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Effect of Vermicompost, Vermiwash and Application Time on Soil Micronutrients Composition

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Abstract— ***Vermicomposting is increasingly becoming popular as an organic solid waste management strategy. The technology results in two bio-fertilizers, vermicompost and vermiwash. The bio-fertilizers were applied to the soil and their impact on the soil micronutrients time was quantified. A maximum of 1000g of vermicompost and vermiwash was applied over 40 days. 2^3 factorial designs were used to determine the effects of the bio-fertilizers and application time on the soil micronutrients. Increasing the vermicompost quantity resulted in increased soil zinc, manganese and iron content. Increased vermiwash quantities resulted in increased soil iron content but resulted in decreased copper content. Furthermore, increased application time of the two bio-fertilizers resulted in enhanced soil copper and iron content but decreased the zinc and manganese content. The loam-clay soil, organic material from the bio-fertilizers and microbial activity played a significant role in altering the soil micronutrients.***

Index Terms—: Vermicompost, vermiwash, application time, soil micronutrients, bio-fertilizer

I. INTRODUCTION

Vermicomposting is a technology that involves the bioconversion of organic waste into bio-fertilizers by the use of the earthworms [1]-[8]. This technology is increasingly becoming popular as a solid waste management strategy. During the vermicomposting process, earthworms feed on the organic waste and their gut act as a bioreactor such that vermicasts are expelled [3]; [9]. These vermicasts are rich in the macro and micronutrients of a fertilizer [3]; [5]; [7]-[9]. Furthermore, vermiwash, a brownish leachate is produced during the vermicomposting process. Vermiwash is also rich in the macro and micronutrients of a fertilizer and can also be used as a foliar spray [7]; [10]-[14]. The macronutrients include nitrogen, phosphorous and potassium whereas the micronutrients include boron, copper, iron, manganese, molybdenum and zinc [7].

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These micronutrients are also critically important in plants. Boron is required for cell wall formation, copper is essential for carbohydrate and nitrogen metabolism, iron is necessary for chlorophyll production, manganese for photosynthesis, molybdenum for enzyme systems that are responsible for nitrogen fixing bacteria and zinc is the major component for enzyme systems required for plant growth regulation and protein photosynthesis [7]; [15]. This study therefore focused on investigating the effect of vermicompost, vermiwash and application time on the soil micronutrient content. Although much emphasis has put on the vermicomposting technology and the impact of these bio-fertilizers on major fertilizer nutrients [7], the vermi-products impact on soil micronutrients still need to be understood.

II. MATERIALS AND METHODS

A. Vermicompost and vermiwash

Vermicompost was obtained from waste corn pulp blended with cow dung manure, vegetables and office paper. Vermicomposting was done for 30 days using *Eisenia fetida* earthworms [6]. 60ml of vermiwash was continuously collected per day from the 10kg of organic waste that was vermicomposted. 4kg of loam-clay soils were used for the study. An AND HR 200 balance was used to measure the vermicompost and vermiwash quantities. The vermicompost and vermiwash were hand mixed with the soil.

B. Experimental design

A 2^3 experimental design with a center point was used (see Table 1). The independent variables used were the vermicompost quantity, vermiwash quantity and the application time of the two bio-fertilizers. The conditions that were used are: vermicompost: 500-1000g, vermiwash: 500-1000g and an application period of 10-40 days. The center conditions employed were: vermicompost 750g, vermiwash 750g and an application time of 25 days. STATISTICA software was used for data analyses. Surface responses were used to determine the trend in the micronutrients upon varying the independent variables.

C. Soil analyses for micronutrients

The soil was analyzed for micronutrients and was found to be rich in zinc, copper, manganese and iron. The composition was determined by a Cary model AAS spectrophotometer. These micronutrients were then noted as the response variables.

Table 1: 2^3 factorial design used for determining the change in parameters

Raw soil sample	Vermicompost (g)	Vermiwash (g)	Time (days)
1	*500*	*500*	*10*
2	1000	500	10
3	500	1000	10
4	1000	1000	10
5	500	500	40
6	1000	500	40
7	500	1000	40
8	1000	1000	40
9	750	750	25

III. RESULTS AND DISCUSSION

A. *Effect of vermicompost, vermiwash and application time on zinc content*

Zinc exists in the soil as Zn^{2+}. Increasing the vermicompost quantity applied increased the soil zinc content to more than 1.6 mg/L (see Figs 1a and 1b). However increasing the vermiwash quantity applied did not change the zinc content in the soil (see Figs 1a and 1c). Increasing the application time of the bio-fertilizers resulted in decreased zinc content to less than 1.0 mg/L (see Figs 1b and 1c).

