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ENHANCING GROWTH, YIELD, AND PHYSIO-CHEMICAL PROPERTIES OF MUSTARD (*BRASSICA NAPUS* L) THROUGH COMBINED APPLICATION OF ORGANIC AND INORGANIC FERTILIZERS UNDER SALINITY CONDITION IN SATKHIRA, BANGLADESH

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ABSTRACT

A field experiment was carried out to evaluate the combined application of organic and inorganic fertilizers on the growth, yield, and physio-chemical properties of mustard (Brassica napus L) during the Rabi season 2021-2022 at the experimental field of BINA in Satkhira, Bangladesh. The experiment had 10 treatments viz. T_1 = 100% Recommended Dose Chemical Fertilizer (RDCF), T_2= 75% RDCF + 3 t ha^{-1} vermicompost, T_3= 50% RDCF + 5 t ha^{-1} vermicompost, T_4= 75% RDCF + 3 t ha^{-1}cow-dung , T_5= 50% RDCF + 5 t ha^{-1}cow-dung , T_6= Absolute control , T_7= 3 t ha^{-1} cow-dung, T_8= 3 t ha^{-1}vermicompost, T_9= 5 t ha^{-1}cow-dung, T_{10}= 5 t ha^{-1} vermicompost with three (3) replications in randomized complete block design (RCBD). The maximum plant height (cm), No. of primary branches $plant^{-1}$, no. of secondary branches $plant^{-1}$, total siliqua $plant^{-1}$, siliqua length (cm), seeds $siliqua^{-1}$, seeds $plant^{-1}$, and yield $plot^{-1}$ were recorded and it was found that the application of 75% RDCF + 3 t ha^{-1} vermicompost was significant over control. The combined effect of organic and inorganic fertilizers was found significant in the growth, yield, and physio-chemical properties of mustard cultivation.

Keywords: Cow-dung, inorganic fertilizers, mustard, vermicompost, yield.

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INTRODUCTION

Bangladesh is a country of about 170 million people consuming about 3.0 million tons of edible oils and fats annually. It is worth mentioning that due to insufficient domestic production, more than 90 % of the annual requirements of edible oils are met through imports and the trend is increasing every year (Miah and Mondal, 2017). Bangladesh imports three types of edible oils namely: palm oil, soybean oil, and mustard/canola oils/seeds, and pays a whooping import bill of 2 billion dollars every year (Pervin et al. 2018).

Mustard (Brassica napus L.) is an exotic oilseed crop grown in the Rabi season in Bangladesh. It is one of the most important sources of vegetable oil in Bangladesh with 2,70,018 ha under cultivation and production of 3, 11,740 tons in 2019 (FAO, 2019)

Increasing cropping intensity in Bangladesh has deteriorated the soil health making it deficient in macro and micronutrients and thus resulting in a decline in productivity. Balanced use of manures and fertilizers has become imperative in changing contexts. The imbalanced and inadequate use of fertilizers may decline crop production whereas, the use of chemical fertilizers in combination with organic manure is essentially required to improve soil health (Prasad et al., 2017). The Use of organic manures along with inorganics may prove a viable option for sustaining productivity (Tejada et al., 2009) and improving the physical, chemical, and biological properties of soil (Nagavallemma et al., 2004, Prasad et al., 2017). Moreover, the combined application of organic and inorganic fertilizers not only sustains high crop production (Verma et al., 2016) but also improves soil health and ensures a safer environment (Babu et al., 2017).

Although mustard is a salt tolerant crop, its productivity is very much affected by salinity. High levels of salinity can inhibit seed germination and seedling growth due to the combined effect of osmotic potential and specific ion toxicity. The yield of mustard under saline conditions can be increased by balanced fertilization (Ashraf and McNeilly, 2004).

