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Manure characteristics of small ruminants fed agroby-products in the guinea savannah agro-ecological zone of Ghana

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ABSTRACT

A 90-day study on evaluating quantity and quality of manure from small ruminants in the Guinea Savannah agro-ecological zone of Ghana was conducted. 36 goats and 36 sheep were randomly allotted to three dietary treatments - Basal diets of maize stover, cassava and yam peels as Treatment one (T1), T1 supplemented with cowpea residues as Treatment two (T2) and T1 supplemented with groundnut residues as Treatment three (T3) in a randomized complete block design. Feed composition and intake and manure characteristics were assessed and data analyzed statistically using Generalized Linear Model procedures of SAS at 5% significance level. The Chemical composition of feed resources ranged from 3.2-17.3% crude protein, 82-97.2% organic matter and 2.8-18% ash. Total feed intake ranged from 519.55-659.72 g/day and 331.84-420.17 g/day for sheep and goats respectively. Sheep manure weighed 319.17-423.33 g/day and contained 20.74-29.01% carbon, 1.87-2.32% nitrogen, 0.77-3.00 potassium, 9.52-26.50% ash, 0.44-0.77 pH and C:N ratio of 10.98-15.53. Goat manure weighed 178.67-216.17 g/day with 19.58-30.61%, 1.56-2.21% nitrogen, 0.82-2.33% potassium, 10.75-19.80% ash, 0.37-1.47 pH and C:N ratio of 9.49-19.92. Results indicated that manure from small ruminants could serve as alternative source of fertilizer in Ghana since its characteristics compare well with chemical fertilizers.

Keywords: sheep; goats; feed resources; manure; fertilizers
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Introduction

Smallholder farmers in potentially high agricultural areas often mine soil nutrients through crop extraction, weed removal, grazing livestock, cutting forage to feed livestock or selling fodder (Powell *et al*., 2004). After limited soil moisture, low soil fertility is the most important constraint limiting crop productivity in Sub-Saharan Africa (Gicheru, 2012; Fischer & Qaim, 2012). In Ghana, for instance, almost all nutrient balances, that is, the difference between the quantities of plant nutrients applied and the quantities removed or lost, show a nutrient deficit (FAO, 2004) since nutrient depleting cultivation practices are still used extensively.

Nutrients from the soil support plants, and crop residues and forages fed to animals are recycled back to the cropland as manure (Bajracharya, 1999). Crop residues ("trash" or agricultural waste) are increasingly becoming a valuable feed resource for livestock (Hofstrand, 2009). About 25% of nitrogen (N) and phosphorus (P), 50% of sulphur (S), and 75% of potassium (K) uptake by cereal crops from the soil are retained in crop residues making them valuable nutrient sources (Dotaniya, 2013). A common practice of eliminating waste after crop harvest in many developing countries is to burn the crop residues left, leading to environmental pollution and loss of otherwise nutritious feed resource for livestock. If used strategically, a country like Ghana could save up to 186 million kg of livestock weight that is lost during the 120-day dry season from its 2.3 million tonnes of cereal crop residues produced (Amaning-Kwarteng, 1991).

Manure contains large amounts of organic matter, hence when used as a soil amendment, builds the soil and nourishes plants (Mitchell, 1992; Giyinyu *et al*., 2005). Application of organic amendments, like sheep and goat manure, increases soil organic matter, supply nutrients to crop, and stimulates the multiplication of organisms that are antagonistic to plant parasitic nematodes (Orisajo *et al.,* 2007; Orisajo *et al.,* 2008). Additional benefits of applying manure include increased soil cation Exchange Capacity (CEC), organic carbon and soil moisture content (Aggarwal *et al*., 1997; Kimani *et al.,* 1999), which in turn enhances biological activity in the soil and ultimately, crop yield (Lekasi, 2001). Sheep and goat manure has been found to contain low C: N ratio below the critical level of 20 as reported by Saha *et al*., (2008) indicating their role in nitrogen mineralization and stabilizing farming systems.

Feeding sheep and goats with crop residues and other agro by-products are common practice amongst farmers in Ghana but evidence on the quantity and quality of manure produced from feeding these crop residues and by-products is scanty. The objective of this study was thus to evaluate the effects of feeding crop residues on the quantity and quality of manure generated by sheep and goats.

