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Effect of Organic Wastes on Soil Heavy Metal Concentration and Growth Characteristics of Cucumber (*Cucumis Sativus* L.) in an Ultisol

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Abstract

An experiment was set up in the 2014 and 20015 cropping seasons to compare the effect of organic wastes as humanure and rumen digesta on soil heavy metal concentration and growth characteristics of cucumber in an Ultisol in Imo State, southeast Nigeria. The study was conducted at the Teaching and Research Farm of the School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri. The treatments comprised of ; T1- Control = 0 kg/ha; T2 - Humanure = 10 t/ha; T3 - Rumen digesta = 10t/ha; T4 - Humanure + Rumen digesta = (5 + 5 t/ha) and T5 - Humanure + Rumen digesta = (10 + 10 t/ha). The experiment was laid out in randomized complete block design (RCBD) and data analyzed using Analysis of Variance (ANOVA) at p = 0.05 probability level. Significant differences were separated with F-LSD. The results obtained showed that both humanure and rumen digesta were good sources of organic manure at the used rates because they did not increase the soil heavy metal properties beyond the WHO permissible limits. There were significant increases in the number of leaves, and branches, relative to the control. The leaf area, vine length, and number of fruits were not affected significantly by the application of the treatments.

Keywords: Cucumber**,** Growth, Heavy, Humanure, Metal, Rumen

1.0 Introduction

Heavy metals are metallic elements with specific gravity greater than 5, such as cadmium, copper, lead and zinc (Brady and Weils,2002) that are found in the environment and are harmful to man, plants and animals. A feature that heavy metals have in common is that they tend to accumulate in the bodies of organism that ingest them. Recently scientists are encouraging the use of organic wastes for soil enrichment in farming because wastes can supply virtually all the nutrients required by plant and improve soil physical and biological conditions for sustainable crop production and environmental safety without paying sufficient attention to their heavy metal contribution to the environment. These wastes also add to the pool of heavy metals in the soil which can become a major problem militating against quality yield of crop. These metals disturb the normal biological or biochemical processes in living organisms (Brady and Weils 2002).

The concentration of heavy metals increases up the food chain. For instance, some marine algae may contain heavy metals at concentrations up to one hundred times that of the water in which they are living. Small fishes eating the algae develop higher concentrations of heavy metals in their flesh; larger fishes that feed on the smaller ones imbibe higher concentrations of the metals and so on, up to fish eating birds or mammals (Jenkins,2005). The humans who produce humanure invariable return these heavy metals to the soil and few people seem to realize that metals lost to our environment pose human health problems(Jonsson et al.,2004). Japanese itri-itri disease was traced to the consumption of rice grown in cadmium contaminated irrigation water, while brain damage and incidences of lung cancer have been attributed to lead and nickel contamination respectively. (FAO,1997 ; M.O.S.E.S, 2009;Thao,1998). The liver, the kidney, respiratory and reproductive systems are mostly affected by heavy metals.

Micronutrient are known to function as welfare minerals to growing crops but in excess, pose great danger to the crop, humans and the ecosystem generally (Brady and Weils,2002). It is important, therefore, that the contributions of organic wastes as credible substitute for inorganic fertilizer should be checked to forestall solving one problem and creating even a bigger one in the process. It was based on this that an experiment to evaluate the effect of humanure and rumen digesta on soil

heavy metal concentration and yield characteristics of cucumber in an Ultisol in Imo South-East, Nigeria was embarked upon.

2.0 MATERIALS AND METHOD

2.1 Site Description

The study area was Ihiagwa, Imo State, southeast Nigeria. Ihiagwa is located in the humid tropics, at Latitude 5˚24˚N and Longitude 7˚01˚E. The annual rainfall and temperature range from 2500 – 3000 mm and 25˚C - 30˚C, respectively. Soils of Ihiagwa are derived from alluvial and coastal plain sands.

