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Effect of cattle manure on soil nutrients dynamics and performances of maize (*Zea mays* L) grown on sandy loam soil in forest-savannah transition zone southwest Nigeria

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Abstract
The contribution of inorganic fertilizer to enhance crop growth and yield cannot be ignored, but on the other hand their indiscriminate use is causing deterioration of the soil structure and soil acidity. A field experiment was conduct at the Teaching and Research Farm of Rufus Giwa Polytechnic, Owo, during the wet season of 2015 to study the effect of variable rate of cattle manure on the growth and yield of maize (*Zea Mays* L). Five rates of cattle manure: control, 5, 10, 15, and 20 t/ha^{-1} replicates three times laid out in a Randomized Complete Block Design (RCBD). Data were collected on vegetative traits and yield component of the maize and statistically analyzed. The growth and yield attributes measured in the field include number of leaves, plant height (cm), leaves length (cm), leaves area (cm), stem girth (mm), number of cobs, cobs length (cm), cobs circumference (cm) number of grain per cobs, cobs weight (kg), grain weight (kg), and husk weight (kg). The growth and yield attributes increased significantly accordingly to the rates of cattle manure due to continuous supply of nutrient. The control plot gives significantly lower means and maize that received 20 t ha^{-1} recorded the highest mean in all growth and yield parameter evaluated in the study. In conclusion, applications of cattle manure at the rate of 20 t ha^{-1} significantly improve vegetative growth and yield attributes of maize plant and therefore recommended that resource-poor farmer can adopt the use of cattle manure at 20 t ha^{-1} as substitute for inorganic fertilizer, thus reduce environmental pollution posed by the disposal of the cattle waste and ultimately improve yield in the study area.

Keywords: cattle manure; substitute; vegetative growth; yield attributes

Introduction
Maize, sometimes referred to as corn is rank with wheat and rice as one of the most produced and consumed cereal crop in Nigeria (Vaidya, 1986) [39]. In spite of its nutritional and economic value its production has been hampered by low yield caused by several factors and chief among it is low soil fertility status. Nigeria soil has a high potential for crop production yield, levels obtained under farmer's condition are usually low due to poor soil management and conservation method. The type of problem is solved through the use of either inorganic or organic fertilizer. However, the use of inorganic fertilizer by resource poor farmers is limited by its scarcity and cost (Akanbi *et al.*, 2001) [7] and untimely availability (Adedoyin, 1995) [5]. Under intensive agriculture, the use of inorganic fertilizer has not been helpful because it is associated with soil acidity, nutrient imbalance and reduction in crop yield (Kang and Juo, 1980; Obi and Ebo, 1995) [23, 25]. The use of organic manure to meet the nutrient requirement of crop would be an inevitable practices since organic manures generally improve the soil physical, chemical and biological properties along with conserving capacity of the moisture holding capacity of soil and this, resulting in enhanced crop productivity along with maintain the quality of crop produce (Mahhesarappa *et al.* 1999) [24]. Although organic manures contain plant nutrients in small qualities compared to inorganic fertilizers, the presence of growth promoting principle like enzymes and hormones, besides plant nutrient make them essential for improvement of soil fertility and productivity (Bhurna, 2001) [13]. Improvement in the public health and environmental condition are also the strong reason for advocating the use of organic material (Aboul El-majd *et al.* 2006) [3]. In the present chemical input farming system, natural (use of organic amendment *viz*. green mature, poultry manure, farmyard manure etc)

can be considered to be a solution to many problems for different cropping system in different agro-ecological zones (Sharma and Militra, 1991) [35].

With the problem associated with inorganic fertilizers already being viewed this project work was carried out to evaluate the effect of cattle manure on the growth and yield performances of maize in forest Savanah transition zone south western Nigeria.

Results

Physiochemical Properties of Soil and Cattle Manure

The physiochemical properties of the soil (0.30cm depth) at the experimental field before cropping showed that the soil textural classification was sandy loam, slightly acidic in nature with pH value of 5.49 and low and low in fertility as indicated by the low content of organic carbon, organic matter, total nitrogen, available phosphorus and exchangeable cations (Table 1).

Soils with low levels of nutrients need to be boosted with soil amendments input in form of inorganic or organic fertilizer in order to improve them for crop production. The low soil fertility status and its acidic nature are expected to benefit from application of cattle manure (Table 2).

Low soil nutrient of the experimental site was probably as a result of: (1) high proportion of sand content of the soil, which implies that basic cations would be leached more easily as texture determines the degree of retention or ease of leaching of basic cations (Wapa and Oyetayo, 2014) [40]. (2) The low NPK levels observed in the soil can be attributed to continuous cropping and increased land use intensity.

