Original Research Article

COMBINED USED OF DRY COCOA BEAN TESTA ASH (*Theobroma cacao L.*) AND POULTRY DROPPING FOR THE IMPROVEMENT OF SOIL FERTILITY AND MAIZE (Zea mays l.) GROWTH AND YIELD ON A HUMID ALFISOL SOUTHWESTERN, NIGERIA

ABSTRACT

The combine use of dry cocoa bean testa ash and poultry droppings for the improvement of soil fertility, maize growth and yield was studied on an Alfisol south western Nigeria, located at Joseph Ayo Babalola University Ikeji-Arakeji, Ilesa Osun State, Nigeria. Research farm from April to July 2018 and from August to November 2018. Four treatments of poultry droppings (PD) at 5 tones ha^{-1}, cocoa bean testa ash (CBTA) ash at 5 tones ha^{-1}, mixture of poultry droppings and cocoa bean testa ash (PD + CBTA) at 2.5 tones ha^{-1} each and control (C) were used in a Randomized Complete Block Design (RCBD) with three replications. The study showed that organic manure is a valuable fertilizer and can serve as a suitable alternative to inorganic fertilizer in the south western Nigeria especially, CBTA that has higher concentration of potassium (K) and organic carbon (OC). Poultry droppings (PD 2.5 tones ha^{-1}) treatments plus cocoa bean testa ash (CBTA 2.5 tones ha^{-1}) produced higher values for plant height, leaf area, chlorophyll, leaf area index, plant diameter, cob length, cob diameter and grain yield against the control that recorded the lowest value. Also, CBTA improves soil pH (94%) and OC (87%) over the control as well as increases minerals such as N, P, K Ca, Mg, and Na at 19%, 37%, 19%, 53%, 43% and 36% respectively. Organic fertilizer applications increase maize growth towards the later stage and were significantly different from the control according to DMRT at $p<0.05$. Cocoa bean testa ash (CBTA) and poultry dropping (PD) application registered over 47% increases of N levels in the soil, from 0.15% to 0.77% to 0.84%. Organic carbon increased as poultry droppings plus cocoa bean testa ash were added to the soil. Maize grain yield increased from control plot to 1.95 t ha^{-1} in CBTA + PD plot. The study recommends an application rate of cocoa testa ash and poultry droppings for maize growth on this type of soil in this agro-ecology.

Key words [soil fertility, potassium, soil chemical properties, dry cocoa bean testa ash (CBTA), soil, poultry droppings (PD)]

Introduction

Combining compost and ashes may play a significant role for tropical soil security by mitigating nutrients leaching [1]. Besides, compost is also known to increase plant yield through the addition of nutrients. Mbau, *et al*, 2014 [2] and Zhang *et al*, 2016 [3]suggest that an addition of organic matter, such as compost, to wood ashes could play this role [4]. Soil fertility is dynamic, changing based on processes such as accumulation or depletion, which are governed by the interplay between physical, chemical, biological and anthropogenic processes [5]. As a result, deteriorating soil fertility is considered a fundamental biophysical factor responsible for declining per-capita food production in SSA [6]. So far, application of mineral fertilizers is the main soil fertility management strategy used by many, but if not handled properly, can cause environmental problems such as soil acidity and eutrophication [7]. It is also un-affordable for most African farmers [6]. In addition to the supply of plant nutrients and organic carbon, the use of organic manure improves soil physical properties and enhances its water holding ability [8]. In Nigeria and other developing countries, the use of mineral fertilizer in crop production has not been sustainable due to its high cost and scarcity and nutrient imbalance [6]. Hence, there is renewal interest in locally available agro-waste such as poultry droppings and dry cocoa bean testa ash by poor resource farmers to fertilize their farms. The farm wastes and animal excreta are used directly as compost manure and farm yard manure. Due to high quantity needed, adequate quantity of organic wastes may not be obtained; hence the farmers often apply different wastes combined. Since the wastes are of different quantity and nutrient composition, their combined use is expected to have positive cumulative and complementary effects in nutrient supply and improvement in crop yield [9]. It is the goal of most farmers in Nigeria to produce sustainable high crop yield. However, decrease in soil fertility after few years of cropping is a major limitation. The need to improve soil fertility and crop production to support the rapidly growing population has led to a renew interest in the use of organic sources of nutrients and mineral fertilizers for soil fertility maintenance. In addition, the continuous use of mineral fertilizers adversely affects soil chemical and physical properties, causing nutrient imbalance, increase soil bulk density and causing low water infiltration rate [9]. Thus, the needs to investigate alternative sources of nutrients that will be less damaging to the soil become imperative.