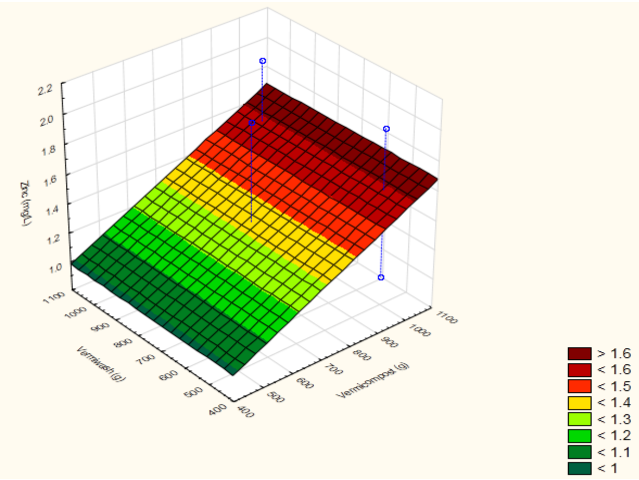

Fig 1a: Effect of vermicompost and vermiwash on soil zinc content at constant application time of 25 days

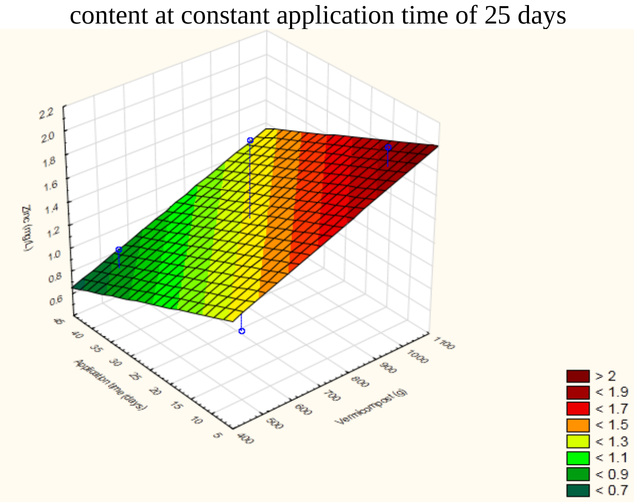

Fig 1b: Effect of vermicompost and application time on soil zinc content at constant vermiwash quantity of 750g

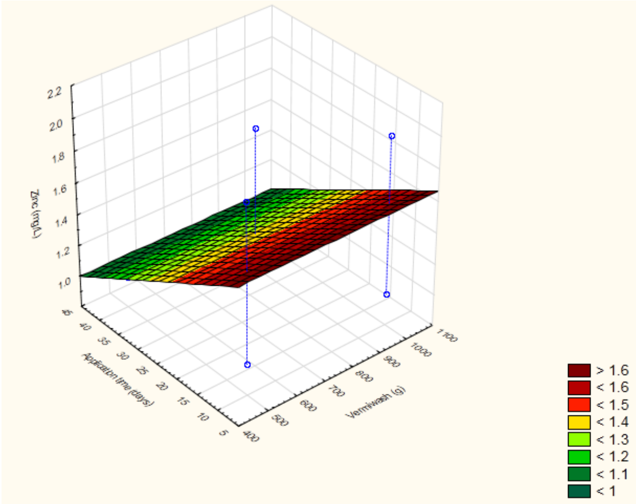

Fig 1c: Effect of vermiwash and application duration on soil zinc content at constant vermicompost content of 750g

B. *Effect of vermicompost, vermiwash and application time on copper content*

Copper exists in the soil as Cu^{2+}. Increasing the vermicompost quantity applied did not result in a significant change in the soil copper content (see Figs 2a and 2b). However, increasing the vermiwash quantity applied resulted in decreased copper content by less than 5.25 mg/L (see Figs 2a and 2c). In addition, increasing the application time of the bio-fertilizers resulted in increased soil copper content by more than 8.0 mg/L (see Figs 2b and 2c).

