QUALITY ASSESSMENT OF COMPOST MANURE PRODUCED BY SMALLHOLDER FARMERS IN MALAWI

A.D.C. Chilimba , B. Shano[1], M.T. Chigowo[2] And M. K. Komwa[3]

Lunyangwa Agricultural Research Station, P.O. Box 59, Mzuzu

[1]CIAT-Malawi, Box 158, Lilongwe, Malawi

[2]Blantyre Agricultural Development Division, Private Bag 379, Blantyre

[3]Depts of Geography & GeoInformation, Environmental Science & Public Policy, Research 1 Hall, George Mason University, 4400 University Dr. Fairfax, VA 22030, USA.

ABSTRACT

Malawi has recently embarked on a campaign to promote use of compost manure and other organic matter technologies to improve the soil fertility status and raise crop yields on resource poor farmers' fields. Farmers are making compost manure using various sources of plant materials but the quality of the compost manure was not assessed, although beneficial effects of applying manure are well known. Therefore the quality of compost manure made across the country with their effect on maize yield was assessed. The analytical results showed that N, P, K, Ca, Mg, Zn and Cu ranged 0.21 to 2.2%, 0.05 to 0.73%, 0.12 to 2.62%, 0.19 to 10.1%, 0.15 to 2.43%, 37 to 208 mg kg^{-1} and 12 to 87 mg kg^{-1} respectively. The application of 5000 kg ha^{-1} the compost manure would supply N, P and K ranging from 10 to 74, 5 to 10 and 17 to 37 kg ha^{-1} across the country respectively. To balance the N to attain the recommended rate, application in the range of 82 to 18 kg ha^{-1} need to be applied. However, compost manure supplied adequate amount of K for maize production. In addition the compost manure supplied S, Ca, Mg, Zn and Cu in the range 4 – 13, 50 – 90, 29 – 75, 0.4 – 0.6 and 0.2 – 0.6 kg ha^{-1} respectively. Increased use of compost manure as part of the integrated soil fertility management in Malawi would reverse soil fertility decline and land degradation and improve food security.

INTRODUCTION

An important measure of soil fertility decline is a decrease in soil organic matter and plant nutrients under cultivation. The most widespread and serious form of land degradation and soil nutrient depletion is loss of soil organic matter content (Giller et al. 1997; Sanchez, 1976). The effects from the loss of soil organic matter are observable through decreased structural stability of the soil, lower infiltration rates, and increased vulnerability of soils to wind and water erosion and the extra draft power needed in land preparation (Grant, 1967a).

Farmers possessing smallholdings have traditionally practiced shifting cultivation, rejuvenating the soil fertility through long fallow periods. However, pressure from rapidly increasing populations has led to short fallow periods or continuous cultivation with little or no added external inputs.

Under such circumstances, agriculture in smallholders' farms is causing nutrient depletion. Low soil fertility is the primary factor responsible for reduced crop yields in the smallholders' sector.

The majority of farmers lack access to alternative technologies that allow them to sustain crop yields and meet their annual household consumption needs. A gradual shift from current total reliance on inorganic fertilizers to integrated soil management through complementary use of organic and inorganic sources would greatly assist small-scale farmers in sustaining crop production. Although using fertiliser is less demanding on human labour, it has been shown that using a combination of organic manures and mineral fertilizer leads to positive, additive effects on crop yields (Giller *et al.*, 1997).

Analysis of soil samples from fertiliser trials carried out on land continuously cropped with tea over 25 years revealed a 41 percent total decline in organic matter, a 38 percent decline in total nitrogen (N), and 5 percent decline in total phosphorus, relative to virgin land (Maida and Chilima, 1981). Research in Malawi shows 5 to 10 years of cultivation under current agricultural methods reduce the soil organic matter status to minimum level. At Chitedze, maize grain yields in unfertilised plots decreased from 3500 to 1500 kg/ha from 1956 to 1963 (DAR, 1965). Continuous cultivation without replenishing the plant nutrients taken up by crops has resulted in a steady decline in soil fertility and crop yields.