Fertilizer management is one of the most important cost-effective agronomic factors known to augment oil seed crop production. The role of chemical fertilizers alone has been estimated to cause a 19 to 48% increase in oilseed production. The productivity of rape seed-mustards is associated with proper fertilizer incorporation especially of nitrogen, phosphorous, potassium and sulfur both under irrigated and rain-fed conditions (Priyanka et al., 2020). Among primary nutrients, Nitrogen and sulfur have a considerable effect on the quality quantity of seed. sulfur is essential to plants and especially has emerged as the third important plant nutrient to oilseed crops. Similarly, Potassium is also known to improve water use efficiency and help to maintain crop yield under moisture stress and reduce the extent of crop loss under saline conditions (Chahal et al., 2020; Anjum et al., 2012; Turcios et al., 2021). Hence, nutrient management is an important aspect of mustard production in areas with salinity problems.

Thus, the use of organic manure (vermicompost, cow-dung) and supplementation of soil fertility through mineral nutrients are not only needed for higher crop production but also to maintain physical, chemical, and biological properties of the soil where organic matter releases all the plant nutrients in available form (Edwards et al., 2015). It is essential to observe the response of mustard to organic and inorganic fertilizers for better yield. Therefore, this study was carried out to find the response of growth and yield contributing characteristics of mustard to application of organic and inorganic fertilizers in saline soil conditions.

MATERIALS AND METHODS

Experimental site

A field experiment was conducted at the Bangladesh Institute of Nuclear Agriculture (BINA), research farm in Satkhira, where the daily average day temperature was 23^0 C, and the night temperature was about 16^0 C during the Rabi season of 2021/2022. The land was characterized by loam to sandy loam soil texture and low to medium organic matter contents with pH 5.7. Soil fertility level was medium with high CEC and deficit of N, P, K, S, and Zn. Excrescent soil moisture was utilized to sow the mustard seeds. During the Rabi season, soil water remained limited with no rainfall.

Experimental design

A randomized complete block design (RCBD) with 3 replications was used with 10 treatments each having a unit plot size of 4mx3m. Distance between replication to replication was 1m and plot to plot 50 cm whereas, line to line distance was 25 cm. The treatments were:

T_1=100% Recommended dose of chemical fertilizer (Urea= 207 $kgha^{-1}$, TSP=183 $kgha^{-1}$, MoP= 122 $kgha^{-1}$, Gypsum= 134 $kgha^{-1}$, Zinc sulphate= 10 $kgha^{-1}$, Boric Acid= 7 $kgha^{-1}$)

T_2= 75% RDCF + 3 t ha^{-1} vermicompost,

T_3= 50% RDCF + 5 t ha^{-1} vermicompost,

T_4= 75% RDCF + 3 t ha^{-1}cow-dung ,

T_5= 50% RDCF + 5 t ha^{-1}cow-dung , T_6= Absolute control ,

T_7= 3 t ha^{-1} cow-dung, T_8= 3 t ha^{-1}vermicompost,

T_9= 5 t ha^{-1}cow-dung, T_{10}= 5 t ha^{-1}vermicompost

Field preparation

The experimental field was prepared after harvesting Aman rice where, the rice straws were removed, and land was ploughed 2-3 times with the help of a power tiller.

Soil sampling and analysis

Before setting up and completion of the experiment, composite soil samples were collected from each plot (three replications) at 0-15 cm depth. Three auger soil samples were collected from different locations of an experimental field and divided into two sets of sub samples. The collected samples were then air-dried and ground to pass through a 2 mm (10 meshes) sieve and stored in a clean plastic container for physical and chemical analyses. The physical and chemical properties of the soil before setting up the experimental plots are presented in table 1 and 2 respectively.

Table 1. Physical properties of the initial soil of the experimental plot, 2021-2022.

