International Journal of Agricultural Research

ISSN 1816-4897

Academic Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 2 (11): 929-936, 2007
ISSN 1816-4897

Survey of Animal Manure Production, Management, Use and Effect on a Degraded Kandiudult

[1]E.U. Onweremadu, [2]C.C. Asiabaka, [3]C.P. Anyanwu,
[4]G.A. Anyanwu, [4]E.B. Etuk and [4]B.O. Esonu
[1]Department of Soil Science and Technology,
[2]Department of Agricultural Extension,
[3]Department of Crop Science and Technology,
[4]Department of Animal Science and Technology,
Federal University of Technology, P.M.B. 1526, Owerri, Nigeria

Abstract: This study evaluated animal manure production, management techniques, utilization and effect on soil productivity in Amuzu Mbaise, Southeastern Nigeria. The study, which was conducted in 2006 used structured interview schedule at a phase of the study. In another phase, we studied the effects of animal manures from muturu (Local cattle), goats, sheep and pigs on a degraded Isohyperthermic Kandiudult using maize (*Zea mays* L.) as a test crop. The potted experiment was set up in a greenhouse using a Completely Randomized Design (CRD), with each treatment replicated 9 times. Five treatments used included manures from Muturu, goats, sheep, pigs and control. Relevant measures of central tendency and dispersion were used in the statistical analysis of socio-economic and agronomic data. Results showed that a greater number of households engaged in goats and sheep, thereby making their manures relatively more abundant than other livestock. Majority of the livestock fend for of themselves in rangelands with pigs being more confined. Animal manures were collected and used although they were inadequate and bulky while there was poor knowledge of urine as biofertilizer quality of manures differed with handing technique and manure improved maize (*Zea mays* L.) performance significantly ($p = 0.05$). Soil chemical fertility was significantly ($p = 0.05$) improved. Integrated studies especially is if affects indigenous knowledge will be helpful.

Key words: Animal manure, handling technique, remediation, soil quality, tropical soil, utilization

INTRODUCTION

Agriculture remains the backbone of many African economics (Mbabu and Ochieng, 2006), accounting for 57% of total employment, 17% of Gross Domestic Product (GDP) and 11% of export earnings in Africa (FAO, 2005). A very important aspect of African agriculture is farm animal production which according to IIRR and ACT (2005) provides meat, milk, hides, power and manure. But agricultural productivity on the continent continues to raise serious concerns, including under-utilization of agricultural resources (Hazell *et al*., 2003) and poor information dissemination (Gachie and Ruault, 2006). In Southeastern Nigeria, livestock production is not keeping pace with population growth (Onu and Madukwe, 2002) while animal manures are discarded. Often times, animal manures are wrongly disposed leading to pollution of natural resources and decreased biosafety. It has been reported that mismanagement of animal manures increases the risk of water pollution

Corresponding Author: E.U. Onweremadu, Department of Soil Science and Technology, Federal University of Technology, P.M.B. 1526, Owerri, Nigeria

(Spalding and Exner, 1993) and air contamination (Sommer and Hutchings, 2001) and this is worst for some manures such as pig slurry containing greater than 60% NH_4^+ (Sommer and Husted, 1995) although it is rapidly nitrified in soils after application (Chantigny *et al*., 2001) or denitrified and leached (Chantigny *et al*., 2004).

Traditional means of increasing crop production by expanding cultivable farmland is not feasible due to increased demographic pressure and consequently heightened anthropogenic activities. Currently, farmers are beginning to shift from extensive to more intensive mixed crop and livestock farming systems. But animal manures are mainly disposed by open dump systems, thereby exposing them to open air when some nutrients, such as nitrogen are lost by volatilization and leaching (Matsumoto *et al*., 1997). It becomes necessary to investigate the existing techniques of producing, managing and utilization of animal manures and effects on highly degraded soils of the study area. This is in line with the recommendations of Tanner *et al*. (1993) and Onweremadu *et al*. (2007) that indigenous knowledge and practices should be used as starting point for scientific intervention, as such Agricultural Knowledge and Information System (AKIS) may spill into innovations (Mbabu and Ochieng, 2006). The major objective of this study was to evaluate animal manure production, management and utilization techniques and their implications on soil productivity.

