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Response of Mustard Yield (cv. BARI Sarisha-14) to Different Fertilizer Management Under Subtropical Condition

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Abstract: The yield of mustard can be significantly enhanced by the appropriate application of fertilizers. Utilizing fertilizers effectively holds considerable promise for improving mustard yields. To evaluate the effect of fertilizers on mustard yield, a study was carried out at the Agronomy Field Laboratory (AFL), Bangladesh Agricultural University (BAU), Mymensingh, between November 2022 and February 2023. This study involved seven different fertilizers treatments: control (no fertilizer) and incremental additions of nutrients starting from nitrogen (N) alone to a full combination of nitrogen, phosphorus, potassium, Sulphur, zinc, and boron (N-P-K-S-Zn-B). The BARI (Bangladesh Agricultural Research Institute) sarisha-14 variety was used as the crop under study. The study was conducted using a randomized complete block design (RCBD) with three replications. The findings suggested that, fertilizers application had a significant impact on several growth parameters and yields. The most comprehensive fertilizers mix (N-P-K-S-Zn-B) resulted in the maximum observed values for plant height (PH) (83.63 cm), number of branches plant^{-1} (NBP) (4.74), number of siliquae plant^{-1} (NSP) (63.17), and seed yield (SY) (2.19 t ha^{-1}) and stover yields (7.27 t ha^{-1}). This treatment also resulted in the highest biological yield (BY) (4.51 t ha^{-1}), indicating a robust growth response. In contrast, control (no fertilizers) produced the lowest SY (0.19 t ha^{-1}) and stover yield (0.70 t ha^{-1}). It can be concluded that BARI sarisha-14 produced the highest yield of mustard with the recommended rate of N-P-K-S-Zn-B and farmers can cultivate this mustard variety at large scale with mentioned recommended dose of fertilizer.

Keywords: Recommended fertilizer; Branches plant^{-1}; Percent yield increase; Harvest Index

INTRODUCTION

A widely used source of cocking oil, mustard (*Brassica napus* L.) is a broadleaf, cruciferous plant that belongs to the family of Cole crops (Rahman *et al* 2018). It is a major oil crop in Bangladesh and is grown alongside soybean, groundnut, sunflower, and rape seed. It is Bangladesh's top seed of oil crop in terms of hectares and production. The total cropped area of mustard and rape seed production in Bangladesh is 330730.494 ha, with a yield of 0.203 t ha^{-1} and 409659.06 metric tons (BBS, 2023). The production is insufficient to meet domestic needs.

Consequently, Bangladesh remains a net importer of oils, and the oil demand is substantial. Bangladesh made 7.48 thousand US dollars in revenue from the export of mustard in 2021, a decrease from the previous year. Nearly all of the revenue from this amount, or $72, 42,000 United States (US), came from the United Arab Emirates (UAE). Exports to Switzerland accounted for the remaining income. It should be noted that Bangladesh has not been exporting rapeseed lately (Tridge, 2021).

In terms of enhanced production per unit area, the high-yielding mustard cultivars produced by the BARI may have beaten the native variety (Mandal and Sinha 2004). BARI Sarisha-14, a high-yield producing mustard variety, thrives in plain and char land areas and does not affect the subsequent crop growth (Islam *et al* 2011).

Mustard is a substantial oil source utilized for industrial, medicinal, and culinary purposes. Mustard is an essential component strongly rooted in Bangladesh's culinary traditions. There are numerous industrial uses for rapeseed and mustard, and its oilcake can be utilized as manure

(Bora *et al* 2021). Mustard oil is one of the major cooking oils because of its strong flavor. Mustard seeds are used to make pickles, which give preserved vegetables a spicy bite. Mustard is valued for its medicinal qualities beyond the kitchen, where it is employed in massage and conventional treatments. The mustard seeds content of oils ranges between 37% and 49%. (Bhowmik *et al* 2014). Mustard oil is high in calories (approximately 9 kcal g^{-1}) and contains high levels of soluble vitamins like A, D, E, and K.

