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ACCUMULATION OF NITROGEN, PHOSPHORUS, POTASSIUM AND SULFUR IN CAPSICUM (*CAPSICUM ANNUUM* L.) AS INFLUENCED BY VERMICOMPOST AND NPK FERTILIZERS

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Abstract

Soil fertility is one of the most promising factors that directly impact sustainable crop production. Therefore, a pot experiment was conducted in net house on capsicum (*Capsicum annuum* L.) in the agricultural soil to study the effects of vermicompost (VC) and inorganic fertilizers (NPK) on growth, yield and nutrient content in capsicum plants. The growth parameters and nutritional values were observed during the experiment under eleven treatments. The treatments variables are T_1 (control, -VC & -NPK), T_2 (VC 5 ton/ha), T_3 (VC 10 ton/ha), T_4 (VC 15 ton/ha), T_5 ($N_{60}P_{35}K_{60}$ kg/ha), T_6 (VC 5 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha), T_7 (VC 10 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha), T_8 (VC 15 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha), T_9 (VC 5 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha), T_{10} (VC 10 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha), T_{11} (VC 15 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha) which were arranged in a completely randomized design (CRD) with three replications. There were statistically significant differences in each treatment for growth and yield parameters. The highest plant height (45 cm), the highest number of leaves (44 no/plant), and the highest leaf area index (90 cm^2) were found in the treatments T_6, T_5 and T_9 respectively. The lowest values for all of the above parameters were found in the treatment T_1 (control). Then the highest yield parameters fruit no/plant (3), total fresh weight (39.60 g/plant), and total dry weight (2.38 g/plant) were observed under the treatment T_{11}. The results of the growth and yield parameters varied significantly ($p<0.05$). The concentrations of total N, P, K and S in different parts were measured and varied significantly ($p<0.05$) in leaf, stem, root and seeds. Analysis of post-harvest soil also revealed that every physico-chemical property and nutritional value were changed significantly due to different treatments.

Introduction

Capsicum or sweet pepper (*Capsicum annuum* L.) popularly known as the "King of spices" belongs to the plant family Solanaceae. It is a popular vegetable and spice crop was originated in Mexico. Sweet pepper is grown as an annual crop due to its sensitivity to frost and is actually an herbaceous perennial and will survive and yield for several years in tropical climates[1]. Ideal growing conditions for sweet peppers include warm soil, ideally 21°**C** to 29°C (70°**F** to 84°F) that is kept moist but not waterlogged. The fruits of capsicum (*Capsicum annum* L.) are used extensively as in all local soups, stews and sauces[2]. The

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nutritional quality of the fruits, especially as an excellent source of antioxidants- ascorbic acid, carotenoids and phenolic compounds makes the daily intake of pepper a health-protecting factor in the prevention of chronic human degenerative and systemic sicknesses including cancer, diabetes, liver cirrhosis and cardiovascular diseases[3]. Sweet pepper is famous for its pleasant aromatic flavor, pungency and high coloring substance. It is used very widely in the culinary, pharmaceutical and beverage industries.

There is no spice probably as popular as chili and no other spice has become such an indispensable ingredient of the daily food of the majority people of the world[4]. As agriculture technologies develop and become more intensive in their use of land and water resources in order to increase food production to meet the nutritional demand of the vast growing population, its negative impacts on agricultural ecosystems become more destructive[5]. For getting higher yield, unrestricted and excessive use of inorganic fertilizer increases crop yield in some extent but deteriorates soil health and prompts environmental pollution[6]. Consequently, great attention has been given to clean agriculture and the application of eco-friendly practices. One of the most significant ways to achieve this is by using organic and biofertilizers farming. Organic farming of vegetables is most appropriate as most of the vegetables are consumed in fresh form and chemical residues have an adverse effect on human health. Nitrogen is a major limiting nutrient for crop production. It can be applied through chemical or biological means. Over-application can result in negative effects such as leaching, pollution of water resources and destruction of microorganisms and friendly insects. Due to the prohibitive cost of chemical fertilizers, the majority of farmers who are mostly marginal and small, do not apply the recommended dose of fertilizers. The use of organic fertilizers provides soil with essential nutrients and adsorbs nutrients against leaching. It also improves soil texture, increases ion exchange capacity of soil, increases soil microbial populations and activity, improves the moisture-holding capacity of the soil and enhances soil fertility[7]. Lower availability of plant nutrients in plots applied with organic amendments is expected due to slower release rates of nutrients from organic materials, particularly during the initial years of conversion to organic production[8]. Organic manures supply the major nutrients and micronutrients, besides improving soil properties. Over-application can result in negative effects such as leaching, pollution of water, acidification and reduces the availability of the trace element or alkalization of the soil. Chemical fertilizer enhances the decomposition of soil organic matter, which leads to the degradation of soil structure and a decrease in soil aggregation results in nutrients being easily lost from soils through fixation, leaching, and gas emission and can lead to diminishing fertilizer efficiency[9,10,11]. Over-application of chemical fertilizers can destroy decomposers and other soil organisms, reduce the colonization of plant roots with mycorrhizae and inhibit symbiotic N-fixation by rhizobia due to high N-fertilization and also hazardous to the soil environment. This showed that over-treatment of chemical fertilizer causes problems not only to the soil health but also to the human health and physical environment[12,13]. Organic farming for capsicum production is increasing day by day in Bangladesh[14].