Materials and Methods

Study area

The study began in April 2014 at Atebubu and Amantin in the Atebubu-Amantin district of the Brong-Ahafo Region which falls in the Guinea Savannah agro-ecological zone of Ghana. Mean temperatures fluctuate between a minimum of 24°C and a maximum of 30°C (Ghana Statistical Service, 2013). The South-Southwest (SSW) wind blows with a speed of 6 kmh^{-1}. The area receives bimodal rainfall distribution with a mean annual rainfall of 1400-1800 mm (Ghana Statistical Service, 2010). The major rainy season extends from May to August and the minor season lasts from September to November followed by the dry season from December to April.

Selection of farmers and animals

Purposive sampling was used in selecting sheep and goat farming project sites. Stratified sampling technique was employed to sample cereal and legume crop farmers, who also rear small ruminant (sheep and goats). 12 farmers comprising six farmers (three males and three females) from Atebubu and another six farmers (three males and three females) from Amantin were selected for the study. A total of 72 animals comprising 36 male West African Dwarf goats and 36 male West African Dwarf sheep aged 12-14 months were used in the study. Mean initial live-weights ranged from 14.85-15.17 kg and 10.00-10.30 kg for sheep and goats respectively. Feed, water and mineral salt lick (Sodium Chloride; Sodium content: 38.05%) were offered ad libitum. Each farmer used six animals (three sheep and three goats) in the study.

Experimental design and data analysis

Animals were randomly allotted to three crop residue-based dietary treatments. Treatment one (T1) comprised a Basal diet of maize stover, cassava and yam peels; Treatment two (T2) being the supplementation of T1 with cowpea residues and Treatment three (T3) being supplementation of T1 with groundnut residues in a randomized complete block design. Each block (location – Atebubu and Amantin) had three dietary treatments and six replicates (animals) per treatment each for sheep and goats in each town. The animals were housed near the homes of each farmer. The animals were stall-fed ad-libitum with basal diets comprising mostly of cereal residues and kitchen waste comprising cassava and yam peels (about 5% of the body weight of the animal with 3, 1 and 1% maize stover, cassava peels and yam peels respectively). These basal feeds were supplemented with cowpea and groundnut residues at 300g/animal/day. Table 1 shows the percentage compositions of the experimental diets in both towns.

TABLE 1

Percentage (%) nutrient composition (DM basis) of the experimental diets.

Composition	***Location***					
	Atebubu			***Amantin***		
	T1	*T2*	*T3*	*T1*	*T2*	*T3*
Dry Matter	84.2	88.04	84.5	83.6	89.4	88.8
Organic Matter	89.4	91.2	91.1	89.0	85.6	88.5
Crude Protein	6.41	11.5	11.6	5.32	10.2	10.3
Ash	9.57	8.80	8.88	11.04	12.4	11.5

Cited in Ansah et al (2014).

[#] T1 = Basal diet of maize stover, cassava and yam peels; T2 = Treatment 2 (T1 supplemented with cowpea residues); T3 = Treatment 3 (T1 supplemented with groundnut residues). * All nutrient composition on DM Basis

The randomized complete block design (RCBD) was applied to the daily manure produced by sheep and goats in each town with the feed type being the treatments and the animals (sheep and goats) being the replicates. The feed was offered *ad libitum* twice daily (09:00 hours and 16:00 hours). The feed was weighed daily with a weighing scale before offering to the animals. Feed intake was measured and recorded daily as the difference between feed offered and feed refused.

All the data collected were statistically analysed using the Generalized Linear Model (GLM) procedures of SAS (SAS, 2006). All the statistical tests were done at a significance level of 5%. The Waller K-ratio test was used to compare significant differences between the treatment means.

Parameters measured

Two samples of each feed type per farmer were collected, pooled and taken to the Animal and Soil Science Laboratories of the Kwame Nkrumah University of Science and Technology (K.N.U.S.T.), Kumasi-Ghana for proximate analysis (Table 1) using procedures described by AOAC (2002). Manure sampling was done for 90 days after two weeks of adaptation to the feed. Daily manure produced by sheep and goats in each town were collected from pens every morning., Sample was then taken, pooled together, bagged and analysed for organic carbon, nitrogen, pH, potassium and ash at the Crop and Soil Science Laboratories, K.N.U.S.T., Kumasi-Ghana.

