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The use of cattle manure and their implication on soil chemical properties amongst the smallholder farms in Lushoto District, Tanzania

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Abstract

The use of cattle manure in agricultural fields improves soil quality in terms of nutrients and physical properties. This study was conducted at Lushoto District, in Tanga region, to understand the cattle manure management and utilization practices undertaken by smallholder farmers to improve soil productivity. 180 smallholder farmers in six villages were surveyed, and sixteen composite soil samples collected in each village from farms were manure has been applied and were manure not applied. Important soil nutrients and some important physical-chemical parameters namely Nitrogen, Phosphorus, Potassium, Organic Carbon, Organic Matter, soil pH, Cation Exchange Capacity and Electro Conductivity were analyzed. On average, farms applied with manure were found to have better soil fertility compared to those without manure application. The average NPK for farms with manure application was 0.21%, 0.23%, 1.63% and 0.12%, 0.11%, 0.61% for farms where manure were not applied respectively. For soil pH, EC, CEC, SOC and SOM the average value recorded were 6.95, 0.12 dS/m, 24.26 Meq 100g^{-1} of soil, 2.43%, 4.19% and 6.72, 0.09 dS/m, 10.50 Meq 100g^{-1} of soil, 1.40, 2.42 for the farms applied with manure and farms where manure was not applied respectively. With regard to manure management, the data show that only 37.7% of respondents practice pit compost and the average range for the composting period reported being 5-6 month. The study asserts that improper manure management and utilization practices might contribute to the low levels of the potential nutrients and therefore appropriate manure management and utilization are recommended.

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Introduction

Cattle manure is an organic vital resource that can supply plant nutrients and replenish organic matter content of most agricultural soils, particularly in the tropics (Reddy *et al.,* 2000). The use of manure in agricultural fields can improve soil quality relative to the inherent chemical properties of the soil. This reduces the use of synthetic fertilizers that are associated with high cost, limited access and technical capabilities on their use, attributes that are not always attractive to small-scale farmers (Carmo *et al.,* 2016). The animal manure applied back to the soil contributes to nutrient recycling and assist in preventing further deterioration of the land resource (Liu *et al.,* 2008). Both cattle and crops production makes an important contribution to household income and food security (Lekasi *et al.,* 2001). Majority of small-scale farmers in Tanzania apply onto their crops manure obtained from their cattle. However, due to poor storage and handling, such types of manure have the low capability to conserve nutrients and low soil fertility improvement and thus contributing less to sustaining agricultural production (Ndakidemi 2015).

Generally, animal manure has become an important factor in maintaining land productivity in various areas (Lekasi *et al.,* 2001). Manure accounts for about 14% of Nitrogen, 25% Phosphorus and 40% of Potassium (Herrero *et al,* 2009) inputs into the soils. Poor soil fertility has been pointed as the fundamental biophysical cause of declining per capita food production on smallholder farms in Africa (Sanchez, 2002). Low or no agricultural residues are returned to the soil (Baitilwake *et al.,* 2011) and as a result soil nutrient mining becomes a major cause of decreasing crop yields and per capita food production in Africa (Henao and Baanante, 2006). Maerere *et al.* (2001) reported that efficient use of animal manure could alleviate the problem of declining land productivity in most parts of Tanzania.

In Tanzania, amount of nitrogen and phosphorus removed from the soil every year by the main crops was estimated to be 251,448 tons N and 115,112 tons P by the year 2000 and only 21% N and 14%P removed was projected to be replaced through fertilizer application (Kaihura *et al.,* 2001). Due to the low income, the majority cannot afford to purchase expensive agricultural inputs (Ndakidemi, 2015) and most of them raise cattle for milk production which guarantees the presence of manure. However, poor manure handling was reported at Lushoto that might result in accelerating the loss of potential nutrients (Rukiko *et al.,* 2018). So the overall objective of this study was to explore the status of manure management and utilization practices that contribute to the soil fertility status in smallholder farms.

