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Assessing the Integrated Effect of Organic and Inorganic Amendments on Soil Fertility and Rapeseed (*Brassica napus* L.) Yield

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Abstract: For assuring food security of a growing population, increasing crop production is essential. But to meet this demand excessive use of chemical fertilizers are raising concern about long term soil health. That's why a balanced approach combining organic and inorganic fertilizers provide solution for promoting both higher crop yield and sustainable soil health for future use. A field study was conducted to assess the integrated effect of organic and inorganic amendments on the yield and yield contributing attributes of rapeseed and post-harvest soil fertility in the Rabi season of 2022-23 at the Bangladesh Institute of Nuclear Agriculture (BINA) substation, Jamalpur. The treatments used for the study were: T_1: Indigenous soil fertility (control); T_2: 100% Chemical Fertilizers (CF); T_3: CF+2.5t ha^{-1} rice straw; T_4: CF+3t ha^{-1} poultry manure and T_5: CF+4t ha^{-1} cow dung. The test crop was Binasarisha-9, whose seeds were sown in line following a Randomized Completely Block Design (RCBD) with three replications. The experiment's results showed that the highest seed yield of Binasarisha-9 (2.00 tha^{-1}) was obtained in the application of CF+4t ha^{-1} cow dung followed by CF+3t ha^{-1} poultry manure (1.81 tha^{-1}). Similarly, in the application of CF+4t ha^{-1} cow dung provided the highest plant height (105.2 cm), number of branches per plant (3.93), number of siliquae per plant (92.2), siliqua length (5.62 cm), number of seeds per siliqua (29.27), thousand seed weight (3.87 g) and stover yield (3.93 tha^{-1}) followed by CF+3t ha^{-1} poultry manure. The post-harvest soil attributed the higher organic matter (1.29%), N (0.21%), P (11.75%), K (0.25 $meq100g^{-1}$), S (22.13 ppm), Zn (2.48 ppm) and B (0.29 ppm) in CF+4t ha^{-1} cow dung application; however, soil pH value (7.03) was the lowest among others in the same treatment.

Keywords: Rapeseed; Organic fertilizers; Inorganic fertilizers; Rice straw; Poultry manure; Cow dung

INTRODUCTION

A member of the family Cruciferae and genus Brassica, mustard is one of the most significant oilseed crops grown worldwide, second only to soybeans (Islam et al. 2023). In Bangladesh, about seven different oilseed crops are grown but only two of them—rapeseed and mustard (Local and HYV), occupy roughly 946632.07 acres of the 1361710.96 acres of oilseed cultivated land and 547425.32 metric tons of the total 954182 metric tons, or about 60% of the country's oilseed production (BBS 2023). There are three species of Brassica that produces edible oil, namely, *Brassica napus*, *Brassica juncea* and *Brassica campestris*. Mustard oil is superior to soybean oil for consumption because it contains more mono and polyunsaturated fats like omega-3 and less saturated fat which also lacks trans-fat (Yadav and Kumari 2015). Mustard seeds have 40-44% oil, 20-25% protein and 6.4% nitrogen (FAO 2012). In Bangladesh, the total area and output of mustard in 2022–2023 were 383.28 thousand hectares and 547 thousand MT, respectively, with an average yield of 1.43 t ha^{-1} (BBS 2023). Among all of the oilseed crops grown in

Bangladesh, mustard and rapeseed are the most cultivated in terms of area and output but their average yield is still quite poor when compared to other countries that produce oil seeds (Islam et al. 2023). The government must import almost 88% more edible oil to meet the country's demand because our nation only produces about 0.4 million tons of edible oil annually compared to the 2.4 million tons that are required (BBS 2022). The soil fertility in Bangladesh is decreasing due to increase in cropping intensity, use of HYV crops and improper soil management (Hassan et al. 2016). The issues connected with inorganic fertilizers can be mitigated by using organic fertilizers, which are readily available mineral sources with a reasonable level of plant-essential minerals. These organic fertilizers maintain balanced nutrient levels for good crop performance by releasing nutrients into the soil solution gradually (Shaji et al. 2021). Organic fertilizers raise the organic matter of the soil (Bvenura and Afolayan 2013) which in turn improve the soil physical features (Agbede et al. 2008) and chemical attributes (Becher et al. 2018). In addition, they supply essential nutrients (Panday et al. 2024) that promotes crop yields (Yao et al. 2024). Poultry manure, Cow dung and rice straw are a reasonably priced nutritional supplier that has a moderate amount of micro and secondary nutrients in it. They may also be extremely important in enhancing soil fertility (Azad et al. 2022).