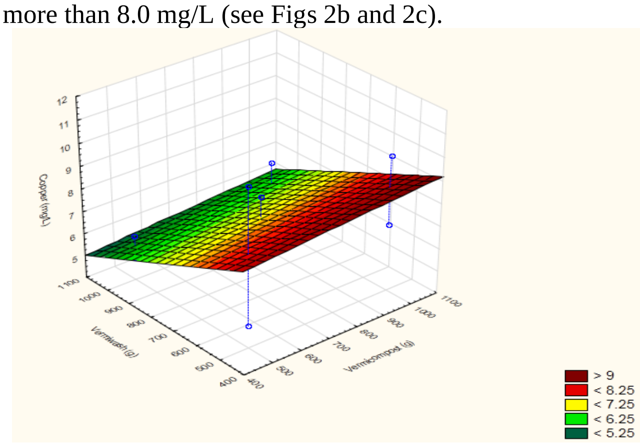

Fig 2a: Effect of vermicompost and vermiwash on soil copper content at constant application time of 25 days

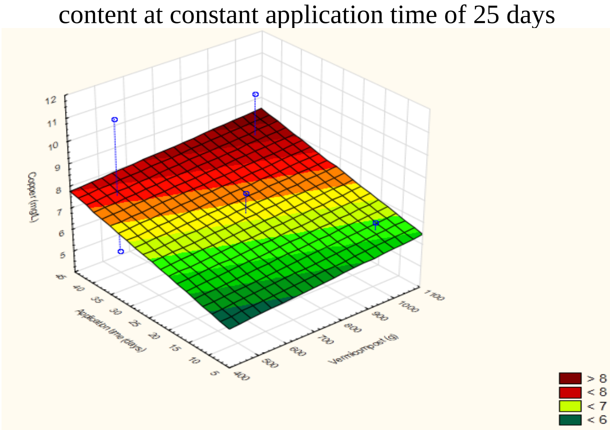

Fig 2b: Effect of vermicompost and application time on soil copper content at constant vermiwash quantity of 750g

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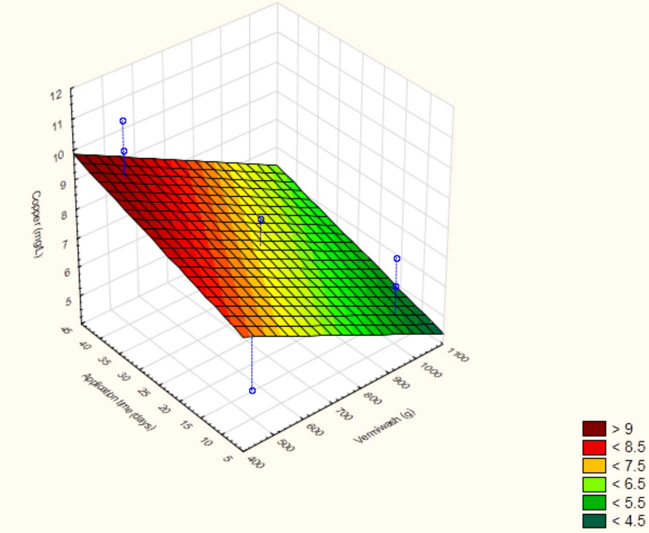

Fig 2c: Effect of vermiwash and application time on soil copper content at constant vermicompost quantity of 750g

C. Effect of vermicompost, vermiwash and application time on manganese content

Manganese exist in the soil as Mn^{2+}. Increasing the vermicompost quantity applied in the soil resulted in increased manganese content by more than 200 mg/L (see Figs 3a and 3b). However, increasing the vermiwash quantity did not alter the soil manganese content (see Figs 3a and 3c). Furthermore, increasing the application time of the bio-fertilizers resulted in decreased manganese content by less than 70 mg/L (see Figs 3b and 3c).

