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EFFECT OF VERMIWASH AND VERMICOMPOST ON SOIL PARAMETERS AND PRODUCTIVITY OF OKRA (*ABELMOSCHUS ESCULENTUS*) IN GUYANA

Abdullah Adil Ansari* and Kumar Sukhraj**

ABSTRACT: Present investigations were carried out during 2006-2007 at University of Guyana, Georgetown focusing on recycling organic waste using vermitechnology and use of vermicompost and vermiwash obtained from the vermitech in varied combinations for exploring the effect on soil and productivity of Okra (*Abelmoschus esculentus*) in Guyana. The soil quality was monitored during the experiment along with plant growth parameters of Okra. The study revealed that combination organic fertilizers vermicompost and vermiwash combination [VW+VC] compared with control [CON] and chemical fertilizers [CHM], had great influence on plant growth parameters. The average yield of Okra during trial showed a significantly greater response in VW+VC compared with the control by 64.27 %. The fruits have a greater percentage of fats and protein content in VW+VC when compared with those grown with chemical fertilizers by 23.86% and 19.86%, respectively. The combination treatment [VW+VC] also have a significant influence on the biochemical characteristics of the soil with marked improvement in soil micronutrients. The combination treatment [VW+VC] was found better suggesting qualitative improvement in the physical and chemical properties of the soil, which is substantiated by ANOVA and composite index {Rank 1 for [VW+VC] with composite index of 9}. This biological method of crop cultivation is sustainable and improves soil health rather than conventional methods based on the earlier observations.

Key Words: Okra; Organic Waste; Vermicompost; Vermiwash; Soil Fertility; Guyana.

INTRODUCTION

Many of agricultural industries use compost, cattle dung and other animal excreta to grow plants. The technology of vermicomposting can effectively manage the waste. This process allows to compost the degradable materials and at the same time utilize the products obtained after composting to enhance crop production in Guyana, and eliminate the use of chemical fertilizers. Application of chemical fertilizers over a period has resulted in poor soil health, reduction in produce, and increase in incidences of pest and disease and environmental pollution (Ansari and Ismail, 2001). To cope with these trenchant problems, the vermitechnology has become the most suitable remedial device (Kumar, 2005). Therefore organic farming helps to provide many advantages such as eliminate the use of chemical in the form of fertilizers/pesticides, recycle and regenerate waste into wealth; improve soil, plant, animal and human health; and creating an ecofriendly, sustainable and economical bio-system models (Ansari and Ismail, 2001).

In Guyana as many as 75% of the agricultural industries mainly use chemical fertilizers, herbicides and pesticides for cultivating plants. Guyana exports agricultural products to Antigua, Barbados, Dominica, Grenada, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, US and UK. If the level of chemical fertilizers and pesticides are too high in the agricultural products, then producers would have to face the dilemma of having their produces dumped and lose their money (Budhan, 2004).

*Department of Biological Sciences, Kebbi State University of Science and Technology, Aliero Kebbi State, Nigeria.

**Department of Biology, University of Guyana, Georgetown, Guyana.

The objective of the study was to assess the plant productivity by the use of organic fertilizers in different combinations and the effect on soil physical and chemical parameters in comparison to control and chemical fertilizers.

MATERIALS AND METHODS

The present study was carried out during 2005-2006 at University of Guyana, Georgetown to effectively recycle the organic waste like grass clippings and cattle dung. The locally available earthworm species *Eisenia fetida* was used for the purpose.

The vermicompost units were set up using large baskets of dimension (diameter 45 cm and height 40 cm). The basal layer of the vermi-bed comprised broken bricks followed by a layer of coarse sand (10 cm thick) to ensure proper drainage. A layer (10 cm) of loamy soil was placed at the top. Hundered locally collected earthworms were introduced into the soil. Fresh cattle dung was scattered over the soil and then it was covered with a 10 cm layer of dried grasses. Water was added to the unit to keep it moist. The dried grasses along with cattle dung were turned once a week. After 60 days, vermicompost units were regularized for the harvesting of vermicompost every 45 days. Approximately 1 kg per unit was collected at every harvest. Vermicompost produced was subjected to physico-chemical characterization.

