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PRODUCTIVITY AND NUTRIENT COMPOSITION OF CUCUMBER (*CUCUMIS SATIVUS* L.) GROWN UNDER INTEGRATED APPLICATION OF VERMICOMPOST, PHOSPHOROUS AND ZINC FERTILIZERS

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Keywords: Cucumber, Vermicompost, Phosphorous, Zinc, Growth and yield, Nutrient content

Abstract

To evaluate the integrated effect of vermicompost, phosphorous, and zinc fertilizer on plant yield and nutritional quality of cucumber *(Cucumis sativus* L.), a pot experiment was conducted in the net house at Soil, Water, and Environment Department of the University of Dhaka. In this study, eight treatments *viz.* T_1: control, T_2: VC_6 t ha^{-1}, T_3: P_{25} kg ha^{-1}, T_4: $Zn_{1.5}$ kg ha^{-1}, T_5: VC_6 t ha^{-1} + P_{25} kg ha^{-1}, T_6: VC_6 t ha^{-1} + $Zn_{1.5}$ kg ha^{-1}, T_7: P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1}, T_8: VC_6 t ha^{-1} + P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1} with three replicates were used by following a completely randomized design (CRD). A one-way ANOVA with a Tukey post-hoc test revealed statistically significant differences in growth and yield metrics between the treatments ($p \leq 0.05$). The maximum growth and yield contributing attributes *viz.* plant height (123 cm), leaf number (30 $plant^{-1}$), leaf area (155.45 cm^2), stem girth (2.70 cm), branch number (18 $plant^{-1}$), fruit number (7 $plant^{-1}$), and fruit fresh (382 g) and dry (33 g) weight were detected in the treatment VC_6 t ha^{-1} + P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1} (T_8). The treatment T_1 (control) exhibited the lowest values for all the aforementioned treatments. The nutrient quality attributes in fruits were analyzed highest in the same treatment T_8. So, farmers are advised to apply VC_6 t ha^{-1} + P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1} in their fields because it can help make land management and cucumber production more sustainable.

Introduction

The cucumber (*Cucumis sativus* L.) is one of the most popular vegetable crops and belongs to the Cucurbitaceae family(1). It is widely consumed as fresh in salad, fermented (pickles) items, or as a cooked vegetable(2). Cucumber is known as garden cucumber, apple cucumber, and gherkin, and in Bangladesh, its local name is 'Khira'. There are several cucumber varieties, but the edible cucumber is classified under two groups the slicing and pickling cucumber. Cucumber plays a vital role in meeting the vegetable shortage during the scarce period and helps to improve the malnutrition problem in Bangladesh. It was found helpful against human constipation and improvement in digestion. It is a cooling food in summer(3). Cucumber contains nutrients that are vital for

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body development[4]. It also has several other health benefits, such as rehydrating the body, regulating blood pressure, body weight management, cholesterol reduction, cancer prevention, bone health, diabetes cure, and antioxidant activity[5]. In a 100 g serving, raw cucumber (with peel) contains 95% water, provides 16 kcal energy, 3.63 g carbohydrates, 1.67 g sugars, 0.50 g dietary fiber, 0.11 g fat, and 0.65 g protein and supplies low content of essential nutrients, as it is notable only for vitamin K at 16% of the daily value[6]. A fresh cucumber provides vitamin A and C, niacin, iron, calcium, thiamine, fibers, and phosphorus[7].

Cucumbers are believed to possess antidiabetic, lipid-lowering, and antioxidant properties. It grows on moist, well-drained (sandy) soils rich in organic matter and slightly alkaline. It prefers full sun exposure in warm and humid climates; it is not frost-resistant[8]. Cultivating cucumbers requires soil with a high water-holding capacity and good drainage. It also requires soil rich in organic matter and manure. The soil pH ranges from 5.5 to 7.0. More than 50% production of cucumber comes from Asia[6]. It is profitable, and its net return per hectare is relatively higher. In Bangladesh, cucumber is an important summer vegetable crop. The total production of cucumber was 73220 Mt during the year 2018-2019[9].

Unfortunately, the soils of Bangladesh are deficient in organic matter and plant nutrients, especially nitrogen and phosphorus. Due to poor management practices and unbalanced use of chemical fertilizers, organic matter content is getting reduced day by day, which ultimately reduces microbial activity and causes macro and micronutrient deficiencies. Vermicompost is a potential input and nutritive organic fertilizer rich in humus, macro and micronutrients, growth hormones (auxins, gibberellins, and cytokinins), and beneficial for soil microbes. It is an excellent soil amendment and conditioner[10]. Phosphorous is essential for the normal development of plants' roots and reproductive organs (flowers, fruits, seeds). Cucumber plants that grow with Zn exhibited decreased fusaric acid (FA) transportation to shoots and a 17% increase in toxicity mitigation with the antioxidant enzyme activity in both roots and leaves[11]. So, this study aimed to apply vermicompost, phosphorous and zinc in combination to have a fruitful outcome in cucumber plant growth and fruit development.