Results and Discussions

Quality of sheep manure

The weight and quality of manure from sheep in the study areas are presented in Table 2. Feed type affected the percent carbon ($p=0.0003$), and nitrogen ($p=0.018$), Carbon to Nitrogen (C:N) ratio ($p<0.0001$), potassium ($p=0.005$) and weight of manure produced by sheep ($p=0.0128$). Feed type however did not affect pH ($p=0.718$) and Ash content of the manure produced by sheep ($p=0.2355$). Nitrogen and potassium contents of sheep manure were higher ($p < 0.05$) in T2 and T3 than in T1. The high N contents of T2 and T3 could be attributed to the high crude protein contents in the supplements used in those treatments. Carbon contents and C: N ratio of sheep manure was higher for sheep on T1 than T2 and T3. The higher C: N ratio of T1 could be attributed to the generally low crude protein contents of basal diets hence reduced nitrogen. The locational effect tended to approach significance for the weight of manure produced by sheep ($p=0.0636$) but was different for percent carbon ($p=0.0288$), carbon to nitrogen ratio ($p=0.0188$), pH ($p=0.0009$), potassium ($p<0.0001$) and ash ($p=0.0135$) content of manure produced by sheep.

The location however had no effect on the nitrogen content of sheep manure. An interaction existed between the feed and location for nitrogen ($p=0.0021$), ash ($p=0.0009$) and potassium content ($p=0.0106$) as well as pH ($p=0.0001$) of manure produced by sheep. No location by feed interaction existed for weight ($p=0.0602$), carbon (p=0.1737) and C: N ($p=0.0630$) of manure produced by sheep in the two locations.

TABLE 2

Quantity and chemical composition of Sheep manure in Atebubu and Amantin

	ATEBUBU			***AMANTIN***			***SEM***	***P***			
	T1	***T2***	***T3***	***T1***	***T2***	***T3***		***REP***	***LOC***	***FEED***	***LOC*-FEED***
No. of Animals	**6**	**6**	**6**	**6**	**6**	**6**					
Mean live-weight of sheep(kg)	15.00	15.2	14.6	15.1	15.15	15.02					
Feed intake, g/day	660^{a}	559^{b}	520^{c}	677^{a}	544^{bc}	554^{b}	13.1	0.200	0.267	<0.0001	0.190
MWT, g	378^{a}	391^{ac}	423^{c}	392^{ac}	319^{b}	399^{ac}	17	0.220	0.0636	0.0128	0.0602
Carbon (g/kg DM)	290.1^{a}	254.0^{c}	270.0^{cd}	283.0^{ad}	207.4^{b}	259.0^{c}	1.13	0.953	0.0288	0.0003	0.174
Nitrogen (g/kg DM)	19.1^{a}	23.2^{b}	19.8^{a}	18.7^{a}	18.9^{a}	21.5^{b}	0.074	0.589	0.111	0.0180	0.0021
Carbon:Nitrogen	15.5^{a}	11^{b}	13.6^{d}	15.1^{a}	11^{b}	12.1^{c}	0.317	0.0025	0.0188	<0.0001	0.063
Acidity (pH)	0.68^{b}	0.77^{b}	0.51^{a}	0.45^{a}	0.44^{a}	0.64^{b}	0.046	0.148	0.0009	0.718	0.0001
Potassium(g/kg DM)	23.0^{b}	30.0^{d}	22.3^{b}	7.7^{a}	13.5^{c}	16.6^{c}	0.174	0.0202	<0.0001	0.0050	0.0106
Ash(g/kg DM)	210.0^{b}	95.2^{d}	185.0^{ab}	145.0^{a}	265.0^{c}	253.0^{c}	2.61	0.997	0.0135	0.236	0.0009

[#]MWT=Manure weight, LOC=Location effect; FEED=Feed effect; LOC*FEED=Location by feed interaction.

[a,b, c]*Means in a row with similar or no superscript are not different (P>0.05).*

The high N contents of T2 and T3 could be attributed to the higher crude protein contents in the feed supplements used in those treatments. Carbon contents and C: N ratio of sheep manure was higher for sheep on T1 than T2 and T3 and could be attributed to the generally low crude protein contents of basal diet hence reduced nitrogen. The manure weights obtained in for sheep, was generally, similar to those (430-458 g/day) obtained by Irungu et al. (2005). Differences *($p<0.05$)* were observed in the percent carbon of sheep manure between T1, T2 and T3 in both towns. The differences in the carbon content of manure could be attributed to the nature of the feed, level of decomposition and losses as carbon dioxide (CO_2) (Larney *et al.,* 2006). Differences ($p<0.05$) were also observed in the total nitrogen content of sheep manure between T3 and the rest of the treatments in Amantin. Differences ($p<0.05$) were also observed between all treatments for Total Nitrogen of manure in Atebubu.

