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Growth, Yield and Varietal Responses of Cassava to time of Planting into Plantain Stands in a Plantain/Cassava Intercrop in Akure, South-West Nigeria

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Abstract

A field experiment was carried out at the Teaching and Research Farms of The Federal University of Technology Akure to evaluate the responses of cassava varieties to time of planting in plantain-based intercropping system in the rainforest zone of Nigeria. The objectives were to identify the more compatible cassava variety for intercrop with plantain examine e the appropriate time to introduce cassava varieties into plantain/cassava intercrop and to identify the more compatible cassava variety for intercrop with plantain. The experiment involved the use of two varieties of cassava (TME 419 non branching and TMS 98/0581 moderately branched) planted at spacing of 1 x 1 m into the alleys of false horn plantain variety space at 3 x 2 m. The treatments were sole plantain, sole cassava varieties (TME 419 poorly branched variety and TMS 0581 branching variety), plantain + he respective cassava varieties (TME 419 and TMS 98/0581) at the same time, and plantain + the respective cassava varieties (TME 419 and TMS 98/0581) at 4 weeks after planting>the treatment plot size was 9 m x 6 m. The plantains and the two cassava varieties were planted sole as the control treatments. The introduction of cassava into plantain as intercrop was carried out at different times which were; at the same time with plantain, and at four (4) weeks after planting plantain. Data on growth parameters such as; plant height, pseudo-stem girth, number of leaves were taken for plantains, while plant height, stem girth, number of leaves, number of branches, height at branching were taken for cassava at 4, 8, 12, 16, 20 and 24 weeks after planting (WAP). Yield parameters such as; bunch weight, number of fingers, number of hands, length of fingers, girth of fingers, weight of hands, weight of fingers were taken for plantains while number of tubers, weight of tubers, girth of tubers, length of tubers, fresh root yield, shoot biomass, were taken for cassava at harvest. The data collected were subjected to statistical analysis. The results showed a higher growth and yield performance for TME419 (49.2 t/ha) and TMS98/0581 (45.7 t/ha) planted sole, and TME 419 (39.5 t/ha) intercropped at planting compared to TMS 98/0581 (24.4 t/ha) intercropped at planting, TME 419 (21.7 t/ha) and TMS 98/0581 (15.7 t/ha) intercropped at 4 week after planting (WAP), respectively. But there was no significant difference ($P<0.05$) recorded for the growth of plantain, whereas the yield of sole plantain was higher and differed significantly ($P<0.05$) from the yields of intercropped plantain. All the treatment combinations had land equivalent ratio (LER) and area time equivalent ratio (ATER) greater than 1. Plantain + TME 419 intercropped at the same time recording the highest LER and ATER (1.48 and 1.5) while plantain + TMS 98/0581 had the least 1.11 and 1.14 respectively. The cost benefit analysis for the treatment combinations showed that TME 419 planted sole had the highest return of ₦3.567 per ₦1 invested, TME 419 intercropped at the same time gave a return of ₦3.416 per ₦1 invested, which was greater than other intercropped treatments. Intercropping cassava with plantain at the same time, as well as the use of TME 419 variety gave the best performance in terms of growth, yield, land equivalent ratio, area time equivalent ratio and returns on investment. This combination are recommended for plantain-based intercropping system involving cassava in the study area.

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Introduction

The English word plantain apparently was derived from the Spanish plátano[1, 2, 3]. Plantains resemble bananas but are longer in length, have a thicker skin, and contain more starch. They are also a major staple food in Africa, Latin America, and Asia. They are usually cooked and not eaten raw unless they are very ripe. Plantains are more important in the humid lowlands of West and Central Africa. One hundred or more different varieties of plantain grow deep in the African rainforest [4, 5, 6].

The area harvested of plantains in West Africa increased fairly steadily and nearly doubled between 1990 and 2011, from approximately 955,000 hectares (ha) to 1,700,000 ha In 2011, 12.46 million metric tons (MT) of plantains were produced, representing 32.0% of worldwide production [7]. They rank as the fourth most important global food commodity after rice, wheat and maize in terms of gross value of production [5, 8].

Plantain is a carbohydrate source and the vitamin C content of plantain is very similar to those of sweet potatoes, cassava, though the concentration may vary with the crop, maturity at harvest, soil and farming conditions [9,10].

Prominent among major characteristics of plantain is its ability to survive extended periods of drought unlike most other crops. It can also grow well under a wide range of soil conditions, with its fruits being produced almost all year round. Almost all parts of the plant have one economic use or another and may be harvested for household use or sale to raise income. Plantain also co-exists well with a wide range of plants and trees, except allelopathic plants and is traditionally grown in mixed cropping systems [10] .

Cassava (*Manihot esculenta* L. Crantz) is a dicotyledonous plant growing 1-3 m high and belonging to the family Euphorbiaceae (Spurge) the *Manihot* genera. Cassava is a perennial woody shrub with an edible root, which grows in tropical and subtropical areas of the world ([4] IITA, 2009). The tuber flesh is composed of about 62 % water, 35 % carbohydrate, 1-2 % protein, 0.3 % fat, 1-2 % fibre and 1 % mineral matter [11,12]. It is an important subsistence crop for many communities with flexible planting and harvest times [13].

Due to ever increasing human population especially in Africa leading to diminishing agricultural land sizes, intercropping, with its advantages of risk minimization, reduction of soil erosion, increased food security should be practiced. Most crops can now be intercropped including fruit trees, and therefore farmers with small pieces of land should no longer worry [14, 15]. However research still needs to be carried out particularly with respect to row orientations and light interception and the economic benefits as more horticultural crops are intercropped [16, 17]. Therefore in this project the type of intercrop used based on spatial arrangement is the "row intercropping" where the two crops were simultaneously planted in a well defined row arrangement. Meanwhile the intercropping system used is the plantain based intercropping system where the plantain was intercropped with cassava a tuber crop. In the tropics, farmers use any available cassava variety when intercropping with plantains and some of these varieties may suppress the growth and yield of plantain; hence there is a need to identify a more compatible variety to farmers.\and determine the best time to introduce cassava into plantain plantation so that the component crop yield will not be affected negatively.

