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ABSTRACT

This research was carried out in the biological garden of the University of Lagos, Akoka Lagos, Nigeria. The aim of the research is to evaluate the response of *Spinacia oleracea* (spinach) to a liquid content (vermi tea) produced from the passage of non-chlorinated water, such as distilled water through a compost of epigeic earthworm species (vermicompost) and also physico-chemical analysis of the vermi tea using flame atomic absorption spectroscopy (FAAS). Significant results were observed in nutrients such as nitrogen (N), potassium (K), phosphorus (P) and organic carbon at three different concentrations of vermi tea (430, 730 and 940 g/L). The results significantly revealed a positive response of *S. oleracea* to the vermi tea through increase in number of leaves, plant height and leaf area at increasing concentration (430, 730 and 940 g/L). This vermi tea can be utilized for the effective production of *S. oleracea* and it is therefore recommended for growing other vegetable plants as well.

1. Introduction

The agricultural development strategy for Nigeria in the 21st century must be through increasing productivity of the land under cultivation with no harm to the environmental quality. The use of chemicals, fertilizers and pesticides by farmers to get a better yield of various field crops decreased soil fertility, pollute the environment and cause health problems to consumers. Due to adverse effects of chemical fertilizers, interest has been stimulated for the use of organic manures [1]. The use of organic matter such as animal manures, human waste, food wastes, yard wastes, plant's wastes and biodegradable waste's composts has long been recognized to improve plant growth and yield and the maintenance of soil fertility and environmental quality. To further increase lists of organic manures, this research introduced vermi tea, which effectively improved the growth and yield of *S. oleracea*.

Vermi tea is a liquid that is collected after the passage of water through earthworm compost [2]. In this research, non-chlorinated water was used so as to preserve the plant growth promoting rhizobacteria (PGPR) present in the vermicompost [3]. Vermicompost or worm compost is an organic matter that has been decomposed and recycled by earthworm [4]. It is a collection of excretory products and mucus secretion of earthworms along with micronutrients from soil organic molecules [5]. Vermi tea is rich in nutrients such as nitrogen, phosphorous, potassium, calcium, and growth promoting rhizobacteria. It plays an important role in plant growth and development, contribute to initiation of rooting, root growth, increase the soil organic matter and also preserve the environmental quality.

An earthworm is a tube-shaped, segmented worm found in the *Phylum annelida* [6]. It is a member of the class oligocheata and the order megadrilacea [7]. Worldwide, about 150 families and over 3,320 species of earthworms have been described [8]. The different species of earthworms have individual requirements; some earthworm species live in compost (e.g. *Eisenia fetida*). Some are surface burrowers found on the soil surface (epigeic), while some are sub-surface burrowers found deep down in the soil (endogeic), making complex networks of tunnels as they explore the earth (e.g. *Lumbricus terrestris*) [9]. Earthworms play a vital role in plant growth and productivity by the secretion of product of their decomposition which is known as vermi tea. Vermi tea stimulate growth and yield of crops and even develop resistance in crops receiving this spray [10].

Spinacia oleracea (spinach) is an edible flowering plant in the order *Caryophyllales*, and family *Amaranthaceae* [3]. *S. oleracea* is native to central and western Asia. But, it is now widely distributed in the western and southern parts of Africa [11]. *S. oleracea* is an annual plant or rarely biennial. It grows up to 30 cm (12 in) tall [12]. The leaves are alternate, simple, and ovate to triangular, and vary in size from 2–30 cm (1–12 in) long, and 1–15 cm (0.4–5.9 in) broad. The leaves are larger at the base of the plant, while small leaves are placed higher on the plant stem. The flowers are inconspicuous, yellow-green in color, and 3–4 mm (0.1–0.2 in) in diameter [11]. Spinach is eaten as a vegetable. It has a high nutritional value [13] which is a rich source of vitamin A, C, and K, including magnesium, manganese, iron and folate [11]. Spinach is also a good source of the B vitamins, riboflavin and vitamin B6, vitamin E, calcium, and potassium [12].

2. Experimental Methods

About 500 earthworms of different unidentified species of epigeic earthworms were used to produce vermicompost in a worm bin (41 cm height, 50 cm length and 35 cm width). The earthworms were obtained from moist and mud soils around the Biological garden of the University of Lagos, Akoka Lagos, Nigeria. The worm bin was filled with 21 kg of moist soil following Dominguez [9]. The bin was made shallow and lined with two pages of newspaper stripes to encourage moisture for the earthworms' metabolic activities [3].