In southwestern Nigeria, huge quantity of poultry wastes (manure) is generated and also constitute environmental hazard [10]. Studies also showed that poultry manure increased soil organic matter and nutrient status [11]. However, the huge amount of poultry manure required for field crop production and its handling problems limits its use to distant farmers. There is also a renewed interest in the use of burnt organic residues from plants as sources of phosphate and potash fertilizers [12]. The cocoa bean testa, which constitutes about 40% of the seed, is a by-product of the cocoa processing industry. It is considered a waste hence; vast quantity is being disposed off day in day out as a result of ignorance of its potential as an organic source of fertilizer. Though, cocoa bean testa ash is being locally used to manufacture black soap [Adeoye et al, 2001[13]. Its potentials as an organic fertilizer have not been researched upon. It is a recommended cheap source of K, which prevents leaching and therefore makes nutrient more available to plants, because, it releases nutrient slowly relative to inorganic fertilizers [Adeoye et al, 2001[13]. Cocoa bean testa has found its usefulness in concentrating K. It has been found to have a high level of K that is about 4.31% dry bases. Cocoa testa ash is organic fertilizer obtains from dried cocoa beans during industrial processing, it is abundant in Nigeria as well as in other parts of West Africa such as Ghana, Ivory Coast as well as South America e.g Brazil etc.; therefore, this work is aimed to study cocoa testa ash as an alternative source of organic fertilizer either alone or in combination with poultry droppings as well as to evaluate its effect on some soil chemical properties.

2. MATERIAL AND METHODS

2.1: Site Description

The experiment was conducted on the teaching and research field plot of the College of Agricultural Science of Joseph Ayo Babalola University, Ikeji Arakeji which lies between latitude 07º16^{1} and 07º 18^{1} and longitude 05º 09^{1} and 05º 11^{1} E between April to July and August to November, 2018. The area is characterized by a tropical climate and is situated in the humid tropical forest zone of Nigeria. It has an annual average rainfall of between 1500-1800mm and relative humidity of between 80-85% annually. It has a gentle undulating elevation of about 1150m-1250m above sea level [14].

Experiment Design

The experiment was laid out as a randomized complete block design (RCBD) with four treatments and three replicates. A 12m × 15m plot was demarcated on the teaching and research farm of Joseph Ayo Babalola University Ikeji-Arakeji, Nigeria. The plot was partitioned into three blocks of 4m × 15m separated by 1.0m buffer. Each 4m × 15m block was further partitioned into four 3m x 3m plots separated by buffer of 1.0m wide.

The ash was produced before it was applied to the soil.

The treatments were:

a. Poultry droppings (from layers) at 5 tones ha^{-1}.
b. Cocoa testa ash at 5 tones ha^{-1}.
c. Mixture of poultry droppings and cocoa testa ash at 2.5 tones ha^{-1} each.
d. Control.

Poultry dropping, cocoa testa ash and the mixture of poultry droppings and cocoa testa ash were incorporated and mixed with the top soil a week before the seeds were planted.

The test crop was maize (*Zea mays* L.). Planting of Maize was done between April to July and August to November, 2018. Maize seeds (SUWAN-1) medium maturing maize cultivar was obtained from the Institute of Agricultural Research and Training (IAR&T), Ibadan, Nigeria. Two seeds were planted in a hole at 0.75m x 0.25m spacing. Maize seedlings were later thinned to one plant per stand to obtain plant population of 53,333 Plants per hectare. All treatments were allocated to the plots in each block at random. However, control plot did not receive any amendment. Weeding was done manually, diseases were controlled by cultural method since Maize seeds planted (SUWAN-1) is resistant to most of the diseases found in Nigeria while pest such as maize streak borer was controlled by the applications of powder of neem tree (Azadiracchta indica. A) to the plant at their early growth stage and land preparation was ploughed and harrowed once [15].

Cocoa Bean Testa Ash Preparation

Dry cocoa bean testa was collected from cocoa products and processing factory located in the major communities producing in Nigeria, up till now, cocoa testa was a waste product after the beans for producing beverages were removed and many a time constitutes major environmental problem in such area. It was carefully dried in the sun and set fire on it, until it turns into ashes, the ashes were carefully packed in jute bags and kept in a safe place.