Materials and Methods

Description of experimental site: The soil sample was collected at 0-15 cm depth from an agricultural field of Duptara village, Araihazar thana, Narayanganj district, Bangladesh (latitude 23° 48' 15" N and longitude 90° 36' 47" E). The sampling site is a medium highland in AEZ-19 (Old Meghna Estuarine Floodplain). There were different agricultural practices in different seasons, such as mustard, wheat, grass peas, and potatoes during the Rabi, B. Aus, and T. Aman.

Analysis of soil samples and vermicompost: The collected soil was air-dried and sieved through a 2 mm stainless steel sieve. There was a relatively low quantity of sand (12.45%)

and clay (20.28%), with a high quantity of silt (67.27%) in the soil, hence; the textural class of the soil was silt loam. Some other physico-chemical properties of the pre-planting soil and vermicompost were determined with the standard method described by Jackson[12], presented in Table 1.

Table 1. Analysis of pre-planting soil (0-15 cm depth) and vermicompost for physico-chemical characteristics.

Soil attributes	Values	Vermicompost attributes	Values
pH	7.39	pH	6.95
EC (µS cm^{-1})	128.8	EC (µS cm^{-1})	425
OM (%)	0.58697	OC (%)	7.85
OC (%)	0.34047	OM (%)	13.67
Available N (%)	0.0084	Total N(%)	0.943
Available P (ppm)	2.9853	Total P (ppm)	7597
Available K (ppm)	48.5	Total K (ppm)	648.2
Available S (ppm)	11.083	Total S (ppm)	7865
Total Fe (ppm)	13420	Total Fe (ppm)	12965
Total Zn (ppm)	40.25	Total Zn (ppm)	123.31

Pot preparation and experimental design: The pot preparation was conducted in the kharif season at the net house of the Department of Soil, Water and Environment, University of Dhaka, Bangladesh (Fig. 1). This experiment consisted of eight different treatments, each with three replications.

The pots were arranged in a completely randomized design (CRD). Six-kg soil samples were taken in eight-kg capacity pots and marked by the treatment and replication numbers. Vermicompost, TSP for phosphorous, and ZnO for Zn fertilizer were used. The certified cucumber seeds were collected from Bangladesh Agricultural Research Institute (BARI) in Gazipur. The seeds have an 80% germination rate and 98% physical purity. All fertilizers were collected from the Bangladesh Agricultural Development Corporation (BADC) sales center, Motijheel, Dhaka. The experiment comprised organic manure (vermicompost), inorganic fertilizers (macronutrient phosphorus and micronutrient zinc), and control. Treatments were T_1: control, T_2: VC_6 t ha^{-1}, T_3: P_{25} kg ha^{-1}, T_4: $Zn_{1.5}$ kg ha^{-1}, T_5: VC_6 t ha^{-1} + P_{25} kg ha^{-1}, T_6: VC_6 t ha^{-1} + $Zn_{1.5}$ kg ha^{-1}, T_7: P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1}, T_8: VC_6 t ha^{-1} + P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1}. Watering was conducted at 3 days intervals for 60 days. The plants are exposed to direct sunlight for five hours a day, and the relative humidity was 50-60%.

Fig. 1. Cucumber plants during their growing period.

Harvesting: Data on plant height, leaf number, leaf area, stem girth, and branch number were recorded at 15 days intervals of up to 60 days. Cucumber fruits were harvested after 60 days. The fruit number and fresh weight fruit were recorded. After being dried by air and in an oven, samples were weighed on a dry weight basis and kept for further chemical testing.

