THE INFLUENCE OF LEVELS AND MODES OF NPK FERTILIZER APPLICATION ON GROWTH AND YIELD OF SOME IMPROVED CASSAVA VARIETIES IN NSUKKA, SOUTH EASTERN NIGERIA

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A DESERTATION SUBMITTED TO THE DEPARTMENT OF CROP SCIENCE IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN CROP PRODUCTION IN THE FACULTY OF AGRICULTURE, UNIVERSITY OF NIGERIA NSUKKA

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CERTIFICATION

Muojiama, Stella Ogochukwu, a postgraduate student in the Department of Crop Science, with registration number, PG/M.SC/13/65966, has satisfactorily completed the requirements for research work for the degree of Master of Science in the Department of Crop Science (Crop Production). This work is original and has not been submitted in part or in full for any other diploma or degree of this or any other University.

Dr C.U. Agbo
(Supervisor) Date

Dr S.C. Eze
(Supervisor) Date

Professor B.C. Echezona
(Head of Department) Date

DEDICATION

This work is dedicated to God the Father, God the Son and God the Holy Spirit and to the Blessed mother Mary.

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ABSTRACT

A study was carried out at the Department of Crop Science, Faculty of Agriculture Experimental Farm, University of Nigeria, Nsukka to: (i) evaluate the growth and yield of four improved cassava varieties, (ii) determine optimum NPK fertilizer rate for increased productivity and (iii) determine the best mode of fertilizer application for increased productivity. The experiment was laid out in a randomized complete block design with three replications. Four varieties of cassava; TMS 01-1368 (yellow root), TME 419, TMS 98 05 05 and TMS 05 10, four levels of NPK fertilizer 0, 200, 400 and 600 and three modes of fertilizer application; single at 4 weeks after planting (WAP), split at 4 and 8 WAP and split-split at 4, 8 and 12 WAP were used for the study. Data were collected on the following agronomic and yield parameters: survival count, number of branches, number of leaves, plant height, stem girth, canopy diameter, tubers and garri yields (tonnes/ha). The variety TME 419 under the early establishment gave significantly ($p<0.05$) higher percentage survival count of 91 % although it was statistically similar to TMS 01 1368 (yellow root) with 90.8 %. The variety TMS 98 05 05 gave significantly ($p<0.05$) lower survival count and was statistically similar to variety TMS 05 10.The variety TMS 98 05 05 gave significantly ($p< 0.05$) higher number of leaves. TME 419 variety had significantly ($p< 0.05$) lower number of leaves in the second and fourth month after planting. Fertilizer application rate of 200 kg/ha gave significantly higher number of leaves at the second month after planting while 600 kg/ha gave significantly ($p<0.05$) higher number of leaves in the fourth month. The control gave the lowest number of leaves in both months and the single application of fertilizer gave significantly ($p<0.05$) higher number of leaves of 67 at the fourth month of crop growth. The variety TMS 98 05 05 at the early season planting gave significantly higher tuber and garri yields of 39.8 and 9.68 t/ha, respectively, at 12 months of crop growth although it was statistically similar to TMS 01 05. The rate of 200 kg/ha of NPK gave significantly ($p < 0.05$) higher tuber and garri yields of 24.69 t/ha and 5.15 t/ha, respectively at 6 months of growth. However, the rate of 400 kg/ha of NPK gave significantly ($p < 0.05$) higher tuber and garri yields of 39.4 and 10.12 t/ha at 12 months of growth. The 400 kg/ha rate of fertilizer gave similar growth and yield results when compared with 600 kg/ha rate and should be adopted because of lower production cost. Split application of fertilizer is statistically similar to split - split application and should be adopted for cassava production since it is more economical to farmers because it minimizes cost of labour for fertilizer application and reduction in total cost of cassava production. TMS 98 05 05 that showed significantly highest growth and yield measures could be adopted for production in Nsukka in order to boost cassava production.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz.) is a perennial shrub of the family Euphorbiaceae. It is a root crop that is propagated vegetatively from stem cuttings for commercial purposes but can also be propagated through seed. Cassava has been a crop of South America where the indigenous tribes learnt to extract the poisonous juice from the root for the preparation of meal (Leon, 1997). After the conquest of the Americans, the plant was taken to Africa and Asia where it became an important crop for human as well as animal consumption (Ross, 1975). The leaves and tender shoots are important source of vitamins, minerals and proteins (Balagopalan, 2002; Nweke *et al.,* 2002). It was introduced into the southern part of Nigeria during the period of slave trade proliferated by Portuguese explorers and colonizers in the sixteenth century. Nigeria is the worldǿs largest producer of cassava. The Presidential Cassava Transformation Initiative in Nigeria in 2003 sought to position cassava as a commodity crop and foreign exchange earner, beyond its traditional role as a food crop. Due to its adaptability to marginal soils and erratic rainfall, high productivity per unit of land and labour and possibility of supply throughout the year has been obtained (Nweke *et al*., 2002). The adaptation to different edapho-climatic conditions (Adeniji *et al*., 2011) makes cassava a favorite dry season crop grown in inland valleys in west and central Africa (Lahai and Ekanayake, 2009) and it is highly susceptible to excessive water (Ande, 2011). It displays an exceptional ability to adapt to climate change (Albuquerque, 1978). Cassava can grow and yield reasonably well on soil of low fertility where production of most other crops would be uneconomical (Carter *et al*, 1992). Under favorable soil and climatic conditions, fresh tuber yields of 40-60 t/ha can be obtained (IITA, 2005) It has high resistance to drought, pest and diseases conditions. Also it is suitable to store its roots for long periods underground even after they have matured. Cassava is one of the efficient producers of carbohydrates among the higher plants (Rogers and Appan, 1971). Due to tolerance of cassava to water stress, cassava is used as a famine crop in North Africa where it is the main food source during prolonged periods of drought (Purseeglove, 1954). The root of cassava is made into flours. It has other products as dry extraction of starch, glue or adhesives and modified starch, in pharmaceutical as dextrines, as processing inputs, as industrial starch for drilling and processing food (Arene, 1978). It is extensively used as filler in the manufacture of paints (Godfrey *et al.,* 2012). Interest has recently been developed in its large scale exploitation as an animal feed or as a raw material for the production of starch or power alcohol. On a worldwide basis, it is ranked as the sixth most important source of calories in the human diet (FAO, 1999). Cassava is the worldôs sixth most important crop (Lebot, 2009) and constitutes a staple food for over 700 million people (Njoku *et al*., 2010)

Depending on the varietal and ecological factors of cassava, some of the varieties are early maturing while others have longer periods to mature. The long duration of 8-24 months of cassava in the soil requires steady supply of nutrient for optimum growth and yield of the crop. However, it has been suggested that commercial cassava be established in marginal soils (Evenson and Keating, 1978). Use of fertilizers and other organic manures are limited in cassava farms as farmers always grow the crop on fallow lands (Acosta and Perez, 1954). Fallow land is expected to supply the nutrient needs of cassava. It has been reported that cassava extracts large amounts of nutrients from the soil especially K and N and continuous cultivation without adequate fertilization would lead to soil depletion and reduced yield (Kurmarohita, 1978). Cassava removes about 55 kg/ha N, 132 kg/ha P and 112 kg/ha K (Howeler, 1991)

Based on the foregoing, it is important to determine NPK fertilizer requirement and best mode of application for increased cassava productivity in improved cassava varieties.

Hence, the objectives of the study were to:

1. evaluate growth and yield of four improved cassava varieties
2. determine optimum NPK fertilizer rate for increased productivity, and
3. determine the best mode of fertilizer application for increased productivity.

LITERATURE REVIEW

Botany of Cassava

Cassava (*Manihot esculenta* Crantz) is a perennial shrub of the Family Euphorbiaceae cultivated mainly for its starchy roots. Cassava is a monoecious species producing both male (Pistillate) and female (staminate) flowers on the same plant.

Cassava can be propagated from either stem cuttings or biological seed, but the former is a common practice. Propagation from true seed occurs under normal conditions and is widely used in breeding programmes. Plants from true seeds take longer time to become established, and they are smaller and less vigorous than plants from stem cuttings. It reaches the height of 1-4m. It is a dicotyledoneous crop. The manihot genus is reported to have about 100 species, among which the only commercially cultivated is the *Manihot esculenta*. There are two distinct plant types and they are the erect which is with or without branching at the top or the spreading types. The morphological characteristics of cassava are highly variable which indicate a high degree of inter-specific hybridization.

Production area of cassava

In Nigeria, Cassava production is well developed as an organized agricultural crop. It is produced in 24 states of the 36 states in Nigeria (USAID, 2013). Cassava production dominates the southern part of the country. The major states that produce cassava include Anambra, Imo, Delta, Edo, Benue, Cross River, Oyo and Rivers and to a lesser extent Kwara and Ondo (IITA, 1992).

In the year 1999, Nigeria produced 33 million tonnes (IITA, 2013) while a decade later, it produced approximately 45 million tonnes, which is almost 19 % of production in the world (Adekanye *et al*., 2013). As of the year 2000, the average yield per hectare was 10.6 tonnes (IITA, 2013). It displays an exceptional ability to adapt to climate change (CGIAR, 2012).

Importance of Cassava

Cassava is one of the most important food staples in the tropics. It is estimated that 250 million people in sub-Saharan Africa derive half of their daily calories from cassava being the second most important food staple and supplier of calories after maize (Nweke, 2004; FAO, 2005; Anyaegbunam *et al*., 2010). Production figures ranked Nigeria as the leading producer of cassava in the world (FAO, 2004; Yakasi, 2010) and puts ready money and food in the very vulnerable segments of society of the country. The tubers are mostly processed into cassava flour, garri and fufu in Nigeria. It can also be cooked or eaten pounded and consumed in its raw form, most especially the sweet variety (Ogundari and Ojo, 2007).

