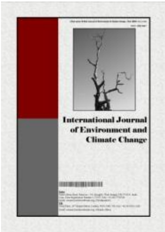

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Effect of Organic Manures, Sulphur and Foliar Application of Micronutrients (Zinc and Boron) on Growth and Yield of Mustard (*Brassica juncea* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was performed on growth and yield of mustard (*Brassica juncea* L.)" variety NRCHB-101 at Agricultural college, PJTSAU, Polasa, Jagtial, during spring 2021-2022. The soil of the experimental site was sandy clay loam in texture. The present research work was tested in randomized block design with 11 treatments comprising of different nutrient management practices i.e. T_1: Control, T_2: 100% NPK @60-40-40 NPK Kg ha^{-1}, T_3: 100% NPKS @60-40-40-40 NPKS Kg ha^{-1}, T_4: 100% NPK+ Vermicompost @2.5 t ha^{-1}, T_5: 100% NPK+ FYM @5 t ha^{-1}, T_6: 100% NPK+ Foliar spray of 0.5% Zinc-EDTA at flower initiation and at 50% flowering, T_7: 100% NPKS + Foliar spray of 0.5% Zinc-EDTA at flower initiation and at 50% flowering, T_8: 100% NPK + Foliar spray of 0.2% Boric acid at flower initiation and at 50% flowering, T_9: 100% NPKS + Foliar spray of 0.2% Boric acid at flower initiation and at 50% flowering, T_{10}: 100% NPK+ Foliar spray of 0.5% Zinc-EDTA and 0.2% Boric acid at flower initiation and at 50% flowering and T_{11}: 100% NPKS+ Foliar spray of 0.5% Zinc-EDTA and 0.2% Boric acid at flower initiation and at 50% flowering. The results revealed that significantly higher plant height (174 cm), Leaf area index (LAI) (2.94), No. of primary

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branches plant^{-1} (10), No. of secondary branches plant^{-1} (19.3) dry matter accumulation (4260 kg ha^{-1}) No. of siliquae plant^{-1} (189.33), seeds siliqua^{-1} (16.13), test weight (5.97 g), seed yield (1271 kg ha^{-1}) and stover yield (3141 kg ha^{-1}) with the application of 100% NPKS along with foliar spray of 0.5% Zinc-EDTA and 0.2% Boric acid at flower initiation and at 50% flowering.

Keywords: Growth; micronutrient foliar application; organic manures; sulphur; yield.

1. INTRODUCTION

Mustard (*Brassica juncea* L.) belongs to the family of Cruciferae. The seed contains 40-45% oil and 20-25% protein. The seed and oil of mustard are used as a condiment in the preparation of pickles, flavoring curries and vegetables as well as for cooking and frying purposes. Mustard oil is used in many industrial products, oil cake is used as cattle feed and also as manure while the green leaves are used as vegetable and green fodder [1]. Rapeseed and Mustard is one of the most important oil seed crops of the world with a production of 68.87 M t ha^{-1} (Statista Research Department) [2]. In India, it is cultivated in an area of 6.70 M ha with an average production of 10.21 M t with productivity of 11524 kg ha^{-1} (Indiastat [3]). Rajasthan is the leading producer of mustard followed by Uttar Pradesh. In Telangana, mustard is grown over an area of 2000 ha with a production of 2.42 M t and productivity of 1524 kg ha^{-1} (Indiastat [3]).

Adoption of intensive and modern cropping practices with high-yielding crop cultivars and unbalanced fertilizer application resulted in emergence of widespread secondary and micronutrient deficiency in soils and crops of India leading to reduced crop yield and low micronutrient concentration in agricultural produce. The soils in Telangana state are deficient of secondary nutrients (Sulphur) and important micronutrients like zinc and boron. Sulphur (S) is a crucial element for rapeseed-mustard in determining its seed yield, oil content, quality and resistance to various biotic and abiotic stresses. Besides promoting chlorophyll formation and oil synthesis, it is an important constituent of seed protein, amino acids, various enzymes and glucosinolate. It increases the seed yield of mustard by 12 to 48% under irrigated and 17 to 124% under rainfed conditions [4]. Sulphur deficiency in soils of Indian states varied from 5 to 83% with an overall mean of 41% [5]. Mustard, in general is very sensitive to micronutrient deficiency, especially zinc and boron. Zinc being one of the essential micro-nutrients in plant nutrition, plays an important role in building and growing plants through its participation in many vital processes, including photosynthesis and energy production [6]. It can activate many enzymes that are associated with the regulation of growth, gene expression, and protein formation [7]. Recent years have witnessed wide spread deficiency of boron in our soils [8]. Boron plays a vital role in cell wall synthesis, root elongation, glucose metabolism, nucleic acid synthesis, lignification and tissue differentiation [9]. Application of organic manures substantially increased the seed and stover yield of mustard over sole application of inorganic fertilizers. The increase in yield due to addition of organics might be the result of overall improvement in soil physico-chemical properties of soil. These beneficial effects favored greater availability of essential plant nutrients and their steady supply throughout the crop growth period for optimum development [10]. Hence, the present study was carried out to assess the role of organic manure, sulphur and micronutrients (Zinc and Boron) on growth and yield of mustard (*Brassica juncea* L.).