The cultivation of mustard in Bangladesh is currently limited due to farmers' reluctance to use fertile land and lower yields. A primary cause of mustard's low yield in the country is the cultivation of low-yielding local varieties (Alam & Rahman, 2006). However, the country's agroclimatic conditions are favorable for mustard growth. Farmers typically produce mustard by ploughing and use minimal fertilizers and irrigation. However, improved management practices could increase mustard yield. In Bangladesh, the uneven application of chemical fertilizers to crops is widespread. Because of the decreased crop output from reduced soil fertility, integrated nutrient management is becoming increasingly necessary. Before getting into fertilizers management, it's critical to understand the nutrient requirements of the mustard crop. Mustard plants specifically require essential macronutrients such as N, P, and K and secondary macronutrients like S. The production of oilseed rapeseed depends heavily on mineral N fertilization (Abdallah *et al* 2010; Rathke & Schuster, 2001). Rapeseed needs a large amount of N, and its availability is often limited in many places globally (Rossato *et al* 2001; Kessel, 2000). Phosphorus is vital for chlorophyll production and participates in numerous metabolic and physiological processes in plants, essential for their normal growth and development. Potassium (K), as a macronutrient, is crucial for plant growth and development and plays a key role in osmoregulation by maintaining low water potential in plant tissues. Additionally, Sulphur aids in synthesizing essential amino acids such as methionine, cystine, and cysteine (Kumar & Yadav, 2007). Furthermore, micronutrients such as zinc (Zn) and boron (B) are necessary for the healthy development of mustard crops. This research is important because it offers useful advice on managing fertilizers for mustard crops, emphasizing the important factors to keep in mind for effective farming.

Considering the above-mentioned points, the study aimed to assess the impact of various fertilizer combinations on mustard yield and identify the optimal combinations that enhance both yield and yield-contributing traits of mustard.

MATERIALS AND METHODS

Experimental site

The study was carried out at the AFL of BAU in Mymensingh during the Rabi season, between November 2022 and February 2023. The experimental site was precisely situated at 90°50' E longitude, 24°25' N latitude, and an elevation of 18 meters above sea level, located on the Old Brahmaputra floodplain (Figure. 1). The soil type was non-calcareous, dark grey floodplain from the Sonatola series (AEZ-9) (FAO & UNDP, 1988). The land featured a medium-high topography and was characterized by a sandy loam soil texture with a pH value of 6.9. Composite samples of the topsoil (0–15 cm depth) were collected for analysis before initiating the experiment. The report details the soil's morphological, chemical, and physical properties in Tables 1-3. The mustard crop was grown over the winter, a season marked by shortening daylight hours and unexpected rainfall events at the start and during the harvest period. Table 4 presents data on the average monthly temperature, humidity, rainfall, and sunlight hours experienced throughout the study, from November 2022 to February 2023.

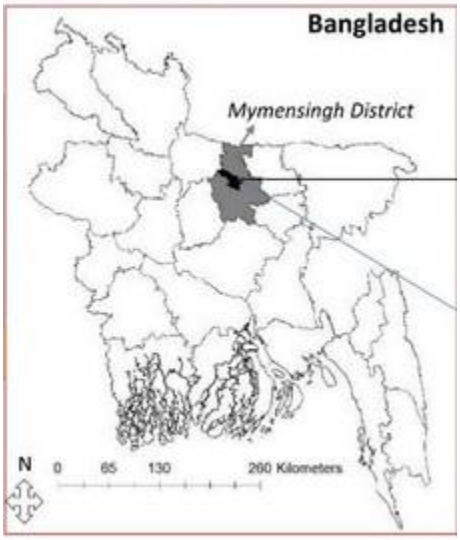

Figure 1. Map of the study area

Experimental treatments

Seven different fertilizer doses have been included in the experiment, viz., T_1 - control, T_2 - recommended rate (RR) of N (90 kg ha^{-1}), T_3 - RR of N-P (90-30 kg ha^{-1}), T_4 - RR of N-P-K (90-30-50 kg ha^{-1}), T_5 - RR of N-P-K-S (90-30-50-15 kg ha^{-1}), T_6 - RR of N-P-K-S-Zn (90-30-50-15-2 kg ha^{-1}), and T_7 - RR of N-P-K-S-Zn-B (90-30-50-15-2-1.5 kg ha^{-1}). The experiment was laid out in an RCBD with three replications, where the total number of unit plots was 21. Each plot was measured at 4.0 m × 2.5 m (10 m^2).