Chemical analysis: The harvested cucumber fruits and post-harvested soil of each treatment were further chemically analyzed for their total and available nutrient content. Post-harvest soil analysis was done for organic matter, organic carbon and available N, P, K, S, Fe and Zn. Available nitrogen of the soils was determined by the micro steam distillation method proposed by Jackson[12]. Olsen extractant was used to extract phosphorous from alkaline soils (pH>7.0). Available phosphorus was determined calorimetrically by a HACH DR 5000 spectrophotometer at 880 nm wavelength after developing a blue color with sulfuric acid. A flame photometer was used to determine the available potassium after extracting the soil with 1 N ammonium acetate at pH 7.0[13]. Available sulfur in the soil samples was determined by the turbidity method. The extractant is 0.7 N sodium acetate plus 0.54 N acetic acid at pH 4.8[14]. A HACH DR 5000 spectrophotometer measured the turbidity at 420 nm wavelength. The organic carbon content of the soils and organic matter was estimated volumetrically by the wet oxidation method, as referred to by Walkley and Black[15]. A grounded fruit sample of 0.2 g from preserved samples was digested using concentrated nitric and perchloric acid at a ratio of 2:1 on a hot plate, as described by Jackson[12]. According to Nagornyy[16], 0.2g fruit and 0.5g vermicompost were digested for total nitrogen content in a Kjeldahl digestion flask. 0.2g fruit and 0.5g vermicompost were digested with nitric-perchloric acid (HNO_3:$HClO_4$ = 2:1) to determine the total P, K, and S as described by Huq and Alam[18]. Based on early determinations, the average nitrogen (N) content of proteins was found to be about 16 percent, which led to the calculation N*6.25 (1/0.16 = 6.25) to convert nitrogen content into protein content[17]. A VARIAN Atomic Absorption Spectrometer (AAS) was used to measure the iron and zinc in the digest (model AA240).

Statistical analysis: Statistical analyses of the collected data were performed using Minitab Statistics 20. The analysis of variance (ANOVA) was performed using a general linear model, and the significance test was performed by Tukey's range test at $p \leq 0.05$.

Results and Discussion

Effect of vermicompost, phosphorous, and zinc on cucumber's vegetative growth performance: Cucumber's growth performance under various treatments is presented in Table 2. Most parameters differed significantly ($p \leq 0.05$) among different treatments. The pots treated with VC_6 t ha^{-1} plus P_{25} kg ha^{-1} plus $Zn_{1.5}$ kg ha^{-1} (T_8) produced higher values for plant height, leaf number per plant, leaf area, stem girth, and branch number, whereas the control (T_1) showed statistically lower values for all parameters. However, T_8 had no significant difference from the application of VC_6 t ha^{-1} (T_2) in some cases. The remaining treatments showed intermediate effects. Using vermicompost and inorganic fertilizer significantly improved soil physico-chemical properties, mineral nutrients, and biological properties, increased cucumber yield, and improved fruit quality[18]. Syed *et al.*[19] found that vermicompost significantly improved spinach growth performance and increased yield attributes. Hossain *et al.*[20] reported that the overall best growth, yield, and nutrient accumulation in the height of chili were achieved in trichocompost 4 t ha^{-1} plus $N_{23}P_{10}K_{25}$ kg ha^{-1} treatment.

Effect of vermicompost, phosphorous, and zinc on cucumber's yield attributes: The fruit number and fresh and dry weight of cucumber fruits are shown in Table 3. There was a significant response of cucumber yield to various treatments. This experiment showed that the number of fruits and fresh and dry weights were significantly higher in pots treated with VC_6 t ha^{-1} plus P_{25} kg ha^{-1} plus $Zn_{1.5}$ kg ha^{-1} (T_8). The lowest value was observed in the control T_1 which produced a lower quantity of fresh and dry matter. Other treatments were also statistically significant than the control (T_1). Treatments T_2, T_3, T_4, T_5, T_6, and T_7 were statistically similar in the number of fruits. However, they showed significant differences in the weight of fresh and dry fruits. According to Novizan's[21] findings, the administration of micro plus macro fertilizers positively increased the fresh weight of cucumbers. Azarmi *et al.*[22] reported that the addition of vermicompost improved qualitative and quantitative properties and resulted in a higher total yield of cucumber.

Table 2. Integrated effect of vermicompost, phosphorous, and zinc fertilizer on cucumber's vegetative growth performances at 60 days after sowing (DAS). Means that do not share a letter are significantly different at 5% level by Tukey's Range Test performed separately for various treatments.