2. MATERIALS AND METHODS

The field experiment was carried out during spring 2021-2022 at college farm (18º 84’28.62” N latitude, 78º 95’03.57” E longitude and 250.4 m above mean sea level) of Agricultural college, Polasa, Jagtial, Professor Jayashankar Telangana State Agricultural University. The weekly mean maximum temperature during the crop growth period ranged from 28.2℃ to 32.9℃. The weekly mean minimum temperature during the crop growth period ranged from 10.7℃ to 22.2℃. The weekly mean relative humidity recorded at 7.30 hr (RH-I) during the crop growth period varied from 84.4% to 95.0%. The mean weekly relative humidity at 14.00 hr (RH-II) varied from 32.3% to 77.3%. The weekly mean evaporation during the crop growth period ranged between 1.1 mm and 3.7 mm. The weekly mean bright sunshine hours day^{-1} varied from 3.8 to 9.2 hours. Wind velocity throughout the crop growing period ranged from 1.8 to 3.4 km hr^{-1}. The soil of the experimental field was sandy clay loam in texture having slightly alkaline nature with pH (7.74), EC (0.18), organic carbon (0.58%), low in available nitrogen (179.2 kg ha^{-1}), medium in available phosphorous (13.8 kg ha^{-1}), high in available potassium (310 kg ha^{-1}), The soil had $CaCl_2$ extractable sulphur content of 9.2 mg kg^{-1}, DTPA extractable Zn (0.57 mg kg^{-1}) and hot water soluble B (0.45 mg kg^{-1}). The current research work was laid in randomized block design (RBD) with three replications comprising of eleven treatments viz. T_1: Control, T_2: 100% NPK @60-40-40 NPK Kg ha^{-1}, T_3: 100% NPKS @60-40-40-40 NPKS Kg ha^{-1}, T_4: 100% NPK+ Vermicompost @2.5 t ha^{-1}, T_5: 100% NPK+ FYM @5 t ha^{-1}, T_6: 100% NPK+ Foliar spray of 0.5% Zinc-EDTA at flower initiation and at 50% flowering, T_7: 100% NPKS + Foliar spray of 0.5% Zinc-EDTA at flower initiation and at 50% flowering, T_8: 100% NPK + Foliar spray of 0.2% Boric acid at flower initiation and at 50% flowering, T_9: 100% NPKS + Foliar spray of 0.2% Boric acid at flower initiation and at 50% flowering, T_{10}: 100% NPK+ Foliar spray of 0.5% Zinc-EDTA and 0.2% Boric acid at flower initiation and at 50% flowering and T_{11}: 100% NPKS+ Foliar spray of 0.5% Zinc-EDTA and 0.2% Boric acid at flower initiation and at 50% flowering. The seeds of mustard hybrid "NRCHB-101" was sown on 29th October 2021, at 45 × 15 cm spacing by dibbling method in the plot size of 5.4 × 4.8 m. N, P, K, and S were applied at the time of sowing in the form of urea, single super phosphate, muriate of potash and elemental sulphur, respectively, while urea was applied in split doses (½ as basal dose and remaining ½ at 40 DAS). FYM and vermicompost were supplemented during land preparation. Recommended crop management practices were adopted during the crop growth period. Observations were recorded on growth, yield attributes and yield. The collected data was statistically analysed by Analysis of Variance utilizing Randomized Block Design Panse and Sukhatme [11]. Statistical difference (CD) will be tested by applying F-Test at 0.05 level of probability.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The experimental results revealed that plant height of hybrid mustard was significantly influenced by the different nutrient management practices ranging from 123 cm to 174 cm. The highest plant height (174 cm) was recorded in T_{11}-100% NPKS+ Foliar spray of 0.5% Zinc-EDTA and 0.2% Boric acid at flower initiation and at 50% flowering which remained statistically at par with the T_{10} (167 cm), T_9 (153 cm), T_8 (151 cm), T_7 (166 cm), T_6 (163 cm), T_5 (158 cm) and T_4 (162 cm) treatments but significantly superior over rest of the treatments. This might be due to sulphur fertilization which helps in producing more amino acids leads to enhanced the cell division Raja et al. [12] and cumulative effect of Zn and B. The lowest plant height (123 cm) was registered in T_1-Control. The results are in agreement with the findings of Kour et al. [13], Sarkar et al. [14]. Dry matter accumulation was influenced by various nutrients supplied to the plant. Availability of all the required nutrients will able the plant to accumulate more amount of photosynthates. Treatments dry matter ranged from 2806 kg ha^{-1} to 4260 kg ha^{-1} (Fig. 1). Maximum dry matter accumulation was recorded in T_{11} (4260 kg ha^{-1}) which was 51.8% higher than control-T_1 (2806 kg ha^{-1}) but statistically at par with all other treatments except T_1 (2806 kg ha^{-1}) and T_2 (3599 kg ha^{-1}). These results are in conformity with the findings of Sarkar et al. [14]. Application of 100%NPKS along with foliar spray of Zn-EDTA (0.5%) and Boric acid (0.2%) at flower initiation and 50% flowering (T_{11}) increased the number of primary and secondary branches $plant^{-1}$. Maximum number of primary branches $plant^{-1}$ (10) was reported in T_{11} which was 69.49% higher than control (5.9). The results are in corroborative with the finding of Sarkar et al. [14]. Similarly, maximum number of secondary branches $plant^{-1}$ was found in T_{11} (19.3) which was 124.41% higher than T_1 (8.6). Supplementation of all the required nutrients for crop growth aids in increasing the height and vigour of the crop that results in increase in branching and total dry matter production. Holmes [15]. Similar findings were reported by Kour et al. [13]. The leaf area of the plant represents the opportunity to intercept the solar radiation necessary for photosynthesis. The highest leaf area index (LAI) was obtained in T_{11} (2.94) which was statistically at par with T_{10} (2.80). About 52.3% and 45.07% higher LAI was observed with T_{11} and T_{10} over T_1 (1.93) respectively. Higher LAI may be due to better leaf growth owing to favorable effect of fertilization on plant growth Tripathi et al. [16] The positive effect of foliar application of micronutrients also reported by Sarkar et al. [14]. These results are depicted in (Table 1).

