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Effect of Vermiwash and Vermicompost on Soil Parameters and Productivity of Okra (*Abelmoschus esculentus*) in Guyana

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Abstract: In Guyana 75% of the Agricultural Industries, mainly use chemical fertilizers for cultivating crops. Guyana is among many countries to adopt and practice organic agriculture; however, this is done on a small scale. There are also problems in disposal of organic waste. The present study was carried out during the year 2006-2007 at University of Guyana, Georgetown focusing on recycling organic waste using vermitechnology and use of vermicompost and vermiwash obtained from the vermitech improvement in soil and enhanced productivity of Okro (*Abelmoschus esculentus*) in Guyana. It was found that combination organic fertilizers (vermicompost+vermiwash) had great influence on the nutritional value of the fruits. These fruits were found to have a greater percentage of fats and protein content when compared with those grown with chemical fertilizers. The vermiwash and the vermicompost combination were also found to have a significant influence on the biochemical characteristics of the soil with marked improvement in soil micronutrients. The combination treatment was the found to be best for improving soil quality.

Key words: Organic waste · Vermicompost · Vermiwash · Soil fertility · Okra · Guyana

INTRODUCTION

Many of agricultural industries use compost, cattle dung and other animal excreta to grow plants. In today's society, we are faced with the dilemma of getting rid of our waste from our industries, household etc. In order for us to practice effective waste management we can utilize the technology of vermicomposting to effectively manage our waste. This process allows us 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. As indicated by Ansari and Ismail [1], the 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. In order to cope with these trenchant problems, the vermitechnology has become the most suitable remedial device [2]. 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 [1]. In Guyana as many as 75% of the agricultural industries mainly use chemical fertilizers, herbiicides 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 [4].

MATERIALS AND METHODS

The present study was carried out during the year 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. The basal layer of the vermi-bed comprised of broken bricks followed by a layer of coarse sand

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(10 cm thick) in-order to ensure proper drainage. A layer (10 cm) of loamy soil was placed at the top.100 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 in-order to keep it moist. The dried grasses along with cattle dung was 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 physicochemical 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. 5 cm of broken pebbles 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 regularized after 60 days for collection of vermiwash every day. Approximately 0.5 liters 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 [4]. Chemical analysis of samples was done at the Guyana Sugar Corporation Central Laboratory.

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

Treatments	Abbreviation	Quantity/ plant
T1: Control	[CON]	No additions
T2: Cattle dung	[CD]	100 g
T3: Chemical fertilizers (Urea)	[CHM]	15.30 g
T4: Vermiwash	[VW]	100 ml
T5: Vermicompost	[VC]	100 g
T6: Vermiwash + Vermicompost	[VW + VC]	100 ml + 100 g

There were three replicates for each treatment. The trial was run for six weeks which is the usual period for seedling growth after transplanting. Application of treatments to the plants was as follows.

- When seedlings are planted.
- Three weeks after seedlings are planted.
- Before flowering (Approximately 5 weeks after planting).

The following growth parameters were measured for the plants in each treatment on weekly bases from 1-6 weeks after transplanting.

- Number of leaves.
- Plant Height (cm).
- Stem Circumference (cm).

The following growth parameters were recorded at harvest.

- Number of fruits.
- Fruit Circumference (cm).
- Fruit Length (cm)
- Fresh weight of fruits (cm)
- Fresh and dry weight of plants (g)

On the sixth week the plants were taken out of the pot and the above listed growth parameters were measured. These plants were then weighed and place to dry and their dry mass was then measured. The fruits of the plant for each treatment were analyzed for (protein and fat content) nutritional values. These biochemical analyses [4] were done at the Government Food Analyst, food chemistry laboratory (Ministry of Health).

RESULTS AND DISCUSSION

The physiochemical properties of vermiwash listed Table 1 is in agreement with the work done by Ismail [5] and Lalitha, *et al.* [6]. Chemical analyses of the vermicompost listed in Table 1 are in agreement with work done by Ismail [5] and Lalitha, *et al.* [6].