2.2. Experimental Materials and Treatment Combinations

Seeds were bought at the Agricultural Development Programme (ADP), Owerri, Imo State. Five (5) bags of rumen digesta were gotten from the Abattoir at Relief Market, Imo State and 5 bags of humanure from the sewage dumping ground at Onitsha expressway, Irete, Imo state. The treatments comprised of T1- Control at 0 kg/ha; T2 – Humanure at 10 t/ha; T3 - Rumen digesta at 10t/ha; T4 - Humanure + Rumen digesta at (5 + 5 t/ha) and T5 - Humanure + Rumen digesta at (10 + 10 t/ha).

2.3. Field Layout and Experimental Design

There were 20 plots in the experimental field. Each of the plots measured 3 x 3 m with 1m alley between blocks and between plots. The experiment was laid out in a randomized complete block design with 5 treatments replicated 4 times. The diagrammatic representation of the field layout is shown in Figure 1.

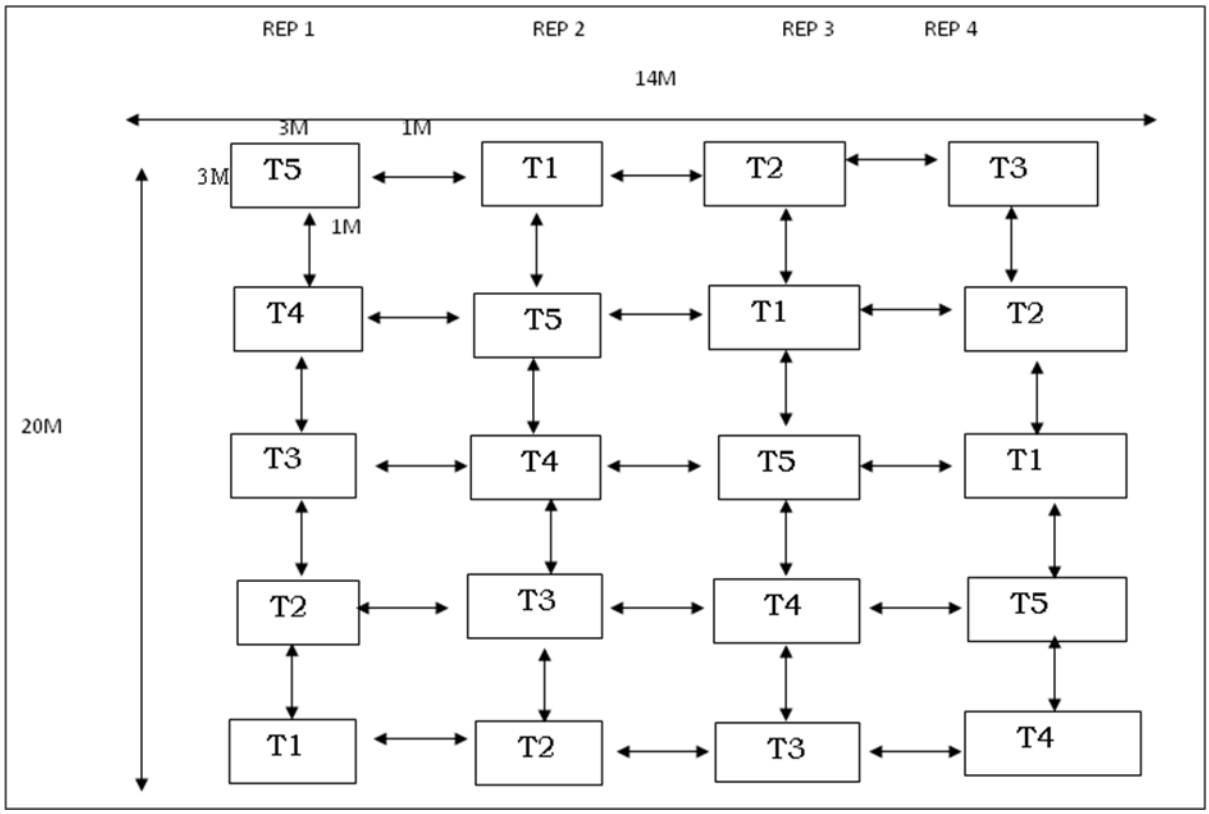

Fig.1. The treatment allocation in a Randomized Complete Block Design (RCBD) with 5 treatments and 4 replications.