Particle size distribution	Value
Sand (%)	47
Silt (%)	25
Clay (%)	29
Textural class	Sandy Loam
Bulk density (g/cm^3)	1.58
Particle density (g/cm^3)	2.39
Total porosity (%)	33.39

Table 2. Chemical properties of the initial soil of the experimental plot, 2021-2022

Soil characteristics	Analytical value (Initial soil)	
	Value	Interpretation
Soil p^H	5.7	Slightly acidic
Organic matter (%)	1.10	Moderate
Organic C (%)	0.64	
Total N (%)	0.067	Very low
Available P (ppm)	13.94	Medium
Exchangeable K (meq/100g soil)	0.17	Low
Available S (ppm)	5.98	Very Low
Available Zn (ppm)	0.41	Very low
Available Boron (ppm)	0.24	Medium

After harvesting of mustards again the soil samples were collected from each plot and composite soil samples were made treatment-wise and marked as post soil samples. After that, the soil was air-dried at room temperature. Then pH, organic matter, organic carbon (%), total N (%), available P (ppm), exchangeable K (meq/100g soil), S, Zn, B, and all other physical and chemical properties were analyzed and compared

against the initial soil samples, using the standard methods of Jackson (1973); Nelsons and Sommers (1982); Black(1965); Olsen and Sommers (1982); Thomas (1982). The post experiment soil test results are presented in Table 5.

Field measurement in soil salinity

Data on soil salinity was collected every 7 days interval between 9.00 am to 11.00 am. This data collection was taken from sowing until harvesting. The salinity was measured by EC meter (HANNA: HI 9835). Data were collected from the middle of each plot and later analyzed using the ANOVA procedure. The findings are presented in fig.1 below.

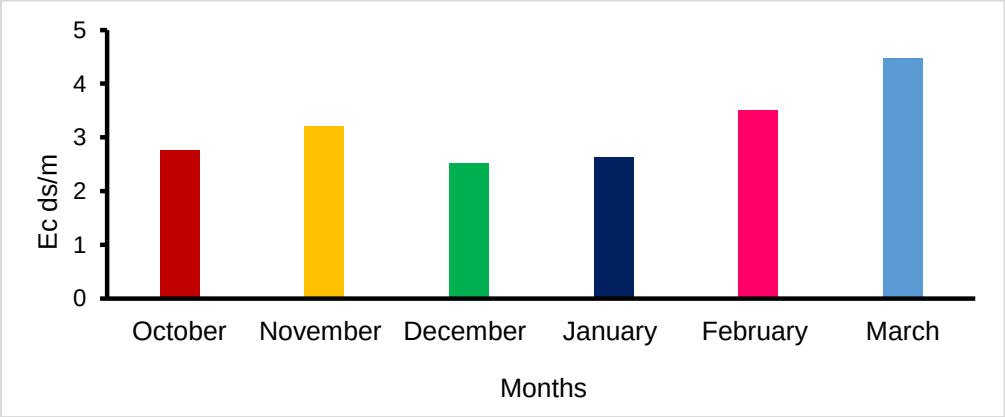

Figure 1. Average soil EC of Rabi season (October 2021 to March 2022) in Satkhira.

Seed sowing and fertilizers application

The mustard variety Binasarisha-9 was sown as line broadcasting as per 6 $kgha^{-1}$ on 17 November 2021 having replication to replication distance, plot to plot distance, and line to line distance of 1m, 50cm, and 25cm, respectively. N, P, K, S, Zn, and B fertilizers were applied in the form of urea, TSP (triple super phosphate), MoP (murite of potash), Gypsum, Zinc sulfate, and Boric acid at the rate of 207 kg ha^{-1}, 183 kg ha^{-1}, 122 kg ha^{-1}, 134 kg ha^{-1}, 10 kg ha^{-1}, and 7 kg ha^{-1} respectively following medium soil fertility interpretation level. A total amount of P, K, S, Zn, and B fertilizers were applied as a basal dose during land preparation (Ahmmed et al., 2018). One-third of the urea was applied as the basal dose and the rest of the urea in two equal split doses at 20 DAS and 40 DAS, respectively.

