EFFECTS OF FERTILIZER TYPE AND HARVESTING TIME ON YIELD OF CASSAVA (*Manihot esculenta* Crantz) IN IBADAN, NIGERIA

BY

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ABSTRACT

Cassava productivity is limited by soil fertility status and maturity period. Frequently used mineral fertilizer is expensive and detrimental to soil health and productivity while information on specific harvest period is scarce. Thus, studies were conducted to assess the influence of Organomineral Fertilizer (OF) and harvesting period on cassava yield.

Field experiments were conducted at Ajibode and Oluana in Ibadan. Five OF rates (1.5, 2.5, 3.5, 4.5, 6.0 t/ha), NPK 15:15:15 at 600 kg/ha and No Fertilizer (NF) treatments were evaluated on the performance of two cassava varieties: TMS 30572 (V1) and TMS 92/0326 (V2). Cassava (main plot) was planted at 10,000 plants per hectare and fertilizer (sub-plot) applied at planting using a split-plot arrangement in a randomized complete block design with three replicates. After harvest at 12 Months After Planting (MAP), cassava was replanted *in-situ* without fertilizer application to assess the residual effects of fertilizer. Optimum fertilizer rate was selected based on cassava performance and subsequently used to assess the best period of harvest at 9, 12, 15 and 18 MAP. Data on Plant Height (PH) and Number of Leaves (NL) at 1-6 MAP, Shoot Yield (SY), Root Yield (RY), Harvest Index (HI) and Root Dry Matter Yield (RDMY) were analysed using ANOVA at $p = 0.05$.

The mean NL (118 ± 0.37) at 6 MAP obtained with 3.5 t OF/ha was significantly higher than that of NF (82) treatment. Similar result was obtained for SY and PH while RY (36.5, 31.8 ± 0.49 t/ha) recorded in 2.5 and 3.5 t OF/ha treatments respectively were significantly higher than NF (21.5 t/ha). The same results were obtained for RDMY and HI. The RDMY of V2 (12.3 ± 0.67 t/ha) was significantly higher than for V1 (10.5 ± 0.41 t/ha). Highest RDMY (13.2 t/ha) obtained with 2.5 t OF/ha was comparable with yields of higher rates of OF and NPK. Residual effects of OF rates above 1.5 t/ha produced significantly higher RY of 36.8 t/ha (4.5 t/ha) > 36.7 t/ha (6.0 t/ha) >35.9 t/ha (3.5 t/ha) >31.6 t/ha (2.5 t/ha) than NPK (19.8 t/ha) and NF (18.9 t/ha) in the first season. Similar trend was observed in the following season on RDMY and HI. The RDMY of 17.6 t/ha

and 17.2 t/ha obtained at 15 MAP (V2 and V1 respectively) were significantly higher than that obtained at 9 MAP (6.6, 10.9 t/ha) and 12 MAP (7.1, 11.8 t/ha) in V1 and V2 respectively. The RDMY of V1 (18.8 t/ha) and V2 (13.2 t/ha) at 18 MAP were comparable with that obtained at 15 MAP. Application of OF at 2.5 t/ha and NPK produced RDMY of 15.0 t/ha and 14.2 t/ha respectively which were significantly higher than that of NF (7.8 ± 0.54 t/ha).

Optimum root yield of cassava was obtained with application of 2.5 t/ha of organomineral fertilizer. One application supported optimum crop yields in two cropping seasons. The best time to harvest TMS 30572 and 92/0326 in Ibadan was at 15 months after planting.

Keywords: Organomineral fertilizer, Cassava root yield, Harvest index.

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CERTIFICATION

I certify that this work was carried out by Mr. Michael Asuquo Edet in the Department of Agronomy, University of Ibadan

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DEDICATION

This Thesis is dedicated to God Almighty, the Omnipotent, Omniscient and Omnipresent.

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CHAPTER 1

INTRODUCTION

Cassava is one of the most important food crops in Africa, and a major source of edible carbohydrate for over 800 million people around the world. World production of the crop increased from 209 million tonnes in 2005 to 237 million tonnes in 2010 (FAO, 2011). More than half of the world's cassava production is concentrated in 5 countries viz Nigeria, Thailand, Brazil, Indonesia and Democratic Republic of Congo (FAO, 2009). However, the ten major countries in the world whose food energy comes from cassava are all in Africa, as more is now being produced in Africa than in South America where it originated from (Dahniya, 1994; Nweke *et al*., 2004). In tropical Africa, cassava is the most widely grown source of calorie, feeding more than 200 million people. The crop has been rated as Africa's second most important food staple after maize, with respect to calories consumed, being a major source of calorie for two out of every five Africans (Nweke, 2004).

However, cassava is a marginalized crop because of the stigma of being an inferior, low protein food compared with glamour crops such as rice and wheat (CIAT, 1992; Nweke *et al.*, 2002). Nigeria is the leading producer of cassava in Africa and the current production level is expected to double to about 80 million tonnes per annum in 2020 due to international consortium, government and agencies support of commercial cassava production (Nweke *et al*., 2004). Cassava is a basic staple food for more than 70% of Nigerian population, playing an important role in Nigeria's food security as majority of Nigerians eat cassava products at least once a day (Sanni *et al.,* 2007). The estimated daily per capita consumption of cassava in Nigeria is such that it contributes about one megajoule (MJ) to the diet (Sanni *et al.,* 2004) while people in Congo, Gabon, Mozambique and Zaire, derive about 1000 calories a day from cassava tubers (Ojeniyi *et al.,* 2009; Eke-Okoro *et al.,* 2009).

Cassava roots can be eaten boiled, processed into gari, flour and livestock feeds. It is also an industrial raw material for the production of alcohol, dextrose for soft drinks, fuel, sweeteners, paper, textiles, plywood, sodium glutamate food seasoner and flour for confectioneries (CGIAR, 2004; Okechukwu *et al.*, 2005; Bud, 2008). Apart from the root tubers, cassava leaves are also eaten as vegetable in East, Central and some West African countries (Okpara *et al.*, 2010).

Though cassava is an important crop, its productivity is limited by a number of factors. The constraints include soil moisture availability, weed infestation (Ezedinma *et al.*, 2007), diseases especially the African cassava mosaic disease (ACMD) which can cause yield reduction of between 20-60% (Ogbe, 2001) and genetic factors which are inherent in the development process necessary for the attainment of characteristic form and function (IITA, 1990). Low soil fertility adversely affects cassava yield since cassava extracts large amounts of the macro nutrients from the soil to produce optimum yield (Obigbesan, 1977). In order to achieve sustainable production to feed the ever-increasing population amidst the prevailing landuse pattern and shortened fallow periods, it is imperative to use fertilizers to obtain optimum yield of the crop.

Numerous cassava varieties exist in each locality where the crop is grown. Cultivars are distinguished on the basis of morphology, pigmentation, cyanide content as well as leaf and root shapes. Most farmers prefer improved varieties such as Tropical Manioc Selection (TMS) 30572 and 92/0326 which combine high yield, disease resistance and better response to applied fertilizer (Dixon *et al.*, 2010) while some rural farmers maintain the local varieties (Odongbo, Nwocha and Okobo) alongside the improved ones on their farms. Yield of local unimproved varieties are generally low compared to the improved varieties (IITA, 2005).

Cassava is compatible with most farming systems and peasant farmers mostly grow it primarily as staple in mixtures with other food crops. It has the ability to adapt to diverse environmental conditions such as low rainfall (Porto, 1993) and fertility depleted soils where other crops cannot thrive, due to its ability to extract nutrients from marginal soils to produce reasonable yield (Obigbesan, 1999).

Most farmers in Nigeria practice intercropping of cassava with a wide range of arable crops, hence cassava-based farming system. Cassava can be intercropped with maize, melon, cowpea and fluted pumpkin. Intercrop combination is largely determined by household needs, soil nutrient status as well as resources available to the farmer. Planting of cassava in pure stands (monocropping) is done in marginal fields especially by some commercial farmers and outgrowers. Yields of 25-30 t/ha has been realized in monocrop with 400-600kg of NPK 15-15-15 while yield of 15-23 t/ha has been obtained by a combination of 5 t/ha organic manure+100 kg/ha NPK 15-15-15 (Ayoola and Makinde, 2011; Vanlauwe *et al*., 2013).

Cassava requires few production inputs and is amenable to agronomic and genetic improvements. However, to obtain optimum yield, the crop requires friable light textured and well drained soils with sufficient moisture (at least 1000 mm rainfall) and a balanced amount of plant nutrients (Cock, 1985; IITA, 1990).

Most soils in Nigeria are low in nutrient content while fallow periods are becoming shorter. Therefore, additional nutrient in form of organic or inorganic fertilizer must be applied to boost soil nutrient content for the production of high cassava yield. Cassava requires higher amounts of nitrogen and potassium than phosphorus for optimum tuber yield (Obigbesan, 1977; Howeler, 2002). The crop extracts 164 kg N/ha, 31 kg P/ha and 200 kg K/ha as well as other macro- and micro nutrients from soil for optimum yield. However, one of the major problems has been that of ascertaining the rates of fertilizer combinations to apply in order to meet the need of the crop for optimum yield.

For effective management of soil fertility, fertilizer types and nature of the soil must be taken into consideration. Soils in Nigeria have predominantly low activity clays and low cation exchange capacity (CEC) which are major constraints to the use of mineral fertilizers, making them to have short term effect in soil (Ogunwale *et al.*, 2003). High rainfall in humid and sub-humid agroecological zones aggravates the situation, leaching nutrients beyond root zone of crops. Balancing of nutrient supplies by fertilizer application is therefore crucial since excess nutrient application increases shoot growth to the detriment of root yield (Okpara *et al*., 2010). Poor organoleptic and post harvest qualities due to mineral fertilizer application have been reported (Sanni *et al.*, 2007), therefore the need for an alternative source of nutrients as fertilizers.

Due to the nature of tropical soils with inherent poor nutrient retention ability, an appreciable amount of organic matter through the application of organic components must be incorporated into the soil to raise the CEC. A better alternative which integrates inorganic and organic fertilizers has been recommended (Eneji *et al.,* 1996). While the inorganic component releases nutrients faster for the initial growth of crop, the organic component improves soil structure for nutrient and moisture retention, and subsequently release nutrients slowly for crop use, such fertilizers combine decomposable organic materials and mineral fertilizers and have been successfully used in the production of rice, potato and cassava (Satyanarayana *et al.*,2002; Zebarth *et al.*, 2005; Rasheed, 2007).

Cassava has a long growth cycle and no specific time of harvest, although most farmers prefer to harvest the crop between 12 and 18 MAP. Appropriate time of harvest of the crop for optimum yield must be ascertained while taking into consideration the clone, socio-economic factors and uses (Nweke *et al.* 1994; Alleman and Dugmore, 2004). Small-scale farmers who grow cassava varieties as primary staple, can leave the roots in the ground even beyond 18 MAP and harvest when needed, thus serving as a security during famine, unlike maize, rice and vegetables (FAO, 1991). As the plant grows, its roots continue to bulk until about 18 MAP when yield increases become insignificant (Nweke, 2004). Depending on utilization, some researchers have suggested harvesting the crop before 12 Months After Planting (MAP) for good flour quality, 12-14 MAP for quality starch, but beyond this period, cassava roots become fibrous and susceptible to tuber rot especially where inorganic fertilizer is used in production (Apea-Bah *et al*., 2011). Apart from poor quality root tubers, prolonged maturity period beyond 15 MAP limits landuse for further cultivation as appropriate time of harvest cannot be ascertained. Therefore there is the need to determine the optimum time to harvest cassava genotypes for optimum yield and desired quality (Ngendahayo and Dixon, 2001).

Evidently, cassava productivity is limited by soil nutrient status and prolonged period of harvest. Mineral fertilizers are believed to have detrimental effects on soil health, productivity and product quality, beside their short term effect in soil (Obigbesan, 1999). Again, leaving cassava roots longer than 15 MAP on the farm limits land use, compromises quality of roots such that the exact time for optimum yield attainment cannot be determined.

In addressing the constraints of low soil nutrient status and optimum harvest time, using a mixture of organic and inorganic materials as organomineral fertilizer has been advocated, however further research is needed to determine the optimum rate of application and the optimum time to harvest the crop.

These have provided a platform for further investigation of the efficacy of fertilizer in cassava production and the optimum harvesting time of the crop.

Therefore, the specific objectives of this investigation were to:

1. determine the effects of organomineral fertilizer on cassava yield
2. evaluate the residual effects of applied organomineral fertilizer on cassava yield and
3. assess the effects of organomineral fertilizer and harvesting time on cassava yield.

CHAPTER 2

LITERATURE REVIEW

2.1 Morphology and growth of cassava

Cassava is a perennial shrub grown mainly in the tropics for its starchy roots. It grows between latitudes 30^o N and 30^o S (Cock, 1985). Cassava is propagated mainly by stem cutting, though under natural conditions and breeding purposes seeds are used. Optimum temperature for seed germination is between 25^{o}C and 35^{o}C (Ellis and Roberts, 1979). Cuttings for commercial production are commonly 10-30 cm long taken from the woody part of mature plants. However, tip shoot cuttings have also been investigated and successfully used in cassava multiplication (IITA, 1990). Large cuttings give vigorous initial growth but may not necessarily correlate with final yield (Wholey, 1974). Sprouting of cassava cuttings is sensitive to temperature, fastest sprouts are produced between 28.5 - 30^{o}C (Keating and Evenson, 1979). Cassava cuttings bearing nodes may be planted vertically, inclined or horizontally. Horizontally planted cuttings produce more shoots but may not necessarily translate to highest yield (Cock, 1985; Osiru *et al.*, 1995). Cassava produces both nodal and basal roots and the rooting of cassava is known to be polarized therefore planting the cutting upside down would increase the time of sprouting and may lead to poor establishment of the crop (Ekanayake, 1993). Generally, sprouting takes place between 5 and 6 days after planting with fresh healthy cuttings but emergence rate may be influenced by planting position of the cuttings (Ekanayake, 1996).

Axillary and adventitious roots (like fibrous root system) are produced in the first few weeks after planting and initial growth of the shoot system is relatively slow. Initiation of storage root may begin as early as 6 weeks after planting (WAP) in some cultivars, but generally it occurs from 8 to 12 WAP and continues to develop until 8 to 15 months (El-Sharkawy *et al.*, 1989; Ekanayake, 1993). Cassava has a coarse, relatively thick and poorly branched root system with few root hairs while some roots extend deeply, most are shallow (Howeler *et al*., 1981).

Average height of the crop is between 1 and 2 meters while leaves are spirally arranged on the stem. The leaves comprise of petiole, stipules, leaf blade or lamina which is usually palmate or lobed in odd numbers between three and nine (IITA, 1990). In cassava, the shoots and roots develop simultaneously such that assimilate supplies are partitioned between them resulting in intensive competition. Leaf formation is given higher preference over storage roots for available assimilates in the first twelve weeks after planting. Leaf area index in cassava ranges from 3 to 7 depending on variety and soil fertility. However, large leaf area index values of 10 or more have been obtained (Keating, 1981). Leaf area increases with age of the plant, reaching peak at 4 to 6 months after planting (MAP) and declining thereafter (Cock, 1984; IITA, 1990).

Some cassava varieties exhibit two types of branching, forking and lateral, while some which do not branch may produce lateral shoots. Branching in cassava can be influenced by environmental conditions and genotype, however, the plants produce forks at different heights up to four or five levels depending on the clone. Multi-level branching promotes early canopy closure which reduces weed growth (Okpara *et al*., 2010). Cassava is monoecious, and production of flowers is also influenced by genotype, environment, altitude as well as photoperiod. Flowering is frequent and regular in some varieties, while it is rare or non-existent in others, but this may also be governed by a set of factors (IITA, 1990).

2.2 Varietal differences in cassava

The International Board for Plant Genetic Resources (IBPGR) has identified a set of relatively stable morphological traits as descriptors which are useful in the classification and varietal identification of cassava (Aina, 2006). Shoot characteristics refer to above ground morphological characters such as leaf shape, petiole colour, petiole length, branching habit, plant height, stem colour, stay green, and length of internodes. Root characteristics include number of roots, root size, root shape, skin colour, peel colour, time of maturity, dry matter content, yield, and hydrocyanic acid content (Osiru *et al.*, 1995). Preference of farmers for different varieties has been on the basis of economic yield, maturity period, pest and disease resistance, organoleptic qualities, early and aggressive canopy formation to suppress weeds and compatibility with the farming system (IITA, 1990). Improved varieties of cassava such as TMS 30572, TMS 4(2)1425, TMS 92/0326, TMS 98/0505 have been bred by IITA and National Root Crop Research Institute, Umudike, tested and released to various areas of cultivation (IITA, 2005; Dixon *et al.*, 2010; Okpara *et al.*, 2010). Local varieties such as Odongbo, Nwocha, Isunikankiyan, Kamkerefere, Okobo, Rogo and Panya are also commonly found on farmers' farms (Edet, 1989; Edet, 1995).

According to Dixon *et al*. (2010), the TMS 92/0326 is a product of a cross between TMS 91934 and a local variety, TME 1 (Antiota) and has proved to be one of the leading varieties in yield and other qualities. The variety is high yielding, early maturing, possesses multiple resistance to diseases and pests, and responds well to fertilizer application. The TMS 30572 is highly preferred in areas where cassava is grown due to its ability to combine high yield with disease resistance especially African Cassava Mosaic Disease which can cause drastic yield reduction in cassava (IITA, 1990). With a vigorous growth rate and positive response to fertilizer application, this variety is capable of establishing early canopy structure which reduces weed growth.

2.3 Nutrient requirements of cassava

Cassava may grow well and produce reasonable yields in poor and degraded soils where other arable crops cannot thrive. It is often called scavenger crop due to its efficiency in nutrient absorption from a low nutrient soil. Although cassava can be cultivated in impoverished, nutrient-deficient and marginal soils, the crop requires adequate quantities of nutrients to produce a good crop yield (Obigbesan and Fayemi, 1976; Howeler, 1991; Obigbesan, 1999). It responds to generous doses of N, P and K as well as other macronutrients such as magnesium, calcium and sulphur.

