Soil moisture deficit effect on nutrient contents of cassava leaves during the early and late cropping seasons in soils amended with poultry manure - palm bunch ash mixture

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ABSTRACT

Soil moisture deficit affects the translocation of nutrients for photosynthesis and the transformation of sucrose into various nutrient content in cassava leaves. The objective of the study was to compare the nutrient contents of cassava leaves as affected by poultry manure-palm bunch ash mixtures and cropping seasons with the hypothesis that poultry manure-palm bunch ash mixture could improve the nutrient contents of cassava leaves during the early and late cropping seasons. The treatments consisted of four rates of poultry manure (0, 5, 10, and 15 t ha^{-1}) mixed thoroughly with four rates of palm bunch ash (0, 1, 2, and 3 t ha^{-1}) and applied to the cassava variety TMS 30572 during the early and late cropping seasons. Zero application of poultry manure-palm bunch ash mixture was the control. The experimental design was a 4 × 4 × 2 factorial experiment in a completely randomized design and replicated three times. Application of 10 t ha^{-1} of poultry manure significantly ($P < 0.05$) lowered moisture content (75.95 ± 0.49%) but increased crude protein (18.26 ± 0.60%), vitamin C (6.93 ± 0.29 mg/100mg), and carbohydrate (30.46 ± 2.67 g) contents of cassava leaves while control produced cassava leaves with lower vitamin C (5.81 ± 0.10 mg/100mg) and crude protein (15.71 ± 0.06%) contents. Application of 2 t ha^{-1} of palm bunch ash significantly increased crude protein (17.85 ± 0.78%) and vitamin C (6.68 ± 0.07 mg/100mg) contents of cassava leaves while control produced cassava leaves with low crude protein (16.85 ± 0.47%) and vitamin C (6.05 ± 0.21 mg/100mg) contents. Moisture deficit during the late cropping season resulted in significantly ($P < 0.05$) lower crude protein (16.80 ± 0.11%) content of cassava leaves while the early cropping season had higher crude protein (18.07 ± 0.47%) content of cassava leaves. The application of 10 t ha^{-1} of poultry manure mixed with 2 t ha^{-1} of palm bunch ash is recommended for improved nutrient contents of cassava leaves during the early and late cropping seasons. The results of this study imply that the application of poultry manure-palm bunch ash mixture during the early and late cropping seasons can serve as a nutrient booster in cassava leaves, early cropping season is still the best period for the availability of high nutritive vegetables, while cassava leaves can cushion the effect of vegetable scarcity and malnutrition during the dry season.

Keywords: Cassava leaves, poultry manure, palm bunch ash, nutrient contents, soil deficit

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INTRODUCTION

Cassava leaf is one of the underutilized vegetables (Nassar and Marques, 2006). However, cassava leaves are consumed in almost all countries of the cassava belt in Africa (Bokanga, 1994). Countries like Nigeria, Congo, Sierra Leone, and Madagascar have a wide variety of cassava leaf-based recipes and have established cassava leaves as a major component of the diet in Africa (Achidi *et al.,* 2005). Cassava is produced all year round, and thus the leaves are available throughout the year. Cassava leaves have high protein content (Latif and Muller, 2015) and have been classified as the cheapest source of protein (Nassar and Marques, 2006). However, the presence of cyanogenic glucosides in cassava leaves is the major drawback in cassava leaves consumption which causes various diseases depending on the consumption level (Latif and Muller, 2015). Cooking cassava leaves significantly reduces toxicity from 35.09 ± 0.40 to 107.50 ± 0.80 mg HCN (hydrogen cyanide) to 0.30 ± 0.04 to 1.9 ± 0.2 mg HCN equivalent kg^{-1} dry weight below the recommended FAO/WHO safe limit set at 10 mg HCN equivalent kg^{-1} dry weight (Ngudi *et al.,* 2003).

The availability of cassava leaves throughout the year tends to bridge the gap between the scarcity and the high cost of vegetables during the dry season. Despite the fact that cassava is hardy; however, the season of production affects leaf nutrient quality (Long *et al.,* 2006). The rainforest agroecology of southeastern Nigeria is characterized by two distinct seasons (eight months of rainy and four months of dry seasons). The bimodal rainfall pattern created the early and late cropping seasons (Selemo *et al.,* 2012). The early cropping season is characterized by abundant rainfall and suitable environmental conditions for crop production while the late cropping season runs into three months of a dry spell which discourages rain-fed agriculture and results in a high cost of fruits and vegetables (Okoli *et al.*, 2020). The dry season is characterized by high temperature and evaporation as well as less soil moisture (Okechukwu and Mbajiorgu, 2020). Most rural farmers without access to irrigation cultivate vegetables during the early cropping season. During the late cropping season, vegetables are scarce and expensive, and therefore, cassava leaves become an important source of cheap vegetables for most resource-poor households.

Cassava grown during the early cropping season have adequate soil moisture and sufficient soil moisture encourages high photosynthate assimilation in the leaves (Long *et al.,* 2006) because optimum environmental conditions for photosynthesis and protein synthesis are available (Kala and Godara*,* 2011) while cassava planted during the late cropping season experienced moisture stress and moisture stress reduced nutrient absorption by roots of cassava, and thus, hinders photosynthesis in the leaves. Moisture deficit during the late cropping season induced an increase in vitamin C and dry matter but decreased moisture content and sugar levels in tomatoes (Medyouni *et al.*, 2021). Moisture stress decreased total protein and moisture content in leaves of *Ziziphus mauritiana* (Kala and Godara, 2011).

The application of poultry manure has been reported to improve nutrient content in okra (Adekiya *et al.,* 2019). Organic and inorganic manure applications have been reported to improve the nutrient contents of amaranth and leafy vegetables (Onwordi *et al.,* 2009; Oyedeji *et al.,* 2014). Due to the underutilization of cassava leaves as a vegetable, there is a paucity of information on the use of poultry manure-palm bunch ash mixture to boost cassava leaf nutrient contents and the influence of cropping seasons on the nutrient contents of cassava leaves. Therefore, the objective of this work was to determine the effect of poultry manure-palm bunch ash mixture on cassava leaves nutrient content during the early and late cropping seasons in Nigeria.

MATERIALS AND METHODS

Location of the Experiment

The experiment was carried out at the Teaching and Research Farm of the Federal University of Technology, Owerri, located in the humid tropics of Nigeria (latitude 5° 27ˈ N and 7° 02ˈ E). The annual rainfall is about 2,500 mm and is bimodal with peaks in July and September. The area is characterized by daily minimum and maximum temperatures of 20°C and 32°C, respectively. In terms of geology and geomorphology, the predominant parent material from which most of the soils are formed is the Coastal Plain Sands popularly known as Acid Sands (Orajaka, 1975).

Treatments and Experimental Design

Treatments (factors) consisted of four rates of poultry manure (0, 5, 10, and 15 t ha^{-1}) mixed thoroughly with four rates of palm bunch ash (0, 1, 2, and 3 t ha^{-1}) and applied to the cassava variety TMS 30572 during the early and late cropping seasons of 2010. Zero application of poultry manure and palm bunch ash was the control. The experimental design was a 4 × 4 × 2 factorial experiment in a completely randomized design and replicated three times. A total of 32 treatment combinations were made.

