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Assessment of Micro and Secondary Nutrient Combinations for Yield, Yield Attributes, and Economic Profitability of Mustard in Mid Indo-Gangetic Plains of Bihar

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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

An on-farm trial was established at Saran district of Bihar, aiming to assess the different combinations of micro and secondary nutrients on yield and economic profitability of mustard (*var. Rajendra suphalam*). The experiment comprised three treatments *i.e.,* T_1: RD-S+Zn (Farmer practices), T_2: RD-S+B and T_3: RD-S+B+Zn and seven replications performed under a completely randomized block design during 2018-19. Results of the experiment revealed that combined application of sulphur, boron and zinc significantly improved the number of seeds per siliqua: 37.2%, stover yield: 12.3% & seed yield: 33.3% over farmers practice (T_1: RD-S+Zn). The highest seed yield and gross return in treatment T_3: RD-S+B+Zn was well reflected in the maximum net

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return (Rs. 40954.0 ha^{-1}) and benefit-cost ratio (2.29). In conclusion, the combined application of sulphur, boron and zinc was performed better for mustard cultivation in the middle Indo-Gangetic plains of Bihar.

Keywords: Mustard; sulphur; boron; zinc; yield; net return.

1. INTRODUCTION

Mustard (*Brassica juncea L.*) is grown under different agro-climatic zones of the world, differing in soil nutrient status [1]. In India, mustard is considered as a major oilseed crop with an importance that is comparable to that of groundnut, both in cultivated areas and production. The estimated area, production and yield of rapeseed-mustard in the world were 36.59 million hectares, 72.37 million tonnes and 1980 kg ha^{-1}, respectively, during 2018-19. During the last eight years, there has been a considerable increase in productivity from 1840 kg ha^{-1}in 2010-11 to 1980 kg ha^{-1} in 2018-19, and production has also increased from 61.64 m t in 2010-11 to 72.42 metric tonnes in 2018-19 [2].

Sulphur (S) is the main nutrient in oilseed production. Deficiency of sulphur affected forage to oilseed crops, but the clearest effects have been seen in mustard for the cause that of its high sulphur required [3]. For maximum seed yield mustard, the sulphur requirement is greater than that for cereals [4, 5]. Therefore, mustard is more likely to respond to sulphur fertilization. Sulphate sulphur application is reported to increase the concentration of oil in mustard seed [6].

Boron (B) and zinc (Zn) are two essential micronutrients required for the growth and development of higher plants. Boron plays important role in cell wall synthesis and structure and possibly membrane stability [7, 8]. The deficiency of boron causes abnormal development of reproductive organs [9] and reduces plant yield [10]. It promotes the strength and rigidity of cell wall structure and, therefore, supports the figure and power of the plant cell [7]. Applying zinc to Zn-deficient soil could also advance the seed yield of mustard [11]. Zinc deficiency also affects carbohydrate metabolism, damages pollen structure, and decreases the yield [12]. It is a cofactor of over 300 enzymes and proteins and has an early and effect on cell division and protein synthesis [13].

Boron and zinc deficiencies are more possible early in the growing period, the reason that the translocation of elements from the root to the aboveground part may not be sufficient before leaf expansion [14]. The positive effects of zinc and boron on chlorophyll contents in boron - and zinc-deficient plants had been observed by Kaya and Higgs [15]. Synergistic interactions among zinc and boron in mustard have also been reported [16] when both nutrients were also in small or excess supply.

Most researchers have studied the effect of a single element fertilizer on crop yield. In contrast, only a few have paid attention to the combined applications of nutrients in improving the yield. In this present study, the effects of sulphur, zinc and boron nutrients on crop performances, economics and availability of nutrients under mustard cultivation has been made.

2. MATERIALS AND METHODS

2.1Study Area

An on-farm trial was established during 2018-19 at farmers' fields of district Saran, Bihar, under the supervision of Krishi Vigyan Kendra, Manjhi, Saran, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar. The area falls in the subtropical, humid agro-climatic zone of Bihar. The average annual rainfall of the area is about 800-1100 mm. During cropping season, the total rainfall recorded was 22.9 mm, and mean monthly maximum & minimum temperature varies from 24-33ºC and 16-23ºC, respectively (Fig. 1). The soil of the experimental site was sandy loam in texture with alkaline pH (8.62), low in organic carbon content (0.30%), and available sulphur, zinc & boron *i.e.,* 8.5, 0.67 & 0.45 mg kg^{-1}, respectively.