Materials and methods

Study site description

The study was conducted in Lushoto district, Tanga region. The district is situated in the North Eastern corner of Tanzania at latitude 4°25’–4°55’and 30°10’–38°35’ with an altitude range of 1000–2100 m.a.s.l. Rainfall seasons in Lushoto are divided into three: the short rainy season (October-December), the long rainy season (March-May) and an intermediary season (July-September). Lushoto district is covered by steep-sided, narrow valleys, which limit mechanized farming and require substantial soil erosion control. The average temperature is between 18-23°C with the maximum occurring in March and minimum in July while rainfalls are between 600-2000mm per annum. According to NBS (2012), the population of Lushoto District Council is estimated to be 332436 (153847 Male and 178589 female) with the population growth rate of 1.1%.

Study design

The Households survey

A cross-sectional survey was conducted from September to October 2016. A combined qualitative and quantitative method was used whereby focus group meetings, observations, and household surveys were conducted. Villages were selected based on the pre-set criteria which included at least 50% of the households keeping dairy cattle and practicing crop-livestock production systems. Six villages namely Viti, Hambalawei, Bombo, Ngulwi, Ubiri and Mbuzii were selected into which farmers were pre-selected based on the number of herds (Three or more dairy cattle) and land size of not less than 0.25 acre. Thirty (30) households (in each village) were randomly sampled from a list of farmers in a village interviewed through a structured questionnaire and ten (10) household were identified for focus group discussion. The selection process involved the resident village extension officers and village executive officers to provide the list of the farmers in respective villages and take part in the focus group discussion as key informants.

Soil sampling

Soil samples were taken from farms which were previously applied with manure and those which were not applied with manure. To enable this, fertilizer and manure application history of the farms was sourced through the household survey. A total of one hundred and twelve (112) soil sample from farms applied with and farms not applied with manure was sampled. The soil was taken using soil auger from five points of the farm (four points from the corner and one at center) at a depth of 0-20cm and mixed together to make one representative sample per farm of approximately 0.5kg was taken. The samples were then stored in plastic bags, well labeled and transferred to the Nelson Mandela African Institution of Science and Technology laboratory for analysis.

Laboratory analysis

The samples were air-dried, then sieved through 0.25mm for enabling the analysis. Soil pH and EC were determined at a soil to water ratio of 1:2.5 using pH meter and electrical conductivity (EC) meter respectively. The determination of organic carbon was done according to Walkley and Black, (1934) and soil organic matter concentration was computed by multiplying the organic carbon values by 1.724 (Ellert and Bettany, 1995). Total nitrogen (N) was determined by the Kjeldahl method, Potassium (K), available phosphorus (P) were determined through atomic absorption spectrophotometry as described in Mehlch III procedure (Gregorich and Carter, 2007) Cation exchange capacity (CEC) was determined by ammonium acetate method (Ross and Ketterings, 1995).

Statistical analysis

Data obtained in the survey were analyzed using Statistic Package for Social Science (IBM-SPSS) Computer Software. Descriptive statistics namely means, frequencies, percentages and cross-tabulation were used to determine relationships between variables.

Laboratory data were subjected to analysis of variance (ANOVA) and the computation was performed with the software program STATISTICA 8. The fisher's least significance difference (L.S.D.) was used to compare treatment means at $p = 0.05$ level of significance.

Result and discussion

Socio-economic and demographic characteristics of the respondents

Focus group discussion (FGD) and questionnaire administering were held in six villages; Viti, Hambalawei, Ubiri, Bombo, Ngulwi and Mbuzii of the Lushoto District. The average response was between 6 to 12 smallholder farmers per village; whereby men were 38 (73.08%) and women were 14 (26.92%).

The discussion was held in the respective government office in the village. Many respondents were aged between 40–60 years (Fig. 1), and these were adults who had various family responsibilities, therefore they were investing in agriculture to solve a number of their family problems. Farmers marital status was; 156 (86.67%) married, 21 (11.67%) widow, 2 (1.28%) divorced and 1 (0.5%) single (Table 1).

This implies that smallholder farming provides employment to widows and this is facilitated by traditional way of life or culture, whereby villagers give an animal to anybody who requests regardless of gender and in the future, she/he is expected to return a female cow compared with other tangible resources.

This finding is in agreement with the study done by Herrero *et al.* (2013) who reported that it's often easier for women to acquire livestock through inheritance or market than land or other physical assets. About 86.67% had primary education, 2.22% secondary education and 3.87% college education. Literacy was very low and this might contribute to negative effects of adoption and perception of technology uptake and ultimately low production (Adeoti, 2008).