But there is a limited information regarding the application of organic and inorganic fertilizers in the production of rapeseed. That's why the current study was carried out to evaluate the interactions of different rates of organic and inorganic amendments on yield, yield contributing attributes and post-harvest soil quality of rapeseed.

MATERIALS AND METHODS

The field study was carried out at BINA, sub-station farm, Jamalpur (AEZ-8) during the Rabi season from November, 2022 to January, 2023. The study site is situated between 89° 55' and 32.08" East Longitude and between 24° 56' and 14.01" North Latitude (Figure-1). The farm region has a medium-high terrain topography with sandy loam soil. Two weeks prior to the rapeseed seeding, the preparation of the field was initiated. The four cross ploughing followed by laddering was done and all type of stubble, previous crop's residue was completely removed from the field. Table-1 displays the results of the preliminary soil analysis conducted in the experimental field. Table-2 displays the nutritional status of chicken manure, cow dung, and rice straw.

Figure-1. Study area map of the experimental area (Source: Google map)

Binasarisha-9 was the test crop and it's the seeds were sown in 15 November, 2022 by following line sowing method and the spacing was 25cm × 20cm. A total of 15 plots were prepared and the experiment was set up by following RCBD with 3 replications. Each plot size was 4m × 5m and the distance between the main plot and the replications were 0.5 m and 1.0 m, respectively. The treatments of the study were T_1: No fertilizer application; T_2: 100% Chemical fertilizers (CF) $N_{100}P_{30}K_{60}S_{15}B_3$ (BARC 2018); T_3: CF ($N_{86}P_{26}K_{25}S_{12}B_2$) + 2.5 tha^{-1} Rice straw (IPNS basis with Rice straw); T_4: CF ($N_{64}P_{20}K_{47}S_9B_2$) + 3 tha^{-1} Poultry manure (IPNS basis with Poultry manure); T_5: CF ($N_{79}P_{22}K_{54}S_{10}B_2$) + 4 tha^{-1} Cow dung (IPNS basis with cow dung). All chemical, organic fertilizers and half of the Urea was administered as a basal dose at the time of land preparation. After 20 days of seed sowing, the remaining half of the Urea was applied. Irrigation and drainage were done at proper time. Pest and diseases were controlled when necessary.

The phenotypical plant parameters of plant height (cm), number of branches per plant, number of siliquae per plant, siliqua length (cm), number of seeds per siliqua, thousand seed weight (g), seed yield (t/ha), stover yield (t/ha) and days to maturity was recorded carefully at the time of harvesting period.

Table-1. Chemical composition of initial soil status of the study field

Soil P^H	Organic matter (%)	Total N (%)	Exchangeable K ($meq100g^{-1}$)	Available P (ppm)	Available S (ppm)	Zn (ppm)	B (ppm)
7.2	0.78	O.34	0.12	10.22	10.95	0.54	0.17
Neutral	Low	Low	Low	Low	Low	Medium	Low

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Table-2. Nutrient composition of compost from Rice straw, Poultry manure, Cow dung

Item	N (%)	P (%)	K (%)	S (%)
Compost from rice straw	0.56	0.13	1.4	0.28
Poultry Manure	1.03	0.40	0.30	0.10
Cow dung	1.2	0.35	0.42	0.23

Statistical analysis

Data collected for various yield and post-harvest soil metrics were properly tabulated and the acquired data on several morphological and yield attributes were statistically appropriately analyzed. The software R Studio 4.2.2 was used to determine the mean of each treatment, perform an analysis of variance (ANOVA), and evaluate the differences in treatment means using the least significant difference (LSD) test (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Integrated effect of organic and chemical amendments on growth and morphological qualities of Binasarisha-9