According to Howeler (2008), cassava extracted 198 kg N, 70 kg P_2O_5, 220 kg K_2O, 47 kg MgO, 143 kg CaO and 19 kg S per hectare to produce a yield of 37.0 tonnes while 35 kg N, 58 kg P_2O_5, 7.0 kg CaO and 4.1 kg Mg/ha is required to produce root yield of 15.0 t/ha. Thus at lower yields, nutrient removal would be considerably lower, however, compared to other crops, nitrogen and phosphorus removal per tonne of dry matter in cassava were found to be much lower than those of other crops such as maize, rice and sweet potato (Howeler *et al*., 1981). Although yields of about 10 t/ha or lower obtained in some farmers' fields may not seriously deplete the nutrients level of the soil, it is advisable to apply 60 kg N, 15 kg P_2O5 and 50 kg K_2O to prevent further decline in nutrient levels in soil for an expected good yield (Nweke, 2004; Howeler, 2002).

Among tropical root crops, cassava has the highest ratio of potassium to nitrogen in the harvested root tubers and demands the largest amount of potassium from the soil. This situation makes cassava yield more closely associated with the concentrations of N and K in the roots than phosphorus (Howeler, 2002). Cassava tuber yield can generally be increased by N and K rather than P, since the crop has ability to adapt to low levels of available P as a result of the association of its roots with mycorrhiza which helps to solubilize and mobilize P levels as well as increase the availability in the soil (Howeler, 1994). Adequate N levels stimulate vegetative growth and production of assimilates while K enhances sink and dry matter accumulation in the root tubers (Onwueme and Charles, 1994).

However, nutrients do not react independently but work with each other, high concentration of K in the soil may reduce uptake of calcium and magnesium while excess of N leads to luxuriant shoot growth at the expense of tuber formation (Sanchez and Miller, 1986; Howeler, 2002). Furthermore, frequent use of sulphate fertilizers should be avoided due to its ability to raise the acidity and thereby not allowing lime dressing to cause any significant increase in tuber yield (Omoti and Ataga, 1980; Ande, 2010).

Cropping systems and practices influence fertilizer requirements and recommendation for cassava. Continuous cropping without adequate soil amendment leads to faster depletion of major nutrients, especially N and K, which can cause yield decline from 28.0 to 11.0 t/ha after 20 years of cultivation. However, yields can be maintained at 20 t/ha with the application of NPK 15-15-15 at the rate of 600 kg/ha (Sittibusaya, 1993; IITA, 2005). Intercropping of cassava with legumes may reduce the requirement for N and P due to the ability of legumes to fix N for use by cassava while P is made available for plant use through mycorrhizal association (Howeler, 1994; Edet, 1995). Ayoola (2010) reported the depletion of soil P in a crop mixture involving cassava/maize/melon/okra on farmers’ field in the tropics and attributed it to crop removal and fixation. Furthermore, high demand of exchangeable K was reported after maize/melon harvest before cassava inclusion in mixture (Adeyemi, 1991).

2.4 Response of cassava to fertilizer application

The role of fertilizer in increasing crop yield and production to feed the ever increasing population has been severally investigated (Agbaje and Akinlosotu, 2004; Makinde *et al*., 2010). Higher yields of cassava are usually recorded in areas where fertilizer is frequently used and increase in cassava yield due to fertilizer application has been severally reported (Obigbesan, 1977; Lema *et al.*, 2004; Fermont *et al.*, 2010; Okpara *et al*, 2010).

Response of cassava to applied nutrients, however, depends to a large extent on the soil nutrient status at the time of application but higher response to a particular nutrient element is envisaged when the level is low in soil. The heterogeneous nature of soils in Africa has strong effects on the crop response to fertilizer due to difference in soil type, historical management and resource allocation (Zingore *et al.*, 2007), soil nutrient status and rainfall regime (Vanlauwe *et al.*, 2006). There is a high variability in fertilizer response even on infertile soils, indicating interactions between factors which should be considered when choosing and developing fertilizer recommendations and models (Fermont *et al*., 2010).

This however requires a careful consideration of the fertilizer type, rate, as well as fertilizer materials, before application of fertilizer to cassava. Furthermore, the crop's response to fertilizer in sole cropping differs from that of cassava grown in mixed stands. Therefore the judicious management and conservation of soils for sustainable cassava-based intercropping under intensive cropping must be taken into consideration. It has been reported that crops especially under intercropping take up more nutrients than in monocrops (Howeler and Cadavid, 1983). Iwueke (1991) found that aggregate uptake of each nutrient was higher in the intercrop of cassava/maize/melon than in the sole crops suggesting that soil nutrients would deplete faster under intercropping than in sole crops unless a fertilizer regime of NPK 15-15-15 at 400 kg/ha is maintained.

Fertilizer recommendations for optimum response should take into consideration the companion crops. In cassava/maize intercrop with low K in soil status, application of 100kg K/ha annually is recommended to sustain optimum yields of cassava roots (Howeler and Cadavid 1990). Cassava in intercrop generally responds to generous dose of organic based fertilizer complemented with inorganic fertilizer especially NPK

(Ayoola and Makinde, 2011). In Southwestern Nigeria, intercropping cassava with arable crops is a common practice. Averagely, 60 – 70% of the cropped land is devoted to growing crops in mixtures of 2-6 crops on a particular farm especially intercropping with cassava (Olukosi *et al*., 1991). Makinde *et al* (2007) obtained cassava root yield of 22.3 t/ha with the application of a combination of 5 t/ha of organic manure + 75kg N and 50 kg P in cassava/maize/melon/soybean intercrop which was lower than 18.2 t obtained when NPK 15-15-15 was applied at 450 kg/ha. In the same agroecological zone, application of 5 t/ha of organic based fertilizer + 100 kg/ha NPK produced 13.9 t/ha of cassava roots, higher than 10.0 t/ha obtained by applying 400 kg/ha NPK 15-15-15 alone in a cassava/maize intercrop. Significant increase in soil nutrient status was also observed after two cropping seasons (Ayoola and Makinde, 2011).

Cassava responds promptly to both macro and micronutrients application. Adequate level of potassium stimulates N-response while excess N suppresses response to applied K in soil. Although cassava is a heavy macro-nutrient feeder, it also requires other meso-/micro-nutrients to produce good yields (Howeler 2008; Nguyen *et al.*, 2002). Research on the response of cassava to Agrolyser (which supplies mainly micronutrients) and Alfigol are on-going at IITA, Ibadan and NRCRI, Umudike (Ano and Ikwelle, 1998).

Response of cassava to applied organomineral fertilizer has also been reported by Oluleye and Akinrinde (2009). Agbaje and Akinlosotu, (2004) observed that at late planting, high nutrient concentration of fertilizers at 400 and 800 kg NPK/ha depressed cassava tuber yield in favour of top biomass. Similar findings have been reported by Sanchez and Miller (1986). But the application of NPK at the rate of 600 kg/ha was found to increase the number of tuberous roots per plant as well as the overall yield (Ojeniyi *et al*., 2009).

2.5 Organic fertilizer use in crop production

Organic fertilizers are substances of plant or animal origin capable of increasing the organic fraction of the soil and soil nutrients when applied to the soil (Dupriez and Deleener, 1988). Organic manures occupied top position as major sources of soil fertility maintenance until the mid sixties when the use of inorganic fertilizers came into prominence. This may have been due to the transition from traditional to modern agriculture practices, but China, India and Japan have successfully incorporated the use of organic fertilizer in supplying soil nutrients for crop production, thereby reducing the rate of chemical fertilizer use (Gibberd, 1995)

A number of organic wastes have been investigated and reported as being rich in elements such as N, P, K, Ca, Mg, Zn, Cu, Fe, and Mn (Titiloye *et al.*, 1985). Positive effects of the use of various farm wastes on a number of crops such as cereals, vegetables, tuber, legumes, and tree crops have been investigated and reported (Schippers, 2000; Ayeni, 2010; Babatola *et al*., 2003). The use of weeds such as *Chromolaena odorata* and Napia grass on coffee have also been reported (Obatolu, 1991) and the use of water hyacinth in vegetable production has been recommended (Adeoye *et al.*, 2001). Farmyard manure, poultry manure, vermicompost, green manure, crop residues, water weeds and city wastes have been found suitable as substitutes to inorganic fertilizers in maintaining crop production and environmental quality. Similarly, high yields of crops treated with various organic fertilizers have been reported cutting across a wide range of agricultural crops such as cassava (Rasheed, 2007), vegetables (Ayeni, 2010; Makinde *et al*., 2010) and yam, (Eze *et al*., 2010).

Nutrient content of organic manures depends to a large extent on the source (Edward and Daniel, 1992). The traditional farmers recognize the fact that organic manures differ in quality. Highest yield (29.4 t/ha) of cassava roots was obtained with the application of 6.25 t/ha of poultry manure, probably due to a season long supply of quality nutrients, suggesting poultry manure as one of the best sources of nutrient for use in cassava production (Rasheed, 2007). Similarly, Kumar *et al*. (1977) has reported a favourable response of cassava to poultry manure compared to other organic sources. Poultry wastes have been found to contain all essential plant nutrients when applied to the soil. Increased soil phosphorus availability and decreased P-sorption within the soil profile has been documented with its application (Field *et al.*, 1985). Gibberd (1995) reported significant yield increases in both cereals and legumes when farmyard manure (FYM) was applied at the rate of 10 t/ha on three different food crop rotations which included both sole and intercrops. The use of ash derived from cocoa pod husk, wood saw dust, rice bran, oil palm bunch, fruit shafts, plantain peels, water hyacinth, market wastes and brewers grain as fertilizers in crop production have been variously investigated by a number of researchers. Positive effects of these fertilizer materials on soil organic matter, pH, available phosphorus, exchangeable K, Ca, Mg, N, P and K availability have been reported. (Odediya *et al*., 2003; Owolabi *et al*., 2003).

However, there are some constraints to the use of materials of organic origin as fertilizer. Nutrient contents of organic fertilizer materials are generally low, hence large quantities of organic fertilizer would be needed to satisfy nutrient needs of crops. This entails additional cost of transportation on the part of the farmer apart from the cost of labour for fertilizing large-scale commercial farms. Furthermore, information on the correct quantity and amounts required by different crops is scarce. Other constraints of using organic materials as fertilizer include; bad odour, pest infestation and demand for large storage space (Omueti *et al*., 2000). The rate of decomposition of organic material and subsequent release of nutrients into the system is slow (Flaig, 1974) and nutrients may be lost through volatilization and run-off hence the need for fortification with mineral fertilizer for immediate use before mineralization of organic manures to release plant nutrients. It is also assumed that the indiscriminate use of municipal and industrial wastes could lead to toxicity of some heavy metals (Mc Calla, 1975); however, the use of organic wastes as fertilizer is advantageous from both economic and environmental standpoint (Kiel, 1999).

2.6 Organomineral fertilizer use in crop production and residual effects

Organomineral fertilizer (OF) or humic fertilizer can be defined as fertilizer that consists of organic matter and mineral compounds bound to it either chemically or by adsorption. The fertilizer has various compositions and names: humoammophos, peat-ammonia fertilizer (PAF) and Peat-mineral-ammonia fertilizer (GSE, 2010). Organomineral fertilizer combines the characteristics of organic and mineral fertilizers and may be formulated in granular and pellet forms. The product has been used in both conventional crop production and in low environmental impact farming.

The use of chemical fertilizers alone in intensifying crop production in space is neither sustainable nor effective in the long run. It usually leads to decline in soil organic matter content, soil acidification and soil physical degradation which consequently lead to increased soil erosion (Rodale, 1995; Doran *et al*., 1996). On the other hand, organic fertilizers alone are slow in nutrient release for initial establishment and growing of short season crops. Apart from bulkiness, large quantities are required to meet crops nutrient needs and labour costs of application may be high (Nyathi and Campbell, 1995).

Organinomineral fertilizer application will give the benefits of applying organic fertilizer and a little dose of inorganic fertilizer (Makinde, 2007). The inorganic portion serves as source of quick nutrient release to support crop establishment while the organic fertilizer undergoes mineralization to release nutrient slowly to support the later growth cycles of the crop (Titiloye, 1982; Ayeni, 2010). A complementary use of organic and mineral fertilizers has been recommended for sustenance of long term cropping in the tropics (Palm *et al.*, 1997). Highest grain yield of rice has been obtained with the application of 10 t/ha of FYM combined with NPK (Satyanarayana *et al.*, 2002), while combination of 5 t/ha FYM with 20 kg N + 10 kg P/ha has been recommended for optimum yield of sorghum (Baju *et al.*, 2006). Zebarth *et al.*, (2005) has made a recommendation of 1.5 t/ha of OF at planting by band method for root crop production. Studies in Nigeria show that organic based fertilizers are less leached into ground water than chemical fertilizers (Sridhar and Adeoye, 2003), and leaching losses were also observed to be lowest in soils treated with OF than soils treated with mineral fertilizer (Tejada *et al.*, 2006).

Significant yield increase with melon crop fertilized with 3 t/ha of OF has been reported (Makinde, 2007). Ayoola 2010 found that cassava yields were increased by the application of organomineral fertilizer. Organic and organomineral fertilizer combinations were found to increase yield of yam, maize, vegetables such as pepper, tomato, okra, amaranthus (Ipinmoroti *et al.*, 2003; Fagbola and Dare, 2003; Makinde, 2007; Adeoye *et al.*, 2008; Ojeniyi *et al.*, 2009, Olowokere, 2009). In University of Ibadan, Nigeria, organic wastes: city wastes, market wastes and farmyard manure have been fortified with inorganic fertilizers (nitrogen and phosphorus) to compound OF. Different organic wastes and combinations of organic and mineral fertilizers as well as the residual effects on soil and soil properties have been variously investigated and successfully used by a number of researchers; kola pod husks + NPK on amaranthus (Makinde *et al.*, 2010), cocoa pod ash + NPK on tomato (Ayeni, 2010).

2.7 Effects of harvesting time of cassava on yield

Although cassava is a perennial plant, starchy roots are commercially harvested between 6-24 MAP (El-Sharkawy, 1993). In humid lowlands in tropical countries, the roots can be harvested after 6-7 MAP while in cold and drought areas, cassava may be harvested after 18-24 MAP (Cock, 1984).

As cassava grows, the roots continue to bulk until maturity time when further growth or leaving it in the soil does not result in significant sink accumulation in the roots. The time of harvesting cassava depends on the variety, socioeconomic factors and utilization (Nweke *et al.,* 1994). Improved cassava varieties mature early at about 9 MAP while others may require up to 15 MAP to accummulate reasonable root dry matter. Most unimproved local varieties planted by local farmers take a longer time to mature compared to the improved varieties. Some cassava varieties can be left in the ground up to 24 months and harvested when needed in order to preserve the tuberous roots which are highly perishable.

Githunguri *et al.* (1998) obtained yield of above 25 t/ha in TMS 30572, TMS 4(2) 1425 and TMS 30555 cassava varieties at 8 MAP, but Ezedinma *et al.* (1980) obtained root yield of 26.0 t/ha in TMS 30572 cassava variety up to 12 MAP and observed yield decline thereafter. Alleman and Dugmore, (2004) reported significant yield increases of 32.0 t/ha in same variety when harvest was delayed to between 15 to 21 MAP. Okpara *et al.* (2010) in a different report stated that 12 MAP appeared to be the optimum time of harvesting cassava variety TMS/98/505 to obtain storage root dry matter yield of 13.5 t/ha, with no significant additions beyond this period. Fresh cassava tuber yield of 41.0 t/ha obtained at 14 MAP with same variety was also reported but the yield obtained by Eke-Okoro (2001) with TMS 30572 was lower at harvest between 12-14 MAP.

The uses of cassava tuberous roots also determine the period of harvest. Cassava meant for flour production should be harvested before 12 MAP for better quality flour (Apea-Bah *et al.,* 2011). According to Obigbesan (1999), when cassava is allowed to grow up to 15 MAP starch yield triples yield obtained at 9 MAP. Reduction in quality of harvested roots that has been left beyond 15 MAP has been reported (Sanni *et al.,* 2007) and most early maturing cassava varieties are prone to root rot and poor quality of harvested roots when left in the ground beyond this period, especially where fertilizer is used in its production. Ebah-Djedji *et al* (2012) obtained higher starch content of 23 and 18% in Ay 15 and 90/00039 cassava varieties respectively during harvest at 13 MAP than 17 and 16% starch contents obtained from the same varieties at 17 MAP harvest.

Harvesting time affects the organoleptic qualities of cassava. Mulualem and Ayenew (2012) reported that delaying harvest of cassava beyond 18 MAP resulted in undue cellulose accumulation, low starch and high hydrocyanic acid content in the roots. Out of 10 cassava varieties evaluated, 45/72NW produced the highest yield of 36 t/ha when harvest was delayed up to 18 MAP. Although yield of 41 t/ha was obtained for the same variety harvested at 24 MAP, problems of poor quality, pests and diseases were common within this period. Furthermore, yield related traits in most of the characters showed dramatic yield increases when harvested between 12-15 MAP. Harvesting at 12-14 MAP also ensures quality stakes (planting material) for propagation (Ezedinma *et al*., 1980; Mulualem and Ayenew, 2012).

Ngendahayo and Dixon (2001) stressed the need to determine the optimum harvesting time for cassava varieties in different ecological zones of Nigeria. However, the harvest time for cassava depends on the variety, ecological factors, socioeconomic factors and uses. This will equip farmers with the knowledge of appropriate time to harvest cassava for optimum yield of high quality tuberous roots, avoid losses and maximize the use of land.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of Experimental Sites

Experiments were conducted at the University of Ibadan Teaching and Research Farm and Oluana village, Akinyele Local Government Area, Ibadan between 2007 and 2010. The University of Ibadan Teaching and Research Farm is located at Ajibode end of the University of Ibadan.