The objectives of the present experiment were to evaluate the accumulation of nutrients (nitrogen, phosphorus, potassium and sulfur) in root, shoot, leaf and fruit of capsicum grown in soil as influenced by the application of vermicompost and chemical fertilizers.

Materials and Methods

Soil samples were collected by composite soil sampling method from Dhamrai, Dhaka district which is situated at 23°54′53.4″N Latitude and 90°13′2.76″E Longitude. The sample was collected at a depth of 0-15 cm, and then air-dried, grounded and sieved through a 2 mm sieve. The soil had a pH of 7.3 (1:2.5 w/v H_2O), organic carbon 0.265%[15], available nitrogen 2.55%[16], available phosphorus 0.41%[17], exchangeable potassium 0.88%[18], available sulfur 0.28%[19], sand 4.68%, sillt 69.45% and clay 26.1% and silt loam[20] textural class.

A pot experiment was conducted in the net house of the Department of Soil, Water and Environment, the University of Dhaka during the rabi season (November, 2020 - March, 2021). Eleven treatments with three replications were T_1: Control (without vermicompost and NPK fertilizer / -VC and -NPK), T_2: VC 5 ton/ha, T_3: VC 10 ton/ha, T_4: VC 15 ton/ha, T_5: 100% NPK fertilizer / $N_{60}P_{35}K_{60}$ kg/ha, T_6: VC 5 ton/ha + 80% NPK fertilizer / $N_{48}P_{28}K_{48}$ kg/ha, T_7: VC 10 ton/ha + 80% NPK fertilizer / $N_{48}P_{28}K_{48}$ kg/ha, T_8: VC 15 ton/ha + 80% NPK fertilizer / $N_{48}P_{28}K_{48}$ kg/ha, T_9: VC 5 ton/ha + 60% NPK fertilizer / $N_{36}P_{21}K_{36}$ kg/ha, T_{10}: VC 10 ton/ha + 60% NPK fertilizer / $N_{36}P_{21}K_{36}$ kg/ha and T_{11}: VC 15 ton/ha + 60% NPK fertilizer / $N_{36}P_{21}K_{36}$ kg/ha. Different doses of fertilizers were applied according to the Fertilizer Recommendation Guide-2012[21]. Fertilizers were thoroughly mixed with soil. Water was added to bring the soil approximately to the field capacity and was kept in this condition for three days with the occasional addition of water whenever necessary. The experimental pot was arranged in a Completely Randomized Design (CRD).

Capsicum was harvested after 120 days from the date of germination of seeds. Plants were uprooted and the roots were washed with distilled water to remove any adhering particles on the root surface. The collected plants were separated into different parts like roots, stems, leaves and fruits. The fresh weights of the samples were taken. After that, the samples were oven dried at 65°C for 48 hours that previously packed in envelops and then oven-dried weights were taken. The dried samples were then ground separately and preserved in plastic bottles for chemical analysis.

Total nitrogen of plant samples was determined by micro Kjeldahl's method following concentrated sulphuric acid (H_2SO_4) digestion[22]. The total phosphorus content of the plant samples was determined by colorimetric method using a spectrophotometer wavelength ranging from 400 to 490 nm by developing blue color with ascorbic acid[23]. The total potassium content was determined by a flame photometer[23]. Total sulfur was measured by a spectrophotometer at 420 nm[24].

All the data in the study were subjected to statistical analysis with the help of Microsoft Excel. For the interpretation of results, the mean differences of the treatments were compared using the LSD method at 5% level of significance[25].

Results and Discussion

Plant growth was observed and evaluated in terms of plant height, the number of leaves, leaf area, fresh and dry weight of root, shoot, leaf and fruit (data not shown) which increased significantly with the increasing doses of vermicompost. The maximum plant height (45 cm) was observed at treatment T_6 (VC 5 ton/ha + 80% NPK), the highest number of leaves (44 no/plant) was observed at treatment T_5 (100% NPK) and the highest leaf area index (90 cm^2) was recorded at treatment T_9 (VC 5 ton/ha + 60% NPK). The lowest values for all of the above parameters were found in the treatment T_1 (control, -VC and -NPK). Then the highest yield parameters fruit no/plant (3), total fresh weight (39.60 g/plant), and total dry weight (2.38 g/plant) were observed under the treatment T_{11}. The results of the growth and yield parameters varied significantly ($p<0.05$).