Data collection

Collection of data commenced three weeks after planting and was done at two weeks interval till tasseling stage.

Plant sample collection

This was done at four and four weeks after planting (WAP) and two weeks after treatments application, plant height and diameter of ten randomly selected plant stems were taken with meter rule and veneer caliper.

Also, four plants were uprooted per plots, per treatment and washed and bulked into composite samples. Fresh weights of the samples were taken. Sub-samples of each treatment per plot were oven dried at 100^{o}C for 48hrs to constant weight to determine dry matter content. Sub-sample dry weight was used to compute the total dry weights, using the relationship [16]:

Sample dry wt. (g) = Sample fresh wt (g) x sub-sample dry wt. (g) / sub-sample fresh wt. (g).

At maturity (six weeks after transplanting WAT), ten plants were randomly selected from each plot, harvested and weighed and calculated as tone per ha based on this formula [16]: Pp= {(B + b) (L + l) / lb} × N (16), where

Pp = Plant population, L = Length of the farm, B = Breadth of the farm, l = Length of spacing of the farm, b = Breadth of spacing of the farm and N = Number of fruits per farm stand.

Determination of the total leaf area per plant, leaf area index and chlorophyll content:

The total leaf areas of fifteen randomly selected maize plants per plot were taken at 60 days after planting and the corresponding leaf area index computed. The leaf area was measured following the procedure of [17, 18] by multiplying the length of a leaf by its widest width by alpha, where alpha is 0.743 (L x W x 0.743). The leaf area index was computed by dividing the area of a maize plant stand by the total land area occupied by single stand [19]. The chlorophyll was determined by extraction in 80% acetone and reading the absorbance of the solution at 645, 663 and 652 nm [20].

Soil sample collection and analysis

Soil samples were collected before planting, 60 days after planting (DAP). After the manure application, for the first maize crop planted in April, 2018 and to observe the residual effects of the applied manure, soil samples were taken at 60 days after planting for the second maize crop planted in August 2018 using a 3.5 cm diameter soil auger. There were four auger points in each plot and samples were collected at 0-20cm depth. Samples from each plot were bulked and composite were collected and taken to the laboratory for analysis.

Soil Analysis

The soil samples collected were air dried and sieved through a 2 mm mesh and analyzed for soil chemical properties [21]. pH was determined using a glass electrode 1:1 (w/v) in a deionized water. Organic matter was determined using method described by [22]. K, Ca, Mg, Na, P, will be determined by plasma-atomic emission spectroscopy [23]. The total N was determined using micro-kjeldahl method and the available P extracted colorimetrically by the molybdenum blue method. Cation exchange capacity was determined by the summation of NH4OAC – extractable cations plus 1.0N KCl extractable acidity.

Data analysis

The data collected were subjected to analysis of variance (ANOVA) and the means were compared by the use of Duncan multiple range test (DMRT) at 5% significance level. Statistical Package for Sciences and Social Sciences (SPSS) version 20 (statistical package for social sciences). T-test was used to determine the significant difference between cocoa bean and wood ash.

RESULTS AND DISCUSSION

RESULTS

Properties Soil of the Experimental Site

Table 1 shows some of the physical and chemical properties of the soil of the experimental site before the treatments were applied. The texture of the soil sandy loam with 6.95 g kg^{-1} sand and organic matter 0.32g kg^{-1}. The pH (H_20) show that the soil was slightly acidic (pH =5.72). The soil contains high organic matter, low total nitrogen but relatively adequate phosphorus content.0.15% and 12.24 (mg dm^{-3}) respectively. The OC was 1.87 while the cation exchange capacity was 2.83cmolc kg^{-1} of soil [24]).

Table 1: Physical and chemical properties of the experimental soil

Soil properties	Soil test value
pH (H_20) 1:1	5.72
Sand (g kg^{-1})	6.95
Silt (g kg^{-1})	1.64
Clay (g kg-1)	1.41
Ca (cmol$_c$ kg^{-1})	73
Na (cmol$_c$ kg^{-1})	0.35

K ($cmol_c$ kg^{-1})	0.5
Mg ($cmol_c$ kg^{-1})	0.82
H ($cmol_c$ kg^{-1})	0.12
Al ($cmol_c$ kg^{-1})	0.06
CEC ($cmol_c$ kg^{-1})	3.52
OC (g kg^{-1})	0.19
OM (g kg^{-1})	0.32
TN (g kg^{-1})	0.015
AvP (mg dm^{-3})	12.24
Cu (mg dm^{-3})	3.15
Fe (mg dm^{-3})	142.4
Mn (mg dm^{-3})	6.16