MATERIALS AND METHODS

Study Area

Amuzu Aboh Mbaise is in Imo State Nigeria and lies on latitude 5°48'33". 010 N and 7°37'10". 040 E and on an altitude of 90 m using (Handheld Global Positioning System (GPS) Receiver (Garmin Ltd., Kansas, USA). Soils are derived from Coastal Plain Sands (Benin geological formation) and it has a lowland geomorphology. The study area is humid tropical, has an annual rainfall of about 2500 mm and annual temperature range of 27-29°C. It has a rainforest vegetation and mixed farming practices are dominant among other farming systems, local cattle, fowls, pigs, goats, turkeys and sheep are predominant. However, rabbit production is becoming important as a socio-economic activity. Intensive and semi-intensive livestock production is becoming prominent although extensive systems are still prominent as they emerge from the people's tradition.

Animal Manure Studies

The study was conducted in 2006. Farming is a major socio-economic activity in Amuzu Aboh-Mbaise made up of 9 villages. Four villages were surveyed and from each village a simple random sampling was used to select 20 farmers who practice mixed farming. The villages used included Umulolo, Umuogu, Nriukwu and Umuebee because of high population of mixed farmers. Personal communication and structured interview schedule, containing simple, clear, logical, less ambiguous, close and/or open-ended questions were developed and used for the study. The interview schedule was divided into four sections, namely census of livestock household, feeding systems, manure collection activities and manure handling techniques, utilization and limitations. Validation of the interview schedule was done, using content validity method, which is a way of determining the suitability of items included in the study (Chuta, 1992). Following jury method as used by Ajayi (1996), items contained in the draft interview schedule for the research work were subjected to thorough examination and criticism by three lecturers in the Department of Agricultural Extension, Federal University of Technology, Owerri, Nigeria. The relevance and suitability of items as determined by the lecturer-experts formed the base for the development of the final interview schedule which was used to collect data for the study.

Manure Sampling

Samples of manure in dumps and stores considered useful for fertilization in crop production and not more than 28 weeks old were collected and used for the investigation. Manure was collected by scooping from 4 random spots on the manure heap to a depth of 30 cm (Zhang *et al*., 2001) and the 4 samples were mixed together. Representative sub-samples of about 0.25 kg were stored in plastic bags. Manures samples were kept in a cool base with ice cubes during transportation and later kept in a deep freezer in readiness for laboratory analysis.

Laboratory Analyses

Total Nitrogen (N) in the manures and soil was determined after Kjeldahl digestion with a Kjeltec Auto 1030 system (Tecator, Hoganas, Sweden). Total manure and soil carbon were estimated after dry combustion of a Leco model 521-275 (Leco Corporation, Sevenska AB, Upplands Vasby, Sweden). Organic matter was got by multiplying carbon by 1.724. Cation Exchange Capacity (CEC) was determined by repeated saturations using I M NH_4OAc followed by washing, distillation and titration (Soil Survey Staff, 1996). Soil pH was measured (1:1 soil to solution) in water (Thomas, 1996). Exchangeable cations: Calcium, magnesium, potassium and sodium were estimated by inductively coupled plasma atomic emission spectrometer (ICP-AES) (Integra XMP, GBC, Arlington Heights, IL). Available phosphorus was determined by Olsen method (Emteryd, 1989). Particle size distribution of soils used for the greenhouse study was analysed by hydrometer method (Gee and Or, 2002). The dry matter content of the manures was obtained by oven drying or sub-sample at 105°C for 24 h. Carbon-nitrogen ratio was obtained by dividing the value of carbon by that of nitrogen.

Soil Sampling and Experimental Design

Bulked and potted soil samples were collected from the 0-30 cm depths in the study site, maintained at field capacity (20% gravimetric moisture content) and planted with maize in a Completely Randomized Design (CRD), with each treatment replicated 9 times. Earlier, soil used for the greenhouse study was classified as Isohyperthermic Arenic Kandiudult (Onweremadu *et al*., 2006). Maize height and dry matter yield were recorded at 6 weeks after planting. Soil samples were air dried and sieved using 2 mm sieve before laboratory analysis. These soil samples included those used for pre-planting and post harvest analyses. Maize seeds were sown at a seed rate of one seed per pot containing 5 kg of soil.