There were significant difference in the number of leaves in plants treated with [CD], [CHM], [VW], [VC], [VW+VC] between week one and week six. The number of leaves observed during week six, was maximum for plants treated with T3 [CHM], followed by T6 [VW + VC], T5 [VC], T4 [VW] and T2 [CD] respectively (Table 2). The maximum number of leaves was observed with T3 [CHM] can be accounted for by the fact that chemical fertilizers is high in nitrogen which is responsible for rapid plant growth. However, the number of leaves with T4 [VW], T5 [VC] and T6 [VW + VC] does not differ significantly from those of T3 [CHM]. There were significant difference in the height of those plants that were treated with [CD], [CHM], [VW], [VC], [VW+VC] between week one and week six. The height observed

Table 1: Physiochemical properties of Vermiwash and vermicompost (Mean ± SD)

Parameters	Vermiwash	Parameters	Vermicompost
pH	7.11 ± 0.02	pH	6.12 ± 0.03
Total salts (ppm)	9841.67 ± 123.32	Total salts (ppm)	3148.67 ± 48.58
Total Nitrogen (%)	0.02 ± 0.002	Total Nitrogen (%)	1.11 ± 0.05
Organic Carbon (%)	0.18 ± 0.020	Organic Carbon (%)	9.77 ± 5.05
Available Phosphate (ppm)	48.86 ± 0.13	C/N ratio	8.80
Calcium (ppm)	192.4 ± 30.22	Available Phosphate (ppm)	597.67 ± 0.58
Magnesium (ppm	142.53 ± 38.90	Calcium (ppm)	322.33 ± 24.91
Potassium (ppm)	245.67 ± 9.50	Magnesium (ppm	137.33 ± 19.50
Manganese (ppm)	0.04 ± 0.02	Potassium (ppm)	2428.33 ± 326.28
Iron (ppm)	2.21 ± 0.04	Manganese (ppm)	0.69 ± 0.01
Copper (ppm)	0.35 ± 0.01	Iron (ppm)	0.11 ± 0.01
Zinc (ppm)	0.03 ± 0.01	Copper (ppm)	0.01 ± 00
		Zinc (ppm)	2.13 ± 0.05

Table 2: Increase in the number of leaves over a six-week period (Mean ± SD)

	Number of leaves						
Treatments	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	t-test
T1: [CON]	6 ± 0.58	6 ± 01	6 ± 0.57	7 ± 01	7 ± 1.53	9 ± 2.53	N
T2: [CD]	5 ± 0.58	6 ± 01	6 ± 1.52	8 ± 2.08	9 ±1.89	10 + 2.89	S
T3: [CHM]	6 ± 0.58	7 ± 00	8 ± 0.57	10 ± 1.15	12 ± 2.51	14 ± 3.05	S
T4: [VW]	6 ± 0.58	7 ± 0.58	8 ± 0.58	8 ± 01	9 ± 0.58	11 ± 00	S
T5: [VC]	5 ± 0.58	6 ± 0.58	7 ± 01	8 ± 02	10 ± 2.52	12 ± 2.31	S
T6: [VW + VC]	6 ± 0.58	7 ± 0.58	8 ± 01	9 ± 01	10 ± 0.58	13 ± 1.15	S

Confidence level 95% S- Significant N- Not significant

Table 3: Increase in the plant height over a six-week period (Mean ± SD)

	Plant Height (cm)						
Treatments	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	t-test
T1: [CON]	19.33 ± 2.08	21.67 ± 2.89	26.06 ± 3.81	27.00 ± 3.00	29.00 ± 1.00	31.67 ± 3.79	N
T2: [CD]	14.66 ± 2.31	20.33± 2.08	29.33 ± 5.13	31.33 ± 5.03	34.67 ± 4.41	36 ± 3.46	S
T3: [CHM]	18 ± 0.00	23 ± 1.73	28.67 ± 1.53	33.5 ± 2.18	41.33 ± 7.31	44.33 ± 10.02	S
T4: [VW]	19.16 ± 2.75	26.67 ± 4.16	34.33 ± 2.89	38.67 ± 2.36	41 ± 2.00	42.33 ± 2.52	S
T5: [VC]	15.03 ± 6.29	21.33 ± 7.02	28 ± 7.00	29.66 ± 4.93	36.33 ± 4.16	39.33 ± 5.86	S
T6: [VW + VC]	17.83 ± 5.20	24.67± 6.51	32 ± 7.21	36 ± 5.20	45 ± 4.09	45.83 ± 5.62	S