Table 1. Gender and marital status of respondents in the study sites (%).

Villages	Viti	Hambalawei	Bombo	Ngulwi	Mbuzii	Ubiri	Total %
Gender							
Male	86.7	96.7	80	96.7	73.3	73.3	84.44
Female	13.3	3.3	20	3.3	26.7	26.7	15.55
Marital Status							
Single	-	-	-	-	3.3	-	0.5
Married	90	96.7	80	100	80	73.3	86.67
Divorced	-	-	-	-	-	6.7	1.28
Widow	10	3.3	20	-	16.7	20	11.67

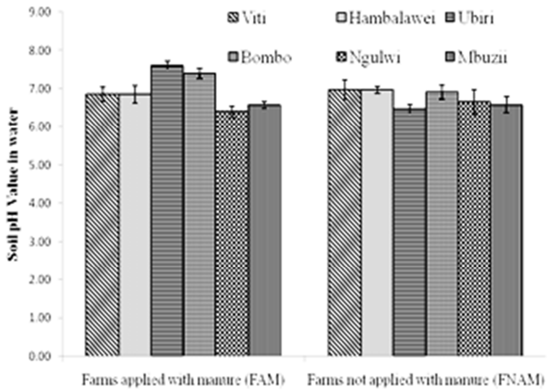

Fig. 1. Soil pH in FAM and FNAM

Land tenure system from the study area showed that majority of smallholder farmers own land (98.6%) through inheritance from parents. This finding is closely related to the finding from Northern Ghana as reported by Cofie *et al.* (2005) where 84% also inherited land from the parents. This ownership is important for farmers because they will receive long-term use (Henao *et al.,* 2006) when investing in on-farm infrastructure i.e. houses, cowshed, biogas plant and production of perennial crops.

On average farmers owned 0.5-3.3 acres which are almost within the range reported by Kiratu *et al.,* (2011). Small land size owned could be attributed to high population density recorded in the area which is due to the agricultural productivity potential of the areas that encourages settlement. Most of the farm activities among smallholder are done by family members who are positively related to farming size (Waithaka *et al.,* 2007).

About 13.8% of smallholder farmers rent land for other farming production activities as reported during the survey. An average price per acre is 35,000 Tsh (16 USD) per season and the priority crops grown were maize, beans, and potato.

Maize and beans are produced 1-2 times in a year for family consumption and vegetables such as cabbage, onion, spinach, carrot, etc are produced 3-4 times in a year and are regarded as cash crops for household income. Vegetable and potato alone were allocated to a smaller area (Table 2) and the reason could be those crops are not stapled food and they are the short season and produced 3-4 time per year compared with beans and maize which are meant for ensuring household food security.

Generally, vegetable plots commercially reported to have early and high return in terms of cash compared with maize/beans fields because they mature in a short period of time and are highly valued fetching high market prices.

Table 2. Average land size (acre) per household allocated for various crops.

Villages	Maize only	Beans only	Maize-beans intercrop	Maize-beans-potatoes	Potato alone	Vegetable
Viti	1.47*(20.9)**	0.75 (10.64)	0.25 (3.55)	3.31 (46.91)	0.83 (11.83)	0.44 (6.21)
Hambalawei	1.03 (20.34)	0.53 (10.46)	1 (19.75)	1.53 (30.24)	0.47 (9.33)	0.5 (9.87)
Ngulwi	0.9 (17.55)	0.7 (13.66)	1.13(22.04)	1.15 (22.35)	0.5 (9.75)	0.75 (14.63)
Bombo	1.66 (25.2)	1.13 (17.16)	1.2 (18.22)	1.4 (21.26)	0.43 (6.5)	0.77 (11.64)
Ubiri	1.26 (24.72)	0.64 (12.56)	0.97 (19.03)	0.89 (17.52)	0.63 (12.26)	0.71 (13.89)
Mbuzii	1.97 (29.79)	0.8 (12.09)	1.7 (25.71)	1.44 (21.84	0.38 (5.67)	0.32 (4.89)

*Number of acres, ** Percentage of respondents.