The objectives of the experiment are to determine the appropriate time to introduce cassava varieties in a plantain/cassava intercrop and Identify a

more compatible cassava variety for intercrop with plantain.

Materials and Methods

Description of Experimental Site

The research experiment was conducted at the Teaching and Research Farm of the Federal University of Technology Akure (7^0 16′ N, 5^0 12′ E) located in the rainforest area of southwestern Nigeria. The location is characterized by bimodal pattern of rainfall with an annual mean of about 1300 mm with mean temperature 27^0C, and the climate is sub-humid type. The total size of the experimental plot was 80 x 40 m, the land is slightly slope with a pH of 6.5, and the land has been under fallow for some years. The textural class of the soil is sandy clay loam with 35.5% clay, 11.3% silt, and 58.2% sand. The fauna observed on the land were termites and different kinds of ants as this was evident due to the presence of termite mound and ant hill in the experimental site. Larger holes made by small mammals (rodents) were also observed in the land. This is an indication that the soil possibly has a good structure and it is well aerated.

Cropping History of the Experimental Site

The experimental site has over the years been used for cassava production and was left fallowed for about six years with weeds such as *Chromolaena odorata, Euphorbia heterophylla, Panicum maximum, Pennisetum purpureum, Callopogonium mucunoides* and *Leucaena leucocephalla - a* shrub predominating on the land before the clearing commenced on the land.

Planting Materials

Plantain

The planting materials used were sourced from the Teaching and Research Farm of the Federal University of Technology Akure. The plantain suckers used were sword suckers of the false horn cultivar with medium sized pseudo stem.

Cassava

cassava stems were also obtained from the Teaching and Research Farms FUTA. Two improved varieties developed by IITA, TME 419 (a non-branching variety), and TMS98/ 0581 (an averagely branching variety) were used for the experiment.

Land Preparation

A mini excavator was used to uproot the trees and shrubs, then the leaves were allowed to fall off, afterwards chainsaw was used to cross cut the uprooted trees into logs and then moved manually out of the field. No tillage operation was carried out. The weeds left on the field were sprayed with a broad spectrum herbicide (*Glyphosate*). Holes were dug for the planting of plantain; the size of the holes was 30 x 30 cm x 30 cm at a spacing of 3 x 2 m.

Field Layout and Experimental Design

The experiment was made up of seven treatments arranged in a Randomized Complete Block Design (RCBD) with three (3) replications. Plot size measured 54 m^2 (9 x 6 m) with 2 m alley between each plot and 3 m walkway between the blocks.

Soil Sampling and Analysis

Soil samples collected from 0 – 30 cm depth, using a soil auger at pre-planting and at crop maturity were subjected to laboratory analysis to determine the physical properties; soil texture, and chemical properties; pH, nitrogen ,phosphorus, potassium, organic carbon, organic matter ,calcium, magnesium, and sodium.

Physical and Chemical Analysis of Soil Samples

Pre-cropping physical and chemical analysis of the experimental soil was carried out before land preparation and repeated at the harvest to determine the nutrient status of the soil. The soil samples were air dried, crushed and sieved to pass through a 2 mm sieve after which physical analysis was carried out using the hydrometer method ([18] Bouyoucos, 1962). Total N was analyzed using the macro Kjeldahl procedure. Organic carbon analysis was done using the Walkley and Black procedure. Soil organic matter content was derived by multiplying organic carbon content by 1.72; pH was determined in soil/water ratio of 1:2 using a pH meter with glass electrode; Available phosphorus was by the Bray 1 method. Exchangeable K, Ca and Mg were determined by extraction with 1M ammonium acetate at pH 7.0 and the amounts of K, and Ca in the filtrate were determined using a Corning flame photometer with appropriate filter, while Mg was determined by using a Perkin-Elmer Atomic Absorption Spectrophotometer

(AAS). The result of the laboratory analysis is presented in Table 1.

Planting

The plantains were planted in September 2015 and cassava planted alongside the plantains in treatments four and five, while cassava was introduced into treatments six and seven four weeks after planting of the plantain. The plantain suckers were pared with sharp knife in order to remove any possible pest (weevil) embedded in the corm, then treated with nematicide/insecticide (carbofuran) dissolved in water in order to prevent termite and banana weevil attack. The suckers were planted in holes 30 cm x 30 cm x 30 cm and covered with top soil at a spacing of 3 m x 2 m resulting in 16 plants per plot of 54 m^2, hence giving 1667 stands per hectare equivalent.

The cassava cuttings were treated with insecticide (cabofuran) to prevent termite attack before planting sole and inter-planting them with the plantains at spacing of 1m x 1m. The spacing resulted in 70 plants per sole plot (10,000 plant stands per hectare equivalent), and 54 plants in intercrop (8333 plant stands per hectare equivalent)

Experimental Treatments

These Were

Sole plantain as control; Sole cassava (TME 419) poorly branched variety; Sole cassava (TMS 98/0581) branched variety; Plantains + TME 419 at the same time; Plantains + TMS 98/0581 at the same time; Plantain + TME 419 at 4 weeks after planting; and Plantain + TMS 98/0581 at 4 weeks after planting.