Ajibode lies within the derived savanna zone of Southwestern Nigeria on latitude 7^{o}30'N and longitude 3^{o}54'E. The soil at the site of the experiment is Alfisol soil type (Ogunkunle, 1989). Rainfall pattern at Ajibode is bimodal with peaks in June/July and September/October. The rainy season begins in April and ends in October while November to March constitutes the dry season. The total annual rainfall and the monthly mean temperature, relative humidity and solar radiation for the experimental site during 2009-2010 are shown in Table 4.1. The site was previously under continuous cultivation with arable crops such as maize, cassava and melon between 1999 and 2004. In 1999 to 2001, urea fertilizer was applied to planted maize at the rate of 200 kg/ha while NPK 15-15-15 was used during 2002 and 2004 on cassava intercropped with maize and melon. However, the land was left to fallow for about three years prior to the establishment of the experiment. The dominant vegetation at the site included *Tithonia diversifolia*, *Ageratum conyzoides*, *Chromolaena odorata* and *Euphobia heterophyla.*

Oluana location lies towards the northern part of Ibadan on Oyo Road. It is located on latitude 7^{o}30' 8" N and longitude 3^{o}54' 37" E with an altitude of 243 meters above mean sea level in the derived savanna agro ecological zone. Rainfall pattern and soil type at Oluana are similar to those obtained at Ajibode location. The total annual rainfall, monthly mean temperature and relative humidity for Oluana experimental site during the period of 2009 -2010 investigation are shown in Table 4.2.

The site was under cultivation with maize, cassava and cowpea for about four years without fertilizer application and left to fallow for 10 years prior to establishment of the experiment. The dominant vegetation at the experimental site included *Chromolaena odorata*, *Tithonia diversifolia*, *Gliricidia sepium*, *Leucaena leucocephala, Vernonia sp. and Cassia sp.*

3.2 Experiment Materials

3.2.1 Cassava varieties

The two cassava varieties (TMS 30572 and TMS 92/0326) evaluated in the study were developed at IITA, Ibadan and have the following indicated descriptors:

TMS 30572: This is a popular variety with good response to fertilizer. It is used as a national check in most cassava trials (IITA, 2005). The variety is characterized by multiple levels of branching, early spread of canopy, high yield and moderate resistance to pest and diseases.

TMS 92/0326: This is a recommended cassava variety recently developed in IITA Ibadan. It responds well to fertilizer application, branches moderately and combines high yield with disease and pest resistance.

3.2.2 Fertilizers used

Organomineral Fertilizer (OF)

The organomineral fertilizer used for the experiment was Grade A type (fortified with Nitrogen and Phosphorus). The fertilizer was procured from Oyo State Pace-setter fertilizer plant at Kara, Bodija Ibadan. The fertilizer consisted of livestock dung, market waste, vegetable residues, husks of fruits, seeds and nuts, peels of fruits and food wastes which constituted about 92% of the organic component while 2% single super phosphate and 6% urea constituted the inorganic component. The recommended rate of OF (1.5 t/ha) by Zebarth *et al.* (2005) was used as a guide for calculating the OF rates.

Inorganic Fertilizer

Commercial inorganic fertilizer, NPK 15-15-15 was used at the recommended rate of 600 kg/ha (IITA, 2005).

3.2.3 Chemical analysis of the organomineral fertilizer

Ten grammes of the OF was ground and sieved through 2 mm-sieve and analysed in the laboratory by standard methods (IITA, 1979). The total N was determined by a semi-micro digestion technique. The phosphorus was determined with spectronic 20; potassium and sodium with flame photometer while calcium and magnesium were determined with Atomic Absorption Spectrophotometer (AAS). The organic carbon content of fertilizer was determined by the Walkley and Black procedure (Nelson and Sommers, 1982) while pH was determined in distilled water at ratio 1:1.

3.3 Soil Sampling and Analysis

Soil samples were taken from the experimental sites before planting to assess the initial nutrient status. Twenty one core soil samples were randomly collected on the field at a depth of 0-30 cm for physical and chemical analyses. The samples were bulked into a composite sample from where a representative sample was taken, air-dried and crushed. Soil samples were sieved through 2 mm and 0.5 mm mesh for the determination of particle sizes, pH (H_20), % organic carbon, available phosphorus (P), iron (Fe), copper (Cu), zinc (Zn) and exchangeable cations.

The particle size analysis was carried out using the hydrometer method (Odu *et al.,* 1986). Total nitrogen was determined by Kjeldahl method (Bremner, 1965) while available P was by Bray's 1 method (Bray and Kurtz, 1990) and read from the spectrophometer. Organic carbon was determined by Walkley and Black procedure (Nelson and Sommers, 1982) while exchangeable bases in the samples were extracted with 1 N ammonium acetate (pH 7). Potassium and sodium present were determined using flame photometer, calcium and magnesium were determined using AAS. Using a soil to water ratio of 1:1, pH meter was used to measure soil pH.

3.4 Description of Experiments

3.4.1 Experiment 1

Experimental site: The experiment was carried out at Ajibode and Oluana, Ibadan

Title: Effects of organomineral fertilizer rates on the growth and yield of cassava

Objective: This experiment was set up to determine the optimum rate of organomineral fertilizer for optimum yield of cassava.

Experimental design and plot layout:

The land was marked out into plots measuring 8 m x 5 m with 2 m spacing between plots (Fig. 3.1). There were seven plots for each of the cassava varieties (TMS

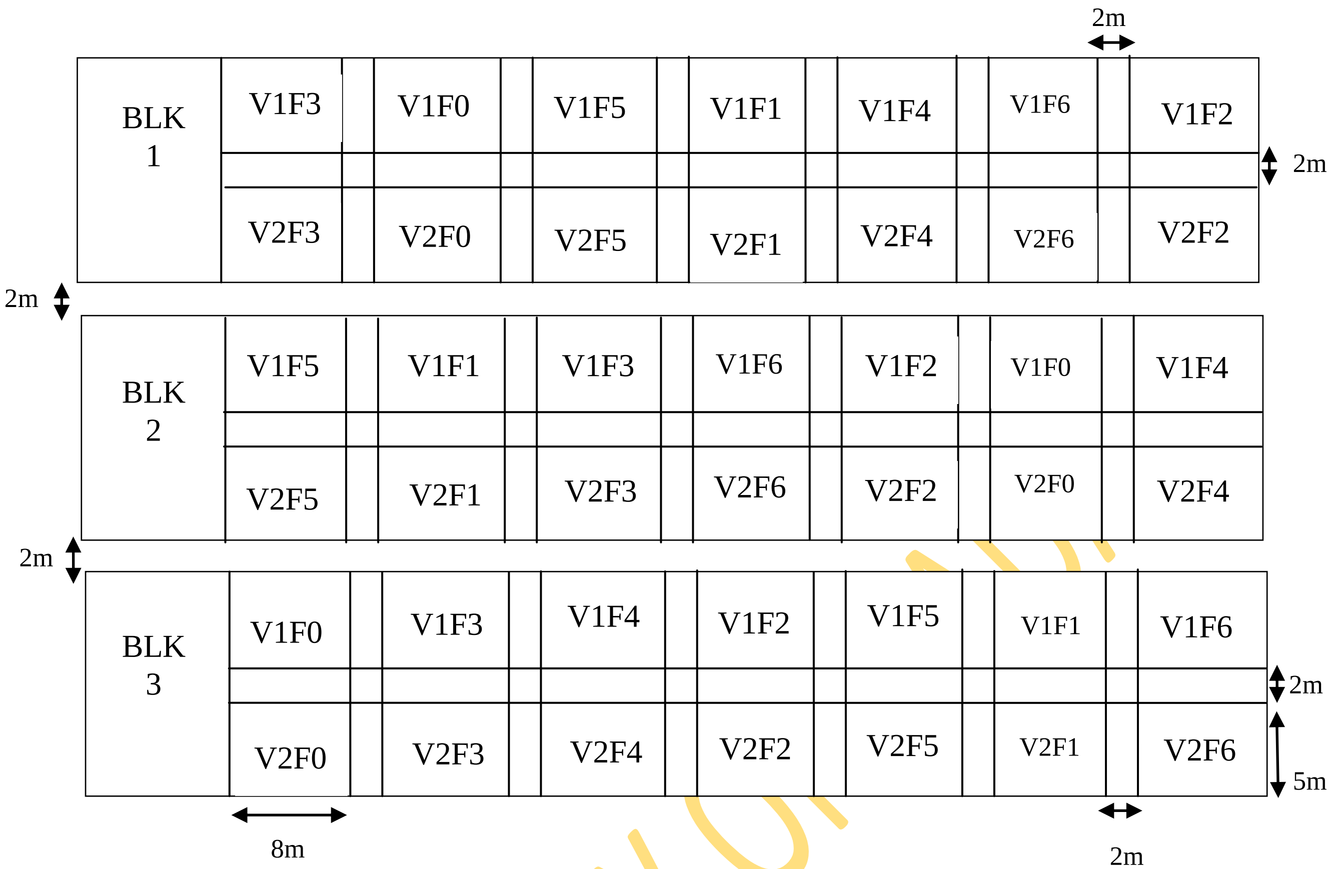

Fig. 3.1: Field Plan for Experiments 1 and 2

V1-TMS 30572

V2-TMS 92/0326

F0 – No fertilizer

F1 – NPK at 600kg/ha

F2 – Organomineral fertilizer at 1.5 t/ha

F3 – Organomineral fertilizer at 2.5 t/ha

F4 – Organomineral fertilizer at 3.5 t/ha

F5 – Organomineral fertilizer at 4.5 t/ha

F6 – Organomineral fertilizer at 6.0 t/ha

BLK – Block

30572 and TMS 92/0526) in a block as main plots while the seven fertilizer treatments viz: No-fertilizer (control), NPK at 600 kg/ha as F1, OF at 1.5 t/ha as F2, OF at 2.5 t/ha as F3, OF at 3.5 t/ha as F4, OF at 4.5 t/ha as F5 and OF at 6.0 t/ha as F6 constituted the subplots. The experiment was laid out in a split-plot arrangement in a Randomized Complete Block Design (RCBD) with three replicates. The total experimental area was 2940 m^2.

Cultural practices

Land preparation

The land used for the experiment was cleared manually with cutlass in May 2007 and June 2008 for 2007/2008, 2008/2009 cropping seasons, respectively. Residues were packed to adjacent fields while the remnants were left *in situ* to decay. The fields at the two locations were ploughed, harrowed and manually ridged at one meter apart before marking them out into plots and blocks.

Planting:

Healthy mature cassava stems of TMS 30572 and TMS 92/0326 obtained from the International Institute of Tropical Agriculture, Ibadan were cut at 25 cm length with 5-8 nodes. Cuttings were planted (one stem cutting per hill) slanting on the crest of ridges at 1 m x 1 m spacing to give a population density of 10,000 plants per hectare. Five rows of eight plants per plot were planted for each cassava variety. Supplying was done at eight days after planting to achieve optimum plant population.

Fertilizer application:

Fertilizer (both organomineral and inorganic) was applied manually by ring method at planting.

Pest control:

Weed was controlled manually using hoe at 3, 7, 12 and 17 weeks after planting. Borders of experimental area were frequently slashed to prevent rodents and dry season bush fire. The experiment was repeated in the following year (2008).

3.4.2 Experiment 2

Experimental site: The experiment was carried out at Ajibode and Oluana, Ibadan.

Title: Residual effects of fertilizer application on the growth and yield of two cassava varieties (TMS 30572 and TMS 92/0326).

Objective: To evaluate the residual effects of applied fertilizer on cassava yield.

The same experimental plot used for Experiment 1 was used to re-establish this experiment in the following cropping season (2008) at Ajibode and Oluana with minimum soil disturbance.

Planting : Healthy mature cassava stems of TMS 30572 and TMS 92/0326 obtained from the International Institute of Tropical Agriculture, Ibadan were cut at 25 cm length with 5-8 nodes. Cuttings were planted (one stem cutting per hill) slanting on the crest of ridges at 1 m x 1 m spacing to give a population density of 10,000 plants per hectare. Five rows of eight plants per plot were planted for each cassava variety. Supplying was done at eight days after planting to achieve optimum plant population. No fertilizer was applied, in order to assess the residual effects of fertilizer rates applied in experiment 1 on the growth and yield of cassava. Cultural practices were the same as in Experiment 1. The experiment was repeated only at Ajibode in 2009.

3.4.3 Experiment 3

Experimental site: The experiment was carried out at Ajibode in 2008 and 2009.

Title: Effects of fertilizer and harvesting time on cassava yield.

Objective: To assess the effects of fertilizer application and harvesting time on cassava yield.

Experimental design and plot layout

The experiment was laid out in a split-split plot arrangement in a randomized complete block design with 3 replicates. The two cassava varieties used in Experiments 1 and 2, constituted the main plot treatments while fertilizer treatments, NPK at 600 kg/ha, OF at 2.5 t/ha (optimum rate in yield performance in Experiments 1 and 2) and no fertilizer application were assigned to the sub-plots. The harvesting periods, 9, 12, 15 and 18 Months After Planting (MAP) were the sub-subplot treatments. The sub-plot size was 110 m^2 while sub-subplot was 18 m^2 with 2 m spacing between plots (Fig 3.2). The experiment was carried out at Ajibode in 2008 and repeated in the same site in 2009.

Cultural practices:

Land preparation, planting, fertilizer application and pest control were the same as in Experiment 1.

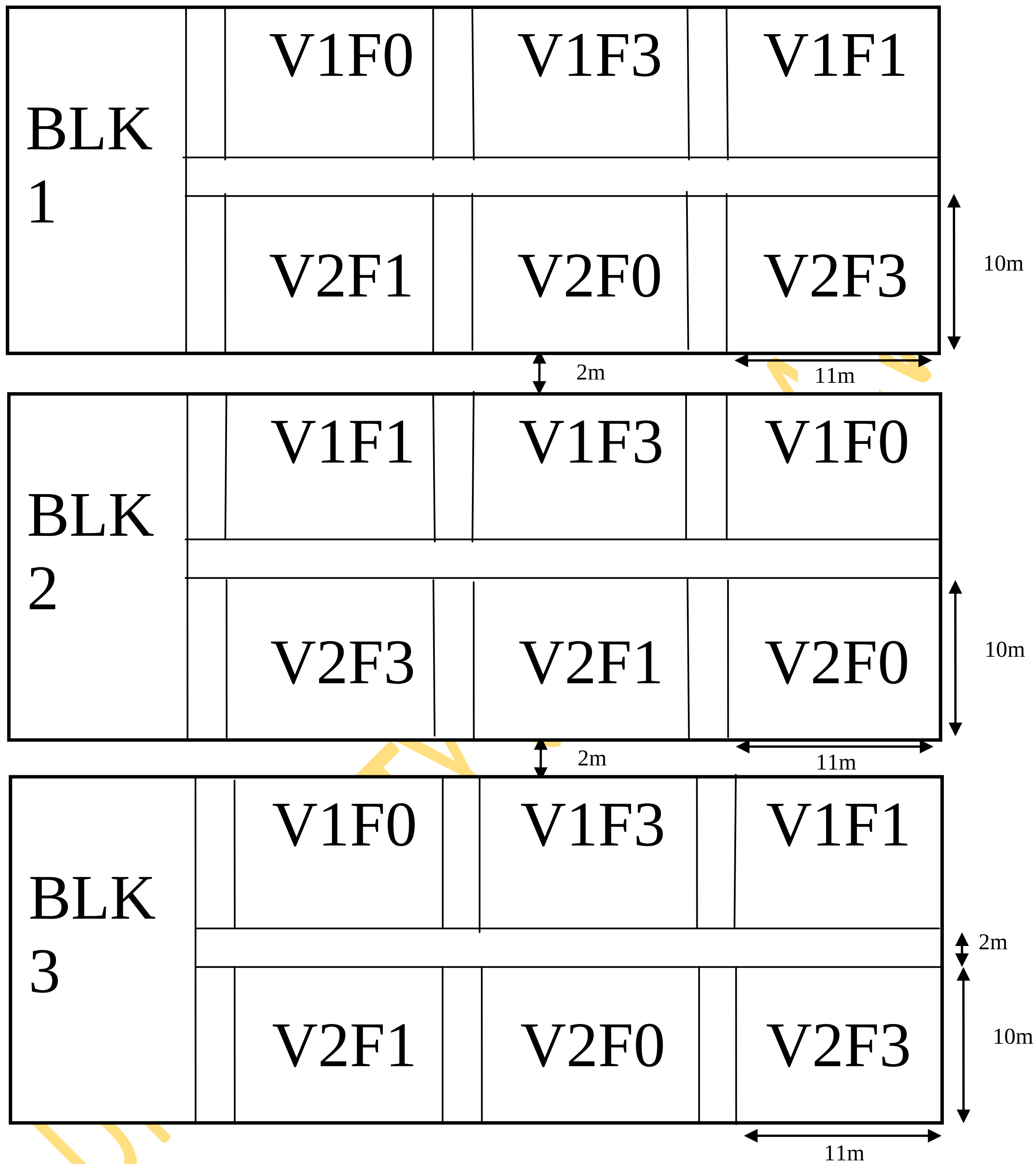

Fig 3.2: Field Plan for Experiment 3

BLK	-	Block
V1	-	TMS 30572
V2	-	TMS 92/0326
F0	-	No-fertilizer
F1	-	NPK at 600 kg/ha
F3	-	OF at 2.5 t/ha

3.5 Data collection:

Parameters measured in all the experiments include;

Emergence count: The number of cuttings that sprouted at 15 DAP in each plot was counted to determine the establishment of the crop

Plant height: Height of cassava plants was measured from the base of the sprout to the tip of the sprout or tallest stem of 18 central stands within the experimental area at monthly intervals at 3 to 6 months after planting (MAP) using a meter rule (Ekanayake,1996)

Number of leaves: The number of all fully expanded leaves per plant of 18 central stands in each plot was counted at monthly interval from 3 MAP up to 6 MAP

Leaf Area: Leaf area (LA) of 12 fully expanded leaves from the central stands in each plot was measured at 3, 4, 5 and 6 MAP using the leaf area meter; (L1-300, L1-Cor, model). The product of the mean values of the 12 leaves measured and the mean of the number of leaves for each treatment in a particular month, divided by the land area was used to calculate the leaf area index (LAI) using the formula: LAI = LA/a

Where a= land area.

Root yield: At maturity (12 MAP for Experiments 1 and 2; and 9, 12, 15 and 18 MAP for Experiment 3), 18 central plants in each plot were harvested. The number of tuberous roots on each plot was counted and weighed.

Shoot yield: The shoots of 18 central plants in each plot were weighed and used to calculate the shoot yield.

Root dry matter:

Dry matter content of the root tubers was determined at harvest using 100 g samples of shredded cassava tubers from each plot. The samples were processed and oven-dried at 65^{o} C to a constant weight and the percentage dry matter content determined.