Manure handling and management practices

Zero-grazing was observed and reported the most intensive livestock production system in the area, involving the 'cut and carry' method of feed management, which is the best for manure collection. The system is common due to the absence of communal grazing land. Most farmers (69%) collect manure and pile out close to the cowshed as the storage area without covering and are done much at Viti (90%), Hambalawei (93.3%) and Mbuzii (83.3%) while few reported to cover at Ngulwi (3.3%) and Bombo (6.7%) (Fig.2.). Faso, (2004) reported that compost obtained from covered-shed composting are of high quality than from open-shed composting; and similarly from pit composting compared with heap or surface composting. However, in this study, it was found that farmers had no information of their manure in-terms of quality. More than 62% of the respondents do not practice pit compost, instead of piling on the ground without turning. This implies that nutrients such as Nitrogen and Phosphorus were lost through leaching and volatilization due to the effect of rain and temperature (Lekasi *et al.*, 2003) and significantly increase soil electrical conductivity and soil pH levels (Eghball *et al.*, 2004). The piling of fresh manure was conducted daily after cleaning and there was no jelling of manure.

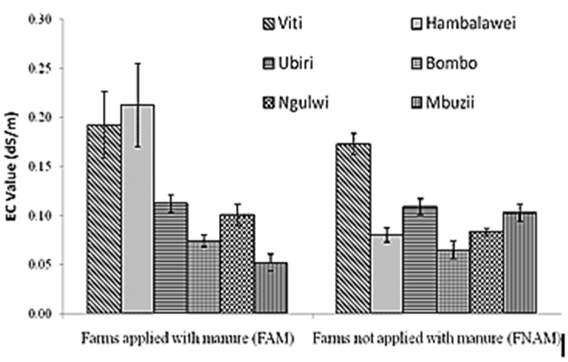

Fig. 2. Soil electro- conductivity in the FAM and FNAM

NB: a = manure stored close to cowshed openly, b = close to cow shed with cover, c = Away from the cow shed openly, d = taking direct to pit after cleaning the cow shed and e = under banana shade.

Storage period varied considerably across the study sites (Table 3). Twenty-five percent practice compost manure for 5-6 months. The same period was reported from Maragua District in Kenya (Lekasi *et al.*, 2003). The result shows that, 19.4% store for more than one year and 16.6% for the un-identified period. Twenty-seven percent of the respondent claimed the deficit of manure produced and the biggest Fig. 3. Was reported at Viti (40%) and Bombo (33%). Anecdotal evidence during the survey showed that farmers with the small herd (number of animals per household and animal body weight of their animals) and feed shortage contributed to the low volume of manure collected per day.

According to Vale *et al.* (2004) manure production per day is averaged to 4.8% (range 3.3-6.5%) of the live animal body weight. However, the majority of smallholder farmers own 2-3 dairy cows, if manure could be managed well would be sufficient to fertilize the small piece of land owned.

During the focus group discussion and personal discussion at Viti, farmers reported that assessment of compost manure is done by looking at the color. Preferred compost was black in color, mixed with soil and presence of white big worms. Other farmers reported that they inserted a stick in the entire heap or in the pit and the extent of heat, hotness or warmth of the stick gave an indication of whether the compost was partially or fully decomposed. It was reported that during manure composting at Viti, farmers mixed manure with sawdust to increase the volume. This is the indigenous/local knowledge used as inherited from parents or copied from other farmers to improve manure quantity.

Only 3.5% of the respondent who practices compost got training outside their district. This indicated that if training could be provided with a trial at farm level many farmers could practice appropriate pit composting. Lack of training (16.7%), time and fatigue work (15%), lack of proper facilities (43.3%) such as wheelbarrow and transportation cost/labor (8.3%) were the constraints reported to hinder pit compost practices. These constraints have also been reported by Rosen and Bierman (2005) in Rwanda.