Cultural Practices

Cultural practices carried out on the cassava/ plantain field. This include weeding which was carried out with the use of herbicides (glyphosate and diuron). The spraying of the field commenced before planting and was done at an interval of six weeks during the rainy season, while it was not sprayed at all during the dry season. Prior to the spraying of the field, the base of the plantain stands were cleared in a ring form so as to avoid contact with the herbicide in use. Chemical method of weeding was adopted because manual weeding may cause damage to the plantain roots which is usually growing within the top soil region. Sucker management was carried out by removing excess suckers from each plantain stand. This was carried out with the use of cutlass at the base of the plant close to the parent. Cassava was harvested manually by pulling the roots from the ground, and then a cutlass was used to cut off the tubers from the stem. Plantains were harvested at maturity by first cutting the pseudo stem, then bunches were cut off. The pseudo-stem cut was left to rot on the ground in order to add organic matter to the soil.

Data Collection

Data were taken from four randomly selected plantain and cassava stands, beginning from 4 weeks after planting. The data taken from plantains were pseudo-stem height and girth, number of leaves/plant while data taken for the yield of plantain at harvest are; bunch weight (kg), number of finger. The data collected on cassava growth and yield parameters were; stem height and girth, number of leaves/plant, number and height at stem branching. The data taken for cassava at harvest were length of tuber (cm), number of tubers, weight of tuber (kg), girth of tuber, root biomass, shoot biomass, dry matter analysis using oven drying method: 100 g of fresh tuber was placed in the oven at 105^0C for 24 hours then it was removed and weighed.

$$\sum_{i=1}^{n} \frac{t_i^m}{t^l} \cdot \frac{Y_i^l}{Y_i^m} = \frac{l}{t^l} \sum_{i=1}^{n} t_i^m \frac{Y_i^l}{Y_i^m}$$

Land Equivalent Ratio (LER)

The Land Equivalent Ratio was calculated at harvest by dividing the yields obtained from sole crops with those of the intercropped. This will be carried out mathematically by using the formula below;

$LER = L_x + L_y = Ax/Px + Ay + Py$

Where *Lx* and *Ly* are the individual RY (relative yield) of two crops *X* and *Y*. *Lx* is obtained by dividing the yield of crop *X* in association *(Ax)* by the yield of the same crop in pure stand *(Px)*. *Ly* is the result of dividing the yield of crop Y in association *(Ay)* by the yield of that same crop in pure stand *(Py)*.

Area-Time Equivalent ratio (ATER)

A concept called "area time equivalency ratio" (ATER) has been developed by Hiebsch [19]. ATER takes into consideration the time taken when the crop

was on the land and it is a means of assessing yield advantages. The ATER is calculated as follows.

t^m_i = growing period of crop *i* in monoculture, t^i = total time of intercropping system

Y^i_i = yield (t/ha) of crop *i* in intercropping, Y^m_i = yield (t/ha) of crop *i* in single culture, and

n= total number of crops in the system

Data Analysis

Data collected on plantain and cassava growth and yield parameters were analyzed using the Analysis of Variance (ANOVA) and the means were compared using Tukey Test at the 5% level of probability. Minitab version 17 was used.

Results

Soil Physical and Chemical Properties of Experimental Site: Pre-Cropping and After Treatment Imposition

Table 1 shows the pre and post-planting soil physiochemical properties. The pH of the soil at pre-planting was (6.54) rated medium, and post planting ranged from 4.00-4.63 rated very low to low. The pH of the soil before planting differed significantly (P<0.05) from that of post harvest. The total nitrogen at pre-planting (3.2 g/kg) rated as medium and post planting ranged from 4.3-7.1 g/kg which was rated medium to high. The nitrogen concentration as shown by the table also indicated that soil from plantain (sole) and TMS98/0581 (sole) had high N concentration and differ significantly (P<0.05) from other treatments as indicated with the letter (a), while the pre-planting showed the least N concentration. The soil planted to sole crops had higher N concentration than the intercropped plots, and are significantly different (p<0.05). The organic carbon (OC) at pre-planting was (21.0 g/kg) rated low, and post planting ranged from 17.2-24.7 g/kg and was rated very low to low. The soil from plantain (sole) had the highest OC concentration (24.7 g/kg) and it differed significantly (p<0.05) from other treatments, while plantain + TMS98/0581 at 4 weeks had the least OC concentration (17.2 g/kg). The available phosphorus at pre-planting was (5.41 mg/kg) rated low, and at post planting ranged from (9.09-15.76 mg/kg) rated very low to low. The P concentration of soil sample from pre-planting and TME419 (sole) differed significantly (P<0.05) from P concentration of TME419 and TMS98/0581 intercropped at 4 weeks. Potassium at pre-planting was 0.21 cmol/kg rated low, and at post planting ranged from 0.26-0.31 cmol/kg rated low to medium. The result from the table showed that there was no significant difference for K concentration in all the treatments at post planting.

Varietal Response and Effects of Planting Time on Growth Parameters of Cassava

The varietal response and effects of planting time on cassava plant height is presented in Table 2. Plant height increased appreciably and differed significantly (P<0.05) across treatments throughout the experiment. TME419 planted sole had the highest height (190 cm) at 24 weeks after planting and differed significantly (P<0.05) from TME419 intercropped at the same time (167.08 cm) and TME419 intercropped at 4 weeks (129.20 cm) respectively. TMS98/0581 intercropped at 4 weeks had the least height (80.67 cm) at 24 weeks after planting. There were no significant differences (P<0.05) in the number of leaves at 16 weeks after planting as shown in Table 3. TMS98/0581 (sole) had the highest number of leaves (76.65) at 24 weeks after planting, while TMS98/0581 intercropped at 4 weeks had the least number of leaves (37.75) at 24 weeks after planting. The data presented in Table 4 showed the effect of cassava variety and time of intercropping on stem girth. The stem girth showed no significant difference (P<0.05) at 4 weeks after planting, for all the treatments. TMS98/0581 intercropped at 4 weeks differed significantly (P<0.05) from other treatments from 8 weeks after planting to 20 weeks after planting, but at 24 weeks, there were no significant differences (P<0.05) with TME419 and TMS98/0581 intercropped at the same time, and differed significantly (P<0.05) with TME419 (sole) and TMS98/0581 (sole) which both had the highest stem girth (2.03) at 24 weeks after planting.