Sheep on all treatments in both Atebubu and Amantin had a C: N ratio of 11-15.5 which was lower than the critical C: N ratio of 20 reported by Saha *et al.* (2008) below which net mineralization would readily occur when applied on soils.

Differences ($p<0.05$) in the potassium and ash contents of sheep manure amongst all treatments in both towns could be attributed to the rate of leaching before collection and losses through urine (Kimani & Lekasi, 2004).

Although there were differences ($p<0.05$) in pH of sheep manure in Atebubu, it was observed that manure produced from all the farms were highly acidic which is in agreement with the assertion made by KATC (2004) that fresh manure is acidic. Differences ($p<0.05$) were also observed in the Ash contents of manure produced by sheep in Atebubu which is an indication of a mixture with soil or varied inorganic component of the manure.

Quality of goat manure

The weight and quality of manure of goats in both towns (Table 3) indicate that feed type significantly affected the percent carbon ($p<0.0001$), nitrogen ($p=0.0002$), C: N ratio ($p<0.0001$) and percent ash ($p=0.0167$) contents of manure produced by goats. Feed type however did not significantly affect pH ($p=0.3562$), percent potassium ($p=0.120$) and weight ($p=520$) of the manure produced by goats in the two locations.

Weight of goat manure was higher in T1 than T2 and T3. Nitrogen content of goat manure was higher in T2 and T3 than in T1. Manure from goats on T1 had a higher (p>0.05) carbon content and C: N ratio than for goats on T2 and T3. Ash, K and pH were all higher (p < 0.05) in T2 than T1 and T3 in Atebubu (Table 3).

TABLE 3

Quantity and quality of Goat manure in Atebubu and Amantin

	ATEBUBU			***AMANTIN***			***SEM***	***P***			
	T1	***T2***	***T3***	***T1***	***T2***	***T3***		***REP***	***LOC***	***FEED***	***LOC*-FEED***
Parameter											
No. of Animals	**6**	**6**	**6**	**6**	**6**	**6**					
Mean live-weight of goats(Kg),	10	10	10.2	10.1	10.3	10.1					
Feed intake (g/day),	420	352	332	443	360	318	8.93	0.144	0.0355	<0.0001	0.759
MWT (g),	208^{a}	218^{a}	180^{b}	210^{a}	179^{b}	216^{a}	10.2	0.432	0.958	0.520	0.0052
Carbon(g/kg DM),	306.0^{a}	258.0^{b}	196.0^{d}	302.0^{a}	251.0^{b}	23^{c}	1.25	0.442	0.452	<0.0001	0.202
Nitrogen(g/kg DM),	18.3^{b}	21.4^{cd}	20.7^{cd}	15.6^{a}	19.6^{bc}	22.1^{d}	0.091	0.999	0.183	0.0002	0.0826
Carbon: Nitrogen	16.6^{b}	12.04^{c}	9.49^{d}	19.9^{a}	12.9^{c}	10.4^{d}	0.924	0.435	0.036	<0.0001	0.351
Acidity (pH)	0.61^{a}	1.47^{b}	0.62^{a}	0.37^{a}	0.50^{a}	0.37^{a}	0.390	0.625	0.139	0.356	0.575
Potassium(g/kgDM)	22.9^{a}	23.3^{b}	22.3^{a}	8.2^{a}	14.7^{a}	15.2^{a}	1.700	0.528	0.0417	0.120	0.169
Ash(g/kg DM),	165.0^{b}	198.0^{b}	173.0^{b}	108.0^{a}	180.0^{b}	123.0^{a}	1.75	0.940	0.0082	0.0167	0.498

[#]MWT=Manure weight, LOC=Location effect; FEED=Feed effect; LOC*FEED=Location by feed interaction.

[a,b,c]*Means in a row with similar or no superscript are not significantly (P>0.05) different.*

Location had an effect on the Carbon to Nitrogen ratio (*p=0.0188*), Potassium (*p=0.0417*) and ash (*p=0.0082*) content of manure produced by goats but had little effect on percent Nitrogen (*p=0.183*), Carbon (*p=0.452*), pH (*p=0.139*) and weight (*p= 0.958*) of manure produced by goats. With the exception of the C: N ratio of goat manure, which was generally higher in Amantin, the weight as well as the Carbon, Nitrogen, K, Ash, C: N ratio and pH of manure produced by goat were generally higher in Atebubu than in Amantin. An interaction existed between the feed and location for weight (*p=0.0052*) of manure produced by goats. No Location by feed interaction existed for Nitrogen (*p=0.0826*), ash (*p=0.498*), Carbon (*p=0.202*) and Potassium content (*p=0.169*) as well as of pH (*p=0.575*) and Carbon to Nitrogen ratio (*p=0.351*) of manure produced by goats in the two locations.

