**EFFECT OF ZINC ON GROWTH AND YIELD OF MUSTARD**

**(*BRASSICA JUNCEA* L.) CROP**

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**Abstract**

A field trial was conducted during the year 2015-2016 the effect of zinc on the growth and yield of mustard, evaluating four Zn treatments against mustarded crop. The treatments included: T1 = Control, T2 = ZnSO4 @ 2.5 kg ha-1, T3 = ZnSO4 @ 5.0 kg ha-1 and T4 = ZnSO4 @ 7.5 kg ha-1. The experiment was conducted in a three replicated Randomized Complete Block Design with net plot size of 6m x 5m (30m2). It was noted that the all the growth and seed yield traits as well as in mustard was significantly (P<0.05) influenced by different Zinc levels. The application of Zn @ 7.5 kg ha-1 resulted 141.6 cm plant height, 22.0 branches plant-1, took 70.0 days to flowering, 81.3 days to maturity, 265.3 pods plant-1, 4.5 g seed index, 7.9 kg seed yield plot-1 and 2640.8 kg seed yield ha-1. Similarly, the application of Zn @ 5.0 kg ha-1 resulted 139.0 cm plant height, 16.3 branches plant-1, took 72.0 days to flowering, 86.6 days to maturity, 212.6 pods plant-1, 4.3 g seed index, 7.6 kg seed yield plot-1 and 2528.9 kg seed yield ha-1. The mustard crop supplemented with Zn @ 2.5 kg ha-1 resulted 134.3 cm plant height, 14.0 branches plant-1, took 76.0 days to flowering, 90.0 days to maturity, 188.6 pods plant-1, 3.3 g seed index, 7.2 kg seed yield plot-1 and 2394.7 kg seed yield ha-1. However, the control plots, where no Zn were applied resulted 128.3 cm plant height, 10.6 branches plant-1, took 79.0 days to flowering, 92.6 days to maturity, 145.6 pods plant-1, 2.8 g seed index, 6.7 kg seed yield plot-1 and 2238.0 kg seed yield ha-1.