In the three experiments, Harvest index (HI) was calculated as a ratio of tuber yield to total yield:

HI = TY/TY+ SY, where TY = Tuber yield

SY = Shoot yield.

3.6 Data analyses

Data collected were subjected to statistical analysis using the ANOVA procedure of the generalized linear model of SAS. The treatment means were compared using the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984). Coefficient analysis was also done for some parameters related to yield.

CHAPTER 4

RESULTS

4.1 Experimental location

4.1.1 Meteorological data

Meteorological data obtained for Ajibode and Oluana are presented in Table 4.1, showing the monthly mean rainfall, temperature and relative humidity during the study period (2007- 2010). Total annual rainfall values obtained were 1336.2, 1393.0, 1115.5 and 1740.7 mm in 2007, 2008, 2009 and 2010, respectively. Highest temperatures (28.7^{o}C and 29^{o}C) were recorded in the month of March in 2007 and 2008 while the corresponding temperatures of 28.7^{o}C and 29.7^{o}C, respectively in 2009 and 2010 were recorded in the month of February. Lowest temperatures were recorded in the month of August throughout the period of the study.

4.1.2 Physico-chemical characteristics of soil at experimental site

The physical and chemical characteristics of soil at the experimental sites are presented in Table 4.2. The pH values, nitrogen, phosphorus and potassium concentration of the soils at Ajibode and Oluana were considered optimum while those of magnesium and iron at Oluana were considered low for cassava production (Howeler, 2002). The result of the analysis showed that the soil at Oluana site had higher organic carbon, nitrogen, phosphorus and potassium content than that of Ajibode while micronutrient (iron and manganese) contents were higher at Ajibode soil than that of Oluana. The result of soil analysis also showed that calcium content of Oluana soil (2.8) was higher than that of Ajibode (1.8). The exchangeable acidity as well as zinc contents of the soil were higher in Oluana soil than those of Ajibode. In contrast, the magnesium content of soil was higher at Ajibode than that of Oluana. The soil at Ajibode had a higher percentage of sand and lower content of silt than that of Oluana soil while clay

Table 4.1 Meteorological data for Oluana and Ajibode in 2007-2010

	2007				2008				2009				2010			
Month	Rainfall cm	No of rainy days	Mean temp. °C	Rel. Humidity %	Rainfall cm	No of rainy days	Mean temp. °C	Rel. Humidity %	Rainfall cm	No of rainy days	Mean temp. °C	Rel. Humidity %	Rainfall cm	No of rainy days	Mean temp. °C	Rel. Humidity %
January	0	0	26.2	54.5	0	0	25.0	54.3	10.1	2	26.7	60.5	0	0	28.0	60.7
February	0.1	1	29.2	67.1	0	0	27.7	57.6	33.7	6	28.7	66.1	64.9	5	29.7	59.3
March	15.9	5	29.8	68.7	99.9	11	28.1	67.6	24.6	5	28.6	66.4	50.9	4	29.4	63.8
April	70.7	6	28.4	76.2	133.1	7	27.7	71.7	174.9	8	27.3	70.3	126.2	12	28.9	70.9
May	201.3	14	27.2	81.7	164.1	12	26.6	73.7	186.2	10	26.9	72.0	173.2	15	27.3	74.8
June	308.3	16	25.9	83.2	208.6	15	25.7	76.7	181.6	13	26.0	72.0	212.2	12	26.8	75.2
July	139.8	19	24.9	86.4	248.9	24	24.9	78.4	160.0	21	24.9	75.1	212.1	18	25.3	75.5
August	121.6	22	24.5	87.2	122.9	18	24.7	76.4	41.3	17	24.1	78.4	275.5	16	25.2	78.5
September	264.8	20	25.1	82.8	292.4	21	25.4	78.4	154.8	15	25.2	77.5	294.7	22	25.9	75.3
October	204.0	19	25.7	80.4	115.8	11	26.2	73.8	115.9	12	25.7	75.9	349.9	20	26.3	76.7
November	9.9	3	26.9	77.3	0.1	2	27.6	66.9	32.5	5	26.5	65.3	162.5	10	26.9	74.4
December	0.1	1	25.8	68.8	7.9	3	27.1	62.3	0	0	27.7	61.0	0.5	1	27.2	62.3

Source: International Institute of Tropical Agriculture (IITA) Ibadan

Table 4.2 Physical and chemical characteristics of soils at Ajibode and Oluana in 2007 before planting

Soil parameters	Location	
	Ajibode	Oluana
pH(H20)	6.0	6.1
Organic carbon(g/kg)	16.3	25.7
Nitrogen (g/kg)	1.7	2.2
Phosphorus (mg/kg)	8.3	11.4
Potassium (cmol/kg)	0.6	0.7
Calcium (cmol/kg)	1.8	2.8
Magnesium (cmol/kg)	3.5	2.1
Sodium (cmol/kg)	1.8	1.3
Iron (cmol/kg)	225.0	158.0
Manganese (cmol/kg)	367.0	250.0
Copper (cmol/kg)	1.3	1.3
Zinc (cmol/kg)	4.9	5.0
Exchangeable acidity	0.4	0.6
Sand (g/kg)	858.0	838.0
Silt (g/kg)	74.0	114.0
Clay (g/kg)	68.0	48.0
Soil textural class	Sandy loam	Sandy loam

content of Ajibode soil (68 g/kg) was higher than 48 g/kg obtained at Oluana. However, both soils belong to the sandy loam textural class and medium fertility (Howeler, 2002).

4.1.3 Nutrient contents of organomineral fertilizer used for the experiment.

Nutrient analyses of the organomineral fertilizer used for the experiments are shown in Table 4.3. The results showed that total N content of fertilizer was 44.2 g/kg, available P was 11.2 g/kg while exchangeable K was 8.4 g/kg. These nutrient concentration values were low compared to the nutrient content of inorganic fertilizer used for the experiment.

4.2 Effects of fertilizer application on growth and yield of the two cassava varieties

The results on the effects of fertilizer on the height, number of leaves/plant, leaf area index (LAI), dry matter production and fresh tuber yield per hectare of the two varieties of cassava at Ajibode and Oluana are contained in Tables 4.4 - 4.17.

4.2.1 Plant height

Plant height differed significantly ($p < 0.05$) between the two cassava varieties at 3 to 6 MAP only at Ajibode in 2007 (Tables 4.4). At Ajibode, TMS 30572 had taller plants than TMS 92/0326 in 2007 (Tables 4.5 and 4.7). Although the same trend was observed in 2008, no significant height difference was recorded in the two varieties and at both locations.

Fertilizer application had significant effect ($p < 0.05$) on height of cassava at 4 and 5 MAP at Ajibode and Oluana, respectively in 2007 (Table 4.4). Application of NPK (15-15-15) at 600 kg/ha, Organomineral fertilizer (OF) at 4.5 and 6.0 t/ha at Ajibode and OF at 3.5 t/ha in addition at Oluana resulted in taller cassava plants than no fertilizer application at both locations and 1.5 t OF/ha in addition at Ajibode. At Ajibode, TMS 30572 tended to grow taller with fertilizer in 2007 than in 2008 at 4 – 6 MAP while TMS 92/0326 grew taller with fertilizer in 2008 than with fertilizer in 2007 within the same period. However, at Oluana, both varieties grew taller with fertilizer application in 2008 than with fertilizer in 2007 (Tables 4.6 and 4.7).

4.2.2 Number of leaves per plant of cassava

Cassava varieties differed significantly ($p < 0.05$) in number of leaves per plant at 5

Table 4.3 Nutrient contents of organomineral fertilizer grade A, fortified with nitrogen and phosphorus

Nutrient element	Concentration
Total N (g/kg)	44.2
Available P (Bray P1) (g/kg)	11.2
Exchangeable K (g/kg)	8.4
Ca (g/kg)	6.8
Na (g/kg)	0.8
Zn (mg/kg)	712.7
Mn (mg/kg)	558.3
Fe (mg/kg)	8153.4
Cu (mg/kg)	257.4

Table 4.4. Effect of fertilizer application on plant height (cm) of cassava varieties at Ajibode in 2007

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	64.6a	95.3a	117.8a	132.8a
TMS 92/0326	47.1b	69.5b	91.6b	102.7b
SE	1.60*	2.42*	3.01*	2.10*
Fertilizer (F)				
No fertilizer (control)	55.3	77.2b	98.6	104.5
NPK at 600 kg/ha	67.1	97.3a	115.8	126.4
OF at 1.5 t/ha	53.2	75.8b	105.1	118.3
OF at 2.5 t/ha	57.5	84.9ab	102.7	117.2
OF at 3.5 t/ha	57.7	90.1ab	110.3	123.1
OF at 4.5 t/ha	50.9	95.0a	100.2	114.7
OF at 6.0 t/ha	51.4	96.6a	106.4	119.8
SE	5.25ns	5.98*	6.49ns	7.37ns
SE (Interaction) F x V	6.66ns	7.59ns	8.53ns	8.57ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.5. Effect of fertilizer application on plant height (cm) of cassava varieties at Ajibode in 2008

Treatments	Months after planting			
	3	4	5	6
<u>Cassava variety (V)</u>				
TMS 30572	59.4	97.9	116.1	132.1
TMS 92/0326	64.0	92.2	113.9	129.3
SE	1.95ns	2.48ns	3.33ns	3.42ns
<u>Fertilizer (F)</u>				
No fertilizer (control)	53.7	86.4	100.9	113.2
NPK at 600 kg/ha	67.6	97.7	113.3	129.5
OF at 1.5 t/ha	64.2	105.1	122.9	137.8
OF at 2.5 t/ha	61.1	98.1	114.6	131.3
OF at 3.5 t/ha	61.2	100.0	118.0	137.9
OF at 4.5 t/ha	58.2	91.8	115.6	131.3
OF at 6.0 t/ha	65.5	96.2	119.7	133.9
SE	3.15ns	4.73ns	5.93ns	6.41ns
SE (Interaction) F x V	4.81ns	6.63ns	8.53ns	9.08ns

ns = Not significant

Table 4.6 Effect of fertilizer application on plant height (cm) of cassava varieties at Oluana in 2007

	Months after planting			
Treatments	3	4	5	6
<u>Cassava variety (V)</u>				
TMS 30572	42.3	69.4	103.1	122.3
TMS 92/0326	49.4	77.5	98.0	120.8
SE	3.57ns	3.50ns	2.84ns	14.49ns
<u>Fertilizer (F)</u>				
No fertilizer (control)	38.7	65.5	80.2b	97.2
NPK at 600 kg/ha	57.3	83.5	107.4a	120.6
OF at 1.5 t/ha	38.0	69.2	93.1ab	115.3
OF at 2.5 t/ha	44.7	73.8	96.3ab	112.7
OF at 3.5 t/ha	46.0	78.2	109.9a	120.9
OF at 4.5 t/ha	48.5	81.3	106.5a	116.5
OF at 6.0 t/ha	47.7	74.5	110.4a	123.3
SE	7.48ns	6.23ns	6.80*	8.97ns
SE (Interaction) F x V	10.07ns	14.51ns	8.65ns	9.28ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.7. Effect of fertilizer application on plant height (cm) of cassava varieties at Oluana in 2008

	Months after planting			
Treatments	3	4	5	6
Cassava variety (V)				
TMS 30572	54.5	97.6	131.7	142.3
TMS 92/0326	58.4	93.5	126.6	139.8
SE	1.57ns	2.25ns	3.12ns	3.75ns
Fertilizer (F)				
No fertilizer (control)	57.7	87.6	109.2	127.7
NPK at 600 kg/ha	63.4	107.5	136.7	149.6
OF at 1.5 t/ha	60.6	110.2	124.8	138.5
OF at 2.5 t/ha	57.9	102.5	130.6	154.2
OF at 3.5 t/ha	61.3	99.3	135.7	150.7
OF at 4.5 t/ha	59.5	98.8	129.4	149.6
OF at 6.0 t/ha	57.6	101.3	128.8	149.7
SE	2.82ns	7.95ns	9.83ns	9.36ns
SE (Interaction) F x V	3.38ns	9.71ns	10.61ns	11.94ns

ns = Not significant

and 6 MAP in 2007 (Table 4.8) and, 3 and 5 MAP in 2008 at Ajibode (Table 4.9). Similarly at Oluana, the varieties differed significantly ($p < 0.05$) in number of leaves at 3 and 4 MAP in both years (Tables 4.10 and 4.11). The TMS 92/0326 produced higher number of leaves than TMS 30572 at 3 MAP in 2008 at Ajibode as well as in all cases at Oluana in 2007. At Ajibode, TMS 30572 consistently produced more leaves per plant than TMS 92/0326 at 4 – 6 MAP in both years of study while the reverse was the case at 3 – 5 MAP in 2007 and 3 - 6 MAP at Oluana, in 2008 (Table 4.11). However, at 5 MAP in both years, TMS 92/0326 produced lower number of leaves than TMS 30572 at Ajibode (Tables 4.8 and 4.9).

Fertilizer application had significant effect ($p < 0.05$) on number of leaves per plant of cassava at 3 MAP in 2007 and 6 MAP in 2008 at Ajibode only. In both cases, maximum number of leaves per plant (54.1 in 2007 and 80.2 in 2008) was produced with the application of OF at 3.5 t/ha (Tables 4.8 and 4.9). Application of OF at 4.5 t/ha in both years, NPK at 600 kg/ha in 2007 and OF at 2.5 t/ha in 2008 resulted in number of leaves per plant comparable to that produced with 3.5 t OF/ha and significantly higher ($p < 0.05$) than the control. However, in both locations, the two varieties produced more leaves per plant with the application of fertilizer in 2007 than with fertilizer in 2008 at 4 – 6 MAP.

4.2.3 Leaf area index

Cassava variety TMS 92/0326 had significantly higher LAI than TMS 30572 at 3 to 6 MAP at Ajibode (Table 4.12) and 4 MAP at Oluana in 2007 (Table 4.14) as well as 3 MAP at Ajibode (Table 4.15) and 4 and 5 MAP at Oluana (Table 4.15) in 2008. The LAIs of 2.86 at 6 MAP in 2007 and 0.93 at 3 MAP in 2008 at Ajibode (Table 4.13) as well as 2.43 at 4 MAP in 2007 and 2.62 at 5 MAP in 2008 at Oluana obtained for TMS 92/0326 were significantly higher ($p < 0.05$) than the corresponding respective values of 1.80, 0.72, 1.40 and 2.27 for TMS 30572.

At Ajibode, TMS 30572 tended to produce greater LAI in 2008 with fertilizer application than in 2007 at 3 - 5 MAP while TMS 92/0326 had greater LAI value in

Table 4.8. Effect of fertilizer application on number of leaves per plant of cassava varieties at Ajibode in 2007

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	48.4	64.0	93.2a	109.0a
TMS 92/0326	45.7	59.3	76.6b	90.6b
SE	6.11ns	2.93ns	3.18*	3.14*
Fertilizer (F)				
No fertilizer (control)	39.3c	53.2	79.4	83.6
NPK at 600 kg/ha	52.4ab	72.3	89.0	103.2
OF at 1.5 t/ha	47.7b	59.6	83.0	101.1
OF at 2.5 t/ha	44.6bc	61.4	89.7	108.4
OF at 3.5 t/ha	54.1a	68.6	88.5	103.6
OF at 4.5 t/ha	49.7ab	62.6	87.9	98.2
OF at 6.0 t/ha	41.8bc	59.1	86.8	100.7
SE	1.97*	6.87ns	5.85ns	5.17ns
SE (Interaction) F x V	3.14ns	8.79ns	7.35ns	6.50ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan’s Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.9. Effect of fertilizer application on number of leaves per plant of cassava varieties at Ajibode in 2008

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	39.8b	58.3	83.0a	65.5
TMS 92/0326	43.3a	56.9	71.8b	65.4
SE	0.90*	2.47ns	3.00*	3.26ns
Fertilizer (F)				
No fertilizer (control)	37.3	60.3	70.7	47.1c
NPK at 600 kg/ha	40.5	50.5	81.6	62.2abc
OF at 1.5 t/ha	41.3	62.3	77.4	54.9bc
OF at 2.5 t/ha	38.7	51.2	75.6	71.2ab
OF at 3.5 t/ha	44.8	63.3	83.0	80.2a
OF at 4.5 t/ha	41.9	57.6	77.1	76.2ab
OF at 6.0 t/ha	46.2	57.9	76.5	66.5abc
SE	3.35ns	3.75ns	4.59ns	7.10*
SE (Interaction) F x V	3.62ns	5.80ns	6.49ns	9.37ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.10. Effect of fertilizer application on number of leaves per plant of cassava varieties at Oluana in 2007

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	34.6b	64.6b	89.5	102.2
TMS 92/0326	50.7a	81.6a	94.7	101.1
SE	3.92*	4.21*	3.97ns	6.36ns
Fertilizer (F)				
No fertilizer (control)	34.1	68.6	81.8	91.6
NPK at 600 kg/ha	42.8	77.9	102.3	101.1
OF at 1.5 t/ha	39.5	78.6	90.1	99.5
OF at 2.5 t/ha	48.9	75.6	96.4	98.4
OF at 3.5 t/ha	43.8	86.4	110.9	111.9
OF at 4.5 t/ha	53.7	81.7	106.6	113.4
OF at 6.0 t/ha	44.6	73.0	96.3	98.9
SE	6.68ns	6.88ns	9.84ns	8.23ns
SE (Interaction) F x V	8.06ns	23.10ns	11.35ns	13.44ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.11. Effect of fertilizer application on number of leaves per plant of cassava varieties at Oluana in 2008

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	39.6b	61.3b	78.9	84.4
TMS 92/0326	44.2a	72.5a	84.6	91.1
SE	1.12*	2.60*	3.97ns	4.25ns
Fertilizer (F)				
No fertilizer (control)	45.7	69.2	78.6	86.1
NPK at 600 kg/ha	47.5	74.0	96.6	90.5
OF at 1.5 t/ha	47.8	76.1	85.4	88.2
OF at 2.5 t/ha	50.3	68.3	83.5	91.9
OF at 3.5 t/ha	48.5	72.7	91.0	89.0
OF at 4.5 t/ha	49.3	69.5	88.1	96.3
OF at 6.0 t/ha	47.7	79.7	84.4	96.4
SE	2.01ns	3.93ns	6.52ns	8.37ns
SE (Interaction) F x V	2.69ns	4.22ns	8.14ns	9.63ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.12. Effect of fertilizer application on leaf area index of cassava varieties at Ajibode in 2007