The growth and morphological parameters were greatly affected by the combined application of organic and chemical amendments. The highest plant height (105.2 cm), branches plant^{-1} (3.93), siliquae plant^{-1} (92.20), siliqua length (5.62) was observed in T_5 (IPNS basis with cow dung) treatment but the highest days to maturity (95) was observed with T_1 (no fertilizer application) (Table-3). The outcome demonstrated that the highest growth and morphological attributes in Binasarisha-9 showed by T_5 was statistically different from all other treatments and similarly, the highest days to maturity observed with T_1 was comparable statistically to alternative treatments too. On the other hand, the lowest plant height (85.27 cm), branches plant^{-1} (2.5), siliquae plant^{-1} (67.47), siliqua length (4.76) was recorded in the application of T_1 treatment but the lowest days to maturity (89) was observed with T_3 (IPNS basis with Rice straw) (Table 3). These outcomes of this study interpreted that the application of IPNS basis with cow dung (CF + 3 tha^{-1} Cow dung) significantly promoted plant growth and morphological parameters of rapeseed.

These results are similar to the outcomes of Reza et al. (2023) who had a notable rise in the growth and morphological attributes of mustard on account of combined use of organic fertilizers and recommended dosed of inorganic fertilizers. Similar findings by Rundala et al. (2013), Bhati et al. (2014), Pal et al. (2016), and Sachan et al. (2022) corroborate this result.

Integrated effect of organic and chemical amendments on yield and yield attributes of Binasarisha-9

The yield and yield metrics of Binasarisha-9 were highly influenced by the combined use of different organic and inorganic amendments as compared to control plot (Table-4). The highest number seed yield (2.00 tha^{-1}) and stover yield (3.93 tha^{-1}) was recorded in T_5 (IPNS basis with cow dung) treatment followed by T_4 (IPNS basis with poultry manure) 1.81 and 3.68 tha^{-1} seed yield and stover yield, respectively. Similarly, the highest seeds siliqua^{-1} (29.27) and 1000 seed weight (3.87 g) was calculated in application of T_5 (IPNS basis with cow dung) treatment but both of them were statistically identical with T_4 (IPNS basis with poultry manure) that resulted a number of seeds siliqua^{-1} and 1000 seed weight of 28.67 and 3.80g, respectively. The lowest seeds siliqua^{-1} (22.97), 1000 seed weight (3.29 g), seed yield (1.43 tha^{-1}) and stover yield (3.21 tha^{-1}) was attained in plots that received no fertilizers (T_1). These results indicate that the application of inorganic fertilizers along with organic amendments provided the highest yield and yield metrics of rapeseed and among organic fertilizers IPNS with cow dung resulted best in comparison to rice straw and poultry manure. The highest seed production and other yield qualities of mustard were obtained by using organic amendments in conjunction with chemical fertilizer dosages, according to Bhalavi et al. (2023) and Dey et al. (2024), who also noted a similar outcome.

Table-3. Influence of organic and chemical amendments on growth and morphological parameters of Binasarisha-9

Treatments	Plant Height (cm)	Branches per Plant (no.)	Siliqua per Plant (no.)	Siliqua Length (cm)	Maturity (Days)
T_1	85.27 d	2.5c	67.47 e	4.76 c	95 a
T_2	95.73 c	3.20 b	75.96 d	5.40 b	92 b
T_3	98.7 bc	3.40 b	82.07 c	5.48 ab	89 d
T_4	102.0 b	3.53 b	87.73 b	5.52 ab	91 c
T_5	105.2 a	3.93 a	92.20 a	5.62 a	92 b
$LSD_{0.05}$	3.43	0.35	3.29	0.14	3.44
CV (%)	1.87	5.68	2.16	1.47	2.00

T_1: Control; T_2: 100% Chemical Fertilizers (CF); T_3: CF+2.5t ha^{-1} rice straw; T_4: CF+3t ha^{-1} poultry manure and T_5: CF+4t ha^{-1} cow dung

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Table-4. Influence of Organic and chemical amendments on yield and yield attributes of Binasarisha-9