Cultural Practices

The early cropping season planting started in April 2010 while the late cropping season planting started in September 2010. Cassava leaves were harvested in July 2010 for the early cropping season while for the late cropping season, cassava leaves were harvested in December 2010 for nutrient contents analysis. Treatments were applied on a per plant basis using side placement at 2 months after planting (MAP) in both seasons. Weeding was manually carried out at three monthly intervals. Harvesting of leaves was done at three months after planting using hand to pluck the five topmost fully open leaves. The experimental field was 75.00 × 24.00 m (1,800 m^2). Each experimental plot was 4.0 × 3.0 m with a 1 m alley separating plots and each ridge with the experimental plot.

Soil of the Experimental Site, Poultry Manure and Palm Bunch Ash Laboratory Analytical Methods

Five soil samples were collected randomly from the experimental site at 0–20 cm depth before planting and on per treatment basis after harvest. Samples were analyzed for physico-chemical properties at the Crop Science Laboratory, Federal University of Technology, Owerri. Soil pH was analyzed using a pH meter (Hendershot *et al.,* 1993). Organic carbon was determined by Nelson and Sommers (1982) while organic matter values were obtained by multiplying total carbon by 1.724 (Van Bemmelen's correlation factor; Nelson and Sommers, 1982). Available phosphorus was determined according to the procedure of Olsen and Sommers (1982). Total nitrogen was done by the micro Kjeldahl digestion technique (Bremner and Mulvaney, 1982). Calcium and magnesium were analyzed by Versenate titration method and potassium by flame photometer method. Poultry manure and palm bunch ash were analyzed for their nutrient status (pH, N, P, K, C, Ca, Mg, and Na) using the same procedures in the soil analysis.

Weather Data of the Cropping Environment

The weather data of the research work collected monthly during the experimental period was recorded by the metrological station, Agricultural Development Programme (ADP), Imo State. The temperature data for the period under study (2010–2011) were recorded with the maximum and minimum thermometers. The standard method of measuring evaporation used was a class A pan with a diameter of 1.2 m kept within the soil at the depth of 250 mm. It protruded above the ground to a height of 150 mm. The water level in the pan was kept at 50–75 mm from the rim.

Laboratory Analytical Methods for Cassava Leaves at 3 MAP

Determination of moisture content

The moisture content of the samples was determined according to the standard method of the Association of Official Analytical Chemists (AOAC, 2010). The crucibles were washed thoroughly and dried in the oven at 100°C for 1 hour. The hot dried crucibles were cooled in the desiccators and weighed (W1). Three grams (3 g) of the samples each were weighed into the crucibles (W2) and dried at 100°C for 4 hours. They were removed, cooled in the desiccators, and weighed (W3). The drying was continued until a constant weight was obtained. The percentage moisture content was calculated as follows:

$$\% \text{ Moisture content} = \frac{W2 - W3}{W2 - W1} \times 100$$

where W1 is the initial weight of the empty crucible, W2 is the summation of the weight of crucible and the weight of sample before drying, and W3 is the summation of the weight of dish and the weight of sample after drying.

Determination of crude fat

The fat content of the samples was determined using the standard AOAC (2010) method. A Soxhlet extractor with a reflux condenser and a 250 mL round bottom flask was fixed. Three grams (3 g) of the sample were weighed into a labeled thimble and petroleum ether (150 mL) was filled into the round bottom flask. The round-bottomed flask was previously dried, cooled, and weighed. The extraction thimble was sealed with cotton wool. The Soxhlet apparatus after assembling was allowed to reflux for 6 hours. The thimble was removed with care and the petroleum ether was collected on the top and drained into a container for reuse. As soon as the flask was free of solvent, it was removed and dried at 70°C for 1 hour in an oven, cooled in desiccators, and weighed.

$$\% \text{ Fat content} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

Determination of crude protein

The protein content of the samples was determined according to the standard methods of AOAC (2010), using Kjeldahl's method. For digestion, 2 g of the sample was weighed into the Kjeldahl digestion flask, and 1 tablet of Kjeldahl catalyst was added. Twenty-five milliliters (25 mL) of concentrated H_2SO_4 was added with a few boiling chips. The flask with its content was heated in the fume chamber until a clear solution was obtained. The solution was cooled to room temperature and filtered into a 250 mL volumetric flask and made up to 100 mL with distilled water.

The distillation unit was cleaned, and the apparatus was set up. A 100 mL conical flask (receiving flask) containing 5 mL of 2% boric acid was placed under the condenser and 2 drops of methyl red indicator were added. A digest of 5 mL was pipetted into the apparatus through a small funnel and washed down with distilled water followed by the addition of 5 mL of 60% NaOH (sodium hydroxide) solution. The digestion flask was heated until 100 mL of distillate (ammonium sulphate) was collected in the receiving flask. The solution in the receiving flask was titrated with 0.1N HCl to get a pink colour. The same procedure was carried out on the blank.

$$\% \text{ Nitrogen (N)} = \frac{(Vs - Vb) \times N_{acid} \times 0.0401}{W} \times 100$$

where Vs is the volume (mL) of acid required to titrate the sample, Vb is the volume (mL) of acid required to titrate the blank, N_{acid} is the normality of acid (0.1N), and W is the weight of sample (g). Then, crude protein was calculated as the followed equation:

% Crude protein = % N × 6.25 (conversion factor)

Determination of ash content

The ash content of the samples was determined according to the standards of AOAC (2010). A preheated and cooled crucible was weighed (W1) and three grams (3 g) of the samples were weighed into the crucibles (W2). The samples were charred on a Bunsen flame inside a fume cupboard. The charred sample in the crucible was transferred into a preheated muffle furnace at 550°C for 2 hours until a white or light grey ash was obtained. It was cooled in a dessicator and weighed (W3) and documented.

$$\% \text{ Ash content} = \frac{W3 - W1}{W2 - W1} \times 100$$

where W1 is the weight of an empty crucible, W2 is the summation of the weight of crucible and the weight of sample before drying, and W3 is the summation of the weight of crucible and the weight of sample after drying.

Determination of crude fibre content

The crude fibre determination was carried out by the method described by AOAC (2010). Two grams of samples were defatted using petroleum ether and boiled under reflux for 30 minutes with 200 mL of 0.125 g of H_2SO_4 per 100 mL of solution. The solution was filtered through linen and was washed with boiled water until the washings are no longer acidic. The residue was transferred into a beaker and boiled with 200 mL of a solution containing 1.25 g of the carbonate-free NaOH per 100 mL for 30 minutes. The final residue was drained and transferred to a silica ash crucible which was dried in an oven at 100°C for 2 hours and cooled until a constant weight is obtained. The cooled sample was incinerated or ashed in a muffle furnace at 600°C for 5 hours, cooled in a dessicator, and weighed. The loss in weight was taken as the crude fibre.

$$\%\ \text{Crude fibre} = \frac{\text{Weight of oven dried sample (g)} - \text{Weight of sample after incineration}}{\text{Initial weight of sample (g)}} \times 100$$

Determination of carbohydrates

Total carbohydrate content was calculated according to James (1995) as follows:

% Carbohydrate = 100 – (% Moisture + % Fat + % Protein + % Ash)

Determination of vitamin A and C

Vitamin C content was determined using the iodometric determination method of Ikewuchi and Ikewuchi (2011). Vitamin A was determined using the spectrophotometric method of Aremu and Nweze (2017).