Prior to the pronouncement of the Presidential Initiative on Cassava in Nigeria in 2002, several organizations had contributed to the development and improvements on the cassava commodity. The Nigeriaôs presidential initiative on Cassava production is one of the strategies of the past Federal Governmentôs National Economic Empowerment and Development Strategy (NEEDS) whose objective was to generate 3 billion from agricultural exports (National Planning Commission, 2005). Given these various cassava programmes and policies implemented over the years by the government to raise the efficiency of cassava farmers, it is expedient to examine the technical efficiency of farmers and its relationship with socio-economic variables of cassava farmers. This will unequivocally guide policy makers in making policy that will improve the welfare and standard of living of cassava farmers through increased efficiency in the use of available resources. It is noted that poverty reduction can be attained in sub-Sahara Africa by improving the technical and economical efficiencies of food production in crops such as Cassava (IITA, 2004), Cassava products are used in various forms for human consumption, livestock feed, and manufacturing of industrial products (Ene, 1992). Cassava contains about 92.2 percent carbohydrates and 3.2 percent protein in its dry matter, and is said to have high energy content. According to IITA (1990), cassava products are also important feed stuff for livestock formulation. For example, cassava has a capacity of substituting up to 44 percent maize in pig feed without any reduction in the performance of pigs. Okeke (1998) also observed that in compounding feed for pigs, broiler, pullets and layers, cassava meal plays a significant role.

Eagleston *et al.* (1992) provided evidence that the whole cassava plant, boiled root, cassava root meal, chips and pellets could be used in compounding livestock feed. The root could be dried, ground and fed to ruminants and it could be used as substitutes for maize in poultry feed. Many Governments have, or are considering, mandatory blending of mostly imported wheat flour with domestically produced cassava flour in bread making. Nigeria recently raised its levy on wheat floors to 100 percent, and will use revenue for a Cassava bread development fund. It has also announced plans to substitute 10 percent of the maize in poultry feed with Cassava grits which will increase annual demand for cassava roots by 480 000 tonnes.

In East Africa, the animal feed industry is turning to cassava, as maize and wheat become increasingly unaffordable. Today, the amount of food available per person on a global basis is 18 percent higher than 30 years ago. Most developing countries benefited from this development with the result that their nutrition has witnessed very tremendous improvement. As impressive as this improvement is, about 80 million people worldwide still suffer from chronic hunger; and one quarter of this population resides in Africa. The situation gets worse every year and can lead to a catastrophe if it is not possible to increase food supply at a rate faster than that at which the world population increases (Knirsh, 1996). Cassava is a chief source of dietary food energy for the majority of the people living in the low-land tropics, and much of the sub-humid tropics of west and central Africa (Tsegai *et al.,* 2002). Therefore, its production and utilization must be given prime attention in food policy. Ezedinma *et al.*, (2006) noted that farmers have not yet attained the desired technical efficiency in Cassava production as a result of weak access to external inputs such as fertilizers and herbicides. The wide scale adoption of high yielding varieties and the resulting increase in yield have shifted the problem of the cassava sector from supply (production) to demand issues such as finding new uses and markets for cassava. The government of Nigeria considers transition from the present status of usage to the level of industrial raw material and livestock feed as a development goal that can spur growth with increase in employment. This consideration underscores the various research and policy initiatives in cassava improvement, Approximately 16 percent of cassava root production was utilized as chips in animal feed, 5 percent was processed into a syrup concentrate for soft drinks and less than 1 percent was processed into high quality cassava flour used in Biscuits and confectionary, dextrin, adhesives, starch and hydrolysates for pharmaceuticals and seasonings (Ene, 1992)

At present, a wide range of traditional cassava forms such as garri, fufu, starch, abacha *etc*. are produced for human consumption (Kormawa and Akoroda, 2003). In view of the renewed emphasis on cassava production (supply), processing and utilization in Nigeria, it becomes necessary to assess the production, demand and utilization pattern of cassava, and its prospects especially in combating hunger and raising food security among vulnerable groups including women and infants.

Cassava meal is highly digestive and naturally contaminated with lactic acid bacteria and yeast, which improves the micro-flora in the digestive tract of animals. At low level, hydrogen cyanide of an enzyme, lactoperoxidase, which is a natural anti-biotic that kills mycotoxins in the animalȏs body and milk. Animals raised on cassava diets have generally good health, good disease resistance and a low mortality rate. They require few if any antibiotics in their feed. Both the roots and leaves of the cassava plant can be used as on-farm animal feed or as an ingredient in commercial animal feed. Because of their high cyanide content, however, fresh roots or leaves can be fed to animals only in very small quantities. Cassava roots are chipped or sliced, while leaves are chipped into small pieces. Before being fed to animals, the cassava pieces are spread out on a floor overnight in order to release some of the cyanide by evaporation. The root chips and leaf pieces can also be sun-dried to 12 to 14 percent moisture content, then stored for future use. Alternatively, the chipped pieces of roots and leaves can be packed tightly in plastic bags or air-tight container and fermented to make silage. Both sun drying and ensiling will release most of the cyanide, making those products safe as feed for pigs, cattle, buffaloes and chickens.

Cassava is a perennial crop that has a storage root which can be harvested from 6 to 24 months after planting (MAP), depending on the cultivar and the growing conditions (El-sharkawy, 1993). In the humid lowland tropics, the roots can be harvested from 6 to 7 months after planting. In regions with prolonged period of drought or cold, the farmers usually harvest after 8- 24 months (Cock, 1984). Moreover, the roots can be left in the ground without harvesting for a long period of time, making it a very useful crop as a security against famine.

Cassava genotypes/collections and morphological descriptors

There are many Cassava cultivars in several germplasm banks held at both international and national research institutions. The largest germplasm bank is located at Centro International de Agricultura Tropical (CIAT), Columbia, with approximately 4700 accessions (Bonierbale *et al.*, 1997) followed by EMBRAPAôs collections in cruz das Almas, Bahia, with around 1700 accessions (Fukuda *et al.,* 1997).

The Cassava genotypes are usually characterized on the basis of morphological and agronomic descriptors. In the recent past, the International Plant Genetic Resource Institute (IPGRI) defined 54 and 21, morphological and agronomic descriptors respectively (Fukuda *et al.,* 1997). Morphological descriptors (for examples lobe, shape, root pulp colour, stem external colour) have a high heritability than agronomic (such as root length, number of root length, number of root per plant and root yield). Among morphological descriptors, the following were defined as the minimum or basic descriptors that should be considered for identifying cultivars: apical leaf colour, apical leaf pubescence, central lobe shape, petiole colour, stem cortex colour, stem external colour, phyllotaxis length, root external colour, root peduncle presence, root cortex colour, root pulp colour, root epidermis texture and flowering.

Given the large number of cassava genotypes cultivated commercially and the large diversity of ecosystem in which cassava is grown, it is difficult to make a precise description of the morphological descriptors as there is a genotype- by- environment interaction. Thus in addition to morphological characterization, molecular characterization, based mainly on DNA molecular markers, has been very useful in order to evaluate the germ plasm genetic diversity (Beeching *et al.,* 1993; Fregene *et al.,* 1994).

Roots are the main storage organ in cassava. These roots develop to make a fibrous root system. Only a few fibrous roots (between three and ten) start to bulk and become storage roots. Most of the other fibrous roots remain thin and continue to function in water and nutrient absorption. Once a fibrous root becomes a storage root, its ability to absorb water and nutrients decrease considerably. The storage root result from secondary growth of the fibrous roots, thus the soil is penetrated by thin roots and their enlargement begins only after that penetration has occurred. Anatomically, the cassava root is not a tuberous root but a true root which cannot be used for vegetative propagation. The mature cassava storage root has three distinct tissues; bark (periderm), peel (or cortex) and the parenchyma which is the edible portion of the fresh root and comprises approximately 85% of total weight. The root size and shape depend on the cultivar and environmental conditions; variability in size within a cultivar is greater than that found in other root crops (Wheatley and Chuzel, 1993)

Genotypic Selection for Higher Crop Productivity

Low productivity has been reported in cassava based system in the tropics and also in south eastern Nigeria (Okigbo and Greenland, 1976; Leinhner, 1983; Ezeilo, 1974; Nweke *et al.,* 1994; Okeke, 1984). Some of the factors causing low productivity are the use of species unsuitable for cropping, in-appropriate planting date and planting density, cropping pattern, low soil fertility and absence of or deficient phytosanitary measures. In recent years, agronomic interventions such as planting date, plant spacing, cropping patterns and soil fertility studies have been made to address these problems (Ikeorgu *et al*.,1984); Odurukwe and Ikeorgu, 1994; Okeke, 1996; Udealor, 2002) Hitherto, genotype selection for intercropping system has been less considered, even though, identification of suitable genotype has been stressed as one of the major ways of improving intercrop productivity (Francis, 1981). Presently, the farmers are growing cassava land races and very few elite genotypes. The land races are characterized by low yield sometimes due to their susceptibility to disease and other pests, which often result in total crop failure. The popular elite genotypes such as TMS 98 05 05 which is moderately resistant to disease and other pest have bushy canopy at peak vegetative stage and gives higher yield.

Diseases of Cassava

There are many diseases which affect cassava and causes reduction in yield thereby affecting the economy (Onwueme and Sinha, 1999)

They include:

1. African cassava mosaic disease (ACMD): This disease is caused by a virus through a vector known as *Bemisia tabacci* by its feeding habit on cassava leaves and the control

involves the use of resistant varieties, use of healthy planting material, roguing of the affected plant.

2. Cassava bacterial blight (CBB): This is caused by a bacterium (*Xanthomonas campestris* pv. Manihotis). This disease can be controlled by the use of resistant varieties, roguing of plants, fallowing, crop rotation, use of healthy planting material and through quarantine measures.
3. Cassava bud necrosis: Bud necrosis is a fungal disease and can be controlled through planting of healthy materials, good farm practice, and destroying the host range.
4. Brown and white leaf spot disease: This is relatively minor disease of cassava caused by fungi.
5. Root rot disease: This disease can be controlled by site and land selection, disease resistant or tolerant varieties, quarantine measure, good farm sanitation, early harvesting, crop rotation, fallow, clean farm tools, Avoid planting cassava as the first crop after clearing woodland or forest.

Nutritional Needs of the Soil

Water stress has negative influence on cassava tuber yield El-sharkawy (1998) reported that early and mid-season stress significantly reduce top and root biomass than late or terminal stress which occurred during tuber maturity in cassava.

