International Journal of Innovative Agriculture & Biology Research 10(2):1-7, April-June, 2022

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Cowdung and Potassium Fertilizer Effects on Yield and Yield Components of Cocoyam in South-South Nigeria

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ABSTRACT
The performance of cocoyam (*Colocasia esculenta* L. Schott) to varying levels of cow dung and potassium fertilizer was investigated in 2018 and 2019 cropping seasons under field conditions at Research Farm of the Agricultural Science Education Unit of the Delta State University, Abraka, Nigeria. The experiment was a 4 × 2 factorial arrangement in a randomized complete block design with three replications. The treatments were four levels of cow dung (0, 10, 20 and 30 t ha^{-1}) and potassium fertilizer (0, 20, 40 and 60 kg K_2O ha^{-1}). Application of cow dung at the highest rate of 30 t ha-1 significantly ($P < 0.05$) enhanced number of suckers per cocoyam stand, number of corms per cocoyam plant, corm weight at 3 MAP in both planting seasons. In 2019 cropping season, cow dung at the lower rate of 20 t ha^{-1} gave optimum corm yield of 23.3 t ha^{-1}. In general, potassium fertilizer application did not exert much influence on yield of cocoyam as significant effect was observed only in 2019 cropping season. Corm yield was significantly ($P < 0.05$) improved by the application of 60 kg K2O ha^{-1} (22.3 t ha^{-1}) in 2019 cropping season relative to the control. The results of this study have shown the effectiveness of cow dung in improving yield and yield components of cocoyam.
Keywords: Cocoyam, Cowdung, Potassium fertilizer, Yield and Yield Components

INTRODUCTION

Cocoyam (*Colocasia esculenta (*L) Schott) is a starchy tuber crop that has been widely cultivated and consumed in the Southeastern agricultural Zone of Nigeria for decades (Ndon et al., 2003). It is regarded as a poor man's food or a woman's crop and as such has lagged behind the preferred and highly valued staple root/tuber crops such as yam and cassava in research attention (Ikwelle et al., 2003). Nutritionally, it contains more than twice the carbohydrate content of potato and a good source of magnesium, vitamin C, iron and potassium (Buke & Gidago, 2016). Taro starch is also good for peptic ulcer patients, patients with pancreatic disease, chronic liver problems, inflammatory bowel disease and gall bladder disease (Emmanuel-Ikpeme *et al.*, 2007). Also, the high cost of yam and the increased awareness of the industrial and export potential of cassava has given way to high patronage of the relatively obscure crops like cocoyam (Shiyam et al., 2017). The current level of cocoyam production in Nigeria estimated at 15 million metric tonnes in 2016 (FAO, 2017) is grossly inadequate to satisfy the increasing demand for the crop as alternative food crop (Shiyam et al., 2017).

This low level of cocoyam production is attributed to increasing decline in soil fertility levels and lack of soil management practices for continuous cocoyam cultivation (Agbede & Adekiya, 2016). The use of organic and mineral fertilizers are the two major and common ways in which soils are managed since the extinction of shifting cultivation as well as reduction in bush fallow periods (Makinde et al., 2011). The impact of increased use of mineral fertilizers on crops has been high but the resulting soil physical degradation, increased soil acidity and soil nutrient imbalance, resulting in reduced crop yield (Mbah & Mbagwu, 2006), escalating cost and unavailability of mineral fertilizers (Suge et al., 2011) have drawn the attention of researchers back to the use of organic manures. These organic manures are cheaper, readily available and affordable for soil fertility management and improvement in crop yield.

However, sole use of organic manures to sustain cropping has been reported inadequate especially in the year of application (Patel et al., 2000). They are required in rather large quantities to meet crops' nutrient supply because of their relatively low nutrient content (Palm et al., 1997). Supply of nutrients from organic materials can be complemented by enriching them with inorganic nutrients that will be released fast and utilized by crops to compensate for their late start in nutrient release (Ayoola & Makinde, 2009).

In tuber crops, potassium plays a vital role in the movement of sugars produced in the leaf by photosynthesis to the tubers where the sugars are converted to starch (Abd El-Latif et al., 2011). Surveys in Nigeria revealed inconsistencies in the amount of potassium for optimum performance of cocoyam due mainly to differences in soil types and soil potassium status (Obigbesan, 1980; Ohiri et al., 1988). However, the soils in South-South Nigeria are low in potassium and thus require potassium fertilization for good crop yields (Unamba-Opara, 2015). The need to increase the production of cocoyam in a marginal soil using organic and inorganic sources of fertilizer necessitated this study. The objective was therefore to evaluate the effects of cowdung and potassium fertilizer on the performance of cocoyam in Abraka South-South, Nigeria.

