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TWO YEARS EVALUATION OF FOUR CONTRASTING ORGANIC WASTES ON SOIL PRODUCTIVITY AND MAIZE YIELD IN ULTISOL AT IGBARIAM SOIL SOUTH EAST NIGERIA

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ABSTRACT: *Famers since history in agriculture use animal waste to conserve their soil and improve crop yield. A randomized complete block design (RCBD) was set up to study the effect of four (4) contrasting animal wastes on soil productivity and maize grain yield for two consecutive years in Igbariam soil south east Nigeria. The waste comprising of cow dung (CD), pig dropping (PGD), poultry droppings (PD) and goat droppings (GD) were applied at rate of 24kg/plot (equivalent to 20 tha^{-1}) in the first year and their residual effect tested in the second year cropping. Results showed that application of animal wastes significantly (P<0.05) enhanced the soil properties and yield parameters of maize tested, for the 2 years study. The immediate effect of animal wastes in improving the soil pH of the amended plots gave corresponding increases in the values recorded for the soil parameters tested with a reduction in bulk density relative to the control plot for two consecutive years of study. Maize grain yield showed highest value (3.54 tha^{-1}) and plant height 163.9cm in PD first year cropping but second year cropping result depicted PGD to record highest maize grain yield value (1.96 tha^{-1}) among the other treatments. The findings from the study showed that the use of animal wastes in crop production system can improve the productivity of soil and increased crop yield.*

KEYWORDS: Animal waste, organic waste, grain yield, nutrient elements

INTRODUCTION

The quality of life on earth depends largely on the fertility status of soil because the fertility of any given soil is the availability of nutrients to plant in their right proportion and balances. Man and his livestock depend solidly on plants for their life sustenance. The cultivation of crops by farmers in Nigeria is based on the continuous uses of the available nutrients in the soil as fallow system as one of the only means of resuscitating the depleted plant nutrients. In some areas, especially those areas easily accessible in the south east, the fallow period have been reduced to zero.The cropping system of our traditional agriculture further compounds the problem which makes the choice of appropriate nutrients for various crops problematic.Carsky and Ndikawa (1998) reported that continuous cropping leads to depletion of soil nutrients with one resultant poor performance of cultivated crops. Soils of south eastern Nigeria are highly weathered hence, low productivity and sustainability declines over time subject to continuous cultivation. In this region also the land area available for crop production activities continues to decrease due to increased human population growth and to large extent gully erosion.These defects in the region

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notwithstanding the dependent on agricultural products continue to be on the increase hence, the need to intensify effort on land use management to generate higher yield per land area. Due to fragile nature of soils in south eastern Nigeria and its poor inherent capacity to provide plant nutrients it is imperative that the plant nutrients be augmented through integrated soil management necessary for sustaining good soil and crop productivity. Cultural practices leading to bed, ridge and mound making have been found to influence soil quality, nutrient conservation and release, crop growth, development, and yield. Hulugale et al. (1985) reported that tillage leads to rapid oxidation of OM with resultant soil structural deterioration and reduction of potential nutrient supply. Ojeniyi (1997) in his own study carried out in soils of south western Nigeria pointed out that heaps (mounds) and ridges, degrades soil quality and yield insouth west Nigeria. Nweke et al.(2016, 2017)who worked in south east Nigeria observed that ridge, mounds and flats affect the quality of soils and crop yield in the area.