To increase the yield potential of cassava, the crop has been reported to respond to good soil fertility and adequate fertilizer (Gomez *et al*., 1980; Wilson and Ovid,1994; Howeler, 1996). Farmers do not fertilize cassava because they are contented with the minimal yields obtained from using limited inputs or even from their infertile soils. The indifference towards low productivity can be attributed to the low and unstable prices of cassava tubers. However, fertilizer requirement for optimum yield in cassava is determined by the following factors; soil fertility status of the farm land, cropping system adopted and the rainfall pattern during the growing season. Rainfall in the rain forest areas of Nigeria is erratic, unpredictable and it is the most critical factor that determines yield in rain-fed agricultural system.

Rainfall is usually high and this washes fertilizers away making them unavailable to plants (Ofori, 1976) The major nutrient required by cassava for optimum top growth and tuber yields are nitrogen (N) and potassium (K) (Obigbesan and Fayemi 1976; Howeler 1991). Soils that have low N (<0.10% total N) and K (<0.15 meg/100g) will require an additional fertilizer for optimum tuber yield (Kang and Okeke, 1991). Adequate K levels in the soil stimulate response to N fertilizers but excess amount of both nutrient leads to luxuriant growth at the expense of tuber formation (Sanchez 1976, Onwueme and Charles

1994; Wilson and Ovid 1994; Rao *et al*., 1986). Cropping systems influence fertilizer requirements of cassava for example, the continuous cropping of cassava leads to fast depletion of major nutrient especially N and K and will require fertilizer supplement to give stable yield (Kang and Okeke, 1991). Farmers seldom cultivate Cassava continuously on the same land in south-western Nigeria but plant yams as the first crop after a two or three year fallow. Farmers generally consider that cassava exhausts the soil and therefore prefer to plant it as the last Crop in a rotation before returning the land to bush fallow (Annon, 1973). Sittibusaya and Kurmarohita (1978) reported that after 15 years of continuous Cassava production without fertilization in south east Thailand, yields dropped from an initial level of 30 t/ha to only 17 t/ha. When these exhausted soils were fertilized with 373 kg or 164 kg and 312 kgk/ha, yield increased from 22 to 41 t/ha.

In Indonesia, Doop (1937) found that three successive cassava plantings without applying K decreased yields from 15 to 4 t/ha. Various long term experiments have shown that if adequate fertilizer is applied, good yields of continuously grown cassava can be maintained (Birkinshaw, 1926; Hongsapan, 1962). After 15 years of consecutive well-fertilized cassava, a subsequent rubber crop produced excellent yield in Malaysia (Birkinshaw, 1926). Hongsapan, (1962) considered that per ton of food produced, cassava depletes soil nutrient reserves less than maize, sugar cane, bananas or cabbage, on a per crop basis, however, cassava extracts more nutrients than most other tropical crops. According to Prevot and Ollagnier (1958) among tropical crops cassava extracts the largest amount of K from the soil as it has the highest K/N ratio in the harvested product.

Besides nutrients extraction by the crop, soil fertility may deteriorate due to erosion since cassava tends to enhance soil erosion, especially during planting and after harvest. Gomez (1975) calculated an erosion index of 9.8 for cassava as compared with 1.0 for pasture, 1.1 for sugar cane, 1.7 for pineapple and 11.8 for coffee in a volcanic ash soil with 60 % slope in Columbia. Unfortunately, cassava is often the only crop that will still grow on severely eroded slopes, thereby accelerating erosion even further. This practice should be limited as much as possible or combined with erosion control practices such as minimum tillage, contour planting and the use of mulch or cover crops (IITA, 1976).

MATERIALS AND METHODS

Experimental site

The study was conducted at the Teaching and Research Farm of the Department of Crop Science, University of Nigeria, Nsukka. Nsukka is located at Latitude 06^o54^o N, Longitude $07^0 24$ E and altitude of 447 m above sea level. The soil is broadly characterized as sandy clay loam ultisol (oxic paleudult) and belongs to Nkpologu series (Mbagwu, 1992).

Materials

Four cassava varieties used for the study were: TMS 01 1368 (yellow root), TME 419, TMS 98 05 05 and TMS 05 10. They were obtained from the National Root Crops Research Institute (NRCRI), Umudike (Table 1).

The fertilizer used was NPK_mg 12-12-17-2 and was obtained from fertilizer dealers.

Table 1: Characteristics of the four cassava varieties used for the study were:

S/No	Varieties	Descriptors
1.	TMS 01 1368	Duration: 12 Months Growth habit: erect with mixed branching pattern Petiole colour: light lemon Flesh root colour: yellow Yield/Ha : 31.4 tons/ha
2.	TME 419	Duration: 6-8 Months Growth habit: straight Petiole colour: - Flesh root colour: white Yield/Ha : 32.5 tons/ha
3.	TMS 98 05 05	Duration: 12 Months Growth habit: erect with profuse branching pattern Petiole colour: green purple Flesh root colour: white Yield/Ha : 45 tons/ha
4.	TMS 05 10	Duration: 12 Months Growth habit: erect Petiole colour: red Flesh root colour: white Yield/Ha : 30 tons/ha

Seasons of Cassava planting

The early season cassava was planted in May, 2014 at the stabilization of rainy season while the late season was planted in July, 2014 at the mid - month of rainy season.

Land preparation

The experimental plot measuring 107 m × 23 m was ploughed, harrowed, ridged and was divided into three blocks. Each block was sub-divided into 48 plots each with a dimension of 5 m ɉ 2 m and was folded into three places of 16 plots each.

Soil samples were collected at random from three representative locations by augering to the depth of 20 cm with a steel auger. The samples were bulked together and the composite samples were taken for laboratory analysis to determine the physical and chemical characteristics of the site.

Experimental Design

The experiment was 4x4x3 factorial laid out in randomized complete block design (RCBD) with 3 replications. The treatments were four varieties of cassava (namely: TMS 01 1368 (yellow root), TME 419, TMS 98 05 05 and TMS 05 10) and four levels of NPK fertilizer at 0 kg/ha, 200 kg/ha, 400 kg/ha and 600 kg/ha and three modes of fertilizer application as single at 4 weeks after planting, split at 4 and 8weeks after planting and split-split at 4, 8 and 12 weeks after planting. There were total of 48 treatment combinations that were randomized in each of the blocks. The plots were labelled appropriately for ease of identification of treatment applied.

Planting

Healthy stem cuttings of the stated cassava varieties obtained from National Root Crops Research Institute, Umudike were cut with 4-6 nodes where two nodes were exposed above the soil surface and were planted on the ridges at 1m by 1m spacing. Each plot contained 10 stands of cassava cuttings according to the treatment combinations allocated to it.

Fertilizer Application

NPK_mg 12-12-17-2 fertilizer was applied by band placement method. The levels 0 kg/ha, 200 kg/ha, 400 kg/ha and 600 kg/ha and the modes of application (single, split, and split-split) was applied to the allocated plots.

Weed control: The field was weeded three times manually during the period of the research.

Data collection

Data were collected on the following agronomic and processed parameters:

Survival count, number of branches/plant, number of leaves, plant height, stem girth, canopy diameter, tuber and garri yields/ha.

Methods of data collection

1. After 3 weeks of planting, the surviving sprouted stems were counted to ascertain the plant population per plot.
2. Number of branches was counted on monthly basis to note the architecture and branching types from 2 months after planting on four plants per plot.
3. Plant height was measured in centimeters on monthly basis with a meter rule on 4 plants per plot.
4. Number of leaves was counted on monthly basis upto the fourth month using 4 plants per plot.
5. Stem girth was measured at 4 months after planting when the stem is of good size to be measured in mm using Vernier calipers on 4 plants per plot.
6. Canopy diameter was taken to get the area covered by the leaves in cm using 4 plants per plot.
7. Tuber yield measurement was taken in weight at three different sampling periods i.e. at 6 months, 9 months, and 12 months after planting by destructive sampling of two plants in each plot at each period.
8. Garri yields: Tubers harvested at 6, 9 and 12 months were processed into garri at the Faculty of Agriculture, Garri Processing Plant situated at the farm operations unit. The tubers was peeled, washed, grated, sieved and fried into garri and weighed.

Agromet Data

Rainfall, Relative Humidity and Temperature data were collected from the Meteorological Station of the Department of Crop Science, University of Nigeria Nsukka.

STATISTICAL ANALYSIS

The data collected were analyzed according to the procedure outlined by Gomez and Gomez (1984) for a factorial experiment laid out in a randomized complete block design. The computer software used was Genstat (R) version 3.0.

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RESULTS

The bimodal peaks of rain in 2014 were in June (271.79 mm) and September (401.99 mm) (Table 2). The amount of rain in August and December of 2014 were low. There was no rain in June, 2015 and the subsequent months of February to April were low (34-56 mm in a month)

Table 2: Meteorological data for the cropping seasons of 2014 and 2015

2014

		Temperature (^{0}C)		Relative Humidity (%)	
Month	Rainfall (mm)	Min	Max	10am	4pm
April	105.16	22.30	31.30	69.93	70.53
May	241.14	21.06	28.29	72.26	72.26
June	271.79	20.87	29.13	72.00	72.00
July	195.81	20.90	27.74	72.19	72.19
August	92.36	20.71	27.29	73.00	73.00
September	401.99	20.33	27.90	73.00	73.00
October	211.08	20.84	28.90	73.00	72.77
November	77.22	21.00	30.07	73.80	71.97
December	4.83	19.03	30.65	70.58	70.06
Total	1601.38	187.04	261.27	649.7	647.78
Mean	177.93	20.78	29.03	72.20	71.98

2015

		Temperature (^{0}C)		Relative Humidity (%)	
Month	Rainfall (mm)	Min	Max	10am	4pm
January	Nil	20.52	30.32	61.42	59.58
February	56.64	22.68	32.04	70.11	64.21
March	34.80	22.61	32.29	70.61	70.19
April	39.63	22.40	31.47	71.03	67.67
May	267.98	21.81	30.71	71.65	71.42
June	121.43	21.17	29.07	76.00	76.00
July	110.49	20.61	27.87	76.00	76.03
August	410.4	20.43	27.69	76.00	76.10
Total	630.97	151.80	213.77	496.82	485.1
Mean	90.14	21.69	30.54	70.97	69.30

Source: Meteorological Station, Department of Crop Science, University of Nigeria, Nsukka.