**Key words:** Mustard, Zinc levels, Growth, Yield.

**Introduction**

Mustard (*Brassica juncea* L.) is an important member of family *Brassicaceae*. Oilseeds contribute the second highest share in the economy of Pakistan after grain crops. There are number of species producing edible oil mainly the species and sub-species in the Brassicaceae family. The most popular species are *B. juncea, B. juncea, B. oleracea* and *B. rapa* (*B. campestris*). The scientists have sequenced the entire genome of mustard/canola (*B. juncea*) and its constituent genomes present in *Brassica rapa* and *Brassica oleracea* in 2009. This also represents the genome component of the amphidiploid crop species *B. juncea* and *B. juncea* (Bayer, 2010). Mustard has primary centre of its origin in central Asia (northwest India), with secondary centers in central and western China, eastern India, Burma and through Iran to Near East cultivated for centuries in many parts of Eurasia. However, the principal growing countries are Bangladesh, Central Africa, China, India, Japan, Nepal, and Pakistan, as well as southern Russia in north of the Caspian Sea (Perry, 2010). During 2014-15 (July-March), 1.789 million tonnes edible oil of value Rs. 139.344 (US$ 1.377 billion) has been imported showing an increase of 4.07 percent against the same period (July-March) 2013-14. Local production of edible oil during 2014-15 (July March) is estimated at 0.546 million tons. Total availability of edible oil from all sources is provisionally estimated at 2.335 million tons during 2014-15 (July March) (GOP, 2015). The area under mustard and mustard during 2009-10 was 178,000 hectares with production of 151,000 tons, while during 2010-11 the area increased to 194,000 hectares and production to 168,000 tons showing an increase of 11.3 percent. During 2010-11, the oil from the mustard and mustard was 50,000 tons. Zinc is one of the micronutrients required by plants in smaller quantity. Plants take up Zinc as the Zn2+ ion. Zinc functions are mainly as a metal activator for several enzymes including carbonic anhydrate, alcohol dehydrogenase, superoxidase dimutase, and RNA polymerase. Zinc is immobile in soil; zinc deficiencies may occur on calcareous, high pH, sandy texture, high P, and eroded soils.  Zinc deficiencies usually show up under cool wet conditions in early spring when root growth is slow.  Poorly drained soils may be also deficient. Badly eroded soils and eroded knolls are likely to be low in Zn, soil test to be sure.  Deficiency symptoms will most likely show up first in dry bean. Very high rates of P may induce Zn deficiency in flax. Zinc is involved in enzyme systems, metabolic reactions, and is necessary for production of chlorophyll and carbohydrates.  Zinc is not generally translocated within plant and is partly mobile in wheat and barley so the first symptoms appear on the younger leaves.  Symptoms differ from one species to another. In wheat and barley, the older leaves may have light blotches between the veins. Younger leaves will have a normal green color and will be smaller.  In flax, grayish brown spots appear on the younger leaves with shortened internodes appearing stunted (Rashid, 2007). Zinc is an essential micronutrient for higher plants especially oil crops where it is required for activity of various types of enzymes (dehydrogenases, RNA and DNA polymerases), carbohydrate metabolism and protein synthesis. Zinc also plays an important role in the production of biomass (Kaya and Higgs, 2002) and (Cakmak, 2008). Furthermore, zinc may be required for chlorophyll production, pollen function and fertilization (Pandey *et al.,* 2006) Zinc deficiency also affects carbohydrate metabolism, damages pollen structure, and decreases the yield (Das *et al.,* 2005, Fang *et al.,* 2008 and Bybordi and Malakouti, 2007) found that application of zinc had a significant effect on seed yield, seed oil content and 1000-seed weight, where, seed yield (2606.25 kg ha-1), oil content (43.7 %) and 1000-seed weight (4.44g) were obtained with the highest zinc application rate. The Zn content of canola leaves was highest when compared with other micronutrients. Zinc deficiency in soils can result in stunted growth with fewer branches and can reduce canola seed yield by 20 to 30%. Zinc deficiency can also result in lower oil contents. This study was conducted to determine the rate of Zn application necessary for a favorable for mustard growth and yield.

**Materials and Methods**

The field experiment was conducted at the Oil Seed Section, Agriculture Research Institute, Tandojam during Rabi, 2015-16. Experiment will be laid out using Randomized Complete Randomized Design (RCBD) with three replication. The experimental details are given below:

**Experimental design** = Randomized completely randomized design (RCBD)

**Replications =** 03

**Variety =** S-9

**Net plot size =** 6 m x 5 m x = (30 m2)

**Treatments= Zinc levels kg ha-1 (4)**

T1 = Control

T2 = ZnSO4 @ 2.5 kg ha-1

T3 = ZnSO4 @ 5.0 kg ha-1

T4 = ZnSO4 @ 7.5 kg ha-1

 **Observations to be recorded**

1. Plant height (cm)
2. Number of branches plant-1
3. Days to flowering
4. Days to maturity
5. Number of pods plant-1
6. Seed index (1000 seeds, g)
7. Seed yield kg ha-1

**Plant height (cm):** The plant height (cm) will be measured at maturity of the crop by measuring tape from bottom to tip of plant in labelled plants in each treatment.

**Number of branches plant-1:** The number of branches plant-1 will be counted at maturity of the crop in labelled plants in each treatment and mean will be worked out.

**Days to flowering:** The number of days from sowing to initiation of flowering will be considered as the number of days taken to flowering.

**Days to maturity:** The number of days from sowing to physiological maturity of the crop will be considered as the number of days taken to maturity.

**Number of pods plant-1:** The number of pods plant-1 will be counted at maturity of the crop in labelled plants in each treatment and the sum will be then divided with the total number of plants.