2.2 Experimental Design

An experiment on assessment of different combinations of micro and secondary nutrients for the sustainable yield of mustard was established at eight farmer fields of Saran district of Bihar under supervision of Krishi Vigyan Kendra, Manjhi, Saran (Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur) during 2018-19 (one season). The experiment was laid out in Randomized Block Design, replicated eight times involved three treatments *i.e.,* T_1: recommended dose of sulphur and zinc (RD-S+Zn; Farmer practices); T_2: recommended dose of sulphur and boron (RD-S+B); T_3: recommended dose of sulphur, boron and zinc (RD-S+B+Zn). A total of twenty-four plots were established, with each plot sized at 180.0 m × 22.2 m. Irrespective of treatments, the recommended dose of sulphur @ 40.0 kg ha^{-1}, Zinc @ 7.5 kg ha^{-1} and boron @ 2.3kg ha^{-1} in the form of bentonite sulphur, zinc sulphate monohydrate and Di-sodium tetra borate pentahydrate, respectively, were applied.

2.3 Agronomic Practices

Before the execution of the experiment, the field was well ploughed by a tractor followed by planking. Weeds, stones, pebbles, etc. were removed from the field. On the basis of soil test value, calculated amount of fertilizers (*i.e.,* 55.3 kg ha^{-1} bentonite sulphur, 28.4 kg ha^{-1} zinc sulfate monohydrate, and 2.9 kg ha^{-1} Di- sodium tetraborate pentahydrate) were applied at the time of seed sowing. Seed sowing of mustard (var. *Rajendra Suphalam*) was done on 25th November 2018, having a row to row distance of 45 cm with a seed rate of 5 kg ha^{-1}. Thinning was done three weeks after sowing to maintain the plant to plant distance of 10-15 cm. The crop was harvested on 11th March 2019. Two irrigations (4 cm) were sufficient for mustard after sowing of seeds. First irrigation was supply at the pre-bloom stage whereas, the second irrigation was at the pod filling stage. The pesticide was used for crop protection against major and minor pests. Insecticide (Imidacloropid 1 ml 3^{-1} litre water) and Fungicide (Carbendazim @ 2 g l^{-1} of water) were applied at the time of disease and pest infestation [17]. Weed management was done manually at the time of weed infestation.

2.4 Data Collection

Twenty-five selected siliqua taken from the respective plant were threshed, seeds were counted, and the average number of seeds was recorded as the number of seeds/siliqua. From the individual plot, the crop of the net plot area was harvested and dried. After air drying, the produce was threshed, and seeds were cleaned. The final seed weight was recorded in kg per^{-1} plot and converted into q ha^{-1}. The stover yield was calculated by subtracting the grain yield from the biological yield of the respective plots and expressed as kg ha^{-1} and finely converted into q ha^{-1}.

The net return and benefit-cost ratio were calculated by considering the variable as well as fixed inputs and prevailing market rates, the expenditure incurred on various inputs and operations. The fixed cost includes tillage, seed & seed sowing, irrigation, pesticide, harvesting and transportation. Similarly, variable costs included fertilizer. The cost of human labour used for tillage, seeding, irrigation, fertilizer and pesticide application, weeding and harvesting of crops was based on person-days per hectare.

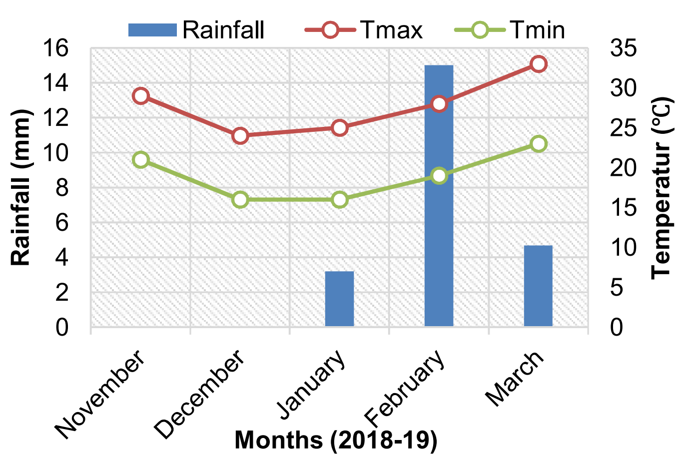

Fig. 1. The monthly minimum temperature (mean), maximum temperature (mean) and rainfall (total) for the crop year 2018-19