2.4. Soil Sampling and Laboratory Analysis

The initial and post harvest soil samples were collected at 0 – 30 cm soil depth. The core sampler attached to a soil auger was used in the soil sampling and these samples were used for the determination of heavy metal content of the soil. The soil samples were air dried, crushed and sieved using 2mm size sieve in preparation for use in analysis. Selected Heavy metals soils were determined according to the procedure outlined by AOAC (2012) for heavy metal determination. The samples were digested and the heavy metals were read out using Atomic Absorption Spectrometer (AAS). The heavy metals determined were Copper (Cu), Zinc (Zn), Cadmium (Cd), and Nickel (Ni).

2.5. Cultural Practices

The land was manually cleared using machetes; stumps were removed after which seed beds were made using hoes and spades. The treatments were incorporated into the soil and allowed to stand for 2 week before seed placement. Cucumber

variety ASHLEY was used and three seeds was planted per hole and later thinned down to one seedling per stand, 2 weeks after planting. The planting was done at the spacing of 50 cm x 50 cm and the arrangement gives a plant population of 40,000 plants per hectare. Weeds were controlled manually using hoe and by hand picking to keep the plot free of weeds as regularly as the need arose.

2.6 Measurement of Growth Parameters; Three plants were tagged in each plot and used for all the agronomic measurements:

2.6.1 Number of Fruits: This was obtained by counting the fruits harvested per plot.

2.6.2 Vine Length: The vine length was measured at flowering using meter rule from the base of the plant to the apex leaf**.**

2.6.3 Number of Leaves: This was done by counting all the leaves on the three tagged plants and the total divided by three to give average number of leaves per plant.

2.6.4 Number of Branches: The number of branches was counted from the three tagged plants**.**

2.6.5 Leaf Area: The leaf area of the three tagged plants was measured using meter rule. The length and breadth of the leaf was measured and multiplied by a factor 0.75.

2.7 Statistical Analysis; Generated soil data were analyzed using Analysis of Variance (ANOVA). Significant differences between means were separated using Fishers Least Significant Difference (F-LSD) at 5% level of probability.

3.0. RESULTS AND DISSCUSION

3.1.0 Effects of Treatments on Selected Heavy Metals

The effect of humanure, rumen digesta and humanure and rumen digesta combinations on selected heavy metals are presented in the table 1.

3.1.1 Cadmium (Cd):

The result of the treatment on soil cadmium revealed that there was statistically significant difference when control was compared with humanure and rumen digesta combination of 10 + 10t/ha which produced 0.025mg/kg cadmium. Also, when the sole rumen digesta application was compared with humanure and rumen digesta combination of 10 + 10t/ha, 0.027mg/kg cadmium was produced.

When humanure and rumen digesta combinations of 5 + 5t/ha and 10 + 10t/ha were compared with each other, 0.027mg/kg cadmium was produced. There were no significant differences when control was compared with the sole humanure; the sole rumen digesta and the humanure and rumen digesta combination of 5 + 5t/ha applications. Also, there were no significant differences when the sole humanure was compared with the sole rumen digesta and humanure and rumen digesta combinations applications. The same result was recorded when the sole rumen digesta application was compared with humanure and rumen digesta combination of 5 + 5t/ha. The values of cadmium recorded were higher than the (0.01mg.kg-1) permissible limits by the WHO.

