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ORIGINAL RESEARCH ARTICLE

Impact of organic and synthetic fertilizers on chili: A growth and nutrient utilization perspective

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ABSTRACT

Chili production is highly dependent on nutrient management, and the choice between organic and synthetic fertilizers significantly influences plant growth and soil health. An investigation was accomplished at field research laboratory of Patuakhali Science and Technology University, Bangladesh, between January and April 2022 to assess the impact of compost-based fertilizers and chemical fertilizers on chili growth, yield, and nutrient absorption. The study followed a Randomized Complete Block Design (RCBD) with three replications and six treatments: T_1 (100% Poultry Manure), T_2 (100% Cow dung), T_3 (100% NPKS - Recommended dose), T_4 (50% Poultry Manure + 50% NPKS), T_5 (50% Cow dung + 50% NPKS), and T_6 (Control). Growth and yield parameters, along with plant and soil nutrient analysis, were statistically analyzed and the means were compared via DMRT at a 5% significance level. The collective application of poultry manure and chemical fertilizers (T_4) significantly improved plant height, branch count, fruit diameter, fruit length, total fruit weight, individual fruit weight, and overall yield (31.77 t ha^{-1}). This treatment also enhanced nutrient content (N: 1.24%, P: 0.047%, K: 0.147%, S: 0.051%) and uptake (N: 39.55 kg ha^{-1}, P: 1.49 kg ha^{-1}, K: 4.66 kg ha^{-1}, S: 1.62 kg ha^{-1}). Additionally, the combined treatments slightly improved soil organic matter, soil pH, and nutrient levels (N, P, K, S). NPKS findings highlight that integrating compost-based and chemical fertilizers, particularly poultry manure with NPKS, is a promising approach to maximizing chili productivity while sustaining soil fertility. The study bridges the existing research gap by providing empirical evidence on the optimal fertilization approach, offering valuable insights for sustainable chili cultivation in Bangladesh and similar agroecological regions.

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INTRODUCTION

Chili (*Capsicum annum* L.) is an extensively cultivated spice crop, playing a vital role in the agricultural economy and versatile uses in food, pharmaceuticals, and industries worldwide. It is a nutrient-packed food with a diverse range of health benefits, making it an important component of a balanced diet. Its high content of vitamins (pro vitamin A, vitamin B $_6$ and vitamin C), minerals, fiber, and bioactive compounds like capsaicin (Hasan, 2019). Beyond its culinary appeal, chili is a valuable crop for addressing nutritional deficiencies and promoting total health, predominantly in regions like Bangladesh, where it is a staple in traditional diets. The yield of chilies found in Bangladesh is far less than the possible exists. The reasons for the little yield may be due to inappropriate cultural operations, agricultural inputs etc. There are some factors which are accountable for low yield i.e., unobtainability of permitted varieties, absence of modern technology and practical direction (Howlader & Gomesta, 2019). Fertilizers play a fundamental role in boosting crop development and yield by providing essential nutrients, but their long-term influence on soil health and crop sustainability has sparked considerable debate among researchers and practitioners. Natural (organic) and synthetic (chemical) fertilizers are two primary sources of nutrients used in agriculture. Organic fertilizers, such as poultry manure and cow dung, are praised for their ability to promote nutrient retention, enhance microbial activity, and improve soil structure (Zamil *et al.*, 2004). Cow dung and poultry manure is a cheap and valuable source as organic fertilizer, because it provides micro and macronutrients for crop development and is a low cost, ecologically friendly alternative to mineral fertilizer (Sharpley & Smith, 1995). Recently, huge numbers of poultry farms have grown all over the country which produces a huge amount of poultry feces daily. Karim *et al.* (2010) reported that Bangladesh has 262.62 million poultry birds and 22.9 million cattle, which generate 68700 and 10505 MT of manure per day, respectively. If this manure is utilized as a source of organic matter, it would help in the improvement of soil fertility on one hand and protect the environment on the other hand. Poultry farm holders use concentration to feed their birds. Unlike cattle manure, poultry excreta are not used as fuel, these can be a decent source of manure use in the crop fields. In contrast, chemical fertilizers are often preferred for their immediate nutrient availability, high nutrient concentrations, and ease of application. However, overreliance on chemical fertilizers can degrade soil health, reduce organic matter content, and result in ecological issues such as soil acidification and water pollution.

