Original Research Article

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

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ABSTRACT

The experiment was conducted in the research field of the Department of Soil Science, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur to investigate the effect of different organic manures in combination with synthetic chemical fertilizers on growth, yield and yield contributing characters of BARI Capsicum I (*Capsicum annuum var. grossum* L.), a variety of sweet pepper. Nutrient content of capsicum and soil fertility status were also assessed. The experiment was established in a randomized complete block design (RCBD) with three replicates. Treatments of the study 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). Results of the experiment showed that application of organic manures along 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 resulted better nutrient uptake as compared to the sole application of chemical fertilizers. Among the treatments, vermicompost treated plots gave the higher yield of sweet pepper and improved the post-harvest soil nutrient status. Vermicompost was found to be suitable as substitute of other organic manures for the production of capsicum.

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Keywords: Capsicum, Manures, Fertilizers, Nutrition, Soil fertility

1. INTRODUCTION

Sweet pepper *(Capsicum annuum* L.) is a highly nutritious spices cum vegetable crop belongs to the family Solanaceae under the genus *capsicum*. It is one of the most popular vegetable crops grown extensively throughout the world especially in the temperate countries. In Bangladesh, some advanced farmers grow capsicum sporadically to meet the demand 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]. Organic manures perform better than inorganic fertilizers related to soil fertility and productivity as 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 increase 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 due to lower supply of nutrients to meet the crop requirement [13]. This implies that application of organic or inorganic fertilizers alone is never a suitable solution for maintaining soil health and increasing crop productivity. Therefore, the integrated nutrient management is the best approach to maintain soil fertility and productivity on 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] including sweet pepper [21]. Integration of organic manures and chemical fertilizers also enhance soil properties particularly the soil organic carbon status and microbial community [22]-[23]. Khanam et al., [24] reported that application of organic and inorganic fertilizers increases cauliflower production in acid soil of Bangladesh. Thus, economic and eco-friendly use of manures in combination 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 influence 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. Keeping these in mind, the preset investigation was undertaken to evaluate the effect of integrated nutrient management (organic and mineral) on yield contributing characters, yield and nutritional quality of capsicum as well as to assess the soil nutrient status.

2. MATERIAL 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, 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 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

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The soil of the experimental field belongs to the Salna series and has been classified Shallow Red Brown Terrace Soil in Bangladesh. According to USDA Soil taxonomy, the soil falls under the order Inceptisol with pH of around 5.8 [25]. The soils are 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 ratio of 1:2.5 [27]. Organic carbon (%) was analyzed by wet oxidation method as prescribed by Walkley and Black [28]. The total nitrogen content of collected soil sample was determined by Kjeldahl method [27]. Available P was determined following Bray and Kurtz [29] method for acid soil. Available sulfur of the soil samples was determined by turbidimetric method as described by Hunter [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 12 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 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, seedling rising 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

Capsicum variety BARI Capsicum I was used as the test crop. Seeds were collected from the olericulture division, horticulture research center, Bangladesh Agricultural Research Institute (BARI) and seedlings were raised in the experimental field of department of Soil Science of BSMRAU, Salna, Gazipur.

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.

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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 methods of Piper [32].

2.10 Statistical analysis

Data were analyzed statistically with the help of computer package Statistix 10 . 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].

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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

Plant height of sweet pepper was markedly influenced by the application of organic manures in combination with synthetic chemical fertilizers as compared to the sole application of chemical fertilizers (Table 1). The highest plant height (59.3 cm) was obtained from treatment T_4 where vermicompost was used with IPNS based chemical fertilizers which was significantly superior to all other treatments. The lowest plant height of (38.3 cm) was found in T_1 treatment receiving only chemical fertilizers but statistically similar result was obtained in cowdung treated plot.

Higher plant height in treatments receiving vermicompost might be due to the higher availability of micro nutrients and macro nutrients that plants can easily assimilate for their growth and development. This type of manure also contains some of the secretions of worms and its associated microbes, which acts as growth promoters along with other nutrients. Because of all these vital substances, vermicompost has multifarious effects that influence the growth of sweet pepper. John and prabha [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) variation was observed in number of branches per plant with the application of organic manures (Table 1). Combined application of organic manures along with chemical fertilizers exhibited remarkable positive effect on number of branches of sweet pepper. The maximum number of branches (9.0) was observed from T_4 treatment which was followed by T_3 and T_2 treatments. The minimum number of branches (4.0) was recorded from T_1 treatment that received only mineral fertilizers. Pariari and khan [35] showed that average number of branches per plant (*Capsicum annuum* L.) was maximum under 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 a very potential organic input for agriculture, contains not only the beneficial microorganisms and major (N, P, K) and micronutrients, 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 per plant.

Table 1. Growth and yield contributing parameters of sweet pepper as 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	0.354
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 indicated 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 obtained from the T_4 treatment followed by T_3 treatment (196.3 g/plant). Among the treatments, the lowest shoot fresh weight 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 agreement with the findings of Uribe-Lorío et al., [37] who illustrated significant increases in shoot fresh weights from plots treated with vermicompost compared to those from plots treated with chemical fertilizer only. 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

Different organic manures in combination with chemical fertilizers showed significant influence on shoot dry weight at 5% level of probability (Table 1). Significantly highest 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 similar with T_2 treatment. Our results are in harmony with the findings of Arancon et al., [38] and Uribe-Lorío et al., [37] who illustrated significant increases in shoot weights from plots treated with vermicompost compared to those from plots treated with chemical fertilizer only.