Table 1: Effects of Treatments on Selected Heavy Metals

Treatment	**Cadmium (**mg.Kg-^{1}**)**	**Zinc (**mg.Kg-^{1}**)**	**Nickel (**mg.Kg-^{1}**)**	**Copper (**mg.Kg-^{1}**)**
Control	0.015^{a}	0.240^{a}	0.316^{a}	14.0^{a}
T2	0.023^{a}	0.310^{b}	14.480^{b}	15.75^{b}
T3	0.017^{a}	0.267^{c}	0.550^{a}	18.25^{c}
T4	0.017^{a}	0.180^{d}	0.613^{a}	25.90^{d}
T5	0.042^{b}	0.145^{e}	1.170^{a}	25.35^{e}
WHO Limit	0.01	15.0	6.5	1.5
F-LSD(0.05)	0.02	0.01	0.84	1.21

Keys: H= Humanure, RD= Rumen Digesta;

Note: Figures with the same super scripts are not statistically significant while figures with different super script are significant

3.1.2. Zinc (Zn):

The result of the effect of treatment on soil Zn shows that there was significant difference when control was compared with the treatments and when the treatments were compared with one another. When control was compared with the sole humanure application, the sole rumen digesta application and humanure and rumen digesta combinations they produced 0.07, 0.027, 0.06 and 0.095mg/kg respectively. The sole humanure when compared with the sole rumen digesta and humanure and

rumen digesta combinations produced 0.043, 0.13, and 0.165mg.kg^{-1}. The humanure and rumen digesta combinations were compared with the sole rumen digesta application and produced 0.087 and 0.122 mg.kg^{-1}. The humanure and rumen digesta combinations of 5 + 5 and 10 + 10t.ha^{-1} when compared produced 0.035mg.kg^{-1}. This shows that there is an increase in the zinc level of the soil with the addition of rumen digesta and humanure. Even with this increase the zinc concentration is far below the 15.0 mg.kg^{-1} permissible limits of the WHO

3.1.3. Nickel (Ni):

The result of the effect of treatment on soil Ni shows that there was significant difference when control was compared with the sole humanure application and produced 13.93mg/kg and when treatments were compared with one another. The sole humanure application was compared with the sole rumen digesta application, humanure and rumen digesta combinations, produced 14.164, 13.867, and 13.31 mg.kg^{-1} respectively. The sole rumen digesta application was compared with humanure and rumen digesta combination of 5 + 5t.ha^{-1}, produced 0.854mg.kg^{-1}. However, there was no significant difference when control was compared with the sole rumen digesta application and humanure and rumen digesta combinations and also when the sole rumen digesta application was compared with humanure and rumen digesta combination of 5 + 5t.ha^{-1} and when the humanure and rumen digesta combinations were compared with one another. This shows that with the addition of humanure there is an increase in the nickel level in the soil while there was no effect when rumen digesta was added. Sole humanure treated plots recorded nickel concentration higher than the permissible limit while the rest of the treatments recorded values much lower than the 6.5 mg.kg^{-1} recommended limits.

3.1.4 Copper (Cu):

The result of the effect of treatment on soil Cu reveals that there was significant difference when control was compared with the treatments and when the treatments were compared with one another. The sole humanure application recorded 1.75 mg.Kg-^{1} when compared with control. The sole rumen digesta and humanure and rumen digesta combinations produced 4.25, 11.9, and 11.35 respectively when compared with control. The sole humanure application when compared with the sole rumen digesta application and humanure and rumen digesta

combinations produced 2.5, 10.15, and 9.6 mg.Kg-^{1}. The sole rumen digesta application recorded 11.6 and 7.1 mg.Kg-^{1} when compared with the humanure and rumen digesta combinations. Nevertheless, there was no significant difference when the humanure and rumen digesta combinations were compared with each other. This shows that there is an increase in soil Cu level with the addition of rumen digesta and humanure. The concentration of cupper in the soil as a result of the treatments fell above the permissible concentration in the soil. The soil native concentration was equally higher than permissible limit of 1.5 mg.Kg-^{1}

3.2. Effects of Treatments on Cucumber Growth Parameters.

The effect of humanure, rumen digesta, and humanure and rumen digesta combinations on cucumber yield, yield and growth parameters are presented in table 2.

Table 2: Effect of Treatments on Cucumber Yield, Yield and Growth Parameters.