At crop maturity, application of different rate of cattle manure slightly increased the soil pH value and total nitrogen ranges from 5.58 to 5.87 and 0.12-0.28 respectively. Percentage organic carbon, Ca and Mg was significantly increased in soil amended with cattle manure compared with control plot and the highest recorded from plots supplied with 20t/ha^{-1}, while available P, Na and K was drastically and slightly decreased across the different level of application respectively (Table 1).

The marginal increase observed in the soil pH level indicates the buffering capacity of the cattle manure in reducing soil acidity. This finding however did not agree with the findings of Adekiya and Agbede (2010) [6]; Sanni (2016) [34] who observed that soil pH tended to reduce with a rise in the amount of poultry manure and application of caw manure, suggesting that poultry and cow manure led to increased acidity in the soil.

The increases in soil organic carbon, Ca and Mg observed at crop maturity from plots incorporated with varying level of cattle manure might be as a result of the slow rate in which their nutrients are released into the soil (Olowoake and Adeoye, 2013) [28] or might be due to the increased in the amount of nitrogen present in the various rates of compost applied which improved microbial activity that led to enhanced production and mineralization of organic matter from natural (native) source in soil (Sanni, 2016) [34].

The higher organic carbon content in the plot treated with cattle manure relative to other treatment plots agreed with findings of Esawy *et al.* (2009) [17] on the increase in organic matter as a result of addition of rice straw compost. While the low P, K level and marginal increase of K observed at crop maturity might be as a result of NPP uptake for the growth and development of the plant.

Table 1: Soil physiochemical properties before planting and at crop maturity

Constituents	Pre-cropping		Post-cropping		
	5t/ha^{-1}	10t/ha^{-1}	15t/ha^{-1}	20t/ha^{-1}	
Chemical					
pH (H_2O)	5.49	5.64	5.58	5.76	5.87
Organic carbon (%)	0.54	0.82	1.43	2.09	3.11
Total Nitrogen (%)	0.08	0.12	0.22	0.28	0.26
Available P (mg/kg)	9.18	4.91	3.82	4.32	4.81
Na (cmol/kg^{-1})	0.93	0.38	0.70	0.77	0.73
Ca (cmol/kg^{-1})	0.42	1.10	1.53	1.81	1.83
K (cmol/kg^{-1})	0.96	0.24	0.18	0.23	0.27
Mg (cmol/kg^{-1})	0.20	0.50	1.04	2.64	2.97
Physical					
Sand %	47	64.80	70.5	72.4	71.9
Silt%	44	8.0	15.7	15.0	12.4
Clay %	9.0	27.20	13.8	12.6	15.7
Textural class	Sand loam	Sandy loam			

Table 2: Chemical analysis of cattle manure used

Cattle manure	value
pH (H_2O)	5.48
Organic carbon (%)	2.47
Organic matter (%)	4.26
Total N (mg/kg)	1.09
Available P (mg/kg)	23.04
K (mg/kg)	1.05
Na (mg/kg)	3.48
Ca (mg/kg)	1.00
Mg (mg/kg)	0.50

Effect of Cattle Manure on mean Vegetative Growth parameters of Maize

The response of maize to the varying levels of cattle manure of the vegetative growth (plant height, number of leaves, leaves area and stem girth) is presented in Table 3. The response of plant in terms of vegetative growth followed the same trend whereby the lowest values were recorded for control plants and higher values for fertilized plants in line with the amount of manure applied i.e. the higher the amount of manure applied the grater the mean value of the vegetative growth parameters. This result suggests that nutrient availability, especially NPK, determines plant vegetative growth and development (Adebayo *et al.* 2009) [4]. The consistent poor performance of control plots (non-fertilized) and those with low level of manure revealed that when nutrients are available in adequate amounts, plant tends to grow at their optimum potential. These improvements in growth parameters with increase in rates of cattle manure applied agree with the findings of Fawuzi (1977) [18]; Uzo (1971) [38] and Aminifard, *et al.*, (2010) [8].

Table 3: Effect of Cattle Manure on mean Vegetative Growth parameters of Maize

Treatments	Plant height (cm)	Number of leaves	Leaves area (cm2)	Stem girth
Control	102.25^{cd}	13.07^{d}	313.62^{d}	22.13^{b}
5 tha-^{1}	103.15^{c}	13.18c	378.07^{c}	22.94^{b}
10 tha-^{1}	114.69^{b}	13.42^{b}	379.91^{c}	22.94^{b}
15 tha-^{1}	118.15^{ab}	13.93^{ab}	381.136^{b}	23.43^{b}
20 tha-^{1}	119.03^{a}	14.27^{a}	403.04^{a}	24.35^{a}
LSD (0.05)	0.81	0.06	0.31	0.86

Mean followed by the same letter (s) in a column are not significantly different according to multiple comparison, LSD $p<$ 0.05.