Treatments	Plant height (cm)	Number of leaves (plant^{-1})	Leaf area (cm^2)	Stem girth (cm plant^{-1})	Number of branches (plant^{-1})
T_1: Control (-VC, -P, -Zn)	50.00^b	15^b	76.00^b	1.85^c	11^b
T_2: VC_6 t ha^{-1}	104.00^a	26^a	100.13^{ab}	2.65^{ab}	16^{ab}
T_3: P_{25} kg ha^{-1}	94.00^{ab}	19^{ab}	99.44^{ab}	2.30^{abc}	16^{ab}
T_4: $Zn_{1.5}$ kg ha^{-1}	88.50^{ab}	18^{ab}	82.88^{ab}	1.95^c	15^{ab}
T_5: VC_6 t ha^{-1} + P_{25} kg ha^{-1}	102.00^a	20^{ab}	104.81^{ab}	2.60^{ab}	17^{ab}
T_6: VC_6 t ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	83.50^{ab}	16^{ab}	90.00a^b	2.10^{bc}	15^{ab}
T_7: P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	93.50^{ab}	17^{ab}	78.07^{ab}	1.95^c	14^{ab}
T_8: VC_6 t ha^{-1} + P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	123.00^a	30^a	155.45^a	2.70^a	18^a
Standard deviation	20.90	5.22	25.43	0.35	2.12

Table 3. Integrated effect of vermicompost, phosphorous and zinc fertilizer on yield of cucumber fruits at 60 days after sowing (DAS). Means that do not share a letter are significantly different at 5% level by Tukey's Range Test performed separately for various treatments.

Treatments	Number of fruits (plant^{-1})	Fresh weight (g plant^{-1})	Dry weight (g plant^{-1})
T_1: Control (-VC, -P, -Zn)	1^b	106^c	7.20^d
T_2: VC_6 t ha^{-1}	3.5^{ab}	326^a	28.80^{ab}
T_3: P_{25} kg ha^{-1}	3^{ab}	142^{bc}	11.90^d
T_4: $Zn_{1.5}$ kg ha^{-1}	2^{ab}	226^{abc}	21.90^{abcd}
T_5: VC_6 t ha^{-1} + P_{25} kg ha^{-1}	5.5^{ab}	272^{ab}	27.00^{abc}
T_6: VC_6 t ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	3^{ab}	124^{bc}	9.90^d
T_7: P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	2.5^{ab}	110^c	15.10^{bcd}
T_8: VC_6 t ha^{-1} + P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	7^a	382^a	33.00^a
Standard deviation	1.94	106.88	9.64

Effect of vermicompost, phosphorous and zinc on macro and micronutrients and protein content of cucumber: The macronutrient concentration (N, P, K, and S), micronutrients (Fe and Zn), and protein content in cucumber are presented in Table 4. Pots treated with VC_6 t ha^{-1} plus P_{25} kg ha^{-1} plus $Zn_{1.5}$ kg ha^{-1} (T_8) significantly increased values of nitrogen and potassium content in fruits, excepting phosphorous that showed maximum concentrations in the treatment P_{25} kg ha^{-1} (T_3) and sulphur in VC_6 t ha^{-1} plus $Zn_{1.5}$ kg ha^{-1} (T_6). Compared to the control (T_1), which gave the least value for all the macronutrients, other pots treated with sole vermicompost or combined with phosphorous and zinc significantly increased the macronutrient composition of cucumber. The micronutrient content also showed significant differences ($p \leq 0.05$) among the treatment. Iron content was maximum in VC_6 t ha^{-1} plus P_{25} kg ha^{-1} (T_5) and zinc in VC_6 t ha^{-1} plus $Zn_{1.5}$ kg ha^{-1} (T_6) and the minimum micronutrient concentration was observed in the control T_1 followed by VC_6 t ha^{-1} plus $Zn_{1.5}$ kg ha^{-1} T_6 for iron (161.88 ppm) and sole VC_6 t ha^{-1} in treatment T_2 for zinc (22.15 ppm). The remaining treatments showed intermediary effects. The maximum (4.25%) protein content was observed in T_8, with a significant difference. The lowest value was observed in the control T_1. In treatment, T_8 fruit production was best, and the protein content of the fruit was maximum.

Table 4. Integrated effect of vermicompost, phosphorous and zinc fertilizer on total macro and micronutrient concentrations and protein content of cucumber fruits at 60 days after sowing (DAS). Means that do not share a letter are significantly different at 5% level by Tukey's Range Test performed separately for different treatments.