Data Collection and Statistical Analysis

Data on vitamin A, vitamin C, carbohydrate, crude fibre, crude protein, moisture content, and ash were collected in the laboratory at three months after harvesting the cassava leaves from the experimental site. Data collected were subjected to analysis of variance (ANOVA) using GENSTAT Release 7.2DE, discovery Edition 3 (GENSTAT, 2007). The means were separated using Fisher's Least Significant Difference at 5 % level of probability.

RESULTS AND DISCUSSION

Physico-chemical Properties of the Experimental Soil, Poultry Manure, and Palm Bunch Ash

The soil pH at planting was highly acidic (5.00), had very low nitrogen (0.02%) and low potassium (0.01 cmol kg^{-1}). Poultry manure was alkaline (8.12), had high nitrogen (4.50%) and low potassium (15.50 cmol kg^{-1}). Palm bunch was alkaline (8.20), had low nitrogen content (1.10%) and high potassium (440.64 cmol kg^{-1}) (Table 1).

Table 1 Physico-chemical characteristics of soil at planting, poultry manure, and palm bunch ash

Physico-chemical characteristics	Soil	Poultry manure	Palm bunch ash
N (%)	0.02	4.50	1.10
P (cmol kg^{-1})	3.64	4.80	38.20
K^+ (cmol kg^{-1})	0.01	15.50	440.64
C (%)	1.26	3.08	0.002
Ca^{2+} (cmol kg^{-1})	2.20	36.40	2.20
Mg^{2+} (cmol kg^{-1})	0.54	6.80	21.87
Na^+ (cmol kg^{-1})	0.002	12.10	88.00
pH (H_2O)	5.00	8.12	8.20
Sand (%)	89.50	0	0
Silt (%)	7.02	0	0
Clay (%)	3.48	0	0
Textural class	Sandy loamy	-	-

Source: Okoli *et al.* (2011)

Weather Data of the Cropping Environment

The weather data of the research work collected monthly during the experimental period was recorded by the metrological station, ADP, Imo State. Data on rainfall, temperature, relative humidity, and evaporation are presented in Table 2. Higher temperature and smaller rainfall resulted in higher evaporation during the time of harvest (December 2010) for the late cropping season planting. Selemo *et al.* (2012) reported that high temperature and low rainfall increased evaporation. Monthly evapotranspiration and rainfall are inversely proportional to each other; thus, evapotranspiration increases as rainfall decreases and vice-versa resulting in lower soil moisture and inefficient crop water and environmental management (Okechukwu and Mbajiorgu, 2020).

Table 2 Weather data of Research Farm of School of Agriculture and Agricultural Technology from April 2010 to July 2011

Year	Month	Rainfall (mm)	Average temperature (°C)		Relative humidity (%)	Evaporation
			Minimum	Maximum		
2010	April	122.00	23.70	31.20	75.00	3.80
	May	240.00	28.50	30.65	76.80	2.90
	June	264.00	28.00	30.00	75.00	2.40
	July	286.00	27.50	31.90	74.40	1.80
	August	305.00	27.80	31.20	74.80	1.75
	September	330.00	27.50	31.50	74.60	1.30
	October	398.50	19.00	32.00	75.00	1.80
	November	108.00	26.00	32.50	78.70	2.30
	December	0.00	26.50	32.00	79.00	3.90

Table 2 Cont.

Year	Month	Rainfall (mm)	Average temperature (°C)		Relative humidity (%)	Evaporation
			Minimum	Maximum		
2011	January	0.00	29.50	33.00	98.00	4.40
	February	40.50	28.50	32.50	98.00	4.60
	March	10.20	26.50	32.50	79.00	2.90
	April	96.00	28.50	32.40	85.00	3.19
	May	104.00	28.00	32.00	80.00	2.40
	June	109.00	28.00	32.00	75.00	2.00
	July	330.00	27.50	31.50	74.80	1.50

Note: Data recorded by Agricultural Development Programme in Imo State

Main Effects of Poultry Manure, Palm Bunch Ash, and Season on Nutrient Contents of Cassava Leaves

The main effects of poultry manure, palm bunch ash, and season are presented in Table 3. The high rate of poultry manure significantly lowered moisture content of cassava leaves and increased crude fibre and ash contents ($P < 0.05$). Control lowered crude protein (15.71 ± 0.06%) while the application of 15 t ha^{-1} of poultry manure produced the highest crude protein (18.59 ± 0.01%). Crude protein increased linearly with the increasing levels of the poultry manure. The increase in crude protein content of cassava leaves could be attributed to the supply of nutrient elements by the poultry manure necessary for photosynthate accumulation which was converted to protein and other nutrient contents (Adekiya *et al.,* 2019). Vitamin A content of the cassava leaves showed a significant decreasing trend with an increase in the application of poultry manure ($P < 0.05$). Control produced the highest vitamin A (18.86 ± 0.09 mg/100mg) while application of 15 t ha^{-1} of poultry manure produced the least vitamin A (14.87 ± 0.64 mg/100mg). This disagrees with the work of Aboyeji *et al*. (2021) who reported an increase in vitamin A content of okra using Zn-fertilizer, green manure, and poultry manure. Application of 10 t ha^{-1} of poultry produced the highest vitamin C (6.93 ± 0.29 mg/100mg) while control produced the least vitamin C (5.81 ± 0.10 mg/100mg). Application of poultry manure reduced moisture contents in cassava leaves and subsequently increased vitamin C content. This is similar to the report of Kala and Godara (2011) who reported that vegetables produced with poultry manure have more vitamin C content. Carbohydrate content of cassava leaves peaked with the application of 10 t ha^{-1} of poultry manure (30.46 ± 2.67 g) and declined with the application of 15 t ha^{-1} of poultry manure (29.57 ± 1.04 g). Increasing rates of poultry manure resulted in lower moisture and higher crude fibre, ash, crude protein, carbohydrate, and vitamin C contents of cassava leaves. Nutrient contents of control leaves were limited by poor soil nutrients in the control plot. Poultry manure is organic manure rich in N, P, and K, thus, it has been reported to improve the nutrient content of vegetables (Onwordi *et al.,* 2009; Oyedeji *et al.,* 2014; Adekiya *et al.,* 2019).