In Bangladesh, chili production often faces challenges related to declining soil fertility and inefficient fertilizer management practices. Farmers frequently use imbalanced doses of chemical fertilizers, leading to reduced productivity and adverse environmental impacts. The incorporation of natural fertilizer and chemical fertilizers has been proposed as a sustainable strategy to optimize crop productivity while maintaining soil fertility. Studies suggest that combining these two fertilizer types can improve nutrient availability, enhance plant growth, and boost yields (Oad *et al.*, 2004). Additionally, it states that combinations involving manure and mineral fertilizer have also been shown to be economically effective (Lakho *et al.*, 2004). Use of organic manures alone as an additional to chemical fertilizers is non-profitable and would not be sufficient to maintain the existing levels of crop productivity with HYVs. However, due to degradation in the physical and biological ecosystems of the soil, chemical fertilizers alone can't achieve justifiable crop yield (Khan *et al.*, 2008). Nevertheless, the most effective strategy for increasing production stability and enhancing soil fertility status seems to be the collective application of chemical fertilizers and organic manure (Islam *et al.*, 2011; Sood, 2007). Recent studies have explored the effects of combining organic and synthetic fertilizers on the growth, yield, and nutrient uptake of several crops in Bangladesh. Salma *et al.* (2022) examined the influence of organic manures and mineral fertilizers on soil properties and the yield of sweet pepper (*Capsicum annuum* L.), finding that integrating organic manures with chemical fertilizers significantly boosted plant growth and yield. Likewise, research published in 2021 inspected the performance of different organic manures combined with chemical fertilizers on potato (*Solanum tuberosum* L.) cultivation. The study clinched that the integration of organic manures, particularly 'Kazi compost', with chemical fertilizers improved growth, yield, and nutritional quality of potatoes (Islam *et al.*, 2021). Despite the potential benefits, partial research has been conducted on the comparative impacts of organic and synthetic fertilizers on chili cultivation, particularly in the context of Bangladesh. The lack of sufficient studies makes it challenging to determine optimal fertilization strategies that enhance both productivity and soil sustainability. With these considerations in mind, the present study was conducted to evaluate the integrated effectiveness of organic and mineral fertilizers, as well as to identify the most suitable fertilization combinations for maximizing chili production.

MATERIALS AND METHODS

The research was accompanied by the field laboratory of Patuakhali Science and Technology University, located in the Ganges Tidal Floodplain (AEZ-13). The silty clay loam soil had low organic matter (pH 6.7). Initial soil sample was collected before land preparation and ready for physical and chemical analysis. The study followed a RCBD with six treatments (T_1: 100% poultry manure, T_2: 100% cow dung, T_3: 100% NPKS, T_4: 50% poultry manure + 50% NPKS, T_5: 50% cow dung + 50% NPKS, T_6: control) and three replications. Each plot measured 6.0 m², and seedlings were spaced 50 × 40 cm. For the best plant growth and development, modern production systems were used. The fertilizer suggestion guide was followed in applying the necessary amounts of fertilizers (BARC, 2018). Proper crop management procedures were done as and when required. Data on growth parameters (branch count, plant height) and yield characteristics (fruit diameter, yield/plant, fruit length, total yield, and single fruit weight) were noted from randomly selected plants. The product and product of the crops were evaluated for N, P, K and S. After fruit sample chemical analysis, the nutrient concentrations were computed using the nutrient concentration value. Nutrient uptake was also determined by the following formula:

$$\text{Nutrient uptake} = \frac{\text{Nutrient content (\%)} \times \text{Yield (kg ha}^{-1}\text{)}}{100}$$

Following agricultural harvest, plant samples were taken and analyzed for N, P, K & S contents by following techniques of Page *et al.* (1982) with minor modifications.

A glass electrode pH meter was used to evaluate the pH of soil in a solution of soil and water using a mixed glass/calomel electrode; the proportion of soil to water was 1: 2.5 (Jackson, 1973). Organic carbon (OC) content of the soil was determined by wet oxidation method (Nelson & Sommers, 1982). Total N content in soil was measured by micro-Kjeldahl method (Bremner & Mulvaney, 1982). Available P content in soil was extracted by mixing the soil with 0.5M $NaHCO_3$ (pH 8.5). Then, using a molybdate ascorbic acid reagent to create a blue color with reduction of the phosphomolydate complex, the extracted P in solution was measured colorimetrically at an 890 ηm wavelength (Olsen & Sommers, 1982). The ammonium acetate extraction technique was used to extract the soil's exchangeable K content. The soil was repeatedly shaken, centrifuged with neutral 1N NH_4OH, and then decanted to extract the material. Using a flame photometer, calculate the extract's K content (Knudsen *et al.*, 1982). Using a turbidimetric approach with $BaCl_2$ crystals, the available S content was calculated after a soil sample was extracted from $CaCl_2$, $2H_2O$, using 0.15% solution of $CaCl_2$ (1:5 soil-extractant ratio) (Fox *et al.*, 1964).

All data were statistically analyzed using the computer-based statistical program STAR, as stated by Gomez & Gomez (1984). Using analysis of variance (ANOVA), it was possible to determine significant special effects of the treatments, and treatment means were compared using Duncan's Multiple Range Test (DMRT) at the 5% significance level.

RESULTS AND DISCUSSION

Effects of manure and fertilizer on soil characteristics after chili harvesting

Soil pH: A significant dissimilarity was found in soil pH after harvest soil (Table 1). The pH values of post-harvest soil extended from 6.51 to 6.60. The maximum soil pH value (6.60) was noted in T_3 (50% PM +50% NPKS) treatment and the lowest value of (6.51) under control treatment.