A significant effect of vermicompost incorporated with inorganic fertilizer on nitrogen content in root, shoot, leaf and fruits of capsicum at 5% level of probability was recorded (Table 1). The integrated application of vermicompost with NPK fertilizer showed a significant result to the single use of vermicompost or NPK fertilizer. The highest nitrogen concentration in fruit (4.45%) and shoot (3.25%) were observed in treatment T_8 (VC 15 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha). Among the treatments, the lowest nitrogen content in fruit (3.44%) and shoot (1.50%) were observed in treatment T_2 (VC 5 ton/ha) and T_1 (Control, -VC and -NPK) respectively. The present study data was in harmony with the findings of another researcher[26] that reported vermicompost-enriched treatments are somewhat superior to other organic manure-enriched treatments in terms of nutrient supply and it also caters to certain plant growth-stimulating substances[27] which might increase nutrient uptake from soil. The solubilization effect of plant nutrients by the addition of vermicompost led to increased uptake of NPK and resulted in the maximum number of flowers per plant in capsicum.

Table 1. Concentration (%) of nitrogen in different parts of capsicum as influenced by vermicompost and NPK fertilizers.

Treatments	Root	Shoot	Leaf	Fruit
T_1: Control (-VC and -NPK)	1.772	1.502	4.441	3.513
T_2: VC 5 ton/ha	2.125	1.565	3.853	3.440
T_3: VC 10 ton/ha	2.778	2.260	5.345	3.980
T_4: VC 15 ton/ha	2.729	1.623	3.615	3.777
T_5: $N_{60}P_{35}K_{60}$ kg/ha	2.456	2.865	3.147	4.175
T_6: VC 5 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	1.780	2.050	4.984	4.065
T_7: VC 10 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	1.943	2.347	5.031	3.921
T_8: VC 15 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	2.398	3.246	4.930	4.445
T_9: VC 5 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	2.245	1.962	5.6	4.266
T_{10}: VC 10 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	3.291	2.440	4.643	3.995
T_{11}: VC 15 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	2.317	2.494	5.345	3.955
LSD at 5% level	1.038	1.021	1.516	0.882

The analysis of variance (ANOVA) of the data showed that phosphorus concentration in different parts of the Capsicum was different because of the different doses of organic and inorganic fertilizers and the results varied significantly ($P < 0.05$). Vermicompost combined with chemical fertilizer significantly increased the phosphorus concentration in fruit and different parts of capsicum are presented in Table 2. The highest phosphorus concentration in root (0.3645%), shoot (0.3645%), leaf (0.6432%) and fruit (0.9068%) were found at treatment T_7 (VC 10 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha), T_8 (VC 15 ton/ha + $N_{48}P_{28}K_{48}$ kg/ ha), T_6 (VC 5 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha) and T_5 ($N_{60}P_{35}K_{60}$ kg/ha) respectively. In root, shoot, leaf and fruit the lowest value was recorded in 0.1492% at T_3 (VC 10 ton/ha), 0.2840% at T_5 ($N_{60}P_{35}K_{60}$ kg/ha), 0.2232% at T_4 (VC 15 ton/ha) and 0.6523% at T_4 (VC 15 ton/ha). With the different doses of vermicompost incorporated with mineral fertilizer showed a more promising result than vermicompost or mineral fertilizer alone except for phosphorous in fruit. This might occur because nutrients are in readily available form in vermicompost for plant uptake[28].

Table 2. Concentration (%) of phosphorus in different parts of capsicum plant as influenced by vermicompost and NPK fertilizers.

Treatments	Root	Shoot	Leaf	Fruit
T_1: Control (-VC and -NPK)	0.3605	0.2845	0.4050	0.8540
T_2: VC 5 ton/ha	0.1718	0.3255	0.4940	0.7564
T_3: VC 10 ton/ha	0.1492	0.3216	0.3328	0.8248
T_4: VC 15 ton/ha	0.2757	0.2901	0.2232	0.6523
T_5: $N_{60}P_{35}K_{60}$ kg/ha	0.3125	0.2840	0.4464	0.9068
T_6: VC 5 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	0.2812	0.3289	0.6432	0.8370
T_7: VC 10 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	0.3645	0.3216	0.4394	0.8951
T_8: VC 15 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	0.2982	0.3645	0.5040	0.7658
T_9: VC 5 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	0.2654	0.3375	0.2840	0.8593
T_{10}: VC 10 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	0.3308	0.3550	0.3219	0.7523
T_{11}: VC 15 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	0.3183	0.3375	0.4869	0.8125
LSD at 5% level	0.0419	0.0573	0.0596	0.2154

