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EFFECTS OF NITROGEN ENRICHMENT ON HEAVY METALS CONTENT OF CATTLE DUNG/POULTRY MANURE COMPOST AND MAIZE YIELD.

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ABSTRACT

The research was carried out at John Ker Nigeria Organo-Mineral Company site at Ikot Ekpene, Akwa Ibom State, Nigeria, to investigate the effect of nitrogen enrichment on contents of heavy metals in cattle dung/poultry manure compost and the growth of maize. Cattle dung was mixed with poultry manure in the ratio of 3:1 volume/volume basis, respectively. The compost treatments were; (i) cattle dung/poultry manure (CDPM), (ii) cattle dung/poultry manure supplemented with 25 kg of urea ($CDPM_U$) and (iii) cattle dung (CD) as control composted alone. The compost treatments; CDPM, $CDPM_U$ and CD were sampled periodically after 2, 6 and 10 weeks of composting for laboratory analysis. After 10 weeks, each of the compost treatments was mixed with 7 kg of dry soil sample at the rate of 10, 20 and 40 t/ha to test its effects on the growth of maize plant for 6 weeks. The enrichment of the CDPM compost resulted in an increase in the levels of all the heavy metals contained in the compost ($CDPM_U$) at two weeks after composting. At 10 weeks of composting, the concentrations of Fe, Zn, Cu, V, Mn and Ni in $CDPM_U$ compost increased by 32.8, 25.6, 14.6, 40.0, 6.8 and 19.0 %, respectively compared with their contents in the CDPM. The C/N ratios ranged from 23.9 to 25.1 in the CD compost, 23.1 to 23.4 in the CDPM compost and 13.6 to 16.9 in the $CDPM_U$ compost within the 10 weeks of composting. The influence of the compost treatments on the growth of maize plant indicated that the plant fertilized with $CDPM_U$ compost at 40 t/ha were significantly ($P<0.05$) higher than those fertilized with the same compost treatment at 0, 10 and 20 t/ha. Those fertilized with CD and CDPM at the rate of 0, 10, 20 and 40 t/ha, had the same trends respectively.

Key words: Nitrogen Enrichment, Heavy Metals, Cattle Dung, Poultry Manure, Compost.

1.0 INTRODUCTION

Application of fertilizers to crops in the humid tropics such as Nigeria is affected by high rate of nutrient losses even when the fertilizers are properly incorporated into the soil. This is caused by the fragile nature of tropical soil, which according to Brady and Weil (1999) is characterized by low activity clay, low water and nutrient holding capacity, low organic matter content and seasonal torrential rains which cause leaching of nutrients and soil erosion.

Manures were the only means of adding extra nutrients to the soil or replacing those removed by crops before mineral fertilizers were introduced (Cook, 1981). Apart from the normal crop rotation and bush fallowing, research on the use of organic manures for arable crop production in Nigeria dates back to more than 60 years starting with the work of Hartley and Greenwood (1933). Proper composting of wastes especially aerobic type in windrows has proved very effective in reducing such problems and enhancing crop yield (Sridhar *et al.,* 1985).

Composting process is currently viewed as a waste management practice used in stabilizing organic wastes, such as manure, yard trimmings, municipal bio-solids and organic urban wastes. Compost is a cured final product of microbial degradation of raw organic wastes used as a soil amendment for crop production (Tyler, 1992). According to John *et al.,* (1995), through composting, organic materials with offensive odour, high moisture, bulkiness and fly infestation are effectively reduced to sweet smelling compost.

Materials with high C/N ratio could be mixed with those of lower C/N quotient to bring the average ratio of the composite input to a desirable level (Karki and Gairtam, 1994). Animal waste, particularly cattle dung has an average C/N ratio of about 24 (Karki and Dixit, 1989). For proper and faster rate of decomposition, materials with high C/N ratio should be composted with high nitrogen containing materials, hence increasing the nitrogen content of the materials for increased decomposition.

Through composting, active organic matter in fresh organic wastes were converted into a source of nutrients for plant growth and soil conditioners for improving the soil physical properties (Hoitink and Fahy, 1986; Chen *et al.,* 1989). Therefore this research combines cow dung with high C/N ratio and poultry manure with a low C/N ratio to enhance the biological decomposition towards the production of compost that will encourage soil life and plant growth.