Collection and preparation of experimental materials

Seeds variety of mustard (BARI Sarisha-14) were obtained from the seed wing of the BARI in Gazipur. These seeds were sown in carefully prepared plots on November 16, 2022, with rows spaced 25 cm apart. Fertilizers were administered according to designated treatments, using urea for N, TSP for phosphorus (P), MoP for potassium (K), gypsum for S, zinc sulphate for zinc (Zn), and boron (B). During the final land preparation, all fertilizers except for

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half of the urea were applied to each plot. The remaining urea was applied 30 days after the seeds were sown.

Preparation of plots and crop husbandry

Initially, the experimental field was tilled with a power tiller, followed by two rounds of ploughing with a traditional country plough and subsequent laddering to achieve medium soil tilth. The field layout was established in November 2022 by the predetermined design. Individual plots were then shaped by spading. Prior to sowing, all weeds and stubble were cleared from each plot. Manual weeding of the experimental plots occurred twice, ten days after sowing (DAS) and again at 25 DAS. Only one irrigation event was conducted on December 16, 2022, to ensure adequate soil moisture. Due to the mustard plant's sensitivity to waterlogging, excess water was carefully drained following irrigation. No disease or insect infestations were observed throughout the experiment; thus, no pest control measures were required.

Harvesting and data collection

Before the harvesting process, five plants were randomly selected and uprooted from each unit plot to gather data on various vegetative and yield-related traits. These included PH (cm), NBP, NSB, SL (cm), NSS, TSW, SY, Stover yield, BY, and HI (%). Harvesting was executed at the optimal maturity stage of the crops, and one m² area within the central part of each plot was designated for measuring SY and stover yield.

Statistical analysis

The collected data were systematically organized and formatted for statistical analysis. An analysis of variance (ANOVA) was performed using the RCBD approach, implemented through the R Studio software package.

Table 1. The morphological features of the experimental plot

Constituents	Characteristics
Location	AFL, BAU
Soil Series	Sonatola
Soil Tract	Old Brahmaputra Alluvium
Land type	Medium High Land
General soil type	Non-calcareous dark grey floodplain
Agro-ecological zone	Old Brahmaputra Floodplain (AEZ-9)
Topography	Fairly level
Soil type and colour	Dark grey Terrace Soil
Drainage	Moderate
Depth of inundation	Above the flood level
Drainage condition	Well drained

Table 2. The physical characteristics of the experimental field

Constituents	Results
Particle size analysis	2.57
Bulk density (g/ce)	1.42
Porosity (%)	44.7
Sand (%) (0.0-0.02mm)	21.75
Silt (1%) (0.02-0.002mm)	66.60
Clay (%) (<0.002mm)	11.65
Soil textural class	Silt loam
Colour	Dark grey
Consistency	Grounder

Table 3. The chemical properties of the experimental field

Constituents	Results
Soil pH	6.8
Organic matter (%)	1.30
Total nitrogen (%)	0.101
Available phosphorus (ppm)	27
Exchangeable potassium (me %)	0.12
Available Sulphur (ppm)	22.7

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Table 4. Weather data of experimental site during the period of the experiment

Year	Month	Air temperature (0°C)			Relative Humidity (%)	Rainfall (mm)	Sunshine (hours)
		Maximum	Minimum	Average			
2022	November	30.4	18.3	24.4	81.6	0.0	265.2
	December	26.4	14.7	20.6	84.8	0.0	187.8
2023	January	24.4	12.3	18.3	83.5	0.0	5.4
	February	27.9	16.3	22.1	78.6	11.0	170.9

RESULT AND DISCUSSION

Effect of fertilizer management on PH

PH was found to be significantly influenced by the dosage of fertilizer (Table 5). The highest PH (83.63 cm) was observed in the recommended N-P-K-S-Zn-B fertilizer mix, whereas the lowest PH (70.65 cm) was found in the control treatment. In a related study by Rahman (2003) on mustard treated with 100 kg of nitrogen, reached a height of 79.3 cm, approximately 29.36% taller than the control plants, which measured 61.3 cm.