Studies conducted reported that application of farmyard manure at 5 t ha^{-1} significantly increased maize yields over the control and that 10 t ha^{-1} was not significantly different to 5 t ha^{-1} in maize yields (DAR, 1965). The residual effects of FYM significantly increased maize yields at Tuchila but no residual effects were observed at Mbawa in maize yields. These results indicate that 5 t ha^{-1} supplied adequate nutrients for the maize crop. A combination of 200 kg ha^{-1} sulphate of ammonium with 5 t ha^{-1} FYM did not significantly improve maize yields over 5 t ha^{-1} FYM application. This finding confirms that 5 t ha^{-1} FYM supplied enough nutrients to the maize crop, indicating that the right combinations of organic and inorganic fertiliser need to be established. Nutrient content of farmyard manure ranging from 1.03 to 1.55 %N, 0.31 to 0.5 % P and 1.26 to 2.07 %K have been reported and open khola without bedding gave the lowest nutrient content compared to open Khola with bedding (DAR, 1965).

Farm yard manure is produced by few farmers who own livestock, but the majority of farmers use compost manure. Although FYM is better in nutrient content than compost manure, the use of compost manure is being popularized in the country in order to address soil fertility decline among smallholder farmers. To maintain soil fertility, fertilization must first and foremost be organic; particularly in highly weathered soils, the aim should be to increase soil organic matter and improve soil structure. The organic matter works as a slow release source of nutrients, thereby reducing the risk of leaching. It buffers the soil pH-value, and regulates the balance of nutrients in soil solution. Organic matter also improves the water holding capacity of soils, soil structure, and is essential as a habitat and source of nutrients for micro organisms. These benefits are well recognized in the country. However, guidelines are needed on the amount of organic manures to be applied per unit area, based on nutrient concentration of the manure, in order to supply the required nutrients by the crop. The extension message on the use of compost manure is available but needs to be based on the quality of manure used. The farmers need to be informed on how much organic manures and inorganic fertiliser is used to attain the fertiliser recommendation.

Current status of soil organic matter

In Malawi, organic matter content have reportedly dropped 59 percent in the first year of cultivation, and nationally, crop yields are estimated to be dropping by 2 percent annually. For example, soil organic matter status in Lilongwe Agricultural Development Division (LADD) was assessed (Fig. 1) and the results showed that the soil organic matter was low in the southern and eastern part of the Agricultural Development Division (ADD) (Fig. 2). The Extension Planning Areas (EPAs) that were low in soil organic matter were Tsangano, Manjawira, Nsipe, Kandeu and Njolomole, Chafumbwa, Mlomba, Sinyala, Minng'ong'o, Chilaza, Demela and Ngwangwa (Figure 2). The other EPAs had medium levels of soil organic matter. Soil organic matter is the basic foundation of soil productivity; the decline of soil organic matter is worrisome and needs to be addressed immediately. Soil organic matter supplies crop nutrients at low cost to farmers. The significance of organic matter in tropical soils is greater than any other soil characteristic apart from soil moisture, which is of fundamental importance to the productivity of tropical soils (Sanchez, 1976). Organic manure use offers one of the best opportunities to alleviate the soil fertility problem under smallholder farm conditions in Malawi.

The Ministry of Agriculture and Food Security has intensified compost manure production in the country. Farmers make compost manure using various plant materials, but the quality of the compost manure will depend on the quality of materials used, methods of preparation and storage. Data on the quality of compost manure produced by farmers was lacking. Therefore, there was a need to assess quality of compost manure produced in all Agricultural Development Divisions, in order to provide guidance on either the amount of compost manure applied per unit to attain the recommended fertiliser application, or, the correct combination of organic and inorganic fertilization to achieve the recommended fertiliser application for maize production."

METHODOLOGY

Compost manures made in all ADDs were sampled for analysis. The information on the composition of materials, the name of the farmer and Extension Planning Area (EPA) were also collected.

Total nitrogen analysis

Total nitrogen was determined using Kjeldahl digestion tubes on digestion block and steam distillation apparatus. Weighed 0.20 g of compost manure into 50 ml digestion tube and added 1.1 g of salt/catalyst mixture, added 3 ml of concentrated H_2SO_4 and slowly heated to 200 ^oC. Once the frothing has subsided, bring the temperature up to 350 ^oC to 375 ^oC and heated until the digest cleared and was digested at 350 to 375 ^oC for an additional 35 minutes to 1 hour past clearing. The digest was cooled and added 20 ml of de-ionized water. Added 5 ml of H_3BO_3 indicator solution to a 50 ml flask and placed the flask under the condenser tube below the surface of the indicator solution. Added 20 ml of 10 M NaOH to the digested sample and immediately transferred the tube to the Kjedahl distillation apparatus and began distillation. Collected distillate until the level in the H_3BO_3 flask has reached approximately 35 ml. Titrated the NH_3 distilled into the H_3BO_3 solution using standard 0.01 M HCl or 0.005 H_2SO_4. The end point is reached when the solution goes to pink colour.