Variety Effects of Cassava and time of Planting on Growth Parameters of Plantain

The data presented in Table 5 showed the effect of cassava variety and time of planting on plantain leaves. There were no significant differences (P<0.05) across the treatment combinations from 4 to 24 weeks, respectively except for plantain (sole) which differed significantly (P<0.05) from other treatments at 12

Table 1. Soil chemical properties of experimental site: pre-planting and after treatment imposition

Treatments	Nutrient elements							
	pH	N	OC	P	K	Ca	Mg	Na
	(H_2O)		(g/kg)	Mg/kg		(cmol/kg)		
Pre-planting	6.54a	3.3e	22.7b	5.42d	0.21b	2.1cd	0.99ab	0.26e
After treatment								
TME419 (sole)	4.62b	6.0b	20.5c	9.09cd	0.26ab	2.2cd	1.00a	0.34cd
TMS98/0581 (sole)	4.61b	6.8a	18.0de	12.38abc	0.30a	2.5b	1.1a	0.32d
Plantain (sole)	4.63b	7.1a	24.7a	12.10abc	0.31a	2.90a	1.13a	0.41a
TME419 + plantain at same time	4.46b	5.4c	18.1de	11.68abc	0.30a	2.3bc	1.1a	0.38abc
TMS98/0581 + plantain at same time	4.47b	5.0c	19.5cd	11.57bc	0.31a	1.97d	0.60b	0.39ab
TME419 + plantain at 4 weeks	4.17c	5.4c	20.5c	15.76a	0.29a	2.1cd	0.90ab	0.36bcd
TMS98/0581 + plantain at 4 weeks	4.23c	4.3d	17.2e	13.65ab	0.29a	2.0d	0.80ab	0.41a

Mean in the same column followed by the same letters are not significantly different at (P <0.05) according to Tukey comparisons.
Sand fractions: 582g/kg, Silt fraction:113g/kg and Clay fraction :305g/kg

Table 2. Cassava varietal response and planting time on plant height (cm)

Treatments	Weeks after planting					
	4	8	12	16	20	24
TME419 (sole)	21.00b	105.08a	124.67a	136.75a	162.75a	190.00a
TMS98/0581 (sole)	18.41b	63.50b	93.67abc	101.00abc	119.50abc	133.25abc
Plantain + TME419 (0wap)	17.17b	100.50a	117.33ab	122.67ab	143.75ab	167.08ab
Plantain + TMS98/0581 (0wap)	17.41b	55.75bc	77.00bcd	88.00bc	100.58abc	116.67bc
Plantain + TME419 (4wap)	30.75a	49.41bc	59.50cd	75.91bc	91.67bc	129.20abc
Plantain + TMS98/0581 (4wap)	22.83b	35.58c	42.58d	53.75c	63.08c	80.67c

Means in the same column followed by the same letter are not significantly different at (P <0.05) according to Tukey comparisons

Table 3. Varietal response and effects of planting time on cassava number of leaves

Treatments	Weeks after planting					
	4	8	12	16	20	24
TME419 (sole)	10.67ab	32.91a	40.25a	31.50a	46.17a	55.00abc
TMS98/0581 (sole)	10.25b	31.58a	42.67a	39.17a	53.63a	76.65a
Plantain + TME419 (0wap)	9.33b	29.83a	36.75ab	28.58a	40.08ab	46.00bc
Plantain + TMS98/0581 (0wap)	10.67ab	32.67a	40.25a	35.17a	50.91a	64.75ab
Plantain + TME419 (4wap)	12.08a	19.33b	22.50bc	26.25a	27.83b	39.68c
Plantain + TMS98/0581 (4wap)	11.08ab	17.67b	15.75c	23.58a	26.75b	37.75c

Mean in the same column followed by the same letter are not significantly different at (P <0.05) according to Tukey comparisons.

Table 4. Varietal response and effects of planting time on cassava stem girth (cm)

Treatment	Weeks after planting					
	4	8	12	16	20	24
TME419 (sole)	0.68a	1.67a	1.80a	1.89ab	1.93ab	2.03a
TMS98/0581 (sole)	0.67a	1.40ab	1.75a	1.94a	2.00a	2.03a
Plantain + TME419 (0wap)	0.72a	1.50a	1.68ab	1.74ab	1.75abc	1.80ab
Plantain + TMS98/0581 (0wap)	0.68a	1.30ab	1.44abc	1.60abc	1.64abc	1.69ab
Plantain + TME419 (4wap)	0.82a	1.05bc	1.16bc	1.20bc	1.30bc	1.60ab
Plantain + TMS98/0581 (4wap)	0.70a	0.84c	1.02c	1.03c	1.09c	1.49b

Means in the same column followed by the same letter are not significantly different at (P <0.05) according to Tukey comparisons.

Table 5. Varietal effects of cassava and time of planting on plantain number of leaves.