Statistical Analyses

Socio-economic and soil data were analyzed using SPSS version 10 computer software (SPSS Inc., 1999). Descriptive statistics, namely means, frequencies, percentages and cross tabulation were used to determine relationships between variables. Means and standard deviations were computed for data on nutrient composition of animal manures. Soil and crop data means were separated using Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Livestock Farming

The mean number of different forms of livestock in the study site is shown in Table 1, with local cattle (Muturu) indicating the least mean value of 8±0.3. The low value in Muturu could be attributed to long gestation period, high population density and shortage of rangeland pastures. Personal communication shows that large herd of local cattle characterized past livestock history due to abundance of forage in the ranges. The trend is also typical of goats and sheep. Domestic pig population was low (9.1±2.1) as its introduction and adoption was not too long. Before then,

Table 1: Distribution of livestock per household in Amuzu Mbaise

Livestock type	No. of households	Mean±SD	Livestock range	Total No. of animals
Muturu*	12	8.0±0.3	2-15	96
Goats	22	11.5±0.9	3-19	253
Sheep	18	10.8±0.9	2-17	116
Pigs	7	9.1±2.1	1-5	64

SD = Standard Deviation; * = Local cattle

Table 2: Feeding systems of different livestock types

Livestock type	Grazing free system	Confinement/tethering (cut and carry)
Muturu (N = 12)	3 (25)	9 (75)
Goats (N = 22)	17 (77)	5 (23)
Sheep (N = 18)	12 (67)	6 (33)
Pigs (N = 7)	1 (14)	6 (86)

Numbers before brackets are number of the households; Numbers within brackets are the percentages of the households

inhabitants knew of the wild pigs, associated the docile domestic pig with worm infestation but the trend is changing with agricultural extension services on modern techniques of pig husbandry. These relatively low values of livestock population in the study area implies low output of animal manures, more so with a preponderance of local livestock. Crossbred dairy cattle produce 4 to 5 kg dry matter manure daily whereas their local counterparts yield 2 to 2.5 kg dry matter manure daily (Fernandez-Rivera *et al*., 1995; Raussen, 1997).

Livestock Feeding

Table 2 shows livestock systems in the study site, indicating a predominance of free grazing in goat (77%) and sheep (67%) husbandry while 86% of pigs were confined and 75% of Muturu tethered. With increasing human population, a greater portion of rangelands have been converted to arable crop production and animals on free grazing browse and graze in these crops leading to social strife and conflicts. However, free grazing still flourishes since most farmlands are communally owned and left fallow for soil fertility regeneration. Similar trend was recorded in Tanzania (Msangi and Kavana, 2002) who reported that natural pasture species were owned by communities and utilized by ruminant animals. Feeding systems of Muturu losses which is consistent with the findings of Schleich (1986) that free grazing local cattle and goats lost 60-70% of the manure. Less losses were less associated with pigs because of confinement and use of household wastes as feed sources.

Manure Collection and Management

Higher values of droppings from goat and pigs are applied as manure (Table 3) the popularity of goat manure application is possibly due to its less bulkiness and convenience when compared to other manures-while high application of pig manure is a matter of necessity as its removal would increase pen hygiene. However, pig manures, were commonly removed after 2-3 days (57%) and this is attributable to high animal hygiene against the belief of many that pigs are naturally unhygienic livestock. Greater values of daily animal manure removals in goat (91%), Muturu (83%) and sheep (55%) is a cultural imperative. This contrasts yearly removal of local cattle manure in southern highlands of Tanzania (IARMW, 1998). It was also observed that the use of beddings is unpopular in the pens and urine collection is not considered as an entity since it mixes with excreta. Urine capture is a good practice since it contains a lot of nitrogen (Raussen, 1997) and this can be preserved by use of beddings.