**Seed index (1000 seeds, g):** Seed index value will be observed on the basis of 1000 seeds weight manually separated by counting in each treatment and will be weighed to record seed index in grams.

**Seed yield kg ha-1:** After harvesting of the crop, the total seed of each treatment in all replications will be weighed and divided with the number of replications to achieve the mean seed yield plot-1 (kg). Later, on the basis of seed yield plot-1, the seed yield (kg ha-1).

**Data analysis:** The collected data subjected to statistical analysis using Statistix-8.1 computer software (Statistix, 2006). The differences among the treatments means will be compared by the LSD test, where necessary.

Results

In order to investigate the effect of zinc on the growth and yield of rape seed, the study was carried out during the year 2015-16 at the experimental fields of Oil seeds Section, Agriculture Research Institute, Tandojam. Four (Zn) treatments were evaluated against three replications which included: T1 = Control, T2 = ZnSO4 @ 2.5 kg ha-1, T3 = ZnSO4 @ 5.0 kg ha-1 and T4 = ZnSO4 @ 7.5 kg ha-1. The observations were recorded on economically important plant characters viz. number of branches plant-1, plant height (cm), number of branches plant-1, days to flowering, days to maturity, number of pods plant-1, seed index (1000 seeds, g) and seed yield kg ha-1. The results achieved on these characters are presented in Tables 1-7 and their results in view of the statistical analysis are interpreted.

**Plant height (cm):** The plant height has an essential role in the crop growth that further influences the overall yield of the crop through different components. The results regarding the plant height of mustard crop as influenced by different Zinc (Zn) levels are given in Table-1. The analysis of variance indicated that the effect of different Zn levels on plant height was significant (P<0.05). The application of Zn at the rate of 7.5 kg ha-1 resulted in maximum plant height of 141.67 cm, followed by Zn application at the rates of 5.0 kg ha-1, resulting average plant height of 139.00 cm, respectively. There was marginal decrease in the plant height when Zn was applied at the rates of 2.5 kg ha-1 i.e. 134.33 cm, respectively. However, the lowest plant height (128.33 cm) plant-1 was recorded in control, where no Zn was applied. This shows that the application of Zn was markedly beneficial to improve the plant height in mustard crop.

**Table-1 Plant height (cm) of mustard as affected by different zinc levels.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **R1** | **R2** | **R3** | **Mean**  |
| T1= Control | 123 | 130 | 132 | 128.33 C |
| T2= ZnSO4 @ 2.5 kg ha-1 | 136 | 134 | 133 | 134.33 B  |
| T3= ZnSO4 @ 5.0 kg ha-1 | 138 | 141 | 138 | 139.00 AB |
| T4= ZnSO4 @ 7.5 kg ha-1 | 142 | 143 | 140 | 141.67 A |
| S.E. | = | 2.3531 |
| LSD 0.05 | = | 5.7578 |
| CV% | = | 2.12 |

Mean values followed by similar letters are not significantly different at P=0.05

**Number of branches plant-1:** Among agronomical crop traits, the number of branches is considered as key component to affect the plant growth and crop yield. This trait is generally influenced by the genetics of the crop variety, but the application of macro and micronutrients in required quantities also influence this trait equally. The data in regards to the number of branches plant-1 of mustard as affected by different Zinc (Zn) levels are presented in Table-2. The analysis of variance demonstrated significant (P<0.05) effect of different levels of Zinc on the number of branches plant-1. The application of Zn at the rate of 7.5 kg ha-1 stimulated the mustard plants to sprout maximum number of branches (22.00) plant-1, while decreasing the rate of (5.0 kg ha-1) resulted in a simultaneous decrease in the number of branches (16.33) plant-1. However, decreasing Zn levels 2.5 kg ha-1 resulted in a decreased number of branches i.e. 14.00 branches plant-1, respectively. However, the lowest number of branches (10.66) plant-1 was recorded in control, where micronutrients were not applied.