Simultaneously, gross returns were worked out for each treatment based on quality and market prices (Minimum Support Price, Government of India) of the produce. The net returns were worked out by deducting the cost incurred from the gross return of the particular treatment. The benefit cost (B: C) ratio was calculated by dividing the net return by the total cost of production.

2.5 Soil Sampling and Analysis

Soil sampling was done before execution of experiment and after harvest of the crop at 0-15 cm soil depth for analysis of soil pH, organic carbon and sulphur, boron and zinc nutrients. For the analysis of soil, the standard procedure follows *i.e.,* pH of the soil was measured with the help of a pH meter [18]. The organic carbon content in soil samples was estimated by Walkley and Black [19] method as suggested by Jackson [18]. Available soil sulphur (S) was estimated by 0.15% $CaCl_2$ solutions as per the method suggested by Williams and Steinbergs [20] and described as turbidimetric method given by Chesnin and Yein [21]. Available zinc (Zn) was estimated by Diethylene Triamine Penta Acetic Acid (DTPA) solution as suggested by Lindsay and Norvell [22]. Available boron (B) estimated by Azomethine-H Method [23].

2.6 Data Analysis

The data generated from the present investigation were subjected to statistical analysis using the statistical package SPSS 13.0. The least significant difference (LSD) at 5% for testing the significant difference among the treatment means [24].

3. RESULT AND DISCUSSION

3.1 Yield Attributes and Yield

Results of the experiment revealed that the combined effect of sulphur, boron and zinc produced a significant effect (Table 1) on yield attributes & yields and economic profitability. The treatment T_3: RD-S+B+Zn had recorded the highest number of seed per siliqua, stover &seed yield, followed by T_2: RD-S+B and T_1: RD-S+Zn. The per cent increment in the number of seed per siliqua, stover and seed yield under treatment T_3: RD-S+B+Zn were 37.2, 12.3 & 33.3% over T_1: RD-S+Zn may be attributed to the combined effect of sulphur, boron and zinc. Whereas treatments T_2: RD-S+B and T_1: RD-S+Zn were statistically similar to each other. This suggested that the beneficial effect of sulphur application probably induced the synthesis of growth-promoting substances, which would stimulate the root growth, cell elongation and protein synthesis, resulting in better plant growth and seed yield [25].

One of the important physiological roles of boron in plants is to improve pollen tube growth and fertilization in reproductive growth [26]. Thus, boron deficiency results in a typical symptom called 'flowering without seed setting' [27]. Also, the application of boron likely enhanced the transport of photosynthate from the pericarp to the seed of mustard grown in B deficient soils [28]. The zinc micronutrient increases photosynthesis rate and improves leaf area duration; thus, seed yield will be increased. Zinc plays an important role in tryptophan biosynthesis [29].

3.2 Economic Profitability

The cost of cultivation was not significantly affected by the application of secondary and micronutrients (Table 1). But the highest cost of cultivation involved in treatment T_3: RD-S+B+Zn followed by T_2: RD-S+B and T_1: RD-S+Zn. The highest gross return incurred from treatment is associated with the highest seed yield *i.e.,* T_3: RD-S+B+Zn, whereas treatments T_2: RD-S+B and T_1: RD-S+Zn were incurred statistically similar gross return. Due to the highest seed yield and gross return, the treatment T_3: RD-S+B+Zn well reflected the maximum net return (Rs. 40954 ha^{-1}) and benefit-cost ratio (2.29).