Table 5. Effect of fertilizer on yield attributes of mustard

Treatments	PH (cm)	NBP	NSB	SL (cm)	NSS	TSW (g)	BY (t ha^{-1})	HI (%)	Seed yield increase over control (%)
T_1	70.65 d	3.54 d	43.97 d	4.29 e	11.00 g	3.13 e	0.89 f	21.39 b	_
T_2	74.46 c	3.73 cd	51.20 c	4.50 d	15.00 f	3.18 de	1.13 e	23.64 b	26%
T_3	77.48 b	3.79 cd	51.53 bc	4.64 c	18.00 e	3.20 d	2.56 d	48.62 a	84%
T_4	79.33 b	3.97 c	52.00 bc	4.70 bc	21.00 d	3.35 c	3.19 c	49.53 a	87%
T_5	81.70 a	4.37 b	54.13 bc	4.73 ab	24.00 c	3.55 b	3.28 c	49.14 a	88%
T_6	82.96 a	4.57 ab	55.53 b	4.77 ab	26.00 b	3.58 b	4.07 b	46.15 a	89%
T_7	83.63 a	4.74 a	63.17 a	4.80 a	29.00 a	4.14 a	4.51 a	48.54 a	91%
Level of significance	**	**	**	**	**	**	**	**	
CV (%)	5.51	6.62	5.25	5.93	5.20	6.05	5.21	10.93	

Here, there is no significant difference between means that have the same letters in the same column, ** - Significant at 1% level of probability, T_1 - Control (no fertilizer), T_2 – RR of N, T_3 – RR of N-P, T_4 – RR of N-P-K, T_5 – RR of N-P-K-S, T_6 – RR of N-P-K-S-Zn, T_7 – RR of N-P-K-S-Zn-B.

NBP as a result of fertilizer management

The study revealed that fertilizer application significantly influenced the NBP. The highest NBP (4.74) was observed in the treatment with the recommended dose (RD) of N-P-K-S-Zn-B. Conversely, the control group exhibited the fewest branches, averaging 3.54 per plant (Table 5). According to Sana *et al.* (2003), both the crop's genetic composition and the environmental conditions. significantly affect the plant's final seed yield, as evidenced by the NBP.

Effect of fertilizer management on NSP

Significant differences in the NSP were observed in mustard production under various fertilizer management treatments (Table 5). Generally, applying fertilizers at different levels increased NSP compared to the control group, which did not receive fertilizer. The highest NSP (63.17) was recorded in the treatment with the RD of N-P-K-S-Zn-B. In contrast, the treatment without fertilizer yielded the lowest NSP (43.97). Mondal *et al.* (1992) reported the highest NSP (136) in the variety J-5004, comparable to Tori-7.

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Length of siliqua as affected by fertilizer management

The length of the siliqua increased with varying fertilizer application levels over control. The SL varied significantly at different fertilizer levels (Table 5). The RD of N-P-K-S-Zn-B resulted in the maximum SL (4.80 cm). Interestingly, the highest SL was produced with fertilizer application, which ultimately increased SY. The treatment without fertilizer in control produced the minimum SL (4.29 cm). Akhter (2005) noted that variations in SL were statistically significant.

NSS as effected by fertilizer management

The fertilizer level had a substantial impact on the NSS. The NSS increased as fertilizer was added in greater quantities (Table 5). Notably, the RD of N-P-K-S-Zn-B produced the highest NSS (29.00), while the control produced the shortest NSS (11.00). A study by Mandal and Sinha (2004) found that 100% RD of NPK combined with FYM greatly increased the NSS of mustard.

Effect of fertilizer management on TSW

Fertilizer quantities significantly influenced the TSW, as shown in Table 5. The highest TSW (4.14 g) was observed in the RD of N-P-K-S-Zn-B treatment, whereas the control group showed the lowest TSW (3.13 g). The result was supported by Rahman (2003). They found a significant effect of fertilizer on TSW. Also, according to Tripathi *et al.* (2011), applying 100% RD of fertilizer in conjunction with FYM resulted in the highest possible TSW of mustard.