**Table-2 Number of branches plant-1 of mustard as affected by different zinc levels.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **R1** | **R2** | **R3** | **Mean**  |
| T1= Control | 9 | 11 | 12 | 10.66 D |
| T2= ZnSO4 @ 2.5 kg ha-1 | 13 | 15 | 14 | 14.00 C |
| T3= ZnSO4 @ 5.0 kg ha-1 | 18 | 16 | 15 | 16.33 B |
| T4= ZnSO4 @ 7.5 kg ha-1 | 21 | 23 | 22 | 22.00 A |
| S.E. | = | 1.1222 |
| LSD 0.05 | = | 2.7458 |
| CV% | = | 8.73 |

Mean values followed by similar letters are not significantly different at P=0.05

**Days to flowering:** Days to flowering are generally influenced by different type of stress which includes environmental conditions and quantities of the inputs applied. The results pertaining to the number of days to flowering of mustard as affected by different Zinc (Zn) levels are shown in Table-3. The results of the analysis of variance exhibited significant (P<0.05) influence of different Zinc levels on the days to flowering. It is evident from the results (Table-3) that the mustard crop receiving application of Zn at in control, where micronutrients were not applied delayed flowering initiation (79.00 days), closely followed by the plots receiving Zn @ 2.5 kg ha-1 and 5.0 kg ha-1 where flowering initiation was noticed in 76.00 and 72.00 days, respectively. The mustard crop supplied with Zn at lower rates of 7.5 kg ha-1 initiated flowering averagely in 70.00 days, respectively.

**Table-3 Days to flowering of mustard as affected by different zinc levels.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **R1** | **R2** | **R3** | **Mean**  |
| T1= Control | 80 | 78 | 79 | 79.00 A |
| T2= ZnSO4 @ 2.5 kg ha-1 | 77 | 75 | 76 | 76.00 B |
| T3= ZnSO4 @ 5.0 kg ha-1 | 73 | 72 | 71 | 72.00 C |
| T4= ZnSO4 @ 7.5 kg ha-1 | 69 | 70 | 71 | 70.00 D |
| S.E. | = | 0.8165 |
| LSD 0.05 | = | 1.9979 |
| CV% | = | 1.35 |

Mean values followed by similar letters are not significantly different at P=0.05

**Days to maturity:** Days to maturity are generally influenced by different type of stress which includes environmental conditions and quantities of the inputs applied. The results pertaining to the number of days to maturity of mustard as affected by different Zinc (Zn) levels are shown in Table-4. The results of the analysis of variance exhibited significant (P<0.05) influence of different Zinc levels on the days to maturity. It is evident from the results (Table-4) that the mustard crop receiving application of Zn in control, where micronutrients were not applied delayed maturity initiation (92.66), closely followed by the plots receiving Zn @ 2.5 kg ha-1 and 5.0 kg ha-1 where maturity initiation was noticed in 90.00 and 86.66, respectively. The mustard crop supplied with Zn at lower rates of 7.5 kg ha-1 initiated maturity averagely in 81.33, respectively.

**Table-4 Days to maturity of mustard as affected by different zinc levels.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **R1** | **R2** | **R3** | **Mean**  |
| T1= Control | 94 | 91 | 93 | 92.66 A |
| T2= ZnSO4 @ 2.5 kg ha-1 | 90 | 89 | 91 | 90.00 A  |
| T3= ZnSO4 @ 5.0 kg ha-1 | 87 | 85 | 88 | 86.66 B |
| T4= ZnSO4 @ 7.5 kg ha-1 | 80 | 83 | 81 | 81.33 C |
| S.E. | = | 1.1941 |
| LSD 0.05 | = | 2.9219 |
| CV% | = | 1.67 |

Mean values followed by similar letters are not significantly different at P=0.05