2.1 Vermi Tea Preparation

To produce the vermi tea, four separate vessels with equal volume (10 L) of non-chlorinated water, such as rain water and distilled water were labelled A, B, C and D following the method of Aira [14]. Vessel A was filled with 9.4 kg of vermicompost, vessel B was filled with 7.3 kg of vermicompost, vessel C was filled with 4.3 kg of vermicompost and vessel D was used as the control for the experiment [15]. The vermicompost was allowed to dissolve completely in water for 24 hours, and then sieved through a 2 mm sieve to produce vermi tea [12]. From this, the vessel A, B and C contained vermi tea of different concentrations (430, 730, 940 g/L), while vessel D remained the control for the experiment.

2.2 Vermi Tea Analysis

The physico-chemical content of the three concentrations (430, 730 and 940 g/L) of vermi tea were analyzed using atomic absorption spectroscopy (AAS). As described by Khanna *et al.* [16] for nitrogen, potassium, phosphorous and total organic carbon.

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2.3 Nursery Bed Preparation and Transplantation

The nursery bed for *S. oleracea* was prepared in a bowl (13 cm in height and 35 cm in diameter) filled with 9 kg (7 cm layer) of sandy-loamy soil. About 20 seeds of *S. oleracea* were dispersed into the bowl. The bed was watered thoroughly on the day prior to sowing. After 21 days, the seeds germinated to seedlings. Twelve (three replicates) earthen pots (20 cm in height and 20 cm in diameter) were filled with 4.5 kg loamy soil following Adeleke et al. [3]. The seedlings were transplanted on the 22nd day of sowing by carefully removing the stronger seedlings into the twelve (three replicates) earthen pots at a depth of 0.49 inches [3]. The earthen pots were labelled A, B, C and D [3].

2.4 Measurements of Plant Growth Parameters

Growth parameters were determined using plant height (cm), number of leaves and area (cm²) of leaves produced by *S. oleracea* [17]. Plant height was measured using a transparent meter rule twice a week. The measurements were taken on the first and sixth day of the week to determine the mean height per week [12]. The number of leaves produced was determined by counting the leaves on each plant once a week [12]. Similarly, the area of leaves produced was determined using Petiole computer application version 1.0.14 [17]. The observations were recorded and compared on weekly bases.

2.5 Data Analysis

Data on all parameters were subjected to statistical analyses using statistical package for social science (SPSS) 10.0 computer program. Analysis of variance (ANOVA) was used to calculate the mean and standard error. The level of significance was set at $p < 0.05$.

3. Results and Discussion

Physico-chemical content of the three different concentrations (430, 730 and 940 g/L) of vermi tea were analyzed using flame atomic absorption spectroscopy (AAS) in Table 1. Significant results were observed in nitrogen, potassium, phosphorus and total organic carbon of the three concentration of vermi tea. The 940 g/L concentration showed high rate of all the nutrients analyzed, while 430 g/L concentration showed low rate of the nutrients analyzed (Fig. 1).

Table 1 Analysis of physico-chemical content of the three concentration of vermi tea

S.No.	Total vermi tea nutrients	Concentrations of vermi tea (%)		
		940 g/L	730 g/L	430 g/L
1	Nitrogen (N)	29.114 ± 0.04	24.211 ± 0.06	9.310 ± 0.04
2	Potassium (K)	23.811 ± 0.05	17.110 ± 0.02	7.002 ± 0.05
3	Phosphorous (P)	20.99 ± 0.07	14.008 ± 0.02	4.811 ± 0.07
4	Organic carbon (C)	37.814	29.202	18.215

All values in the table are arithmetic means ± standard errors for the 3 replicates

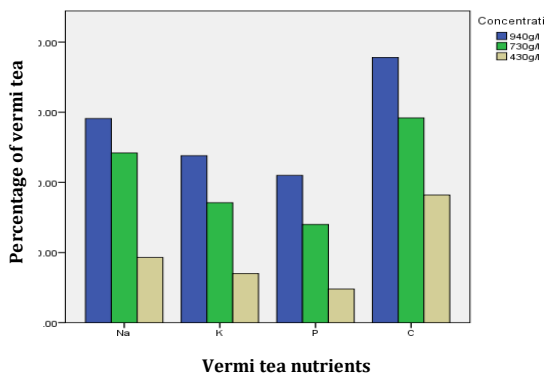


Fig. 1 Vermitea nutrients and the percentage of each nutrient

Growth parameters such as height, leaf number and leaf area of *Spinacia oleracea* by the application of vermi tea at three different concentrations (430, 730 and 940 g/L) and control from 0 day to 50 days were recorded. The height, leaf number and leaf area obtained from the test plant at these concentrations were significantly different from each other at ($p = 0.05$). However, there was no significant difference in the height, leaf number and leaf area between 430 g/L concentration of vermi tea and the control ($p < 0.70$) (Figs. 2-4).