MATERIALS AND METHODS

The location of the field experiment was the Research Farm of the Agricultural Science Education Unit of the Delta State University, Abraka, Nigeria (latitude 50 46'N and longitude 60 5'E). The area has a bimodal rainfall with annual rainfall of 2323mm and a mean temperature of 26.70C. The area is characterized as a humid rainforest zone and the soil is sandy loam. The total annual rainfalls for 2018 and 2019 were 1902.8 and 2210.0 mm, respectively while the total rainfalls during the period of experimentation for 2018 and 2019 were 1775.6 mm and 2009.0 mm, respectively.

The cocoyam (*Colocasia esculenta* var NCe001) cormels used in this study were sourced from National Root Crops Research Institute, Umudike, Abia State. The cow dung was obtained from local ranges found around Abraka metropolis, while the potassium fertilizer (Muriate of potash, K_2O) was obtained from the fertilizer unit of Delta State Ministry of Agriculture, Asaba. Composite sample of the cowdung was air dried, crushed, sieved and then analyzed in the laboratory for its nutrient compositions.

The experiment was a 4 × 2 factorial arrangement in a randomized complete block design and replicated three times. The treatments comprised four rates each of application of cow dung (0, 10, 20 and 30 t ha^{-1}) and potassium fertilizer (0, 20, 40 and 60 kg K_2O ha^{-1}). A total of sixteen treatment combinations and three replications were used. The cow dung was incorporated into the soils of the experimental plots in a single application based on the treatment combinations, at two weeks before planting to allow decomposition while the Potassium fertilizer was applied to the cocoyam stands according to treatment allocation at 3 weeks after planting (WAP) using band placement method. One cormel was planted per hole at a depth of 15 cm and at a spacing of 0.5 m x 1.0m resulting to about twenty-four plants per plot and a total of about 20,000 plants per hectare. All plots were kept weed free by manual weeding.

Five cocoyam plants were randomly selected from each of the net plots, tagged and then used for the determination of number of corms per plant, corm weight (kg/plant) and corm yield (t ha-1) at physiological maturity.

Table 1: Some physicochemical properties of soils of the experimental site in 2018 and 2019

Properties	**2018**	**2019**
Physical		
Sand (%)	67.80	65.80
Silt (%)	14.40	13.40
Clay (%)	17.80	20.80
Textural class	SL	SCL
Chemical		
pH (in H_2O)	4.6	5.5
P (mg/kg)	35.50	44.30
N (%)	0.02	0.04
OC (%)	0.19	0.81
OM (%)	0.32	1.40
Exchangeable bases (cmol kg-^{1})		
Ca	2.40	4.40
Mg	2.00	0.80
K	0.022	0.088
Na	0.31	0.497
EA (cmol kg-^{1})	0.80	0.96
ECEC (cmol kg-^{1})	5.532	6.745
BS (%)	85.53	85.76

SL = sandy soil; SCL = sandy clay loam; OC = organic carbon; OM = organic matter; EA = exchange acidity; ECEC = effective cation exchange capacity; BS = base saturation.

The analysis revealed that the cowdung used in this study is composed of 2.54, 1.34, 1.16, 1.56, 0.46 and 50.70%, N, P, K, Ca, Mg and organic matter, respectively in 2018 and 2.24, 1.67, 0.65, 2.80, 0.61 and 30.76%, N, P, K, Ca, Mg and organic matter, respectively in 2019.