**Number of pods plant-1:** The number of pods plant-1 is a major yield component having direct effect on the seed yield plant-1 under normal growing conditions and generally application of essentially required micronutrients results in achieving desired crop yields. The results regarding the number of pods plant-1 of mustard as influenced by different Zinc (Zn) levels are shown in Table-5. The analysis of variance illustrated significant (P<0.05) variation in the number of pods plant-1 under the effect of different Zinc (Zn) levels. The application of Zn @ 7.5 kg ha-1 resulted in highest number of pods (265.33) plant-1, followed by Zn level of 5.0 kg ha-1, with 212.67 average number of pods plant-1, respectively. There was a marked reduction in the number of pods plant-1 and the plots supplemented with Zn at the rates of 2.5 kg ha-1, resulted in 188.67 pods plant-1, respectively. However, the lowest number of pods (145.67) plant-1 was recorded in control, where micronutrients were not applied. This indicates that there marvellous response of mustard to the combined application of Zn and B, while individual application of these micronutrients was relatively less effective when compared with their combined use.

**Table-5 Number of pods plant-1 of mustard as affected by different zinc levels.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **R1** | **R2** | **R3** | **Mean**  |
| T1= Control | 147 | 140 | 150 | 145.67 D |
| T2= ZnSO4 @ 2.5 kg ha-1 | 190 | 195 | 181 | 188.67 C  |
| T3= ZnSO4 @ 5.0 kg ha-1 | 205 | 213 | 220 | 212.67 B |
| T4= ZnSO4 @ 7.5 kg ha-1 | 223 | 283 | 290 | 265.33 A |
| S.E. | = | 15.370 |
| LSD 0.05 | = | 37.608 |
| CV% | = | 9.27 |

Mean values followed by similar letters are not significantly different at P=0.05

**Seed Index (1000 seeds weight g):** The character seed index is measured to examine the seed quality produced under different treatments; and this trait is measured on the basis of a certain number of seeds taken at random from the seed bulk and weighed. One thousand seeds of mustard were collected from the bulk in each plot and weighed to achieve the seed index value; and the results for this trait as affected by different levels of Zinc (Zn) are shown in Table-6 and its analysis of variance. The results of the analysis of variance showed highly significant (P<0.01) impact of various Zn levels on the seed index value of mustard. The application of Zn @ 7.5 kg ha-1 resulted in maximum seed index (4.52 g), followed by Zn level of 5.0 kg ha-1, with seed index of 4.25 g, respectively. The seed index followed an adversely trend and plots supplemented with Zn at the rates of 2.5 kg ha-1 resulted seed index of 3.31 g, respectively. However, the lowest seed index (2.80 g) was recorded in plots without Zn application (control). The results suggested a positive impact of Zn application on the seed index in mustard crop.

**Table-6 Seed Index (1000 seeds weight g).**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **R1** | **R2** | **R3** | **Mean**  |
| T1= Control | 2.35 | 2.87 | 3.20 | 2.80 D  |
| T2= ZnSO4 @ 2.5 kg ha-1 | 3.35 | 3.11 | 3.48 | 3.31 C |
| T3= ZnSO4 @ 5.0 kg ha-1 | 4.31 | 3.98 | 4.48 | 4.25 AB  |
| T4= ZnSO4 @ 7.5 kg ha-1 | 4.95 | 5.18 | 5.45 | 4.52 A |
| S.E. | = | 0.3285 |
| LSD 0.05 | = | 0.8037 |
| CV% | = | 10.80 |

Mean values followed by similar letters are not significantly different at P=0.05

**Seed yield plot-1 (kg):** The crop yield is a character that is considered as mainstay of all research work carried out for the crop improvement; and factors that influence the crop yield are diversified right from the selection of land to crop harvest. The data in relation to seed yield plot-1 as affected by different levels of Zinc (Zn) are presented in Table-7 and its analysis of variance. The results of the analysis of variance suggested significant (P<0.01) effect of Zn levels on the mustard yield plot-1. The application of Zn @ 7.5 kg ha-1 produced significantly highest seed yield of 7.9225 kg plot-1, followed by Zn level of 5.0 kg ha-1, with seed yield 7.5868 kg plot-1, respectively. The seed yield plot-1 reduced to 7.1840 kg plot-1 when Zn were applied @ 2.5 kg ha-1, respectively. However, the lowest seed yield of 6.7140 kg plot-1 was recorded in plots given no Zn (control). It is evident from the results that soil application of Zn resulted positive impact on the mustard yield, while the impact of individual application of these micronutrients was less effective for yield improvement.