Confidence level 95% S- Significant N- Not significant

Table 4: Increase in the stem circumference over a six-week period (Mean ± SD)

	Stem Circumference (cm)						
Treatments	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	t-test
T1: [CON]	1.2 ± 0.40	1.73 ± 0.41	1.96 ± 0.81	2.06 ± 0.80	2.16 ± 0.80	2.23 ± 0.84	N
T2: [CD]	1.46 ± 0.11	1.76 ± 0.21	1.97 ± 0.06	2 ± 0.10	2.37 ± 0.15	2.5 ± 0.02	S
T3: [CHM]	1.5 ± 0	2.23 ± 0.21	2.4 ± 00	3.07 ± 0.98	3.53 ± 1.29	3.77 ± 1.42	S
T4: [VW]	1.67 ± 0.29	2.03 ± 0.42	2.17 ± 0.38	2.2 ± 0.35	2.33 ± 0.32	2.47 ± 0.29	S
T5: [VC]	1.56 ± 0.46	1.97 ± 0.40	2.7 ± 0.26	2.86 ± 0.15	3.03 ± 0.06	3.17 ± 0.06	S
T6: [VW + VC]	1.6 ± 0.36	2.13 ± 0.42	2.57 ± 0.12	2.93 ± 0.11	3.03 ± 0.11	3.10 ± 0.17	S

Confidence level 95% S- Significant N- Not significant

Table 5: Fresh biomass and dry biomass per plant (Mean ± SD)

	Growth parameters		
Treatments	Fresh biomass (g)	Dry biomass (g)	% Moisture
T1: [CON]	19.22 ± 1.85	5.51 ± 3.90	71.33
T2: [CD]	28.66 ± 1`2.37	7.07 ± 6.21	75.33
T3: [CHM]	161.92 ± 177.85	31.24 ± 35.34	80.71
T4: [VW]	37.26 ± 12.20	9.05 ± 5.12	75.71
T5: [VC]	72.33 ± 22.55	12.26 ± 3.66	83.05
T6: [VW + VC]	77.75 ± 6.92	13.30 ±1.26	82.90

during week six, was maximum for T6 [VW + VC] followed by T3 [CHM], T4 [VW], T5 [VC] and T2 [CD], respectively (Table 3). There were significant difference in the circumference of plants that were treated with [CD], [CHM], [VW], [VC], [VW + VC] between week one and week six. The circumference of stem observed during week six, was maximum for plants treated with T3 [CHM], followed by T5 [VC], T6 [VW + VC], T2 [CD] and T4 [VW], respectively (Table 4). T3 [CHM] had the highest fresh biomass followed by T6 [VW + VC], T5 [VC], T4 [VW], T2 [CD] and T1 [CON] (Table 5). The maximum circumference of stem and the highest biomass in T3 [CHM] can be accounted for by the fact that chemical fertilizers have a greater percentage of available salts such as nitrate, phosphate and potassium, which significantly increases plant growth. However, it was not significantly different from T4 [VW], T5 [VC] and T6 [VW + VC]. The highest number of fruits was observed in T3 [CHM] and T6 [VW + VC]. T5 [VC], T4 [VW] and T1 [CON] have the same number of fruits. However, the mass of the fruit was different for each treatment. T3 [CHM] had the highest marketable yield followed by T6 [VW + VC], T5 [VC], T2 [CD] and T4 [VW], respectively. The yield was comparable i T3 [CHM] and T6 [VW + VC]. The average length of fruits also varies. T3 [CHM] had the greatest length followed by T5 [VC], T6 [VW + VC], T2 [CD] and T4 [VW] respectively (Table 6). The morphometry of the fruit is due to the impact of microbes in bio-fertilizers [6-8].