Husbandsmen rarely compost collected animal manure but dumps them on homestead farms (75%). In large herds, animal manures are dumped around pen environment. Storage before disposal is for a short time in all the animal manures before they are used. Results show that animal manures

Table 3: Manure collection from pens

Variables	Livestock type Muturu (N = 12)	Goats (N = 22)	Sheep (N = 18)	Pigs (N = 7)
Application manure	8 (67)	19 (86)	6 (33)	5 (71)
Daily removal	10 (83)	20 (91)	10 (55)	3 (43)
2-3 days removal	2 (17)	2 (9)	8 (45)	4 (57)
Knowledge of urine as fertilizer	2 (17)	3 (14)	1 (5)	1 (14)

Numbers before brackets are numbers of the households; Numbers within brackets are the percentages of the households

Table 4: Manure handling techniques, utilizations and limitations

Variables	Muturu (N = 12)	Goats (N = 22)	Sheep (N = 18)	Pigs (N = 7)
Handling				
Composted	2 (17)	3 (14)	2 (11)	1 (14)
Not composted	10 (83)	19 (86)	16 (89)	6 (86)
Storage				
Short storage (0 = 10 weeks)	7 (58)	18 (82)	15 (83)	6 (86)
Medium storage (11-24 weeks)	5 (42)	2 (9)	3 (17)	1 (14)
Long storages (Greater than 24 weeks)	0 (0)	2 (9)	0 (0)	0 (0)
Ranking of usage				
Distant farm	3 (25)	7 (32)	13 (72)	2 (29)
Homestead	9 (75)	15 (68)	5 (28)	5 (71)
Limitations				
Bulk	7 (58)	2 (9)	8 (44)	4 (57)
Inadequacy	3 (25)	18 (82)	7 (39)	3 (43)
Weed abundance	2 (17)	2 (9)	2 (17)	0 (0)

Numbers before brackets are numbers of the households; Numbers within brackets are the percentages of the households

Table 5: Variability in manure nutrient composition as affected by handling technique (Mean±SD)

Handling technique	Nutrient content (% dry matter) N	P	K	C	C/N ratio
Muturu					
Indoor	1.92±0.48	0.41±0.20	1.71±0.61	17.55±1.22	9.00
Outdoor	1.61±0.38	0.28±0.12	0.88±0.11	19.61±1.72	12.00
Goats					
Indoor	1.98±0.36	0.38±0.09	1.84±0.26	16.96±1.2	8.24
Outdoor	1.71±0.22	0.32±0.11	0.28±0.33	17.63±1.17	10.00
Sheep					
Indoor	2.02±0.44	0.36±0.011	1.61±0.12	16.23±0.29	8.03
Outdoor	1.76± 0.32	0.28±0.26	0.98±0.36	16.76±0.98	9.52
Pigs					
Indoor	2.25±0.34	0.48±0.011	1.78±0.11	15.62±0.11	7.00
Outdoor	2.12±0.42	0.32±0.26	1.26±0.27	15.96±0.96	7.53

N = Nitrogen, P = Phosphorus, K = Potassium, C = Carbon C/N = Carbon – Nitrogen Ratio, SD = Standard Deviation

are scarcely used in distant farms, possibly due to bulk, especially in Muturu (58%) and pigs (57%) or due to inadequacy as in goats (82%). Weed infestation is not a major limitation in the utilization of animal manures (Table 4). In a similar study, Defoer *et al*. (1998) reported that factors, such as the distance of the crop fields from homestead, available means of transport and labour, influence the extent of manure utilization. Also, farmer rationality (Kloppenburg, 1999) could be a factor in the utilization of these manures. Farmers within the locality practice primarily bush fallowing for fertility restoration, implying that the use of animal manures is secondary and often used in home gardens.

Manure Quality and Soil Productivity

Handling technique influenced quality of manure in all the manure types (Table 5). Indoor stored manure had relatively higher macronutrients than those stored in open spaces. Again, indoor manure storage showed lower carbon-nitrogen ratios in all studied animal manures. Lower macronutrients content in outdoor-stored manures is possibly due to elevated leaching (Kristensea and Thorup-Kristensen, 2004) and volatilization (Rochette *et al*., 2004).