Potassium (K) is one of the 17 essential elements required by plants for healthy growth and reproduction. Along with Nitrogen(N) and Phosphorus(P), Potassium(K) is classified as a macronutrient, and is considered second only to Nitrogen in terms of its importance to plant growth. Potassium content varied with the variation of treatment. The analysis of variance (ANOVA) of the data showed that (Table 3) phosphorus concentration in different parts of the Capsicum was different because of the different doses of organic and inorganic fertilizers and the results varied significantly at $P < 0.05$. The total potassium concentration in roots, shoots, leaves and fruits of Capsicum are influenced by different rates of NPK and vermicompost application. It is revealed that the highest value of K (7.78%) in leaf was obtained with treatment T_3 where 10 ton/ha vermicompost was applied followed by T_6 where K content was 7.02%. The lowest value of K was observed (1.71%) in root in treatment T_4 (VC 15 ton/ha). Conversely, treatment T_4 produced the highest amount of potassium content in fruits of capsicum. It can be concluded from the present study that an increased amount of vermicompost might increase the phosphorous concentration in different parts of the capsicum plants.

Table 3. Concentration (%) of potassium in different parts of capsicum plant as influenced by vermicompost and NPK fertilizers.

Treatments	Root	Shoot	Leaf	Fruit
T_1: Control (-VC and -NPK)	3.31	5.39	5.56	5.25
T_2: VC 5 ton/ha	2.66	4.43	4.71	5.68
T_3: VC 10 ton/ha	3.50	3.50	7.78	4.50
T_4: VC 15 ton/ha	1.71	4.68	3.91	5.91
T_5: $N_{60}P_{35}K_{60}$ kg/ha	2.76	5.88	7.01	3.50
T_6: VC 5 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	2.30	3.23	7.02	3.47
T_7: VC 10 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	2.56	3.47	3.68	3.42
T_8: VC 15 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	2.12	4.20	5.36	4.25
T_9: VC 5 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	4.43	3.69	4.81	5.78
T_{10}: VC 10 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	3.14	3.11	5.79	3.67
T_{11}: VC 15 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	2.52	3.22	4.66	4.50
LSD at 5% level	0.225	0.337	0.382	0.215

Sulfur (S) is one of 17 essential elements required by plants for healthy growth and reproduction. Sulfur (S) content varied with the variation of treatment. The analysis of variance (ANOVA) of the data showed that phosphorus concentration in different parts of the Capsicum was different because of the different doses of organic and inorganic fertilizers and the results are varied significantly ($P \leq 0.05$). The test of the significance of average nitrogen contents at different treatments were evaluated by LSD test at 5% level of significance.

The total sulfur concentration in roots, shoots, leaves and fruits of capsicum were influenced by different rates of NPK and vermicompost application which can be observed in Table 4. It is revealed that the highest value of K (1.33%) in fruit was obtained in treatment T_5 where only NPK fertilizers were applied at $N_{60}P_{35}K_{60}$. The lowest value of Sulfur was observed (0.2145%) in root in treatment T_2 (VC 5 ton/ha).

Table 4. Concentration (%) of sulfur in different parts of capsicum plant as influenced by vermicompost and NPK fertilizers.

Treatments	Root	Shoot	Leaf	Fruit
T_1: Control (-VC and -NPK)	0.4692	0.7882	0.8693	0.7031
T_2: VC 5 ton/ha	0.2145	0.3458	0.5690	0.6383
T_3: VC 10 ton/ha	0.5625	0.5146	0.5875	0.8772
T_4: VC 15 ton/ha	0.5882	0.2241	0.6250	1.0100
T_5: $N_{60}P_{35}K_{60}$ kg/ha	0.5625	0.8333	0.7865	1.3300
T_6: VC 5 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	0.6250	0.9027	0.5833	0.4241
T_7: VC 10 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	0.5000	0.7252	0.9654	0.7954
T_8: VC 15 ton/ha + $N_{48}P_{28}K_{48}$ kg/ha	0.7386	0.5000	0.5419	0.6597
T_9: VC 5 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	0.3923	0.9359	0.8690	1.0714
T_{10}: VC 10 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	0.3947	0.8443	0.7683	0.9000
T_{11}: VC 15 ton/ha + $N_{36}P_{21}K_{36}$ kg/ha	0.6250	0.7500	0.4333	0.8742
LSD at 5% level	0.065	0.053	0.047	0.236

The present experiment indicates that, the integrated application of vermicompost with mineral fertilizers increases the growth and yield of capsicum more than single-use as well as increases the accumulation of nutrients (N, P, K and S) in capsicum. Treatment T_{11} comprising 15 ton/ha vermicompost with 60% NPK fertilizers exhibited better results for the production of capsicum. So, it can be inferred that, integrated applications of vermicompost along with inorganic fertilizers increase soil fertility as well as accumulation of plant nutrients.

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