Palm bunch ash significantly ($P < 0.05$) lowered moisture contents of cassava leaves and increased crude fibre and ash content (Table 3). Control produced the highest moisture content but low crude fibre, and ash. Crude protein was significantly highest with the application of 2 t ha^{-1} of ash (17.85 ± 0.78%) and lowest in control (16.85 ± 0.47%). Vitamin A and vitamin C increased with the increasing levels of palm bunch ash but decreased to the lowest in control. The highest carbohydrate was obtained in the control (29.66 ± 4.21 g) while the lowest was found in cassava leaves that received 2 t ha^{-1} of palm bunch ash (28.22 ± 0.59 g). Palm bunch ash had high content of potassium and low nitrogen. Potassium is involved in the regulation of water and the transport of the plant's reserve substances. Potassium increased photosynthesis capacity, strengthens cell tissue, and activates the absorption of nitrates (Thornburg *et al.,* 2020). Application of palm bunch ash at a higher rate decreased the moisture content and increased the vitamin C content of cassava leaves. Higher vitamin C content was reported in okra fruit fertilized with maize cob ash (Adekiya *et al.,* 2019). Palm bunch ash is rich in potassium which plays an important role in protein synthesis (Long *et al.,* 2006). Higher protein observed in the cassava leaves could be attributed to the influence of potassium in the absorption of nitrates (Thornburg *et al.,* 2020) and subsequent transformation to protein. Carbohydrate was highest in control (zero palm bunch ash) and this agrees with the work of Sugiyama and Goto (1966) who reported that high carbohydrate contents in plants is associated with low potassium content. However, Liebhardt (1968) reported an increase in carbohydrate metabolism and translocation with the application of potassium fertilizer.

Planting cassava during the early cropping season significantly increased moisture content of the cassava leaves and lowered crude fibre content while planting cassava during the late cropping season lowered moisture content and increased crude fibre contents ($P < 0.01$; Table 3). The early cropping season had abundant rainfall while the late cropping season had dry spells. Soil moisture deficit during the late cropping season resulted in lower moisture, ash, crude protein, and carbohydrate content of cassava leaves, but increased crude fibre, vitamin A, and vitamin C content. During the late cropping season, the non-availability of rainfall resulted in increased temperature, decreased relative humidity, and increased evaporation (Table 1), leading to high moisture stress and consequently reduced photosynthates and poor nutrient contents of cassava leaves. Such relationship between dry spells and nutrient contents has been reported in tomatoes (Medyouni *et al*., 2021). Crude protein was highest during the early cropping season (18.07 ± 0.47%) and lowest during the late cropping season (16.80 ± 0.11%). Moisture stress decreased total protein and moisture content in leaves of *Ziziphus mauritiana* (Kala and Godara, 2011). Vitamin A and vitamin C in cassava leaves planted during the late cropping season were higher than in cassava leaves planted during the early cropping season. Carbohydrate was higher when planted during the early cropping season (30.62 ± 4.21 g) compared to the late cropping season (26.96 ± 2.87 g).

Interaction Effect between Poultry Manure and Palm Bunch Ash on Nutrient Contents of Cassava Leaves

Application of 3 t ha^{-1} of palm bunch ash irrespective of the poultry manure rate significantly ($P < 0.05$) lowered cassava leave moisture and increased ash (Table 4). Application of 15 t ha^{-1} of poultry manure with increasing rates of palm bunch ash increased crude protein while increasing rates of palm bunch ash produced low crude protein. Control produced the lowest crude protein (13.94 ± 0.46%) while the combination of 15 t ha^{-1} of poultry manure and 2 t ha^{-1} of palm bunch ash produced the highest crude protein (18.74 ± 0.62%). Vitamin A was highest when applied 2 t ha^{-1} of palm bunch ash (22.43 ± 1.67 mg/100mg) without poultry manure while the application of 15 t ha^{-1} of poultry manure without palm bunch ash produced the lowest vitamin A (13.20 ± 0.82 mg/100mg). Vitamin C was highest in cassava leaves produced with 5 t ha^{-1} of poultry manure mixed with 2 t ha^{-1} of palm bunch ash (7.22 ± 0.46 mg/100mg) while control produced the lowest vitamin C (5.26 ± 0.22 mg/100mg). Cassava leaves produced with 10 t ha^{-1} of poultry manure without palm bunch ash application produced the highest carbohydrate (32.00 ± 2.98 g) while cassava leaves produced with 3 t ha^{-1} of palm bunch ash without poultry manure application produced the lowest carbohydrate (25.89 ± 0.14 g). The interaction between poultry manure and palm bunch ash lowered moisture but increased ash, crude fibre, crude protein, vitamin A, vitamin C, and carbohydrate contents. The result of the experiment showed that a balanced application of nitrogen, phosphorus, and potassium nutrient elements is necessary for improving nutrient contents in cassava leaves. The function of nutrients supplied by soil in plants is complex and includes processes like root, shoot, leaf, and fruit development, production of proteins, hormones and chlorophyll, photosynthesis, etc. (Long *et al*., 2006).

Table 3 Main effects of poultry manure, palm bunch ash, and season on the nutrient contents of cassava leaves

Factors	Moisture content (%)	Crude fibre (%)	Ash (%)	Crude protein (%)	Vitamin A (mg/100mg)	Vitamin C (mg/100mg)	Carbohydrate (g)
Poultry manure (t ha^{-1})							
0	76.75 ± 0.02^{a}	16.03 ± 0.56^{c}	8.99 ± 0.60^{b}	15.71 ± 0.06^{d}	18.86 ± 0.09^{a}	5.81 ± 0.10^{c}	27.14 ± 1.44^{b}
5	77.02 ± 0.22^{a}	17.86 ± 2.11^{b}	8.93 ± 0.76^{b}	17.19 ± 0.06^{c}	17.75 ± 0.08^{b}	6.76 ± 0.06^{a}	27.97 ± 1.99^{b}
10	75.95 ± 0.49^{b}	18.02 ± 0.21^{b}	9.30 ± 0.38^{ab}	18.26 ± 0.60^{b}	16.00 ± 0.55^{c}	6.93 ± 0.29^{a}	30.46 ± 2.67^{a}
15	76.06 ± 0.12^{b}	18.60 ± 0.02^{a}	9.61 ± 0.75^{a}	18.59 ± 0.01^{a}	14.87 ± 0.64^{d}	6.40 ± 0.01^{b}	29.57 ± 1.04^{a}
$LSD_{(0.05)}$	0.70	0.36	0.37	0.30	0.54	0.21	1.01
F-test	**	**	**	**	**	**	**
Palm bunch ash (t ha^{-1})							
0	77.06 ± 0.21^{a}	16.90 ± 0.56^{c}	8.49 ± 0.11^{c}	16.85 ± 0.47^{b}	14.62 ± 0.23^{d}	6.05 ± 0.21^{b}	29.66 ± 4.21^{a}
1	76.31 ± 0.59^{b}	18.01 ± 1.28^{a}	8.99 ± 2.04^{b}	17.55 ± 0.19^{a}	17.41 ± 0.16^{b}	6.48 ± 0.35^{a}	28.50 ± 1.82^{b}
2	76.56 ± 0.78^{b}	18.06 ± 1.73^{a}	9.65 ± 0.91^{a}	17.85 ± 0.78^{a}	18.70 ± 1.70^{a}	6.68 ± 0.07^{a}	28.22 ± 0.59^{b}
3	75.85 ± 0.17^{c}	17.53 ± 0.90^{b}	9.72 ± 0.81^{a}	17.55 ± 0.69^{a}	16.75 ± 0.33^{c}	6.68 ± 0.13^{a}	28.76 ± 1.01^{ab}
$LSD_{(0.05)}$	0.70	0.36	0.37	0.30	0.54	0.21	1.01
F-test	**	**	**	**	**	**	**
Season							
Early	77.24 ± 0.21^{a}	17.10 ± 0.56^{b}	9.33 ± 0.11	18.07 ± 0.47^{a}	16.63 ± 0.23^{b}	6.46 ± 0.21	30.62 ± 4.21^{a}
Late	75.65 ± 0.04^{b}	18.16 ± 1.12^{a}	9.09 ± 1.19	16.80 ± 0.11^{b}	17.11 ± 0.17^{a}	6.49 ± 0.20	26.96 ± 2.87^{b}
$LSD_{(0.05)}$	0.49	0.26	0.26	0.21	0.38	0.15	0.71
F-test	**	**	NS	**	**	NS	**