Treatments	Weeks after planting					
	4	8	12	16	20	24
Plantain (sole)	8.00a	10.41a	9.50b	3.25a	2.83a	2.58a
Plantain + TME419 (0wap)	8.08a	11.17a	10.58a	3.50a	2.67a	2.00a
Plantain + TMS98/0581 (0wap)	8.67a	11.25a	11.17a	3.41a	2.58a	2.25a
Plantain + TME419 (4wap)	8.00a	10.91a	10.58a	3.67a	3.08a	2.91a
Plantain + TMS98/0581 (4wap)	8.16a	11.17a	10.50ab	3.58a	2.83a	2.67a

Means in the same column followed by the same letter are not significantly different at (P <0.05) according to Tukey comparisons.

weeks after planting. Plantain and TME419 planted at the same time had the highest plant height (118.91cm), while plantain and TME419 intercropped at 4 weeks had the least plant height (112.00 cm) at 24 weeks after planting (Table 6). However, there were no significant differences (P<0.05) in the height of plantain for all the treatment combinations. Table 7 showed an increase in pseudo-stem girth for all treatment combinations at 8 weeks after planting, but there was a decline in the pseudo-stem girth from 12 to 24 weeks after planting across the treatment combinations. There were no significant differences (p<0.05) in the pseudo-stem girth from 4 to 24 weeks after planting.

Varietal Response and Time of Planting Effects on Cassava Yield.

The data presented in Table 8 shows the yield of cassava varieties in response to their various treatment combinations. Sole planted TME419 had the highest tuber weight (0.81 kg) while TMS98/0581 intercropped at 4 weeks with plantain had the least tuber weight (0.31 kg). TME419 intercropped with plantain at the same time had a higher tuber weight (0.78 kg) compared to TMS98/0581 planted sole (0.71 kg), but they did not show any significant difference. Cassava varieties,TME419 had higher tuber weight in all the treatment combinations compared to TMS98/0581 (Table 8).

The results further showed that TME419 and TMS98/0581 planted sole, alongside TME419 and TMS98/0581 intercropped at same time did not differ significantly (P<0.05) in tuber girth, while TME419 and TMS98/0581 intercropped at 4 weeks differed significantly (P<0.05) from those intercropped at the same time as indicated with (letter b) in Table 8). TMS98/0581 intercropped at 4 weeks had the least tuber length (21.33 cm) which is significantly different (P<0.05) from all other treatment combinations, while TME419 (sole) had the highest tuber length (44.25 cm). TMS98/0581 (sole), TME419, TMS98/0581 intercropped at same time and TMS98/0581 intercropped at four weeks had significantly different (p<0.05) tuber length. The variety TMS98/0581 planted sole had the highest number of tubers while TME419 and TMS98/0581 intercropped at four weeks differed significantly (P<0.05) from other treatments. The root yield per plant, and the root yield per hectare of TME419 intercropped at the same time did not differ significantly (P<0.05) from TME419 and TMS98/0581 planted sole, but TMS98/0581 intercropped at the same time was significantly different (P<0.05) from TME419 (sole), TMS98/9581 (sole), and TME419 intercropped at same time. Root yield of TMS98/0581 intercropped at the same time or at four weeks differed significantly (p<0.05) from sole crops. The shoot biomass did not show any significant difference (P<0.05) in all the treatment combinations, which indicate that the time of planting and the variety may have no effect on the shoot biomass. Dry matter yield obtained after oven drying at 105^0c for 24 hours showed that TME419 and

Table 6. Varietal effect of cassava and time of planting on plantain height (cm).

Treatment	Weeks after planting					
	4	8	12	16	20	24
Plantain (sole)	53.33a	101.25a	106.83a	107.81a	109.17a	109.91a
Plantain + TME419 (0wap)	58.43a	109.37a	116.51a	117.08a	117.25a	118.91a
Plantain + TMS98/0581 (0wap)	56.70a	105.27a	110.68a	111.08a	111.91a	113.75a
Plantain + TME419 (4wap)	46.17a	97.85a	102.77a	107.50a	108.25a	112.00a
Plantain + TMS98/0581 (4wap)	53.75a	104.93a	113.43a	114.50a	115.33a	116.48a

Means in the same column followed by the same letter are not significantly different at (P<0.05) according to Tukey comparisons.

Table 7. Varietal effects of cassava and time of planting on plantain pseudo-stem girth (cm).

Treatment	Weeks after planting					
	4	8	12	16	20	24
Plantain (sole)	4.07a	7.77a	7.70a	7.35a	7.21a	7.04a
Plantain + TME419 (0wap)	5.40a	8.74a	8.37a	8.20a	7.74a	7.38a
Plantain + TMS98/0581 (0wap)	4.95a	8.25a	7.48a	7.44a	7.35a	6.68a
Plantain + TME419 (4wap)	4.47a	7.60a	7.52a	7.51a	7.38a	7.38a
Plantain + TMS98/0581 (4wap)	4.97a	7.85a	7.84a	7.77a	7.50a	7.20a

Means in the same column followed by the same letter are not significantly different at (P<0.05) according to Tukey comparisons.

Table 8. Varietal response and planting time effects on cassava yield and yield components.

Treatments	Tuber weight (kg)	Tuber girth (cm)	Tuber length (cm)	Number of tubers	Fresh root yield (kg/plant)	Shoot biomass (kg)	Root yield (t/ha)	Dry matter yield (%)
TME419 (sole)	0.81a	6.28a	44.25a	9.58ab	4.92a	4.18a	49.2a	27.5c
Plantain + TME419 (0wap)	0.78a	6.14a	36.25ab	10.58a	4.74a	4.33a	39.5a	22.6d
Plantain + TME419 (4wap)	0.70a	5.15b	33.58b	5.83c	2.93b	4.00a	21.7b	30.2a
TMS98/0581 (sole)	0.71a	6.44a	31.97b	11.11a	4.57a	5.00a	45.7a	20.1e
Plantain + TMS98/0581 (0wap)	0.58ab	6.24a	32.44b	10.52a	2.62b	4.24a	24.4b	20.4e
Plantain + TMS98/0581 (4wap)	0.31b	5.10b	21.33c	7.41bc	1.83b	3.50a	15.7b	29.3b

Means in the same column followed by the same letters are not significantly different at (P <0.05) according to Tukey comparison

TMS98/0581 intercropped at 4 weeks had the highest dry matter yield of 30.2% and 29.3%, respectively. This may be as a result of intercropping or may be as a result of the increase in soil acidity which may result in thickening of the plant roots. TME419 had the highest dry matter yield for the sole planted cassava varieties and the intercropped at 0 week after planting and 4 weeks after planting respectively, while TMS98/0581 had lesser dry matter yield compared to TME419 across treatment combinations (Table 8).

