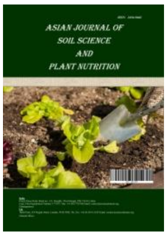

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Effect of Organic Manures and Mineral Fertilizers on Soil Properties and Yield of Sweet Pepper (*Capsicum annuum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Under the intensive agriculture system, it is crucial to maintain the soil fertility for the sustainability of crop production. Therefore, the study was conducted in the experimental field of the Department of Soil Science of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur to investigate the effect of different manures in combination with synthetic inorganic fertilizers on growth, yield and yield contributing characters of BARI Mistimorich 1 (*Capsicum annuum* L.), a variety of sweet pepper. Nutrient content of capsicum and soil fertility status were also assessed.

Materials and Methods: The field trial was established following a randomized complete block design (RCBD) having four replicates. Treatments of the field trial included T_1= 100% recommended dose of chemical fertilizers (RDCF), T_2= 10t/ha cowdung (CD) + IPNS based chemical fertilizers (CF), T_3=10t/ha poultry manure (PM) + IPNS based chemical fertilizers (CF) and T_4= 10t/ha vermicompost (VC) + IPNS based chemical fertilizers (CF).

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Results: Experimental results reveal that application of organic manures in combination with chemical fertilizers produced significantly higher plant height, plant weight, number of branches per plant, number of flowers per plant, number of fruits per plant, fruit weight, fruit length, fruit diameter, total yield and nutrient content and uptake in sweet pepper. Organic manures (CD, PM and VC) in combination with chemical fertilizers ensured higher nutrient uptake when compared with the sole application of inorganic fertilizers. Among the treatments, vermicompost treated plots gave the higher yield of sweet pepper and improved the post-harvest soil nutrient status.
Conclusion: Vermicompost was found to be suitable as substitute of other organic manures for the production of capsicum.

Keywords: Capsicum; manures; fertilizers; nutrition; soil fertility.

1. INTRODUCTION

Sweet pepper *(Capsicum annuum* L.) is a popular spice and vegetable crop throughout the world belonging to the family Solanaceae. Though the crop is very popular as one of the important vegetables all over the globe, particularly in the temperate countries, but in Bangladesh, some advanced farmers only grow this crop occasionally to fulfill the requirement of urban areas. It is generally grown in Rabi season (October to early April) in Bangladesh. Sweet pepper fruits are an excellent source of different vitamins, particularly vitamin C, A, B and E; minerals such as Ca, Mg, P, K and Fe [1]; polyphenols, chlorophylls, carotenoids, and sugars [2]. These compounds are associated with improved health by providing protection against diseases like cancer, cardiovascular disease.

For getting higher yield in vegetable crops, unrestricted uses of inorganic fertilizers are generally practiced in the field. Excessive use of inorganic fertilizer alone causes an increased yield for some extent but this increased yield will not sustain for a long as continuous application of mineral fertilizers deteriorate soil health and create environmental pollution [3]. In terms of soil fertility and productivity, organic manures are superior to inorganic fertilizers because they improve soil health by improving physical, biological and chemical properties of soil [4-8] which result in higher yield and better-quality crop [9]. Moreover, application of organic amendments not only enhance the crop production but also can ameliorate soil salinity [10-12]. But higher crop yield will not be attained by sole supply of organic manures because of lower amount of nutrients to meet the crop requirement [13]. This implies that utilization of organic or mineral fertilizers alone is never a suitable solution for maintaining soil health and increasing crop productivity. Therefore, the integration of inorganic and organic sources of plant nutrients is supposed to the best approach for the maintenance of soil fertility and better crop production on a sustainable basis [14-19]. It has been revealed in literatures that combine application of organic and inorganic fertilizers has significant positive effect on different vegetable crops [20-21]. Integration of organic manures with inorganic fertilizers also enhance soil properties particularly the soil organic carbon status and microbial community [22-23]. It has been also reported that combined application of manures and inorganic fertilizers increases cauliflower production in acid soil of Bangladesh [24]. Thus, economic and eco-friendly application of manures along with mineral fertilizers for profitable vegetable yield and sustainable soil health is a long-awaited demand both in agriculture and horticulture. The information regarding the impact of integrated use of organic manures and chemical fertilizers on yield and its nutritional quality of capsicum is little known in our local climatic condition. Considering these facts, the present study was carried out to assess the influence of integrated nutrient management (organic and mineral) on yield contributing characters, yield and nutritional value of capsicum as well as to assess the soil nutrient status.