Maize one of the most important staple food crops in Nigeria and other tropical countries with high propensity for nutrient competition among other crops, contributes greatly to the rate of nutrient depletion in the soil, hence the resultant poor performance in yield of other crops in mixture.Maize is an important raw material in lives stockfeed production industry,in fishery industry, with added nutrients maize can be made into pellets for the feeding of fish in fish ponds. It makes good silage when cut at succulent stage, a food fodder crop for cattle to graze. The application of fertilizer increases the nutrient status of soil; they are important and applied based on the need of the soil at any particular time for crop growth, development and yield. Over the years, farmers in the study area support the nutrient status of their agricultural field with chemical fertilizer, most often times, these fertilizers are scarce and unavailable, where it is available, it is usually very costly and not within the reach of the poor resource farmers in our society and these are group of farmers whose livelihood and income base depends solely on their agricultural products. Besides, fertilizer has hazardous effect on soil structure and crop yield, decrease base saturation, increase acidification and nutrient imbalance (Isherwood 2008, Adeoye et al., 2008). On the other hand, organic wastes are natural organic fertilizers which are easily available cheap and within the financial capacity of the poor resource farmers though the present economic recession has made them not to be relatively cheap as presumed but still cheap and available than chemical fertilizer. Studies have shown that it improves the nutrient status of soil and with residual effect. Mbah and Mbagwu (2006) reported that application of organic manure increased cation exchange capacity (CEC) of soils, thus, indicating greater nutrient retention capacity of soil. Organic wastes differ in their ability to provide and enhance soil quality due to difference in their rate of decomposition and nutrient release patterns. Mbagwu (1992) noted that the ability of animal wastes in restoring the soil fertility is dependent on soil, climate and crop specific. There are many kind of animal wastes and it is very important to verify them since the system through which nutrients are replenished naturally in soils of south eastern Nigeria is no longer effective and efficient due to serious pressure on land the need therefore arise for the use of cheaper and readily available form of soil treatment like animal wastes for soil fertility improvement and for the production of maize in terms of biomass and economic yield. Based on the foregoing the objective of the study was to evaluate the effect of four contrasting animal wastes on the productivity of Igbariam soil and maize yield.

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MATERIALS AND METHODS

Site Location

The study was carried out at the experimental site of SoilScience Department, Faculty of Agriculture, ChukwuemekaOdumegwuOjukwu University, Igbariam Campus. It is a rain forest zone where precipitation during the rainy season from mid March to late October is usually up to 2000mm the average temperature range from $21^{O}C$-$35^{O}C$ and relative humidity from 65%-80%. Composite samples of the top soils 0-30cm depth was taken with spade before the seed bed preparation. The samples was analysed for physical and chemical properties according to procedures described by Black (1965ab). The result of the soil analysis is presented in Table1.

Land Preparation/Experimental Design/Treatment Application

A land area of 17m x 19m was mapped out and manually cleared using machete, debris removed and raised bed made using hoe. The system consisted of four different animal wastes of 24kg/plot and a control plot that received no treatment were used for the study. The treatments are designated as follows:
Cow dung (CD) 24kg/plot
Poultry Droppings (PD) 24kg/plot
Goat droppings (GD) 24kg/plot
Pig droppings (PED) 24kg/plot
Control (CO) 0kg/plot.

The treatment were laid out in a randomized complete block design (RCBD) with four (4) replications to give 20 plots each measuring 3m x 4m ($12m^2$) plots were separated by 0.5m path and each block was separated by 1m alley. The animal wastes at the rate of 24kg/plot each for the respective waste were incorporated into the soil at their respective plots during bed making and allowed 7 days for aging before planting of the maize seeds (Orbasuper II) used for the field trial. The seeds of maize were sown at the rate of 2 seeds per hill at the spacing of 70cm x 25cm and a depth of about 8cm deep and later thinned down to one plant per stand two weeks after germination. The experimental field was kept relatively weed free to reduce competition between maize roots and weeds for available nutrients, water and light. Ten maize plants from each plot were randomly selected and used for the assessment of plant height, leaf area index at different days after planting and maize grain yield. At the end of the study, soil samples were collected from respective plots at a depth of 0-30cm, the soil samples were air dried and used for the determination of soil physical and chemical parameters following the method of black (1965ab).

Data collected from the study was subjected to the statistical analysis of varianceprocedures for a randomized complete black design according to Steel and Torrie (1980) and treatment means was compared using LSD at 5% alpha level.

RESULTS

The initial soil parameters tested in the study showed that the studied soil is of sandy clay loam hydromorphic in nature and deficient in chemical nutrients and physical parameters are of

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lowervalues (Table 1). The result presented in Table 2 indicated that the animal wastes used in this study were rich in OC and low values in exchangeablebases and available P. The pH value of cow dung and goat manure were slightly acidic, poultry alkaline and pig manure moderately acidic. Based on these values, it is expected that the studied soil and test crop maize will benefit from the wastes when used as soil conditioner.