2.0 MATERIALS AND METHODS

(a) Physiography of the experimental area:

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The study was conducted at John Ker Nigeria Organo-Mineral Company site, 112b Old Itu Road, Ikot Ekpene Local Government Area, Akwa Ibom State, Nigeria, from April to July 2007. The area is located between Latitude 4 ^{0} and 6 ^{0}N and Longitude 32 and 34 ^{0}E, in the rainforest zone. The air temperature ranges from 26 to 30 ^{0}C and the relative humidity from 75 to 95%. The mean annual rainfall ranges from 2000 to 3000 mm (SLUS-AK, 1989).

(b) Composting process and laboratory analysis:

Cattle dung (CD) used for the experiment was obtained from Obo-annang market poultry manure collected from a deep litter system at Ritman Farms Limited, both in Ikot Ekpene district. The Cattle dung and poultry manure were mixed thoroughly at the ratio of 3:1, respectively and shared into two heaps with one heap incorporated with 25 kg of urea. The control was cow dung only. The heaps were sufficiently mixed and watered at intervals of four days for the first two weeks, one week for the next one month and monthly, till end of composting after 10 weeks. Ambient and compost temperatures were taken using a thermometer before and after turning. Moisture content of composite samples of the compost was determined by oven drying. Compost and soil samples were collected, air-dried, ground with mortar and pestle, sieved through a 2 mm sieve before subjecting them to laboratory analysis as follows:

Total nitrogen was determined by micro Kjeldahl digestion method (Jackson, 1962) and organic carbon by Walkley-Black wet oxidation method (Walkley and Black, 1934). Available P was determined using Bray P-1 method as described by Bray and Kurtz, (1945). Zn, Fe, Mn, Ni, V, Pb and Cu were read using an atomic absorption spectrophotometer (Michael and Gilliam, 1998).

Data collected from the test crop (maize) were subjected to statistical analysis. Means and Coefficient of Variation (CV %) were used in evaluating the variability of the nutrient values of the composts their effects on the plants (Gomez and Gomez, 1984).

(c) Pot experiment.

Seven kg of soil sample was mixed with 10, 20 and 40 t/ha of each of the compost treatments and put into polythene bags. The control was soil only. Each treatment was replicated four times. The test crop; maize (*Zea mays*) was planted at the rate of four seeds per bag and later thinned to two plants. Plant height was taken on weekly basis for six weeks using a measuring tape.

3.0 RESULTS AND DISCUSSION:

(a) Composition of fresh organic materials and experimental soil.

The heavy metals content of fresh organic materials (cattle dung and poultry manure) used for composting is presented in Table 1. The heavy metals content of these materials were low except for high content of iron in both organics and manganese in poultry manure. The lowest content of heavy metals in these materials was found in Cu and Ni, followed by V which had a similar content. The content of Fe, Zn, Ni and Cu were higher in cattle dung than in poultry manure, whereas Mn and Pb values were higher in poultry manure than in cow dung. The C/N ratio of cow dung (23.7) was greater than that of poultry manure (22.2).

The physico-chemical composition of the soil used for planting and fertilizing the test crop indicated that the soil was sandy loam and moderately acidic in nature (Table 2). The soil organic matter, nitrogen, available phosphorus, exchangeable bases and base saturation contents were low. These are indices of the low fertile status of the experimental soil.

(b) Content of heavy metals in the various composts during composting

The enrichment of the CDPM compost resulted in an increase in the levels of all the heavy metals contained in the compost (CDPM$_U$) at two weeks after composting. There was a high rate of mineralization in the compost supplemented with urea throughout the composting period though their concentrations reduced with time of composting. However, at 6 weeks after composting, Fe, Mn, Zn and V contents in the enriched compost was still higher than the non-enriched. Only the concentrations of Fe, Zn, Cu and V in the enriched compost remained constantly higher than that of the non-enriched compost at the 10th week of composting (Table 3).

At the 10th week of composting, Fe concentration in CDPM$_U$ was 32.8% higher than its content in the CDPM compost (Table 2). The same was observed for Zn with 25.6%, Cu with 14.6%, V with 40.0%, Mn with 6.8% and Ni with 19.0%. The concentration of Mn in CDPM$_U$ compost reduced by 42.5 % compared with that of CDPM compost. Similar trend was observed for Pb with 54.9 %, Ni with 35.5 % and V with 66.6 % increases in concentration.