The vermiwash units were set up using buckets. A tap was fixed on the lowest side of each bucket. The bucket was placed on a stand to facilitate collection of vermiwash. Broken pebbles 5 cm were placed at the bottom of the buckets followed by 5 cm layer of coarse sand. Water was then allowed to flow through these layers to enable the settling of the basic filter unit. A 15 cm layer of loamy soil was placed on top of the filter bed. Approximately 300 earthworms were introduced into the soil. Dried grass and cattle dung was placed on top of the soil. The vermiwash unit was left to regularize after 60 days for collection of vermiwash every day. Approximately 0.5 l was collected on a daily basis. Vermiwash produced was subjected to physicochemical analysis. Initial and final soil samples, vermiwash, vermicompost and cattle dung were subjected to physiochemical characteristics (Homer, 2003). Chemical analysis of samples was done at the Guyana Sugar Corporation Central Laboratory.

Okra (*Abelmoschus esculentus*) was grown with the following treatments:

Treatment	Abbreviation	Quantity/ plant
T_1: Control	[CON]	No additions
T_2: Cattle dung	[CD]	100 g
T_3: Chemical fertilizers (Urea)	[CHM]	15.30 g
T_4: Vermiwash	[VW]	100 ml
T_5: Vermicompost	[VC]	100 g
T_6: Vermiwash + Vermicompost	[VW + VC]	100 ml + 100 g

The pot experiments were placed using Randomized Block Design with replication for each treatment. The trial was run for six weeks, which is the usual period for seedling growth after transplanting. The pots were filled with sterilized dry soil (5 kg). The initial soil samples were subjected to soil chemical analysis. Application of treatments to the plants was as follows:

- Before seedlings are planted
- Three weeks after seedlings are planted
- Before flowering (approximately 5 weeks after planting)

The following growth parameters were recorded at harvest (after 6 weeks):

- Number of leaves per plant
- Plant height (cm)
- Stem circumference (cm)
- Marketable fruit yield (g)

On the sixth week the plants were taken out of the pot and the above listed growth parameters were measured. The fruits of the plant for each treatment were analyzed for (protein and fat content) nutritional values. These biochemical analyses (Homer, 2003) were done at the Government Food Analyst, Food Chemistry Laboratory, Ministry of Health. Following statistical tools were applied to data recorded:

- LSD
- ANOVA
- Composite index (Nelson, 1993; Karr and Chu, 1999; Spielman and Kelemework, 2009)

RESULTS AND DISCUSSION

The physiochemical properties of vermiwash and vermicompost (Table 1) agree with the work done by Ismail (2005) and Lalitha et al. (2000). The C:N ratio was reduced to 8.80 by vermicomposting which is indicative of completion of composting process. The micronutrients are available in significant quantity. The liquid extract obtained through earthworm worked soil is referred to as vermiwash. The assessment of vermiwash indicated the presence of micronutrients in significant quantity (Kale, 1998; Ismail, 2005).

Table 1. Physiochemical properties of vermiwash and vermicompost (Mean ± SD)

Parameters	Vermiwash	Vermicompost
pH	7.11±0.02	6.12±0.03
Total salts (ppm)	9841.67±123.32	3148.67 ± 48.58
Total Nitrogen (%)	0.02 ± 0.002	1.11 ± 0.05
Organic Carbon (%)	0.18 ± 0.020	9.77 ± 5.05
Available Phosphate (ppm)	48.86 ± 0.13	597.67 ± 0.58
C/N ratio	8.80	-
Calcium (ppm)	192.4 ± 30.22	322.33 ± 24.91
Magnesium (ppm)	142.53 ± 38.90	137.33 ± 19.50
Potassium (ppm)	245.67 ± 9.50	2428.33 ± 326.28
Manganese (ppm)	0.04 ± 0.02	0.69 ± 0.01
Iron (ppm)	2.21 ± 0.04	0.11 ± 0.01
Copper (ppm)	0.35 ± 0.01	0.01 ± 0.00
Zinc (ppm)	0.03 ± 0.01	2.13 ± 0.05