Table 1 Physical and chemical properties of soil of the experimental site

Parameters	Value
Clay	230g
Silt	210g
Fine sand	420
Coarse sand	160g
Textural class	sandy clay loam
Bulk Density	$1.39gm^{-3}$
Total porosity	48.92%
Moisture Content	20.52%
Dispersion Ratio	0.87%
Aggregate Stability	17.02%
Hydraulic conductivity	$4.59cmhr^{-1}$
pHH_2O	5.98
OC	0.76%
N	0.055%
Avail. P	$3.89mgkg^{-1}$
Ca^{2+}	$1.5cmolkg^{-1}$
M_{g2}^{+}	$1.3cmolkg^{-1}$
Na^{+}	$0.24cmolkg^{-1}$
K^{+}	$0.26cmolkg^{-1}$
ECEC	$4.99cmolkg^{-1}$
B S	87%

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Table 2 Nutrient content of the manure before application

Parameter	Cowdung manure	Poultry manure	Goat manure	Pig manure
pHH_2O	6.90	7.20	6.30	5.90
Organic carbon	18.9%	17.95%	13.55%	15.25%
Organic nitrogen	1.52%	2.16%	2.15%	2.23%
Available Phosphorous	2.20mgkg^{-1}	2.51mgkg-^{1}	12.44mgkg^{-1}	2.15mgkg^{-1}
Calcium	2.17Cmolkg^{-1}	4.26Cmolkg^{-1}	2.87 Cmolkg^{-1}	3.26Cmolkg^{-1}
Magnesium	0.61Cmolkg^{-1}	1.21Cmolkg^{-1}	0.96 Cmolkg^{-1}	2.12Cmolkg^{-1}
Sodium	0.25Cmolkg^{-1}	0.47Cmolkg$_{-1}$	0.56 Cmolkg^{-1}	0.43Cmolkg^{-1}
Potassium	1.36Cmolkg^{-1}	1.69Cmolkg^{-1}	0.61 Cmolkg^{-1}	0.69Cmolkg^{-1}

Effect of four contrasting animal wastes on the yield and yield component of maize

The result of maize growth and yield presented in Table 3 showed that the animal wastes positively influenced the growth and yield of maize in both first year and second year planting season. In first year planting season, poultry manure (PD) gave the highest value of plant height (163.09cm), leaf area (149.95cm^2) and grain yield (3.54tha^{-1}). Though, these values were not significantly different from the values obtained from pig manure (PGD)in plant height and grain yield as well as PGD and cow dung (CD) in leaf area. The 2nd year planting result showed a reduction in value in all the parameters assessed.The values obtained from the amended plots showed that effect of the animal wastes on the parameters were statistically similar but significantly different from the control resultexcept for grain yield result where PD, PGD, and CD as well as CD and GD were at par but significantly different from the control value. Nonetheless, the highest recorded yield value follow the order PGD>PD>CD> GD>CO and their percentage yield increase relative to control were 50%, 48.15%, 43.02%, 29.50% respectively.

Table 3 Effect of four contrasting animal wastes on the yield and yield component of maize

Treatment	Year 1			Year 2		
	Plant height cm	Leave area cm^2	Grain yield tha^{-1}	Plant height cm	Leave area cm^2	Grain yield tha^{-1}
CO	112.94	132.7	2.20	99.24	109.16	0.98
CD	143.25	144.28	3.06	123.18	113.75	1.72
GD	134.26	138.33	2.36	121.36	118.13	1.39
PGD	154.15	144.48	3.41	152.47	122.46	1.96
PD	163.09	149.95	3.54	152.31	119.36	1.89
LSD0.05	19.32	6.54	0.37	21.23	5.59	0.52

CO = Control; CD = Cow dung; GD = Goat manure; PGD = Pig manure; PD = poultry manure

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Effect of four contrasting animal wastes on chemical properties of the studied soil