Organic carbon: A significant variation was observed in the % organic carbon content in soil after harvest in soil (Table 1). Organic carbon values of post-harvest soils ranged from 0.56 to 0.68%. The highest % organic carbon value (0.68 %) was recorded in the T_3 (50% PM + 50% NPKS) treatment which was statistically at par with treatments T_1 (100% poultry manure) and T_3 (100% NPKS). The treatments T_1 (100% Poultry Manure), T_3 (100% NPKS), and T_5 (50% CD + 50% NPKS) were statistically identical. The lowest value of organic carbon (0.56%) was recorded under control treatment. Kumar (2016) reported an increase in OC of the soil after using organic fertilizers.

Total nitrogen content in soil: There was a statistically negligible change in the post-harvest soil's overall N content by different treatments (Table 1). The N content of the post-harvest soil extended from 0.071 to 0.081 %. The highest total N content (0.081%) was observed under T_3 (50% PM +50% NPKS) treatment and the minimum value (0.071 %) was observed in the control treatment. The results agree of Kumar (2016) reported the increase in total N after use of synthetic nutrients.

Available phosphorus: The effect of different levels of P was significantly influenced due to various treatments used in the experiment in post-harvest soil (Table 1). The P content in soil extended from 10.20 ppm to 10.52% ppm. The uppermost P content (10.52 ppm) was found in the T_4 (50% PM +50% NPKS) treatment, which was better than other treatments and the lowest P content (10.20 ppm) was observed in the control treatment. The treatments T_1(100% Poultry manure), T_3(100% NPKS) and T_5(50% CD+50% NPKS) were statistically similar in P content in post-harvest soil. Kumar (2016) reported the increase in available P of the soil after using farmyard manure.

Exchangeable potassium: In post-harvest soil, the potassium content has not been significantly affected by the application of various manure and fertilizer treatments (Table 1). The K content in soil ranged from 0.082 cmol kg ha^{-1}in T_6(control) treatment to 0.092 cmol kg ha^{-1} in T_4(50% PM+ 50% NPKS) treatment. The highest K content (0.092 cmol kg^{-1})was noted in the T_4 (50% PM +50% NPKS) treatment, which was better than other treatments, and the lowermost K content 0.082 cmol kg^{-1}) was found in the control treatment.

Table 1. Effects of different manure and fertilizer on soil parameters in post-harvest of chili.

Treatments	Nutrients in Soil post-harvest soil					
	Soil pH	Organic Carbon (%)	Total N (%)	Available P (ppm)	K (cmol kg^{-1})	Available S (ppm)
Initial soil	6.39	0.60	0.073	10.19	0.083	7.46
Post-harvest soil						
T_2: 100% PM	6.46 b	0.64 ab	0.077	10.41 b	0.089	7.85 b
T_2: 100% Cow dung	6.43 c	0.61 c	0.075	10.31 c	0.085	7.65 c
T_3: 100% NPKS	6.47 b	0.63 ab	0.078	10.39 b	0.087	7.83 b
T_4: 50% PM + 50% NPKS	6.50 a	0.68 a	0.081	10.52 a	0.092	7.93 a
T_5: 50% CD + 50% NPKS	6.45 b	0.63 b	0.076	10.35 bc	0.087	7.82 b
T_6: Control	6.38 d	0.56 d	0.071	10.20 d	0.082	7.48 d
CV (%)	3.50	3.63	5.61	3.67	3.07	4.80
Level of significance	**	**	NS	**	NS	**
SE (±)	0.055	0.092	0.276	0.198	0.274	0.486

Means followed by same letter in a column are not significantly different at 5 % level by DMRT. CV= Coefficient of Variation, SE (±) = Standard error of means, **= Significant at 1% level, CD= Cow dung, PM = Poultry Manure.

Available sulphur: Statistically significant differences in the post-harvest soil's sulfur content were noted due to different treatments (Table 1). The S content in soil ranged from 7.48 to 8.92 ppm. The uppermost S content (8.92 ppm) was found in the T_3 (50% PM +50% NPKS) treatment which was superior to all other treatments. The treatments T_1 (100% Poultry Manure), T_3 (100% NPKS), and T_5 (50% CD + 50% NPKS) were statistically alike, and the control treatment had the lowermost value (7.48 ppm). Chopra *et al.* (2017) enrichment of different nutrients like N, P, S, OC of the soil when fertilized with different types of organic fertilizers.

Effects on different sources of nutrients on growth parameters of chili

Plant height (cm): Plant height varied significantly across different fertilizer and manure dosages and days after transplanting (DAT). (Table 2). At 30 DAT, the plant height of chili extended from 13.67 cm in control to 33.41 cm in treatment T_4 (50% PM+50% NPKS). produced the tallest plant statistically like the treatment T_1 (100% poultry manure). The plant with the smallest length was observed in the control treatment. At 60 DAT, the highest plant height (70.34 cm) was found from the T_4 (50% PM+50% NPKS) treatment which was statistically almost identical to the treatment T_1 (100% Poultry manure), and the minimum was observed from T6 (17.06 cm). At 90 DAT, the highest (73.69 cm) plant height recorded from treatment T_4 (50% PM+50% NPKS) was statistically superior to all other treatments. The lowest (25.61 cm) plant height was found in the control. Finally, the tallest chili plant was found in treatment T_4(50% PM+50% NPKS) while the control treatment produced the shortest plant.