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	0.72b	1.11b	1.80b	2.21b
TMS 92/0326	0.90a	1.47a	2.24a	2.86a
SE	0.041*	0.070*	0.081*	0.080*
Fertilizer (F)				
No fertilizer (control)	0.62	0.94b	1.55b	1.96b
NPK at 600 kg/ha	0.97	1.61a	2.15ab	2.68a
OF at 1.5 t/ha	0.86	1.21ab	1.92ab	2.49ab
OF at 2.5 t/ha	0.80	1.34ab	2.12ab	2.74a
OF at 3.5 t/ha	0.87	1.35ab	2.10ab	2.63ab
OF at 4.5 t/ha	0.87	1.29ab	2.18a	2.62ab
OF at 6.0 t/ha	0.71	1.28ab	2.12ab	2.61ab
SE	0.174ns	0.200*	0.210*	0.240*
SE (Interaction) F x V	0.628ns	0.924ns	1.149ns	1.683ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.13. Effect of fertilizer application on leaf area index of cassava varieties at Ajibode in 2008

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	0.72b	1.27	2.07	1.86
TMS 92/0326	0.93a	1.46	2.18	1.99
SE	0.020*	0.064ns	0.071ns	0.088ns
Fertilizer (F)				
No fertilizer (control)	0.61c	1.23	1.78	1.17b
NPK at 600 kg/ha	0.76bc	1.40	2.18	1.8ab
OF at 1.5 t/ha	0.77abc	1.23	2.00	1.57ab
OF at 2.5 t/ha	0.78abc	1.46	2.15	2.14a
OF at 3.5 t/ha	1.01a	1.66	2.43	2.46a
OF at 4.5 t/ha	0.88ab	1.46	2.29	2.34a
OF at 6.0 t/ha	0.96ab	1.46	2.15	1.99a
SE	0.080*	0.161ns	0.215ns	0.260*
SE (Interaction) F x V	0.192ns	0.446ns	0.743ns	0.932ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.14. Effect of fertilizer application on leaf area index of cassava varieties at Oluana in 2007

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	0.62	1.40b	2.25	2.72
TMS 92/0326	1.23	2.43a	3.15	3.36
SE	0.249ns	0.310*	0.307ns	0.483ns
Fertilizer (F)				
No fertilizer (control)	0.71	1.46	1.83	2.25
NPK at 600 kg/ha	1.05	2.14	3.17	3.22
OF at 1.5 t/ha	0.73	1.11	1.92	2.54
OF at 2.5 t/ha	1.23	2.17	2.65	3.10
OF at 3.5 t/ha	1.06	2.33	3.26	3.98
OF at 4.5 t/ha	1.28	2.39	3.33	3.62
OF at 6.0 t/ha	1.06	2.01	2.90	3.18
SE	0.195ns	0.391ns	0.753ns	0.774ns
SE (Interaction) F x V	0.728ns	1.278ns	1.313ns	1.432ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.15. Effect of fertilizer application on leaf area index of cassava varieties at Oluana in 2008

	Months after planting			
Treatments	3	4	5	6
Cassava variety (V)				
TMS 30572	0.75	1.20b[1]	2.27b	2.61
TMS 92/0326	0.84	1.46a	2.62a	3.14
SE	0.076ns	0.070*	0.101*	0.362ns
Fertilizer (F)				
No fertilizer (control)	0.69	1.04	1.93	2.37
NPK at 600 kg/ha	0.95	1.57	2.92	2.92
OF at 1.5 t/ha	0.76	1.32	2.60	3.18
OF at 2.5 t/ha	0.83	1.43	2.89	3.26
OF at 3.5 t/ha	0.82	1.56	2.77	3.44
OF at 4.5 t/ha	0.80	1.48	2.51	2.98
OF at 6.0 t/ha	0.98	1.59	2.83	3.06
SE	0.171ns	0.247ns	0.492ns	0.519ns
SE (Interaction) F x V	0.866ns	1.124ns	1.370ns	1.553ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

2007 with fertilizer than in 2008 at 4 – 6 MAP. However, at Oluana, TMS 30572 had greater LAI in 2007 with fertilizer than in 2008 at 4 – 6 MAP.

In 2007, compared with no fertilizer treatment, application of NPK significantly increased LAI by 41.6 and 26.8% at 4 and 6 MAP, respectively while OF at 4.5 and 2.5 t/ha also increased the values by 28.9 and 25.2 at 5 MAP and 26.9 and 28.4% at 6 MAP. In 2008, application of OF at 4.5 and 6.0 t/ha resulted in LAI comparable to the maximum with OF at 3.5 t/ha and significantly higher ($p < 0.05$) than the lowest of no fertilizer treatment at 3 MAP. At the stage of growth, application of OF at 3.5 t/ha also resulted in higher LAI than that of NPK by 24.7%. Similarly, at 6 MAP, OF application at 2.5 to 6.0 t/ha resulted in higher cassava LAI by 41.2 to 45.3% compared with no fertilizer treatment. Interaction of cassava varieties and fertilizer was not significant on LAI of cassava in all cases (Tables 4.12 to 4.15).

4.2.4 Effects of fertilizer application on yield and yield components of cassava

The effect of fertilizer application on the yield and yield components of cassava are presented in Tables 4.16 and 4.17.

Fresh Root and Dry Matter Yield

The fresh and dry root yields were significantly higher at Oluana location compared with Ajibode in 2007 and 2008. At the two locations, TMS 92/0326 cassava variety produced greater fresh root and dry matter yields compared with TMS 30572 in both years of study. Yield values obtained for root production were generally higher in 2008 than in 2007 (Tables 4.16 and 4.17).

Application of fertilizer had significant effect on both fresh root yield and dry matter production in 2007 and 2008 than in no fertilizer treatment. In both years, application of OF at 6.0 t/ha produced highest yields, however, the yield value was comparable with fresh root and dry matter production obtained in plots treated with NPK. At Ajibode and Oluana, fresh and dry root yields were greater in 2008 with fertilizer application than in 2009 for both varieties.

Number of Roots

The number of roots per plant was significantly greater at Oluana (8.2) than 6.1 roots obtained at Ajibode in 2007 (Table 4.16). The number of roots per plant was

Table 4.16. Effects of fertilizer application on yield and yield components of cassava varieties at Ajibode and Oluana in 2007

Treatments	Root tuber production			Fresh shoot (t/ha)	Harvest index
	Fresh root (t/ha)	Dry matter (t/ha)	No of roots/plant		
Location (L)					
Ajibode	27.3b	9.1b	6.1b	12.1b	0.70
Oluana	35.7a	11.8a	8.2a	14.61	0.71
SE	1.55*	0.53*	0.22*	0.84*	0.01ns
Cassava variety (V)					
TMS 30572	29.9b	10.1b	7.0	10.9b	0.71
TMS 92/0326	37.1a	11.7a	7.2	15.8a	0.70
SE	1.55*	0.53*	0.22ns	0.84*	0.01ns
Fertilizer (F)					
No fertilizer	21.5b	8.2c	5.7c	10.9	0.68
NPK at 600 kg/ha	35.4a	11.7ab	8.0a	14.1	0.72
OF at 1.5 t/ha	29.8a	10.0bc	6.8bc	12.2	0.71
OF at 2.5 t/ha	31.3a	11.1ab	7.1ab	12.9	0.71
OF at 3.5 t/ha	31.8a	11.5ab	7.4ab	14.4	0.69
OF at 4.5 t/ha	34.0a	12.3ab	7.6ab	13.8	0.72
OF at 6.0 t/ha	36.5a	13.7a	7.2ab	15.5	0.70
SE	2.91*	1.00*	0.42*	1.78ns	0.02ns
SE (Interactions)					
L x V	2.20ns	0.75ns	0.31ns	1.19ns	0.01ns
L x F	4.11ns	1.41ns	0.58ns	2.23ns	0.03ns
V x F	4.11ns	1.40ns	0.58ns	2.23ns	0.03ns
L x V x F	5.81ns	1.99ns	0.83ns	3.15ns	0.04ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.17. Effects of fertilizer application on yield and yield components of cassava varieties at Ajibode and Oluana in 2008

Treatments	Root tuber production			Fresh shoot (t/ha)	Harvest index
	Fresh root (t/ha)	Dry matter (t/ha)	Number of roots/plant		
Location (L)					
Ajibode	31.5b	11.10b	8.5	12.1b	0.69
Oluana	37.7a	13.91a	8.4	15.7a	0.68
SE	0.82*	0.42*	0.20ns	0.49*	0.01ns
Cassava variety (V)					
TMS 30572	32.9b	12.0b	8.3	12.7b	0.67
TMS 92/0326	37.4a	14.6a	8.6	16.7a	0.70
SE	0.82*	0.42*	0.20ns	0.49*	0.02ns
Fertilizer (F)					
No fertilizer	22.2c	7.4d	7.3	9.5c	0.68
NPK at 600 kg/ha	39.0a	13.4b	8.3	14.8b	0.70
OF at 1.5 t/ha	27.9b	10.8c	8.2	12.4b	0.67
OF at 2.5 t/ha	35.3ab	13.3b	8.1	15.5b	0.70
OF at 3.5 t/ha	35.7ab	13.8b	9.0	16.3ab	0.68
OF at 4.5 t/ha	39.0a	14.1ab	9.1	16.5ab	0.68
OF at 6.0 t/ha	42.7a	14.7a	9.1	17.9a	0.68
SE	1.53*	0.79*	0.37ns	0.92*	0.01ns
SE (Interactions)					
L x V	1.85ns	0.99ns	0.28ns	0.69ns	0.01ns
L x F	2.16ns	1.11ns	0.52ns	1.29ns	0.01ns
V x F	2.16ns	1.11ns	0.52ns	1.29ns	0.01ns
L x V x F	3.06ns	1.57ns	0.74ns	1.83ns	0.02ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

significantly affected by the application of fertilizer. Application of NPK resulted in number of roots per plant that was significantly greater than without fertilizer but comparable with values obtained with application of OF at 2.5 to 6.0 t/ha in 2007. The trend was not consistent in 2008.

Shoot Yield and Harvest Index

The shoot yield production of cassava was significantly greater at Oluana compared to Ajibode in both years of the trials. At the two locations, TMS 92/0326 produced shoot weight that was significantly greater than shoot production obtained in TMS 30572 in 2007 and 2008. Application of fertilizer resulted in significant increase in shoot production at Oluana in 2008 (Table 4.17).

Harvest index did not differ between the two cassava varieties while the effect of fertilizer treatments was also not significant on the parameter in the two cropping seasons. Interactions of location, fertilizer and variety were not significant on root and shoot production as well as harvest index in the two locations and in both years.

4.3 Residual effect of fertilizer application on growth and yield of cassava

The results on plant height, number of leaves per plant, leaf area index, root dry matter production and fresh yield per hectare, shoot yield per hectare and harvest index of cassava in response to the residual effects of previous fertilizer application are contained in Tables 4.18 to 4.28.

4.3.1 Plant height of cassava

The results of the residual effects of fertilizer application on plant height of two cassava varieties at Ajibode in 2008 and 2009, and Oluana in 2008 cropping seasons are presented in Tables 4.18 to 4.20. The residual effect of fertilizer application resulted significantly ($p < 0.05$) elongation of stem of TMS 30572 compared with TMS 92/0326 at Ajibode in 2009 and 3 to 6 MAP at Oluana in 2008 (Tables 4.18 to 4.20). At Ajibode, there was no significant difference in the height of the two cassava varieties at 3 – 6 MAP in 2008 but in 2009 TMS 30572 grew taller than TMS 92/0326 at 3 - 6 MAP.

At Ajibode in 2008, the residual effect of OF at 4.5 and 6.0 t/ha resulted in significantly taller plants than no fertilizer treatment at 4 and 6 MAP. Furthermore, the

Table 4.18. Residual effect of fertilizer application on plant height (cm) of cassava varieties at Ajibode in 2008

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	48.6	75.8	100.0	113.2
TMS 92/0326	48.7	75.7	101.3	114.7
SE	1.09ns	1.54ns	1.82ns	1.75ns
Fertilizer (F)				
No fertilizer (control)	49.0bc	70.0cd	95.5	99.9b
NPK at 600 kg/ha	47.6bc	68.1d	96.5	98.8b
OF at 1.5 t/ha	43.7c	67.6d	99.6	103.4b
OF at 2.5 t/ha	48.3bc	78.2bc	101.7	114.9ab
OF at 3.5 t/ha	52.1ab	77.0bcd	108.3	121.3a
OF at 4.5 t/ha	57.7a	80.0ab	105.2	116.9a
OF at 6.0 t/ha	53.9ab	88.3a	105.7	122.3a
SE	2.57*[3]	2.28*	4.83ns	4.21*
SE (Interaction) F x V	3.22ns	3.67ns	4.56ns	5.39ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.19. Residual effect of fertilizer application on plant height (cm) of cassava varieties at Ajibode in 2009

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	62.5a	82.1a	99.7a	114.6a
TMS 92/0326	54.2b	72.1b	87.3b	106.2b
SE	1.22*	1.81*	1.23*	1.72*
Fertilizer (F)				
No fertilizer (control)	59.3	67.5	74.5c	88.8b
NPK at 600 kg/ha	53.1	71.1	87.6b	108.1a
OF at 1.5 t/ha	62.1	82.0	98.6a	117.1a
OF at 2.5 t/ha	55.3	78.5	96.6ab	111.6a
OF at 3.5 t/ha	60.3	83.5	103.5a	120.8a
OF at 4.5 t/ha	55.8	75.6	95.3ab	111.6a
OF at 6.0 t/ha	62.5	83.6	98.5a	114.6a
SE	3.43ns	5.69ns	3.80*	5.82*
SE (Interaction) F x V	4.26ns	6.60ns	4.55ns	7.71ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.20. Residual effect of fertilizer application on plant height (cm) of cassava varieties at Oluana in 2008

Treatments	Months after planting			
	3	4	5	6
<u>Cassava variety (V)</u>				
TMS 30572	60.0a	89.2a	110.4a	129.6a
TMS 92/0326	47.8b	74.9b	95.3b	112.3b
SE	3.41*	3.90*	4.01*	5.02*
<u>Fertilizer (F)</u>				
No fertilizer (control)	48.4bc	72.5c	91.2	106.4d
NPK at 600 kg/ha	59.6a	92.2a	108.8	109.7cd
OF at 1.5 t/ha	46.5c	75.1bc	98.6	113.6cd
OF at 2.5 t/ha	54.1abc	80.9abc	102.6	126.8a
OF at 3.5 t/ha	54.5abc	82.5abc	103.7	119.7abc
OF at 4.5 t/ha	58.6a	88.5ab	109.1	126.9a
OF at 6.0 t/ha	55.6abc	82.9abc	106.3	123.5ab
SE	3.00*	4.90*	5.22ns	4.10*
SE (Interaction) F x V	7.06ns	8.83ns	9.22ns	10.31ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

residual effect of 4.5 t/ha at 3 and 4 MAP and 6.0 at 4 MAP resulted in significantly taller cassava plants than no fertilizer treatment (Table 4.18). In contrast, residual effect of NPK and OF at 2.5 t/ha resulted in short plants comparable to no-fertilizer control at 3 MAP. The residue of OF at 1.5 t/ha obviously resulted in significantly shorter plants than OF at 4.5 and 6.0 t/ha at 3 and 4 MAP. Generally, plots with fertilizer had greater residual effects than those without fertilizer application. In 2009, the residual effect of all the plots treated with fertilizer resulted in significantly taller plants than those of the plots without fertilizer at 5 and 6 MAP at Ajibode (Table 4.19).

At Oluana, the residue of NPK consistently resulted in maximum cassava plant height from 3 to 4 MAP only, but significantly shorter plant than the maximum at 6 MAP (Table 4.20). Similarly, the residue of OF at 4.5 t/ha application resulted in significantly taller ($p < 0.05$) cassava plants than those of plots without fertilizer at 3, 4 and 6 MAP, while similar result was obtained at 6 MAP with OF at 2.5, 3.5 and 6.0 t/ha. In contrast, the residue of OF at 1.5 t/ha treatment consistently resulted in significantly shorter plants than the maximum at 3, 4 and 6 MAP.

4.3.2 Number of leaves per plant

The residual effect of fertilizer on number of leaves per plant of cassava at Ajibode in 2008 and 2009, and Oluana in 2008 are presented in Tables 4.21 to 4.23.

The number of leaves differed significantly ($p < 0.05$) between the two varieties of cassava at 3 to 5 MAP in 2008 and 3 to 6 MAP in 2009 at Ajibode. At Ajibode, variety TMS 30572 produced more leaves than TMS 92/0326 at 3 MAP in 2008 (Table 4.21) and 3 to 6 MAP in 2009 (Table 4.22) while the reverse was observed at 4 and 5 MAP in 2008 in same location. However, at 3 – 6 MAP, there was no significant height difference between the two varieties of cassava at Oluana in 2008 (Table 4.23).