The initial soil samples drawn from the soil used in experimental pots, showed the soil pH 7.97; organic carbon, 1%; available nitrogen, 0.1%; magnesium, 5 ppm; calcium, 11 ppm; and zinc, 10.44 ppm. The number of leaves observed after week six, was maximum for plants treated with T_3 [CHM], followed by T_6 [VW + VC], T_5 [VC], T_4 [VW] and T_2 [CD], respectively (Table 2). The maximum number of leaves observed with T_3 [CHM] can be accounted for by the fact that chemical fertilizers are high in nitrogen, which is responsible for rapid plant growth. The plant height observed after week six, was maximum for T_6 [VW + VC] followed by T_3 [CHM], T_4 [VW], T_5 [VC], and T_2 [CD], respectively (Table 2). The stem circumference observed after week six, was maximum for plants treated with T_3 [CHM], followed by T_5 [VC], T_6 [VW + VC], T_2 [CD], and T_4 [VW], respectively (Table 2). The maximum circumference of stem in T_3 [CHM] can be accounted for by the fact that chemical fertilizers have a greater percentage of available salts namely nitrate, phosphate and potassium, which significantly increases plant growth. The marketable yield of the fruits per plant in T_3 [CHM] was maximum followed by T_6 [VW + VC], T_5 [VC], T_2 [CD], and T_4 [VW], respectively (Table 2). The yield was comparable in T_3 [CHM] and T_6 [VW + VC]. The plant growth in T_6 [VW + VC] and T_5 [VC] may be due to the impact of microbes in bio- fertilizers (Lalitha et al., 2000; Ansari, 2008a; b). Mean of treatments does not differ significantly by LSD ($P \leq 0.01$) for plant height. Mean of treatments with T_1: [CON] and T_3:[CHM], T_6:[VW+VC] differ by LSD and hence their differences are sta-

Table 2. Plant growth parameters at harvest (after 6 week period) (Mean ± SD)

Treatment	Plant height (cm)	Number of leaves per plant	Stem circumference (cm)	Marketable fruit yield	Biochemical analysis	
					Fats (%)	Protein (%)
T_1: [CON]	31.67 ± 03.79	09 ± 2.53	2.23 ± 0.84	24.69 ± 17.27	0.52 ± 0.10	3.41 ± 0.25
T_2: [CD]	36.00 ± 03.46	10 ± 2.89	2.50 ± 0.02	31.636 ± 8.81	1.78 ±1.02	6.37 ± 0.38
T_3: [CHM]	44.33 ± 10.02	14 ± 3.05	3.77 ± 1.42	75.43 ± 22.10	2.68 ± 0.81	5.73 ± 0.88
T_4: [VW]	42.33 ± 02.52	11 ± 0.00	2.47 ± 0.29	30.36 ± 11.43	3.00 ± 0.00	6.35 ± 0.15
T_5: [VC]	39.33 ± 05.86	12 ± 2.31	3.17 ± 0.06	59.04 ± 36.26	3.15 ± 0.21	6.82 ± 0.51
T_6: [VW + VC]	45.83 ± 05.62	13 ± 1.15	3.10 ± 0.17	69.11 ± 32.47	3.52 ± 0.24	7.15 ± 0.35

tistically significant ($P \leq 0.01$) for number of leaves. Mean of treatments does not differ significantly by LSD ($P \leq 0.01$) for plant height and marketable yield. Mean of treatments with T_1: [CON] and T_3: [CHM] differ by LSD and hence their differences are statistically significant ($P \leq 0.01$) for stem circumference (Table 3).

Table 3. Least significant difference (LSD at $P \leq 0.01$)

Parameter	Calculated LSD	Mean difference
Plant height (cm)	12.48	Not significant
Number of leaves $plant^{-1}$	3.8	5 (between T_1 & T_3), 4 (between T_1 & T_6)
Stem circumference (cm)	1.26	1.6 (between T_1 & T_3)
Marketable fruit yield (g $plant^{-1}$)	42.9	50.63 (between T_1 & T_3), 44.33 (between T_1 & T_6)

The fat content of fruits was maximum in T_6 [VW + VC] followed by T_5 [VC], T_4 [VW], T_3 [CHM], and T_2 [CD], respectively. The protein content of fruits was maximum in T_6 [VW + VC] followed by T_5 [VC], T_2 [CD], T_4 [VW], and T_3 [CHM], respectively (Table 2). The biochemical qualities of the fruits grown in T_6 [VW +VC] indicated higher nutrient quality, which may be attributed to the presence of plant growth promoters like gibberellins, cytokinins and auxins (Krishnamoorthy and Vajranbhiah, 1986). The vermiwash is a major contributor of micronutrients to soil. Vermicompost and vermiwash are also enriched in certain metabolites and vitamins that belong to the B group or provitamin D which also help to enhance plant growth (Lalitha et al., 2000; Ansari, 2008a; b).