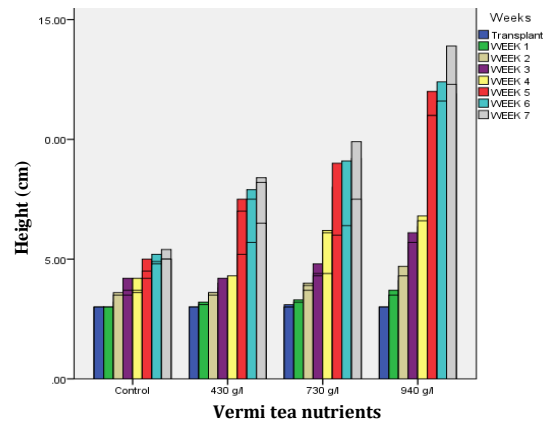


Fig. 2 Effect of vermi tea on the height of *S. oleracea* for 50 days (seven weeks)

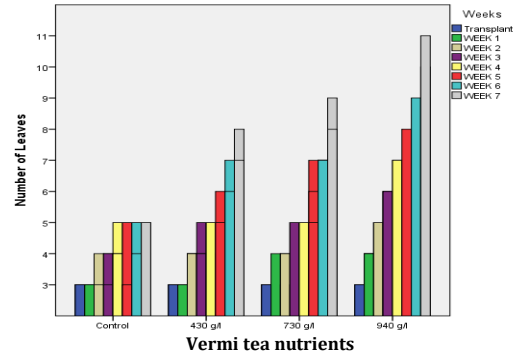


Fig. 3 Effect of vermi tea on the number of leaves of *Spinacia oleracea* for 50 days (seven weeks)

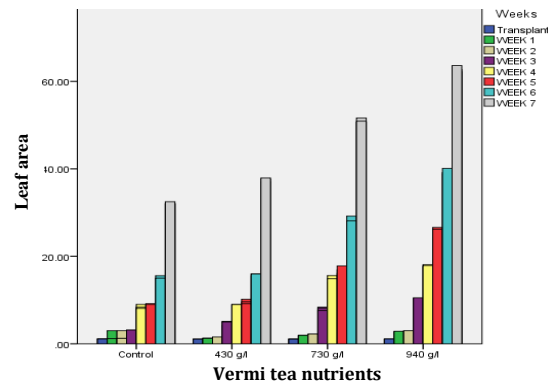


Fig. 4 Effect of vermi tea on leaf area of *S. oleracea* for 50 days (seven weeks)

This study showed that the vermi tea at three different concentration contained essential mineral nutrients such as N, P, K with increasing concentrations (Table 1) required by plants for optimal growth and productivity. This result is consistent with the works of previous authors such as Sundararasu et al. [18]. They conducted a research to evaluate the growth and yielding pattern of *Capsicum chilli* (chilli plant) by the application of vermi tea. They analyzed the physico-chemical nutrients of the vermi tea using flame atomic absorption spectroscopy (AAS) and observed vermi tea contained essential nutrients, such as N, P and K and organic carbon, which enhanced the growth of *C. chilli* with increasing concentration of vermi tea.

This study applied the three concentrations of vermi tea to the soil used to cultivate *S. oleracea* for 50 days. *S. oleracea* plant treated with 430 g/L of vermi tea showed the least plant height. There was no significant effect on the plant grown at this concentration compared to the control. However, the plant treated with 730 g/L of vermi tea showed slight significant differences from the control. *S. oleracea* plant treated with 940 g/L of vermi tea showed a high degree of significant effect relative to the control, and even that of 430 g/L concentration. The most significant effect of vermi tea on plant growth was observed in the plant treated with 940 g/L of vermi tea. These results clearly affirm that vermi tea has positive effects on the growth and height of *S. oleracea*. This is likely due to the high nutrient content obtained from this concentration of vermi tea. These findings corroborate the work of Manyuchi [19] who asserted that the height of vegetable plants may be influenced by the concentration of mineral nutrients, such as N, K and P present in their soil growth medium.

4. Conclusion

The findings of this study indicate that the three concentrations of vermi tea contain essential mineral nutrients, such as N, K and P at increasing concentrations of vermi tea. Also, the test plant showed a positive response to vermi tea by increasing the growth parameters of *S. oleracea* with respect to leaf numbers, leaf area and height. Following these results, it is highly likely that vermi tea can improve the growth of *S. oleracea* and possibly similar herbaceous plant species. Therefore, this study suggests the commercial production of vermi tea as an effective organic fertilizer in the cultivation of *S. oleracea* and other related herbaceous species.

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