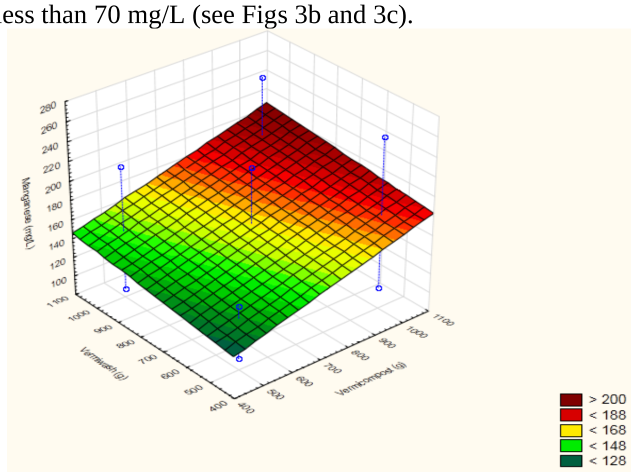

Fig 3a: Effect of vermicompost and vermiwash on manganese content at constant application time of 25 days

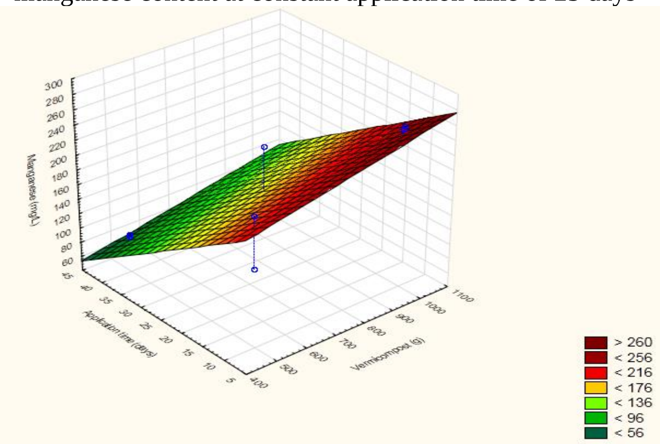

Fig 3b: Effect of vermicompost and application time on manganese content at constant vermiwash content of 750g

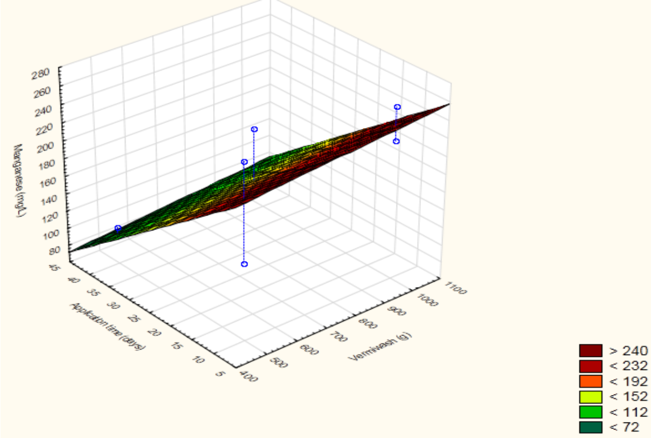

Fig 3c: Effect of vermiwash and application time on manganese content at constant vermicompost quantity of 750g

D. Effect of vermicompost, vermiwash and application time on iron content

Iron exists in the soil as Fe^{2+} and Fe^{3+}. Increase in vermicompost and vermiwash quantity applied did not show a significant change in the soil iron content (see Figs 4a, 4b and 4c). However, increasing the application time of the two bio-fertilizers resulted in increased soil iron content by more than 180 mg/L (see Figs 4b and 4c).

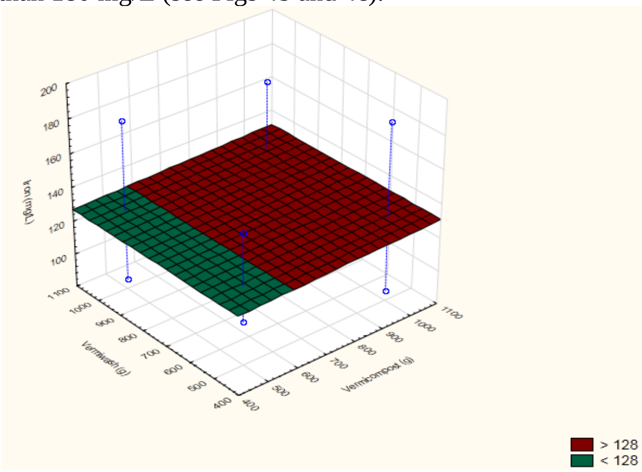

Fig 4a: Effect of vermicompost and vermiwash on iron content at constant application of 25 days