Physico-chemical Properties of the experimental Sites before planting in 2014

The textural class of the site of the early season planting was loamy sand while the site of the late season planting was sandy loam (Table 3). The soil of the experimental sites was highly acidic with pH in H_20 and KCL of 4.7 and 3.8 for the early planting and 4.8 and 3.7 for the late season planting, respectively. The soil was also characterized by low organic matter, exchangeable bases and cation exchange capacity (CEC).

Table 3: Physical and chemical properties of the soil of the experiment

Properties		Early Season Site	Late Season Site
Particle Size Distribution (%)			
Clay		10	14
Silt		5	7
Fine Sand		33	43
Coarse Sand		52	36
Textural Class		Loamy Sandy	Sandy Loam
Chemical Properties			
pH(H_2O)		4.7	4.8
pH(KCL))		3.8	3.7
Organic Carbon(%)		0.95	1.25
Organic Matter(%)		1.63	2.15
Total nitrogen(%)		0.084	0.098
Exchange bases (Meq/100g Soil)			
Sodium	(Na+)	0.12	0.15
Potassium	(K+)	0.15	0.19
Calcium	(Ca+)	11.4	13.2
Magnesium	(Mg+)	0.4	2.4
Cation Exchange Capability (Meq/100g Soil)		13	16.4
Base Saturation (%)		92.85	97.2
Phosphorus (ppm)		6.53	3.73
Exchangeable Acidity (Meq/100g Soil)			
Aluminium Oxide (AL+)		-	-
Hydrogen Oxide (H+)		2.4	2.4

- = Not detected

The variety TME 419 under the early establishment gave significantly ($p<0.05$) higher percentage survival count of 91 % although it was statistically similar to TMS 01 1368 (yellow root) with 90.8 % (Table 4). The variety TMS 98 05 05 gave significantly ($p<0.05$) lower survival count and was statistically similar to variety TMS 05 10.The variety TMS 98 05 05 gave significantly ($p< 0.05$) higher number of leaves. TME 419 variety had significantly ($p< 0.05$) lower number of leaves in the second and fourth month of planting. Fertilizer application rate of 200 kg/ha gave significantly higher number of leaves at the second month after planting while 600 kg/ha gave significantly ($p<0.05$) higher number of leaves in the fourth month. The control gave the lowest number of leaves in both months and the single application of fertilizer gave significantly ($p<0.05$) higher number of leaves at the fourth month of crop growth. TMS 98 05 05 gave the highest number of branches at two months after planting(MAP) and it was significantly ($p< 0.05$) higher than other varieties. The rate and mode of fertilizer application did not cause any significant differences in the number of branches of the cassava varieties over the four months after planting in the early season planting. However, 400 kg rate gave higher number of branches at four MAP. At the fourth MAP, the number of branches/plant was statistically similar across the varieties, rates and modes of fertilizer application.

Table 4: Survival count (%) and number of leaves and branches of the early season planted cassava varieties as influenced by rates and modes of fertilizer application at four Months after planting (MAP)

Treatments	Survival count (%)	Number of leaves/Plant		Number of branches/Plant	
		Months after planting			
Varieties		2	4	2	4
TMS 0I 1368	90.8	10.55	71.80	1.84	3.54
TME 419	91.1	10.05	38.10	1.73	3.09
TMS 98 05 05	80.6	14.78	84.90	2.18	3.64
TMS 05 10	84.2	11.78	44.30	1.79	2.92
LSD(p<0.05)	4.5	0.85	6.01	0.26	NS
Rates					
0		10.27	54.20	1.77	3.33
200		12.54	56.90	1.98	2.87
400		12.17	61.70	1.91	3.61
600		10.47	65.30	1.87	3.38
LSD(p<0.05)		0.85	6.01	NS	NS
Modes					
Single		11.40	67.30	1.91	3.37
Split		11.85	54.60	1.90	3.10
Split-Split		12.12	57.40	1.84	3.42
LSD(p<0.05)		NS	5.21	NS	NS

NS = non - significant

In the late season planting, variety TMS 98 05 05 gave significantly higher survival count of 70.6 % (table 5). The survival count in the later season was generally reduced when compared with the earlier planting. The variety, TMS 98 05 05 also gave significantly higher number of leaves and branches at the late season planting. Fertilizer application rate of 200 kg/ha and 600 kg/ha gave significantly higher number of leaves at 2 and 4 MAP, respectively. Single fertilizer application gave non-significant number of leaves at 2 and 4 MAP. At 4 MAP, the number of branches/plant was statistically similar across the varieties, rates and modes of fertilizer application.

Table 5: Survival count (%) and number of leaves and branches of the late season planted cassava varieties as influenced by rates and modes of fertilizer application at four Months after planting (MAP)

Treatments	Survival count (%)	Number of leaves/Plant		Number of branches/Plant	
		Months after planting			
Varieties		2	4	2	4
TMS 0I 1368	62.8	8.55	61.80	1.44	3.24
TME 419	61.1	7.05	28.40	1.35	3.09
TMS 98 05 05	70.6	12.58	74.60	2.00	3.33
TMS 05 10	64.2	8.80	34.60	1.35	2.22
LSD(P<0.05)	1.5	0.85	5.01	0.26	NS
Rates					
0		8.25	45.20	1.12	3.00
200		10.52	48.90	1.00	2.11
400		10.14	52.70	1.00	3.21
600		9.45	55.30	1.31	3.08
LSD(P<0.05)		0.85	6.01	NS	NS
Modes					
Single		10.40	50.30	1.01	3.16
Split		9.85	49.30	0.98	3.10
Split-Split		9.12	47.40	1.04	3.02
LSD(P<0.05)		NS	NS	NS	NS

NS = non - significant

TMS 98 05 05 variety gave significantly ($p<0.05$) higher canopy diameter at the 10 and 12 MAP (Table 6). The variety also gave significantly higher stem girth at the 6 and 8 MAP. The fertilizer rate of 400 kg/ha gave non-significant higher canopy diameter at 8, 10 and 12 MAP. Single dose of fertilizer gave non-significant higher stem girth and canopy diameter at 6 and 8 MAP, respectively.

Table 6: Influence of cassava varieties x rates x modes of fertilizer application on their canopy diameter and stem girth at twelve Months after planting (MAP) of the early season planting

Treatments	Canopy diameter(cm)			Stem girth(mm)			
	Months after planting						
	8	10	12	6	8	10	12
Varieties							
TMS 0I 1368	96.70	101.50	103.20	3.65	4.01	4.55	5.66
TME 419	113.60	114.70	116.00	4.01	4.48	4.56	6.07
TMS 98 05 05	112.70	115.40	121.70	4.35	4.97	5.06	5.78
TMS 05 10	100.00	101.0	105.70	4.12	4.37	4.39	6.00
LSD(P<0.05)	NS	11.39	15.06	0.43	0.53	NS	NS
Rates							
0	101.90	104.50	107.70	4.22	4.52	4.56	5.62
200	101.30	103.80	105.40	4.26	4.54	4.45	5.42
400	115.90	117.00	120.20	4.23	4.48	4.92	6.31
600	108.80	110.20	114.20	3.72	4.29	4.63	6.12
LSD(P<0.05)	NS	NS	NS	NS	NS	NS	NS
Modes							
Single	109.90	110.20	110.90	4.32	4.51	4.54	5.95
Split	105.60	105.80	107.50	4.25	4.59	5.06	6.06
Split-Split	104.50	105.20	111.30	4.01	4.27	4.33	5.62
LSD(P<0.05)	NS	NS	NS	NS	NS	NS	NS

NS = non - significant

The variety TMS 98 05 05 showed higher canopy diameter and stem girth throughout the months of growth (Table 7). TMS 01 1368 showed non ï significant lower canopy diameter from 8 to 12 months after planting. There were non ï significant effect of the rates and modes of fertilizer application on the canopy diameter stem girth of the varieties over the months of the growth. However, 400 kg/ha of NPK 12-12-17-2 fertilizer gave higher canopy diameter and stem girth at 12 MAP.

Table 7: Influence of cassava varieties x rates x modes of fertilizer application on their canopy diameter and stem girth at twelve Months after planting (MAP) of the late season planting

Treatments	Canopy diameter(cm)			Stem girth(mm)			
	Months after planting						
	8	10	12	6	8	10	12
Varieties							
TMS 0I 1368	60.40	71.50	73.20	2.85	3.01	3.53	3.66
TME 419	73.60	72.70	76.00	3.01	3.48	3.56	3.67
TMS 98 05 05	73.70	75.40	78.70	3.35	3.67	3.76	3.78
TMS 05 10	60.00	71.20	75.70	3.12	3.27	3.39	3.40
LSD(P<0.05)	NS	NS	NS	NS	NS	NS	NS
Rates							
0	60.60	61.50	62.70	3.02	3.12	3.56	3.62
200	71.30	73.80	75.40	3.26	3.54	3.45	3.42
400	72.40	81.00	85.20	3.23	3.48	3.92	3.91
600	72.80	80.20	84.20	3.52	3.29	3.63	3.62
LSD(P<0.05)	NS	NS	NS	NS	NS	NS	NS
Modes							
Single	89.20	80.20	81.90	3.12	3.51	3.42	3.55
Split	75.60	75.80	85.50	3.25	3.49	3.60	3.26
Split-Split	74.50	75.20	86.30	3.01	3.27	3.33	3.62
LSD(P<0.05)	NS	NS	NS	NS	NS	NS	NS

NS = non - significant

TMS 01 1368 variety gave significantly (p<0.05) higher plant height at 2 MAP but TMS 98 05 05 gave significantly (p<0.05) higher plant height at 6 and 12 MAP (Table 8). 400 kg rate of NPK gave significantly higher plant height at 4 and 6 months after planting and 600 kg fertilizer rate gave significantly(p<0.05) higher plant height while 400 kg rate of NPK gave significantly lower yield at 2 MAP.