Treatment	No of fruits.ha^{-1}	Vine length (cm)	No of leaves	No of branches	Leaf area index(cm²)
T1	20,500^{a}	74.6^{a}	51.9^{a}	1.1^{a}	95.4^{a}
T2	42,000b	86^{a}	21.8^{a}	1.6^{b}	114.6^{a}
T3	84.500c	94.2^{b}	21.9^{b}	1.8^{c}	117.8
T4	40,000d	76.9^{a}	20.4^{c}	1.3^{d}	110.9^{a}
T5	40,000e	83.3^{a}	20.2^{d}	1.6^{e}	105.2^{a}
F-LSD(0.05)	10.0	18.2	1.2	0.02	NS

Note: Figures with the same super scripts are not statistically significant while figures with different superscript are significant.

3.2.1. Number of Fruits:

The result of the effect of treatment on number of fruits shows that there was significant difference when the number of fruits produced from the control was compared with the sole rumen digesta application and when the other treatments

were compared with one another. The sole humanure application produced 21,500 fruits when compared with the control while the control produced 64,500 less number of fruits than sole rumen digesta treatment. Also there were 2000 more fruits in both 5 + 5 $t.ha^{-1}$ humanure and rumen digesta combinations when compared with control. Ten tons per hectare rumen digesta treated plots produced 44500 each more fruits than 5 + 5 and 10 +10 $t.ha^{-1}$ humanure and rumen digesta combinations. The higher number of fruit yield from the rumen digesta treated plots showed the superiority of this soil amendment in improving the growing medium of the plants. The humanure amendment also proved superior to the control and their combinations at 5 + 5 and 10 +10 $t.ha^{-1}$.

3.2.2. Vine Length:

The result of the effect of treatment on the vine length shows that there was no significant difference when the control was compared with the treatments and when the treatments were compared with one another. Nevertheless, there was significant difference when the sole rumen digesta application was compared with control. This supports the strong indication that rumen digesta is playing soil enrichment role for cucumber growth and its general yield.

3.2.3. Number of Leaves:

The result of the effect of treatment on number of leaves reveals that there was significant difference when control was compared with the treatments and when the treatments were compared with one another. The sole rumen digesta and humanure and rumen digesta combinations produced 5.9, 1.4 and 1.6 respectively when compared with control. The sole humanure application when compared with the sole rumen digesta application and humanure and rumen digesta combinations produced 5.9, 1.4, and 1.6. The sole rumen digesta application recorded 4.5 and 4.3 when compared with the humanure and rumen digesta combinations. Nevertheless, there was no significant difference when the sole humanure application was compared with control and when the humanure and rumen digesta combinations were compared with each other. This shows that there is an increase in number of leaves of cucumber when rumen digesta was added and not much effect when humanure was added.

3.2.4. Number of Branches:

The result of the effect of treatment on number of branches reveals that there was significant difference when control was compared with the treatments and when the treatments were compared with one another. The sole humanure application produced 0.2 when compared with control. The sole rumen digesta and humanure and rumen digesta combinations produced 0.7, 0.5, and 0.2 respectively when compared with control. The sole rumen digesta application and humanure and rumen digesta combination of 5 + 5t/ha produced 0.5 and 0.3 when compared to the sole humanure application. The sole rumen digesta application recorded 0.2 and 0.5 when compared with the humanure and rumen digesta combinations. The humanure and rumen digesta combinations recorded 0.3 when compared with one another. Nevertheless, there was no significant difference when the sole humanure application was compared with humanure and rumen digesta combination of 10 + 10t/ha. This shows that there is an increase in number of branches with the addition of rumen digesta and humanure.

4.0 Conclusion

It can be concluded that humanure and rumen digesta are good sources of organic manure for crop production since they improve Aq soil physic-chemical properties significantly and increased yield, yield and growth parameters of cucumber. The best rate in terms of yield and growth parameters is the sole humanure application.

5.0 Recommendation

Farmers within and outside Ihiagwa agro ecological zones are advised to make use of humanure and rumen digesta. This will not only help in improving the soil and crop yield but will also improve the environment and prevent pollution. The residual effect should be to determine how long nutrients released from them can last in the soil.

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