Table 1: Main effects of cow dung and potassium fertilizer on yield components: number of suckers per cocoyam stand at 3 MAP, number of corms per cocoyam plant, corm weight (kg plant^{-1}) and corm yield (t ha^{-1}) at harvest in 2018 and 2019

Treatment	**Months after planting (MAP)**							
	NSS	**NC**	**CW**	**CY**	**NSS**	**NC**	**CW**	**CY**
		2018				2019		
Cow dung (t ha^{-1})								
0	3.7	14.2	0.54	10.86	3.8	13.8	0.61	12.19
10	4.9	16.6	0.78	15.59	5.2	18.9	0.99	19.76
20	5.5	19.3	0.97	19.38	5.5	20.8	1.16	23.27
30	6.1	22.0	1.18	23.58	5.7	23.1	1.30	26.04
Mean	5.1	18.0	0.87	17.35	5.1	19.2	1.02	20.32
LSD (0.05)	0.5	1.9	0.12	2.35	0.5	2.1	0.16	3.50
Potassium (kg K_2O ha^{-1})								
0	4.7	17.7	0.85	17.09	4.5	18.15	0.91	17.2
20	5.2	18.3	0.88	17.64	4.9	19.5	1.02	20.33
40	5.1	18.4	0.85	17.00	5.3	19.5	1.02	20.50
60	5.1	17.8	0.88	17.67	5.4	20.4	1.11	22.27
Mean	5.0	18.1	0.87	17.35	5.0	19.2	1.02	20.31
LSD (0.05)	NS	NS	NS	NS	0.5	2.1	0.17	3.50
C x K	NS	NS	NS	NS	NS	NS	NS	NS

NS = not significant.

Application of cow dung had significant effect on the number of suckers produced per cocoyam stand at 3 MAP in both years of cropping (Table 1). In 2018, incremental application of cow dung resulted in significant ($P < 0.05$) increase in the number of suckers produced over the control where as in 2019, application of cow dung above 10 t ha^{-1} did not result in any significant ($P < 0.05$) increase in the number of suckers. Application of potassium fertilizer did not significantly ($P < 0.05$) influence the numbers of suckers produced per cocoyam stand in 2018 but did influence it significantly in 2019.

Potassium fertilizer applied at 40 or 60 kg K_2O ha^{-1} significantly ($P < 0.05$) increased the number of suckers compared to no fertilizer application. The different rates of applied potassium fertilizer recorded statistically similar values. The number of corms produced per plant was significantly ($P < 0.05$) increased by the application of cow dung in both years (Table 1). In 2018, incremental application of cow dung up to the highest rate of 30 t ha^{-1} increased significantly ($P < 0.05$) the number of corms per plant. In 2019 however, increasing cow dung rate up to 30 t ha^{-1} increased significantly the number of corms per plant compared to the lower rates and the control. Application of 10 and 20 t ha^{-1} cow dung rates produced comparable number of corms. Potassium fertilizer application did not have any effect on number of corms per plant in 2018 but in 2019. All cases of applied potassium resulted in higher number of corms than no potassium application. There was no significant interaction effect between cow dung and potassium fertilizer on number of corms produced.

Similarly, application of cow dung significantly increased the weight of corms as the manure rate was raised to 30 t ha^{-1} in 2018 and 20 t ha^{-1} in 2019 (Table 1). Increasing cow dung rate above 20 t ha-1 in 2018 did not result in marked improvement in weight of corms. On the contrary, corm weight was not significantly influenced by potassium fertilizer in 2018 but in 2019 application of potassium fertilizer at the highest rate of 60 kg K_2O ha^{-1} increased corm weight over zero application. Interactions were not significant for corm weight in the two cropping seasons.

Corm yield response to application of cow dung followed the same trend as corm weight in both years (Table 1). There was a significant ($P < 0.05$) linear corm yield response to cow dung application in 2018. In 2019 however, application of cow dung above 20 t ha^{-1} rate did not significantly increase yield. When averaged over the two cropping seasons, cow dung application at the rates of 10, 20 and 30 t ha^{-1} gave corm yields of 17.7 t ha^{-1}, 21.3 t ha^{-1} and 24.81 t ha^{-1}, respectively while zero application gave an average yield of 11.5 t ha^{-1}. Increase in cow dung rate from 0 to 10 t ha^{-1}, increased corm yield by 54%, additional increase to 20 and 30 t ha^{-1} increased corm yield by 85 and 116%, respectively.

Table 2: Effect of cow dung and potassium fertilizer on mean corm yield (t ha^{-1})

Potassium (kg K2O ha^{-1})	0	20	40	60	Mean
Cow dung (t ha-^{1})					
0	8.84	12.38	11.63	18.75	11.52
10	16.00	19.46	17.17	18.04	17.67
20	21.21	20.75	21.50	21.84	21.32
30	24.42	23.37	24.71	26.75	24.81
Mean	17.62	18.99	18.75	19.97	

LSD(0.05) for cow dung (C) mean =2.39 ; LSD(0.05) for potassium (K) mean=NS; LSD(0.05) for C x K mean=NS.