Treatments	Seeds per Siliqua (no.)	TSW (g)	Seed Yield (t/ha)	Stover Yield (t/ha)
T_1	22.97 c	3.29 d	1.43 d	3.21 d
T_2	26.40 b	3.45 c	1.57 c	3.44 c
T_3	27.67 ab	3.70 b	1.74 b	3.53 bc
T_4	28.67 a	3.80 a	1.81 b	3.68 b
T_5	29.27 a	3.87 a	2.00 a	3.93 a
$LSD_{0.05}$	2.22	0.09	0.12	0.20
CV (%)	4.37	1.37	4.00	3.01

T_1: Control; T_2: 100% Chemical Fertilizers (CF); T_3: CF+2.5t ha^{-1} rice straw; T_4: CF+3t ha^{-1} poultry manure and T_5: CF+4t ha^{-1} cow dung

Pearson's correlation value of Binasarisha-9 According to pearson's correlation coefficient value, all of the growth, morphological, yield attributes and yield values are strongly positive correlated with each other except days to maturity of Binasarisha-9. Days to maturity of Binasarisha-9 was moderately and strongly negative correlated with all other attributes but among them Siliqua length showed the highest negative value (-77). Among all others, both of seed yield-stover yield and plant height-siliqua per plant showed the highest positive value (+0.97) (Figure-2).

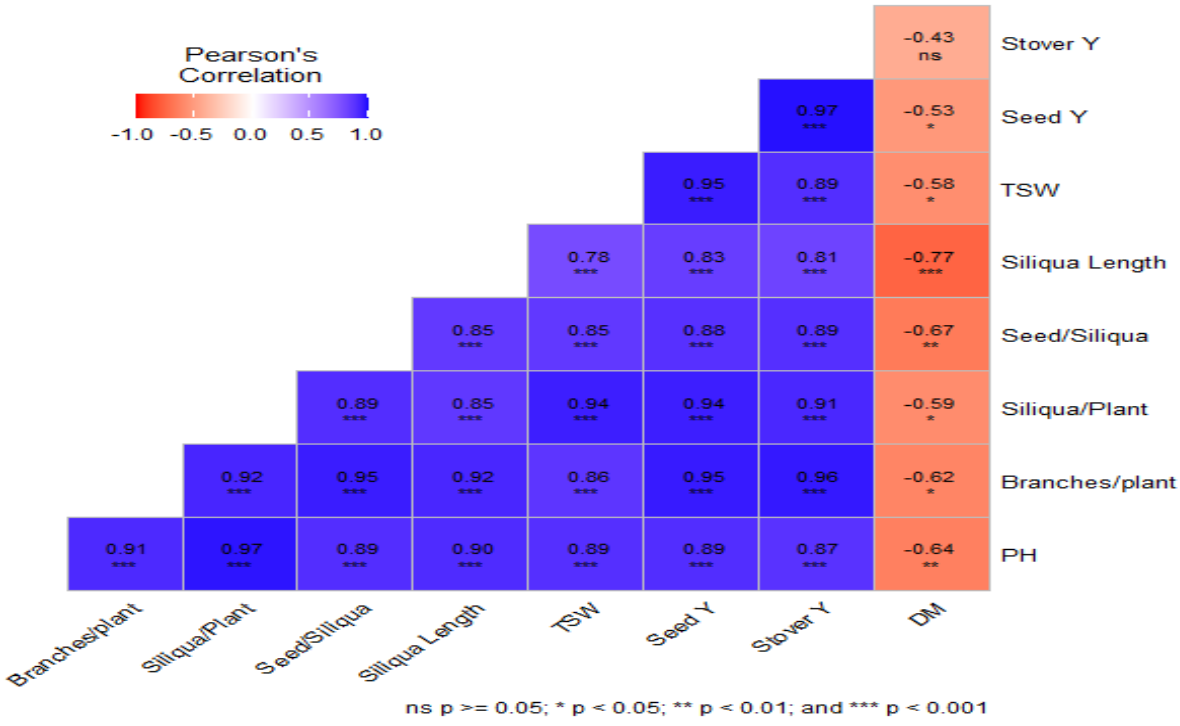

Figure-2. Pearson's correlation among all of the attributes of Binasarisha-9 influenced by organic and chemical amendments