**Table-7 Seed yield plot-1 (kg) of mustard as affected by different zinc levels.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **R1** | **R2** | **R3** | **Mean**  |
| T1= Control | 6.525 | 6.669 | 6.948 | 6.7140 D |
| T2= ZnSO4 @ 2.5 kg ha-1 | 6.981 | 7.135 | 7.434 | 7.1840 C |
| T3= ZnSO4 @ 5.0 kg ha-1 | 7.373 | 7.535 | 7.851 | 7.5868 B |
| T4= ZnSO4 @ 7.5 kg ha-1 | 7.699 | 7.869 | 8.198 | 7.9225 A |
| S.E. | = | 0.0136 |
| LSD 0.05 | = | 0.0334 |
| CV% | = | 0.23 |

Mean values followed by similar letters are not significantly different at P=0.05

**Seed yield ha-1 (kg):** The results in regards to seed yield ha-1 of mustard as influenced by different levels of Zinc (Zn) are presented in Table-8 and its analysis of variance. The analysis of variance demonstrated that the differences in the seed yield ha-1 of mustard crop were significant (P<0.01) under the effect of different levels of Zn. It is apparent from the results in Table-8 that the application of Zn @ 7.5 kg ha-1 resulted in significantly maximum seed yield of 2640.8 kg ha-1, followed by average mustard crop yield of 2528.9 kg ha-1 recorded from the plots receiving 5.0 kg ha-1, respectively. The seed yield ha-1 diminished to 2394.7 when Zn were applied @ 2.5 kg ha-1, respectively. However, the lowest seed yield of 2238.0 kg ha-1 was observed in plots given no Zn (control). The application of Zn resulted in promising impact on the mustard yield ha-1.

**Table-8 Seed yield kg ha-1 of mustard as affected by different zinc levels.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **R1** | **R2** | **R3** | **Mean**  |
| T1= Control | 2175 | 2223 | 2316 | 2238.0 D |
| T2= ZnSO4 @ 2.5 kg ha-1 | 2327.25 | 2378.61 | 2478.12 | 2394.7 C |
| T3= ZnSO4 @ 5.0 kg ha-1 | 2457.75 | 2511.99 | 2617.08 | 2528.9 B |
| T4= ZnSO4 @ 7.5 kg ha-1 | 2566.5 | 2623.14 | 2732.88 | 2640.8 A |
| S.E. | = | 4.5464 |
| LSD 0.05 | = | 11.125 |
| CV% | = | 0.23 |

Mean values followed by similar letters are not significantly different at P=0.05

**Discussion**

Agricultural soils have become deficient of macro as well as micronutrients, but the farmers only use macronutrients to improve crop yields, and majority of the growers are unaware of micronutrient deficiency of their soils (Bloemberg and Lugtenberg, 2010). Among macronutrients, N, P and K are essentially required elements for crop production (Don Eckert Dr. 2010); while P stimulates root development, increase stem strength, improve seed production, more uniform and earlier crop maturity and improvement in crop quality and resistance to plant diseases (Bill Griffith, 2010). However, K is required for plant growth and reproduction, having vital role in photosynthesis (Bob Thompson, Dr., 2010). Similarly, among micronutrients, Zn is an essential nutrient required in some fertilizer programs for crop production; Zn deficient crop plant appears to be stunted (Mortvedt *et al.,* 2010). Boron uptake by plants correlates extractable soil boron and its deficiency in plant results in terminal bud growth stoppage young leaves die, impaired flowering and seed development, thickened, wilted, or curled leaves, thickened, cracked, or water-soaked condition of petioles and stems, discoloration, cracking, or rotting of fruit, tubers, or roots. Hence, the present study was carried out to investigate the effect of zinc on the growth and yield of mustard.