The residual effect of applied fertilizer was significant on number of leaves of cassava at 5 and 6 MAP in both years, 4 MAP in 2009 at Ajibode as well as at 3 MAP at Oluana in 2008 (Tables 4.21 to 4.23). In all cases at Ajibode, the residue of OF at 6.0 t/ha resulted in maximum number of leaves that were significantly higher ($p < 0.05$) than the appropriate lowest value. Furthermore, at Ajibode and Oluana, the residue of applied OF at and 3.5 t/ha at 6 MAP resulted in number of leaves per plant (111.0 and 111.9 respectively) significantly higher compared with that of no fertilizer (control) in 2008

Table 4.21. Residual effect of fertilizer application on number of leaves per plant of cassava varieties at Ajibode in 2008

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	32.0a	45.6b	80.8b	95.6
TMS 92/0326	26.9b	57.4a	88.5a	96.3
SE	0.90*	1.82*	2.31*	2.93ns
Fertilizer (F)				
No fertilizer (control)	27.4	43.4	67.2c	76.0c
NPK at 600 kg/ha	31.2	49.1	75.5bc	91.4b
OF at 1.5 t/ha	33.0	45.8	77.3bc	96.5b
OF at 2.5 t/ha	33.8	58.2	94.9a	106.5ab
OF at 3.5 t/ha	32.6	56.4	97.8a	111.0a
OF at 4.5 t/ha	29.6	48.1	87.8ab	92.4b
OF at 6.0 t/ha	29.7	59.7	92.0a	98.0ab
SE	2.56ns	5.94ns	4.70*	4.62*
SE (Interaction) F x V	2.49ns	5.41ns	6.45ns	6.34ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.22. Residual effect of fertilizer application on number of leaves per plant of cassava varieties at Ajibode in 2009

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	45.6a	67.1a	82.2a	89.8 a
TMS 92/0326	39.0b	61.2 b	74.6b	80.4 b
SE	1.25*	1.34*	1.83*	1.84*
Fertilizer (F)				
No fertilizer (control)	41.0	50.1d	68.8cd	72.3c
NPK at 600 kg/ha	38.3	55.5cd	68.4d	76.2c
OF at 1.5 t/ha	42.3	64.8bc	79.8abc	85.3bc
OF at 2.5 t/ha	40.8	63.1bc	76.0bcd	83.3c
OF at 3.5 t/ha	40.6	63.5bc	79.9abc	87.3abc
OF at 4.5 t/ha	49.0	77.8 a	90.8a	95.7 a
OF at 6.0 t/ha	45.3	74.3ab	87.1ab	94. 3ab
SE	3.79 ns	3.91*	3.70*	3.20*
SE (Interaction) F x V	4.72 ns	4.74 ns	5.06 ns	4.73 ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.23. Residual effect of fertilizer application on number of leaves per plant of cassava varieties at Oluana in 2008

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	46.4	60.6	90.3	112.0
TMS 92/0326	39.9	68.9	95.4	91.4
SE	2.34ns	3.21ns	5.17ns	7.70ns
Fertilizer (F)				
No fertilizer (control)	37.1b	59.8	80.1	87.5
NPK at 600 kg/ha	46.4ab	71.8	101.6	111.8
OF at 1.5 t/ha	39.9ab	67.9	95.3	102.4
OF at 2.5 t/ha	39.4ab	67.0	89.0	95.2
OF at 3.5 t/ha	48.5a	71.7	99.4	111.4
OF at 4.5 t/ha	46.6ab	60.3	92.3	107.1
OF at 6.0 t/ha	44.0ab	64.3	92.2	96.6
SE	3.50*	5.07ns	9.49ns	12.96ns
SE (Interaction) F x V	5.58ns	7.72ns	13.43ns	16.25ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

(Table 4.21 and 4.23) while that of 4.5 t/ha similarly caused highest (90.8 and 95.7) leaf production at 5 and 6 MAP respectively, in 2009 (Table 4.22). At Oluana, the residue of applied OF at 3.5 and 4.5 t/ha at 3 MAP resulted in number of leaves comparable with NPK in 2008 (Table 4.23). At 5 and 6 MAP at Ajibode in both years, at 3 MAP at Oluana in 2008 and 4 MAP at Ajibode in 2009, the lowest number of leaves (67.7, 76.0 and 68.0, 72.3 in 2008 and 2009 respectively) occurred in plots that were not previously treated with fertilizer.

4.3.3 Leaf area index

The residual effects of fertilizer application on leaf area index (LAI) of cassava varieties at Ajibode in 2008 and 2009 as well as Oluana in 2008 are presented in Tables 4.24, 4.25 and 4.26, respectively. Leaf area index differed significantly between the two varieties at 4 to 6 MAP at Ajibode and, 4 and 5 MAP at Oluna in 2008. Cassava variety TMS 92/0326 had significantly ($p < 0.05$) greater LAI than TMS 30572 at 4 to 6 MAP at Ajibode and, 4 and 5 MAP at Oluana in 2008 (Tables 4.24 and 4.26). There was no significant difference between the two cassava varieties at Ajibode in 2009 (Table 4.25).

The residual effect of fertilizer was significant on LAI at 4 MAP at both locations and at 5 MAP at Ajibode in 2008. In all cases, the residue of applied OF at 4.5 t/ha resulted in significantly higher LAI than in plots without previous fertilizer application. Furthermore, the residual effect of applied OF at 6.0 t/ha resulted in higher LAI (1.50 and 2.00) than control at 4 MAP in 2008 at both locations and 2009 at Ajibode. In 2008 at Ajibode, compared with no fertilizer treatment, the residue of OF at 3.5 t/ha resulted in higher LAI at 4 and 5 MAP while that of OF at 2.5 t/ha also caused higher value at 4 MAP (Table 4.24). At Ajibode in 2009, previous application of NPK actually resulted in lower LAI (2.32) than the maximum with OF at 4.5 and 6.0 t/ha treatments at 6 MAP (Table 4.25).

Residue of applied OF at 1.5 t/ha treatment at 4 MAP, also resulted in higher LAI than no fertilizer treatment at Ajibode in 2009 and Oluana in 2008 (Tables 4.25 and 4.26).

4.34 Residual Effect of Fertilizer Application on Yield and Yield Components

The residual effect of fertilizer application on yield and yield related components of cassava varieties in 2008 and 2009 are presented in Tables 4.27 and 4.28.

Table 4.24. Residual effect of fertilizer application on leaf area index of cassava varieties at Ajibode in 2008

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	0.71	1.14b	2.24b	2.82b
TMS 92/0326	0.66	1.61a	2.75a	3.12a
SE	0.020ns	0.061*	0.070*	0.080*
Fertilizer (F)				
No fertilizer (control)	0.69	1.07b	1.90b	2.33
NPK at 600 kg/ha	0.70	1.32ab	2.25ab	2.52
OF at 1.5 t/ha	0.78	1.30ab	2.41ab	3.15
OF at 2.5 t/ha	0.81	1.59a	2.77ab	3.27
OF at 3.5 t/ha	0.80	1.59a	2.97a	3.49
OF at 4.5 t/ha	0.76	1.48a	2.55ab	3.36
OF at 6.0 t/ha	0.74	1.50a	2.59ab	3.24
SE	0.025ns	0.100*	0.300*	0.417ns
SE (Interaction) F x V	0.136ns	0.482ns	0.871ns	0.993ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.25. Residual effect of fertilizer application on leaf area index of cassava varieties at Ajibode in 2009

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	1.00	1.71	2.30	2.63
TMS 92/0326	0.87	1.60	2.20	2.50
SE	0.059ns	0.063ns	0.081ns[2]	0.072ns
Fertilizer (F)				
No fertilizer (control)	0.84	1.20c	1.96	2.10
NPK at 600 kg/ha	0.86	1.40bc	1.92	2.32
OF at 1.5 t/ha	1.02	1.70ab	2.35	2.69
OF at 2.5 t/ha	0.81	1.60abc	2.28	2.59
OF at 3.5 t/ha	0.85	1.60abc	2.41	2.64
OF at 4.5 t/ha	1.08	1.90a	2.49	2.78
OF at 6.0 t/ha	1.25	1.90a	2.53	2.89
SE	0.142ns	0.150*	0.225ns	0.351ns
SE (Interaction) F x V	0.077ns	0.251ns	0.375ns	0.427ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.26. Residual effect of fertilizer application on leaf area index of cassava varieties at Oluana in 2008

Treatments	Months after planting 3	4	5	6
Cassava variety (V)				
TMS 30572	1.05	1.58b	2.56b	3.30
TMS 92/0326	1.08	2.51a	3.22a	3.27
SE	0.075ns	0.100*	0.110*	0.163ns
Fertilizer (F)				
No fertilizer (control)	0.81	1.33b	2.47	2.75
NPK at 600 kg/ha	0.83	1.40b	2.63	2.98
OF at 1.5 t/ha	1.29	2.12a	2.71	3.05
OF at 2.5 t/ha	1.31	1.98ab	2.84	3.04
OF at 3.5 t/ha	1.18	1.98ab	3.07	3.17
OF at 4.5 t/ha	1.20	2.10a	2.90	3.29
OF at 6.0 t/ha	1.21	2.00a	3.02	3.28
SE	0.173ns	0.240*	0.319ns	0.222ns
SE (Interaction) F x V	0.293ns	0.467ns	0.602ns	0.625ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.27. Residual effects of fertilizer application on yield and yield components of cassava varieties at Ajibode and Oluana in 2008

Treatments	Root tuber production			Fresh shoot (t/ha)	Harvest index
	Fresh root (t/ha)	Dry matter (t/ha)	Number of roots/plant		
Location (L)					
Ajibode	27.0b	9.7b	5.5b	15.9	0.62
Oluana	31.8a	11.1a	6.9a	17.4	0.64
SE	0.98*	0.40*	0.28*	0.58ns	0.01ns
Cassava variety (V)					
TMS 30572	27.8b	10.1	6.3	16.1	0.63
TMS 92/0326	31.0a	12.7a	6.1	17.2	0.63
SE	0.98*	0.40ns	0.28ns	0.58ns	0.01ns
Fertilizer (F)					
No fertilizer	18.9c	6.8d	5.7	13.6c	0.58
NPK at 600 kg/ha	19.8c	6.9d	5.8	14.8bc	0.57
OF at 1.5 t/ha	26.6b	9.5c	6.3	17.4ab	0.60
OF at 2.5 t/ha	32.3ab	11.0ab	7.0	16.5b	0.65
OF at 3.5 t/ha	35.9a	12.4ab	5.7	16.7b	0.68
OF at 4.5 t/ha	36.8a	13.1a	6.3	17.7ab	0.67
OF at 6.0 t/ha	37.1a	13.4a	6.4	19.9a	0.65
SE	1.83*	0.74*	0.52ns	1.09*	0.04ns
SE (Interaction)					
L x V	1.15ns	0.79ns	0.28ns	0.69ns	0.01ns
L x F	2.16ns	1.05ns	0.52ns	1.29ns	0.01ns
V x F	2.16ns	1.05ns	0.52ns	1.29ns	0.01ns
Lx V x F	3.06ns	1.48ns	0.74ns	1.83ns	0.02ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.28. Residual effects of fertilizer application on yield and yield components of cassava varieties at Ajibode in 2009

Treatments	Root tuber production				
	Fresh root (t/ha)	Dry matter (t/ha)	Number of roots/plant	Fresh shoot (t/ha)	Harvest index
Cassava variety (V)					
TMS 30572	24.7b	9.6	8.1 a	16.5 b	0.59
TMS 92/0326	26.5a	8.7	6.0 b	19.6 a	0.57
SE	0.50*	0.32ns	0.50*	0.41*	0.09ns
Fertilizer (F)					
No fertilizer (control)	19.0 c	6.3b	6.0	13.7 d	0.58
NPK at 600 kg/ha	18.2 c	6.0 b	6.9	16.2 c	0.54
OF at 1.5 t/ha	25.0b	9.6 a	6.3	15.8cd	0.60
OF at 2.5 t/ha	26.6b	9.9 a	7.5	21.4a	0.55
OF at 3.5 t/ha	27.4ab	9.8 a	7.7	20.2ab	0.57
OF at 4.5 t/ha	30.8ab	11.1 a	7.4	18.8b	0.62
OF at 6.0 t/ha	32.3 a	11.3 a	7.8	20.3ab	0.61
SE	1.50*	0.63*	0.83 ns	0.70*	0.038ns
SE (Interaction) F x V	1.86 ns	0.83 ns	10.41 ns	1.07 ns	0.044 ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Root Production:

The residue of applied fertilizer had significant effect on fresh root and dry matter yield as well as number of roots of cassava.

The fresh root yield was significantly higher at Oluana than at Ajibode in 2008 with corresponding values of 31.8 and 27.0 t/ha, respectively. Similarly, dry matter yield of 11.1 t/ha obtained at Oluana was significantly higher than 9.7 t/ha obtained at Ajibode (Table 4.27). Shoot yield production at Oluana in 2008 and number of roots per plant were greater than those of Ajibode within the same period.

Cassava variety TMS 92/0326 produced significantly higher fresh and dry root yields (31.0 and 12.7 t/ha) compared with TMS 30572 (27.8, 10.1 t/ha) in 2008 and at Ajibode only in 2009 (Tables 4.27 and 4.28). In contrast, TMS 30572 had significantly greater number of roots per plant than TMS 92/0326 at Ajibode in 2009.

Residues of applied fertilizer had significant effects on fresh root and dry matter yields of cassava root in 2008 and at Ajibode only in 2009 (Tables 4.27 and 4.28). The residues of OF at 4.5 and 6.0 t/ha consistently resulted in greater fresh root and dry matter yields of cassava compared to those of NPK and no fertilizer treatments in all the trials. Furthermore, the residues of OF at 2.5 to 6.0 t/ha caused higher fresh and dry root production compared with those of NPK, OF at 1.5 t/ha and no fertilizer treatments.

The residual effect of previous fertilizer application did not have significant effect on number of roots per plant and harvest index of cassava in the three trials (Tables 4.27 and 4.28). Mean yield values between 32.2 and 37.1 t/ha obtained with residues of applied fertilizer in 2008 were comparable with 31.3 and 36.5 t/ha obtained with fertilizer application in 2007.

Shoot Yield: Fresh shoot weight at harvest was significantly affected by fertilizer residue in 2008 and 2009. Residues of applied fertilizer caused significant increase in shoot production in TMS 92/0326 (19.6 t/ha) compared with TMS 30572 (16.5 t/ha) at Ajibode in 2009 (Table 4.28). In 2008, residues of OF at 6.0 t/ha treatment resulted in highest value of shoot weight; although this was not significantly different from shoot production obtained in OF at 1.5 and 4.5 t/ha treatments. In all the trials, shoot production in OF at 2.5 to 6.0 t/ha application was consistently higher than those without fertilizer and NPK treatments. Interactions of location and variety, location and fertilizer, variety and fertilizer as well as location, variety and fertilizer were not significant on root, shoot production and harvest index of cassava in both years of study (Tables 4.27 and 4.28).

4.4 Effects of fertilizer and harvesting time on the growth of cassava varieties

4.4.1 Plant Height

Results on the effect of fertilizer on plant height, number of leaves per plant and leaf area index of the two cassava varieties are shown in Tables 4.29 to 4.37. The effects of fertilizer application and time of harvest on fresh and dry root tuber yields, number of tuberous roots, shoot weight and harvest index of cassava are presented in Tables 4.39 and 4.40.

Cassava varieties differed significantly ($p < 0.05$) in plant height at 3 to 6 MAP only in 2008 with variety TMS 92/0326 consistently having taller plants than TMS 30572.

Fertilizer had significant effect on cassava plant height at 3 to 4 MAP and 6 MAP in 2008 and 3 to 6 MAP in 2009 at the location. In all cases, application of NPK at 600 kg/ha and OF at 2.5 t/ha resulted in plants of similar heights that were significantly taller than those not given fertilizer.

The interaction of fertilizer and variety was significant on plant height of cassava at 3 and 4 MAP in 2008 and 3 MAP in 2009 (Tables 4.30 and 4.32). In 2008, fertilizer (NPK and OF) application only resulted in taller plants of TMS 92/0326 compared to no fertilizer while it had no effect on the height of TMS 30572. Furthermore, with application of OF and NPK, plants of TMS 92/0326 were significantly taller than those of TMS 30572 (Table 4.30). Although similar trend was obtained at 4 MAP, the height of plants of variety TMS 92/0326 treated with NPK at 600 kg/ha was not different from those without fertilizer. Similarly, with the application of NPK, plants of the two varieties had similar heights. In 2009, with the application of NPK, plants of TMS 92/0326 only had significantly taller plants ($p < 0.05$) than TMS 30572 at 3 MAP.

4.4.2 Number of leaves per plant

Number of leaves per plant produced by TMS 92/0326 was significantly greater than that of TMS 30572 at 3 to 6 MAP in 2008 at Ajibode (Tables 4.33).Fertilizer application had significant effect on leaf production of cassava at 4 - 6 MAP in 2008 and 3 - 5 MAP in 2009 at Ajibode (Tables 4.33 and 4.34). Similar to the trend observed with plant height, leaf production were similar with the application of NPK and OF at 2.5 t/ha

Table 4.29. Effect of fertilizer application on plant height (cm) of cassava varieties at Ajibode in 2008

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	68.3b	100.6b	124.9b	149.8b
TMS 92/0326	82.3a	110.4a	135.3a	168.0a
SE	2.30*	2.43*	3.00*	2.94*
Fertilizer (F)				
No fertilizer	64.1b	96.5b	122.0	144.8b
NPK at 600 kg/ha	81.5a	110.6a	136.2	167.8a
OF at 2.5 t/ha	80.5a	109.4a	132.0	164.0a
SE	2.78*	2.98*	3.74ns	3.61*
SE (Interaction) F x V	3.93*	4.21*	5.29ns	5.13ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.30. Interaction of fertilizer and variety on plant height of cassava at 3 and 4 MAP at Ajibode in 2008

Fertilizer	Variety			
	TMS 30572		TMS 92/0326	
	3 MAP	4 MAP	3 MAP	4MAP
No fertilizer	63.9b	98.0b	64.3b	95.0b
NPK at 600 kg/ha	70.4b	105.4b	92.5a	115.7ab
OF at 2.5 t/ha	70.7b	98.3b	90.2a	120.5a
SE	3.93	4.21	3.93	4.21

MAP - Months after planting

Means for the two varieties at the same or different fertilizer levels followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

Table 4.31. Effect of fertilizer application on plant height (cm) of cassava varieties at Ajibode in 2009

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	115.4	141.0	157.2	165.4
TMS 92/0326	120.7	147.4	162.0	167.6
SE	2.07ns	2.57ns	2.22ns	2.79ns
Fertilizer (F)				
No fertilizer	100.5b	123.4b	140.0b	143.9b
NPK at 600 kg/ha	126.8a	153.7a	166.9a	175.3a
OF at 2.5 t/ha	127.0a	155.5a	171.9a	180.1a
SE	2.54*	3.15*	2.72*	3.42*
SE (Interaction) F x V	3.59*	4.45ns	3.85ns	4.83ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.32. Interaction of fertilizer and variety on plant height (cm) of cassava at 3 MAP at Ajibode in 2009

	Variety	
Fertilizer	TMS 30572	TMS 92/0326
No fertilizer	104.2c	96.7c
NPK at 600 kg/ha	118.7b	134.8a
OF at 2.5 t/ha	123.3b	130.7ab
SE	3.59	

Means of varieties at the same or different fertilizer levels followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

Table 4.33. Effect of fertilizer application on number of leaves per plant of cassava varieties at Ajibode in 2008

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	43.5b	54.9b	72.4b	79.4b
TMS 92/0326	52.7a	65.8a	86.1a	88.8a
SE	2.10*	2.01*	2.40*	2.21*
Fertilizer (F)				
No fertilizer	42.9	54.2b	76.2b	71.0b
NPK at 600 kg/ha	51.2	63.7a	87.7a	89.4a
OF at 2.5 t/ha	50.2	63.1a	85.4a	91.7a
SE	2.58ns	2.46*	2.60*	2.70*
SE (Interaction) F x V	3.64ns	3.48ns	3.72ns	3.85ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.34. Effect of fertilizer application on number of leaves per plant of cassava varieties at Ajibode in 2009

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	96.6	123.7	142.0	143.1
TMS 92/0326	109.7	138.5	158.0	163.3
SE	5.80ns	6.27ns	5.51ns	7.44ns
Fertilizer (F)				
No fertilizer	86.9b	103.1b	122.3b	123.5
NPK at 600 kg/ha	112.0a	143.8a	159.8a	164.0
OF at 2.5 t/ha	110.5a	146.4a	167.9a	172.2
SE	7.1*	7.68*	6.74*	9.12ns
SE (Interaction) F x V	10.0ns	10.86ns	9.54ns	12.9ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan’s Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

and significantly higher than that of no fertilizer treatment in all cases.