2. MATERIALS AND METHODS

2.1 Experimental Site and Weather Condition

The experiment was conducted at the experiment field of the Department of Soil Science of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh. The experimental site was located at 24°.09 N latitude and 90°.26 E longitudes with an elevation of 8.4 m from the sea level and about 40 km north from the capital city Dhaka. The site was previously under sal

(*Shorea robusta*) forest and developed later for research purpose. The experimental area has subtropical climate characterized by heavy rainfall during the month from April to September and scanty rainfall during the month from October to March.

2.2 Characteristics of the Experimental Soil

The experimental field soil belongs to the Salna series and are classified as Shallow Red Brown Terrace Soil in Bangladesh. According to USDA Soil classification, the soil falls under the order Inceptisol with pH of around 5.8 [25]. The soil is characterized by heavy clays within 50 cm from the surface and are poor in chemical properties.

2.3 Soil Sampling and Analysis

Soil samples from a depth of 0-15 cm were collected before starting the experiment and after harvesting of the crop following standard protocols [26]. 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 analyses. After harvesting of capsicum, soil samples were also collected and processed following the same techniques. The collected soil samples were analyzed for different parameters. Soil pH was measured by pH meter fitted with glass electrode using a soil: water ratio of 1:2.5 [27]. Organic carbon (%) was analyzed by wet oxidation method [28]. The total nitrogen content of collected soil sample was determined by Kjeldahl method [27]. Available P was determined following molybdate blue–ascorbic acid *colorimetric* [29] method for acid soil. Available sulfur of the soil samples was determined by turbidimetric method [30]. Exchangeable K was determined by ammonium acetate extraction method [27].

2.4 Design of the Field Experimentation and Treatments Combination

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. There were 16 plots each having the dimension of 2 m × 2 m = 4m^2. Distance between replication to replication was 1 m and line to line 50 cm, plant to plant 50 cm. The treatments of the experiment were as, **T_1:**100% Recommended dose of chemical fertilizers (RDCF), **T_2:** Cow Dung (10 ton/ha) + IPNS based RDCF, **T_3:** Poultry Manure (10 ton/ha) + IPNS based RDCF, **T_4:** Vermicompost (10 ton/ha) + IPNS based RDCF.

For T_1 treatment (recommended dose of chemical fertilizers- RDCF), NPKSZn@ 140- 78-114-25-1 kg/ha was applied in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and Zinc Oxide respectively.

2.5 Land Preparation and Transplanting of the Seedlings

Land was prepared for well tilth using a spade. Clods were broken and weeds were removed from the field to obtain good tilth. Plots were prepared according to design and layout. After final harrowing, the experimental field was divided into 2 m × 2 m plots maintaining a distance of 1 m from one plot to another. Seeds were sown in the well-drained seedbeds at 1-2 cm distance. Before sowing, the seeds were soaked in water for 12 hours. Seven to ten days after sowing, seedlings having 3-4 leaves were transferred in the separate poly bags containing the potting media. The potting media contained soil, compost and sand at 3:1:1 ratio. Healthy and uniform sized 30 days old seedlings were transplanted in the experimental plot. Each plot had four rows of 4 plants. Before transplanting the seedlings, polybags were removed from each seedling to facilitate growth of root from basal media so that they can easily establish in the field. At the time of removing polybags, care was taken to protect the earth ball bagged soil. Irrigation was required immediately after transplanting of seedlings. Sufficient soil moisture was present for seedlings establishment. After seedlings establishment, the soil around the base of each seedling was pulverized and the damaged seedlings were replaced by new ones from the same stock if and when needed.

2.6 Planting Materials

As the experimental crop, Capsicum variety BARI Mistimorich 1 was used. Seeds were collected from the olericulture division under horticulture research center of Bangladesh Agricultural Research Institute (BARI) and seedlings were raised in the experimental field of Department of Soil Science of BSMRAU, Bangladesh.

2.7 Application of Inorganic Fertilizers and Manures

The whole amount of P, K, S, Zn and 1/3 N were broadcast and thoroughly incorporated into the soil at the time of final land preparation and the remaining 2/3 N was top dressed in two equal installations at 15 and 35 days after transplanting. Cow dung, poultry manure, and vermicompost were applied in the field before transplanting. The required amount of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and Zinc Oxide as source of N, P, K, S, and Zn respectively were applied as prescribed by horticulture research centre, BARI [31]. Necessary intercultural operations were done as and when necessary.