Note: $LSD_{(0,05)}$ = Least Significant Difference. Means within the column in each factor followed by the same letter are not significantly different.
NS = not significant, ** significant at 1% level of probability.

Table 4 Interaction effect between poultry manure and palm bunch ash on nutrient contents of cassava leaves at 3 months after planting

Poultry manure (t ha^{-1})	Palm bunch ash (t ha^{-1})	Moisture content (%)	Crude fibre (%)	Ash (%)	Crude protein (%)	Vitamin A (mg/100mg)	Vitamin C (mg/100mg)	Carbohydrate (g)
0	0	79.28 ± 0.18^{a}	14.25 ± 0.08^{e}	7.76 ± 0.12^{d}	13.94 ± 0.46^{d}	14.80 ± 0.17^{f}	5.26 ± 0.22^{e}	26.77 ± 5.05^{c}
	1	75.71 ± 1.91^{c}	16.40 ± 1.11^{d}	8.78 ± 4.87^{c}	15.87 ± 0.59^{c}	18.11 ± 0.06^{c}	5.67 ± 0.30^{d}	29.44 ± 2.45^{a}
	2	76.12 ± 0.53^{bc}	16.80 ± 1.63^{d}	9.56 ± 1.72^{b}	16.78 ± 0.64^{c}	22.43 ± 1.67^{a}	5.85 ± 0.09^{d}	26.47 ± 0.97^{c}
	3	75.88 ± 0.06^{c}	16.70 ± 0.88^{d}	9.87 ± 1.48^{a}	16.25 ± 1.15^{c}	20.12 ± 1.63^{b}	6.45 ± 0.22^{b}	25.89 ± 0.14^{c}
5	0	76.72 ± 0.40^{bc}	18.18 ± 2.07^{c}	8.77 ± 0.20^{c}	16.43 ± 0.07^{c}	15.39 ± 0.28^{de}	6.10 ± 0.20^{c}	28.85 ± 0.63^{b}
	1	76.26 ± 0.52^{bc}	17.53 ± 1.10^{c}	8.54 ± 1.00^{c}	17.55 ± 0.48^{b}	18.80 ± 2.23^{c}	6.82 ± 0.32^{a}	27.00 ± 2.72^{b}
	2	78.74 ± 0.57^{a}	17.89 ± 1.60^{c}	9.66 ± 0.08^{b}	17.52 ± 0.59^{b}	20.63 ± 2.84^{b}	7.22 ± 0.46^{a}	26.99 ± 3.24^{c}
	3	76.36 ± 0.79^{bc}	17.85 ± 0.81^{c}	8.77 ± 0.80^{c}	17.25 ± 0.87^{b}	16.16 ± 0.61^{d}	6.88 ± 0.14^{a}	29.05 ± 4.05^{b}
10	0	76.03 ± 0.02^{bc}	17.09 ± 0.78^{d}	8.36 ± 0.31^{c}	18.33 ± 0.67^{a}	15.10 ± 0.60^{de}	6.55 ± 0.42^{b}	32.00 ± 2.98^{a}
	1	76.06 ± 0.71^{bc}	18.23 ± 0.27^{c}	9.36 ± 0.87^{b}	18.41 ± 0.88^{a}	15.97 ± 0.63^{d}	7.18 ± 0.26^{a}	30.37 ± 3.25^{a}
	2	75.90 ± 0.67^{bc}	19.07 ± 2.05^{b}	9.13 ± 1.55^{b}	18.35 ± 0.89^{a}	15.97 ± 0.16^{d}	6.96 ± 0.01^{a}	29.68 ± 0.29^{a}
	3	75.84 ± 0.30^{bc}	17.66 ± 0.34^{c}	10.34 ± 0.59^{a}	17.94 ± 0.96^{ab}	16.97 ± 0.22^{d}	7.03 ± 0.17^{a}	29.79 ± 2.54^{a}
15	0	76.23 ± 0.50^{bc}	18.12 ± 0.29^{c}	9.06 ± 0.21^{b}	18.70 ± 0.03^{a}	13.20 ± 0.82^{fg}	6.31 ± 0.11^{c}	31.03 ± 2.64^{a}
	1	77.23 ± 0.34^{b}	19.89 ± 3.52^{a}	9.24 ± 0.93^{b}	18.37 ± 0.54^{a}	16.74 ± 0.69^{d}	6.24 ± 0.24^{c}	27.18 ± 2.40^{b}
	2	75.48 ± 0.91^{c}	18.46 ± 0.37^{b}	10.26 ± 0.93^{a}	18.74 ± 0.62^{a}	15.77 ± 0.21^{de}	6.70 ± 0.11^{b}	29.76 ± 2.00^{a}
	3	75.31 ± 1.03^{c}	17.92 ± 0.39^{c}	9.87 ± 0.20^{a}	18.54 ± 0.76^{a}	13.75 ± 0.01^{f}	6.37 ± 0.26^{b}	30.31 ± 2.28^{a}
$LSD_{(0.05)}$		1.39	0.73	0.74	0.60	1.08	0.43	2.01
F-test		**	**	**	**	**	**	**

Note: $LSD_{(0,05)}$ = Least Significant Difference. Means within the column followed by the same letter are not significantly different. ** Significant at 1% level of probability.