The pH of the amended plots varied from slightly acidic to alkaline, while control plots remained acidic (Table 4). The exchangeable bases (Ca, Mg, Na, and K), OC, TN, available P and ECEC values of the soil (Table 4) were found to be significantly increased visa-vie their values in the control plots and their initial values (Table 1) in the 1st year planting season. However, the value of Ca showed that GD and PGD values were statistically similar and the value obtained for available P equally indicated that PGD and PD, CD and GD as well as CD and CO values were statistically similar. The 2nd year result (Table 4) showed gradual reduction in the value of all the assessed parameters except for pH of PGD value. The pH values of the treated and non treated soil showed slightly acidic and non significant. The animal wastes showed strong residual effect in most of the parameters visa-vie their initial value in the studied soil (Table1). The variation in value of OC, P, and ECEC follow the order PD>GD>PGD>CD>CO (OC), PGD>PD> GD>CD>CO (avail. P), PD>CD>PGD>GD>CO (ECEC) respectively. The value of % N in PD and PGD were similar but significantly different from the control plot result. Among the amended plots, GD showed lowest value in Mg, Na and K; while PGD recorded lowest value in Ca, these values were significantly different from the control plot values.

Table 4 Effect of four contrasting animal wastes on soil chemical properties

	Year 1									Year 2								
Treatment	pH H_2O	OC %	N %	P $mgkg^{-1}$	Ca	Mg	Na	K	ECEC $cmolkg^{-1}$	pH H_2O	OC %	N %	P $mgkg^{-1}$	Ca	Mg	Na	K	ECEC $cmolkg^{-1}$
PD	7.36	2.60	1.18	10.10	3.43	1.27	0.78	0.67	11.79	6.92	1.04	0.78	2.58	1.39	0.93	0.37	0.39	5.29
CD	6.9	1.90	1.08	6.30	2.73	1.57	0.87	0.74	10.98	6.41	0.76	0.75	1.83	0.91	1 03	0.36	0.39	5.24
GD	6.38	2.15	0.95	7.40	3.50	1.43	0.71	0.54	10.33	6.54	0.94	0.63	2.10	1.26	0.95	0.33	0.30	4.10
PGD	6.67	2.35	1.38	9.30	3.52	1.73	0.63	0.61	11.05	6.80	0.86	0.78	2.78	1.05	1.05	0.34	0.38	5.15
CO	5.50	1.60	0.81	5.30	2.05	1.07	0.53	0.46	8.81	6.01	0.64	0.45	1.58	0.79	0.83	0.29	0.22	3.08
LSD 0.05	0.27	0.22	0.11	1.97	0.10	0.15	0.07	0.06	0.60	NS	0.09	0.01	0.74	0.37	0.05	0.04	0.01	0.15

CO = Control; PD = Poultry manure; CD = Cow dung manure; GD = Goat manure; PGD = Pig manure

Effect of four contrasting animal wastes on soil physical properties

The values recorded for each of the parameters of 1st year planting season indicated positive influence of the animal wastes (Table 5) of which shows significant different among the treatments. The result of bulk density, total porosity and hydraulic conductivity, however, indicated that the effect of the treatment were statistically similar, examples; PGD, GD and PD (bulk density); GD and PGD (total porosity); PD, GD, PGD and CO (hydraulic conductivity) were all statistically similar respectively. The plots treated with CD showed highest value in moisture

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content (MC) and aggregate stability (AS), however, the aggregate stability value were statistically similar with PD, GD, and PGD values. The DR and MWD value indicated an increased value in GD and PD respectively (Table 5). The 2nd year planting season result showed an increased value in some of the parameters assessed relatively to their 1styear values(Table 5) and initial values (Table 1). The bulk density (BD), total and porosity (TP) and moisture content (MC) variation were CO>CD>GD>PGD>PD (BD); PD>GD>PGD>CD>CO (TP) and CD>PGD>PD>GD>CO (MC) respectively. The percentage increase in HC of the amended plots relative to control plots were 45.65% (CD); 34.56% (PD); 26% (GD) and 24.25% (PGD) respectively. The dispersion ratio (DR) value showed an increased value in GD plots, while the effect of the treatments on the AS and mean weight diameter (MWD) values were found not to be effectively influenced by its statistically similar results obtained.