2.8 Data Collection

Five plants were selected randomly from each plot for harvesting the fruits at mature stage. Fruits were harvested at one-week interval starting from the first harvest to the end of the final harvest. Data were collected for different parameters including plant height (cm), number of branches per plant, shoot fresh weight (g), shoot dry weight (g), number of flowers per plant, number of fruits per plant, fruit length (cm), fruit weight (g/plant), fruit diameter (cm), total yield of capsicum (ton/ha) etc.

2.9 Nutrient Analysis in Capsicum Fruit

After harvest, collected fruit samples were analyzed for N, P and K contents by the standard methods [32].

2.10 Statistical Analysis

Data were analyzed statistically with the help of computer package Statistix 10 for windows version. The mean differences of the treatments were observed by least significant difference (LSD) test at 5% level of probability for the interpretation of results [33].

3. RESULTS AND DISCUSSION

3.1 Effect of Organic Manures in Combination with Chemical Fertilizers on Growth, Yield Contributing Parameters and Yield of Sweet Pepper

3.1.1 Plant height

Compared with the application of chemical fertilizer alone, the combined application of manures and chemical fertilizer had a significant effect on the plant height of sweet pepper (Table 1). The highest plant height (59.3 cm) was recorded in T_4 treatment where vermicompost was used with IPNS based chemical fertilizers which was significantly higher than all other treatments. The lowest plant height (38.3 cm) was found in T_1 treatment that received only chemical fertilizers but statistically similar result was obtained in cowdung treated plot.

Higher plant height in treatments receiving vermicompost may be as a result of the higher availability of micro and macro nutrients, which plants can readily uptake to facilitate their growth and development. Vermicompost also contains secretions from worms and their allied microorganisms, which acts as the plant growth promoting substances along with the supply of some other nutrients. Due to all of these important substances, vermicompost might demonstrate multiple effects on the growth of sweet pepper.

Working in the same field, [34] reported that vermicompost applied *Capsicum annuum* plants got the highest shoot length followed by chemical fertilizer applied plants.

3.1.2 Number of branches per plant

Significant ($P<0.05$) difference was found in terms of the number of branches per plant due to the use of organic manures (Table 1). Integration of organic manures and chemical fertilizers displayed notable positive effect on number of branches of sweet pepper. The highest number of branches (9.0) was recorded from T_4 treatment which was followed by T_3 and T_2 treatments. The lowest number of branches (4.0) was found in T_1 treatment that received only mineral fertilizers. With the agreement of our research, [35] showed that average number of branches per plant (*Capsicum annuum* L.) was maximum in the treatment with vermicompost + urea over other treatments, whereas the number of branches per plant was found the least when plant was grown with only chemical fertilizers. Vermicompost is demonstrated as an important organic input for crop production that includes not only the helpful microbes and plant nutrients, but also includes different enzymes and hormones [36] which might have significant positive influences on the vegetative growth of sweet pepper including the number of branches.

Table 1. Growth and yield contributing parameters of sweet pepper influenced by integrated nutrient management

Treatments	Plant height (cm)	Number of branches plant^{-1}	Shoot Fresh weight (g/plant)	Shoot dry weight (g/plant)	No. of flower/ plant	No. of fruit / plant
T_1	38.3c	4.0c	145.8c	36.3c	14.0c	4.9d
T_2	44.1bc	6.6b	170.5bc	42.6bc	23.5b	5.7c
T_3	46.5b	7.0b	196.3b	49.1b	25.3b	6.6b
T_4	59.3a	9.0a	242.0a	60.5a	33.5a	7.2a
$LSD_{0.05}$	5.79	1.60	28.22	7.15	6.20	0.35
CV%	6.16	11.84	7.49	7.59	12.89	2.90

*In a column figures having similar letter (s) do not differ significantly at 5% level of probability; **T_1:**100% recommended dose of chemical fertilizers (RDCF), **T_2:** Cow Dung (10 ton/ha) + IPNS based (RDCF), **T_3:** Poultry Manure (10 ton/ha) + IPNS based (RDCF), **T_4:** Vermicompost (10 ton/ha) + IPNS based (RDCF)*