3.3 Available Nutrients

The availability of nutrients depends upon the soil reaction (pH) and organic carbon. There was no significant effect (Table 2) recorded between combinations of secondary and micronutrients treatment on soil pH, SOC, and available nutrients *i.e.,* sulphur, boron and zinc. However, the highest content of available sulphur, boron and zinc was associated with comparatively lower soil reaction and higher SOC treatment *i.e.,*T_1: RD-S+Zn followed by T_2: RD-S+B and T_3: RD-S+B+Zn, which means comparatively lower removal of nutrient by crop due to the lower yield.

Table 1. Assessment of different combinations of micro and secondary nutrients on yield attributes yields and economic profitability

Treatments	Number of seeds/siliqua	Stover yields (q/ha)	Seed yield (q ha^{-1})	Cost of production (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net Return (Rs. ha^{-1})	B:C Ratio
T_1: RD-S+Zn	10.2b	45.6b	10.5b	17206a	44100b	26894b	1.56b
T_2: RD-S+B	12.6b	48.7b	11.2b	17465a	47040b	29575b	1.69b
T_3: RD-S+B+Zn	14.0a	51.2a	14.0a	17846a	58800a	40954a	2.29a

** Within variable means in the same column followed by different letters are significantly different from each other based on LSD (0.05)*

Table 2. Assessment of different combinations of micro and secondary nutrients on available nutrients in soil

Treatments	Soil pH (1: 2.5)	SOC (g kg^{-1})	Available Sulphur (mg kg^{-1})	Available Boron (mg kg^{-1})	Available Zinc (mg kg^{-1})
T_1: RD-S+Zn	8.51a	3.2a	9.8a	0.58a	0.77a
T_2: RD-S+B	8.55a	3.0a	9.6a	0.56a	0.75a
T_3: RD-S+B+Zn	8.61a	3.0a	9.4a	0.51a	0.71a

** Within variable means in the same column followed by different letters are significantly different from each other based on LSD (0.05)*