The fat content of fruits was maximum in T6 [VW + VC] followed by T5 [VC], T4 [VW], T3 [CHM] and T2 [CD], respectively. The protein content of fruits was maximum in T6 [VW + VC] followed by T5 [VC], T2 [CD], T4 [VW] and T3 [CHM], respectively (Table 7). The biochemical qualities of the fruits grown in T6 [VW +VC] indicated higher nutrient quality which may be attributed to the presence of plant growth promoters like gibberellins, cytokinins and auxins [9]. 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 [6-8].

There was a decrease in pH in T2 [CD], T3 [CHM], T4 [VW], T5 [VC] and T6 [VW + VC] (Table 8). There was a significant increase in organic carbon for T2 [CD], T4 [VW], T5 [VC] and T6 [VW + VC]. The maximum increase was observed in T6 [VW + VC], followed by T5 [VC], T2 [CD] and T4 [VW]. T1 [CON] and T3 [CHM] did not show any significant increase in organic carbon, but instead showed a decrease which is attributed to the deficiency of organic carbon in the chemical fertilizers (Table 9). The organic carbon in vermicompost release the nutrients slowly and steadily into the soil and enables the plants to absorb the available nutrients [6-8]. There was a significant increase in nitrogen for T2 [CD], T3 [CHM], T4 [VW], T5 [VC] and T6 [VW + VC]. The maximum increase was observed for T3 [CHM] followed by T6 [VW + VC], T5 [VC], T4 [VW] and T2 [CD] (Table 10). The maximum increase of nitrogen in T3 [CHM] can be accounted for because of the highest percentage of available nitrate it contains. The significant increase in nitrogen of the soil by using vermiwash and vermicompost may be attributed due to the presence of nitrogen fixing bacteria, which increase the nitrogen content of the soil [6-8]. There was a significant increase in phosphate for T2 [CD], T3 [CHM], T4 [VW], T5 [VC] and T6 [VW + VC]. The maximum increase was observed for T3 [CHM] followed by T6 [VW + VC], T5 [VC], T2 [CD] and T4 [VW] (Table 11). The significant increase in phosphate in the soil by the application of vermiwash and vermicompost in combination, may be due to the presence of phosphate solubilizing bacteria, which increase the phosphate content of the soil [7,8]. There was a significant increase in potassium for T2 [CD], T3 [CHM], T4 [VW], T5 [VC] and T6 [VW + VC]. The maximum increase was observed for T3 [CHM] followed by T6 [VW + VC], T2 [CD], T5 [VC] and T4 [VW] (Table 12).

There was a significant increase in magnesium for T2 [CD], T3 [CHM], T4 [VW], T5 [VC] and T6 [VW + VC]. The maximum increase was observed for T6 [VW + VC], followed by T4 [VW], T5 [VC], T2 [CD] and T3 [CHM] (Table 13). The maximum increase in T6 [VW + VC] is due to greater availability of Mg^{2+} in vermicompost and vermiwash [7,8]. There was a significant increase in calcium for T2 [CD], T3 [CHM], T4 [VW], T5 [VC] and T6 [VW + VC]. The maximum increase was observed for T6 [VW + VC], followed by T4 [VW], T5 [VC], T2 [CD] and T3 [CHM] (Table 14). Calcium increase in T6 [VW + VC] is due to the availability of Ca^{2+} in vermicompost and vermiwash. There was a significant increase in the manganese content of the soil for T2 [CD], T4 [VW] and T6 [VW + VC]. The maximum increase was observed for T6 [VW + VC], followed by T4 [VW] and T2 [CD] (Table 15). There was a significant increase in iron content of the soil for T2 [CD], T4 [VW], T5 [VC] and

Table 6: Fruit parameters at harvest (Mean ± SD)