Figure 1: Map of Lilongwe ADD showing the Extension Planning Areas where soil organic matter content was determined.

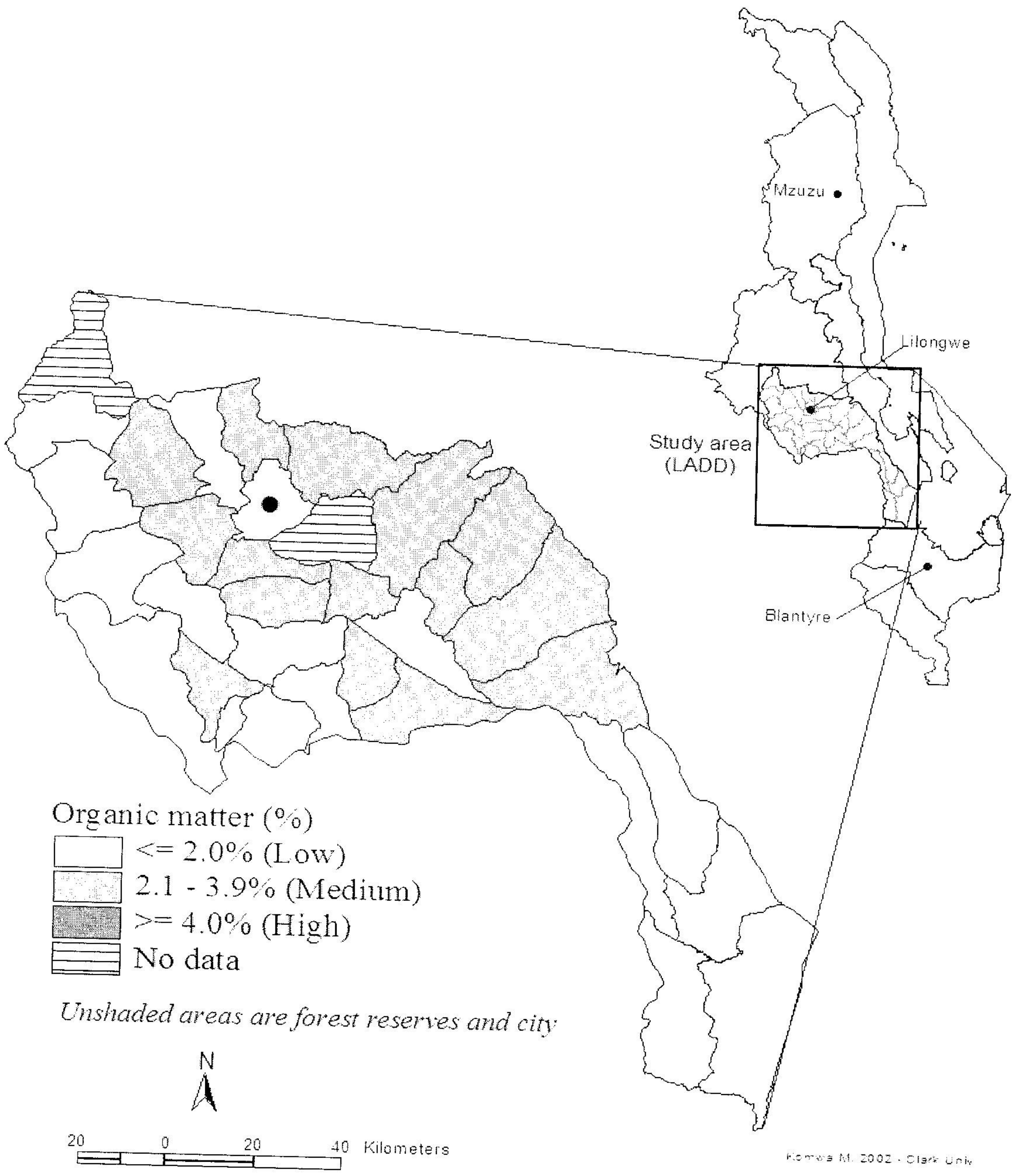

Figure 2: Map of Lilongwe ADD showing soil organic matter content in Extension Planning Areas.