Thinning was done during the 2-3 leaf stage to maintain the line-to-line distance of 25 cm. The experimental field was kept weed-free and disease pests were also controlled with the proper application of chemicals. Disease and insects were always well controlled using the suggested applications. An overview of the weather factor is given in Fig.2

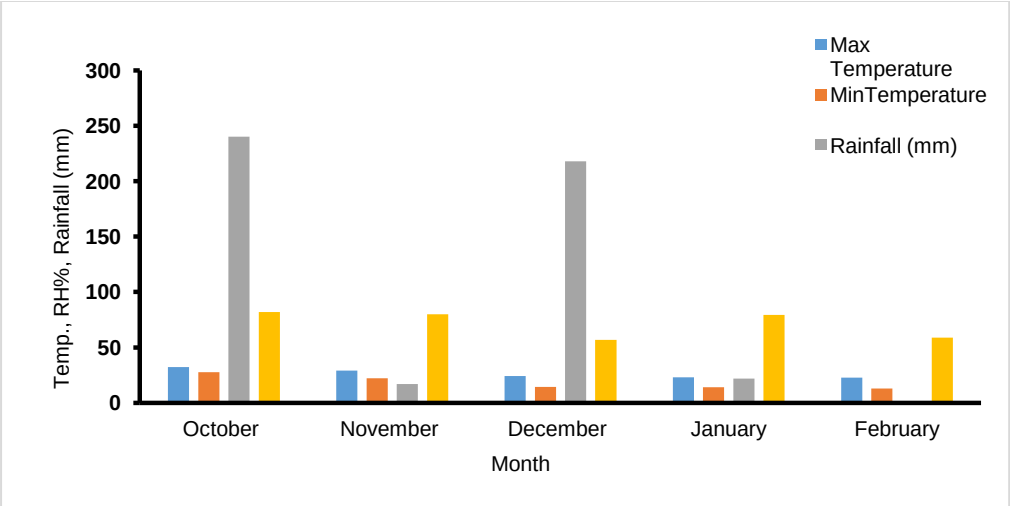

Figure 2. Average weather data of Rabi season (October 2021 to February 2022) in Satkhira. (Source: RMC, Satkhira).

Data collection and Analysis

Mustard was harvested when 75-80% siliqua became golden or brown. Five plants were selected randomly from each plot and data were collected on plant height, number of primary and secondary branches plant^{-1}, days of 1st flowering, number of siliqua plant^{-1}, length of siliqua (cm), number of seeds siliqua^{-1}, days to maturity, seed yield (t ha^{-1}) and seed yield plant^{-1} respectively.

Statistical Analysis

Collected data on the plant growth, growth attributes and seed yield were analyzed using Statistics R software. The means for all treatments calculated analysis of variance (ANOVA) for all parameters were performed and Tukey's range test to determine the significant difference among the treatments. The correlation coefficients were examined by Pearson's correlation analysis.

RESULTS AND DISCUSSION

Influence of combined application of organic and inorganic fertilizers on growth attributes of mustard

It was observed that the growth attributes were significantly influenced by the combined application of different inorganic fertilizers along with organic fertilizers. The highest plant height (81.32 cm), number of primary branches plant^{-1} (5.11), number of secondary branches plant^{-1} (2.34), total siliqua plant^{-1} (80.03), and highest siliqua length (7.87 cm) were observed in T_2 (75% RDCF + 3 t ha^{-1} vermicompost) treatment (Table 3). The result showed that the highest plant height in T_2 which was statistically similar to T_8 whereas, the highest number of secondary branches plant^{-1}

in T_2 was statistically identical with T_5, T_7, T_8 and T_9, total siliqua plant^{-1} was non-significant with T_7, T_8, T_9 and T_{10}, and siliqua length in T_2 was statistically similar with T_8 respectively. On the other hand, the lowest plant height (37.05 cm), primary branches plant^{-1} (2.31), secondary branches plant^{-1} (0.67), total siliqua plant^{-1} (26.68), and siliqua length (5.42 cm) were recorded in T_6 (control) treatment (Table 3). The result of the study interpreted that the application of 75% RDCF + 3 t ha^{-1} vermicompost significantly increased plant growth and yield attributes of mustard.