Post-harvest soil of the experimental site influenced by combined use of organic chemical amendments in Binasarisha-9

Application of various organic and chemical fertilizers had a significant impact on the physio-chemical characteristics of the post-harvest soil. The highest organic matter (OM) (1.29%), total nitrogen (0.21%), potassium (0.25 $meq100g^{-1}$), phosphorus (11.75 ppm), sulfur (22.13 ppm), zinc (2.48 ppm), boron (0.29 ppm) was obtained in the post-harvest soil treated with T_5 (IPNS basis with cow dung) treatment but the highest pH (7.46) was resulted in post-harvest soil with no fertilizer (T_1) application (Table 5). Nevertheless, the lowest OM (1.07%), total nitrogen (0.09%), potassium (0.12 $meq100g^{-1}$), phosphorus (9.10 ppm), sulfur (13.07 ppm), zinc (1.89 ppm), boron (0.21 ppm) was resulted in the post-harvest soil with no fertilizer (T_1) application but the lowest pH (7.03) was resulted in post-harvest soil treated with T_5 (IPNS basis with cow dung) application (Table-5). These outcomes of the study interpreted that the application of IPNS basis with cow

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dung (CF + 3 tha^{-1} Cow dung) significantly increased the physio-chemical attributes of the post-harvest soil compared to that of the initial soil of the study area (Table-1 and Table-5). Similarly, IPNS basis with rice straw and IPNS basis with poultry manure improved the soil physio-chemical properties compared to that of 100% chemical and no fertilizer application. Consequently, the integrated approach that resulted in favorable plant yield characteristics and guaranteed a sufficient supply of nutrients to plants during the Binasarisha-9 growing season is the combined usage and application of organic and inorganic amendment fertilizers.

The increase in yield attributes and yield amended with IPNS the combination of chemical fertilizers and organic fertilizers must have released nutrients or made nutrients available which was effective for photosynthesis, encouraged rapid plant growth (Hussain et al. 2006). Darzi and Hadi (2012) claimed that organic amendments improve the chemical, physical, and biological qualities of soil, they contain significant amounts of nutrients that promote plant growth and yield. The current study may have had similar outcomes. It is also possible that the incorporation of organic amendments stimulated the microbial biomass in the soil, leading to an increase in soil fertility (Belay et al. 2001).

Table-5. Influence of integrated organic with chemical amendments on physiochemical characteristics of post-harvest soil

Treatments	pH	OM (%)	N (%)	P (ppm)	K (meq100g^{-1})	S (ppm)	Zn (ppm)	B (ppm)
T_1	7.46 a	1.07d	0.09e	9.10b	0.12d	13.07c	1.89e	0.21c
T_2	7.10 c	1.14cd	0.10d	11.15ab	0.20c	20.43a	2.08d	0.23bc
T_3	7.40ab	1.18bc	0.11c	12.60a	0.22bc	21.58a	2.23c	0.28a
T_4	7.20bc	1.24ab	0.21b	11.23ab	0.24ab	17.99b	2.38b	0.27ab
T_5	7.03c	1.29a	0.21a	11.75a	0.25a	22.13a	2.48a	0.29a
$LSD_{0.05}$	0.23	0.07	0.002	2.14	0.02	2.41	0.07	0.03
CV (%)	1.67	3.21	0.94	10.19	7.13	6.74	1.70	6.95

T_1: Control; T_2: 100% Chemical Fertilizers (CF); T_3: CF+2.5t ha^{-1} rice straw; T_4: CF+3t ha^{-1} poultry manure and T_5: CF+4t ha^{-1} cow dung

CONCLUSION

According to the results of the study, combined application of organic and chemical fertilizers promoted both higher seed production of rapeseed and better post-harvest soil qualities. But the combination of chemical fertilizers with 3 tha^{-1} cow dung possessed the better seed yield and post-harvest soil attributes than rice straw and poultry manure. So, chemical fertilizers with 3 tha^{-1} cow dung is highly recommended for rapeseed production.

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Conflict of Interest

There is no conflict of interest to declare.

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