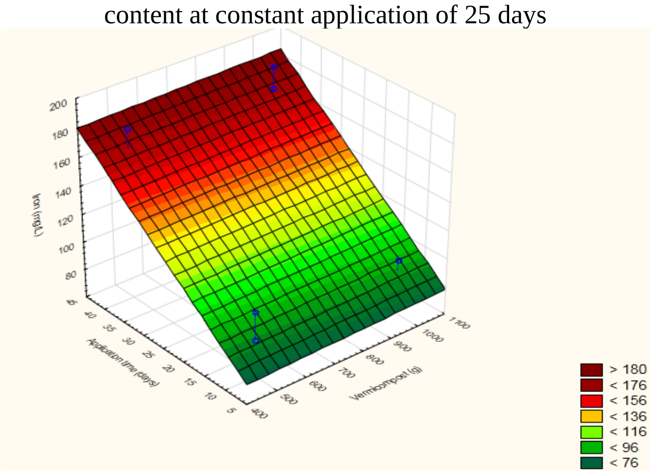

Fig 4b: Effect of vermicompost and application time on iron content at constant vermiwash quantity of 750g

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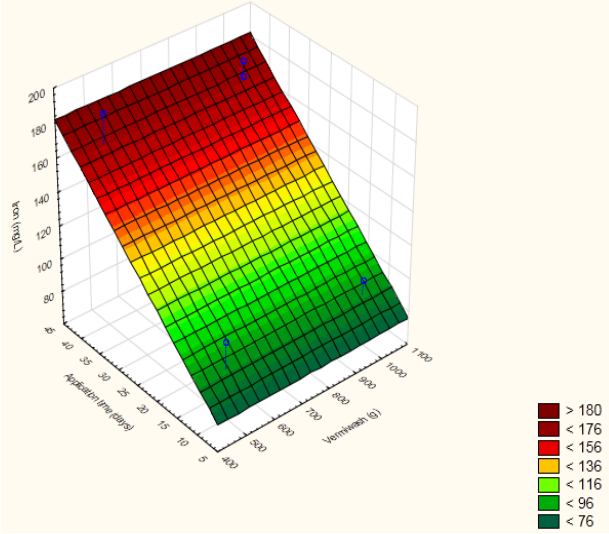

Fig 4c: Effect of vermiwash and application time on iron content at constant vermicompost quantity of 750g

The organic carbon in the vermicompost promotes steady and slow release of nutrients in the soil making them more available in the soil [3]. Vermicompost is rich organic material which is abundant in living micro-organisms. This therefore resulted in the increased zinc and manganese content as the quantity applied increased. Presence of organic material present in the soil increased the availability of these micronutrients due to microbial activity [15]. Furthermore, the micro-organisms in the vermicompost improved the soil aeration due to the movement thereby increasing the zinc and manganese content available [15]. However, a vermicompost quantity of a maximum of 1000g did not significantly increase the copper and iron content possibly because the soil was too compacted for a marked impact of the organic material and the microbial activity to be noted.

Vermiwash is a liquid bio-fertilizer and is mostly comprised of water. This therefore resulted in decreased soil copper content as the quantity of vermiwash applied increased. This was possibly because the copper ions were leached away from the sample as the volume of the vermiwash applied increased. However, increase in the vermiwash quantity applied did not alter the soil zinc, manganese and copper content possibly because the soil was a bit compacted hence could not allow leaching away of nutrients.

Increased application time of the vermicompost and vermiwash quantity resulted in increased soil copper and iron content due to increased organic matter which resulted in improved soil aeration and microbial activity [15]. Furthermore, the loam-clay soils have a potential to retain the nutrients despite the vermiwash quantity added over time. The soil manganese and zinc content decreased with increased application time possibly because highly organic soils have lower manganese content [15]. The organic material in the soil continuously increased with increased vermicompost and vermiwash quantities applied over time. In addition, increased soil iron content has tendencies to lower the manganese content [15].

Lastly, vermiwash and vermicompost are enriched with certain metabolites and vitamins B and D such that when applied over time in the soil they have tendencies of overall improving the soil nutrient quality [15].

IV. CONCLUSION

The micro-organisms in the vermi-products play a significant role in altering the soil micronutrient content. The microbial activity induced by the bio-fertilizers increases the soil micronutrient activity by availing additional substances that are not found in chemical fertilizers.

V. ACKNOWLEDGMENT

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