Treatments	N (%)	P (%)	K (%)	S (%)	Protein (%)	Fe (ppm)	Zn (ppm)
T_1: Control (-VC, -P, -Zn)	0.03^{d}	0.04^{b}	0.32^{b}	0.06^{c}	0.19^{d}	85.80^{e}	11.25^{d}
T_2: VC_6 t ha^{-1}	0.29^{bc}	0.22^{ab}	2.13^{a}	0.14^{a}	1.78^{bc}	207.10^{cde}	22.15^{c}
T_3: P_{25} kg ha^{-1}	0.36^{ab}	1.35^{a}	2.23^{a}	0.19^{bc}	2.26^{ab}	774.88^{abc}	23.79^{c}
T_4: $Zn_{1.5}$ kg ha^{-1}	0.28^{bc}	0.15^{b}	2.40^{a}	0.18^{bc}	1.76^{bc}	1124.88^{ab}	31.21^{b}
T_5: VC_6 t ha^{-1} + P_{25} kg ha^{-1}	0.28^{bc}	0.33^{ab}	2.51^{a}	0.16^{ab}	1.73^{bc}	4495.77^{a}	20.98^{c}
T_6: VC_6 t ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	0.31^{b}	0.15^{ab}	1.78^{ab}	0.26^{b}	1.95^{b}	161.88^{de}	40.07^{a}
T_7: P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	0.24^{cd}	0.09^{b}	2.26^{a}	0.25^{b}	$1.48c^{d}$	922.37^{abc}	27.08^{bc}
T_8: VC_6 t ha^{-1} + P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	0.68^{a}	0.26^{ab}	3.26^{a}	0.17^{a}	4.25^{a}	507.29^{bcd}	43.98^{a}
Standard deviation	0.18	0.42	0.84	0.06	1.12	1448.77	10.64

In treatment P_{25} kg ha^{-1} plus $Zn_{1.5}$ kg ha^{-1} (T_7), Zn content was comparatively low, where zinc and phosphorus fertilizers were jointly applied. Zinc usability by plants decreases by high levels of phosphorus in the soil[23]. Oseni[24] reported decreased Zn concentration in cowpea grains with increased P application.

Available macronutrient content of post-harvest soil: The concentration of available macronutrients concentration of N, P, K, and S of post-harvest soils are presented in Table 5. There were significant differences ($p \leq 0.05$) compared to the control (T_1) among some treatments, while others showed no significant differences. The amount of available nitrogen (0.015%) and phosphorous (7.59 ppm) were observed highest in the treatment containing VC_6 t ha^{-1} plus P_{25} kg ha^{-1} (T_5), where the potassium (117.27 cmol kg^{-1}) and sulphur (34.98 ppm) concentration were highest in the pot treated with P_{25} kg ha^{-1} plus $Zn_{1.5}$ kg ha^{-1} (T_7) and VC_6 t ha^{-1} (T_2), respectively. The lowest amount of macronutrients was observed in the control (T_1). The remaining treatments showed intermediary effects.

Table 5. Integrated effect of vermicompost, nitrogen and zinc fertilizer on available macronutrient concentrations of post-harvest soil of cucumber at 60 days after sowing (DAS). Means that do not share a letter are significantly different at 5% level by Tukey's Range Test performed separately for different treatments.

Treatments	N (%)	P (ppm)	K (cmol kg^{-1})	S (ppm)
T_1: Control (-VC, -P, -Zn)	0.008^{ab}	2.61^{b}	46.02^{b}	12.92^{bcd}
T_2: VC_6 t ha^{-1}	0.015^{cd}	5.39^{ab}	83.68^{ab}	34.98^{a}
T_3: P_{25} kg ha^{-1}	0.005^{ab}	6.62^{ab}	104.04^{ab}	10.57^{d}
T_4: $Zn_{1.5}$ kg ha^{-1}	0.010^{cd}	3.10^{b}	79.60^{ab}	25.81^{ab}
T_5: VC_6 t ha^{-1} + P_{25} kg ha^{-1}	0.015^{e}	7.59^{a}	80.63^{ab}	12.36^{cd}
T_6: VC_6 t ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	0.012^{de}	4.74^{ab}	67.90^{ab}	12.71^{bcd}
T_7: P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	0.004^{a}	3.91^{ab}	117.27^{a}	15.07^{abc}
T_8: VC_6 t ha^{-1} + P_{25} kg ha^{-1} + $Zn_{1.5}$ kg ha^{-1}	0.011^{bc}	6.17^{ab}	86.20^{ab}	18.67^{abc}
Standard deviation	0.004	1.75	21.51	8.44

Zinc deficiency is related to soil pH and its value is very low in calcareous soils with high pH[25]. According to Mamun *et al*.[26] the release of P from the decomposition of the cow dung may be the reason for the rising trend in soil-available phosphorus.

This study revealed that all the vegetative growth parameters performed significantly well with the combination of vermicompost, phosphorus and zinc. Therefore, the optimum dose for better cucumber quality and productivity might be the dose VC_6 t ha^{-1} plus P_{25} kg ha^{-1} plus $Zn_{1.5}$ kg ha^{-1} (T_8) which is suggested to farmers for sustainable crop production.

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