CEC = cation exchange capacity, Al = exchange aluminium

OC = organic carbon, OM = organic matter, TN = total nitrogen, AvP= available phosphorous

Proximate Analysis of the Cocoa Testa Ash and Poultry Droppings

The result of the characterization of dry cocoa bean testa ash and poultry droppings used for the experiment is presented in Table 2. Organic carbon in cocoa bean testa ash was significantly higher than the poultry droppings. while poultry dropping had the higher value of N content of 28.82 g kg^{-1} while dry cocoa bean testa ash (CBTA) had 2.1 g kg^{-1}. There was significant difference ($p < 0.05$) in the N content of the two organic manures. Phosphorous values in poultry droppings (PD) and cocoa bean testa ash (CBTA) showed no significance difference. Potassium values in Cocoa bean testa ash (CBTA) was 25.87 g kg^{-1} as against 13.87 g kg^{-1} in poultry dropping and were significantly different. Calcium values were not significantly different while magnesium values and sodium values were all significantly different. The moisture content value in CBTA was 11.40 g kg^{-1} as against 9. 71 and were significantly different.

Table 2: Paired T Test Value of the Proximate Analysis of Poultry Dropping and Cocoa Testa ash

Properties	Poultry Dropping (PD) g kg^{-1}	Cocoa Bean Testa Ash (CBTA) g kg^{-1}	Mean Differenc e	T-Value
Crude fiber	22.71	17.26	5.45	0.0005*
Ether Extract	2.07	3.2	1.13	0.0003*
Crude protein	19.67	12.77	6.91	<0.0001 *
pH	7.8	6.6	1.3	0.0062*
OC	28.82	31.92	-3.1	0.008*

N	3.17	2.1	1.07	0.0002*
P	0.38	0.34	0.04	0.075ns
K	13.87	25.87	12.00	0.0023*
Mg	0.32	0.28	0.03	0.150*
Ca	0.23	0.22	0.003	0.225ns
Na	0.13	0.17	-0.04	0.0013*
Moisture Content	9.71	11.4	-1.7	<0.0001 *
Ash	11.9	6.55	5.35	<0.0001 *

*Significant @ 0.05: ns = not significant

Note: 1 g kg^{-1} = 0.1%

Response of maize plant to different organic based fertilizer

4.1.2 Vegetative growth of maize plant (plant height cm)

Table 3 shows that there is no significant difference in the effect of the organic materials, their mixture and control on the plant height in the week 2 after planting. At 4WAP and 5WAP, the maize plants treated with combination of cocoa bean testa ash and poultry droppings and sole cocoa bean testa ash respectively, gave the better plant height than other treatments, but the organic treated plants were significantly difference from the control which received no treatment at $p<0.05$ using DMRT.

Table 3: Effect of organic fertilizers on maize plants height (cm)

Treatments	WAP			
	2	3	4	5
Control	19.95a	30.72b	47.46b	73.53c
CBTA 5t ha^{-1}	18.76a	35.21a	63.34a	99.73b
CBTA 2.5 t ha^{-1}+PD 2.5 t ha^{-1}	20.78a	36.15a	64.76a	105.0a
PD 5t ha^{-1}	20.89a	36.74a	62.74a	97.80b

WAP- Weeks after planting
CBTA- Cocoa bean testa ash
PD-Poultry dropping
Means in the same column followed by the same letters are not significantly different by DMRT at $p<0.05$

Effect of organic fertilizer on maize plant stem diameter (mm)

The maize stem diameter increased across all the treatment from 3, 4, and 5 weeks after planting.

At two weeks after planting, there was no pronounced difference in diameter across all treatment because there was no difference in the maize stem.

Between 3WAP and 4WAP, there was a significant difference between treated plot the control using DMRT at $p<0.05$.

Table 4. Effect of organic fertilizers on maize plant diameter (mm)

Treatments	WAP			
	2	3	4	5
Control	3.10b	7.80ab	14.27b	20.33c
CBTA 5t ha^{-1}	3.35ab	10.60a	19.83a	26.90a
CBTA 2.5 t ha^{-1}+PD 2.5 t ha^{-1}	3.40ab	10.07a	20.38a	26.87a
PD 5t ha^{-1}	3.76a	9.27a	18.67a	23.73b

WAP-weeks after planting

CBTA-cocoa bean testa ash

PD-poultry droppings.