4.4.3 Leaf area index

Cassava variety TMS 92/0326 had significantly higher LAI than TMS 30572 at 3 to 6 MAP in 2008 (Table 4.35) but in 2009, there was no consistent trend (Table 4.37). The LAI of the two varieties increased with time to reach maxima of 3.32 and 2.51 at 6 MAP for TMS 92/0326 and TMS 30572, respectively.

Fertilizer application had significant effect on LAI of cassava at 3 to 6 MAP in both years with the result following the trend reported for plant height and number of leaves of cassava.

Interaction of fertilizer and variety was significant on LAI of cassava varieties at 6 MAP and 3 MAP in 2008 and 2009, respectively at Ajibode (Tables 4.36 and 4.38). With the application of NPK and OF, variety TMS 92/0326 had significantly higher LAI than TMS 30572 at 6 MAP in 2008 (Table 4.36) while the reverse was observed at 3 MAP in 2009, with the application of OF (Table 4.38).

4.5 Effects of fertilizer and harvesting time on yield and yield components of cassava varieties at Ajibode.

The results on number of roots, fresh and dry tuber root yields shoot production and harvest index of cassava varieties in 2008 and 2009 are presented in Tables 4.39 and 4.40.

Fresh and dry root yield:

Cassava varieties differed significantly in fresh root yield in 2008 only with TMS 30572 producing higher tuber yields than TMS 92/0326 (Table 4.39).

Fertilizer application had significant effects on fresh and dry root tuber yield in both years ($p < 0.05$). Application of OF at 2.5 t/ha in both years and NPK in 2009 resulted in significantly higher fresh and dry tuber yields compared with no fertilizer. Furthermore, application of OF caused higher dry root yield than that of NPK in 2008.

Time of harvesting had significant effect on fresh and dry root tuber yields of cassava (Tables 4.39 and 4.40). Tuber yield increased with delay in time of harvest from

Table 4.35. Effect of fertilizer application on leaf area index of cassava varieties at Ajibode in 2008

	Months after planting			
Treatments	3	4	5	6
Cassava Variety (V)				
TMS 30572	1.11b	1.57b	2.49b	2.51b
TMS 92/0326	1.43a	2.15a	2.86a	3.32a
SE	0.050*	0.060*	0.040*	0.090*
Fertilizer (F)				
No fertilizer	1.00b	1.49b	2.20b	2.32b
NPK at 600 kg/ha	1.43a	1.98a	2.95a	3.32a
OF at 2.5 t/ha	1.39a	2.10a	2.87a	3.35a
SE	0.070*	0.080*	0.050*	0.110*
SE (Interaction) F x V	0.185ns	0.193ns	0.070*	0.160*

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.36. Interaction of fertilizer and variety on leaf area index of cassava at 6 MAP at Ajibode in 2008

	Variety	
Fertilizer	TMS 30572	TMS 92/0326
No fertilizer	2.12c	2.52bc
NPK at 600 kg/ha	2.70b	3.93a
OF at 2.5 t/ha	2.71b	3.98a
SE	0.160	

Means for the varieties at the same or different fertilizer levels followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

Table 4.37. Effect of fertilizer application on leaf area index of cassava varieties at Ajibode in 2009

Treatments	Months after planting			
	3	4	5	6
Cassava variety (V)				
TMS 30572	1.82	2.78	3.60	3.96
TMS 92/0326	1.75	3.11	3.56	3.75
SE	0.054ns	0.118ns	0.123ns	0.211ns
Fertilizer (F)				
No fertilizer	1.40b	1.85b	2.62b	2.81b
NPK at 600 kg/ha	1.99a	3.54a	3.92a	4.21a
OF at 2.5 t/ha	1.95a	3.46a	4.26a	4.54a
SE	0.060*	0.140*	0.140*	0.260*
SE (Interactions) F x V	0.090*	0.205ns	0.207ns	0.372ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level)

ns = Not significant

* = Significant at 5% level

Table 4.38 . Interaction of fertilizer and variety on leaf area index of cassava at 3 MAP at Ajibode in 2009

	Variety	
Fertilizer	TMS 30572	TMS 92/0326
No fertilizer	1.22c	1.58b
NPK at 600 kg/ha	2.15a	1.84ab
OF at 2.5 t/ha	2.08a	1.80b
SE	0.093	

Means for the two varieties at the same or different fertilizer levels followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

9 to 15 MAP after which no further increase occurred, except for fresh root tuber yield in 2008 which increased up to 18 MAP.

The interaction of variety and time of harvest was significant on dry root yields of cassava at Ajibode in 2008 and 2009 (Table 4.41). Dry matter yield increased with delay in harvest time up to 15 MAP in both varieties in 2008 and in TMS 92/0326 in 2009. The DM however increased up to 18 MAP in TMS 30572 in 2009 but declined between 15 and 18 MAP in TMS 92/0326 in both years. Furthermore, TMS 30572 produced higher dry matter yield than TMS 92/0326 at 18 MAP in the two years while yield of TMS 92/0326 were higher at 12 and 15 MAP in 2008 and 2009.

Interaction of fertilizer and harvest time was significant on fresh and dry root yields of cassava in 2008 and dry root yield only in 2009 (Table 4.39, 4.40 and 4.42). Although fertilizer application had no effect on root dry matter yield at 9 MAP harvest, OF caused significantly higher increase at 12 and 18 MAP than NPK but similar increase at 15 MAP in 2008. Delay in harvest time caused increase in yield at 9 to 15 MAP in NPK and OF treatments in 2009.

Interactions of fertilizer and variety, fertilizer and time of harvest in 2008 and variety and time of harvest in 2008 and 2009 were significant on fresh root yield of cassava varieties at Ajibode (Tables 4.43 to 4.45). Fresh root yield of TMS 92/0326 was significantly higher on plots without fertilizer than that of TMS 30572 while root yield of TMS 30572 was significantly higher than control with OF at 2.5 t/ha but comparable with root production with NPK (Table 4.43). Fresh root yield increased with time of harvest up to 15 MAP without fertilizer and with NPK application and 18 MAP with OF. Although significantly higher yield was obtained with OF application at 18 MAP harvest compared with NPK and no fertilizer, NPK caused higher yield than OF at 15 MAP (Table 4.44). At 15 MAP, fresh root yield production by TMS 92/0326 was significantly higher ($p < 0.05$) than that of TMS 30572 and *vice versa* at 18 MAP in both years (Table 4.45). Yield increased with delay in time of harvest at 9 to 15 MAP in both varieties in 2009 and in TMS 92/0326 in 2008. The yield of TMS 30572 however increased with delay in harvest time till 18 MAP in 2008. In both years, TMS 92/0326 produced higher yield at 15 MAP while that of TMS 30572 was significantly higher at 18 MAP.

Table 4.39. Effects of fertilizer and time of harvesting on the yield and yield components of cassava varieties at Ajibode in 2008

Treatments	Root tuber production			Fresh shoot (t/ha)	Harvest index
	Fresh roots (t/ha)	Dry matter (t/ha)	Number of roots/plant		
Cassava variety (V)					
TMS 30572	30.7a	12.2	6.5	18.1b	0.63
TMS 920326	27.5b	11.9	6.4	20.6a	0.58
SE	0.45*	0.17ns	0.15ns	0.46*	0.025ns
Fertilizer (F)					
No fertilizer	19.5b	7.8c	6.3	16.5b	0.54b
NPK at 600 kg/ha	34.2a	12.9b	6.5	27.3a	0.60a
OF at 2.5 t/ha	36.7a	13.9a	6.6	27.6a	0.59a
SE	0.55*	0.21*	0.17ns	0.57*	0.008*
Time of harvesting (MAP) [T]					
9	14.7d	5.4d	6.4ab	13.2c	0.52b
12	22.9c	9.9c	6.8a	22.7b	0.51b
15	29.8b	16.0a	6.5ab	25.3a	0.61a
18	32.9a	15.9a	6.1b	24.2a	0.57a
SE	0.64*	0.24*	0.20*	0.65*	0.008*
SE (Interaction)					
V x F	0.83*	0.32ns	0.27ns	0.84	0.011*
V x T	0.96*	0.37*	0.31ns	0.98*	0.013ns
F x T	1.17*	0.45*	0.38ns	1.21ns	0.016ns
V x F x T	1.66*	0.63*	0.53ns	1.70ns	0.023ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level and Time of harvesting)

ns = Not significant

* = Significant at 5% level

MAP = Months after planting

Table 4.40. Effects of fertilizer and time of harvesting on the yield and yield components of varieties at Ajibode in 2009

Treatments	Root tuber production			Fresh shoot (t/ha)	Harvest index
	Fresh roots (t/ha)	Dry matter (t/ha)	Number of roots/plant		
<u>Cassava variety (V)</u>					
TMS 30572	33.6	12.8	7.6a	23.8b	0.58a
TMS 920326	32.6	13.5	6.9b	26.7a	0.50b
SE	0.41ns	0.28ns	0.18*	0.90*	0.020*
<u>Fertilizer (F)</u>					
No fertilizer	18.5b	7.9b	6.7b	17.4b	0.51b
NPK at 600 kg/ha	32.4a	15.6a	7.8a	23.6a	0.57a
OF at 2.5 t/ha	33.3a	16.1a	7.2b	26.2a	0.55a
SE	0.73*	0.34*	0.22*	0.89*	0.006*
<u>Time of harvesting (MAP) [T]</u>					
9	21.2c	8.1c	7.15	14.9c	0.57
12	26.6b	12.2b	7.35	21.1b	0.55
15	41.5a	17.2a	7.64	26.8a	0.59
18	33.0a	15.3a	7.01	28.1a	0.54
SE	0.85*	0.70*	0.25ns	1.00*	0.021ns
SE (Interaction)					
V x F	1.10*	0.51ns	0.33ns	1.33*	0.001ns
V x T	1.26*	0.59*	0.42ns	1.54*	0.016ns
F x T	1.55ns	0.73*	0.46ns	1.88ns	0.014ns
V x F x T	2.19ns	1.02ns	0.66ns	2.70ns	0.019ns

Means for different levels of each factor followed by the same letter(s) in a column are not significantly different at 5% level of probability using LSD (Cassava variety) and Duncan's Multiple Range Test (Fertilizer level and Time of harvesting)

ns = Not significant

*= Significant at 5% level

MAP = Months after planting

Table 4.41. Interaction of variety and time of harvest on root dry matter yield (t/ha) of cassava at Ajibode in 2008 and 2009

	Variety	
Time of harvest (MAP)	TMS 30572	TMS 92/0326
	2008	
9	5.0d	5.8d
12	9.4c	10.3bc
15	15.7a	16.2a
18	16.6a	13.1b
SE	0.37	
	2009	
9	7.7d	8.5d
12	10.9c	13.4b
15	15.4b	19.0a
18	17.4a	13.2b
SE	0.59	

Means for the two varieties at the same or different times of harvest in each year followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

MAP = Months after planting

Table 4.42. Interaction of fertilizer and time of harvest on root dry matter yield (t/ha) of cassava at Ajibode in 2008 and 2009

	Fertilizer		
Time of harvest (MAP)	No fertilizer	NPK at 600 kg/ha	OF at 2.5 t/ha
		2008	
9	4.4g	6.6fg	5.3g
12	6.9f	10.8d	12.0c
15	10.6d	18.0a	19.4a
18	9.2e	16.4b	18.0a
SE		0.45	
		2009	
9	5.3e	9.8d	9.2d
12	6.9e	14.4c	15.2c
15	9.5d	20.4ab	21.7a
18	9.8d	17.9b	18.4b
SE		0.73	

Means for the three fertilizer treatments at the same or different times of harvest in each year followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

MAP = Months after planting

Table 4.43. Interaction of variety and fertilizer on fresh root yield (t/ha) of cassava at Ajibode in 2008

	Variety	
Fertilizer	TMS 30572	TMS 92/0326
No fertilizer	20.9d	24.1c
NPK at 600 kg/ha	33.0ab	29.3b
OF at 2.5 t/ha	34.4a	31.6b
SE	0.83	

Means for the two varieties at the same or different fertilizer levels followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

Table 4.44. Interaction of fertilizer and time of harvest on fresh root yield (t/ha) of cassava at Ajibode in 2008

	Fertilizer		
Time of harvest (MAP)	No fertilizer	NPK at 600 kg/ha	OF at 2.5 t/ha
9	12.6f	15.8ef	15.8ef
12	17.4e	22.2d	23.2d
15	23.6d	33.6b	29.1c
18	24.4d	33.1b	38.8a
SE		1.17	

Means for the three fertilizer treatments at the same or different times of harvest followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

MAP = Months after planting

Table 4.45. Interaction of variety and time of harvest on fresh root yield (t/ha) of cassava at Ajibode in 2008 and 2009

Time of harvest (MAP)	Variety	
	TMS 30572	TMS 92/0326
	2008	
9	15.1d	16.3d
12	25.2c	26.6c
15	37.7b	39.8a
18	41.0a	27.7c
SE	0.96	
	2009	
9	24.2d	18.3e
12	31.2c	32.0c
15	38.5b	44.6a
18	40.6b	25.8cd
SE	1.26	

Means for the two varieties at the same or different times of harvesting followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

MAP = Months after planting

The interaction of variety, fertilizer and time of harvest was significant on fresh and dry root yields at Ajibode in 2008 (Table 4.46). In 2008, highest fresh root yields of 59.9 t/ha for TMS 30572 and 56.8 t/ha for TMS 92/0326 were obtained with harvests at 18 and 15 MAP, respectively from plot given OF at 2.5 t/ha. The corresponding plot given NPK also produced yields of 51.3 t/ha for TMS 30572 and 50.9 t/ha for TMS 92/0326 that were significantly higher than those of the other treatment combinations. Dry matter yield due to NPK and OF application were similar in both varieties at 9 to 15 MAP but significantly higher ($p < 0.05$) than no fertilizer treatments. Dry matter yield of TMS 30572 increased with delay in time of harvest up to15 and 18 MAP in NPK and OF treatments, respectively while yield only increased up to 15 MAP in TMS 92/0326 for both fertilizers (Table 4.46).

Shoot yield:

Shoot production in TMS 92/0326 was significantly higher ($p < 0.05$) than that of TMS 30572 in both years (Tables 4.39 and 4.40). Shoot weight obtained in NPK and OF plots were similar but significantly higher ($p < 0.05$) than those of cassava plots without fertilizer in both years. Shoot production of cassava harvested at 15 and 18 MAP were similar and significantly higher ($p < 0.05$) than those of plants harvested at 9 and 12 MAP. Interactions of fertilizer and variety as well as variety and harvesting time were significant ($p < 0.05$) on shoot production in both years.

Interactions of fertilizer and variety as well as variety and time of harvest were significant on shoot production of cassava varieties at Ajibode in 2009, and 2008 and 2009 respectively (Tables 4.47 and 4.48). The TMS 92/0326 had higher shoot production than TMS 30572 without and with NPK fertilizer application. While shoot production were similar with the two fertilizer treatments and higher than no fertilizer in TMS 92/0326, production followed the order F3 > F1 > F0 in TMS 30572.

Shoot production increased with delay in time of harvest till 15 MAP in the two varieties in 2008 (Table 4.48).TMS 92/0326 produced higher shoot weight at 18 MAP while there was no difference between the varieties at earlier harvests in 2008. In 2009, TMS 92/0326 produced higher shoot weight than TMS 30572 at all harvesting dates. Shoot

Table 4.46. **I**nteraction of variety and fertilizer and time of harvest on fresh and dry root yields (t/ha) of cassava at Ajibode in 2008

		Time of harvest (MAP)			
Variety	Fertilizer	9	12	15	18
			Fresh root		
TMS 30572	No fertilizer	15.0h	20.2gh	30.8ef	30.7ef
	NPK at 600 kg/ha	20.2gh	26.6f	44.9c	51.3b
	OF at 2.5 t/ha	21.4g	26.9f	43.2cd	59.9a
TMS 92/0326	No fertilizer	16.3h	19.4gh	26.3fg	21.1gh
	NPK at 600 kg/ha	19.6gh	32.4e	50.9b	33.4e
	OF at 2.5 t/ha	21.5g	38.7d	56.8a	36.5de
	SE		1.66		
			Dry matter		
TMS 30572	No fertilizer	4.4g	7.7f	12.2cd	11.0de
	NPK at 600 kg/ha	5.9fg	9.7e	17.1b	18.0b
	OF at 2.5 t/ha	4.8g	10.9de	17.9b	21.0a
TMS 92/0326	No fertilizer	4.4g	6.1fg	9.0ef	7.3fg
	NPK at 600 kg /ha	7.3fg	11.8d	18.9b	14.8c
	OF at 2.5 t/ha	5.8g	13.1cd	20.8a	17.1b
	SE		0.63		

Means of combinations of variety, fertilizer and time of harvest followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

MAP = Months after planting

Table 4.47. Interaction of fertilizer and variety on fresh shoot weight (t/ha) of cassava at Ajibode in 2009

	Variety	
Fertilizer	TMS 30572	TMS 92/0326
No fertilizer	12.6c	17.4b
NPK at 600 kg/ha	20.0b	27.5a
OF at 2.5 t/ha	24.8a	28.2a
SE	1.33	

Means for the two varieties at the same or different fertilizer levels followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

Table 4.48. Interaction of variety and time of harvest on fresh shoot weight (t/ha) of cassava at Ajibode in 2008 and 2009

	Variety	
Time of harvest (MAP)	TMS 30572	TMS 92/0326
	2008	
9	12.3c	14.2c
12	22.2b	24.8b
15	29.9a	28.6a
18	25.4b	30.8a
SE	0.98	
	2009	
9	20.7d	29.1bc
12	23.5cd	30.8b
15	26.0c	37.6a
18	24.9cd	31.3b
SE	1.54	

Means for the two varieties at the same or different times of harvesting in each year followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

MAP = Months after planting

production at 15 MAP was significantly higher than that of 9 MAP in TMS 30572 and 9 and 12 MAP in TMS 92/0326.