Analyses of P, K, Ca, Mg, S, Cu, Zn,

The samples were oven dried at 105°C for one hour, cooled and ground the sample and weighed 1.00 g into 100 ml Kjedahl flasks. Added 7 ml conc. nitric acid and swirled the flask gently and waited for 5 minutes and then added 3ml conc. perchloric acid, and swirled the flask gently and left to stand for 1 hour. Placed the flask on the Kjeldahl heating unit at very low heat and swirled frequently. When the initial frothing subsided the mixture was brought to a boil. Rotated the flask occasionally and continued boiling until there was a marked lessening in the amount of brown fumes (nitric oxide) evolved and the remaining liquid became pale. The mixture was evaporated to dryness. Cooled and diluted the digest with 15ml distilled water and washed the flask into 50ml volumetric flask through filter paper no.42. Washed the digestion flask and filter paper several times into the volumetric flask and filled to the mark with distilled water. The digest was used to determine P, K, Ca, Mg, S, Cu and Zn with atomic absorption spectrophotometer for K, Ca, Mg, Cu and Zn while spectrophotometer was used to determine P and S.

RESULTS AND DISCUSSIONS

The quality of compost manure varied across the country as shown in figure 3. The compost manure produced in Karonga Agricultural Development Division (KRADD) and Salima Agricultural Development Division (SLADD) were superior in N; P was higher in SLADD, while K was higher in KRADD. The distinction is due to variation in the composition of the compost manure. In KRADD and SLADD, cattle and goat manure dominated the composition of the material used in the compost, hence the increase in the nutrients. Although Shire Valley Agricultural Development Division (SVADD) has a high animal population, this did not reflect in the quality of compost manure produced. This might indicate that the animal manure did not dominate the composition of the compost. Despite variation of quality compost manure, the compost manure contained wide range of nutrients compared to inorganic fertilisers, which contained few nutrients.

The nutrient concentrations of the compost manure are shown in figures 3, 4 and table 1. The Nitrogen content of the compost manure ranges from 0.21 to 2.2%N, Phosphorus ranges from 0.05 to 0.73%P, Potassium ranges from 0.12 to 2.62%, Calcium ranges from 0.19 to 10.1% Ca, Magnesium ranges 0.15 to 2.43% Mg, Zinc ranges from 37 to 208 ppm and Copper ranges from 12 to 87ppm (Table 1). The application of 5000 kg ha^{-1} would supply most of the nutrients required for a maize crop;at this rate the nitrogen, phosphorus and potassium ranged from 10 to 74, 5 to 10 and 17 to 37 kg ha^{-1} across the country respectively (Table 1). This would mean that inorganic fertiliser should be applied as a source of nitrogen in the range of 82 to 18 kg ha^{-1}, but the compost manure supplied adequate amount of P and K for maize production. The compost manure supplied S, Ca, Mg, Zn and Cu in the range 4 – 13, 50 – 90, 29 – 75, 0.4 – 0.6 and 0.2 – 0.6 kg ha^{-1} respectively across the country (Table 1). Combination of organic sources of nutrients and inorganic fertiliser could reduce the cost of production. Inorganic fertiliser could be removed, if the quality is improved by using high quality organic materials, as can be seen in KRADD where the total nitrogen of 72 kg ha^{-1} is coming from the compost manure. Similar results of increased nutrients resulting from incorporation of maize stovers in the third and fourth year were reported in the country, which included pH increase (Chilimba, 2000). The results have shown that compost manure also contributed higher amounts of K, Ca and Mg, which is likely to increase soil pH.