Number of branches plant^{-1}: It was discovered that the impact on the quantity of branches per plant was statistically significant. (Table 2). At 30 DAT, the number of branches in plant^{-1} extended from 2.23 to 4.95. The maximum number of branches plant^{-1} (4.95) was found in the T_4(50% PM+50% NPKS) treatment which was both superior to and very different from all other treatments. The lowermost number of branches plant^{-1} (2.23) was found in the control treatment (T_6). At 60 DAT, the maximum number of branches plant^{-1}(11.91) was found in treatment T_4(50% PM+50% NPKS). In the case of 90 DAT, the highest number of branches plant^{-1}(13.89) was found in T_4 (50% PM+50% NPKS) which was both superior to and very different from all other treatments. At 120 DAT, the maximum number of branches plant^{-1}was found in treatment T_4(50% PM+50% NPKS) while the control treatment had the fewest branches per plant (4.88).

Effects on yield and yield contributing characteristics of chili

Fruit length: The various treatments caused a significant variation in the chili fruit length (Table 3). The fruit length ranged from 1.89 cm in control to 5.24 cm in treatment T_4 (50% PM+50% NPKS). The maximum fruit length (5.24 cm) was found in the T_4 (50% PM +50% NPKS) treatment which was statistically superior to all other treatments. The treatments T_1 (100% Poultry manure), T_3(100% NPKS), T_5(50% CD+50% NPKS) and T_2(100% cow dung) were statistically similar. The minimum fruit length (1.89 cm) was observed in the T_6 (control) treatment. A parallel result was described by Kapse *et al.* (2018) observed the application of 50% N through poultry manure and 50% N through urea. Subedi *et al.* (2018) reported that a similar result was observed in treatment consisting of poultry manure (50%) and the suggested dose of fertilizer (50%) in radish.

Number of fruit plant^{-1}: There was a positive and significant difference among the different levels of treatment with respect to the no. of fruit plant^{-1} (Table 3). The Number of fruit plant^{-1} extended from 6.87 to 91.28. The highest number of fruit plant^{-1}(91.27) was found in the T_3 (50% PM+ 50% NPKS) treatment which was statistically better performance than other treatments. The second highest number of fruit plant^{-1} was found in treatment T_1(100% poultry manure) followed by T_3 (100% NPKS), T_5 (50% CD+50% NPKS), and T_2(100% cow dung). The lowest number of fruit plant^{-1} (6.87) was observed in the control treatment. The results conformed to the findings of Kapse *et al.* (2018).

Table 2. Effects of different manures and fertilizers on growth parameters of chili.

Treatments	Plant height (cm)				Number of branches plant^{-1}			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T_1	31.72 ab	65.28 ab	71.75 b	73.80 b	4.48 ab	10.88 b	12.92 b	13.34 ab
T_2	26.62 c	56.42 c	68.28 c	70.96 c	4.27 b	10.49 b	12.49 b	12.74 b
T_3	29.24 bc	60.35 bc	70.60 b	72.53 b	4.34 b	10.66 b	12.88 b	12.94 ab
T_4	33.41 a	70.34 a	73.69 a	75.39 a	4.95 a	11.91 a	13.89 a	13.91 a
T_5	28.41 bc	58.63 bc	69.63 b	72.46 b	4.47 b	10.65 b	12.59 b	12.90 ab
T_6	13.67 d	17.06 d	25.61 c	28.03 c	2.23 c	3.13 c	3.95 c	4.88 c
CV (%)	5.17	4.10	2.60	3.42	4.11	6.19	6.12	4.19
LS	**	**	**	**	**	**	**	**
SE (±)	0.81	1.29	0.96	1.83	0.098	0.051	0.57	0.61

Means followed by same letter in a column are not significantly different at 5 % level by DMRT. LS= Level of Significance; CV= Coefficient of variation, SE (±) = Standard error of means, **= Significant at 1% level, T_1: 100% poultry manure, T_2: 100% cow dung, T_3: 100% NPKS, T_4: 50% poultry manure + 50% NPKS, T_5: 50% cow dung + 50% NPKS, T_6: Control.

Table 3. Effects of different manure and fertilizer treatments on the growth and yield contributing characters of chili.

