than other treatments in comparison.

In India, area, production and yield of rapeseed-mustard was 6.34 million hectares, 7.82 million tonnes and 1233 kg/ha, respectively, during 2012-13 (Anon. 2013).The productivity is quite lower than other developed countries mainly due to sub-optimal or imbalanced application of fertilizers, cultivation on marginal lands and under rainfed conditions (Tripathi *et al.* 2010). In Jammu and Kashmir, rapeseed mustard crop is grown on an area of 61000 hectares with an average productivity of 801 kg/ha (2013-14) which 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. Identification of the critical inputs is necessary for enhancing mustard production. Balanced fertilization is critical for realizing higher yield but oilseed crops are generally supplied with major nutrients and application of micronutrients are ignored by the farmers. However, mustard has been found to be quite responsive to micronutrients.

Little information on these aspects is available (Nawaz *et al.* 2012, Tripathi *et al.* 2010, Rattan *et al.* 2009). Hence the present study has been carried out with a view to evaluate the effects of Zn and B on mustard and their residual effects on the succeeding maize crop.

The field experiments were carried out at the Research Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, during the Rabi and Kharif seasons of 2010-11 and 2011-12. Geographically, the experimental site is located at $32^{o}$ - $40^{o'}$ N latitude and 74 - $58^{o'}$ E longitude with an altitude of 332 meters above mean sea level in the Shiwalik foothills of north-western Himalayas. The soil had moderate levels of available sulphur (12.51 ppm), available zinc (0.57 ppm) and available boron (0.45) ppm.

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The experiment consisted of 12 treatments, i.e. $T_1$: Recommended dose of fertilizers (RDF) @ 60 : 30 : 15 : 20 kg/ha N: $P_2O_5$ : $K_2O$: S as urea, DAP, MOP, gypsum respectively , $T_2$: RDF + 5 kg Zn/ ha, $T_3$ : RDF + 10 kg Zn/ ha, $T_4$: RDF +1 kg B/ ha, $T_5$: RDF + 2 kg B/ ha ,$T_6$: RDF +5 kg Zn + 1 kg B/ ha, $T_7$: RDF +5 kg Zn + 2 kg B/ha, $T_8$ : RDF +10 kg Zn + 1 kg B/ ha, $T_9$: RDF +10 kg Zn + 2 kg B/ ha, $T_{10}$ : RDF + foliar spray of $ZnSO_4$ @0.5 %, $T_{11}$: RDF + foliar spray of borax @0.1 %, $T_{12}$: RDF + Foliar spray of $ZnSO_4$ @0.5 % + borax @0.1 % which were arranged in randomized block design with three replications. Mustard variety "RL-1359" was sown in rows 30 cm apart on 1st and 4th November of 2010 and 2011 and harvested on 8th and 7th April of 2011 and 2012, respectively. Half of the N and full amount of P, K, S, Zn and B were applied at the time of sowing and the remaining N was top-dressed at first irrigation. Foliar spray of Zn and B was applied at 15 days after planting and flower initiation stage. Maize variety 'Kanchan 517' was raised as residual crop with recommended dose of fertilizers during the following Kharif season on the undisturbed layout of the experiment during both the years of experimentation.

Yield attributes were recorded at harvest. Siliquae of five sample plants were counted and expressed as number of siliquae/plant. Seeds of five sampled siliquae were counted and expressed as seeds per siliquae. Seed and stover yields were computed in q/ha. The nutrient uptake by seed and stover (Zn and B) were estimated. Dried and processed seed and stover samples were digested in diacid mixture of $HNO_3$ - $HClO_4$ (Jackson 1973) and the Zn content was estimated using atomic absorption spectrophotometer. Boron content was determined by igniting the seed and stover samples in a muffle furnace at $550^0$C and boron content in the aliquot was determined by Azomethine-H method (Gains and Mitchell 1979). The economics was calculated on the basis of costs involved and output received at prevailing market rates.

All yield attributes of mustard including number of siliquae per plant, number of seeds/siliquae differed with different treatments of zinc and boron during both the years of study (Table 1). In general, the higher values of yield parameters were recorded during 2011-12 than 2010-11. Number of siliquae per plant was reported to be the highest in treatment $T_9$ though it was at par with most of the treatments but remained significantly superior over $T_1$ and foliar spray of borax @ 0.1% during first year however, during second year, this treatment remained significantly superior to all treatments expect $T_8$. Number of seeds per siliquae were also higher in treatment $T_9$ and remained at par with $T_3$, $T_6$, $T_7$ and $T_8$ (Table 1). Positive effect of supplementary nutrients on yield attributes of Indian mustard was observed by Rana *et al*. (2005).