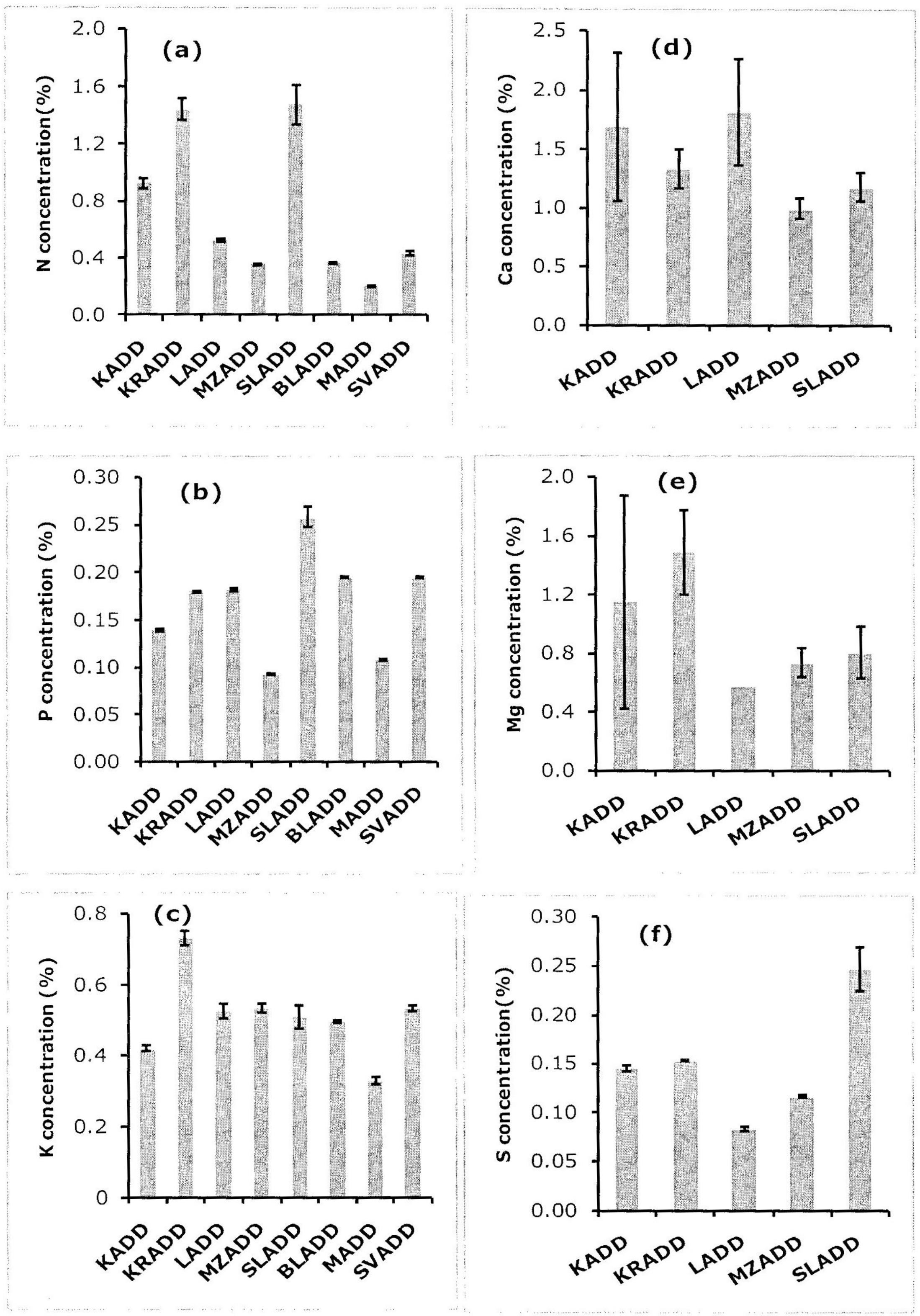

Figure 3. Nutrient concentrations, N% (a), P% (b), K %(c), Ca % (d), Mg% (e) and S %(f) in compost manure produced by smallholder farmers in Agricultural Development Divisions. Bars of standard of error for mean are shown.