Table 3. Manure storage period identified by smallholder farmers in surveyed villages (%)

Village	Viti	Hambalawei	Mbuzii	Ubiri	Ngulwi	Bombo	Total
Decomposition/storage period							
1-2 month	1*(3.3)**	-	1 (3.3)	-	-	1 (3.3)	3 (1.6)
3-4 month	9 (30)	8 (26.6)	3 (10)	3 (10)	3 (10)	-	26 (14.4)
5-6month	12 (40)	10 (33.3)	4 (13.3)	6 (20)	4 (13.3)	9 (30)	45 (25)
7-11 month	6 (20)	6 (23.3)	8 (26.6)	4 (13.3)	11 (36.6)	6 (20)	41 (22.7)
1 year +	2 (6.6)	3 (10)	7 (23.3)	8 (26.6)	6 (20)	9 (30)	35 (19.4)
Un-identified period	-	3 (10)	7 (23.3)	9 (30)	6 (20)	5 (16.6)	30 (16.6)

*Number of respondents per village, ** Percentage of respondents.

Utilization of cattle manure by smallholder dairy farmers

Before manure utilization, the heap of manure (surface storage) is emptied in every cropping season starting from the bottom with the assumption that manure is completely decomposed. Application of manure by the respondent from the surveyed villages reported to use drilling application method put manure followed by seed at the same time. Smallholder farmers they don't have a common measurement when applying manure in the field. This may cause an individual farmer to apply too low or high and might lead to nutrient imbalance (Rosen and Bierman, 2016). The majority of farmers measure the manure with both two hands to a hole with the reason that the little manure they have should cover big area compared with the broadcasting method. Some effects reported by farmers when utilize partially composted manure that results to plant death or unhealthy growth and poor yields. The effect of applying immature composts to the soil was pointed to cause severe damages to plant (Ko *et al.,* 2008).

It was further observed that manure is applied in different times per year as follows: once per year (17.7%), twice per year (52.2%), thrice per year (4%) and four times (24.4%) depending on the cropping season and type of crop. Although repeated applications of manure can result in the building detrimental levels (Kuepper 2000). Majorities do apply two times, in November and March/April. Most notably, Lushoto farmers' fields are located in three areas as follows: 1) lower land areas (valleys) where vegetable production is dominant; 2) in the highland area (upland field) where maize and beans are grown and 3) around homestead (middle) where banana and potato are produced. The study observed that majority use manure to valleys and around homestead where vegetable and potatoes are highly produced which is unlike to Vihiga western Kenya where manure use is more important to the production of food crops (Waithaka *et al.,* 2007). The finding from this study suggests that manure utilization is negatively affected by distance and landscape. These findings are similar to those by Ketema and Bauer, (2011) who reported that the use of manure was decreasing with an increase in steepness of the slope and farmers preferred to apply manure in farms near the household (Harris and Yusuf, 2001).

The common inorganic fertilizer reported to be used are Urea (11.1%), Nitrogen, Phosphorus, and Potassium (NPK) (6.1%), Diammonium phosphate (DAP) (46.1%). In Viti and Hambalawei villages, the mineral fertilizers are mostly used in vegetable plots and little in maize but the rest of the villages apply mostly to upland farms. A similar trend was also reported by Nkamleu and Adesina, (2000) in Cameroon. Some reported that they use manure to the upland fields because when it rains the entire nutrients drop to the valley bottom plots. The reports from farmers survey on use and not using manure showed that the average production of maize was 0.5t ha^{-1} - 1.4t ha^{-1} (hybrid varieties) in farms that were not applied with manure, while 0.7–0.9t ha^{-1} (local varieties) and 1.98t ha^{-1} (hybrid varieties) were obtained where manure applied. In this study, our results clearly show that applying manure boosted yield although these increases were very low. The increase in maize yield ranged from 1.4t ha^{-1} and 1.98t ha^{-1} in non-manured and manured fields respectively.

Nkonya (1998) reported the potential yield and for expected yield under good husbandry is averaged to 7.5t ha^{-1} and 5.4t ha^{-1}. A study done in Kenya showed that in unfertilized maize farm, the yield ranged from 1.2–1.3t ha^{-1} while the fertilized fields with manure the yield were higher and ranged from 3.8–4.2 t ha^{-1} (Smaling *et al.,* 1992). In view of the above, the use of manure in Lushoto district is contributing very little to yield increase in various crops grown in the area. Therefore, proper analysis of manure to establish their nutrient status is of paramount importance and this will enable to design appropriate manure management strategies and boost crop production in Lushoto district.