Table 8: Plant Height of the early season cassava varieties as influenced by rates and modes of fertilizer application

Treatments	Plant Height (cm)					
	Months after planting					
Varieties	2	4	6	8	10	12
TMS 0I 1368	9.33	52.80	103.70	114.20	116.40	122.10
TME 419	6.11	55.90	123.40	129.90	132.70	137.30
TMS 98 05 05	8.50	56.90	134.00	138.30	142.30	148.50
TMS 05 10	5.56	49.50	81.50	111.00	114.90	121.90
LSD(p<0.05)	0.67	NS	8.24	NS	NS	15.79
Rates						
0	7.67	41.70	84.20	90.80	92.90	97.70
200	7.75	48.30	109.50	111.10	113.80	117.50
400	6.88	58.40	118.50	118.20	121.20	136.90
600	7.19	56.70	110.40	117.30	115.50	125.80
LSD(p<0.05)	0.67	8.20	8.24	NS	NS	12.43
Modes						
Single	7.71	52.80	107.90	115.60	118.50	122.70
Split	7.19	55.30	114.80	118.90	121.40	131.40
Split-Split	7.22	53.30	109.20	113.00	112.90	123.10
LSD(p<0.05)	NS	NS	NS	NS	NS	NS

NS = non - significant

The variety TMS 98 05 05 at the early season planting gave significantly higher tuber and garri yields of 39.8 and 9.68 t/ha, respectively at 12th months of crop growth although it was statistically similar to TMS 01 05 (Table 9). The rate of 200 kg/ha of NPK gave significantly ($p < 0.05$) higher tuber and garri yields of 24.69 t/ha and 5.15 t/ha, respectively at 6 months of growth. However, the rate of 400 kg/ha of NPK gave significantly ($p < 0.05$) higher tuber and garri yields of 39.4 and 10.12 t/ha at 12 months of growth. Split-split application of NPK fertilizer gave highest yield of tuber and garri at 12 Months of growth. Significantly higher peel weight of 8.94 t/ha was obtained in TME 419 at 6 MAP as well as non-significant higher peel weight of 6.25 t/ha at 9 MAP. At 12 MAP, TMS 98 05 05 gave significantly higher peel weight of 9.36t/ha.

Table 9: Harvest index and garri yield of the early season planted Cassava Varieties as influenced by rates and mode of NPK fertilizer application

Treatments	Tuber Yield (t) /ha			Peel wt(t)/ha			Garri yield (t) /ha		
	Months after planting								
	6	9	12	6	9	12	6	9	12
Varieties									
TMS 01 1368	19.83	18.74	30.20	7.94	5.68	8.08	3.79	4.24	6.62
TME 419	19.17	20.58	26.70	8.94	6.25	6.81	3.79	5.44	7.31
TMS 98 05 05	24.06	22.43	39.80	8.86	5.42	9.36	4.72	4.94	9.68
TMS 05 10	21.28	22.50	31.70	6.97	5.79	7.12	4.29	5.83	8.33
LSD(P<0.05)	3.17	NS	5.62	1.37	NS	1.44	0.66	1.78	1.40
Rates									
0	16.25	14.10	19.30	5.83	4.18	4.19	2.90	3.46	4.35
200	24.69	21.43	31.00	9.44	5.79	8.71	5.15	5.36	7.76
400	21.69	25.62	39.40	8.78	6.97	9.24	4.40	5.97	10.13
600	21.69	23.10	38.70	8.67	6.19	9.24	4.14	5.67	9.71
LSD(P<0.05)	3.17	3.30	5.62	1.37	1.06	1.44	0.66	1.03	1.40
Modes									
Single	21.94	20.05	30.00	8.46	5.69	7.66	4.03	4.66	7.14
Split	22.67	21.34	32.10	8.71	5.82	8.05	4.77	5.38	8.29
Split-Split	18.65	21.79	34.20	7.38	5.84	7.82	3.65	5.31	8.48
LSD(P<0.05)	2.74	NS	NS	NS	NS	NS	0.57	NS	NS

NS = non - significant

The variety TMS 98 05 05 gave significantly ($p<0.05$) higher tuber and garri yields at the sixth month of test period of the late planting season (Table 10). The variety also had higher non significant yield at the twelvth months of harvest. TME 419 gave higher garri yield at the nineth month. Fertilizer application at 400kg/ha gave higher tuber and garri yields at nineth and twelvth month of harvest. Application of 200kg/ha of NPK fertilizer gave significantly higher tuber and garri yields at the sixth month of harvest. Split method of fertilizer application gave significantly higher tuber yield but non significant higher garri yield at the sixth month of harvest. Split ï split fertilizer application gave non significant higher tuber and garri yields at 12 MAP. There was about 50% reduction in tuber and garri yields in the late planting when compared to the early one.

Table 10: Harvest index and garri yield of the late season planted Cassava Varieties as influenced by rates and mode of NPK fertilizer application

Treatments	Tuber Yield (t) /ha			Peel wt(t)/ha			Garri yield (t) /ha		
	Months after planting								
	6	9	12	6	9	12	6	9	12
Varieties									
TMS 01 1368	10.73	11.54	20.20	3.94	4.28	5.08	1.29	2.32	3.48
TME 419	10.17	10.58	16.70	4.14	4.23	5.31	1.53	3.04	3.41
TMS 98 05 05	15.06	16.43	29.80	4.46	4.42	6.36	2.62	2.64	4.38
TMS 05 10	12.20	13.50	21.70	3.37	4.12	5.12	2.09	2.93	3.53
LSD(P<0.05)	2.27	NS	3.72	1.37	NS	1.44	0.66	NS	NS
Rates									
0	6.25	5.10	11.30	1.83	2.13	2.12	1.30	1.46	2.33
200	14.29	13.13	25.00	4.44	3.79	5.71	2.45	3.32	4.76
400	11.69	17.32	31.20	3.58	4.37	6.24	2.40	3.93	5.43
600	10.39	15.10	30.30	4.17	4.16	6.24	2.14	3.62	5.31
LSD(P<0.05)	2.27	3.30	NS	NS	NS	1.44	0.66	NS	NS
Modes									
Single	11.34	14.05	20.10	3.46	3.89	5.66	2.03	2.66	3.34
Split	12.62	15.34	22.13	3.71	4.22	6.05	2.57	3.48	3.29
Split-Split	8.25	15.09	24.20	2.18	3.84	6.82	2.45	3.31	3.45
LSD(P<0.05)	2.26	NS	NS	NS	NS	NS	NS	NS	NS

NS = non - significant

TMS 98 05 05 gave significantly ($p<0.05$) higher number of leaves at 2 and 4 months after planting when the fertilizer was applied split - split (Table 11). The result is statistically similar to TMS 01 1368 at single and split dose of fertilizer application. The variety also had non-significant higher number of branches, stem girth and canopy diameter at 4,8 and 12 MAP, respectively. TME 419 variety gave significantly lower number of leaves and non ï significant lower number of branches at 4 MAP.

Table 11: Interaction of varieties x mode of NPK fertilizer on the number of leaves, branches, canopy diameter and stem girth at different months after planting (MAP)

Varieties	Modes	Number of leaves		Number of branches		Canopy Diameter (cm)			Stem girth (cm)			
		2	4	2	4	8	10	12	2	4	6	8
TMS 01 1368	Single	12.23	70.90	2.00	3.62	105.50	104.4	104.80	7.21	3.90	4.53	5.72
	Split	10.09	75.00	1.77	3.51	100.20	93.10	105.20	8.19	4.38	5.22	5.80
	Split ï Split	9.32	68.80	1.75	3.49	98.70	92.70	99.70	8.00	3.78	3.88	5.45
TME 419	Single	9.48	38.30	1.61	2.75	114.20	115.10	119.30	8.77	4.43	4.49	6.09
	Split	9.69	36.90	1.69	3.08	108.00	110.20	105.80	8.41	4.55	4.68	6.16
	Split ï Split	10.98	39.20	1.88	3.46	113.00	115.50	116.80	8.37	4.46	4.50	5.97
TMS 98 05 05	Single	13.69	72.90	2.21	3.70	117.50	114.50	121.40	4.29	5.05	4.64	5.95
	Split	14.06	64.10	2.17	2.95	111.80	117.70	119.00	4.39	5.25	6.07	5.17
	Split ï Split	16.58	78.40	2.15	4.26	113.90	117.90	124.60	3.77	4.61	4.48	6.23
TMS 05 10	Single	10.17	47.00	1.83	3.42	104.79	105.60	98.00	3.68	4.65	4.47	6.04
	Split	13.57	42.40	1.57	2.88	103.20	101.30	100.20	3.68	4.19	4.25	6.07
	Split ï Split	11.59	43.50	1.96	2.46	94.90	96.10	103.90	3.55	4.26	4.45	5.88
LSD(p<0.05)		1.47	10.41	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = non - significant

The TMS 98 05 05 variety gave significantly ($P < 0.05$) higher plant height at 6 MAP at the split - split fertilizer application mode though it is statistically similar to the single dose of fertilizer application (Table 12). There were non ï significant effect of the interaction of variety x mode of fertilizer application on plant height before and after 6 MAP of the cassava growth.

Table 12: Interaction of variety x mode of NPK fertilizer on the plant height

Varieties	Modes	Months after planting					
		2	**4**	**6**	**8**	**10**	**12**
TMS 01 1368	Single	10.0 1	49.90	89.90	111.30	112.60	118.30
	Split	8.95	57.20	114.30	120.00	115.70	125.60
	Split-S	9.03	51.30	106.90	111.30	109.00	122.50
TME 419	Single	5.72	49.90	119.20	115.00	119.50	119.60
	Split	6.62	59.90	129.20	126.50	131.90	137.30
	Split-S	5.98	60.80	121.60	118.10	119.90	125.10
TMS 98 05 05	Single	9.03	60.20	134.90	117.90	122.80	133.40
	Split	7.81	55.50	131.80	118.30	122.10	140.50
	Split-S	8.67	52.00	135.30	118.70	113.10	120.60
TMS 05 10	Single	6.08	51.10	87.60	118.30	119.00	119.50
	Split	5.39	48.50	83.80	110.70	115.90	122.00
	Split-S	5.20	48.90	73.10	104.10	109.70	124.20
LSD($p<0.05$)		NS	NS	14.27	NS	NS	NS

NS = non ï significant ; split-s = split split

TMS 98 05 05 varieties gave non-significant higher branches and canopy diameter in all the months (Table 13). The varieties were statistically similar to each other in stem girth size at the tenth and twelfth MAP. TME 419 varieties that received 600 kg/ha of NPK as single application gave significantly higher stem girth at 6 MAP. Stem girth size of the cassava varieties were not significant across the other months of growth.