Means in the same column followed by the letters are not significantly different by DMRT at $p<0.05$.

Effect of Cocoa Bean Testa Ash and Wood Ash on leaf area, leaf area index and chlorophyll of maize plant

Cocoa bean testa ash (CBTA) + poultry dropping (PD) Table 5, recorded highest values for leaf area with 97.8 cm^2 while the lowest value of 38.18d cm^2 was recorded in the control plot. There were significant differences between CBTA + PD, CBTA, PD and control, in contrast, there was no significant difference between CBTA and PD. In the same vein, Cocoa bean testa ash (CBTA) + poultry dropping (PD) recorded highest value for leaf area index and chlorophyll with 2.68 and 3.61 mg g^{-1} respectively while the lowest value was recorded in the control plots with values of 1.62 and 1.11 mg g^{-1}. There were significant differences between CBTA + PD, CBTA, PD and control for both comb diameter and grain yield, in contrast, there was no significant difference between CBTA and PD for both leaf area index and chlorophyll respectively.

Table 5: Effect of Cocoa Bean Testa Ash and Wood Ash on leaf area and chlorophyll of maize plant (7WAP)

Treatments	Leaf Area (cm^2)	Leaf Area index	Chlorophyll ($mg\ g^{-1}$)
Control	38.18d	1.62d	1.11d
CBTA 5t/ha	86.58b	2.57b	2.89b
PD 5t/ha	76.17c	2.07c	2.31c
CBTA 2.5t/ha+ PD 2.5t/ha	97.8a	2.68a	3.61a

CBTA-Cocoa bean testa ash

CTA+PD - Cocoa bean testa ash + Poultry droppings

PD- Poultry droppings

Means in the same column followed by the same letters are not significantly different by DMRT at $p<0.05$.

Soil chemical properties of the experimental site as influenced by the application of organic fertilizer.

On the table 6 are presents the result of the analysis carried out to determine the effect of the organic fertilizer in the soil. This is to access the ability of the organic fertilizer to improve the soil condition for future production. Comparing tables 1 and table 6 statistically, the soil pH of the experimental site was slightly acidic (5.72) before the treatment were applied, but was 5.8 after the application of treatment (poultry) as seen in the table 5. Some macro-nutrients such as N, Ca, Mg of the location improved across the whole treatment plots. It was only the combination of poultry droppings and cocoa bean testa ash that increased the soil organic carbon (OC) from 1.87% before treatment application to 3.12% after treatment application [25].

Table 6: Some Soil chemical properties of the study site as affected by the application of organic fertilizers.

Parameters	pH	OC (gkg^{-1})	N (gkg^{-1})	P (mg dm^{-3})	K (cmol$_c$ kg^{-1})	Na (cmol$_c$ kg^{-1})	Ca (cmol$_c$ kg^{-1})	Mg (cmol$_c$ kg^{-1})
Control	5.72^{c}	1.87^{c}	0.15^{b}	2.24^{d}	0.10^{c}	0.15^{c}	1.73^{b}	0.82^{b}
PD5t ha^{-1}	5.80^{b}	2.12^{b}	0.84^{a}	4.93^{c}	0.26^{b}	0.34^{b}	3.25^{a}	1.93^{a}
CBTA 5tha^{-1}	6.04^{a}	2.14^{b}	0.77^{a}	6.00^{b}	0.52^{a}	0.42^{a}	3.24^{a}	1.91^{a}
CBTA 2.5tha^{-1}+PD 2.5tha^{-1}	6.12^{a}	3.12^{a}	0.81^{a}	7.17^{a}	0.54^{a}	0.56^{a}	3.48^{a}	1.97^{a}

CBTA-Cocoa bean testa ash

CBTA+PD - Cocoa bean testa ash + Poultry droppings

PD- Poultry droppings

Means in the same column followed by the letters are not significantly different by DMRT at $p<0.05$.

Effect of Cocoa Bean Testa Ash and Wood Ash on cob diameter, length and grain weight of maize plant.

Cocoa bean testa ash (CBTA) + poultry dropping (PD) table 7, recorded highest values for cob diameter with 6.81 cm while the lowest value of 3.08 cm was recorded in the control plot. There were significant differences between CBTA + PD, CBTA, PD and control, in contrast, there was no significant difference between CBTA and PD.