Treatments	Number of fruits	Fruit Length (cm)	Fruit Circumference (cm)	Marketable yield (g/plant)
T1: [CON]	3 ± 1.53	10.8 ± 1.44	7.06 ± 0,90	24.69 ± 17.27
T2: [CD]	3 ± 0	12.6 ± 2.152	7.03 ± 0.643	31.636 ± 8.81
T3: [CHM]	4 ± 0.58	15.77 ± 5.036	9.7 ± 1.835	75.43 ± 22.10
T4: [VW]	3 ± 1.5	11.8 ± 0.72	7.23 ± 0.32	30.36 ± 11.43
T5: [VC]	3 ± 1	15.07 ± 2.21	8.73 ± 0.95	59.04 ± 36.26
T6: [VW + VC]	4 ± 1	14.9 ± 0.56	8.27 ± 1.51	69.11 ± 32.47

Table 7: Bio-chemical analysis of fruits (Mean ± SD)

Treatments	Fats (%)	Protein (%)
T1: [CON]	0.52 ± 0.10	3.41 ± 0.25
T2: [CD]	1.78 ±1.02	6.37 ± 0.38
T3: [CHM]	2.68 ± 0.81	5.73 ± 0.88
T4: [VW]	3.00 ± 0.00	6.35 ± 0.15
T5: [VC]	3.15 ± 0.21	6.82 ± 0.51
T6: [VW + VC]	3.52 ± 0.24	7.15 ± 0.35

Table 8: Soil pH

Treatments	Initial soil	Final Soil	% Increase	t- test
T1: [CON]	7.97 ± 0.02	8.03 ± 0.01	0.75	N
T2: [CD]	7.97 ± 0.02	7.86 ± 0.13	-1.38	N
T3: [CHM]	7.97 ± 0.02	7.06 ± 0.02	-11.42	N
T4: [VW]	7.97 ± 0.02	7.94 ± 0.03	-0.38	N
T5: [VC]	7.97 ± 0.02	7.57 ± 0.07	-5.02	N
T6: [VW + VC]	7.97 ± 0.02	7.69 ± 0.11	-3.51	N

Confidence level 95% S- Significant N- Not significant (-) -% Decrease

Table 9: Organic Carbon

Treatments	Initial soil (%)	Final Soil (%)	% Decrease	t- test
T1: [CON]	1 ± 0.1	0.93 ± 0.09	-91.00	N
T2: [CD]	1 ± 0.1	1.27 ± 0.04	27.00	S
T3: [CHM]	1 ± 0.1	0.85 ± 0.07	-15.00	N
T4: [VW]	1 ± 0.1	1.14 ± 0.04	14.00	S
T5: [VC]	1 ± 0.1	1.64 ± 0.03	64.00	S
T6: [VW + VC]	1 ± 0.1	1.73 ± 0.00	73.00	S

Confidence level 95% S- Significant N- Not significant

Table 10: Total Nitrogen

Treatments	Initial soil (%)	Final soil (%)	% Increase	t- test
T1: [CON]	0.1 ± 0.01	0.09 ± 0.01	-10	N
T2: [CD]	0.1 ± 0.01	0.45 ± 0.05	350.00	S
T3: [CHM]	0.1 ± 0.01	0.75 ± 0.07	650.00	S
T4: [VW]	0.1 ± 0.01	0.50 ± 0.11	400.00	S
T5: [VC]	0.1 ± 0.01	0.53 ± 0.04	430.00	S
T6: [VW + VC]	0.1 ± 0.01	0.65 ± 0.07	550.00	S

Confidence level 95% S- Significant N- Not significant (-) -% Decrease

Table 11: Available Phosphate

Treatments	Initial soil (ppm)	Final soil (ppm)	% Increase	t- test
T1: [CON]	14.5 ± 0.762	13.78 ± 2.16	-4.90	N
T2: [CD]	14.5 ± 0.762	98.83 ± 2.63	581.58	S
T3: [CHM]	14.5 ± 0.762	176.44 ± 57.10	1116.83	S
T4: [VW]	14.5 ± 0.762	41.84 ± 26.60	188.55	S
T5: [VC]	14.5 ± 0.762	102.68 ± 38.80	608.14	S
T6: [VW + VC]	14.5 ± 0.762	110.50 ± 0.71	662.06	S