Cassava Variety Response and Time of Planting Effect on Height at Branching and Number of Branches 24 Months After Planting.

The data recorded in Table 9 showed that number of branches for TME419 (sole) and TMS98/0581 (sole) was higher than TME419 and TMS98/0581 intercropped at 0 and 4 weeks after planting. TMS98/0581 had higher number of branches compared to TME419 because it is habitually a branching variety. Height at branching was lower for the branched TME419, this was observed in TME419 (sole) and TME419 intercropped at the same time. They branched at 17.91 cm and 19.1 cm respectively, while TME419 intercropped at 4 weeks did not produce any branch. TMS98/0581 intercropped at 4 weeks branched at 13.83 cm compared to the ones planted at the same time which branched at 33.67 cm, and the sole planted which branched at 58.75 cm.

Effects of Intercropping and Time of Planting on Plantain Yield

The results presented in Table 10 showed the yield of plantain at harvest. Plantain (sole) recorded the highest bunch weight (10.53 kg), and differed significantly ($P<0.05$) from other treatment combinations, meanwhile plantain intercropped with TME419 at the same time had the least bunch weight 7.11 kg. There was no significant difference in the bunch weight of the intercropped treatment combinations. The number of fingers, number of hands, length of fingers and girth of fingers did not differ significantly ($P<0.05$) across the treatment combinations. TMS98/0581 planted at the same time had the least weight of hand 1.53 kg and differed significantly ($P<0.05$) from other treatment combinations while TME419 intercropped at the same time had the least weight of finger 0.37 kg and was significantly different ($P<0.05$) from other treatment combinations.

Cassava Varietal Effects and Time of Planting on Land Equivalent Ratio (LER), and Area Time Equivalent Ratio (ATER).

Plantain and TME419 planted at the same time had the highest LER of 1.48, while plantain and TMS98/0581 intercropped at the same time had an LER of 1.23 (Table 11). Plantain and TME419 intercropped at 4 weeks had an LER of 1.22. Plantain and TMS98/0581 intercropped at 4 weeks had the least LER of 1.11. The

Table 9. Varietal response of cassava and time of planting on number of branches and height at branching at 24 weeks after planting.

Treatments	Number of branches	Height at branching (cm)
TME419 (sole)	0.33a	17.91d
TMS98/0581(sole)	2.00a	58.75a
Plantain + TME419 (0wap)	0.17b	19.1c
Plantain + TMS98/0581 (0wap)	1.58ab	33.67b
Plantain + TME419 (4wap)	0.00b	0.00f
Plantain + TMS98/0581 (4wap)	0.83ab	13.83e

Means in the same column followed by the same letter are not significantly different at ($P<0.05$) according to Tukey comparisons.

Table 10. Effects of intercropping and time of planting on plantain yield and yield components.

Treatment	Weight of bunch (kg/ plant)	Number of fingers/ bunch	Number of hands/ bunch	Length of fingers (cm)	Girth of fingers (cm)	Weight of hands (kg)	Weight of fingers (kg)	Bunch weight (t/ha)
Plantain sole	10.53a	28.33a	5.67a	26.00a	4.53a	2.13a	0.53a	17.55a
Plantain + TME419 (0Wap)	7.11b	26.33a	6.00a	26.00a	4.07a	1.63ab	0.37b	11.86b
Plantain + TMS98/0581 (0Wap)	7.47b	24.67a	5.41a	22.91ab	4.18a	1.53b	0.50ab	12.44b
Plantain + TME419 (4Wap)	8.30b	27.00a	6.00a	26.33a	4.13a	1.68ab	0.48ab	13.83b
Plantain + TMS98/0581 (4Wap)	8.08b	26.67a	6.00a	24.33ab	4.33a	2.10ab	0.53a	13.47b

Means in the same column followed by the same letter are not significantly different at (P <0.05) according to Tukey comparisons.

Table 11. Effects of cassava varieties and time of planting on land equivalent ratio (LER), and area time equivalent ratio (ATER) of plantain cassava intercrop.

Treatment	Yield t/ha		LER	ATER
	Bunch	Fresh root		
Plantain sole	17.55		-	
TME419 sole		49.2	-	
TMS98/0581 sole		45.7	-	
Plantain + TME419 0WAP	11.86	39.5	1.48	1.5
Plantain + TMS98/0581 0WAP	12.44	24.4	1.23	1.17
Plantain + TME419 4 WAP	13.83	21.7	1.22	1.34
Plantain + TMS98/0581 4WAP	13.47	15.7	1.11	1.14

treatment combination with the highest ATER was the Plantain + TME419 planted at the same time with 1.5, while plantain + TMS98/0581 intercropped at 4 weeks had the least ATER of 1.14. Plantain + TMS980581 intercropped at the same time had an ATER of 1.17 while plantain + TME419 intercropped at 4 weeks had an ATER of 1.34.