Seed yield is the manifestation of yield-attributing characters. Highest seed yield of mustard was observed in treatment $T_9$ which remained at par with all other treatments expect $T_1$ and $T_{11}$. Almost similar trend was observed in the second year except the treatments where foliar application of nutrients was done. Stover yield was recorded to be highest at treatment $T_8$ and remained significantly superior over all the treatments except treatments $T_9$ and $T_3$ during 2010-11. However, during second year, it was the highest in treatment combination of RDF + 10 kg Zn + 2 kg B/ha and was found to be at par with other treatments $T_8$, $T_7$, $T_6$ and $T_3$ but significantly superior to other treatments. Harvest index was found to be non-significant during both the years but varied from 20.32 to 24.50% in 2010-2011 and 21.81 to 25.30% in 2011 - 2012 (Table 1). The higher values of yield may be attributed to application of zinc and boron along with RDF as zinc and boron are involved in cell division and enzyme activation. With the increment in supply of essential micronutrients to mustard, their availability, acquisition, mobilization and influx into the plant tissues increased and thus improve growth attributes and yield components and finally the yield (Singh and Pal 2011). Effect of micronutrient addition in balanced fertilization schedule has also been found to increase use efficiency of macronutrients in different cropping systems and thus

**Table 1. Effect of Zn and B application on yield attributes, yield, harvest index and B: C ratio of mustard in mustard-maize cropping Sequence.**

| Treatments | Siliquae/ plant | | Seed yield (q/ha) | | Stover yield (q/ha) | | Harvest index (%) | | Seeds/ siliquae | | B : C ratio | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010-11 | 2011-12 | 2010-11 | 2011-12 | 2010-11 | 2011-12 | 2010-11 | 2011-12 | 2010-11 | 2011-12 | 2010-11 | 2011-12 |
| $T_1$: Recommended dose of fertilizer (RDF) | 185.9 | 202.9 | 9.80 | 10.66 | 30.62 | 32.98 | 24.27 | 24.50 | 8.8 | 9.3 | 1.01 | 1.13 |
| $T_2$: RDF + 5 kg Zn/ha | 203.1 | 233.8 | 11.03 | 12.06 | 34.44 | 36.11 | 24.42 | 25.06 | 9.8 | 10.86 | 1.14 | 1.31 |
| $T_3$: RDF + 10 kg Zn/ha | 210.4 | 243.7 | 11.21 | 12.46 | 42.98 | 40.76 | 20.69 | 23.57 | 10.3 | 11.1 | 1.03 | 1.09 |
| $T_4$: RDF + 1 kg B/ha | 202.5 | 224.07 | 10.62 | 11.55 | 32.84 | 34.51 | 24.50 | 25.30 | 9.5 | 10.5 | 0.90 | 1.02 |
| $T_5$: RDF + 2 kg B/ha | 201.7 | 227.33 | 10.84 | 12.15 | 35.86 | 35.83 | 23.22 | 25.30 | 9.8 | 10.7 | 0.72 | 1.0 |
| $T_6$: RDF + 5 kg Zn + 1 kg B/ha | 213.2 | 240.07 | 11.26 | 12.29 | 38.74 | 40.76 | 22.59 | 23.19 | 10.6 | 11.1 | 0.91 | 1.10 |
| $T_7$: RDF + 5 kg Zn + 2 kg B/ha | 219.1 | 242.33 | 11.10 | 12.43 | 34.65 | 42.70 | 24.42 | 22.64 | 10.5 | 11.3 | 0.68 | 0.89 |
| $T_8$: RDF + 10 kg Zn + 1 kg B/ha | 220.8 | 248.07 | 11.59 | 12.83 | 45.69 | 46.18 | 20.32 | 21.81 | 10.8 | 11.5 | 0.86 | 1.0.3 |
| $T_9$: RDF + 10 kg Zn+ 2 kg B/ha | 222.6 | 263.73 | 11.76 | 13.28 | 43.81 | 47.46 | 21.23 | 21.99 | 11.0 | 11.8 | 0.72 | 0.88 |
| $T_{10}$: RDF + foliar spray of $ZnSO_4$ @ 0.5% | 199.2 | 220.67 | 10.69 | 11.56 | 39.92 | 36.2 | 21.10 | 24.15 | 9.8 | 10.5 | 0.95 | 1.05 |
| $T_{11}$: RDF + foliar spray of borax @ 0.1% | 187.1 | 206.67 | 9.78 | 11.24 | 33.60 | 34.51 | 22.63 | 24.73 | 9.2 | 10.3 | 0.77 | 1.01 |
| $T_{12}$: RDF + foliar spray of $ZnSO_4$ @ 0.5%+ borax @0.1% | 200.7 | 215.33 | 10.75 | 11.58 | 38.67 | 37.83 | 21.82 | 23.44 | 9.9 | 10.6 | 0.83 | 1.0 |
| CD (p = 0.05) | 22.87 | 17.66 | 1.15 | 1.29 | 5.67 | 6.63 | NS | NS | 0.79 | 1.24 | | |