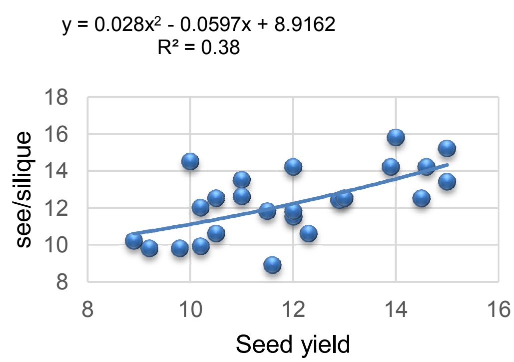

Fig. 2. Polynomial relationships among seeds/ silique and seed yields

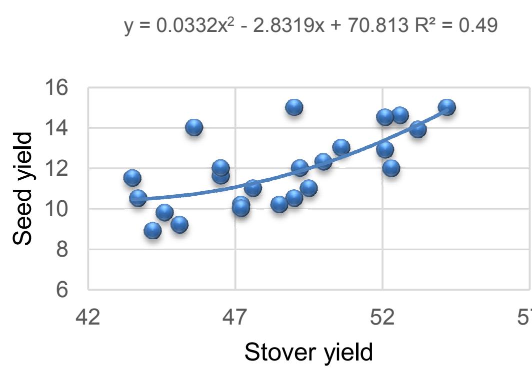

Fig. 3. Polynomial relationships among stover yields and seed yields

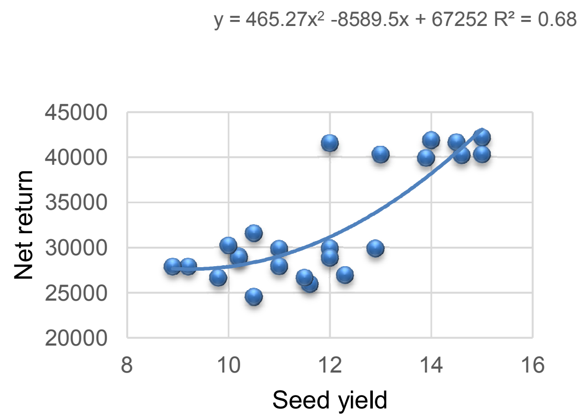

Fig. 4. Polynomial relationships among seed yield and net return

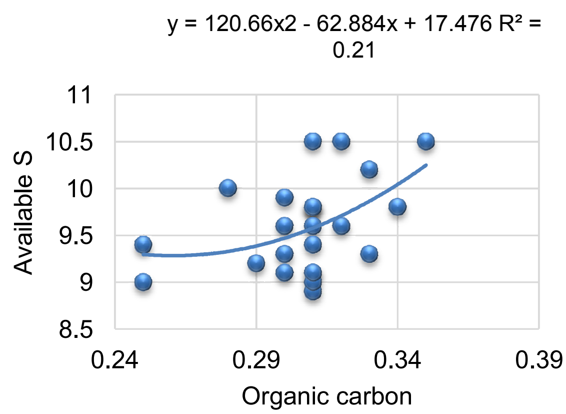

Fig. 5. Polynomial relationships among soil organic carbon and available sulfur of soil

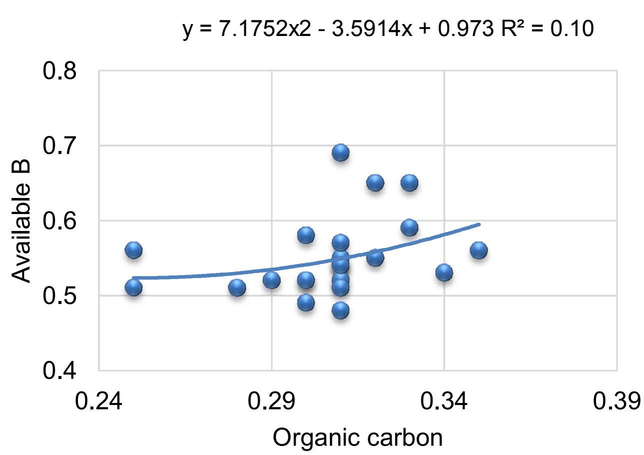

Fig. 6. Polynomial relationships among soil organic carbon and available boron of soil

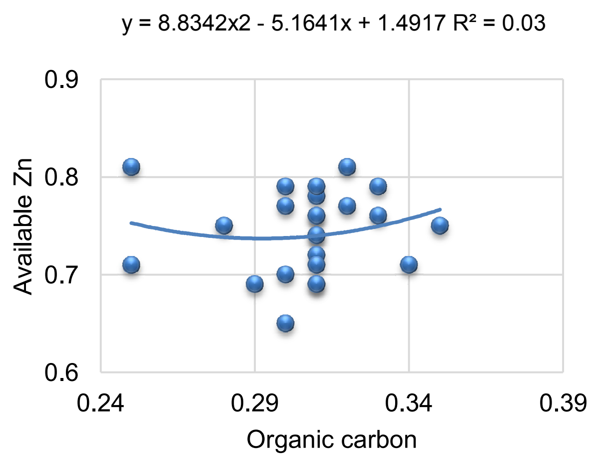

Fig. 7. Polynomial relationships among soil organic carbon and available zinc of soil

3.4 Correlation

In the present study, a positive correlation was observed between the number of seeds/ silique & stover yields (Fig. 3); stover yield & seed yield (Fig. 4), seed yield & net return, and soil organic carbon (SOC) and available nutrients (sulphur, boron and zinc) of mustard. However, the highest polynomial correlation value was obtained between seed yield & net return (R^2 = 0.68), followed by stover yield & seed yield (R^2 = 0.49) and the number of seeds/silique & stover yield (R^2 = 0.38). Among the SOC and available nutrients, the highest polynomial correlation value was found between SOC & available sulphur (R^2 = 0.21) followed by available boron (R^2 = 0.10) and available zinc (R^2 = 0.03) under mustard cultivation.This beneficial effect might be due to the interaction effect of sulphur, zinc, boron and their role in the synthesis of IAA, metabolism of auxin and formation of chlorophyll synthesis [29].

4. CONCLUSION

In conclusion, application of recommended dose of sulfur, boron and zinc (T_3: RD-S+B+Zn.) were produced significant effect on yield attributes yield and net return in mustard cultivation. The treatment T_3: RD-S+B+Zn recorded the highest seed yield, which was well reflected to the highest net return. Among the combinations of secondary and micronutrients, the combination of sulphur, boron and zinc (T_3: RD-S+B+Zn) was the most effective in respect of productivity and profitability for mustard in the middle Indo-Gangetic plains of Bihar.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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