Soil quality in farms applied (FAM) and farms not applied with manure (FNAM) Soil pH

In table 4, the results showed that there was a significant difference between sites and treatments ($p \le 0.05$) in soil pH with a range of 6.4-7.6 and 6.5–6.9 for FAM and FNAM respectively. However, there was no significant difference at Ubiri (FNAM), Mbuzii (FAM), Ngulwi (FNAM), Viti (FAM) and Hambalawei (FNAM). The reason at Bombo and Ubiri in FAM to have high pH (Fig. 4) might be the soil of those two villages is rich in calcium carbonate materials which also increase the level of soil pH. The ranges are for most favorable agriculture soils according to Sanchez *et al.* (2003) and Magdoff and Bartlett, (1985). However, the more pH may harm the plant life's, though pH of 6.5-7.5 is where most potassium is available for plants and pH ≤ 5 could be associated with deficiencies of phosphorus according to Ndakidemi and Semoka *et al.* (2006).

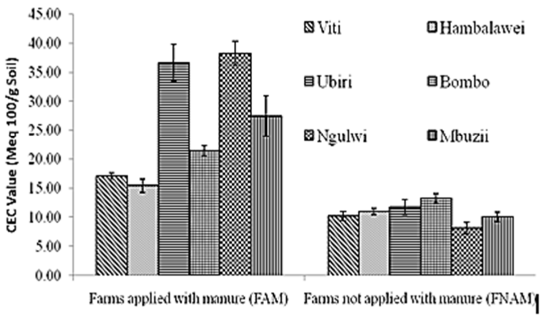

Fig. 3. Soil cation exchange capacity in FAM and FNAM

Electrical conductivity (EC)

EC of the soil was ranged from 0.05–0.21 dS/m across the study sites and was significant different ($p \le 0.001$) between site and treatment, however, the value of the same number has no significantly different (Table 4). EC is one of the indicators for measuring soil attributes that influence soil productivity/fertility (Grisso *et al.*, 2005).

Sands have a low conductivity (0–0.04 dS/m), silts have a medium conductivity (0.04 – 0.15 dS/m), and clays have a high conductivity (0.1-10 dS/m) (Grisso *et al.*, 2005). The highest EC was found at Viti (FAM, FNAM) and Hambalawei (FAM) that indicate the soil has high clay soil while the lowest was observed at Mbuzii (FAM) and Bombo (FNAM) that indicating the soil had high silt (Fig. 2).

Richards, (1969) reported that high electrical conductivity values associate with soils that contain high levels of soluble nutrients.

Table 4. Chemical properties of soil in farms applied with (FAM) and farms not applied with manure (FNAM).

Sites	Treatments (Soil categories)	pH	EC	CEC	SOC	SOM	AP	TN	K
			dS/m	Meq $100g^{-1}$of soil			%		
Viti	FAM	6.86±0.2cd	0.19±0.03a	17.13±0.5cd	2.31±0.2abc	3.93±0.3abc	0.25±0.02b	0.21abc	1.16±0.03c
Viti	FNAM	6.98±0.3bc	0.17±0.01a	10.21±0.8fg	1.32±0.4e	2.28±0.6e	0.14±0.01de	0.16±0.02bcdef	0.58±0.07ef
Hambalawei	FAM	6.86±0.2cd	0.21±0.4a	15.41±1.2de	2.48±0.3ab	4.29±0.4ab	0.29±0.03ab	0.23±0.04a	1.03±0.1cd
Hambalawei	FNAM	6.97±0.1bc	0.08±0.01bcd	10.96±0.6efg	1.40±0.1e	2.41±0.2e	0.14±0.01de	0.12±0.01efg	0.76±0.08de
Ubiri	FAM	7.61±0.1a	0.11±0.01b	36.60±3.1a	2.11±0.4bcd	3.65±0.6bcd	0.25±0.08b	0.22±0.04abc	2.91±0.29a
Ubiri	FNAM	6.4±0.1cd	0.11±0.01b	11.73±1.3efg	1.34±0.2e	2.31±0.3e	0.11def	0.09±0.02g	1.06±0.01cd
Bombo	FAM	7.40±0.1ab	0.07±0.01bcd	21.45±0.9c	2.12±0.3bcd	3.65±0.4bcd	0.34±0.03a	0.17±0.04abcde	1.21±0.05c
Bombo	FNAM	6.92±0.2bc	0.06±0.01cd	13.24±0.8def	1.29±0.3e	2.23±0.6e	0.07±0.01ef	0.10±0.01fg	0.58±0.09ef
Ngulwi	FAM	6.40±0.1d	0.10±0.01bc	38.21±2.1a	2.73±0.2ab	4.71±0.3ab	0.15±0.01d	0.22±0.02ab	2.94±0.16a
Ngulwi	FNAM	6.66±0.3cd	0.08±0.1bcd	8.17±1.0g	1.63±0.2cde	2.82±0.4cde	0.10±0.1def	0.12±0.02efg	0.43±0.08ef
Mbuzii	FAM	6.58±0.1cd	0.05±0.01d	27.48±3.5b	2.96±0.2a	5.11±0.3a	0.14±0.01de	0.20±0.04abcd	1.63±0.15b