Cost Benefit Analysis for Plantain/Cassava Intercrop

Table 12 showed the cost of production (input) and the income (output) per hectare for the sole crops and the intercrops. The cost of producing sole cassava was lower at ₦208,000/ha compared to the cost of producing sole plantain which was ₦283,350/ha. The cost of production in the intercrop was higher at ₦345,860/ha because, it required more labour and planting materials compared to the sole crops. From the sole treatments, plantain (sole) had the highest net farm income of ₦581,450/ha compared to TME 419 (sole) which had net farm income of ₦566,500/ha and TMS98/0581 (sole) which had a net farm income of ₦510,500/ha. From the intercropped treatment combinations, plantain + TME419 intercropped at the same time had the highest net farm income of ₦866,440/ha, while plantain + TMS98/0581 intercropped at 4 weeks had the least net farm income of ₦566,140/ha. TMS98/0581 intercropped at the same time had a net farm income of ₦653,840/ha, and TME 419 intercropped at 4 weeks had ₦680,140/ha net farm income. TME419 (sole) had the highest return per ₦1 invested ₦3.567, while plantain + TMS98/0581 had the least return per ₦1 invested ₦2.579. TME419 intercropped at the same time had the highest returns on investment (₦3.416) for the intercrops.

Discussion

The result of the pre-planting soil analysis carried out on the soils showed that the soil in the experimental site was a sandy clay loam according to soil textural triangle. The low nutrient concentration at pre-planting may be as a result of the opening of the fallowed land which involved uprooting of trees and shrubs, which might have exposed the nutrients to leaching and volatilization. The pH of the soil decreased from the pre-planting pH of 6.54 (slightly acidic) to a pH less than five (< 5) which were 4.62, 4.63, 4.63 (low) for the sole crops and 4.46, 4.47, 4.00, 4.20 (very low) for the intercropped treatment combinations. There was an increase in nutrient concentration when post planting soil analysis was carried out. The increase in nitrogen concentration, organic matter, available phosphorus, calcium, magnesium, potassium, and sodium in the soil may be as a result of the decomposition of the organic materials (leaves from trees, broad leaf weeds, succulent shrubs left in the soil when the land was opened, as well as the protection of the soil from exposure to sunlight and direct impact of rain fall by the cultivated crops.

The effects of the dry spell encountered during the dry season from November 2015 to March 2016 resulted in the decline in pseudo stem girth of the plantain which resulted in the lodging of poorly developed stands, as well as decline in the number of functional leaves to an average of (2.5) leaves per stand, this reduction in the number of leaves may be a kind of survival strategy for the plant [20]. The plant increased in height at a very slow rate, and contrary to the complete canopy formation at 5 – 6 months stated by [4], it took 9 months to obtain complete canopy cover. This may be as a result of late planting, and reduced rainfall frequency and quantity in 2015 rainy season.

The time of planting cassava into plantain in an intercrop is very important. The reduced height of the cassava intercropped at 4 weeks was a sign that plantains are quick to establish their roots. This was supported by Lavigne [21] report that the root extension rate is at 2 - 4 cm per day, being 30 % faster during the daylight hours. The cassava intercropped at 4 weeks could not attain a higher height compared to those intercropped at the same time due to competition for soil nutrients and moisture by plantain though they had higher height compared to those intercropped at the same time at 4 weeks after planting but they could not keep up with the competition from 8 to 24 weeks after planting. At 16 weeks after planting, the sole planted cassava and those planted at the same time with plantain experienced a decline in number of leaves, this may be as a result of older leaves shedding in order to reduce the rate of transpiration during the dry spell [20], [22, 23].

But the cassava varieties intercropped at 4 weeks did not experience any decline in its number of

Table 12. Cost benefit analysis for cassava varieties and time of planting effects on plantain-cassava intercrop.

	Plantain (sole)	TME419 (sole)	TMS98/0581 (sole)	Plantain+TME419 at same time	Plantain+TMS98/0581 at same time	Plantain+TME419 at 4 weeks	Plantain+TMS98/0581 at 4 weeks
A. Yield t/ha							
i. Plantain	7.55	-	-	11.86	12.44	13.83	13.47
ii. Cassava t/ha		49.2	45.7	39.5	24.4	21.7	15.7
iii. Price ₦	50,000	16,000	16,000	50,000 + 16,000	50,000 + 16,000	50,000 + 16,000	50,000 + 16,000
iv. Gross income ₦	877,500	787,200	731,200	1,225,000	1,012,400	1,038,700	924,700
B. Variable cost ₦							
Land clearing/ha							
Tree felling (mini excavator)/h	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Log removal (manual)/ha	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Digging of hole/ha	17,000	-	-	17,000	17,000	17,000	17,000
Herbicides	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Planting materials/ha							
Plantain sucker	83,350	-	-	83,350	83,350	83,350	83,350
Cassava cutting	-	15,000	15,000	12,510	12,510	12,510	12,510
Insecticide	5,000	5,000	5,000	5,000	5,000	5,000	5000
Planting/ha							
Labour hired	40,000	50,000	50,000	90,000	90,000	90,000	90,000
Weeding (herbicide)	12,000	12,000	12,000	12,000	12,000	12,000	12,000
Miscellaneous	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Total variable cost	283,350	208,000	208,000	345,860	345,860	345,860	345,860
C. Fixed cost							
Land rent/ha	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Depreciation	2,700	2,700	2,700	2,700	2,700	2,700	2,700
Total fixed cost	12,700	12,700	12,700	12,700	12,700	12,700	12,700
D. Total cost ₦	296,050	220,700	220,700	358,560	358,560	358,560	358,560
E. Gross margin ₦	594,150	579,200	523,200	879,140	666,540	692,840	578,840
F. Net farm income	581,450	566,500	510,500	866,440	653,840	680,140	566,140
G Returns/₦ invested	2.964	3.567	3.313	3.416	2.823	2.897	2.579