Confidence level 95% S- Significant N- Not significant (-) -% Decrease

Table 12: Potassium

Treatments	Initial soil (ppm)	Final soil (ppm)	% Decrease	t- test
T1: [CON]	114.67 ± 6.80	105.00 ± 7.78	-8.43	N
T2: [CD]	114.67 ± 6.80	472 .00 ±168.29	311.62	S
T3: [CHM]	114.67 ± 6.80	1380.00 ± 21.21	1103.45	S
T4: [VW]	114.67 ± 6.80	204 ± 0.00	77.90	S
T5: [VC]	114.67 ± 6.80	361.00 ± 72.12	214.82	S
T6: [VW + VC]	114.67 ± 6.80	372.50 ± 3.53	224.84	S

Confidence level 95% S- Significant N- Not significant

Table 13: Magnesium

Treatments	Initial soil (ppm)	Final soil (ppm)	% Decrease	t- test
T1: [CON]	5 + 0.10	4.61 + 0.54	-7.80	N
T2: [CD]	5 + 0.10	5.734 + 0.33	14.68	S
T3: [CHM]	5 + 0.10	5.35 + 0.07	7.00	S
T4: [VW]	5 + 0.10	5.9 + 0.14	18.00	S
T5: [VC]	5 + 0.10	5.64 + 0.01	12.80	S
T6: [VW + VC]	5 + 0.10	6.00 + 0.43	20.00	S

Confidence level 95% S- Significant N- Not significant

Table 14: Calcium

Treatments	Initial soil (ppm)	Final soil (ppm)	% Increase	t- test
T1: [CON]	11 + 0	8.55 + 0.64	-22.27	N
T2: [CD]	11 + 0	12.79 + 0.39	16.27	S
T3: [CHM]	11 + 0	12.15 + 0.60	10.45	S
T4: [VW]	11 + 0	15.07 + 0.70	37.00	S
T5: [VC]	11 + 0	14.40 + 0.07	30.91	S
T6: [VW + VC]	11 + 0	16.00 + 0.14	45.45	S

Confidence level 95% S- Significant N- Not significant (-) -% Decrease

Table 15: Manganese

Treatments	Initial soil (ppm)	Final soil (ppm)	% Decrease	t- test
T1: [CON]	27.10 ± 2.98	21.50 ± 2.12	-20.00	N
T2: [CD]	27.10 ± 2.98	35.06 ± 1.81	29.30	S
T3: [CHM]	27.10 ± 2.98	28.21 ± 3.22	4.10	N
T4: [VW]	27.10 ± 2.98	35.70 ± 0.14	31.73	S
T5: [VC]	27.10 ± 2.98	31.81 ± 6.45	17.39	N
T6: [VW + VC]	27.10 ± 2.98	36.00 ± 0.52	32.84	S

Confidence level 95% S- Significant N- Not significant

Table 16: Iron

Treatments	Initial soil (ppm)	Final soil (ppm)	% Decrease	t- test
T1: [CON]	2.50 ± 0.10	2.00 ± 0.14	-20.00	N
T2: [CD]	2.50 ± 0.10	4.76 ± 0.31	90.40	S
T3: [CHM]	2.50 ± 0.10	2.92 ± 0.59	16.80	N
T4: [VW]	2.50 ± 0.10	12.46 ± 0.11	398.40	S
T5: [VC]	2.50 ± 0.10	6.08 ± 0.01	143.20	S
T6: [VW + VC]	2.50 ± 0.10	13.00 ± 1.41	420.00	S

Confidence level 95% S- Significant N- Not significant

Table 17: Copper

Treatments	Initial soil (ppm)	Final soil (ppm)	% Decrease	t- test
T1: [CON]	2.00 ± 00	1.85 ± 0.07	-7.5.00	N
T2: [CD]	2.00 ± 00	3.26 ± 1.10	63.00	N
T3: [CHM]	2.00 ± 00	2.12 ± 0.45	06.00	N
T4: [VW]	2.00 ± 00	2.32 ± 0.00	16.00	S
T5: [VC]	2.00 ± 00	2.43 ± 0.01	21.5	S
T6: [VW + VC]	2.00 ± 00	3.75 ± 0.03	87.50	S