3.1.3 Shoot fresh weight

Experimental results demonstrated in Table 1 reveal that organic manures in combination with chemical fertilizers increased the shoot fresh weight which became significant at 5% level of probability. Significantly highest shoot fresh weight (242 g/ plant) was found from the T_4 treatment followed by T_3 treatment (196.3 g/plant). Among different treatments, the lowest fresh weight of shoot was observed in T_1 treatment (145.8 g/plant) but it was statistically similar with T_2 treatment. It is interesting to noteworthy that present results are in harmony with the findings of [37] who illustrated significant increases in shoot fresh weights due to the application of vermicompost when compared with the plants treated with only chemical fertilizer. The vigorous plant growth might be attained in vermicompost treated plots due to the increased uptake of plant nutrients.

3.1.4 Shoot dry weight

Combined application of organic manures and chemical fertilizers showed significant influence on shoot dry weight at 5% level of probability (Table 1). Maximum shoot dry weight (60.5 g/ plant) was obtained from the vermicompost treated plots followed by poultry manure treatment (49.1 g/plant). Among the treatments, significantly lowest shoot dry weight was measured in T_1 treatment (36.3g/plant) which was statistically comparable with T_2 treatment. Our results are in harmony with the findings of [38] and [37] who illustrated significant increases in shoot weights from the plants receiving vermicompost when compared with the plants receiving only chemical fertilizer.

Research findings demonstrate the vermicompost as a good source of vitamins, enzymes, hormones, macro and micronutrients and thus applying to soil contributes better plant growth [39]. Higher plant growth might be due to increased uptake of macro and micronutrients present in the vermicompost, which may lead to increased biomass in plants treated with vermicompost. Earthworms utilize beneficial soil microflora, destroy soil pathogens and alter organic wastes into enzymes, vitamins, growth hormones, antibiotics, and protein containing casts, which might help the sweet pepper plant for greater accumulation of shoot biomass.

3.1.5 Number of flowers per plant

In the present study, the number of sweet pepper flower was increased in organic manure applied plots (Table 1). There were significant differences in the number flowers per plant as a result of applying different organic and chemical fertilizers. Significantly highest number of flowers (33.5) was observed in vermicompost treated plots followed by poultry manure and cowdung treated plots and significantly lowest number of flowers per plant was documented in T_1 (14.0) where no organic manures were applied but only chemical fertilizers was used. Comparable finding was described by [38] who recorded significantly highest number of strawberry flowers in plots applied with vermicompost compared to the plots receiving only chemical fertilizers. Production of growth hormones by vermicompost might enhance the higher flower production in sweet pepper. More number of flowers is expected to have a greater number of fruits in sweet pepper plant which will ensure profitable production of sweet pepper at farmer's level.

3.1.6 Number of fruits per plant

Treatments containing different sources of organic manures significantly influence the number of fruits per plant (Table 1). Data showed that vermicompost treated plot produced significantly maximum number of fruits per plant (7.2) which was followed by poultry manure (6.6) and cowdung treatments (5.7). Significantly lowest number of fruits per plant (4.9) was noted from the treatment that received only synthetic chemical fertilizers. The findings were in line with many research results. In their research findings [40] and [35] observed the highest fruit number due to the application of vermicompost in soil along with chemical fertilizers.

3.1.7 Fruit diameter

The effect of organic manures in combination with chemical fertilizers displayed highly significant influence on fruit diameter of sweet pepper (Table 2). The fruit diameter ranged from 4.3 cm to 8.7 cm. Vermicompost applied treatment produced significantly highest fruit diameter (8.7 cm) while the lowest fruit diameter was observed in T_1 treatment receiving no organic manures. Fruit diameter of 7.4 cm was obtained from poultry manure amended plots which was statistically similar with the cowdung applied treatments (6.5 cm). Similar findings were observed by [35] where they showed significant increase of fruit diameter of *Capsicum annuum* due to the integrated use of vermicompost with the inorganic fertilizers. Vermicompost is beneficial organic manure which might facilitate higher uptake of the nutrients by the plants results not only the higher growth and yield of sweet pepper but also the fruit diameter.