Table 13: Interaction of variety x rate x mode of fertilizer application on the number of branches, canopy diameter and stem girth of some cassava varieties

			Months after planting								
Varieties	**Rates**	**Modes**	**Branches**		**Canopy diameter(cm)**			**Stem girth (mm)**			
			2	**4**	**8**	**10**	**12**	**6**	**8**	**10**	**12**
TMS 01 1368	0	Single	2.00	3.87	106.60	104.50	97.80	5.67	4.37	4.57	5.10
		Split	1.60	3.87	112.30	77.80	117.50	8.13	4.73	4.80	6.23
		Split-Split	1.33	2.47	93.70	93.40	83.00	7.80	3.57	3.70	4.33
	200	Single	3.00	4.03	97.70	96.00	99.20	7.83	4.17	4.27	5.33
		Split	1.80	2.20	93.30	100.80	115.70	8.37	5.23	5.37	6.30
		Split-Split	1.83	2.77	85.40	84.30	110.10	8.17	3.33	3.47	5.50
	400	Single	1.50	3.63	115.00	115.10	116.20	7.03	3.37	4.90	6.73
		Split	1.83	3.03	92.40	91.60	89.50	8.23	3.80	6.73	5.63
		Split-Split	1.50	4.20	115.80	107.80	100.30	8.30	4.17	4.27	5.30
	600	Single	1.50	2.93	102.70	101.80	105.90	8.30	3.70	4.40	5.73
		Split	2.33	4.93	102.90	102.30	98.00	8.03	3.73	4.00	5.03
		Split-Split	1.83	4.53	100.10	85.10	105.30	7.73	3.97	4.10	6.67
TME 419	0	Single	1.50	3.43	103.10	104.80	120.30	4.60	4.47	4.63	6.07
		Split	2.00	1.87	98.10	100.40	97.90	7.49	4.27	4.43	5.77
		Split-Split	2.00	3.37	116.10	110.50	120.80	6.87	4.50	4.43	5.93
	200	Single	1.27	3.93	115.60	116.10	108.20	8.67	4.53	4.63	5.63
		Split	1.50	2.83	118.30	119.00	118.20	7.97	5.23	5.73	5.63
		Split-Split	2.40	2.33	84.10	103.90	108.10	7.43	3.50	3.40	4.83
	400	Single	2.23	1.77	126.20	126.60	130.30	8.67	4.70	4.87	6.90
		Split	1.53	4.00	106.60	106.10	109.30	9.53	4.07	4.17	6.60
		Split-Split	2.00	4.97	135.40	136.30	115.80	8.53	5.17	5.27	6.33
	600	Single	1.43	1.87	111.90	113.10	118.30	9.87	4.00	3.83	5.77
		Split	1.73	3.60	109.00	115.10	97.80	8.67	4.63	4.40	6.63
		Split-Split	1.13	3.17	116.50	111.10	122.70	7.67	4.67	4.90	6.80
TMS 98 05 05	0	Single	2.00	3.63	129.20	132.30	132.40	4.60	5.30	5.53	6.53
		Split	2.00	2.70	106.10	107.00	103.00	4.47	5.17	5.23	5.83
		Split-Split	2.33	3.53	106.80	113.00	111.80	4.53	5.13	4.70	5.60
	200	Single	2.00	2.20	98.50	103.00	98.20	4.07	5.30	4.40	5.80
		Split	2.50	3.17	101.20	104.20	99.00	3.93	5.10	4.63	4.63
		Split-Split	1.83	3.63	81.00	82.80	76.50	2.93	3.50	3.10	3.37
	400	Single	2.50	4.37	118.60	123.00	125.00	4.57	5.27	5.00	6.30
		Split	1.83	2.60	111.90	124.30	130.50	4.93	5.30	5.17	6.87
		Split-Split	2.10	5.20	138.00	126.30	149.40	3.73	4.93	5.10	5.50
	600	Single	2.33	4.60	123.50	99.90	129.90	3.93	4.33	3.63	5.17
		Split	2.33	3.33	128.10	135.30	143.60	4.23	5.43	9.23	7.60
		Split-Split	2.33	4.67	145.20	149.60	160.70	3.87	4.87	5.03	6.20
TMS 05 10	0	Single	1.33	3.17	98.80	97.10	89.70	3.83	4.73	4.67	5.87
		Split	1.33	3.37	93.90	89.80	76.20	3.87	4.20	4.03	5.20
		Split ï Split	1.83	2.70	89.50	92.70	94.70	3.33	3.80	3.97	4.93
	200	Single	1.67	3.63	107.40	107.40	94.70	4.27	5.57	5.43	6.37
		Split	2.33	2.10	126.30	127.10	130.70	4.93	5.77	5.83	7.50
		Split ï Split	1.67	1.60	77.50	71.50	82.90	2.73	3.23	3.13	4.70
	400	Single	2.17	3.20	125.50	127.40	133.00	3.83	4.90	5.00	7.13
		Split	2.33	3.53	92.80	88.00	92.30	3.07	3.50	3.67	5.47
		Splitï Split	1.33	2.77	116.90	118.40	126.90	3.93	4.53	4.97	6.90
	600	Single	2.17	1.67	87.20	90.40	74.80	2.77	3.40	2.80	4.80
		Split	1.83	2.50	99.90	100.30	101.50	2.83	3.30	3.47	6.10
		Splitï Split	1.43	2.77	95.70	101.00	111.30	4.20	5.47	5.73	7.00
		LSD(0.05)	NS	NS	NS	NS	NS	1.49	NS	NS	NS

NS = non ï significant

The interaction of varieties x modes of fertilizer application showed that single application of NPK to TMS 05 10 at 6 MAP gave the highest tuber yield of 24.92 t/ha while the split split application of NPK to TME 419 gave the lowest tuber yield although they were statistically similar (Table 14). There were no significant differences at 9 MAP but split ï split NPK fertilizer application to TMS 05 10 gave the highest tuber yield of 25.29 t/ha while the split application of NPK fertilizer to TMS 01 1368 gave the lowest tuber yield.

Table 14: Interaction of variety x mode of NPK on the tuber yield at 6, 9 & 12 MAP

Varieties	**Modes**	**Months after planting**		
		6	**9**	**12**
TMS 01 1368	Single	20.58	16.71	31.70
	Split	21.50	22.92	31.40
	Split ï Split	17.42	16.58	27.70
TME 419	Single	18.25	17.50	27.10
	Split	23.33	21.83	24.20
	Split ï Split	15.92	22.42	28.70
TMS 98 05 05	Single	24.00	23.12	35.20
	Split	24.75	21.29	38.80
	Split ï Split	23.42	22.88	45.50
TMS 05 10	Single	24.92	22.88	26.10
	Split	21.08	19.33	34.10
	Split ï Split	17.83	25.29	34.90
LSD(p<0.05)		NS	NS	NS

NS = non - significant

The single application of 200 kg/ha NPK rate had the highest tuber yield while the control had the lowest at 6 MAP (Table 15). The split application of 400 kg/ha NPK rate of fertilizer gave significantly ($p<0.05$) higher tuber yield of 28.54 t/ha at 9 MAP. It is statistically similar to split ï split application of 200 and 400 kg/ha rate , single and split application of 600 kg/ha NPK fertilizer rates. There were no significant differences at 12 MAP but the split ï split application of 400 kg/ha NPK fertilizer had the highest tuber yield of 42.4 t/ha while the control had the lowest tuber yield of 16.8 t/ha

Table 15: Interaction of rate x mode of NPK fertilizer rate on tuber yield

		Months after planting		
		6	9	12
Rates	Modes			
0	Single	16.25	15.29	18.70
	Split	18.33	13.33	16.80
	Splitï Split	14.17	13.67	22.40
200	Single	28.50	18.83	30.20
	Split	25.00	19.25	31.50
	Splitï Split	20.58	26.21	31.30
400	Single	21.25	20.83	35.00
	Split	24.00	28.54	40.70
	Splitï Split	19.83	27.50	42.40
600	Single	21.75	25.25	36.00
	Split	23.33	24.25	39.60
	Splitï Split	20.00	25.79	40.60
LSD($p<0.05$)		NS	5.72	NS

NS = non - significant

The variety TMS 98 05 05 that received 600 kg/ha rate of fertilizer application gave significantly ($p < 0.05$) higher tuber yield of 27.89 t/ha and 50.1t/ha at the sixth and twelvth months of harvest, respectively (Table 16). It is statistically similar to TMS 05 10 that gave 27.44 t/ha at 200 kg/ha of NPK and 45.6 t/ha at the twelfth month after planting.

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Table16: Interaction of varieties x rate of NPK fertilizer application on cassava tuber yield at 6, 9 and 12 MAP

		Months after planting		
Varieties	**Rates**	**6**	**9**	**12**
TMS 01 1368	0	18.56	10.94	27.40
	200	20.56	19.44	24.60
	400	19.33	25.89	40.30
	600	19.56	18.67	28.70
TME 419	0	12.11	13.00	11.90
	200	23.44	18.89	26.40
	400	22.11	26.56	37.80
	600	19.00	23.89	30.60
TMS 98 05 05	0	19.44	18.06	19.20
	200	27.33	25.39	42.20
	400	21.56	24.39	47.80
	600	27.89	21.89	50.10
TMS 05 10	0	12.56	14.39	18.70
	200	27.44	22.00	30.90
	400	23.78	25.67	31.60
	600	21.33	27.94	45.60
LSD($P<0.05$)		6.33	NS	5.67

NS = non - significant

The interaction of variety, rate and mode of fertilizer application showed that TMS 05 10 gave significantly higher tuber yield of 36.67 t/ha at 200 kg/ha of NPK that was applied singly at 6 MAP (Table 17). At 9 and 12 MAP, TMS 98 05 05 gave higher tuber yield of 37 t/ha and 60t/ha at 600 kg rate that was applied by split and split - split application, respectively.