3.2 Yield Attributes

Nutrient management practices had significantly influenced yield attributes of mustard such as number of siliquae plant^{-1}, number of seeds siliqua^{-1} and 1000 seed weight (g). The maximum number of siliquae plant^{-1} was observed in T_{11} (189.33) which was found at par with T10 (167.67). S-Zn-B were found beneficial for siliquae plant^{-1} due to interaction effect of S, Zn and B and their role in synthesis of IAA, metabolism of auxin and formation of chlorophyll synthesis Shoja et al. [17]. The minimum number of siliquae plant^{-1} was acquired in T_1 (87.33) which was 116.79% lower than T_{11}. The highest number of seed siliqua^{-1} was observed in T_{11} (16.13) where foliar application of Zn-EDTA (0.5%) and Boric acid (0.2%) along with 100% NPKS. Production of more chlorophyll and IAA which delayed plant senescence and thus prolonged the period of photosynthesis. This improves carbohydrate production and their transfer to the growing seeds Vitosh et al. [18]. and Zn helps in formation of male and female reproductive organs and pollination process Brown et al. [19]. The lowest number of seeds siliqua^{-1} was noted in T_1 (8.03) which was 100.87% lower than T_{11}. The superior test weight was obtained in T_{11} (5.97 g) which was at par with all other treatments except T_1 (4.77 g) and T_2 (5.37 g) and remained 25.15 % higher than T_1 (4.77 g). This may be due to provision of macro and micro nutrients at latter stages which might have improved accumulation of assimilate in seeds and thus resulting in heavier seed Shoja et al. [17]. These finding are in the close vicinity with those reported Kumari et al. [20] in linseed, Kour et al. [13] in mustard and Ravikumar et al. [21] in sunflower. These observations are furnished in (Table 2).