3.1.8 Fruit length

Experimental results revealed that fruit length of sweet pepper was significantly influenced by different treatment combinations (Table 2). Among the treatments, vermicompost treated plots showed significantly highest fruit length (11.0 cm) which was followed by poultry manure treatment (8.6 cm) and cow dung applied plots (7.5 cm). Significantly lowest fruit length (6.2 cm) was recorded from the treatment receiving only chemical fertilizers but statistically identical with cow dung applied treatment. The findings were in line with the findings of [35] who described increasing fruit length of *Capsicum annuum* with the application of organic amendments over sole use of chemical fertilizers.

3.1.9 Fruit weight

Effect of different sources of organic manures (cow dung, poultry manure and vermicompost) on fruit weight of sweet pepper was found significant (Table 2). Significantly highest average fruit weight (31.5 g/fruit) was recorded from T_4 treatment. Significantly lowest fruit weight (26.0 g/fruit) was obtained in T_1 treatment. The present results were at par with the findings of [40]. Application of organic manures maintain better soil environment through increasing the microbial action that might enhance the nutrient availability for sweet pepper and accordingly increase the fruit weight of pepper as compared to the application of synthetic chemical fertilizers alone.

3.1.10 Fruit yield (t/ha)

Fresh fruit yield of sweet pepper was significantly affected by different treatments (Table 2). All the organic amended plots demonstrated significantly higher fresh yield over the chemical fertilizer treated plots. It was notable to mention that significantly the highest yield (9.1 t/ha) was recorded in T_4 treatment receiving vermicompost in combination with synthetic chemical fertilizers, whereas the T_1 treatment that received only chemical fertilizers showed significantly the lowest sweet pepper yield (5.1 t/ha).

Table 2. Yield and yield contributing parameters of sweet pepper as influenced by integrated nutrient management

Treatments	Fruit diameter (cm)	Fruit length (cm)	Fruit weight (g/fruit)	Fruit yield (t/ha)
T_1	4.3c	6.2c	26.0d	5.1d
T_2	6.5b	7.5bc	28.2c	6.4c
T_3	7.4b	8.6b	29.5b	7.9b
T_4	8.7a	11.0a	31.5a	9.1a
$LSD_{0.05}$	1.09	2.17	0.50	0.44
CV%	8.07	13.05	0.87	3.13

In a column figures having similar letter (s) do not differ significantly at 5% level of probability.
***T_1:**100% recommended dose of chemical fertilizers (RDCF), **T_2:** Cow Dung (10 ton/ha) + IPNS based (RDCF),*
***T_3:** Poultry Manure (10 ton/ha) + IPNS based (RDCF), **T_4:** Vermicompost (10 ton/ha) + IPNS based (RDCF)*

Experimental result demonstrated that sweet pepper yield was increased due to integrated use of organic manures and inorganic fertilizers [21] that indicated the contribution of organic manures in producing higher crop yields and suggested possible positive tradeoff between organic and chemical fertilizers providing sufficient plant nutrients. Therefore, it is assumed that the nutrient use efficiency might be enhanced because of the combined application of organic and inorganic fertilizers. The findings were in harmony with many other researchers. In a similar research, [41] observed that fruit production of pepper was significantly more in plants raised in vermicompost. Similar findings were also reported by [38]. The improved plant growth and increased fruit yield may be due to the increase in soil microbial biomass after vermicomposting, resulting in the production of hormones or humates in the vermicompost, which act as plant growth regulators independent of nutrient supply [35].

3.2 Effect of Organic Manures in Combination with Chemical Fertilizers on the Nutrient Content of Sweet Pepper Fruit

3.2.1 Nitrogen content in sweet pepper fruit

Different organic manures in combination with chemical fertilizers showed significant influence on nitrogen content in fruits of sweet pepper at 5% level of probability (Fig. 1). The highest nitrogen content in fruit (3.0%) was obtained from the vermicompost treated plots followed by poultry manure treatment (2.7%). Among the treatments, the lowest nitrogen content was observed in T_1 treatment (2.0%). The results were in harmony with the findings of [42] who reported that treatment with enriched vermicompost was superior to other treatments for the nutrient content like N, K, P, Ca and Mg in cowpea. In addition to nutrient supply, vermicompost also provides some plant growth promoting substances [36] which might produce healthy plants and thus the healthy plants might uptake higher amounts of nutrients from soil.