Table 6: Some characteristics of the topsoil (0 – 30 cm) used in the greenhouse study (pre-planting)

Soil property	Value	Soil property	Value
Sand (g kg^{-1})	800.0	Organic matter (g kg^{-1})	52.1
Silt (g kg^{-1})	40.0	Total nitrogen (g kg^{-1})	1.7
Clay (g kg^{-1})	160.0	Total carbon (g kg^{-1})	30.2
Texture	Sandy loam	Carbon-nitrogen	17.7
Exchangeable calcium (cmol kg^{-1})	2.2	Available phosphorus (mg kg^{-1})	12.5
Exchange magnesium (cmol kg^{-1})	1.7	Exchangeable potassium (cmol kg^{-1})	0.2
Exchangeable sodium (cmol kg^{-1})	0.1	Cation exchange capacity (cmol kg^{-1})	7.8
		Soil pH (water)	4.7

Table 7: Maize performance of animal manures

Animal manure	Plant height (cm) 6 WAP	DM yield (g pot^{-1})
Muturu dung	82.9	348.6
Goat dung	83.5	324.2
Sheep dung	83.7	326.3
Pig dung	83.9	355.8
Control	38.4	110.6
$LSD_{(0.05)}$	9.2	6.4

WAP = Weeks After Plating

Table 8: Residual effects of animal manures on some soil properties

Animal manure	pH (water)	CEC (cmol kg^{-1})	K (cmol kg^{-1})	N (g kg^{-1})	Av. (P mg kg^{-1})	OM (g kg^{-1})	C/N
Muturu dung	5.20	9.90	0.40	2.5	18.2	58.6	12.4
Goat dung	6.10	10.20	0.70	2.7	25.6	55.1	11.8
Sheep dung	5.80	9.60	0.50	2.6	21.7	54.6	12.2
Pig dung	5.60	8.70	0.60	2.9	19.6	55.6	11.1
Control	4.50	5.90	0.10	0.9	10.8	30.2	19.4
$LSD_{(0.05)}$	0.94	1.26	0.06	0.9	3.6	4.4	1.1

CEC = Cation Exchange Capacity, C/N = Carbon-Nitrogen Ratio, K = Potassium, N = Nitrogen, Av. P = Available Phosphorus, Om = Organic matter

Animal manures were applied on degraded soils whose properties are shown in Table 6, with maize (*Zea mays* L.) used as test crop. Maize growth (plant height) and yield (dry matter) parameters varied significantly (p = 0.05) at 6 weeks after planting as a result of animal manures applied on this soil (Table 7). Least height value was recorded in local cattle manure which van Kessel *et al*. (2000) attributed to lower N-content and high lignin content. Similar improved result in maize performance was obtained by Oguike and Mbagwu (2001). Higher contents of N in pigs and sheep manures (Table 5) could be responsible for increased maize height (Table 7). Higher (Dry Mater) yield was recorded in pig manure, which is consistent with the findings of Okpara and Mbagwu (2003).

There were significant (p = 0.05) changes in selected soil properties as influenced by animal manures (Table 8). These residual results agree with the findings of Spaccini *et al*. (2002) that organic amendment improved soil chemical fertility of degraded soils. There were further depletion of soil chemical properties in the control pots, indicating effect of animal manures on treated pots.

In conclusion, this study has revealed that a good number of households keep goats and sheep using free grazing with fewer households rearing Muturu and pigs under tethering/confinement. Farmers use solid droppings as manure with little knowledge of the use of urine as biofertilizer. Composting of animal manure is an unpopular practice in the study area as they are disposed almost immediately after production. Bulk and inadequacy are major factors limiting use of these manures, especially in distant farms. The study also found that indoor-stored manures had higher macronutrients than outdoor-stored ones. There was significant (p = 0.05) difference in the maize performance and post-harvest soil quality using these manures in the study area.

REFERENCES

Ajayi, A.R., 1996. An evaluation of the socio-economic impact of the Ondo State Ekiti-Akoko ADP on the rural farmers. Ph.D Thesis, University of Nigeria, Nsukka, Nigeria, pp: 134-158.