Interaction Effect between Poultry Manure and Season on Nutrient Contents of Cassava Leaves

Moisture content was not significantly ($P > 0.05$) affected by poultry manure and season interaction (Table 5). However, on a mean value basis, early cropping season and soil amendment with 5 t ha^{-1} of poultry manure resulted in high moisture content in cassava leaves (77.68 ± 0.22%) while the use of 10 t ha^{-1} of poultry manure during the late cropping season reduced cassava leaves moisture content (74.90 ± 0.02%). The moisture content of cassava leaves was higher in the early cropping season than in the late cropping season and reduced with increased rates of poultry manure. The crude fibre was highest in cassava planted with 15 t ha^{-1} of poultry manure during the late cropping season (19.64 ± 0.89%) while cassava planted during the early cropping season without soil amendment produced the lowest crude fibre in cassava leaves (15.88 ± 0.64%). Ash was highest in cassava planted with 15 t ha^{-1} of poultry manure during the early cropping season (9.74 ± 1.10%) while the early cropping season of cassava without soil amendment produced the lowest ash in cassava leaves (8.75 ± 0.26%). Crude protein was highest in cassava leaves planted during the early cropping season and amended with 10 t ha^{-1} of poultry manure (19.37 ± 0.60%) while the lowest protein content was observed in the control during the late cropping season (15.57 ± 0.52%). Crude protein was highest in the early cropping season irrespective of the poultry manure rates than in the late cropping season. Vitamin A was not significantly affected by poultry manure and season interaction. Vitamin C increased significantly with the application of poultry manure in both seasons. Early cropping season planting and application of 10 t ha^{-1} of poultry manure produced the highest vitamin C (7.13 ± 0.29 mg/100mg) while planting cassava in the early cropping season without poultry manure produced the lowest vitamin C (5.66 ± 0.09 mg/100mg). Carbohydrate was highest in cassava leaves planted during the early cropping season with 10 t ha^{-1} of poultry manure (33.17 ± 2.67 g) while cassava planted in the early cropping season without poultry manure produced the lowest carbohydrate (25.16 ± 1.95 g). Nutrient contents of cassava leaves peaked at 10 t ha^{-1} of poultry manure in the early cropping season. Application of poultry manure during the early cropping season showed greater improvement in the nutrient contents of cassava leaves. The early cropping season had higher rainfall and less evaporation of soil moisture which could be directly related to higher nutrient contents in cassava leaves (Table 2). Lower nutrient contents of the cassava leaves in the late cropping season irrespective of the rate of poultry manure could be related to soil moisture deficit which limited nutrients translocation to the leaves through the xylem (Long *et al*., 2006).

Application of poultry manure during the late cropping season also improved the nutrient contents of cassava leaves but in lesser quantities compared to the nutrient contents of cassava leaves grown in the early cropping season. This is because cassava plants had higher rainfall at the time of application of poultry manure and palm bunch ash during the early and late cropping seasons. However, at harvest, there was no rainfall and evaporation was very high in the late cropping season which could have resulted in lower amount of nutrient contents of cassava leaves. This is similar to the report of Kala and Godara (2011).

Table 5 Interaction effect between poultry manure and season on nutrient contents of cassava leaves at 3 months after planting

Poultry manure (t ha^{-1})	Season	Moisture content (%)	Crude fibre (%)	Ash (%)	Crude protein (%)	Vitamin A (mg/100mg)	Vitamin C (mg/100mg)	Carbohydrate (g)
0	Early	77.38 ± 0.26	15.88 ± 0.64^{d}	8.75 ± 0.26^{b}	15.85 ± 0.43^{e}	18.80 ± 0.37	5.66 ± 0.09^{d}	25.16 ± 1.95^{e}
	Late	76.11 ± 0.16	16.20 ± 0.48^{d}	9.25 ± 0.47^{a}	15.57 ± 0.52^{e}	18.93 ± 0.09	5.96 ± 0.32^{d}	29.12 ± 6.48^{c}
5	Early	77.68 ± 0.22	17.19 ± 2.11^{c}	9.40 ± 0.76^{a}	17.93 ± 0.06^{b}	17.18 ± 0.08	6.72 ± 0.06^{bc}	31.41 ± 1.99^{b}
	Late	76.36 ± 0.15	18.53 ± 3.66^{b}	8.46 ± 0.20^{b}	16.45 ± 0.13^{d}	18.31 ± 0.86	6.79 ± 0.30^{b}	24.53 ± 3.44^{e}
10	Early	77.01 ± 0.49	17.77 ± 0.21^{b}	9.42 ± 0.38^{a}	19.37 ± 0.60^{a}	15.83 ± 0.55	7.13 ± 0.29^{a}	33.17 ± 2.67^{a}
	Late	74.90 ± 0.02	18.26 ± 0.78^{b}	9.19 ± 0.31^{ab}	17.14 ± 0.67^{c}	16.18 ± 0.60	6.73 ± 0.42^{b}	27.75 ± 2.98^{d}
15	Early	76.91 ± 0.35	17.56 ± 0.60^{b}	9.74 ± 1.10^{a}	19.13 ± 0.50^{a}	14.71 ± 1.06	6.33 ± 0.03^{c}	32.72 ± 2.95^{a}
	Late	75.21 ± 0.14	19.64 ± 0.89^{a}	9.48 ± 1.32^{a}	18.04 ± 0.53^{b}	15.03 ± 1.90	6.48 ± 0.14^{c}	26.42 ± 5.59^{de}
$LSD_{(0.05)}$		0.98	0.51	0.52	0.40	0.76	0.30	1.42
F-test		NS	**	**	**	NS	**	**

Note: $LSD_{(0,05)}$ = Least Significant Difference. Means within the column followed by the same letter are not significantly different. NS = not significant, ** significant at 1% level of probability.

Interaction Effect between Palm Bunch Ash and Season on Nutrient Contents of Cassava Leaves

Moisture content was not significantly (P > 0.05) affected by palm bunch ash and season interaction (Table 6). The crude fibre was highest in cassava leaves planted with 2 t ha^{-1} of palm bunch ash during the late cropping season (19.10 ± 1.73%) while cassava fertilized during the early cropping season without palm bunch ash had the lowest leaf crude fibre (16.54 ± 0.56%). Cassava planted during the early cropping season with 2 t ha^{-1} of palm bunch ash had the highest ash in the leaves (10.07 ± 0.91%) while cassava planted during the late cropping season without palm bunch ash had the lowest ash in the leaves (8.36 ± 0.47%). The crude protein content in the cassava leaves was highest when applied 2 t ha^{-1} of palm bunch ash during the early cropping season (18.42 ± 0.78%) and was lowest in the late cropping season cassava planting without soil amendment (16.31 ± 0.52%). Vitamin A increased significantly as palm bunch ash rates increased irrespective of the cropping season. Vitamin C was not significantly affected by palm bunch ash and season interaction. Carbohydrate was highest in cassava leaves planted during the early cropping season and amended with 3 t ha^{-1} of palm bunch ash (31.21 ± 1.01 g) while leaves of cassava planted during the late cropping season and amended with 3 t ha^{-1} of palm bunch ash had the lowest carbohydrate (26.31 ± 1.12 g). Application of palm bunch ash during the early cropping season showed greater improvement in the nutrient contents of cassava leaves compared to the nutrient contents of cassava leaves amended with palm bunch ash in the late cropping season. Lower nutrient contents of the cassava leave in the late cropping season irrespective of the palm bunch ash rate could be related to soil moisture deficit which limited nutrients absorption and translocation to the leaves through the xylem (Long *et al*., 2006). Application of 3 t ha^{-1} of palm bunch ash during the late cropping season resulted in the lowest moisture content of cassava leaves and the highest amount of vitamin C. Potassium increases both yield and quality of crops in moisture stress conditions (Nijira and Nabwami, 2015) by maintaining moisture content in crops through improved turgor of cells (Ganeshamurthy *et al.,* 2011).