Yield attributes and yield are positively correlated (Fig. 2). The treatment with maximum yield attributes recorded highest seed yield and stover yield. Therefore, T_{11} acquired highest seed yield (1271.3 kg ha^{-1}) and stover yield (3141.9 kg ha^{-1}). However, T_{11} was at par with T_{10} (1101.4 kg ha^{-1}), T_7 (1085.7 kg ha^{-1}), T_6 (1073 kg ha^{-1}) and T_4 (1065 kg ha^{-1}) while, stover yield of T_{11} was remained at par with all other treatments except T_1 (1482.5 kg ha^{-1}) T_2 (2303.7 kg ha^{-1}) and T_3 (2511.1 kg ha^{-1}). For higher seed yield, the S requirement for rapeseed is greater than that for cereals Hamm. [22] and micronutrients increase photosynthesis rate and improves leaf area duration thus seed yield will be increased Shoja et al. [17] The lowest seed yield was noted in T_1 (525.67 kg ha^{-1}) which was 141.84% lower than T_{11}. The minimum stover yield was found in control (1482.5 kg ha^{-1}) which was 111.93% lower than the treatment with 100% NPKS and foliar spray of micronutrients (Zn-EDTA-0.5% and Boric acid-0.2%) at flower initiation and 50% flowering. Kour et al. [13] in mustard, Kumari et al. [20] in linseed and Ravikumar et al. [21] in sunflower were also reported increase in yield with foliar application of zinc and boron. These values are shown in (Table 2).

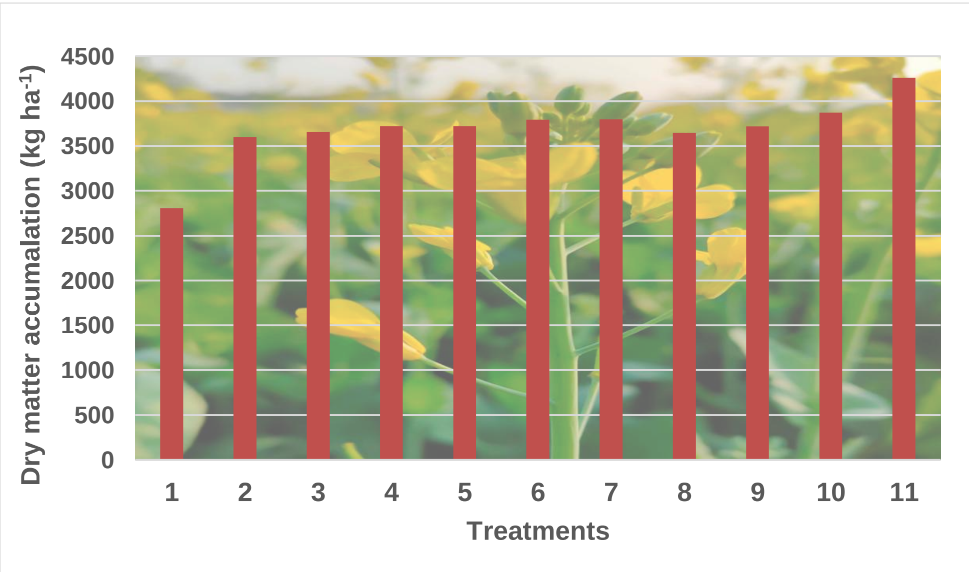

Fig. 1. Treatment effect on dry matter accumulation

Table 1. Growth parameters of mustard at harvest as influenced by application of organic manures, sulphur and foliar application of micronutrients

Treatments	Plant height (cm)	Dry matter accumulation (kg ha^{-1})	Primary branches plant^{-1}	Secondary branches plant^{-1}	Leaf area index (LAI)
T_1-Control	123	2806	5.9	8.6	1.93
T_2-100% NPK @60-40-40 NPK Kg ha^{-1}	144	3599	7.1	11.5	2.23
T_3-100% NPKS @60-40-40-40 NPKS Kg ha^{-1}	146	3658	7.2	12.6	2.28
T_4-100% NPK+ Vermicompost @2.5 t ha^{-1}	162	3720	7.7	16.1	2.53
T_5-100% NPK+ FYM @5 t ha^{-1}	158	3719	7.7	14.7	2.43
T_6-100% NPK+ Foliar spray of 0.5% Zinc-EDTA at flower initiation and at 50% flowering	163	3791	7.9	17.1	2.60
T_7-100% NPKS + Foliar spray of 0.5% Zinc-EDTA at flower initiation and at 50% flowering	166	3795	8.3	17.6	2.67
T_8-100% NPK + Foliar spray of 0.2% Boric acid at flower initiation and at 50% flowering	151	3647	7.4	12.8	2.37
T_9-100% NPKS + Foliar spray of 0.2% Boric acid at flower initiation and at 50% flowering	153	3717	7.5	14	2.47
T_{10}-100% NPK+ Foliar spray of 0.5% Zinc-EDTA and 0.2% Boric acid at flower initiation and at 50% flowering	167	3870	8.8	18.5	2.80
T_{11}-100% NPKS+ Foliar spray of 0.5% Zinc-EDTA and 0.2% Boric acid at flower initiation and at 50% flowering	174	4260	10	19.3	2.94
SEm ±	9.23	222.84	0.67	1.02	0.09
CD (P=0.05)	27.22	657.37	1.39	3.01	0.26