Table 5 Effect of four contrasting animal wastes on soil physical properties

	Year 1							Year 2						
Treatment	BD	TP	HC	MC	Agg. Stab.	DR	MWD	BD	TP	HC	MC	Agg. Stab.	DR	MWD
	gcm^{-3}	%	$cmhr^{-1}$	%	%		mm	gcm^{-3}	%	$cmhr^{-1}$	%	%		mm
PD	1.23	47.16	5.60	38.70	24.52	0.84	3.33	1.13	55.90	7.35	43.07	22.26	0.72	3.93
CD	1.37	41.32	6.10	46.35	25.91	0.74	2.93	1.27	40.85	8.85	49.64	24.07	0.62	3.24
GP	1.27	44.38	5.40	34.20	22.99	0.91	3.05	1.19	50.53	6.50	41.85	18.47	0.80	3.62
PGD	1.25	43.90	5.28	42.30	24.28	0.84	3.28	1.18	46.23	6.35	45.09	21.97	0.71	4.0
CO	1.55	35.46	5.25	28.80	20.06	0.72	2.66	1.58	34.40	4.81	37.63	17.11	0.60	2.62
LSD 0.05	0.17	1.20	0.40	1.76	2.41	0.18	0.41	0.15	2.20	1.12	0.84	NS	0.07	NS

PD = Poultry droppings; CD = Cow dung; GD=Goat droppings; PDG =Pig droppings

DISCUSSION

The result of initial soil analysis of the studied soil is of evidence that the soil nutrients tested were below their critical values according to the ratings ofEnwezor, et al. (1986)and FMANR, (1990) for crop production in south east soils of Nigeria. This probably may be partly due to its hydromorphic characteristics and intensive crop production activities through clean clearing and cultivation of the soil for annual cropping all year round. The low level of OC is an indication that the soil lacks the ability to hold cations in the exchangeable forms. Krasilinikoff et al. (2002) reported that soils with low OC have low ability to hold cations in the exchangeable forms. Greenland (1992) however, opined that low OC of the soil is characteristics of the savannah that result from rapid decomposition and mineralization of organic matter and to poor management of the soils by the famers. Also, the low level of the exchangeable bases (Ca, Mg, K, and Na) indicated that the studied soil is of low base status and suggest the supplementary fertilizer application to provide for the deficit between the inherent basic nutrient status and the amount picked up by the crops and leaching losses for adequate crop performance. Hence, the application of animal wastes rich in most of these plants nutrients to the tune of 24Kg/plot ($20tha^{-1}$) become

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ideal as the wastes positively influenced the studied soil and the test crop- maize of which the results were recorded in Table 3,4 and 5. These positive influences probably result from increase in soil pH, macro-nutrients and micro-organism population playing an important role in N and P transformations leading to increased maize yield observed in the study.

The reduction in the values of the chemical parameters tested in the study in the 2nd year planting season relative to 1styear results may be due to non-manure application. The rise in the soil pH relative to the control plots in both 1st and 2nd year result following animal wastesapplication can be adduced to release of certain exchangeable bases into the soil solution during the microbial decarboxylation of the wastes. The wastes decomposed and nutrients were released to the soil. The decrease in soil pH in the 2nd year planting as compared to the 1st year planting could be ascribed to uptake of exchangeable cationsby maize plant during the growing period and leaching of the exchangeable bases. This generally affected the chemical result of the 2nd year planting. The rise in soil pH of the control plots of 2nd year planting as against 1st year result may be due to cultivation that further decomposes the inherent OM content of the soil, increasing the activities of the microorganisms leading to the release of alkaline base metals that led to rise in soil pH of the control plots. The low content of OC and TN in the 2nd year planting can be explained in the light of the residual effect of the 1st year coupled with the non wastes application or partly due to uptake of the nutrients by maize plants high productivity and reduced decomposition. The two nutrients are linked together as OM is the main source of N in the soil so the lower the OC the lower the N. Nonetheless, it is worthy to know that the values of the two parameters (OC and TN) recorded in 2nd year planting were above their critical levels of 0.17-0.2% for crop production in soils of south east Nigeria (FMANR 1990, Enwezor et al. 1986, IRRI, 1969) this indicate positive residual effect of the wastes on the productivity of the soil and crop production. Animal wastes are manure that supply soil nutrients in small quantities and OM in large quantities. According to Paul (2011), this has to be converted to inorganic form prior to use. So with this scenario, the rise in P content of the soil following wastes application might have resulted from the increase in the rate of desorption of phosphate (Zsolnayand Gorlitz et al., 1994) thus improving the availability of P content. When pH is increased to near 6.5 aswas obtained from the study phosphorous availability occurs in most soils (Lee et al., 2007). The critical levels of exchangeable bases according to the ratings of USDA (1986) where K = 2.0 $cmolkg^{-1,}$Ca = 2.0-5.0$cmolkg^{-1}$, (moderate), Mg = 3.0-8.8 $cmolkg^{-1}$ (very low to high).In the light of these, the values of the exchangeable bases of the 2nd year planting are below their critical levels of which may be attributed partly to the uptake of the nutrients by the maize plant as they are adequately needed at various development stages of the maize plant. For example, Ca is very important for cell wall development and Mg as a dissolvedcation is known to improve P availability, uptake and chlorophyll development. It can also be ascribed to reduce organic matter decomposition, leaching, weathering and ferrolysis. Hence, low in inherent fertility status of the soil. However, Landon (1991) working on tropical soil reported that Ca level as low as 0.2$cmolkg^{-1}$can effectively support crop growth and yield. The implication of the 2nd year result is that without another application of the animal wastes in 2ndyear planting season, farmers can still get reasonable yield from their crop production activities all things being equal.The ECEC values of the studied soil varied from 8.81—11.79$cmolkg^{-1}$ (1st year) and 3.0 8—5.29$cmolkg^{-1}$ (2nd year), the ECEC values from 7.75—12.39$cmolkg^{-1}$ were rated low to moderate (FAO 1983), thus,