As mean across two years, corm yield increased significantly ($P < 0.05$) with incremental application of cow dung up to 30 t ha^{-1} while application of potassium had no effect on yield (Table 2). In both cropping seasons, there was no significant cow dung x potassium interaction effect on corm yield

DISCUSSION

In general, application of cow dung resulted in increase in number of corms per plant, corm weight (kg/plant) and corm yield (30t ha^{-1}) at physiological maturity. Cow dung at 30 t ha^{-1} produced the highest corm yield in the relatively more acidic and less fertile sandy loam soil. However, for the more fertile sandy clay loam soil with higher pH of 5.5, cow dung at the lower rate of 20 t ha^{-1} gave optimum corm yield. This implies that at these rates in these soils, cow dung released and made available adequate nutrients for optimum crop development. Cocoyam like any other root and tuber crop is a heavy feeder, exploiting a large volume of soil for nutrient and water (Osundare, 2004). This could explain the high rate of cowdung (20 to 30 t ha-1) required for optimum production of this crop as reported in this study. Gyllapsy et al. (1993) reported that the availability of sufficient nutrient facilitates sink function as this plays a role in the control of carbohydrate accumulation and partitioning. Plants nourished with sufficient amount of nutrients in adequate proportion are expected to have higher number and size of cells (Akanbi et al., 2007) and hence more yield.

In this study application of cow dung at 30 t ha^{-1} supported yield components of cocoyam. The level of treatment produced average corm yield of 24.8 t ha-1 and this was higher than the yields of cow dung at 0, 10 and 20 t ha^{-1} by 116, 40 and 16%, respectively. Similarly, cow dung at 20 t ha-1 produced average corm yield of 21.3 t ha^{-1}, which was higher than the values at 0 and 10 t ha^{-1} cow dung rates by 85 and 20%, respectively. These yields recorded in these investigations were higher than the yields obtainable in Nigeria (5 to 7 t ha-1), Ghana (4 to 8 t ha^{-1}) and China (17.5 to 19 t ha-1) but compared favourably with the yields obtainable in Egypt (23.5 to 35.0 t ha-1) (Onyeka, 2014).

Okpara et al. (2010) reported improvement in root yield of cassava following application of 50 kg K_2O ha-1 in south eastern Nigeria with a native soil potassium level of 0.19 to 0.25 cmol kg-1, while FFD (2002) observed an improvement in cassava yield at 75 kg K2O ha-1 of applied potassium fertilizer when the native soil potassium was between 0 and 0.15 cmol kg-1. In this study, the native soil potassium level was 0.02 cmol kg-1 in 2012 and 0.09 cmol kg-1 in 2013. According to Murata and Akazawa (1968) the

beneficial effects of potassium fertilizer have mostly been attributed to the fact that potassium increases the activities of starch synthetase, which results to high yield, especially if there are inadequate native supplies of the nutrient. Potassium plays a vital role in the movement of sugars produced in the leaf by photosynthesis to the tubers where the sugars are converted to starch (Abd El-Latif *et al.*, 2011).
In this study, the level of percentage soil nitrogen was higher in 2019 than in 2018 so also the organic matter content (Table 1), which upon decomposition releases nitrogen and other nutrients to the soil. This may perhaps explain the positive yield response of cocoyam found in 2019 cropping season. Potassium did not also exert as much influence as cow dung on cocoyam yield and only affected yield in 2019. This is expected since cow dung contains nutrients other than potassium, which are necessary for plants growth and development. In addition, cow dung being an organic manure releases nutrients slowly from decomposing organic manure, which are stored for a longer time in the soil thereby ensuring a long residual effect, improved root development and higher crop yields (Agbede & Adekiya, 2016). They were lower values for organic matter, nitrogen and potassium in the cow dung but higher rainfall of 2009.0 mm in 2019, in which corm yield appeared higher by 17% compared to 2018. This supports the report by Onwueme (1987) that cocoyams require rainfall above 2000 mm per annum for optimum yields.

CONCLUSION

This study showed that both cow dung and potassium fertilizer improved yield and yield components of cocoyam with cow dung having a better improvement than potassium fertilizer. Optimum yields were obtained at 30 t ha^{-1} cow dung rate and 60 kg K_2O ha^{-1} of potassium fertilizer.

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