Confidence level 95% S- Significant N- Not significant

Table 18: Zinc

Treatments	Initial soil (ppm)	Final soil (ppm)	% Decrease	t- test
T1: [CON]	10.44 ± 0.76	8.94 ± 0.09	-14.37	N
T2: [CD]	10.44 ± 0.76	15.56 ± 3.09	49.04	S
T3: [CHM]	10.44 ± 0.76	11.30 ± 0.14	8.24	N
T4: [VW]	10.44 ± 0.76	11.17 ± 0.25	6.99	N
T5: [VC]	10.44 ± 0.76	20.68 ± 2.96	98.08	S
T6: [VW + VC]	10.44 ± 0.76	26.06 ± 4.71	149.62	S

Confidence level 95% S- Significant N- Not significant

T6 [VW + VC]. The maximum increase was observed for T6 [VW + VC], followed by T4 [VW], T5 [VC], T2 [CD] and T3 [CHM] (Table 16). There was a significant increase in copper content of the soil for, T4 [VW], T5 [VC] and T6 [VW + VC]. The maximum increase was observed for T6 [VW + VC], followed by, T5 [VC], T2 [CD], T4 [VW] and T3 [CHM] (Table 17). There was a significant increase in zinc content of the soil for T2 [CD], T5 [VC] and T6 [VW + VC]. The maximum increase was observed for T6 [VW + VC], followed by T5 [VC], T2 [CD], T3 [CHM] and T4 [VW] (Table 18).

The vermiwash and vermicompost were found to improve the trace element content of the soil. However the combination of these biofertilizers was found to be 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.* [6], 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 [10,11]. Data clearly indicate a better performance of Okra using the combination of vermiwash and vermicompost. Similar results are in agreement with those obtained by Lalitha *et al.* [6] Ismail, [5] Ansari, [7,8] Ansari and Ismail [1].

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REFERENCES

1. Ansari, A.A. and S.A. Ismail, 2001. A Case Study on Organic Farming in Uttar Pradesh. J. Soil Biol. and Ecol., 27: 25-27.
2. Kumar, A., 2005. Verms and Vermitechnology. Vedams eBooks (P) Ltd, New Delhi 110 034, India.
3. Budhan, R., 2004. Diversifying Agriculture: Guyana's Biodiversity for Food Security. Government Information Agency, Georgetown Guyana.
4. Homer, F., 2003. Soil Analysis Manuel. Central Analytical and Environmental Monitoring Services, Agriculture Research Department, LBI, Guyana.
5. Ismail, S.A., 2005. The Earthworm Book. Other India Press, Mapusa, Goa., pp: 101.
6. Lalitha, R., K. Fathima and S.A. Ismail, 2000. The impact of biopesticide and microbial fertilizers on productivity and growth of *Abelmoschus esculentus*. Vasundara The Earth., 1 & 2: 4-9.
7. Ansari, A.A., 2008a. Effect of Vermicompost and Vermiwash on the Productivity of Spinach (Spinacia o leracea), Onion (Allium cepa) and Potato (Solanum tuberosum). World J. Agric. Sci., 4(5): 554-557.
8. Ansari, A.A., 2008b. Effect of Vermicompost on the productivity of Potato (*Solanum tuberosum*), Spinach (*Spinach oleracea*) and Turnip (*Brassica campestris*). World J. Agric. Sci., 4(3): 333-336.
9. Krishnamoorty, R.V. and S.N. Vajranbhiah, 1986. Biological activity of earthworm casts: An assessment of plant growth promoter levels in the casts. Proc. Indian Acad. Sci. Anim. Sc., 95: 341-351.
10. Kale, R.D., 1998. Earthworm Cinderella of Organic Farming. Prism Book Pvt Ltd, Banglore, India, pp: 88.
11. Ansari and Ismail, 2008. Reclamation of sodic soils through vermitechnology. Pakistan J. Agric. Res., 21(1-4): 92-97.