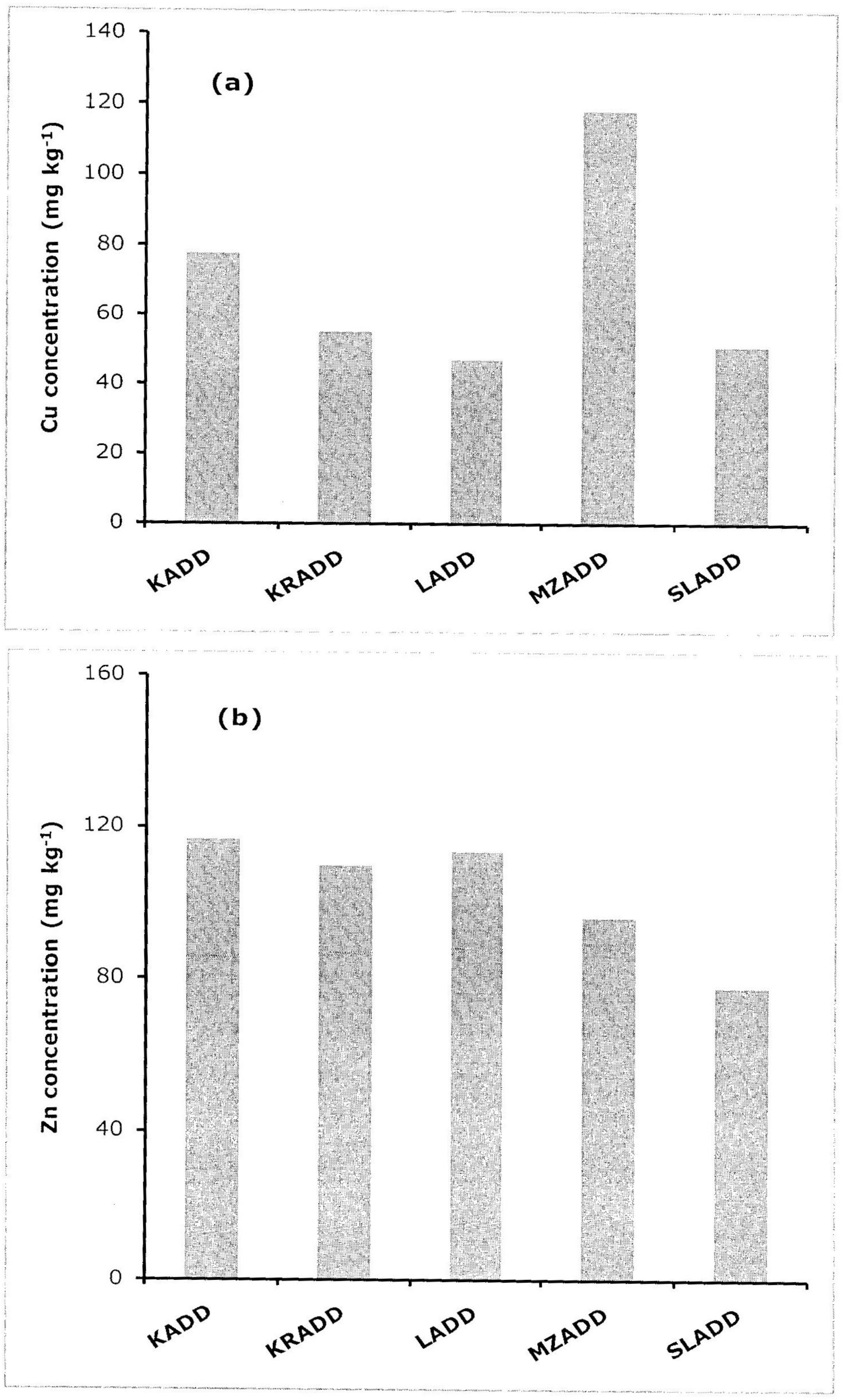

Figure 4. Nutrient concentrations, (a) Cu and (b) Zn (mg kg^{-1}) of compost manure produced by Smallholder farmers in Agricultural Development Divisions