Therefore, the combined application of chemical fertilizers along with organic fertilizers in an integrated system exerted a positive result on plant growth parameters and ensured sufficient nutrients supply to plants throughout the growth period of mustard (Brassica napus L.). These results are similar to the findings of Pal et al, (2016), who attained increased values of growth attributes and yield of mustard due to the combined application of organic fertilizers with recommended chemical fertilizers doses. Rundal et al, (2013) and Bhati et al, (2014) also found a similar result. These findings also revealed that the application of chemical fertilizers along with vermicomposting may mitigate the salinity effects on the mustard plant. A similar result was also observed by Reza et al., (2022) where the application of vermicompost along with chemical fertilizer improved mustard plant growth.

Table 3. Impacts of different doses of organic and inorganic fertilizers on growth attributes

Treatments	Plant height (cm)	No. of primary branches/plant	No. of secondary branches/plant	Total siliqua/plant	Siliqua length (cm)
T_1	63.78 d	3.11 bcd	1.33 abc	44.44 bc	6.66 bc
T_2	82.32 a	5.11 a	2.34 a	80.03 a	7.87 a
T_3	66.56 cd	3.52 bc	1.55 abc	36.78 cd	6.75 bc
T_4	66.0 cd	3.33 bcd	1.44 abc	46.44 bc	7.00 abc
T_5	71.67 bc	3.67 b	1.73 ab	49.96 b	6.88 bc
T_6	37.05 e	2.31 d	0.67 c	26.68 d	5.42 d
T_7	74.55 b	2.72 bcd	1.83 ab	77.67 a	6.52 bc
T_8	81.12 a	2.46 cd	2.00 ab	70.24 a	7.26 ab
T_9	63.2 d	2.80 bcd	1.91 ab	77.23 a	6.27 cd
T_{10}	63.13 d	3.09 bcd	1.30 bc	70.54 a	6.94 abc
CV%	5.01	21.72	37.59	12.58	8.07

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per LSD at 5% level of probability.

Effects of combined application of inorganic and organic fertilizers on yield and yield attributes of mustard

The uptake of nutrients differed significantly due to the application of different treatments (Table 4). The application of different doses of inorganic and organic fertilizers either singly or in combination has significantly influenced on yield and yield attributes. The highest seeds siliqua^{-1} (28.89), 1000 seeds weight (2.90 g), yield plant^{-1} (3.38 g) and yield plot^{-1} (2.20 t ha^{-1}) were recorded in T_2 (75% RDCF + 3 t ha^{-1} vermicompost). Whereas, the lowest seeds siliqua^{-1} (20.00), 1000 seeds weight (0.93 g), yield plant^{-1} (1.39 g), and yield plot^{-1} (0.94 t ha^{-1}) were recorded from T_6 (control) treatment.

The study indicated that the application of 75% recommended dose chemical fertilizers along with vermicompost gave the highest yield and yield attributes of mustard.

Table 4. Impacts of different doses of organic and inorganic fertilizers on yield and yield attributes of mustard.

Treatments	Seeds siliqua^{-1}	1000 seeds weight (g)	yield plant^{-1} (g)	Yield plot^{-1} (t ha^{-1})
T1	23.33 ab	1.83 bc	2.24 de	1.64 cd
T2	28.89 a	2.90 a	3.38 a	2.20 a
T3	25.22 ab	1.91 bc	2.84 bc	1.66 cd
T4	25.56 ab	1.14 d	1.87 ef	1.47 d
T5	24.99 ab	1.90 bc	3.12 abc	1.39 d
T6	20.00 bc	0.93 d	1.39 f	0.94 e
T7	29.27 a	1.67 bc	2.74 cd	1.67 cd
T8	27.68 a	1.81 bc	2.95 abc	1.61 cd
T9	20.34 bc	1.98 b	3.32 ab	1.83 bc
T10	15.91 c	1.63 c	2.96 abc	1.98 ab
CV%	15.60	10.86	11.85	10.97

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per LSD at 5% level of probability.