Sites	Treatments (Soil categories)	pH	EC	CEC	SOC	SOM	AP	TN	K
			dS/m	Meq 100g-1of soil			%		
Mbuzii	FNAM	6.58±0.2cd	0.10±0.01bc	10.06±0.9fg	1.46±0.2de	2.52±0.4de	0.05±0.01f	0.15±0.01cdefg	0.44±0.05ef
F-Statistics	Sites	3.5**	12.86***	17.9***	1.5ns	1.5ns	5.6***	1.1ns	40.6***
	Treatment	6.01*	6.8*	238.3***	62.8***	62.8***	72.1***	44.9***	273.4***
	Sites*treatment	3.9**	5.6***	19.6***	0.5ns	0.52ns	3.7**	0.7ns	28***

Value presented in the table are means ± SE; *, **,***; whereby * = significant at $p \le 0.05$, ** = $p \le 0.01$, *** = ≤ 0.001 respectively, ns = not significant and SE = Standard Error. Means followed by same letter(s) in a column are not significantly different from each at P = 0.05 according to Fischer least significance difference (LSD)

Cation Exchange Capacity (CEC)

CEC of soils ranged from 13.6 to 38.2 and 8.2 to 13.2 Meq/100g1 of FAM and FNAM respectively (Table 4). FAM had the highest value (13.60–38.20), this implied that the FAM had the highest capacity to absorb trace elements as supported by the finding of Grisso *et al.* (2005) who reported that the higher the CEC the greater is the capacity of the soil surface to adsorb trace elements without potential deleterious effects on plants and/or soil biological functions. Treatment effects were low in FNAM (Fig. 3). Highest CEC recorded in FAM might be due to the presence of high organic matter in the soil (Table 4). The lower CEC of a soil, tend to decrease the soil pH faster with time, (Gillman, 1981). To avoid decrease of soil pH in FNAM smallholder farmers may be advised to apply manure in all crop fields.

Soil Organic Carbon (SOC) and Soil Organic Matter (SOM)

SOM has a role in retaining some trace elements (such as Zn) and capacity to absorb other trace elements (such as Cu and Mn). There were no significant differences between sites and treatments (Table 7). Nevertheless, FAM had the highest value in both SOC (2.11–2.96%) and SOM (3.65–5.11%). These significant differences in values are similar to the one reported by Gyapong and Ayisi, (2015) in Ghana. Bot and Benites (2005) reported that most of SOM in soil range from 2–10 %. According to these results it is evident that addition of cattle manure in the soil increases organic matter (Reeves, 1997).

Available Phosphorus (AP) in soil

AP ranged from 0.14–0.33% and 0.05–0.16% for FAM and FNAM respectively, Table 4. The significant difference was observed across the villages (P ≤ 0.001).

Highest available phosphorus was found in FAM. Phosphorus values in the soil were found to be 0.4 1.2% and 30–50% of total phosphorus which is constituted by organic matter (OM) in most soils (Rodrı´guez and Fraga, 1999). Low AP was found in both FAM and FNAM (Fig. 4) which might be attributed to soil degradation (Lynch, 2011) resulting from poor agricultural management practices i.e. in steep areas managing the loss of topsoil. Another reason could be improper manure/fertilizer application rates. Nkonya, (1998) recommended amount of phosphorus in the low land is 20kg ha^{-1} and high land is 20-40kg ha^{-1}. Smallholder farmers could opt to use organic materials in their farms such as compost, plant or animal materials/waste, or green manure that influences the increase of AP (Mkhabela and Warman, 2005).