There was a decrease in pH in T_3 [CHM], T_5 [VC], T_6 [VW + VC], T_2 [CD] and T_4 [VW] (Table 4). The maximum increase organic carbon percentage was observed in T_6 [VW + VC], followed by T_5 [VC], T_2 [CD], and T_4 [VW]. T_1 [CON] and T_3 [CHM] did not show any increase in organic carbon, but instead showed a decrease, which is attributed to the deficiency of organic carbon in the chemical fertilizers (Table 4). The organic carbon in vermicompost releases the nutrients slowly and steadily into the soil and enables the plants to absorb the available nutrients (Lalitha et al., 2000; Ansari, 2008a; b). The maximum increase in available nitrogen percentage was observed for T_3 [CHM] followed by T_6 [VW + VC], T_5 [VC], T_4 [VW], and T_2 [CD] (Table 4). The maximum increase of available nitrogen in T_3 [CHM] can be accounted for the highest percentage of available nitrate it contained. Using vermiwash and vermicompost may attribute the significant increase in nitrogen of the soil by using vermiwash and vermicompost due to the presence of nitrogen fixing bacteria, which increase the nitrogen content of the soil (Lalitha et al., 2000; Ansari, 2008a; b). The maximum increase in magnesium was observed for T_6 [VW + VC], followed by T_4 [VW], T_2 [CD], T_5 [VC], and T_3 [CHM] (Table 4). The maximum increase in T_6 [VW + VC] is due to greater availability of Mg^{2+} in vermicompost and vermiwash (Ansari, 2008a; b). The maximum increase in calcium was observed for T_6 [VW + VC], followed by T_4 [VW], T_5 [VC], T_2 [CD] and T_3 [CHM] (Table 4). Calcium increase in T_6 [VW + VC] is due to the availability of Ca^{2+} in vermicompost and vermiwash. The maximum increase in

Table 4. Soil chemical analysis (Mean ± SD)

	Change in					
Treatment	pH	OC %	N %	Mg (ppm)	Ca (ppm)	Zn (ppm)
T_1	-0.06	-0.07	-0.01	-0.39	-2.45	-1.50
T_2	0.11	0.27	0.35	0.73	1.79	5.12
T_3	0.91	-0.15	0.65	0.35	1.15	0.86
T_4	0.03	0.14	0.40	0.90	4.07	0.73
T_5	0.40	0.64	0.43	0.64	3.40	10.24
T_6	0.28	0.73	0.55	1.00	5.00	15.62

-=Decrease

Table 5. Composite index based on soil chemical analysis

Treatment	pH	OC	N	Mg	Ca	Zn	Composite index	Rank
T_1	6	6	6	6	6	6	36	5th
T_2	4	3	5	3	4	3	22	4th
T_3	1	5	1	5	5	4	21	3rd
T_4	5	4	4	2	2	5	22	4th
T_5	2	2	3	4	3	2	16	2nd
T_6	3	1	2	1	1	1	9	1st

zinc was observed for T_6 [VW + VC], followed by T_5 [VC], T_2 [CD], T_3 [CHM] and T_4 [VW] (Table 4). The treatment T_6 [VW + VC] was highly significant with improvement of soil physical and chemical properties. This is established by composite index (Table 5). ANOVA carried out at $P \leq 0.01$ is suggestive of deviation in productivity to be highly significant due to different treatments. The calculated F value of 4.53 is greater than F crit. value of 3.01 at $P \leq 0.01$.

The vermiwash and vermicompost improve the trace element content of the soil. However the combination of these biofertilizers was more effective in improving soil micronutrients content. Bio-fertilizers (vermicompost and vermiwash) contribute macronutrients and micronutrients in amount that is required by plants. According to Lalitha et al. (2000), applications of organic fertilizers have an emphatic effect on plant growth and production. The soil enriched with vermicompost provides additional substances that are not found in chemical fertilizers (Kale, 1998; Ansari and Ismail, 2008). Data clearly indicate a better performance of Okra using the combination of vermiwash and vermicompost. Results are in agreement with those obtained by earlier workers (Lalitha et al., 2000; Ismail, 2005; Ansari, 2008a; b; Ansari and Ismail, 2008).

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