A similar result was also observed by Reza et al., (2022) and Tripathi et al, (2010) who narrated that application of 50% RDCF along with vermicompost produced the highest yield and yield attributes of mustard. Furthermore, the combined application of 75% RDCF with 3 t ha^{-1} vermicompost also may reduce the risk of salinity stress on mustard yield. The plant growth and productivity affected by the combined

application of vermicompost and chemical fertilizers may be ascribed to its direct and indirect involvement in the availability of major nutrients to crop plants (Reza et al, 2016).

On the other hand, vermicompost having balance nutrition under a favorable environment might help to rush chlorophyll content at the flowering stage. Besides, soil physical and biological properties improved due to vermicompost application and increased availability of nutrients. These findings are also in agreement with Reddy and Reddy, (1998) and Dhaka et al, (2001).

Moreover, vermicompost may contain almost all essential plant nutrients, its incorporation with the soil promotes rapid vegetative growth and branching, thereby influencing to increase flowering days and seed setting and ultimately increasing to days of maturity (Fig. 3).

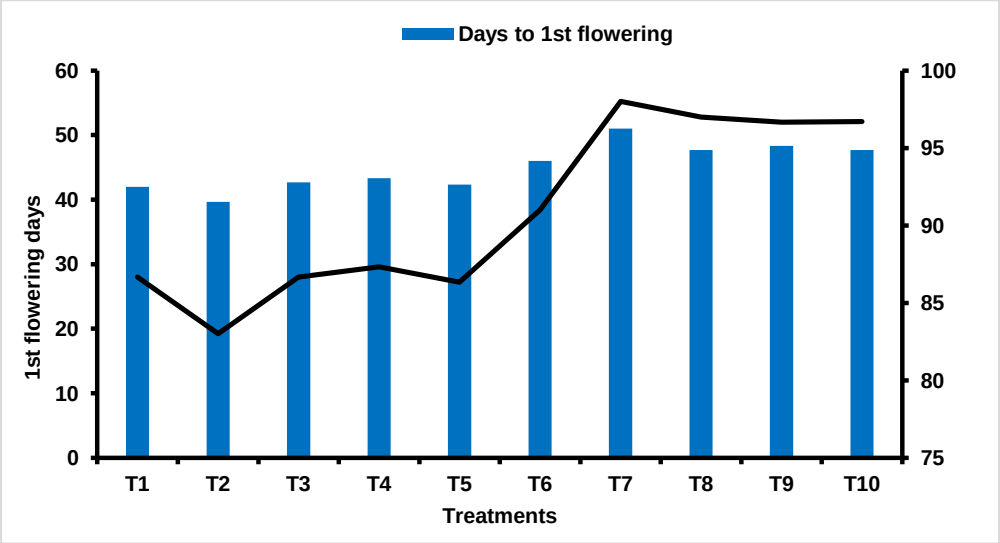

Figure 3. Combined application of different doses of organic and inorganic fertilizers on 1st flowering and days to maturity.

The correlation effect of different doses of organic and inorganic fertilizers showed (Fig. 4) that seed yield per plant was positively correlated with yield per plant, total seed per plant, primary branches plant-^{1}, total seed plant^{-1}, secondary branches plant^{-1}, siliqua length, plant height but negatively correlated with days to maturity and flowering days.