Chantigny, M.H., P. Rochette and D.A. Angers, 2001. Short-term C. and N dynamics in a soil amended with pig slurry and barley straw: A field experiment. Can. J. Soil Sci., 81: 131-137.

Chantigny, M.H., D.A. Angers, T. Morvan and C. Pomar, 2004. Dynamics of pig slurry nitrogen in soil and plant as determined with ^{15}N. Soil Sci. Soc. Am. J., 68: 637-643.

Chuta, C.R., 1992. Comparative assessment of training needs for agricultural administrators in Imo and Bornu States of Nigeria. Ph.D Thesis, University of Nigeria, Nsukka, Nigeria, pp: 1-89.

Defoer, T., A. Bubelman, C. Toulmin, S. Carter and J. Ticheler, 1998. Soil fertility management in Africa. Resource Gudie for Participatory Learning and Action Research. Part 1, pp: 1-59.

Emteryd, O., 1989. Chemical and physical analysis of inorganic nutrients in plant, soil, water and air. Stencil No. Uppsala, Swedish University of Agricultural Sciences.

FAO (Food and Agriculture Organization), 2005. Special event on Green Revolution in Africa. Background document prepared by the SDR Committee on World Food Security, 31st Session, May 23-26.

Fernandez-Rivera, S., T.O. William, P. Hiernax and M. Powell, 1995. Faecal Excretion by Ruminant and Manure Availability for Crop Production in Semi-Arid West Africa. In: Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of Sub-Saharan Africa. Powell, J.W., S. Fernandez-Rivera, T.O. William and C. Renard (Eds.), Vol. 11, Technical Papers. Proceedings of an International Conference held in Addis Ababa, Ethiopia, 22-26 Nov. 1993. IL CA, International Livestock Center for Africa Addis Ababa, Ethiopia, pp: 149-169.

Gachie, I. and L. Ruault, 2006. Facilitating and managing information for rural development: Information Services tools, methods and experiences. CTA Wageningen. The Netherland, pp: 171.

Gee, G.W. and D. Or, 2002. Particle Size Analysis. In: Methods of Soil Analysis. Dane, J.H. and G.C. Topp (Eds.), Part 4. Physical Methods. Soil Sci. Soc. Am. Book Series No. 5, ASA and SSSA, Madison, WI., pp: 255-293.

Hazell, P., S. Haggblade, I. Kirsten and R. Mkandawire, 2003. African agriculture: Past performance, future imperatives. Paper Presented at the INWENT, IFPRI, NEPAD. CTA Conference at Pretoria, South Africa, Dec. 1-3.

IARMW, 1998. Final Report. Integrated Agro-Ecological Research of the Miombo Woodlands in Tanzania, Tanzania, pp: 413.

IIRR (International Institute for Rural Reconstruction) and ACT (African Conservation Tillage), 2005. Conservation agriculture: A manual for farmers and extension workers in Africa. IIRR, Nairobi and ACT, Harare, pp: 251.

Kloppenburg, J., 1991. Social theory and the de/reconstruct-tion of agricultural science local knowledge for an alternative agriculture. Rural Sociol, 56: 519-548.

Kristensea, H.L. and K. Thorup-Kristensen, 2004. Root growth and intrate uptake of different catch crops in deep soil layers. Soil Sci. Soc. Am. J., 68: 529-537.

Matsumoto, T., M. Noshiro and M. Hojito, 1997. The Effect of Farm Yard Manure of Different Degradation Levels on Grass Production. In: Plant Nutrition for Sustainable Food Production and Environment. Ando, T., K. Fujita, T. Mae, H. Matsumoto, S. Mori and J. Sekiya (Eds.), Kluwer Academic Publisher, Japan, pp: 591-592.

Mbabu, A.N. and C. Ochieng, 2006. Building an agricultural research for development system in Africa. International Food Policy Research Institute Discussion Paper, Washington DC., pp: 54.

Msangi, B.S.J. and P.Y. Kavana, 2002. Survey and Evaluation of Grasses and Legumes for Feeding Dairy Cattle in Morogoro and Kibaha District. In: Proceedings of the 1st Collaborative Research Workshop on Food Security. Batamuzi, E.K. and A.J.P. Tarimo (Eds.), 28-30 May TARPII-SUA Project Morogoro, pp: 163-167.