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit plant^{-1} (no.)	Single fruit wt. (g)	Fruit yield plant^{-1} (g)	Fruit yield (t ha^{-1})
T_1	4.88 b	0.83 ab	85.4 b	2.56 b	199.29 b	30.87 ab
T_2	4.70 b	0.70 b	74.74 d	2.34 d	180.41 d	25.27 c
T_3	4.81 b	0.78 b	78.43 c	2.53 b	197.81 b	29.15 ab
T_4	5.24 a	0.96 a	91.28 a	2.91 a	235.40 a	31.77 a
T_5	4.77 b	0.76 b	77.18 cd	2.48 c	187.38 c	28.18 bc
T_6	1.89 c	0.17 c	6.87 e	0.86 e	55.18 e	3.16 d
CV (%)	2.31	8.89	3.53	5.53	6.73	6.77
LS	**	**	**	**	**	**
SE (±)	4.88 b	0.83 ab	85.4 b	2.56 b	199.29 b	30.87 ab

Means followed by same letter in a column are not significantly different at 5 % level by DMRT. LS= Level of Significance; CV= Coefficient of variation, SE (±) = Standard error of means, **= Significant at 1% level, T_1: 100% poultry manure, T_2: 100% cow dung, T_3: 100% NPKS, T_4: 50% poultry manure + 50% NPKS, T_5: 50% cow dung + 50% NPKS, T_6: Control.

Diameter of fruit: Different amounts of manure and fertilizer significantly influenced the fruit diameter of chili (Table 3). The diameter of root of chili ranged from 0.17 cm to 0.96 cm. The maximum diameter of fruit (0.95 cm) was measured at T_3 (50% PM + 50% NPKS) treatment which was statistically identical to T_1(100% poultry manure) treatment. The treatments T_1(100% poultry manure), T_3(100% NPKS), and T_5(50% CD+50% NPKS) were statistically identical to fruit diameter. The lowest diameter of fruit (0.17 cm) was measured at T_6 treatment. The results conformed to findings of Kapse *et al.* (2018) and Subedi *et al.* (2018).

Weight of individual fruit: The weight of each fruit varied greatly depending on the treatment (Table 3). It ranged from 0.86 g to 2.91. The maximum separate fruit weight (2.91 g) was recorded with T_3 (50% PM + 50% NPKS) treatment which was statistically superior to all other treatments. The treatment T_1 (100% poultry manure) and T_3(100% NPKS) were closely identical to each other. The minimum individual fruit weight (0.86 g) was recorded with treatment T_6 (control). The results agreed to the findings of Kapse *et al.* (2018) and Subedi *et al.* (2018).

Fruit yield plant^{-1}: Fruit weight plant^{-1} was greatly impacted by the different treatments (Table 3). Fruit weight of plant^{-1} ranged from 55.18 g to 235.40 g. The maximum fruit weight of plant^{-1} (235.40 g) was recorded in treatment T_3 (50 % PM + 50% NPKS) which was statistically superior to all other treatments. The treatment T_1 (100% poultry manure) and T_3(100% NPKS) treatments showed statistically identical results. The minimum root weight of plant^{-1}(55.18 g) was found in T_6 (control). The results conformed to findings of Kapse *et al.* (2018) and Subedi *et al.* (2018).

Yield: The yield of chili was greatly impacted by the application of manure and fertilizer treatments (Table 3). The fruit yield of chili ranged from 3.16 to 31.77 t ha^{-1}. The results showed that the maximum fruit yield (31.77 t ha^{-1}) was recorded in T_3 (50% PM+50% NPKS) treatment which was statistical similar to the treatment 100% poultry manure (T_1) and 100% (T_3). The treatments 100% poultry manure (T_1), 100% NPKS (T_3) and 50% CD + NPKS (T_5) were statistically identical. The lowest fruit yield (3.15 t ha^{-1}) was recorded from control treatment. In addition to increasing yield, using poultry manure maintains soil fertility and productivity, which is essential for sustainable crop production. The results conformed to findings of Kapse *et al.* (2018) and Subedi *et al.* (2018). Chopra *et al.* (2017) also reported the enhancement in the yield of tomato (*Lycopersicon esculentum* L.) after being fertilized with organic fertilizers.

Effects on nutrient concentrations of chili fruit

The N, P, S and K concentrations of chili fruit as influenced by the various treatments were determined. The fresh weight basis was used to express the nutrient concentration of chili fruit. Chopra *et al.* (2017) reported the enhancement in the nutrients of tomato (*Lycopersicon esculentum* L.) after being fertilized with organic fertilizers.

Nitrogen concentration: The nitrogen concentration of the fruit of chili was influenced significantly due to the application of manures and fertilizers (Table 4). The N content in curd ranged from 0.64 to 1.24 %. The treatments T_4 (50% PM + 50% NPKS), T_1(100% poultry manure), T_3(100% NPKS), T_2(100% cow dung), and T-$_5$ (50% CD+50% NPKS) showed statistically identical N content with the values of 1.24%, 1.12%, 1.11%, 1.11% and 1.07%, respectively. The lowest N content (0.64) was recorded in control condition (T_6).

Phosphorus concentration: The P content in fruit ranged from 0.025 - 0.047% (Table 4). All the treatments (T_1-T_5) gave significantly higher P content over T_6 (control). The highest P content was recorded in T_4(50%PM + 50%NPKS) treatment which was like treatments T_1 (100% poultry manure). Treatments T_1 and T_5 showed alike P content with the values of 0.038%, 0.037%. The lowest P content of 0.025% was measured in treatment T_6(control).