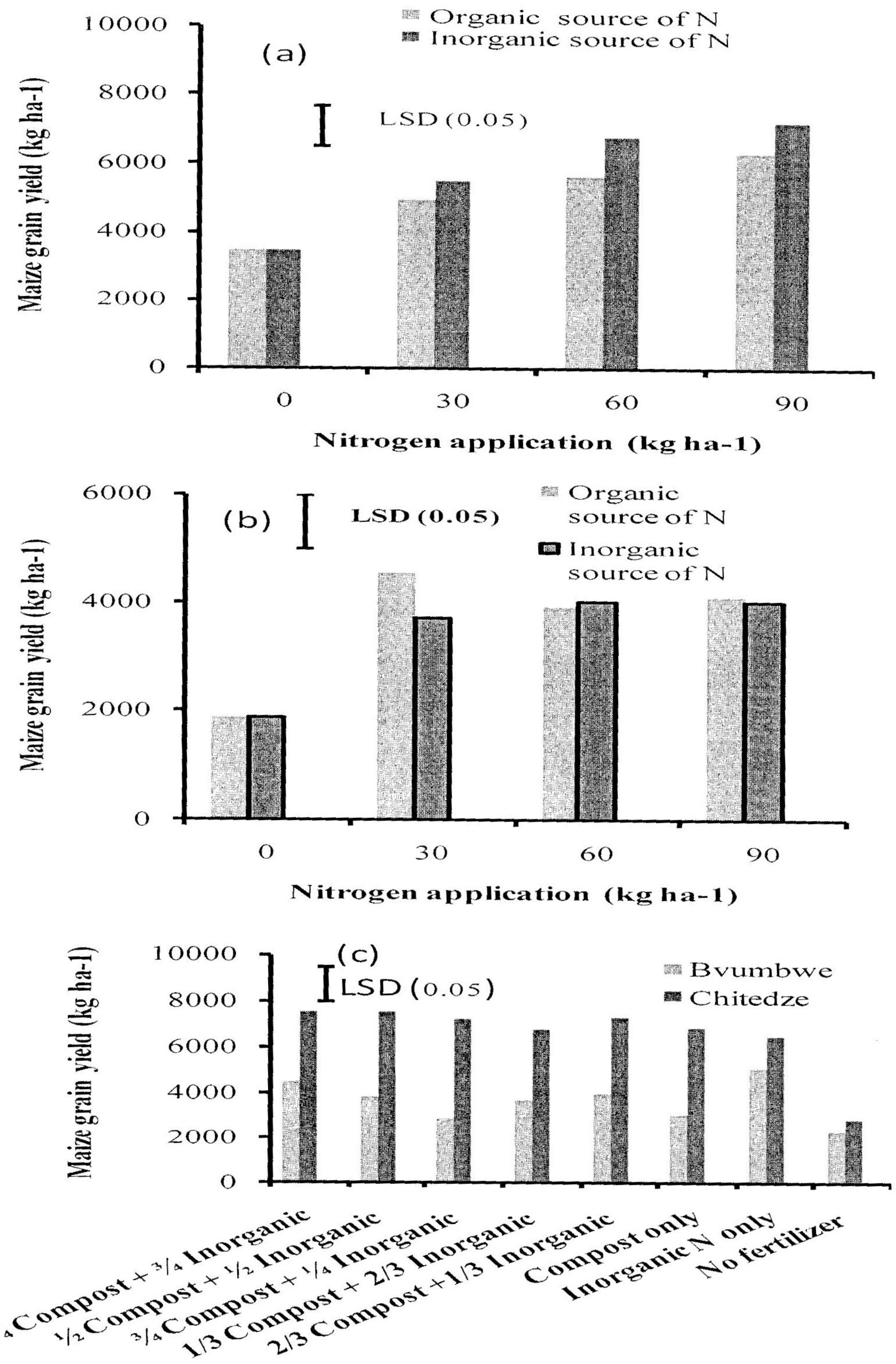

Figure 5. Effect of organic and inorganic source of nitrogen application on maize yields at Chitedze (a) and farmers field (b) and organic and inorganic combination on maize yield at Bvumbwe and Chitedze (c).