Oguike, P.C. and J.S. Mbagwu, 2001. Effects of hyacinth residues on chemical properties and productivity of degraded tropical soils. Agro. Sci., 2: 44-51.

Okpara, I.M. and J.S.C. Mbagwu, 2003. Effectiveness of Cattle dung and seine waste as biofertilizers on an Ultisol at Nsukka. Proceedings of the 28th Annual Conference of Soil Science Society of Nigeria, at NRCRI, Umudike Umuahia Nigeria 4-7 Nov. 2003, pp: 71-80.

Onu, M.O. and M.C. Madukwe, 2002. Adoption levels and information sources of brood and sell poultry operators. Agro. Sci., 3: 63-67.

Onweremadu, E.U., C.C. Opara, U. Nkwopara, C.I. Duruigbo and I.I. Ibeawuchi, 2006. Yield response of a cowpea variety on ground seashells on Isohyperthermic Arenic Kandiudult. Int. J. Soil Sci., 1: 251-257.

Onweremadu, E.U., C.C. Asiabaka, O.M. A Desope and N.S. Oguzor, 2007. Application of indigenous knowledge on land use activities among farmers in Central Southeastern Nigeria. Online J. Earth Sci., 1: 47-50.

Raussen, T., 1997. Integrated Soil Fertilizer Management on Small-Scale Farms in Eastern Province of Zarabia. English Press Ltd. Narobi, Kenya, pp: 87.

Rochette, P., D.A. Angers, G. Belanger, M.H. Chanting, D. Prevost and G. Levesque, 2004. Emissions of NO from alfalfa and soybean crops in Eastern Canada. Soil Sci. Soc. Am. J., 68: 493-506.

Schleich, K., 1986. The use of cattle dung in agriculture. Nat. Resour. Resour. Dev., 23: 53-87.

Sommer, S.G. and S. Husted, 1995. The chemical buffer system in raw and digested animal slurry. J. Agric. Sci. (Cambidge), 124: 45-53.

Sommer, S.G. and N.J. Hutchings, 2001. Ammonia emission form field applied manure and its reduction. Eur. J. Agron., 15: 1-15.

Spaccini, R., A. Piccolo, J.S. C. Mbagwu, A. Zena-Teshale and C.A. Igwe, 2002. Influence of the addition of organic residues on carbohydrates content and structural stability of some highland soils of Ethiopia. Soil Use Manage., 18: 404-411.

Spalding, R.F. and M.E. Exner, 1993. Occurrence of nitrate in groundwater. A review. J. Environ. Qual., 22: 392-402.

SPSS Inc., 1999. SPSSBase 10. 0. Applications guide. SPSS Inc. Chicago, IL.

SSS (Soil Survey Staff), 1996. Soil Survey Laboratory Methods Manual. Soil Survey Investigations Rep. No. 42, Ver. 3. 0 USDA, Washington DC.

Tanner, J.C., S.J. Holden, M. Winu groho, E. Owen and M. Gill, 1993. Feeding Livestock for Composite Production: A Strategy for Sustainable Upland Agriculture in Java. In: Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of Sub-Saharan Africa. Powell, J.M., S. Fernandes-Rivern, T.O. Williams and C. Renard (Eds.), Vol. II, Technical Papers. Proceedings of an International Conference, Held at Add is Ababa, Ethiopia, 22-26 November, ILCA International Livestock Centre for Africa Addis Ababa, Ethiope, pp: 115-128.

Thomas, G.W., 1996. Soil pH and Soil Acidity. In: Methods of Soil Analysis, Part 3. Chemical Methods SSSA Book Series No. 5, SSSA and ASA, Madison, WI., pp: 475-490.

Van Kessel, J.S., J.S. Reeves and J.J. Meisinger, 2000. Nitrogen and carbon mineralization of potential manure components. J. Environ. Qual., 29: 1669-1677.

Zhang, H., D.W. Hamilton and J.G. Britton, 2001. Sampling Animal Manure. University Press, Oklahoma, USA., pp: 70.