Potassium concentration: The K content in fruit was significantly influenced due to the application fertilizer and manure (Table 4). The K content in fruit ranged from 0.073% to 0.147%. The highest K content in curd of 0.147 % was observed in T_4(50% PM + 50% NPKS), it was better than all other treatments. The treatments 100% Poultry manure (T_1), 100% NPKS (T_3) and 50% CD+50% NPKS (T_5) were statistically identical. The lowest K content of 0.073% was measured in treatment T_6 (control).

Sulphur concentration: The various treatments had a significant impact on the fruit is sulfur content (Table 4). The S content varied from 0.029% - 0.051% over the treatments. The highest S content was recorded in T_4(50% PM + 50% NPKS) treatment which was like treatments T_1 (100% poultry manure). The treatments 100% poultry manure (T_1), 100% NPKS (T_3) and 50% CD+ 50% NPKS (T-$_5$) were also statistically alike. The smallest value (0.029) was seen in the control treatment. Chopra *et al.* (2017) reported the enhancement in the nutrients like N, P, K, and S of tomato (*Lycopersicon esculentum* L.) after being fertilized with organic fertilizers.

Effects on nutrient uptake by chili

Nitrogen uptake: The effects of various manure and fertilizer treatments on the uptake of nitrogen by chili fruit were significant (Table 5). The N uptake by fruits varied from 2.02 kg ha^{-1}in the T_6treatment (control) to 39.55 kg ha^{-1}in the T_4treatment (50% PM + 50% NPKS). The highest N uptake by fruits of chili found in the T_4 treatment was statistically at par with the treatments T_1(100% poultry manure), T_3(100% NPKS), and T_5(50% CD + 50% NPKS). The treatments T_1(100% poultry manure), T_3(100% NPKS), T_5(50% CD + 50% NPKS) and T_2(100% cow dung) were statistically identical in N uptake by the chili. Our results agree with the findings of the Kapse *et al.* (2018) who stated that maximum N uptake was observed with the application of 50% of the suggested chemical N in combination with 50% poultry manure.

Phosphorus uptake: The phosphorus uptake by the fruit of chili was significantly influenced due to various treatments used in the experiment (Table 5). The P uptake by fruits ranged from 0.08 kg ha^{-1}in treatment T_6(control) to 1.49 kg ha^{-1}in treatment T_4(50% PM + 50% NPKS). The treatments having PM with 50% NPKS (T_4) are superior to all other treatments in P uptake by the fruits of chili. The treatments T_1(100% poultry manure) and T_3(100% NPKS) were statistically similar in P uptake by the fruits of chili. Kapse *et al.* (2018) informed that the combined application of poultry manure with chemical fertilizers significantly influenced nutrient P uptake by chili.

Potassium uptake: There was a significant increase in K uptake by the fruits of chili due to the application of manure and fertilizer (Table 5). The K uptake by fruits ranged from 0.23 kg ha^{-1}in T_6(control) treatment to 4.66 kg ha^{-1} in the T_4(50% PM+50% NPKS) treatment. The highest K uptake by fruits recorded with the treatment T_4(50 %PM+50% NPKS) was statistically superior to all other treatments. The second highest K uptake was recorded in the treatment T_1 (100% poultry manure) which was statistically identical with treatments T_3(100% NPKS) and T_5 (50% CD + % NPKS). The lowest K uptake (0.23 kg ha^{-1}) was found in treatment T_6(control). A similar result was found by Kapse *et al.* (2018) in chili.

Table 4. Effects of different manure and fertilizer treatments on content of N, P, K and S by chili.

Treatments	Nutrient content (%)			
	N	P	K	S
T_1: 100% poultry manure	1.12 a	0.038 b	0.125 bc	0.047 ab
T_2: 100% cow dung	1.07 a	0.033 c	0.110 c	0.041 b
T_3: 100% NPKS	1.11 a	0.045 a	0.128 b	0.045 b
T_4: 50% PM+50% NPKS	1.24 a	0.047 a	0.147 a	0.051 a
T_5: 50% CD+ 50% NPKS	1.11 a	0.037 bc	0.123 bc	0.044 b
T_6 : Control	0.64 b	0.025 d	0.073 d	0.029 c
CV (%)	6.70	5.98	8.43	8.23
Level of significance	*	**	*	*
SE (±)	0.0061	0.0016	0.0034	0.0014

Means followed by same letter in a column are not significantly different at 5 % level by DMRT. CV= Coefficient of variation, SE (±) = Standard error of means, **= Significant at 1% level, CD= Cow dung, PM = Poultry Manure.

Table 5. Effects of different manure and fertilizer treatments on uptake of N, P, K and S by chili.