Interaction Effect of Poultry Manure, Palm Bunch Ash, and Season on Nutrient Contents of Cassava Leaves

The interaction of poultry manure, palm bunch ash, and season presented in Table 7 showed a significant interaction effect on the moisture content of the cassava leaves (P < 0.01). Control planted in the early cropping season had the highest moisture content (79.51 ± 1.54%) while cassava leaves produced with 1 t ha^{-1} of palm bunch ash without poultry manure in the early cropping season had the least moisture content (76.03 ± 1.27%). During the late cropping season, application of 1 and 2 t ha^{-1} of palm bunch ash without poultry manure produced the lowest moisture content (75.39 ± 1.06%) while cassava leaf fertilized with 5 t ha^{-1} of poultry manure mixed with 2 t ha^{-1} of palm bunch ash produced the highest moisture content (79.29 ± 2.84%). The early cropping season is characterized by higher rainfall, lower temperature, higher relative humidity, and lower evaporation rate compared to the late cropping season (Selemo *et al.,* 2012) which has a positive effect on crop growth and yield (Okechukwu and Mbajiorgu, 2020). The addition of poultry manure to the soil had a positive effect on soil moisture conservation (Alagba *et al.,* 2017). Palm bunch ash, which is friable in nature, does not perform the function of soil moisture conservation and as such, cassava leaves fertilized with palm bunch ash and the control had higher moisture content because soil moisture was easily available in the soil while soil fertilized with poultry manure had slow release of nutrients. This is supported by the findings of Oyedeji *et al.* (2014) who reported higher moisture content and lower nutrient contents in three amaranth leaves produced without manure. The interaction between poultry manure, palm bunch ash, and season did not significantly affect crude fibre, ash, crude protein, vitamin A, vitamin C, and carbohydrate contents (Table 7). However, the result showed that nutrient contents increased with the application of poultry manure mixed with palm bunch ash in both early and late cropping seasons. This observation agrees with the works of Aboyeji *et al*. (2021), Oyedeji *et al.* (2014), and Onwordi *et al.* (2009), who reported independently that improved soil fertility increased nutrient contents in okra, amaranth, and three leafy vegetables respectively. The higher increase in the nutrient contents of cassava leaves with an increase in the poultry manure-palm bunch ash mixture rates during the early cropping season could be attributed to the availability of soil moisture evidenced by the higher rainfall (Table 1) at the time of application of the manure mixtures. The rainfall aided the process of mineralization of the organic manure applied to the cassava plants. Better performance of nutrient contents of cassava leaves during the early cropping season than during the late cropping season agrees with the report of Medyouni *et al*. (2021) and Kala and Godara (2011) who stated that moisture stress as observed in the late cropping season (Table 1) reduced nutrient contents in tomatoes and *Ziziphus mauritiana*, respectively.

Table 6 Interaction effect between palm bunch ash and season on nutrient contents of cassava leaves at 3 months after planting

Palm bunch ash (t ha^{-1})	Season	Moisture content (%)	Crude fibre (%)	Ash (%)	Crude protein (%)	Vitamin A (mg/100mg)	Vitamin C (mg/100mg)	Carbohydrate (g)
0	Early	77.26 ± 0.21	16.54 ± 0.56^{c}	8.61 ± 0.11^{bc}	17.39 ± 0.47	14.48 ± 0.23^{d}	6.08 ± 0.21	30.65 ± 4.21^{a}
	Late	76.87 ± 0.16	17.28 ± 0.48^{b}	8.36 ± 0.47^{c}	16.31 ± 0.52	14.76 ± 0.09^{d}	6.03 ± 0.32	28.68 ± 6.48^{b}
1	Early	76.30 ± 0.21	17.25 ± 0.56^{b}	8.94 ± 0.11^{b}	18.31 ± 0.47	16.92 ± 0.23^{c}	6.51 ± 0.21	30.51 ± 4.21^{a}
	Late	76.32 ± 1.91	18.78 ± 1.11^{a}	9.03 ± 4.87^{b}	16.80 ± 0.59	17.89 ± 0.06^{b}	6.45 ± 0.30	26.49 ± 2.45^{c}
2	Early	76.57 ± 0.71	17.10 ±1.73^{b}	10.07 ± 0.91^{a}	18.42 ± 0.78	17.95 ± 1.70^{b}	6.58 ± 0.07	30.09 ± 0.59^{a}
	Late	76.54 ± 0.71	19.10 ±1.73^{a}	9.23 ± 0.90^{b}	17.28 ± 0.79	19.45 ± 1.70^{a}	6.78 ± 0.07	26.36 ± 0.60^{c}
3	Early	76.20 ± 0.71	17.51 ± 0.90^{b}	9.68 ± 0.81^{a}	18.17 ± 0.69	17.16 ± 0.12^{bc}	6.67 ± 0.13	31.21 ± 1.01^{a}
	Late	75.50 ± 0.87	17.55 ±1.86^{b}	9.75 ± 0.98^{a}	16.82 ± 1.39	16.35 ± 2.73^{c}	6.69 ± 0.20	26.31 ± 1.12^{c}
$LSD_{(0.05)}$		0.98	0.51	0.52	0.40	0.76	0.30	1.42
F-test		NS	**	*	NS	**	NS	**

Note: $LSD_{(0,05)}$ = Least Significant Difference. Means within the column followed by the same letter are not significantly different. NS = not significant, * significant at 5 % level of probability, ** significant at 1% level of probability.

Table 7 Interaction effect between poultry manure, palm bunch ash and season on nutrient contents of cassava leaves at 3 months after planting