Weight of goat manure was higher in T1 than T2 and T3. Nitrogen content of goat manure was higher in T2 and T3 than in T1. The high N contents of T2 and T3 could be attributed to the high crude protein contents in the supplements used in those treatments. Carbon contents and C: N ratio of goat manure was higher for T1 than T2 and T3. The higher C: N ratio of T1 could be attributed to the generally low crude protein contents of basal diet hence reduced nitrogen content. Ash, K and pH were all higher in T2 than T1 and T3.

The range of values for Carbon (23-30.6%) and Total Nitrogen (1.56-2.21%) were similar to the 26.4- 38.1% organic Carbon and 1.4 - 2.3% Total Nitrogen reported by Moral *et al.* (2005) for goat manure. Also, a general assessment of the potassium values obtained in our study indicates that the values obtained for goats in Amantin are lower than the 2.4% reported by Kausar (1983) for goat manures in the tropics. The range of values for K in Atebubu was however higher.

The C: N ratios for manures in both locations were lower than 20%, which indicate potential or likely net Nitrogen mineralization if applied directly on soils. This is considered an important extra benefit of using manure as a soil amendment (Mando *et al.,* 2005). The differences in N content of manure between treatments could be due to the differences in feed digestibility, the crude protein content of feed, nature of manure (amount of urine and feed refusals combined with faeces) and the level of volatilization of ammonia (lower in soils with low pH).

High-quality manure has been defined as that with N content greater than 1.6% or C: N ratios less than 10; while low-quality manure has N content less than 0.6% and C: N ratio greater than 17 (Bationo *et al.,* 2004). A general observation from the study was that although all the C: N ratio of sheep and goat manure in both communities were greater than 10, their N contents were comparatively higher indicating the quality of manure produced.

It was also observed that manure produced from all the animals were highly acidic which was in agreement with the assertion made by KATC (2004) that fresh manure is acidic. This manure when applied on the soil would make it acidic hence amendments aimed at neutralizing acid content is needed when applying fresh manure from sheep and goats fed crop residue-based diets on soils.

From the results obtained, it is estimated that a WAD sheep of an average weight of 15.0 kg is capable of producing as much as 138 kg of manure on DM basis per year, supplying 2.63 kg N and 3.17 kg K per annum. Similarly, a WAD goat with an average weight of 10.0 kg is capable of producing 79.7 kg of manure on DM basis per year, supplying 1.71 kg N and 1.86 kg K per annum. Osuhor *et al*. (1998) reported similar values (3.00 kg N and 1.2 kg K) for Red Sokoto goats. This indicates that the fertilizer value of sheep and goat manure is comparable to Nitrogen and Potassium values in inorganic fertilizers and with the reported 10.3 million small ruminant population in Ghana (SRID, 2014), the tonnes of manure they are capable of producing on DM basis can significantly reduce or replace the quantity of the inorganic fertilizers used by the farmers. The general recommended N and K rate for a crop like maize in Ghana is 90 kg N and 60 kg K_2O per hectare (Adu *et al*., 2014). From the study, a total of 30-50 goats and 20-35 sheep fed crop residue-based diets can achieve this N and K rates required for optimum growth and increased productivity of maize. This not only makes beneficial use of crop residues but also help meet the fertilizer needs of crops and crop farmers alike. Since these manures are much cheaper and could even be obtained free of charge, crop farmers need to be encouraged to consider using them to fertilize their crop fields.

Conclusion

Supplementing small ruminant feed with leguminous residues resulted in manure with relatively higher Nitrogen contents than those without such supplements. Such manures have great potential as a substitute or alternative for relatively expensive inorganic fertilizers for amending low fertile soils in rural towns. The fertilizer value of sheep and goat manure is comparable to nitrogen, potassium and carbon values in inorganic fertilizers commonly used in Ghana indicating their potential role in amending soils of declining fertility. As campaigns for organic food productions is on the rise, crop farmers can take advantage of using sheep and goat manure to fertilize their farms.

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