Leaf area index (LAI) is a crucial growth index determining the capacity of plant to trap solar energy for photosynthesis and has marked effect on growth and yield of plant. The influence of cattle manure on leaf area remained significant under different application levels; maximum leaf area index (403.04) was recorded at 20 ton ha-1 which was statistically higher than 15 ton ha^{-1} (381.13), 10 ton ha^{-1} (379.91), 5 ton ha^{-1} (378.07) and 0 ton ha^{-1}(313.62). However, no significant was observed among the treatments with plants amended with 10 ton ha^{-1} (379.91) and 5 ton ha^{-1} (378.07) cattle manure. Nitrogen (N) is one of the main plant nutrients affecting plant growth and yield (Tafteh and Sepaskhah, 2012) [37] and leaf area increase with increase in N level (Oscar and Tollennar, 2006) [30]. Increased leaf area in soil amended with organic fertilizer could probably be attributed to N availability which promoted leaf area during vegetative development and also helped to maintain functional leaf area during the growth period (Cox *et al.* 1993) [14].

Stem diameter was significantly ($p< 0.05$) influenced by varying level of cattle manure application. Application of 20 t ha^{-1} cattle manure gave the highest response in respect, which was followed by application of 20 t ha^{-1}, while the control treatment gave the least plant diameter. Mean treatment value obtained from plant amended with 15, 10, 5 and controls were similar and in comparison were not significantly different. Organic manures have been said to improve soil fertility by activating soil microbial biomass, which in turn leads to development in corps (Ayuso *et al.*, 1996) [12] and this may have been responsible for the observed increase in stem diameter resulting from nutrient application. Plant diameter would have positive implication on lodging, particularly during fruiting; the thicker the stem, the less likely the plant would lodge as a result of fruit carriage or other lodge inducing factors, such as wind.

Plants provided with 20 t $ha^{-1}$of cattle manure were significantly ($p<0.05$) taller than the other levels of manure and control plants. The steady increase in height of maize plants with increase in rate of cattle manure suggests that quantity of manure applied affects nutrients availability for uptake by plants which promoted vigorous plant growth through efficient photosynthesis (Ayoub *et al.* 1991; Islam, 2002; Iqtidar *et al.* 2006) [11, 21, 20].

The highest number of plant leaves in the present study was recorded in plants amended with 10 kg m−2 of organic fertilizer which was significantly ($p<0.05$) higher than the control but not statistical different with plants amended with 5 and 7.5 kg m−2. The application of cattle manure to the soil at varying levels may have improved soil fertility and soil structure, increased soil organic matter and enhanced microbial activity (Rehman *et al.* 2010) [33] and the nutrients released from manure thus support and enhanced rapid root development (Abou El-Magd *et al.* 2005) [2] which might have enhanced leaf growth.

Effect of cattle manure application on mean yield attributes of maize

Table 4: Effect of cattle manure application on mean yield attributes of maize.

Treatments	No of Cobs	No of Grains/ Cob	Cob Length (cm)	Cob Diameter(cm)	Grain Weight (Kg)	Husk Weight (Kg)
Control	5.33^{a}	400.12^{de}	15.05^{c}	3.49^{c}	1.13^{c}	0.11^{a}
5 tha^{-1}	5.33^{a}	439.67^{d}	15.43^{c}	3.77^{c}	1.24^{c}	0.16^{a}
10 tha^{-1}	5.67^{a}	447.40^{c}	15.69^{c}	3.66^{c}	1.54^{c}	0.15^{a}
15 tha^{-1}	5.67^{a}	473.49^{b}	16.61^{b}	3.94^{c}	1.70^{b}	0.20^{a}
20 tha^{-1}	6.07^{a}	516.83^{a}	17.38^{a}	4.18^{c}	2.04^{a}	0.21^{a}
LSD (0.05)	0.89	0.41	0.41	0.63	0.39	0.81

Mean followed by the same letter (s) in a column are not significantly different according to multiple comparison, LSD $p< 0.05$.