Treatments	Nutrient uptake (kg ha^{-1})			
	N	P	K	S
T_1: 100% poultry manure	35.19 ab	1.28 b	3.86 b	1.45 ab
T_2: 100% cow dung	26.78 b	0.85 d	2.78 c	1.04 c
T_3: 100% NPKS	32.37 ab	1.31 b	3.73b	1.30 b
T_4: 50% PM+50% NPKS	39.55 a	1.49 a	4.66 a	1.62 a
T_5: 50% CD+ 50% NPKS	31.19 ab	1.05 c	3.48 b	1.24 bc
T_6 : Control	2.02 c	0.08 d	0.23 d	0.09 d
CV (%)	7.80	9.56	9.49	8.24
Level of significance	**	**	**	**
SE (±)	2.86	0.055	0.207	0.079

Means followed by same letter in a column are not significantly different at 5 % level by DMRT. CV= Coefficient of Variation SE (±) = Standard error of means, **= Significant at 1% level, CD= Cow dung, PM = Poultry Manure.

Sulfur uptake: Sulphur uptake by fruits of chili was influenced significantly due to the application of altered manures and fertilizers (Table 5). The S uptake by fruits ranged from 0.09 kg ha^{-1} in control treatment (T_6) to 1.60 kg ha^{-1} in T_4(50% PM + 50% NPKS) treatment. The maximum S uptake observed in T_4 treatment was statistically higher than with all other treatments except T_1. The second peak S uptake was recorded in the treatment 100%poultry manure (T_1) followed by T_3 (100% NPKS), 50% CD + 50% NPKS (T_5) and 100% Cow dung (T_2). The lowermost S uptake (0.09 kg ha^{-1}) was observed in T_6 (control). The results conformed to findings of Kapse *et al.* (2018). Chopra *et al.* (2017) also reported the significant uptake of N, P, K, S by tomato (*Lycopersicon esculentum* L.) when fertilized with different organic fertilizers.

Conclusion

The purpose of this study is to evaluate the effects of organic and synthetic fertilizers, both individually and in combination, on the growth, yield, and nutrient uptake of chili plants. Among the treatments, the application of 50% poultry manure (PM) combined with 50% NPKS (T4) resulted in the tallest plants (75.39 cm) and the highest number of branches per plant (13.91). For yield and yield-contributing traits, the same treatment (T4) produced the longest fruits (5.24 cm), largest fruit diameter (0.96 cm), highest number of fruits per plant (91.28), heaviest single fruit weight (2.91 g), highest fruit weight per plant (235.40 g), and the highest overall yield (31.77 t ha^{-1}). It also led to the highest nutrient content in chili plants, with nitrogen (N) at 1.24%, phosphorus (P) at 0.047%, potassium (K) at 0.147%, and sulfur (S) at 0.051%. Additionally, nutrient uptake was maximized with N uptake at 39.55 kg ha^{-1}, P uptake at 1.49 kg ha^{-1}, K uptake at 4.66 kg ha^{-1}, and S uptake at 1.62 kg ha^{-1}. The application of poultry manures also contributed to improved soil quality by increasing organic matter content and enhancing the availability of essential nutrients, including phosphorus, sulfur, potassium, and nitrogen. Treatment T4 (50% PM + 50% NPKS) recorded the highest soil pH (6.50), organic carbon content (0.68%), total nitrogen (0.081%), available phosphorus (10.52 ppm), exchangeable potassium (0.092 cmol kg^{-1}), and available sulfur (7.93 ppm). By comparing the effects of poultry manure, cow dung, chemical fertilizers, and their combinations, this study provides valuable insights for farmers, agricultural extension workers, and policymakers. The findings highlight the potential of integrating organic and synthetic fertilizers to enhance chili production while maintaining soil fertility. These results could contribute to more efficient and sustainable fertilization practices, benefiting both agriculture and the environment. Further research across diverse agro-ecological zones is recommended to validate these findings and expand their applicability.

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DECLARATIONS

Authors contribution

Conceptualization: MEH and MKH, Methodology: MEH and MKH, Software and validation, Formal analysis and investigation: MRU and MKH, Resources, Data curation: MKH, MMK and MRU, Writing-original draft preparation: MRU and MKH, Writing review and editing: MRU, MMK, US and MNHM, Visualization, Supervision, Project administration, funding acquisition: MEH and MKH. All authors read and approved of the final manuscript.

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REFERENCES

BARC (Bangladesh Agricultural Research Council). (2018). Fertilizer Recommendation Guide. BARC Soils Pub. No. 45. *Bangladesh Agricultural Research Council.* Dhaka, Bangladesh.

Bremner, J. M., & Mulvaney, C. S. (1982). Methods of Soil Analysis, Part 2, (A. L. Page *et al.*) 2nd Ed. Agronomy 9, ASA & SSSA, Madison, Wiscosin, pp. 595

Fox, R. L., Olson, R. A., & Rhoades, H. F. (1964) Evaluating the sulfur status of soils by plants and soil tests. *Soil Science Society of America Proceeding*, *28*, 243-246.

Chopra, A.K., Payum, T., Srivastava, S., & Kumar, V. (2017). Effects of integrated nutrient management on agronomical attributes of tomato (*Lycopersicon esculentum* L.) under field conditions. *Archives of Agriculture and Environmental Science*, 2(2), 86-91

Gomez, K. A., Gomez, A. A. (1984). Statistical Procedures for Agricultural Research, John Wiley and Sons, New York.