In the same vein, cocoa bean testa ash (CBTA) + poultry dropping (PD) recorded highest value for cob length and grain yield with 23.80 cm and 1.95 tones ha^{-1} respectively while the lowest value was recorded in the control plots. There were no significant differences between CBTA + PD and CBTA. However, there were significant differences between all treated plots and control plot, in contrast. There was no significant difference between CBTA and PD for both cob diameter and cob length yield respectively

Table 7: Effect of Cocoa Bean Testa Ash and Wood Ash on cob diameter, length and grain weight of maize plant

Treatments	Cob Diameter (cm)	Cob Length (cm)	Maize grain weight (ton/ha)
Control	3.08c	16.58c	0.64c
CBTA 5t/ha	5.67b	22.98b	1.82a
PD 5t/ha	5.15b	22.40b	1.75b
CBTA 2.5t/ha+ PD 2.5t/ha	6.81a	23.80a	1.95a

CBTA-Cocoa bean testa ash

CTA+PD - Cocoa bean testa ash + Poultry droppings

PD- Poultry droppings

Means in the same column followed by the letters are not significantly different by DMRT at $p<0.05$.

Discussion

Pre-Planting Physico-Chemical Properties of Soil of the Experimental Site.

The pH 5.72 of the soil in the experimental site before the application of manure indicated the soil to have medium acidity level. Soil with a pH range of 5.2 - 5.76 had been reported to be of medium acidity Brady and Weil, 1999 [26]; Adekayode and Olojugba, 2010 [27]. N, P, K, Ca, Mg and Na were low in the study area. This may be due to the over cropping,texture of the soil which may lead to leaching of soluble cations, soil erosion as well as lack of proper land management practices in the area, Tisdale *et al*. 2003 [28] had explained with Mitscherlich's principle of plant's positive response to applied nutrients that were previously limiting in the soil. The acidic nature of the soil may be due to the leaching of soluble cations observed in the area as well as the distribution of exchangeable acidity. Leaching of Na, K, Ca and Mg were largely responsible for the development of acidity in the soil. The texture of the soil may be the reason why there was low value of organic matter in the area and also may be due to continuous cropping without the addition of organic manure Adekayode and Olojugba, 2010 [27].

Nutrient Concentration in Cocoa bean testa ash (CBTA) and Poultry dropping (PD) Used for the Experiment

The value of OC in both CBTA and PD showed that they are good sources organic matter for soil fertility and crop growth and yield, however, the significantly higher value of organic carbon in CBTA over that of PD showed that the former might be better source of organic carbon than the latter. Cocoa bean testa ash (CBTA) has pH of 6.6 while poultry dropping has pH of 7.8, it shows that more nutrients would be more available and soluble if CBTA is used to fertilize soil than poultry dropping (PD). This is in agreement with the findings of Pagani and Mallarino, 2015 [29]. They were of the opinion that more nutrients such as N, P, K, S, Ca, Mg are more available between pH 6.5 to 7.5. Also, high proportion of potassium (K) as well as moisture content in CBTA shows that it might be a better source of potassium as well as moisture content. This finding is in agreement with that of Adeoye *et al*. 2001 [13].

Changes in Growth Parameters as a results of addition of Cocoa Bean Testa Ash (CBTA) and Poultry Dropping (PD)

The significantly higher values of maize length and diameter in the cocoa bean testa ash (CBTA) and poultry dropping (PD) treated plots over that of the control plot may be due to the concentration of essential minerals, OC and N in the manure used which might responsible for the high yield of maize length and diameter. This finding is in agreement with the that of Marcel *et at*, 2016 [30], they were of the opinion that there was a significant interaction among doses of wood ash and soil moisture for length of flower spikes and of flower stems at harvest. The higher values of maize length and diameter obtained from CBTA and CBTA+PD plots might be due to the concentration of K in CBTA. Cocoa bean testa ash has been known to have high value of potassium Adeoye *et al*. 2001 [13], According to Mirza *et al*, 2018 [31], they found out that among the plant nutrients,K is one of the vital elements required for plant growth and physiology. Potassium is not only a constituent of the plant structure but it also has a regulatory function in several biochemical processes related to protein synthesis, carbohydrate metabolism, and enzyme activation. Several physiological processes depend on K, such as stomata regulation and photosynthesis. Potassium regulates the biosynthesis, conversion, and allocation of metabolites that ultimately increases the yield. Many research works strongly supported the notion that K is directly or indirectly responsible for higher yield of crops Islam and Muttaleb, 2016 [32], Cheema *et al*, 2012 [33], Uddin *et al*, 2013 [34].