leaves up to 24 weeks after planting, this might be as a result of the competition they experienced from the day they were planted which resulted in their slow growth. At 24 weeks after planting, the cassava intercropped at 4 weeks showed significantly lesser number of leaves compared to the sole planted and those intercropped at the same time. This is an indication that late intercropping may have effect on cassava number of leaves. The stem girth for TMS98/0581 intercropped at 4 weeks was consistently less compared to other treatment combinations; this may be as a result of competition for light. The yield obtained from the cassava showed that the yield of (TME419) intercropped with plantain at the same time was of no significant difference ($P<0.05$) with TME419 and TMS98/0581 planted sole in terms of tuber length, tuber girth, tuber weight, root biomass, and shoot biomass. TME419 was significant ($P<0.05$) in terms of performance compared to TMS98/0581 intercropped regardless of planting time and variety. The TME419 and TMS98/0581 intercropped at 4 weeks, showed a significantly low yield except in the case of tuber weight and shoot biomass for TME419, and shoot biomass for TMS98/0581 which did not differ significantly ($P<0.05$) from the sole planted and those intercropped at the same time. TMS98/0581 intercropped at the same time had a lesser root yield which was significantly different ($P<0.05$) from the sole crop, and TME419 planted at the same time. Therefore, with the result of the yield obtained from each cassava treatments, TME419 had the highest yield which may be as a result of its less competition for light due to the plant architecture, which further buttress the point made by Reddy and Willey [24] and Agele et al.[15] that plant architecture allows one intercrop to capture sunlight that would not otherwise be available to others. This is important to growth and yield of cereal and legume crops. Agele et al. [15] stated as well that the branching habit of the cassava plant is important to farmers who practice intercropping because it affects both the yield of cassava and the crop grown in association with it. Also the time of planting contributed as well to the higher yield obtained from the intercrop. Intercropping cassava with plantain at the same time gave a higher yield for the two cassava varieties (TME419 and TMS98/0581) used in this experiment, compared to intercropping at 4 weeks. This may be because there was a competition gap for the nutrient requirement stage of the two crops. This may be related to the reports of [23, 25] that intercropping system were most rewarding in terms of yield of the component crops when there was a competition gap between the periods the component crops made maximum demand on the micro environment (soil nutrient, moisture, light). The low yield recorded for TME419 and TMS98/0581 intercropped at 4 weeks was confirmed by [26] that cassava planted 3 weeks after groundnut significantly decreased cassava storage root yields as compared to cassava planted at the same time as groundnut in the cassava-groundnut intercrop, probably due to the inter specific competition for growth resources (space, moisture and nutrients) between the two crops. Plantain (sole) had the highest yield while TME 419 intercropped at the same time had the least plantain yield, and the other treatment combinations had lesser yield which differ significantly ($P<0.05$) from the yield of plantain (sole). This confirmed the report of [27]which demonstrated that intercropping with cassava reduced plantain yield relative to sole crop. The land equivalent ratio for all the treatment combinations were greater than one (>1), plantain + TME419 at same time had the highest LER 1.48, which was an indication that 48% more land would be required to obtain the same yield in sole crops as obtained in intercrop. This might be an indication that the combination will be the most compatible compared to other treatments. Plantain + TMS98/0581 at the same time had an LER 1.23 which was an indication that 23% more land will be required to obtain the same yield in sole crops as obtained in intercrop. Plantain + TME419 had an LER 1.22 which is an indication that 22% more land will be required to obtain same yield in sole crops as obtained in intercrop. Plantain and TMS98/0581 intercropped at 4 weeks had an LER 1.11 which is an indication that 11% more land will be required to obtain same yield in sole crops as obtained in intercrop. The LER obtained implies that there was a yield advantage, this confirms the reports of [15, 20] that when LER is greater than 1 or more, it signals yield advantage and a ratio less than 1, is yield disadvantage.

The ATER obtained from all treatment combinations was greater than 1, this may be an indication that the ATER obtained in all the treatment combinations was advantageous in terms of land used

and the time for which the intercrop lasted.

The cost benefit analysis revealed that intercropping plantain using TME419 at the same time had more economic advantage compared to plantain sole, TMS98/0581 intercropped at the same time and at 4 weeks had lesser return per ₦1 invested compared to TME419 intercropped at the same time and at 4 weeks. The result further revealed that planting TME419 and TMS98/0581 sole had higher return on investment compared to plantain sole, but in the long run plantain will be most profitable, because there would be little cost on maintenance before the next harvest compared to the initial cost of production.

Conclusions

The aim of this experiment to find out the cassava variety which is compatible with plantain for intercropping purpose, and the appropriate time to introduce such into the alley of plantain, as well as the effects of the intercrop on the soil nutrients. The following conclusions were reached;

TME 419 is compatible for intercrop with plantain, and the most compatible time to intercrop should be at the same time. The poor branching architecture of TME419 may explain its compatibility with plantain,

Cassava can be used as a companion crop in the first year of establishing a plantain plantation so as to maximize profit,

The result of the post planting soil analysis revealed that there was an increase in soil nutrients concentration and soil pH. This may be as a result the decomposed soil organic materials,

In the intercrop, planting cassava into plantain alley at 4 weeks may increase the dry matter yield of cassava, but may not be of advantage because of the low tuber yield,

Sole crop of plantain produced significantly higher yields compared with the intercropped, regardless of time of planting, plantain yields among the intercropped treatments did not differ significantly,

The land equivalent ratio (LER) and area time equivalent ratio (ATER) of the intercrop combinations were greater than one (>1), an indication that additional land will be required to obtain the same yield in sole crop as obtained in intercrop.

It is recommended that further research should be carried out in the same location by planting at different times of the year so as to be able to recommend most suitable of the year for sowing cassava/plantain mixtures, and a short duration leguminous cover crop can be introduced to the intercrop, this can be an additional and quick source of income as well as suppression of weeds before the cassava-plantain mixture forms complete canopy cover

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