3.2.2 Phosphorous content in sweet pepper

As compared to the chemical fertilizers alone, combination of organic manures and inorganic fertilizers significantly increased the phosphorus content in the sweet pepper fruits (Fig.1). Significantly highest phosphorous content in sweet pepper was determined (0.29%) in T_3 treatment which was statistically different from all other treatments. On the contrary, the lowest phosphorous content (0.20%) in the sweet pepper fruit was estimated in T_1 treatment. The findings indicate that the combination of organic manures and synthetic fertilizers increases the nutrient content in sweet pepper. Nutrients in organic manures are existing in readily available forms for plant uptake [43] which might have significant positive influence on nutrient content in plant.

3.2.3 Potassium content in sweet pepper

The effect of organic manures in combination with chemical fertilizers displayed highly significant influence on potassium content in sweet pepper. Potassium content in pepper fruit ranged from 1.60% to 2.45% (Fig.1). Vermicompost applied plant produced significantly highest K content (2.45%) while the lowest K content was observed in T_1 treatment receiving no organic manures. Potassium content of 2.25% was obtained from poultry manure treated plots and 2.00% from cowdung applied treatments. Similar findings were reported by [44].

3.3 Effect of Organic Manures and Chemical Fertilizers on Soil Properties

3.3.1 Initial soil nutrient status

Study results shown in Table 3 indicated that soil of the experimental site was slightly acidic in reaction according to the criteria set by [26] as the pH of the initial soil was 5.8. Organic matter content (organic carbon content 0.9%), available P (9.8 ppm) and available S content (10.8 ppm) was low, whereas, total nitrogen content (0.06%) was very low according to the fertilizer recommendation guide, 2012. On the other hand, exchangeable K content (0.2 meq/100 g soil) was medium.

Table 3. Initial soil nutrient status of the experimental site

Parameter	Value
pH	5.80
OC (%)	0.90
Total N (%)	0.06
P (ppm)	9.80
K (meq/100g of soil)	0.20
S (ppm)	10.80

3.3.2 Residual nutrient content in soil after harvesting of sweet pepper

3.3.2.1 Soil pH

Soil pH value was sharply influenced by the experimental treatments. After harvest, significant (P<0.05) variation on soil pH was found in T_4 (6.26) treatment (Table 4) which was statistically different from other treatments. Significantly lowest pH value was found in T_1 (5.84) treatment that received only chemical fertilizers. It was noted that soil pH value increased in organic matter amended plots might be due to the addition of calcium from the organic manures especially from poultry manure and vermicompost. It has also been reported elevated levels of soil pH after vermicomposting [34].

3.3.2.2 Organic carbon

Study results demonstrated a significant variation (P<0.05) in the organic carbon content of post-harvest soil samples as influenced by the application of different organic manures along with chemical fertilizers (Table 4). Among the treatments, T_4 treatment that received vermicompost showed the highest organic carbon content (1.14%) in post-harvest soil. On the other hand, the lowest organic carbon content (0.95%) was recorded in T_1 treatment receiving no organic manures. Similar findings were reported from another experiment conducted by [45] who explained that soil organic carbon increased when organic manures were supplied in combination of NPK fertilizers instead of NPK fertilizers alone. It is very likely that addition of organic manures in soil will increase the organic carbon content.

3.3.2.3 Total nitrogen

Significant (P<0.05) difference was observed in the nitrogen content in soil after harvest of the crop due to different treatments (Table 4). Significantly highest total nitrogen (0.092%) was found in vermicompost treatment followed by poultry manure treated plots. The lowest N content (0.059%) was found in T_1 treatment that received only chemical fertilizers but statistically similar with the cowdung treated plots. From their experiment [46] observed that organic fertilizers enrich the nitrogen content in soil. This might due to the accumulation of nitrogen in soil by the mineralization of organic matter. Combined application of organic manure and chemical fertilizers in soil facilitates the release of plant nutrients as well as reduce the loss of nitrogen, therefore increases the nitrogen use efficiency [47].

3.3.2.4 Available phosphorous

Experimental findings reveal that phosphorous content of postharvest soil was significantly (P<0.05) influenced by different treatments (Table 4). Combination of organic and chemical fertilizers showed significant difference regarding available phosphorous content in soil. Among the different treatments, the highest available phosphorous (17.16 ppm) was found in T_3 treatment which was statistically superior to all other treatments. The lowest (11.50 ppm) was found in T_1 treatment. Present findings were in line with the results of [45] who described that the amendment of organic manures increased the phosphorous content in soil.