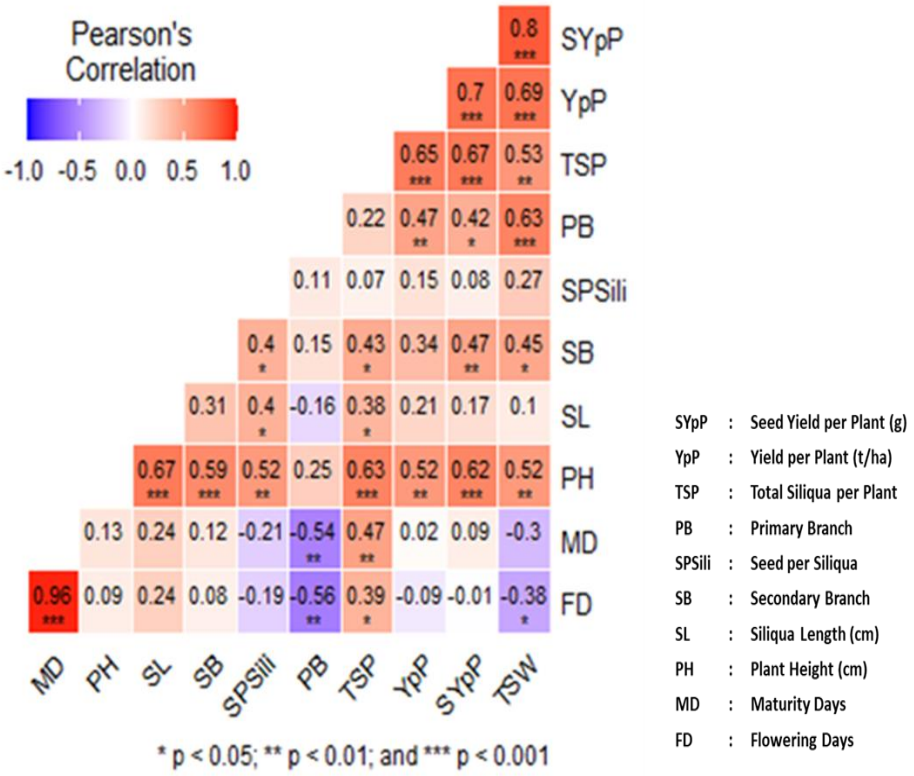

Figure 4. Correlation effect of selected traits of mustard (Brassica napus L.)

After harvesting mustard, a significant variation in soil pH was found (6.2) where the initial soil pH was (5.7). Kamal et al., (2002) stated that organic matter content increased with combined application of organic fertilizers and NPK fertilizers (Table 5). In post-harvest soil, the organic matter content was 1.26% whereas in initial soil was 1.12%. Significant variation was observed in total nitrogen content (0.13), available P (19.83 ppm), exchangeable K (0.22 meq/100g soil), S (11.42 ppm), and Zn (0.48 ppm) and B (0.26 ppm) content in the soil (Table 5). Organic fertilizers enriched the nitrogen content and increased the availability of phosphorous in soil due to the mineralization of organic nitrogen in the soil (Banger et al., 1990; Guan, 1989). Application of organic fertilizers with NPK increased organic carbon content and fertility status as reflected by the available status of micronutrients such as Zn, B were higher and lower the bulk density in soil that received organic fertilizers plus N, P, and K than in the treatments with N, P and K alone (Vasanthi and Kumaraswamy, 1999).

Table 3. Chemical properties of the post-harvest soil of the experimental field at BINA substation, Satkhira during the rabi season of 2021-2022

Soil characteristics	Analytical value (soil before sowing)	Analytical value (Soil after harvest)	Critical levels
		Value	Interpretation
Soil p^H	5.7	6.2	Slightly acidic
Organic matter (%)	1.10	1.26	Moderate
Organic C (%)	0.64	0.91	
Total N (%)	0.067	0.13	Low
Available P (ppm)	13.94	19.83	Optimum
Exchangeable K (meq/100g soil)	0.17	0.22	Moderate
Available S (ppm)	5.98	11.42	Low
Available Zn (ppm)	0.41	0.61	low
Available Boron (ppm)	0.24	0.30	Medium

CONCLUSION

It can be concluded that the combined application of organic and inorganic fertilizers is the best strategy for improving soil fertility for a longer period of time as it improves the physio-chemical properties of soil. The combined application of fertilizers increases the yield and yield contributing characteristic of mustard as the plant produced maximum growth and yield due to the application of 75% RDCF + 3-t ha^{-1} vermicompost (T_2).

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