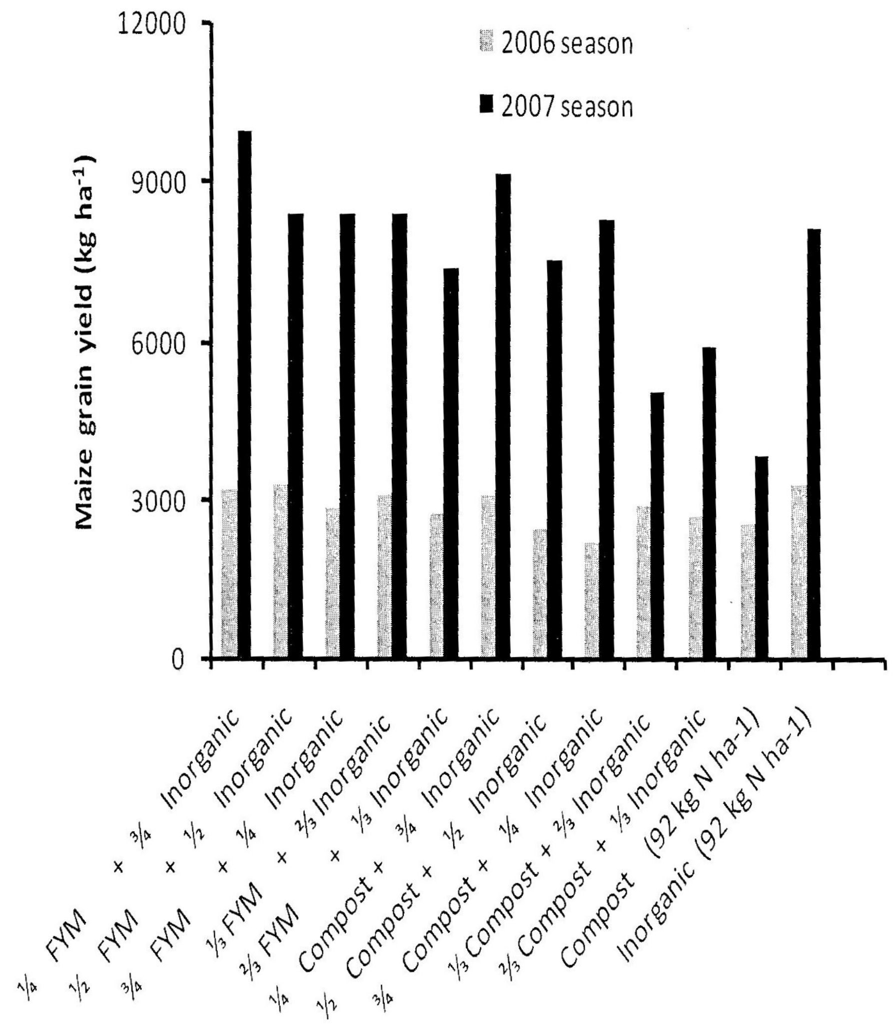

Figure 6. Maize grain yield as affected by a combination of organic and inorganic fertiliser application in 2006 and 2007 at Bvumbwe.

Table1. Nutrients supplied by application of 5000 kg ha^{-1} of compost manure produced by farmers in Agricultural Development Divisions

	%						mg kg^{-1}		Kg ha^{-1}							
ADD	N	P	K	Ca	Mg	S	Zn	Cu	N	P	K	Ca	Mg	S	Zn	Cu
KADD	0.92	0.14	0.42	1.7	1.15	0.14	116	78	46	7	21	85	58	7	0.6	0.4
KRADD	1.44	0.18	0.73	1.3	1.49	0.15	110	55	72	9	37	65	75	8	0.6	0.3
LADD	0.52	0.18	0.53	1.8	0.57	0.08	113	47	26	9	27	90	29	4	0.6	0.2
MZADD	0.35	0.09	0.53	1	0.73	0.12	95	118	18	5	27	50	37	6	0.5	0.6
SLADD	1.48	0.26	0.51	1.2	0.8	0.25	78	51	74	13	26	60	40	13	0.4	0.3
BLADD	0.37	0.2	0.49	nd	nd	nd	Nd	nd	19	10	25	nd	nd	nd	nd	nd
MADD	0.2	0.11	0.33	nd	nd	nd	Nd	nd	10	6	17	nd	nd	nd	nd	nd
SVADD	0.43	0.19	0.53	nd	nd	nd	Nd	nd	22	10	27	nd	nd	nd	nd	nd

nd = no data

CONCLUSION

These results have shown that compost manure properly made can supply all the required nutrients for maize production or part of the required nutrients for crop production. Application of manure increased maize yields and is likely to have residual effects and increase maize yields in subsequent year. The analytical results of the compost manure have confirmed that the compost manure is superior in that it supplies a wide range of nutrients, including micronutrients to crops. The existing practice in southern Malawi of incorporating crop residues into the soil should be encouraged because promotes recycling of crop residues that leads to improved soil fertility under in smallholder farmers' fields. The quality of the manure could be improved through training farmers on compost making and storage.

Application of 5000 kg per hectare of the compost made in the ADDs would supply most of the nutrients for maize production. This amount of compost manure can be obtained at farm level as crop residues produced per hectare are higher than 5000 kg ha^{-1}. Farmers should be encouraged to compost all the crop residues soon after harvesting in order for farmers to have adequate compost manure. Considering the benefits of application of compost manure, farmers should be encouraged to make compost manure soon after harvesting when crop residues are plentiful, not before harvest as is the case now.

References

DAR, 1965. Annual Report of the Department of Agriculture for the Year 1962/63 (part II), Zomba Government Printer.

Giller K, G. Cadisch, C. Ehaliotis, E. Adams, W. Sakala and P. Mafongoya. 2003. Building Soil Nitrogen Capital in Africa. In Buresh RJ, Sanchez PA, Calhoun F. 1997. Replenishing Soil Feryility in Africa. *SSSA Special Publication Number 51.*

Grant, P.M. 1967a. The fertility of sandveld soil under continuous cultivation. Part III. The effect of manure and mineral nitrogen fertilisers on the base status of the soil. *Rhodesia. Zambia, Malawi Journal of Agricultural Research* 5:117-128.

Maida J.H.A. and Z.W. Chilima, 1976. Changes in Soil Fertility under continous cropping of Tea: *Technical Bulletin No.1/Bv/76. Bvumbwe Research Station, Limbe, Malawi.*

Sanchez, P.A. and R.H. Miller, 1986. Organic Matter and Soil Fertility Management in Acid Soils of the Tropics. *International Society of Soil Science Transactions 13th Congress 6: 609-625*

Sanchez, P.A. 1976. Properties and Management of Soils in the Tropics. pp.618 Soil Science Department, NCSU, A Willey Inter-science Publ. Raleigh.