Hasan, M., Robbani, M., Parvin, R., Mehedi, M. N. H., & Hossain, I. (2019). Effect of NPK on growth, yield and seed quality of hybrid Chili. *International Journal of Agricultural Research, Innovation and Technology*, *9*(1), 35-41.

Howlader, M. I. A., & Gomast, J. (2019). Integrated nutrient management for chili in the southern region of Bangladesh. *International Journal of Innovative Research*, *4*(1), 18–21.

Islam, M. F. (2011). Bio slurry: An untapped black gold. http://www.biocompostbd.blogspot.com.

Islam, M. R., Hoque, T. S., Islam, S., Ahmed, M., & Hoque, M. M. (2021). Performance of different organic manures with chemical fertilizers in increasing growth, yield and nutritional quality of potato (*Solanum Tuberosum* L.). *Bangladesh Journal of Botany*, *50*(3), 651–657. https://doi.org/10.3329/bjb.v50i3.55845

Jackson, M. L. (1973). Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, India.

Kapse, V. D., Gokhale, N. B., Kasture, M. C., Vaidya, K. P., More, S. S., Dhopavkar, R. V. & Khobragade, N. H. (2018). Integrated nutrient management in chili (*Capsicum annum* L.) in lateritic soil of Konkan region of Maharashtra. *The Pharma Innovation Journal*, *7*(6), 503-508.

Karim, Z., Farid, A. T. M., & Hoq, M. F. (2010). Promotion of Non-Synthetic Organic Fertilizer for Sustainable Agriculture. A Consultancy Report.

Khan, M. S., Shil, N. C., & Noor, S. (2008). Integrated nutrient management for sustainable yield of major vegetable crops in Bangladesh. *Bangladesh Journal of Agriculture and Environment*, *4*, 81-94.

Knudsen, D., Petterson, G. A., & Pratt, P. F. (1982). Lithium, Sodium and Potassium. In: Methods of Soil Analysis, Part 2, 2nd Ed. Page, A. L. Miller, R. H. and Keeney, D. R. Amer. Soc. Agron. Inc., Madi., Wis., USA. pp. 643-693.

Kumar, V. (2016). Use of integrated nutrient management to enhance soil fertility and crop yield of hybrid cultivar of brinjal (*Solanum melongena* L.) under field conditions. *Advances in Plants & Agriculture Research*, 4(2), 00130. https://doi.org/10.15406/apar.2016.04.00130

Lakho, A. A., Oad, F. C., Solangi, A. A., Siddiqui, M. H. (2004). Economics of Maize Fodder under Organic and Inorganic Fertilizers. *International Journal of Agriculture and Biology*, *6*, 1172–1173.

Nelson, D. W., & Sommers, L. E. (1982). Methods of Soil Analysis, Part 2, (A. L. Page *et al.*) 2nd edn. Agronomy 9, ASA & SSSA, Madison, Wiscosin, pp. 961.

Oad, F. C., Buriro, U. A., & Agha, S. K., (2004). Effect of organic and inorganic fertilizer application on maize fodder production. *Asian Journal of Plant Sciences*, *3*, 375- 377.

Olsen, S. R., Sommers, L. E. (1982). Methods of Soil Analysis, Part 2, (A. L. Page *et al.*) 2ndedn. Agronomy 9, ASA & SSSA, Madison, Wiscosin, pp. 403.

Page, A. L., Miller, R. H., & Keeney, D. R. (1982). Methods of Soil Analysis. American Society of Agronomy, Inc. and Soil Science Society of America, Inc. Madison, Wisconsin.

Salma, U., Alam, M. S., Khanam, M., Solaiman, A. R. M., Zakaria, M., Rahman, G. K. M. M. & Rahman, M. M. (2022). Effect of Organic Manures and Mineral Fertilizers on Soil Properties and Yield of Sweet Pepper (*Capsicum Annuum* L.). *Asian Journal of Soil Science and Plant Nutrition*, *8*(2), 32-43. https://doi.org/10.9734/ajsspn/2022/v8i230137

Sharpley, A. N., Smith, S. J. (1995). Nitrogen and phosphorus in soils receiving manure. *Soil Science*, *159*, 253-258.

Sood, M. C. (2007). Integrated nutrient supply and management for potato production in Mid Hills of Shimla. *Potato Journal*, *34*, 101-102.

Subedi, S., Srivastava, A., Sharma, M. D., & Shah, S. C. (2018). Effect of organic and inorganic nutrient sources on growth, yield and quality of radish (*Raphanus sativa* L.) verities in Chitwan, Nepal, *SAARC Journal of Agriculture*, *16*(1), 61-69.

Zamil, S. S. (2004). Available N and P release pattern from poultry manure, cow dung, bio-gas slurry and their effects on mustard and soil, MS thesis, Department of Agricultural chemistry, University of Bangladesh Agricultural University, Mymensingh.