3.3.2.5 Exchangeable Potassium

Data shown in table 4 illustrated significant (P<0.05) variation in exchangeable K content in soil after harvest of the sweet pepper as influenced by different combination of organic and chemical treatments. Significantly highest exchangeable K content (0.37 meq/100g soil) was found in T_4 treatment. Next to T_4 treatment, T_3 treatment showed higher K content in soil which was statistically similar with the T_2 treatment. On the other hand, significantly lowest exchangeable K (0.29 meq/100g soil) was obtained from T_1 treatment that received no organic manures. Similar findings were reported by [48] where they demonstrate that vermicompost significantly increased potassium content by 40% over the control.

3.3.2.6 Available sulphur

Experimental results demonstrated that incorporation of different types of organic manures along with chemical fertilizers significantly (P<0.05) alter the sulphur content in soil (Table 4). The highest sulphur (16.41 ppm) content was estimated in T_4 treatment which was statistically alike with T_3 treatment. On the contrary, significantly lowest sulphur content (10.92 ppm) was determined in T_1 treatment but statistically similar with T_2 treatment. Organic manure is a vital source of sulphur in soil. Therefore, mineralization of organic manure might release more sulphur in soil that resulted increased sulphur content in organic manure plots as compared to the application of chemical fertilizers alone.

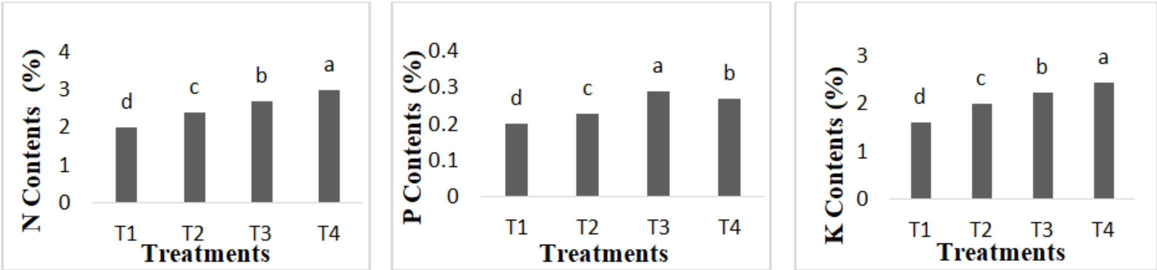

Fig. 1. Effect of organic and chemical fertilizers on the nitrogen, phosphorous and potassium content in the fruits of sweet pepper

T_1:100% recommended dose of chemical fertilizers (RDCF), T_2: Cow Dung (10ton/ha) + IPNS based (RDCF), T_3: Poultry Manure (10 ton/ha) + IPNS based (RDCF), T_4: Vermicompost (10 ton/ha) + IPNS based (RDCF)

Table 4. Residual nutrients in soil after final harvest of sweet pepper

Treatment	pH	OC (%)	Total N (%)	P (ppm)	K (meq/100g of soil)	S (ppm)
T_1	5.84c	0.95c	0.059c	11.50d	0.29c	10.92c
T_2	6.02b	1.03bc	0.065c	13.50c	0.32b	13.17bc
T_3	6.11b	1.08ab	0.079b	17.16a	0.34b	14.95ab
T_4	6.26a	1.14a	0.092a	15.50b	0.37a	16.41a
$LSD_{0.05}$	0.12	0.09	0.01	0.58	0.03	2.29
CV (%)	1.02	4.16	7.69	2.00	3.91	8.27

In a column figures having similar letter (s) do not differ significantly at 5% level of probability.
T_1:100% recommended dose of chemical fertilizers (RDCF), T_2: Cow Dung (10 ton/ha) + IPNS based (RDCF), T_3: Poultry Manure (10 ton/ha) + IPNS based (RDCF), T_4: Vermicompost (10 ton/ha) + IPNS based (RDCF)

4. CONCLUSION

Integrated application of organic manures with mineral fertilizers had a significant positive impact on growth, yield contributing characters, yield and nutrient content in capsicum (*Capsicum annuum*). Treatment comprising 10 t/ha vermicompost with IPNS based inorganic fertilizers exhibited better result for the production of capsicum. Integrated applications of vermicompost along with inorganic fertilizers displayed higher performance in terms of nutrient status in post-harvest soil indicating the improvement of soil fertility when compared with the application of inorganic fertilizers only.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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