Micronutrients (Fe, Cu, Zn and Mn) concentrations in these composts were higher than the concentrations of the other heavy metals, viz; Pb, Ni and V throughout the composting period.

The C/N ratios of both the enriched and non-enriched composts were within the limit for the mineralization of the essential elements in these composts. These ratios ranged from 23.1 to 23.4 in the CDPM compost and 13.6 to 16.9 in the CDPM$_U$ compost within the 10 weeks of composting (Table 3). The lower C/N ratio of the enriched compost than the non-enriched compost treatments might have resulted from the supplementation of the compost with a mineral nitrogen source that had increased the supply of nitrogen for microorganisms involved in the decomposition of the organic materials in the urea enriched compost. Comparing the levels of these nutrients to the work of Canet (2000), they are within the same range of concentration. Generally, the concentrations of all the elements are within international standard as required by plant for good productivity.

(c) Influence of applied compost on fresh and dry weights of maize plant

The fresh and dry weights of maize plant at different rates of application of cattle dung/poultry manure compost at 6 weeks after planting (WAP) are presented on Figure 1. The result indicated that there was no significant (P>0.05) difference in both fresh and dry weights of plant fertilized with CDPM and $CDPM_U$ both at 40 t ha^{-1} but were significantly (P<0.05) taller than those fertilized with CD at 10, 20 and 40 t ha^{-1}, CDPM and $CDPM_U$ both at 10 and 20 t ha^{-1} and soil only.

This implies that the enriched cattle dung/poultry manure compost and its high rate of application increased the fresh and dry matter weights of maize plant.

TABLE 1: Heavy metals content of fresh organic materials used for the composting

Fresh organic material	Heavy metal ($mgkg^{-1}$)						
	Fe	Mn	Zn	Cu	Ni	Pb	V
Poultry manure	996.80	746.40	181.80	14.68	14.38	189.60	16.48
Cattle dung	1120.40	114.60	366.40	18.32	18.96	148.20	16.42
Mean	1058.60	430.50	274.10	16.50	16.67	168.90	16.45

Table 2: The physio-chemical properties of the experimental soil before planting.

Properties	Sand (%)	Silt (%)	Clay (%)	pH	Org. mat. (%)	N (%)	Avail. P mg kg-$^{-1}$	Exchangeable cation (cmol kg^{-1}) K	Ca	Mg	Na	E.A (cmol kg^{-1})	ECEC (cmol kg^{-1})	Base sat. (%)
Content	80.4	9.4	10.2	5.2	2.16	0.09	107.8	0.08	2.26	1.10	0.06	3.58	7.08	49.44

TABLE 3: Some heavy metals content of the cow dung/poultry manure compost with time of composting.

Time of composting (weeks)	Compost treatment	Heavy metals ($mgkg^{-1}$) Fe	Mn	Zn	Cu	Pb	Ni	V	C/N
	CD	1168.8	621.0	360.0	26.14	146.2	44.24	11.63	25.1
	CDPM	952.8	605.8	196.8	10.87	229.4	11.26	10.14	23.3
2	$CDPM_U$	1492.6	868.2	480.4	14.66	341.2	78.40	15.28	16.9
	Mean	1204.7	698.1	345.7	17.20	238.9	44.60	12.40	21.8
	CV (%)	22.6	21.1	41.2	46.20	41.0	75.20	21.40	0.16
	CD	886.6	440.8	239.4	22.64	180.4	22.68	13.08	24.4
	CDPM	921.0	882.6	254.7	16.88	240.0	20.20	8.25	23.1
6	$CDPM_U$	1004.2	925.4	274.0	14.82	189.6	18.48	10.56	16.5
	Mean	937.3	749.6	256.0	18.10	203.3	20.50	10.60	21.3
	CV (%)	6.5	35.8	6.8	22.40	15.8	10.30	22.80	0.20
	CD	1057.4	158.2	190.8	38.14	181.4	26.44	7.84	23.9
	CDPM	577.8	324.6	160.6	26.14	160.8	45.32	9.84	23.4
10	$CDPM_U$	859.2	227.8	216.0	30.60	103.8	33.44	10.66	13.6
	Mean	831.6	236.9	189.1	31.60	148.7	35.00	11.40	20.3
	CV (%)	29.0	35.3	14.7	19.20	27.0	27.20	40.40	0.28