The study indicated that all the growth and seed yield traits in mustard crop was significantly (P<0.05) influenced by different Zn levels. On the basis of seed yield ha-1, the application of Zn 7.5 kg ha-1 resulted 141.67 cm plant height, 22.00 branches plant-1, took 70.00 days to flowering, 81.33 days to maturity, 265.33 pods plant-1, 4.52 g seed index, 7.9225 kg seed yield plot-1 and 2640.8 kg seed yield ha-1. Similarly, the application of Zn @ 5.0 kg ha-1 resulted 139.00 cm plant height, 16.33 branches plant-1, took 72.00 days to flowering, 86.66 days to maturity, 212.67 pods plant-1, 4.25 g seed index, 7.5868 kg seed yield plot-1 and 2528.9 kg seed yield ha-1. The mustard crop supplemented with Zn @ 2.5 kg ha-1 resulted 134.33 cm plant height, 14.00 branches plant-1, took 76.00 days to flowering, 90.00 days to maturity, 188.67 pods plant-1, 3.31 g seed index, 7.1840 kg seed yield plot-1 and 2394.7 kg seed yield ha-1. However, the control plots, where no Zn were applied resulted 128.33 cm plant height, 10.66 branches plant-1, took 79.00 days to flowering, 92.66 days to maturity, 145.67 pods plant-1, 2.80 g seed index, 6.7140 kg seed yield plot-1 and 2238.0 kg seed yield ha-1. It was concluded that application of Zn proved to be more effective to increase seed yield in mustard crop. These results are categorically supported by many researchers, who worked on the similar aspects of mustard in different parts of the world. (Chen and Aviad, 2010; Asad and Rafique *et al.,* 2010) examined the effect of foliar applied Boron at concentrations from 0.04 to.0.3 percent on *Brassica juncea* L. (Bora and Hazarika, 2011) carried out studies to investigate the effect of micronutrients on the growth, seed yield and stover yield of rape seed. The results showed that the highest stover yield (2770 kg ha-1) was obtained with Zn + B + Mo and followed almost the same trend of seed yield. In a similar investigation, (Grewal *et al.,* 2008) investigated the interaction effect of applied zinc (Zn) and boron (B) on early vegetative growth and uptake of Zn and B by two oilseed rape (*Brassica juncea*L.) genotypes and reported that the crop growth and development positively affected by the application of Zn and B. The study of (Mandal and Sinha, 2014) examined the effect of Zn and B application in addition to NPK fertilizers on production and yield of Indian mustard. Plant height, number of branches per plant, number of siliqua per plant, number of seeds per siliquae, 1000-seed weight, seed and oil yield of Indian mustard improved at 100% recommended rates of NPK (N-P-K at 80-17.2-33.2  kg  ha−1)  + 10 kg ha−1 borax + 20 kg ha−1 ZnSO4. (Rana *et al.,* 2013) investigated the response of mustard for zinc and boron application in addition to the recommended NPK and reported that the combination of Zn + B gave significantly higher values of yield attributes and recorded the highest 1000 seed weight and seed yield which accounted for 24 percent increase over the recommended NPK alone. (Moniruzzaman *et al.,* 2008) found that B 1.5 and 8 kg ha-1 combination caused the highest rape seed yields and gross margin and marginal rate of return. (Yang *et al.,* 2009) reported that the combined application of B with Zn resulted in higher seed yield than the application of B or Zn alone, and the seed yield of the B+Zn treatment was the highest in all treatments, 68.1% above the control.

Conclusion

It was concluded that applications of Zn proved to be more effective to increase seed yield in mustard (S-9) variety. The mustard crop supplemented with 7.5 kg ha-1 ZnSO4 for obtaining significantly higher seed yield ha-1.

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