leads to yield improvement (Shukla 2011). Zinc and boron uptake differed in different treatments and in general more uptake of these micronutrients was observed in the year 2011-12 than 2010-11. Zinc uptake by both seed and stover of mustard crop was observed to be the highest in treatment $T_9$ though it remained at par with treatment $T_8$, $T_3$, $T_6$, $T_7$ and $T_{10}$ during both the years. (Table 2). Boron uptake was also reported highest in $T_9$ though it remained at par with treatments $T_8$, $T_5$, $T_6$, $T_7$ and $T_{12}$ during both the years. The higher values of nutrient uptake (Zn and B) in seed and stover of mustard was mainly attributed to higher levels of these nutrients as the nutrient uptake was increased with successive increase in chemical fertilization. The balanced nutrition also enhanced the synergistic effect on uptake of plant nutrients (Ahmad *et al.* 2007).

**Table 2. Effect of various treatments on Zn and B uptake (g/ha) by mustard in mustard-maize cropping sequence.**

| Treatments | 2010-11 | | | | 2011-12 | | | |
|---|---|---|---|---|---|---|---|---|
| | Seed (g/ha) | | Stover (g/ha) | | Seed (g/ha) | | Stover (g/ha) | |
| | Zn | B | Zn | B | Zn | B | Zn | B |
| $T_1$: Recommended dose of fertilizer (RDF) | 96.30 | 15.13 | 184.16 | 54.12 | 122.41 | 19.94 | 227.25 | 61.76 |
| $T_2$: RDF + 5 kg Zn/ha | 118.14 | 17.76 | 233.44 | 62.89 | 141.07 | 24.95 | 279.48 | 80.89 |
| $T_3$: RDF + 10 kg Zn/ha | 125.77 | 18.43 | 314.60 | 97.73 | 150.78 | 26.24 | 341.15 | 98.03 |
| $T_4$: RDF + 1 kg B/ha | 105.76 | 21.11 | 227.33 | 71.45 | 126.70 | 26.21 | 241.93 | 81.53 |
| $T_5$: RDF + 2 kg B/ ha | 108.34 | 24.94 | 239.82 | 82.55 | 131.67 | 28.79 | 251.20 | 83.58 |
| $T_6$: RDF + 5 kg Zn + 1 kg B/ ha | 129.31 | 26.33 | 283.78 | 86.51 | 155.77 | 30.75 | 339.06 | 110.16 |
| $T_7$: RDF + 5 kg Zn + 2 kg B/ ha | 133.28 | 27.84 | 294.0 | 84.17 | 158.08 | 33.54 | 374.26 | 115.58 |
| $T_8$: RDF + 10 kg Zn + 1 kg B/ ha | 142.52 | 28.46 | 371.56 | 117.71 | 166.22 | 35.90 | 422.85 | 135.20 |
| $T_9$: RDF + 10 kg Zn+ 2 kg B/ ha | 144.58 | 29.26 | 385.82 | 125.78 | 170.95 | 38.80 | 451.68 | 144.40 |
| $T_{10}$: RDF + foliar spray of $ZnSO_4$ @0.5 % | 124.58 | 21.17 | 255.46 | 78.62 | 136.84 | 23.64 | 242.85 | 74.0 |
| $T_{11}$: RDF + foliar spray of borax @0.1 % | 96.45 | 23.45 | 234.46 | 80.79 | 121.84 | 22.08 | 237.69 | 82.61 |
| $T_{12}$: RDF + foliar spray of $ZnSO_4$ @0.5 %+ borax @0.1 % | 120.52 | 24.70 | 264.28 | 83.90 | 137.42 | 26.04 | 257.39 | 86.83 |
| CD (p = 0.05) | 21.38 | 7.16 | 95.53 | 26.97 | 28.79 | 6.0 | 109.34 | 23.30 |

Application of different combinations of zinc and boron in preceding mustard crop resulted in increased yield of succeeding maize crop but the yield increase was non-significant. Increased level of zinc up to 10 kg/ha and boron up to 2 kg/ha recorded highest seed and stover yield in maize crop during both the years. Seed yield increase was 8.38 and 19.60% more over no use of Zn and B during Ist and IInd year, respectively.

The result showed that the cost of cultivation of mustard was the lowest for RDF whereas it was the highest when RDF was combined with the zinc and boron at their higher doses. However, the highest benefit: cost ratio of 1.14 and 1.31 was noted under treatment $T_2$ (RDF+ 5 kg Zn/ ha)

during first and second year respectively, (Table 1). From the two year investigation, it is concluded that recommended dose of N-P-K-S fertilizers (60 : 30 : 15 : 20) along with 5 kg Zn/ha is promising for attaining higher productivity and profitability of mustard crop. Addition of micronutrients increased their availability in succeeding maize crop thereby improving soil fertility but showed non-significant increase in grain and stover yield of succeeding maize crop.

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