SY as affected by fertilizer management

Fertilizer amount had a major impact on seed production (Figure. 2). In general, varying fertilizer levels influenced mustard SY. The RD of N-P-K-S-Zn-B produced the maximum SY (2.19 t ha^{-1}), statistically larger than the control and other fertilizer treatments yield. The control condition had the lowest SY (0.19 t ha^{-1}). The yield in the control condition may have been significantly lowered due to a high seedling mortality rate brought on by insufficient soil moisture. Hossain *et al.* (2018) reported that fertilizer management significantly affected GY. The highest GY was 6.03 t ha^{-1} in BINA dhan-8 and the lowest in BRRI dhan-28.

It is observed that the percentage of SY is increasing over control at a considerable rate. The highest SY (91%) was found in the RD of N-P-K-S-Zn-B treatment over control, followed by 89% in the RD of N-P-K-S-Zn, 88% in the RD of N-P-K-S, 87% in the RD of N-P-K, 84% in the RD of N-P, and 26% in the RD of N (Table 5). According to Kumar et al. (2016), applying 75% NPK + 5 t FYM + PSB + Sulphur resulted in a higher mustard seed yield compared to other treatments and the control.

Impact of fertilizer management on Stover Yield

Fertilizer management influenced the stover yield, as shown in Figure 2. The highest stover yield (2.32 t ha^{-1}), occurred with the recommended dose of N-P-K-S-Zn-B, while the control produced the lowest yield, (0.70 t ha^{-1}). In their research, Singh et al. (2014) explored the effects of integrated nutrient management (INM) in Kanpur, discovering that a combination of 100% recommended dose of fertilizers (RDF) and 5.0 t ha^{-1} of vermicompost significantly increased the stover yield of mustard.

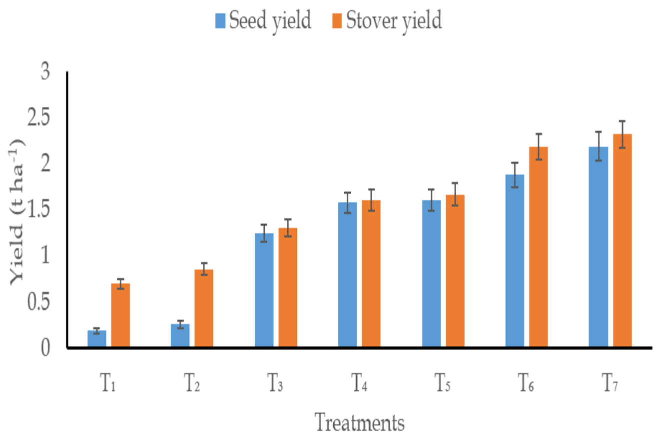

Figure 2. Effect of fertilizer on the seed and stover yield of mustard

Impact of fertilizer management on biological yield and harvest index

Different levels of fertilizer management had a significant impact on both the BY and HI of the variety, with the highest BY (4.51 t ha^{-1}) and highest HI (48.54%) observed in the RD of N-P-K-S-Zn-B. In comparison, the lowest BY (0.89 t ha^{-1}) and lowest HI (21.39%) were observed in the control group (Table 5). According to Saini et al. (2017), the combination of Azotobacter + PSB along with 0.03 t ha^{-1} N from inorganic fertilizers and 0.03 t ha^{-1} N from poultry manure resulted in the highest SY (.15 t ha^{-1}), stover yield (0.38 t ha^{-1}), and HI (28.36%) for mustard. However, further experiments in different agro-ecological zones of the country are needed to confirm these results.

CONCLUSION

In conclusion, effective fertilizers management is crucial for enhancing the yield-contributing characteristics of mustard. To achieve maximum yield of the mustard crop, farmers can ensure optimal production via timely and appropriate use of fertilizers. Fertilizers encourage plant growth by providing vital nutrients in optimal amounts. The current study's findings prove that different fertilizers treatment degrees favorably affect seed and stover output. The treatment with the highest SY was the one that included the application of N-P-K-S-Zn-B. Farmers should cultivate mustard during the *rabi* season to maximize seed production by following the specified planting time and applying all required fertilizers.

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Conflict of Interest

The authors have declared no conflicts of interest.

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