Vermicompost is a rich source of vitamins, hormones, enzymes, macro and micronutrients which when applied to plants help in efficient growth [39]. The growth rate was fast due to increased uptake of macro and micronutrients present in the vermicompost, which might result in increased biomass production in vermicompost applied plants. Earthworms effectively harness the beneficial soil micro flora, destroy soil pathogens and convert organic wastes into vitamins, enzymes, antibiotics, growth hormones and protein rich casts which might help the sweet pepper plant for greater accumulation of shoot biomass.

3.1.5 Number of flowers per plant

The number of flowers of sweet pepper was increased in organic manure amended plots under the present study (Table 1). There was significant variation in the number flowers per plant due to application of 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 recorded in T_1 (14.0) where no organic manures were applied but only chemical fertilizers was used. Similar result was reported by Arancon et al., [38] who recorded significantly highest number of strawberry flowers in plots treated with vermicompost compared to those that received chemical fertilizers only. 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 highest 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 recorded from T_1 treatment receiving only synthetic chemical fertilizers. The findings were in line with many research results. Kumar and Dahiya [40] and Pariari and Khan [35] observed the highest number of fruits per plant 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 treated plots which was statistically similar with the cowdung applied treatments (6.5 cm). Similar findings were observed by Pariari and Khan [35] where they showed significant increase of fruit diameter of *Capsicum annuum* due to the integrated use of vermicompost with the chemical fertilizers. Vermicompost is effective organic manure which would facilitate increased 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 Pariari and Khan [35] who described increasing fruit length of *Capsicum annuum* with the application of organic amendments over sole use of chemical fertilizers.

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)*

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 Kumar and Dahiya [40]. Application of organic manures maintain better soil environment through increasing the microbial activity that might enhance the nutrient availability for sweet pepper production and thus increase the fruit weight of pepper as compared to the sole application of synthetic chemical fertilizers.

3.1.10 Fruit yield (t/ha)

Fresh 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).

Experimental results demonstrated that sweet pepper yields were increased due to combined application of organic and chemical fertilizers 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 increased due to the integrated use of organic and chemical fertilizers. The findings were in agreement with many other researchers. Huerta et al., [41] observed that fruit production of pepper was significantly more in plants raised in vermicompost. Similar findings were also reported by Arancon et al., [38]. The improvements in plant growth and increases in fruit yields might be due to the increases in soil microbial biomass after vermicompost applications, leading to production of hormones or humates in the vermicomposts acting 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 Kumari and Ushakumari [42] who reported that treatment with enriched vermicompost was superior to other treatments for the nutrient content including N, P, K, Ca and Mg in cowpea.

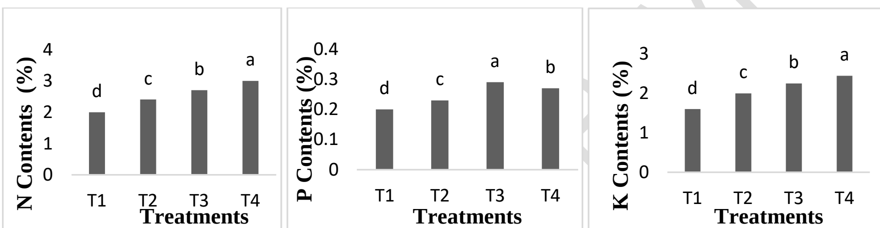

Fig. 1. Effect of organic and chemical fertilizers on the nitrogen, phosphorous and potassium content in the fruits of sweet pepper

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)

3.2.2 Phosphorous content in sweet pepper

Organic manures significantly increased the phosphorus content in the fruits of sweet pepper as compared to the chemical fertilizer treated plots (Fig.1). Significantly highest phosphorous content in sweet pepper was found (0.29%) in T_3 treatment which was statistically superior to all other treatments. The lowest phosphorous content (0.20%) was found from T_1 treatment. The results indicated that the application of organic manures in combination with chemical fertilizers increases the nutrient content in sweet pepper. Nutrients in organic manures are present in readily available forms for plant uptake; e.g. NO_3, exchangeable P, K, Ca and Mg [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 Klara [44].

3.3 Effect of organic manures in combination with 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 [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 (0.056%) 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	5.8
OC (%)	0.9
Total N (%)	0.056
P (ppm)	9.8
K (meq/100g of soil)	0.2
S (ppm)	10.8

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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 significantly different from others 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. John and Prabha [34] also reported elevated levels of soil pH after vermicomposting.

3.3.2.2 Organic carbon

Study results indicated 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 by Zhang et al., [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) variation was recorded on 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. Bangar et al., [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. Compared with applying only chemical fertilizers, combined application of organic manure and chemical fertilizers as a total basal dressing is beneficial to the balanced release of nutrients and reduction of N loss, thus increasing the N use efficiency [47].

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)

3.3.2.4 Available phosphorous

Experimental findings revealed that phosphorous content of postharvest soil was significantly (P<0.05) influenced by different treatments (Table 4). Combined effect of different types of organic and chemical fertilizers showed significant variation on available phosphorous content in postharvest 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 results were supported the findings of Zhang et al., [45] who reported that the application of organic fertilizers increased the availability of phosphorous 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. Ramalingam [48] reported that vermicompost increased significantly potassium 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 sole application of chemical fertilizers.

4. CONCLUSION

Integrated application of organic manures with mineral fertilizers had a significant positive effect on growth, yield contributing characters, yield and nutrient content in capsicum (*Capsicum annuum*). Treatment comprising 10 t/ha vermicompost with IPNS based chemical fertilizers showed better performance for the production of capsicum. Integrated applications of vermicompost in combination with chemical fertilizers showed better performance in terms of nutrient status in post-harvest soil indicating the improvement of soil fertility as compared to the sole application of synthetic chemical fertilizers.

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