Changes in Leaf Area, Leaf Area Index and Chlorophyll as a results of addition of Cocoa Bean Testa Ash (CBTA) and Poultry Dropping (PD)

The order of size of total leaf area the leaf area index and chlorophyll values which were significantly higher in Cocoa bean testa ash plus poultry dropping (CBTA+PD) and Cocoa bean testa ash (CBTA) plots might be due to higher values of K and OC in CBTA as opposed to control and PD plots and which also reflected in the yield of maize grain. The corroborated the assertion that K helps to increase the utilization of carbohydrates and it increases the leaf area index, which helps to increase the dry matter accumulation and ultimately increase the yields of many field crops Cheema *et al*, 2012 [33]. In the same vein, Subedi and Ma, 2005[35], maintained that leaf area was essential for simulation of light interception and photosynthate production. Potassium controls photosynthesis through sunlight interception. The leaf surface area and sunlight interception were both reduced dramatically when the K was below the level required by the plant Mirza *et al*, 2018 [31], Le *et al*, 2016 [36].

The leaf number and the leaf size are reduced while the plant is deficient in K. The leaf number and size reduction later hasten the diminished photosynthetic rate per unit leaf area and thus account for an overall reduction in the amount of photosynthetic assimilates available for growth Mirza *et al*, 2018 [31], Le *et al*, 2016 [36].

Changes in some soil chemical properties as a results of addition of Cocoa Bean Testa Ash (CBTA) and Poultry Dropping (PD)

The higher pH values of 6.04 and 6.12 in cocoa bean testa ash (CBTA) and cocoa bean testa ash plus poultry dropping (CBTA+PD) mixture plots might due to the liming effects of CBTA due to high concentration of potassium (K) nutrient Adeoye *et al*. 2001 [13]. Marcel *et al*, 2016 [30] submitted that the pH increases can be attributed mainly to the release of K carbonate by reaction of ash in the soil. Also, Demeyer *et al*. 2001[37] and Lickaaz 2002 [38] had described wood ash to be similar to burned or hydrated lime as it contained oxides and hydroxides of K, Na, Ca and Mg. The significant higher in nitrogen, potassium, calcium and phosphorous could be attributed to their higher in cocoa bean testa ash (CBTA).

Changes in Maize yield as a results of addition of Cocoa Bean Testa Ash (CBTA) and Poultry Dropping (PD)

The highest grain yield values of 1.82 t ha^{-1} and 1.95 t ha^{-1} obtained in cocoa bean testa ash (CBTA) and cocoa bean testa ash plus poultry dropping (CBTA+PD) compared with other treatments showed a high yield obtainable when cocoa bean testa ash (CBTA) alone or in combination with other organic manure was used to improve soil fertility for increased crop production. The high maize grain yield in plot fertilized with CBTA alone or with PD might be due to high concentration of K and OC in CBTA. According to Cheema *et al* 2012 [33] K helps to increase the utilization of carbohydrates and it increases the leaf area index, which helps to increase the dry matter accumulation and ultimately increase the yields of field crops. The total leaf area, leaf area index and chlorophyll content which had positive correlation with the maize grain yield (r = 0.96, 0.97 and 0.95 respectively) confirmed the assertion of Mohamed *et al*. 2008 [39]. Uddin *et al*. 2013 [34] found that 1000 grain weight, grain yield increased by K. Also, when other nutrients are in optimum condition, K played an important role to increase the yield of NERICA 1 rice.

Conclusion and Recommendation

The improvement of soil fertility and subsequent higher maize grain yield obtained in 5t ha^{-1} CBTA and 2.5t ha^{-1} CBTA + 2.5t ha^{-1} PD confirmed that a combination of both organic sources gave higher maize grain yield than when each was applied separately. Also, Cocoa bean testa ash (CBTA) contained higher quantity of K which made it to perform better than poultry dropping (PD) in improving soil fertility in term of pH increment as well as other nutrients such as N, P, Ca, Mg and Na. CBTA also increased maize grain better than PD. Application of CBTA and PD appeared to have performed better in both soil fertility improvement and maize grain yield due to higher concentrations of K in CBTA and OC in PD. I therefore recommend that cocoa testa ash for maize production and improvement of some soil chemical properties in the the study site

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