A non-significant treatment effect was revealed from mean value showed in Table 4 for number of harvested cob per plant, cob diameter and husk weight, however maize plants amended with 20 t ha^{-1} had superior absolute treatment mean numbers which decreased with each decrease in level of cattle manure applied. Meanwhile, the treatment mean obtained for number of grains per cobs, cob length and grain weight increased accordingly to the increase in the cattle manure application rates; with 20 t ha^{-1} having the highest mean value which was significant different from mean value obtained from other application rates and control plots recorded the lowest mean treatment value. But cattle manure applied at the rates of 10 and 5 t ha^{-1} did not differ significantly compared to control treatment. The highest number of grains, cob length, grain weight and husk weight obtained from 20 t ha^{-1} was as a result of higher nutrient base supplied by the rate when compared with other rates where there was reduction with decrease in rate of cattle manure applied. The higher yield attributes obtained from the application of higher rates of cattle manure is in accordance with the studies of Devi *et al.*, (2002) [15]; Ogar and Asiegbu, (2005) [26]; Aujla *et al.*,(2007) [10]; and Aminifard, *et al.*, (2010) [8] where higher rates of nutrients increased the average crop weight and volume. This might be attributed to the stimulating effect of cattle manure 480 that supplies plant with nutrients required for better yield (Abdelrazzag, 2002) [1].

The application of increasing levels of cattle manure increased the maize growth, which might have been due to the balance availability of nutrients to the plants that resulted in a favourable soil environment. These favourable conditions increased the nutrient availability and water holding capacity of the soil resulting in enhanced growth and yield (Rashid *et al.*, 2013) [32]. Therefore, it is recommended that resource-poor farmers in the study area should utilize cattle manure at the rate of 20 t ha^{-1} for sustainable cultivation and optimum yield of maize in the study area as the manure contribute to the improvement of the low fertility status of the soil.

Materials and Methods

Experimental layout and land preparation

The field experimental was laid out in a randomized complete block design (RCBD) replicated three (3) times with five treatments on a 104m^2 area of land at the Teaching, Research and Commercial farm, Rufus Giwa

Polytechnic, Owo, Ondo state, Nigeria, located on latitude 7˚ 12´N, longitude 5˚ 35´E within the forest savanna transition zone, south western Nigeria.

The land was occupied by Sida *acuta, Impereta cylnidrica*, Siamweeds and some other common weeds, the land had being under continuous cultivation for the past four years without application of either inorganic and organic fertilizers. The land was cleared and stumps manually and thereafter ploughed and harrowed mechanically in order to obtain a clean fine hit soil. The experimental land was divided into 3blocks of 12m x 2m (24 m^2) each with a distance of 0.50m between each plots and each plot size was 2m x 2m ($4m^2$) which produced a total number 15 plot. The treatments are: T_1 – 0tons/ha of cattle manure, T_2 – 5tons/ha of cattle manure, T_3–10tons/ha of cattle manure, T_4 – 15tons/ha of cattle manure and T_5 – 20tons/ha of cattle manure. The cattle manure was applied to the plot 2 week after planting (WAP) using ring method of application after being pulverized.

Crop Establishment and Management

Two seeds of improved maize seed downy middle resistance early streak resistance yellow (DMR-ESR-Y) obtained from National Center for Genetic Resource and Biotechnology (NACGRAB) Ibadan, Oyo State Nigeria was per hole at a spacing of 50cm x 50cm at a depth of 3 to 5cm; which was later thinned to one healthy plant per stand. Immediately after planting Atrazine mixed with Paraquat was applied as pre-emergence and contact weed control, when necessary rouging was carried out to eliminate emerging weeds.

Cow manure and soil analysis

Cattle manure obtained from the livestock session of the Teaching, Research and Commercial Farm, Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria. The sample was air dried, crushed through a 2mm sieve and subjected to laboratory analysis following standard procedure in order to determine the chemical properties (IITA, 1989) [19]. Prior to the commencement and at the end of the experiment, top soil samples of 20 cm- 30 cm deep were collected randomly from five spots using soil auger from the experimental plot and mixed together to form a composite sample. It was air dried, sieved with a 2mm mesh-size sieve and taken to the laboratory to determine the soil's physicochemical properties using standard laboratory procedures (Olsen *et al.* 1954 [29]; Jackson, 1973 [22]; Page *et al.* 1982 [31]; Dirk and Hargarty, 1984 [16]; Okalebo *et al.* 2002) [27].

Data collection and statistical analysis

Five plants were randomly tagged from two middle rows in each plot for sampling data collection for vegetative growth and yields assessment. The following data on vegetative growth (number of leaves, leaf area, stem girth and plant height) and yield attributes (number of grains per cobs, cob circumference, grain weight and husk weight) were collected at crop maturity and harvest. Data collected from the experimental field were subjected to analysis of variance (ANOVA) using Statistical Package for Social Science (SPSS Inc., 2011) [36]. Significant treatment mean were compared using Duncan Multiple Range Test (DMRT) at 5% probability level.

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