Poultry manure (t ha^{-1})	Palm bunch ash (t ha^{-1})	Moisture content (%)		Crude fibre (%)		Ash (%)	
		Early	Late	Early	Late	Early	Late
0	0	79.51 ± 1.54^{a}	79.06 ± 2.61^{a}	14.27 ± 1.54	14.22 ± 3.41	7.37 ± 0.93	8.15 ± 1.06
	1	76.03 ± 1.27^{cd}	75.39 ± 1.06^{d}	16.40 ± 2.31	16.33 ± 1.30	8.30 ± 1.48	9.27 ± 0.06
	2	76.61 ± 1.66^{cd}	75.39 ± 1.06^{d}	16.37 ± 1.82	17.24 ± 0.39	10.06 ± 1.17	9.06 ± 0.21
	3	76.24 ± 1.16^{cd}	75.53 ± 0.92^{d}	16.70 ± 0.90	16.70 ± 0.93	10.29 ± 1.07	9.46 ± 0.25
5	0	77.36 ± 1.42^{bc}	76.09 ± 0.36^{d}	17.59 ± 1.38	18.77 ± 1.14	9.45 ± 0.97	8.09 ± 1.12
	1	77.20 ± 0.75^{bc}	75.32 ± 1.13^{d}	17.59 ± 0.04	17.75 ± 0.12	9.06 ± 0.51	8.02 ± 1.19
	2	78.19 ± 1.74^{b}	79.29 ± 2.84^{a}	17.42 ± 0.21	18.36 ± 0.73	10.08 ± 0.87	9.24 ± 0.03
	3	77.38 ± 1.00^{bc}	75.35 ± 1.10^{d}	17.77 ± 0.14	17.92 ± 0.23	9.21 ± 0.00	8.32 ± 0.89
10	0	76.75 ± 0.30^{cd}	75.31 ± 1.14^{d}	17.22 ± 1.48	16.97 ± 0.66	8.39 ± 1.17	8.32 ± 0.89
	1	76.90 ± 0.45^{cd}	75.20 ± 1.25^{d}	18.33 ± 0.70	18.13 ± 0.50	9.90 ± 0.70	8.87 ± 0.34
	2	76.83 ± 0.38^{c}	74.97 ± 1.48^{e}	18.31 ± 0.68	19.84 ± 2.21	9.68 ± 0.59	8.60 ± 0.61
	3	76.71 ± 0.26^{cd}	74.97 ± 1.48^{de}	17.74 ± 0.11	17.59 ± 0.04	10.10 ± 0.89	10.59 ± 1.38
15	0	77.08 ± 1.46^{c}	75.38 ± 1.07^{d}	17.66 ± 1.96	18.58 ± 0.95	9.29 ± 0.97	8.84 ± 0.37
	1	78.02 ± 1.57^{b}	76.42 ± 0.03^{cd}	18.38 ± 0.75	21.40 ± 3.77	9.35 ± 0.14	9.13 ± 0.08
	2	76.10 ± 0.35^{d}	74.86 ± 1.59^{de}	18.38 ± 0.75	18.67 ± 1.04	10.55 ± 1.34	9.97 ± 0.76
	3	76.36 ± 0.09^{cd}	74.26 ± 2.19^{e}	17.62 ± 0.01	18.23 ± 0.60	9.69 ± 0.48	10.13 ± 0.92
$LSD_{(0.05)}$		0.90		2.31		1.56	
F-test		**		NS		NS	

Note: $LSD_{(0,05)}$ = Least Significant Difference. Means followed by the same letter are not significantly different. NS = not significant, ** significant at 1% level of probability.

Table 7 (Cont.) Interaction effect between poultry manure, palm bunch ash and season on nutrient contents of cassava leaves at 3 months after planting

Poultry manure (t ha^{-1})	Palm bunch ash (t ha^{-1})	Crude protein (%)		Vitamin A (mg/100mg)		Vitamin C (mg/100mg)		Carbohydrate (g)	
		Early	Late	Early	Late	Early	Late	Early	Late
0	0	14.40 ± 2.00	13.48 ± 3.96	14.52 ± 1.23	15.08 ± 1.79	5.11 ± 0.53	5.41 ± 1.05	23.02 ± 4.20	30.52 ± 1.73
	1	16.24 ± 1.33	15.51 ± 1.94	17.91 ± 1.52	18.31 ± 1.44	5.60 ± 0.62	5.74 ± 0.72	27.81 ± 3.31	31.07 ± 2.28
	2	16.42 ± 1.20	17.15 ± 0.30	22.04 ± 3.32	22.82 ± 5.95	5.71 ± 0.60	6.00 ± 0.46	24.96 ± 3.08	27.97 ± 0.82
	3	16.17 ± 1.34	16.33 ± 1.12	21.34 ± 2.65	18.89 ± 2.02	6.49 ± 0.34	6.42 ± 0.04	26.54 ± 3.46	25.23 ± 3.56
5	0	16.45 ± 0.90	16.42 ± 1.03	15.35 ± 1.52	15.43 ± 1.44	6.16 ± 0.49	6.04 ± 0.42	30.81 ± 3.42	26.89 ± 1.90
	1	18.07 ± 0.62	17.04 ± 0.41	18.06 ± 2.77	19.54 ± 2.67	6.76 ± 0.30	6.88 ± 0.42	29.54 ± 0.75	24.46 ± 4.33
	2	18.23 ± 0.79	16.85 ± 0.50	19.56 ± 2.69	21.69 ± 4.82	7.09 ± 0.63	7.35 ± 0.89	29.57 ± 0.78	24.41 ± 4.38
	3	18.06 ± 0.62	16.44 ± 1.00	16.83 ± 0.04	15.49 ± 1.38	6.96 ± 0.50	6.81 ± 0.35	32.06 ± 3.27	26.04 ± 2.75
10	0	18.95 ± 1.01	17.72 ± 0.28	14.81 ± 0.92	15.39 ± 1.48	6.80 ± 0.35	6.30 ± 0.16	34.00 ± 3.01	30.00 ± 1.21
	1	19.29 ± 1.85	17.52 ± 0.08	15.72 ± 1.15	16.23 ± 0.64	7.24 ± 0.78	6.87 ± 0.41	32.73 ± 3.94	28.11 ± 0.61
	2	19.29 ± 1.85	17.40 ± 0.04	15.73 ± 1.14	16.21 ± 0.66	7.07 ± 0.61	6.79 ± 0.33	32.41 ± 3.62	26.95 ± 1.84
	3	18.81 ± 1.37	17.08 ± 0.36	17.46 ± 0.59	16.47 ± 0.40	7.06 ± 0.60	7.00 ± 0.54	31.42 ± 2.63	28.16 ± 0.63
15	0	19.20 ± 0.87	18.21 ± 0.77	13.07 ± 1.67	13.34 ± 3.53	6.26 ± 0.26	6.37 ± 0.09	33.40 ± 3.42	28.66 ± 0.13
	1	18.71 ± 1.27	18.04 ± 0.60	16.74 ± 0.13	16.75 ± 0.12	6.30 ± 0.16	6.19 ± 0.27	29.60 ± 0.81	24.75 ± 4.04
	2	19.03 ± 1.59	18.45 ± 1.00	15.87 ± 1.00	15.67 ± 1.20	6.63 ± 0.17	6.76 ± 0.30	31.51 ± 2.72	28.01 ± 0.78
	3	18.47 ± 1.03	18.62 ± 1.18	13.45 ± 3.42	14.05 ± 2.82	6.19 ± 0.27	6.55 ± 0.09	32.11 ± 3.32	28.51 ± 0.28
$LSD_{(0.05)}$		1.03		1.80		0.37		3.36	
F-test		NS		NS		NS		NS	

Note: $LSD_{(0,05)}$ = Least Significant Difference. Means followed by the same letter are not significantly different. NS = not significant, ** significant at 1% level of probability.

CONCLUSION

Poultry manure-palm bunch ash mixture had a significant effect on the cassava leaves nutritional values. Crop growing season also played a crucial role in crude protein and vitamin C availability in the cassava leaves. These results showed that cassava leaves are rich in nutrients and can be utilized as vegetables in both early and late cropping seasons. The results of the experiment showed that cassava leaves can ameliorate the gap in the scarcity of vegetables during the dry season and in drought-prone areas. Vitamin A, vitamin C, and crude protein peaked in both early and late cropping seasons with the application of 10 t ha^{-1} of poultry manure mixed with 2 t ha^{-1} of palm bunch ash. Thus the use of 10 t ha^{-1} of poultry manure mixed with 2 t ha^{-1} of palm bunch ash is recommended in both early and late cropping seasons to improve nutrient contents of cassava leaves.

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