Table 17: Interaction of variety, rate and mode of NPK fertilizer on cassava tuber yield

			Months after planting		
Varieties	**Rates**	**Modes**	**6**	**9**	**12**
TMS 01 1368	0	Single	13.33	14.50	28.70
		Split	30.33	11.00	22.00
		Split ï Split	19.00	7.33	31.70
	200	Single	22.67	14.67	35.70
		Split	16.33	23.00	19.30
		Split ï Split	22.67	20.67	18.70
	400	Single	18.67	19.00	31.00
		Split	21.33	30.33	46.70
		Split ï Split	18.00	22.33	43.30
	600	Single	27.67	18.67	31.30
		Split	18.00	21.33	37.70
		Split ï Split	10.00	16.00	17.00
TME 419	0	Single	12.33	12.67	12.00
		Split	12.00	9.67	9.70
		Split ï Split	12.00	16.67	14.00
	200	Single	22.00	17.33	22.30
		Split	32.33	17.00	23.70
		Split ï Split	16.00	22.33	33.20
	400	Single	18.33	20.00	41.00
		Split	30.00	30.33	35.30
		Split ï Split	18.00	29.33	37.20
	600	Single	20.33	20.00	33.00
		Split	19.00	30.33	28.30
		Split ï Split	17.67	21.33	30.30
TMS 98 05 05	0	Single	24.33	18.17	20.30
		Split	17.00	20.00	18.30
		Split ï Split	17.00	16.00	19.00
	200	Single	32.67	21.00	28.30
		Split	25.67	21.00	54.30
		Split ï Split	23.67	34.17	44.00
	400	Single	21.00	19.00	37.30
		Split	25.00	27.17	53.00
		Split ï Split	18.67	27.00	53.00
	600	Single	18.00	34.33	54.70
		Split	31.33	37.00	40.00
		Split ï Split	34.33	34.33	60.00
TMS 05 10	0	Single	15.00	15.83	14.00
		Split	14.00	12.67	17.00
		Split ï Split	8.67	14.67	25.00
	200	Single	36.67	22.33	34.70
		Split	25.67	16.00	28.70
		Split ï Split	20.00	27.67	29.30
	400	Single	27.00	25.33	30.70
		Split	19.67	20.33	28.00
		Split ï Split	24.67	31.33	36.20
	600	Single	21.00	28.00	25.00
		Split	25.00	28.33	52.70
		Split ï Split	18.00	27.50	49.00
LSD(p<0.05)			10.97	NS	19.48

NS = non - significant

TMS 98 05 05 variety gave significantly ($p < 0.05$) higher peel weight at 6 MAP at 600 kg/ha NPK rate (Table 18). It is statistically similar to TME 419 variety that received 200 kg/ha and 400 kg/ha rates of NPK application and TMS 05 10 that received 400 kg/ha NPK. Variety TMS 01 1368 that received 400 kg/ha of NPK gave the highest non ï significant peel weight of 7.89 t/ha while TMS 98 05 05 had the lowest peel weight at the control level. At 12 MAP, TMS 98 05 05 gave significantly ($p<0.05$) higher peel weight of 12.00 t/ha. The variety is statistically similar to the 600 kg/ha NPK rate on TMS 05 10.

Table 18: Interaction of variety x rate of NPK fertilizer application on peel weight of cassava

		Months after planting		
Varieties	Rates	6	9	12
TMS 01 1368	0	7.89	4.00	8.00
	200	8.11	5.61	7.83
	400	7.67	7.89	9.67
	600	8.11	5.22	6.83
TME 419	0	7.11	5.22	2.89
	200	9.89	5.22	7.72
	400	10.11	7.00	9.28
	600	8.67	7.56	7.33
TMS 98 05 05	0	5.33	2.72	2.78
	200	11.11	6.94	11.56
	400	8.11	6.89	11.11
	600	10.89	5.11	12.00
TMS 05 10	0	3.00	4.78	3.11
	200	8.67	5.39	7.72
	400	9.22	6.11	6.89
	600	7.00	6.89	10.78
LSD($p<0.05$)		2.75	NS	2.88

NS = non - significant

There were no significant differences in the interaction of varieties and mode of fertilizer at the peel weight of tubers at 6, 9 and 12 MAP. (Table 19) TMS 98 05 05 that received fertilizer as split split gave higher peel weight of 10.75 t/ha at 12 MAP. TME 419 that received split fertilizer application had the highest peel weight at 6 MAP. TMS 01 1368 that received split fertilizer application gave the highest peel weight of 6.92 t/ha while TMS 01 1368 under single application gave the lowest peel weight of 4.88 t/ha at 9 MAP.

Table 19: Interaction of variety x mode of NPK fertilizer application on peel weight of Cassava

		Months after planting		
Varieties	Modes	6	9	12
TMS 01 1368	Single	7.42	4.88	8.38
	Split	8.92	6.92	9.29
	Split ï Split	7.50	5.25	6.58
TME 419	Single	8.75	6.17	6.88
	Split	10.00	6.17	6.54
	Split ï Split	8.08	6.42	7.00
TMS 98 05 05	Single	8.58	6.08	8.50
	Split	9.67	4.92	8.83
	Split ï Split	8.33	5.25	10.75
TMS 05 10	Single	9.08	5.62	6.88
	Split	6.25	5.29	7.54
	Split ï Split	5.58	6.46	6.96
LSD(p<0.05)		NS	NS	NS

NS = non - significant

The 200 kg/ha applied singly gave the highest peel weight while the control gave the lowest at 6 MAP (Table 20). The rate of 400 kg/ha and 600 kg/ha applied split and singly gave significantly higher peel weight of 7.67 t/ha at 9 MAP. At 12 MAP, there were no significant differences on peel weight of the cassava varieties as a result of interaction of rate and mode of fertilizer application.

Table 20: Interaction of fertilizer rate x mode of NPK fertilizer on peel weight

		Months after planting		
Rates	Modes	6	9	12
0	Single	4.75	4.46	4.29
	Split	7.25	4.42	4.04
	Split ï Split	5.50	3.67	4.25
200	Single	10.67	4.62	9.62
	Split	9.75	5.12	8.38
	Split ï Split	7.92	7.62	8.13
400	Single	9.33	6.00	7.54
	Split	8.92	7.67	10.17
	Split ï Split	8.08	7.25	10.00
600	Single	9.08	7.67	9.17
	Split	8.92	6.08	9.62
	Split ï Split	8.00	4.83	8.92
LSD($p<0.05$)		NS	1.83	NS

NS = non - significant

The variety, TME 419 gave significantly ($p < 0.05$) higher garri yield of 5.54 t/ha at 6 MAP under split fertilizer application (Table 21). The split ï split application of fertilizer gave the lowest garri yield in all the varieties at 6 MAP. The variety, TMS 05 10 had significantly ($p < 0.05$) higher garri yield at the split ï split application in the nineth month of harvest while TMS 01 1368 had the lowest garri yield of 3.25 t/ha in the split ï split fertilizer application. The variety, TMS 98 05 05 gave the highest garri weight of 10.42 t/ha at 12 MAP under the split ï split NPK application while TMS 01 1368 had the lowest weight of 6.17 t/ha under the single fertilizer application.

Table 21: Influence of variety x mode of NPK fertilizer application on garri yield

		Months after planting		
Varieties	**Modes**	**6**	**9**	**12**
TMS 01 1368	Single	3.50	3.88	6.17
	Split	4.42	5.58	7.12
	Split ï Split	3.46	3.25	6.58
TME 419	Single	2.92	4.21	6.92
	Split	5.54	6.08	6.79
	Split ï Split	2.92	6.04	8.21
TMS 98 05 05	Single	4.83	4.88	8.46
	Split	4.79	5.00	10.17
	Split ï Split	4.54	4.96	10.42
TMS 05 10	Single	4.88	5.67	7.21
	Split	4.33	4.83	9.08
	Split ï Split	3.67	7.00	8.71
LSD($p<0.05$)		1.15	1.78	NS

NS = non - significant

Split application of 400 kg/ha of NPK gave significantly higher garri yield of 7.25 t/ha at 9 MAP while the control had the lowest garri weight (Table 22). Split application of 200 kg/ha and 400 kg/ha of NPK fertilizer gave a non significant highest garri yield at the 6 and 12 MAP, respectively.

Table 22: Interaction of fertilizer rate x mode of NPK fertilizer on garri yield

		Months after planting		
Rates	**Modes**	**6**	**9**	**12**
0	Single	2.42	3.83	4.38
	Split	3.46	3.33	3.92
	Split ï Split	2.83	3.21	4.75
200	Single	5.75	3.88	7.04
	Split	5.83	5.17	8.71
	Split ï Split	3.87	7.04	7.54
400	Single	4.29	4.25	8.55
	Split	5.00	7.25	11.58
	Split ï Split	3.92	6.42	10.25
600	Single	3.67	6.67	8.79
	Split	4.79	5.75	8.96
	Split ï Split	3.96	4.58	11.38
LSD(p<0.05)		NS	1.78	NS

NS = non - significant

The variety TMS 05 10 gave significantly ($p<0.05$) higher garri yield of 8.33 t/ha at 200 kg/ha of NPK applied singly (Table 23). It is statistically similar to the garri yield of the TMS 98 05 05 that received 200 kg and 600 kg of NPK fertilizer rate at 6 MAP. The variety TMS 98 05 05 had the highest garri yield of 9.33 t/ha under the 400 kg NPK applied split ï split while the control gave the lowest garri weight at all the rates and varieties at 9 MAP. The variety TMS 98 05 05 had significantly ($p<0.05$) higher garri yield of 18.33 t/ha at 12 MAP at 600 kg/ha NPK rate. It is statistically similar to the 600 kg/ha NPK rate of fertilizer at split application to TMS 05 10 variety. Variety TME 419 that received 200 kg/ha of NPK at split application and TMS 98 05 05 that received 600 kg/ha of NPK at split ï split doses gave significantly ($p<0.05$) higher garri weight of 7.67 t/ha at 6 MAP.