Key: CD = cattle dung
CDPM = cattle dung + poultry manure
$CDPM_U$ = cattle dung + poultry manure enriched with urea

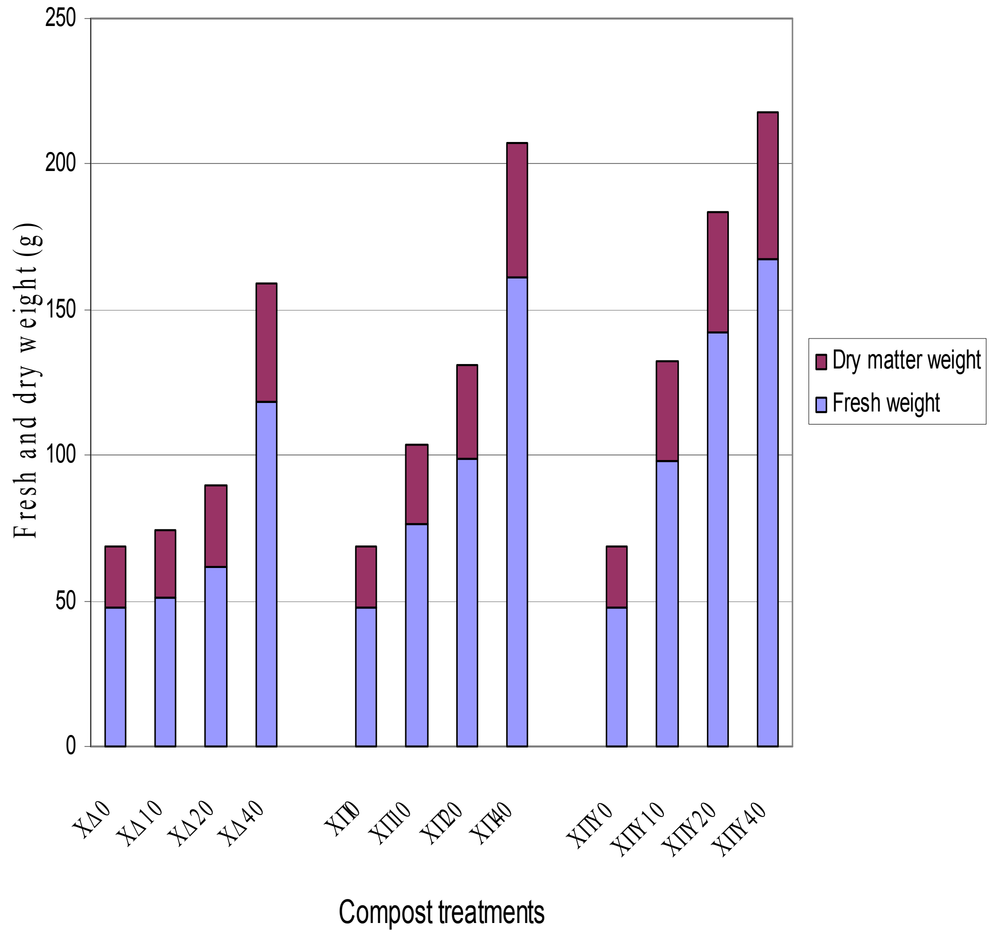

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Figure 1: Fresh and dry matter weights of maize plant fertilized with cattle dung/poultry manure compost at 6 weeks after planting.

KEY:
CD = Cattle dung
CP = Cattle dung + Poultry manure
U_{0-40} = Rates of Urea incorporated (t ha^{-1})

5.0 CONCLUSION

The composting of cattle dung with poultry manure provides for the development of suitable soil conditioners with an array of essential plant nutrients for growing crops. Supplementation of this compost with a nitrogen source, such as urea helps to speed up the organic matter decomposition process, and increases the amount of the elements in the compost and availability of the nutrients it contains. Also, the heavy metals concentration in this compost was not toxic to plants. On application, the prepared cattle dung/poultry manure compost supplemented with urea improved the soil fertility status and also resulted in the increased growth and yield of maize.

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