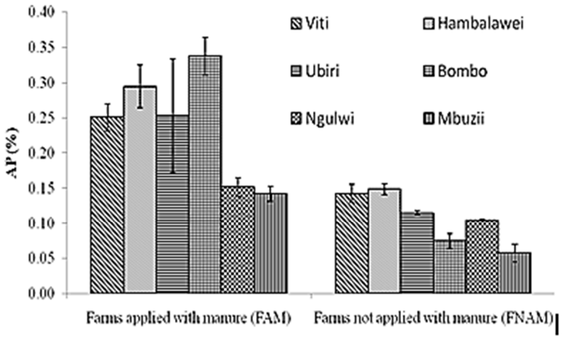

Fig. 4. Soil available phosphorus in FAM and FNAM

Total Nitrogen in soil (TN)

Total nitrogen (TN) ranged from 0.17–0.23% in FAM and 0.09–0.16% in FNAM. There were no significant effects between site and treatments (Table 7). The recommended critical level in Tanzania is 2.0g kg^{-1} for most crops (Ndakidemi *et al.*, 2006).

The application rate of nitrogen-based to altitude in the northern and eastern zones was reported to be 40-112kg N ha^{-1} (High altitude) and 20-45kg N ha^{-1} (low altitude) (Nkonya, 1998). These results indicate low nitrogen in all soils across the sites as per recommendations. The smallest variation of nitrogen concentration in FAM could be contributed by the low-quality manure as a result of the poor of cowshed where the manure is collected. Poultry manure is reported to have higher nitrogen than cattle manure (Gyapong and Ayisi, 2015), so this can be used as a fertilizer for crop production but the challenge is the amount per household per farm. Digested slurry also can be used to improve soil nitrogen as it contains 1.60% N, 1.55% P and 1.00% K and slurry compost comprises of 0.75% N, 0.65% P and 1.05% K (Karki and Expert, 2006).

The low percent of chemical properties in FNAM could be contributed by the loss of topsoil that transports soil organic matter during the rainy season which is facilitated by the steepness of the slope at Lushoto.

Potassium in soil (K)

K ranged from 0.43–2.95% in FAM and FNAM (Table 4) and was significantly higher ($p \leq 0.001$) in FAM at Ubiri and Ngulwi (Fig. 5). The FAM had statistically higher potassium than FNAM. Lowest K was recorded in FNAM at all villages but a bit higher at Ubiri. The value found in FNAM is similar to those reported by Bressers (2014) though was not indicated whether the soil was utilized with manure.

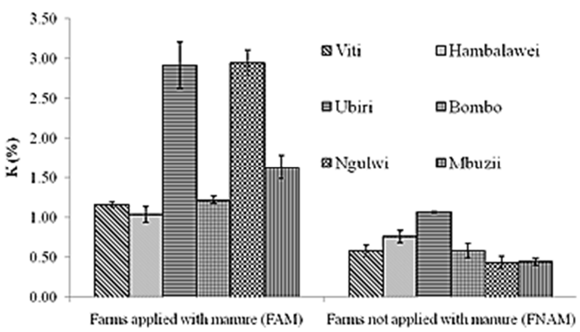

Fig. 5. Soil potassium in FAM and FNAM

Conclusions and recommendation

In conclusion, the study asserts that the use of manure in the farms was contributed to improving the level of soil chemical properties compared with farm not applied manure. Some soil fertility indicators (e.g. soil pH, CEC, EC and SOM) indicate the potential for crop production. This study revealed that manure in the studied villages is poorly handled and the following should be adhered to smallholder farmers as part of management. 1. Construction of appropriate manure storage facilities that provide shade to reduce temperatures, evaporation of urine and rainy water 2. In the storage area, it's better to install an impermeable base/concrete base below the manure collecting area to prevent leaching of nutrients and loss of urine before it is absorbed by bedding materials 3. Application of manure in the field should base on the recommended rate of manure per a given area to prevent detrimental effects to plant and soil. Furthermore; there is a need to have on-farm training by having a trial which are participatory among smallholder farmers and extension officers that will encourage farmers to practice the appropriate technologies.

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