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the value obtained especially with the regard to the 2nd year result suggest the influence of low OM content in the soil. However, Sanchez et al., (1997) and Sanchez(2010) reported that soils with ECEC value above 4.0cmolkg^{-1}could withstand heavy leaching. The implication of this is that amended plots can withstand leaching problems that will increase nutrient availability to the plant resulting to good yield compared to control plots.The results of the present study haveindicated that animal wastes being organic manure can supply practically all the elements of fertility (Zia et al, 2012) which the maize plant requires.

The soil physical properties tested, varied in their content of which is associated to type of wastes used and rate applied. The decrease in bulk density and increase in TP and MC recorded in the study could be ascribed to increased microbial activity associated with nutrient availability at that rate of amendmentthis attest to the fact that the wastes are rich in OM which reduces the soil compaction. Soils with low bulk density and high total porosity contain the required water and oxygen that are important for organisms that live in the soil to survive, root development and proliferation. The increase in HC as a result of waste application may be due to higher pores in plotsamended with animal wastes of which means better water transmission and all that dissolve therein. Hence reduction in water logging as the studied soil is hydromorphic in nature. The high value of HC is more pronounced in the 2nd year planting and might have resulted from reduction in soil compaction by wastes application. Adeleyeet al. (2010) worked on south west soil of Nigeria and reported that organic wastes application improved soil physical properties, reduce soil bulk density, temperature and also increase soil porosity and soil moisture retention capacity. The increased aggregate stability and MWD in the amended plots relative to control plots attest to the cementing ability in the OM in soil particles of which resulted to an increase in total OC (Table 4) that bounds smaller aggregates into larger ones necessary for soils under continuous cultivation. Soil OC influences the stability of soil by reducing the rate of wetting and increasing the resistance to stress generated during wetting (Caron et al., 1996). Perfect et al. (1990) observed that structural stability of a soil has an impact on a wide range of processes that influence crop growth, erosion, and runoff. The significant difference in DR recorded both in 1st and 2nd year planting in the study showed positive influence of the wastes in improving the micro aggregates of the studied soil. The decrease in soil dispersion ratio in amended plots relative to control plots were in line with the report of Mbah et al (2010).

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CONCLUSION

The findings from the present study have shown that animal manure is a source of many nutrients. Some nutrient deficiency is usually localized within a field and would not be corrected with common rates of manure. Therefore, some improvements are achieved when a higher rate such as the rate applied in this study are recommended for the study area. Exceeding, this rate may supply an excess amount of nutrients that might affect the crops adversely. Results finding also attest that animal manures vary widely in the amount of plant nutrients that they contain and supply to soil some are more concentrated than others.

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