Table 23: Interaction of variety x rate of fertilizer application and mode of NPK fertilizer on garri yield

			Months after planting		
Varieties	**Rates**	**Modes**	**6**	**9**	**12**
TMS 01 1368	0	Single	3.33	4.00	4.50
		Split	2.00	2.83	2.00
		Split ï Split	3.00	2.00	2.00
	200	Single	3.33	2.50	8.17
		Split	3.33	5.83	4.00
		Split ï Split	4.33	5.00	4.50
	400	Single	3.00	4.00	3.00
		Split	5.00	9.00	11.33
		Split ï Split	4.00	4.00	10.00
	600	Single	4.33	5.00	6.00
		Split	3.33	4.67	6.17
		Split ï Split	1.50	2.00	2.83
TME 419	0	Single	2.17	3.00	3.00
		Split	3.00	4.00	2.50
		Split ï Split	2.67	4.00	2.67
	200	Single	4.00	3.50	5.00
		Split	7.67	4.67	5.00
		Split ï Split	2.67	6.83	9.00
	400	Single	2.50	3.83	11.00
		Split	7.00	8.00	12.00
		Split ï Split	3.33	7.67	9.50
	600	Single	3.00	6.50	8.67
		Split	4.50	7.67	7.67
		Split ï Split	3.00	5.67	11.67
TMS 98 05 05	0	Single	2.33	3.33	3.00
		Split	1.83	3.00	2.83
		Split ï Split	2.33	2.17	3.00
	200	Single	7.33	5.17	6.17
		Split	5.00	5.83	15.50
		Split ï Split	4.50	9.33	8.33
	400	Single	6.00	3.17	10.50
		Split	5.67	5.00	15.33
		Split ï Split	3.67	7.00	12.00
	600	Single	3.67	7.83	14.17
		Split	6.67	4.17	7.00
		Split ï Split	7.67	3.33	18.33
TMS 05 10	0	Single	1.83	5.00	4.00
		Split	3.00	3.50	3.33
		Split ï Split	2.33	4.67	4.33
	200	Single	8.33	4.33	8.83
		Split	7.33	4.33	10.33
		Split ï Split	4.00	7.00	8.33
	400	Single	5.67	6.00	9.67
		Split	2.33	5.00	7.67
		Split ï Split	4.67	9.00	9.50
	600	Single	3.67	7.33	6.33
		Split	4.67	6.50	15.00
		Split ï Split	3.67	7.33	12.67
	LSD(p<0.05)		2.29	NS	4.84

NS = non - significant

DISCUSSION

The early season planted cassava took place in May and there were high rainfall in June and July which supported its rapid early growth and canopy cover. The late season crop which was established in July had low rainfall in that July but a heavy rainfall in August which was at extreme (stress) and may suggest the basis for low growth and slow canopy cover. Early growth indices in cassava have been reported to support high tuber yield in cassava (Akoroda *et al.,* 2001*).* El-shakarwy *et al.,* (1998) had also reported that early and mid-season stress significantly reduce top and root biomass than late and terminal stress which occurred during tuber maturity in cassava.

The physico-chemical properties of soil as contained in Table 2 revealed that the soil of the early season had loamy sand texture and was also highly acidic while the late season site has sandy loam texture and was highly acidic. The soil textural classes of both sites suggest very good support for optimum growth and yield of cassava. Sandy loam of late seasons site has been described as best for cassava growth (Onwueme and Sinha, 1999) even though the site gave lower yield in this study which might be as a result of reduced effective growth period before dry season started. The late season site was also identified to posses moderate and high levels of organic carbon and organic matter as compared to the early site with low and moderate levels of organic carbon and organic matter, respectively (Black, 1975).

Early season planting that showed higher survival count in all the varieties suggested better growth conditions when compared to the late season with lower survival counts after 3 weeks of planting. The variety TMS 98 05 05 that was consistently higher than 70% in both seasons indicate higher survival rate from rottening and termite attack that evident in poor lowering survivors in the late and early seasons, respectively.

The growth of the plants was higher during the early season planting, that was indicated in higher number of leaves and branches at 4 MAP (September) in the early season planting when compared to the late season planting (November). The results are in agreement with the reports of Oliveira et al., (1982), Vilamayor *et al.,* (1985), and El-sharkawy *et al.,* (1998) on the severe stress effects of dry season on vegetative growth of late season cassava. This suggested that stress at vegetative stage caused reduction in yield of cassava for vegetative growth and eventual tuber yield. Rate of leaf formation in the varieties was related to branch number and rate of leaf retention. The variety TMS 98 05 05 had consistently higher number of branches and leaves in both seasons and suggested that the rate of leaf formation in the varieties was related to the number of branches. The report agreed with that of Irikura *et al*. (1979) that early branching increased leaf formation rate. Also, Okogbenin (1999) noted that cultivars with high branching characteristics produce more leaves than non-branching ones and that the planting methods that favoured leaf production profusely shed more leaves than planting methods with less leaf formation. According to Okogun *et al.,* (1999) an increase in number of branches per plant is important to expose the cassava leaves to sunlight for photosynthesis and increased translocation for higher photosynthate accumulation.

TMS 98 05 05 gave significantly ($p < 0.05$) higher canopy diameter at the 10 and 12 months after planting and a non- significant higher diameter at 8 month after planting. It was an indication that the variety exhibited a full canopy closure. Such variety has the advantage of weed suppression and erosion control because of the vegetation cover. Pellet *et al., (*1977) had noted that once a complete ground cover is reached, cassava shed out weeds. Aneke *et al.,* (2010) reported that the application of fertilizer in cassava production ensures that the canopy closes up within approximately 3 MAP giving potential for weed suppression. Canopy closure has also been suggested to help to reduce water runoff and consequently reducing soil erosion (Zhang *et al.,* 1998).

The high level of 50 % reduction in tuber and garri yield in the late season planting when compared to the early season suggested that the optimum vegetative and tuberization growth period in the late seasons cropping fell into the stress periods of November to March when there was no rainfall. The less than full expression of the leaves and canopy diameter in the late season resulted in lower tuber yield. This is most probable as Lebot (2009) has shown that leaf size and tubers develop simultaneously, also, that increased canopy increases assimilate produced and partitioned between growth and tuberization. The higher tuber and garri yields in TMS 98 05 05 might be as a result of higher canopy cover which increased assimilates produced in the variety for growth and tuber development. The 400 kg NPK/ha that gave significantly higher tuber yield at the 9^{th} and 12^{th} month is more economical for adoption for production. The non statistical difference in tuber yield between single and split fertilizer application across the three months of tuber harvest suggested the resilience of the varieties in the utilization of available fertilizer nutrients in their growth and tuberization. Cassava crop has been shown to give relative yields in fallow and marginal soils without fertilizer where other crops cannot do well (Evenson and Keating, 1978).

Split-split application of fertilizer to the cassava varieties gave non-significant higher tuber yield across three of the four varieties used for study at the 12^{th} month. The result suggested that cassava requires gradual application of fertilizer most probably because of long gestation period of about 12 months. However, the cost of labour should be taken into consideration in the choice of split or split-split vis-a-vis tuber yield compensation from each method. At 9 MAP, the non-significantly higher tuber yield at 400 kg/ha of fertilizer rate applied split as against the tuber yield at 600 kg/ha that was applied split-split suggested that 400 kg/ha rate is more adequate and economical for higher tuber yield in the varieties. Similar result of higher tuber yield at 400 kg/ha as against 600 kg/ha at the 12 month indicated that 400kg/ha rate of fertilizer is suitable for production of the varieties in Nsukka environment because it is more economical and gave high yield. The relatively lower yield from 600 kg/ha might be as result of luxuriant growth of the plants at the expense of tuber formation and development. Many authors have reported luxuriant vegetative growth in cassava against tuber formation because of excess nitrogen and potassium levels (Rao *et al.,* 1986, Onwueme and Charles, 1994, Wilson and Ovid, 1994).

The high level of interaction of the cassava varieties with the rates and modes of fertilizers application suggested that the varieties behaved differently to the rates and modes of fertilizers application. At 6 MAP, in most cases, the single fertilizer application across the levels gave higher tuber and garri yields when compared with the split and split-split. However, single dose application lost its nutrients to leaching over time of growth resulting in lower tuber and garri yields at 9 and 12 MAP. The split ï split application of 600 kg/ha fertilizer that gave non significant higher tuber yield of 60 t/ha when compared with split-split application of 400 kg/ha suggested relatively higher fertilizer utilization in the vegetative and tuber bulking and eventual yields. The higher but non-significant differences in the yields of 600 kg/ha rate may not pay for the cost of extra fertilizer when compared with 400 kg/ha fertilizer rate. Hence, the lower fertilizer rate of 400 kg/ha that gave high yield over the two seasons could be recommended based on the native nutrients of the research site. The variety TMS 98 05 05 also responded in a better way to the rates and modes of fertilizer application as it gave mostly higher tuber yield across the rates and modes of fertilizer application. TME 419 characterised as early (6 months) duration cassava did not perform better than other varieties at 6 MAP and did not show rotten tubers at 12 MAP in the seasons in Nsukka environment. Hence, the variety could be grown for 12 MAP harvest as is applicable in some varieties available in Nsukka.

Further studies will be needed to establish when rottening of cassava tubers will commence in Nsukka as it has been characterised in other environments.

Peel weight of the varieties at 6 MAP in most cases across the fertilizer rates and modes of application were higher when compared to the peel weight at the 9th month. The result indicated that the cassava peels at an early stage in development were thicker and high but reduced with tuber enlargement and development resulting in thinner peels with reduced weight. The variety TMS 98 05 05 that gave highest tuber yield also gave highest peel weight.

Conclusion

This study showed that TMS 98 05 05 significantly had high growth parameters, high tuber and garri yield and could be adopted for production in Nsukka environment. 400 kg/ha rate of fertilizer gave similar growth and tuber yields when compared with 600 kg/ha rate and should be adopted because of lower cost. Split application of fertilizer though statistically similar to split ï split application had the highest growth, tuber and garri yield and should be adopted because it is more economical to the farmer as it will avoid extra labour cost of the fertilizer application.

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