Table 2. Yield parameters and yield of mustard as influenced by application of organic manures, sulphur and foliar application of micronutrients

Treatment	Number of siliquae plant^{-1}	Number of seeds siliqua^{-1}	1000 seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1-Control	87.33	8.03	4.77	525.67	1482.5
T_2-100% NPK @60-40-40 NPK Kg ha^{-1}	119.00	10.13	5.37	833.67	2303.7
T_3-100% NPKS @60-40-40-40 NPKS Kg ha^{-1}	126.67	10.80	5.47	943.67	2511.1
T_4-100% NPK+ Vermicompost @2.5 t ha^{-1}	145.67	12.37	5.80	1065	2747.4
T5-100% NPK+ FYM @5 t ha^{-1}	142.33	12.10	5.77	1036.3	2705.9
T6-100% NPK+ Foliar spray of 0.5% Zinc-EDTA at flower initiation and at 50% flowering	156.33	13.27	5.83	1073	2766.6
T7-100% NPKS + Foliar spray of 0.5% Zinc-EDTA at flower initiation and at 50% flowering	158.00	13.43	5.87	1085.7	2776.0
T8-100% NPK + Foliar spray of 0.2% Boric acid at flower initiation and at 50% flowering	134.00	11.40	5.60	959.67	2538.2
T9-100% NPKS + Foliar spray of 0.2% Boric acid at flower initiation and at 50% flowering	138.00	11.73	5.70	1026.7	2717.4
T10-100% NPK+ Foliar spray of 0.5% Zinc-EDTA and 0.2% Boric acid at flower initiation and at 50% flowering	167.67	14.07	5.93	1101.4	2767.7
T11-100% NPKS+ Foliar spray of 0.5% Zinc-EDTA and 0.2% Boric acid at flower initiation and at 50% flowering	189.33	16.13	5.97	1271.3	3141.9
SEm ±	8.43	0.70	0.24	77.34	201.81
CD (P=0.05)	24.87	2.06	0.51	228.14	595.34

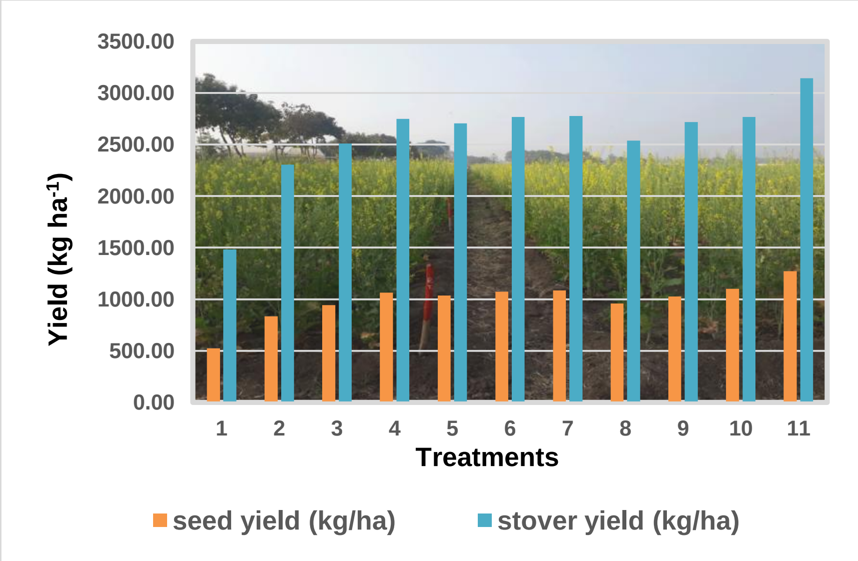

Fig. 2. Effect of organic manures, sulphur and micronutrients (foliar spray of Zn-EDTA at 0.5% and Boric acid at 0.2% at flower initiation and 50% flowering) on seed and stover yield of mustard

4. CONCLUSION

It is concluded from the study that the micronutrients especially Zinc and Boron plays major role for enhancing growth parameters, yield attributes and yield of mustard crop. Among the foliar application of micronutrients, application of Zinc and Boron in conjugation with 100% NPKS (basal application) was found to be more beneficial in terms of growth and yield. Hence, it is suggested from the experiment that an integration of 100% RDF (NPKS @60-40-40-40) with foliar application of Zinc-EDTA at 0.5% and Boric acid at 0.2% at flower initiation and 50% flowering augmented the growth and yield of mustard crop.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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