Number of roots:

The effects of fertilizer and harvesting time on number of roots per plant of cassava varieties was significant at Ajibode in 2009 with TMS 30572 having higher number of roots than TMS 92/0326 (Table 4.44). Similarly, application of NPK resulted in significantly higher number of cassava roots compared with that of OF at 2.5 t/ha and no fertilizer (control) in the same year. However, time of harvest only had significant effect on number of roots of cassava in 2008 with more roots produced at 12 MAP than 18 MAP.

Harvest index (HI):

Cassava variety TMS 30572 had significantly higher HI than TMS 92/0326 in 2009 at Ajibode (Table 4.40)

The harvest index obtained with the application of NPK and OF were similar and significantly higher ($p < 0.05$) than that of cassava without fertilizer application in both years (Table 4.43 and 4.40). Harvest index obtained with harvesting at 15 and 18 MAP were significantly higher than those of earlier harvests at 9 and 12 MAP in 2008 only. Interaction of fertilizer and variety was significant on harvest index of cassava varieties at Ajibode in 2008 (Table 4.39). The harvest index of TMS 30572 was significantly higher than that of TMS 92/0326 when no fertilizer was applied (Table 4.49).

Correlation

In the first experiment conducted in 2007, fresh shoot weight, root dry matter production, number of roots, number of leaves per plant at 3 to 4 MAP and leaf area index (LAI) at 3 to 6 MAP of cassava were all significantly positively correlated with the fresh root yield in 2007 (Table 4.50). However, in 2008, number of leaves per plant at 3 MAP, LAI at 4 and 6 MAP, root dry matter production, fresh shoot weight, number of roots and harvest index were positively correlated with fresh root yield of cassava (Table 4.51). The result of correlation coefficient analysis on the relationship among various parameters as affected by the residual effect of fertilizer application in 2008 and 2009 are presented in Tables 4.52 and 4.53. The root dry matter, fresh shoot weight and harvest

Table 4.49. Interaction of fertilizer and variety on harvest index of cassava at Ajibode in 2008

Fertilizer	Variety: TMS 30572	TMS 92/0326
No fertilizer	0.62a	0.56b
NPK at 600 kg/ha	0.62a	0.64a
OF at 2.5 t/ha	0.63a	0.65a
SE	0.011	

Means for the two varieties at the same or different fertilizer levels followed by the same letter(s) are not significantly different at 5% level of probability using Duncan's Multiple Range Test

index were positively correlated with fresh root yield of cassava in 2008 and 2009. Furthermore, in 2009, plant height at 4 and 5 MAP, number of leaves per plant and LAI each at 4 to 6 MAP were also positively correlated with fresh root yield.

The results of the relationship of cassava root yield with various parameters at different times of harvest in 2008 and 2009 at Ajibode are presented in Tables 4.54 and 4.55. The plant height at 3 to 6 MAP, number of leaves per plant at 3 and 4 MAP, leaf area index at 3 to 6 MAP and fresh shoot weight were negatively correlated with fresh root yield of cassava at 9 MAP in 2008 while the root dry matter was positively correlated with the same parameter at 9 and 12 MAP in 2009. Furthermore, plant height at 5 MAP, LAI at 6 MAP in 2008 and number of leaves per plant at 3 MAP in 2009 were negatively correlated with fresh root yield at 12 MAP

The fresh shoot weight, LAI at 6 MAP at 15 months harvest and plant height at 3, 5 and 6 MAP, LAI at 6 MAP at 18 months harvest in 2008 as well as number of leaves per plant at 3 MAP also at 18 MAP in 2009 were negatively correlated with fresh root yield of cassava. Furthermore, the root dry matter, number of roots and harvest index were positively correlated at 18 MAP in both years of the study (Table 4.54 and 4.55).

Table 4.50 Correlation coefficient (r) among cassava growth parameters, yield and yield components in 2007 (n= 22)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	PH 1 MAP																					
2	PH 2 MAP	0.48**																				
3	PH 3 MAP	0.45**	0.86**																			
4	PH 4 MAP	0.45**	0.71**	0.85**																		
5	PH 5 MAP	0.53**	0.48**	0.62**	0.75**																	
6	PH 6 MAP	-0.11	-0.11	-0.09	-0.08	-0.10																
7	NL 1 MAP	-0.52*	-0.01	-0.08	-0.08	-0.37	0.21															
8	NL 2 MAP	-0.43*	0.28	0.18	0.12	-0.21	-0.01	0.83**														
9	NL 3 MAP	-0.25	0.31*	0.35*	0.45**	0.18	-0.12	0.54**	0.69**													
10	NL 4 MAP	-0.10	0.34*	0.40**	0.64**	0.35*	-0.06	0.55**	0.63**	0.76**												
11	NL 5 MAP	0.16	0.34*	0.35*	0.66**	0.58**	-0.08	0.22	0.33*	0.59**	0.79**											
12	NL 6 MAP	0.22	0.18	0.26	0.59**	0.56**	-0.01	0.03	0.05	0.35*	0.61**	0.87**										
13	LAI 2 MAP	-0.54	0.18	0.09	0.02	-0.27	0.03	0.84**	0.92**	0.64**	0.54**	0.22	-0.02									
14	LAI 3 MAP	-0.43	0.25	0.24	0.24	-0.08	-0.08	0.68**	0.78**	0.89**	0.63**	0.36*	0.14	0.83**								
15	LAI 4 MAP	-0.38	0.26	0.27	0.38*	0.01	-0.01	0.76**	0.81**	0.73**	0.86**	0.54**	0.34*	0.83**	0.82**							
16	LAI 5 MAP	-0.35	0.23	0.19	0.35*	0.11	-0.06	0.68**	0.75**	0.73**	0.80**	0.69**	0.49**	0.79**	0.78**	0.91**						
17	LAI 6 MAP	-0.34	0.11	0.10	0.31*	0.08	-0.01	0.61**	0.62**	0.62**	0.74**	0.68**	0.63**	0.68**	0.69**	0.84**	0.94**					
18	RDMY	-0.12	0.05	-0.01	0.03	0.10	-0.19	0.17	0.19	0.07	0.15	0.22	0.10	0.28	0.12	0.24	0.42**	0.35*				
19	SY	-0.46	-0.29	-0.18	-0.03	-0.10	-0.03	0.46**	0.34*	0.27	0.43**	0.19	0.17	0.41**	0.34*	0.52**	0.48**	0.52**	0.42**			
20	FRY	-0.43	-0.02	-0.04	-0.03	-0.12	-0.23	0.60**	0.59**	0.37*	0.43**	0.25	0.06	0.67**	0.50**	0.61**	0.67**	0.59**	0.65**	0.59**		
21	NR	0.05	0.32*	0.39*	0.51**	0.38*	-0.27	0.08	0.23	0.42**	0.53**	0.50**	0.40**	0.21	0.31*	0.43**	0.49**	0.44**	0.52**	0.44**	0.55**	
22	HI	0.16	0.33*	0.18	0.00	-0.01	-0.11	0.05	0.19	0.05	-0.09	0.00	-0.16	0.16	0.07	-0.03	0.04	-0.08	0.05	-0.65	0.20	-0.04

PH = Plant height; NL = Number of leaves; LAI = Leaf area index; RDMY = Root dry matter yield; SY = Shoot yield; FRY = Fresh root yield;
NR = Number of roots; HI = Harvest index
MAP = Months after planting

Table 4.51 Correlation coefficient (r) among cassava growth parameters, yield and yield components in 2008 (n= 22)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	PH 1 MAP																					
2	PH 2 MAP	0.34*																				
3	PH 3 MAP	-0.07	0.17																			
4	PH 4 MAP	0.09	-0.10	0.51**																		
5	PH 5 MAP	0.04	0.04	0.56**	0.84**																	
6	PH 6 MAP	0.07	0.05	0.51**	0.85**	0.96**																
7	NL 1 MAP	-0.20	0.21	0.10	-0.30	-0.18	-0.21															
8	NL 2 MAP	0.21	0.16	0.11	-0.05	0.02	-0.01	0.08														
9	NL 3 MAP	-0.18	0.06	0.15	0.04	0.11	0.10	0.31*	0.08													
10	NL 4 MAP	-0.16	-0.18	-0.03	0.20	0.08	0.04	-0.16	-0.18	0.39**												
11	NL 5 MAP	-0.17	-0.39	0.11	0.37*	0.12	0.11	-0.15	-0.16	0.30	0.49**											
12	NL 6 MAP	-0.08	-0.16	0.23	0.31*	0.31*	0.33*	0.05	-0.23	0.38*	0.20	0.58**										
13	LAI 2 MAP	0.20	0.24	0.12	-0.08	0.03	0.01	0.21	0.97**	0.19	-0.19	-0.22	-0.17									
14	LAI 3 MAP	-0.14	0.16	0.10	-0.08	0.04	0.07	0.47**	-0.06	0.85**	0.21	0.11	0.40**	0.13								
15	LAI 4 MAP	-0.18	0.02	0.02	0.00	0.05	0.03	0.19	-0.17	0.63**	0.77**	0.29	0.32*	-0.05	0.69**							
16	LAI 5 MAP	-0.12	-0.23	0.10	0.26	0.12	0.14	0.08	-0.14	0'.48**	0.41**	0.87**	0.72**	-0.11	0.45**	0.50**						
17	LAI 6 MAP	-0.06	-0.08	0.18	0.23	0.27	0.30	0.15	-0.20	0.45**	0.18	0.50**	0.96**	-0.09	0.56**	0.44**	0.75**					
18	RDMY	0.05	0.44**	0.37*	0.03	0.16	0.15	0.31*	0.01	0.45**	0.06	0.01	0.33*	0.14	0.60**	0.39**	0.27	0.43*				
19	SY	-0.09	-0.05	0.29	0.15	0.16	0.21	0.11	0.02	0.45**	0.04	0.11	0.30*	0.12	0.58**	0.35*	0.36*	0.43**	0.61**			
20	FRY	0.24	0.40**	0.26	0.05	0.19	0.25	0.42**	-0.04	0.42**	-0.01	-0.12	0.30	0.13	0.60**	0.37*	0.20	0.44**	0.78**	0.50**		
21	NR	0.23	0.01	0.01	0.09	0.08	0.12	0.02	0.12	0.29	-0.07	0.05	0.29	0.22	0.42**	0.23	0.30	0.38*	0.46**	0.61**	0.39**	
22	HI	0.34*	0.49**	0.01	-0.11	0.05	0.06	0.34*	-0.08	0.06	-0.05	-0.26	0.04	0.01	0.16	0.09	-0.13	0.08	0.31*	-0.33	0.62**	-0.11

PH = Plant height; NL = Number of leaves; LAI = Leaf area index; RDMY = Root dry matter yield; SY = Shoot yield; FRY = Fresh root yield;
NR = Number of roots; HI = Harvest index
MAP = Months after planting

Table 4.52 Correlation coefficient (r) among cassava growth parameters, yield and yield components in 2008 (Residual effect of fertilizer; n= 22)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	PH 1 MAP																					
2	PH 2 MAP	0.71**																				
3	PH 3 MAP	0.67**	0.67**																			
4	PH 4 MAP	0.59**	0.61**	0.94**																		
5	PH 5 MAP	0.57**	0.52**	0.74**	0.83**																	
6	PH 6 MAP	0.59**	0.54**	0.81**	0.84**	0.93*																
7	NL 1 MAP	0.27	0.42**	0.48**	0.46**	0.44**	0.52**															
8	NL 2 MAP	0.43**	0.57**	0.54**	0.62**	0.54**	0.59**	0.58**														
9	NL 3 MAP	0.56**	0.56**	0.63**	0.70**	0.63**	0.62**	0.50**	0.71**													
10	NL 4 MAP	-0.08	0.13	0.21	0.30*	0.30*	0.33*	0.46**	0.41**	0.36*												
11	NL 5 MAP	0.09	0.27	0.28	0.36*	0.41**	0.40**	0.27	0.48**	0.35*	0.67**											
12	NL 6 MAP	0.41**	0.51**	0.54**	0.62**	0.59**	0.59**	0.22	0.57**	0.63**	0.43**	0.78**										
13	LAI 2 MAP	0.06	0.22	0.21	0.33*	0.34*	0.37*	0.59**	0.71**	0.35*	0.58**	0.49**	0.29									
14	LAI 3 MAP	0.35*	0.43**	0.50**	0.60**	0.58**	0.58**	0.61**	0.68**	0.86**	0.57**	0.49**	0.58**	0.64**								
15	LAI 4 MAP	-0.25	-0.01	0.05	0.17	0.21	0.21	0.40**	0.27	0.18	0.94**	0.60**	0.29	0.62**	0.51**							
16	LAI 5 MAP	-0.21	0.07	0.05	0.15	0.23	0.21	0.24	0.31*	0.12	0.72**	0.88**	0.52**	0.57**	0.42**	0.78**						
17	LAI 6 MAP	0.17	0.38*	0.38*	0.50**	0.51**	0.49**	0.21	0.48**	0.49**	0.58**	0.85**	0.91**	0.43**	0.60**	0.54**	0.76**					
18	RDMY	0.05	0.01	-0.12	-0.09	0.17	0.15	0.18	0.04	0.08	0.17	0.19	0.07	0.13	0.15	0.18	0.22	0.13				
19	SY	-0.04	-0.02	-0.08	-0.02	0.18	0.19	0.03	-0.17	-0.14	0.14	0.25	0.17	0.00	0.00	0.19	0.29	0.26	0.48**			
20	FRY	-0.04	-0.03	-0.15	-0.08	0.18	0.14	0.21	0.07	0.10	0.24	0.24	0.07	0.20	0.20	0.27	0.29	0.16	0.96**	0.51**		
21	NR	0.30	0.17	0.32*	0.30*	0.43**	0.47**	0.33*	0.33*	0.23	0.24	0.27	0.31*	0.32*	0.25	0.17	0.17	0.25	0.14	0.13	0.06	
22	HI	-0.01	-0.05	-0.14	-0.09	0.08	0.06	0.20	0.19	0.19	0.18	0.14	0.01	0.25	0.22	0.18	0.16	0.05	0.81**	-0.04	0.82**	0.02

PH = Plant height; NL = Number of leaves; LAI = Leaf area index; RDMY = Root dry matter yield; SY = Shoot yield; FRY = Fresh root yield;

NR = Number of roots; HI = Harvest index

MAP = Months after planting

Table 4.53 Correlation coefficient (r) among cassava growth parameters, yield and yield components in 2009 (Residual effect of fertilizer; n = 22)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	PH 1 MAP																					
2	PH 2 MAP	0.27																				
3	PH 3 MAP	0.43**	0.64**																			
4	PH 4 MAP	0.36*	0.48**	0.76**																		
5	PH 5 MAP	0.33*	0.24	0.56**	0.89**																	
6	PH 6 MAP	0.30	0.08	0.38*	0.72**	0.89**																
7	NL 1 MAP	0.09	0.30*	0.27	0.23	0.09	0.13															
8	NL 2 MAP	0.04	0.59**	0.41**	0.26	0.21	0.15	0.22														
9	NL 3 MAP	0.15	0.52**	0.70**	0.52**	0.41**	0.23	0.17	0.51**													
10	NL 4 MAP	0.17	0.26	0.45**	0.58**	0.64**	0.54**	0.15	0.24	0.69**												
11	NL 5 MAP	0.27	0.36*	0.54**	0.60**	0.61**	0.47**	0.14	0.30	0.72**	0.91**											
12	NL 6 MAP	0.19	0.28	0'.49**	0.60**	0.64**	0.53**	0.10	0.35*	0.59**	0.83**	0.89**										
13	LAI 2 MAP	0.13	0.57**	0.44**	0.32*	0.27	0.24	0.23	0.91**	0.54**	0.32*	0.36*	0.39**									
14	LAI 3 MAP	0.16	0.54**	0.63**	0.46**	0.40**	0.28	0.12	0.50**	0.90**	0.60**	0.64**	0.53**	0.63**								
15	LAI 4 MAP	0.24	0.29	0.45**	0.57**	0.66**	0.61**	0.15	0.21	0.60**	0.87**	0.81**	0.74**	0.37*	0.68**							
16	LAI 5 MAP	0.30*	0.38*	0.52**	0.54**	0.54**	0.48**	0.19	0.23	0.60**	0.76**	0.81**	0.74**	0.39*	0.72**	0.91**						
17	LAI 6 MAP	0.18	0.28	0.41**	0.47**	0.52**	0.50**	0.15	0.28	0.44**	0.64**	0.67**	0.79**	0.40**	0.57**	0.81**	0.89**					
18	RDMY	0.14	0.11	0.26	0.49**	0.53**	0.42**	0.18	0.03	0.33*	0.69**	0.71**	0.71**	0.12	0.32*	0.66**	0.61**	0.59**				
19	SY	-0.15	-0.08	-0.29	0.01	0.12	0.10	0.12	-0.28	-0.21	0.18	0.07	0.07	-0.30*	-0.20	0.15	0.05	0.09	0.35*			
20	FRY	0.06	0.07	0.07	0.32*	0.35*	0.28	0.26	-0.08	0.23	0.63**	0.62**	0.59**	0.01	0.23	0.58**	0.53**	0.50**	0.88**	0.60**		
21	NR	0.06	0.11	0.28	0.41**	0.54**	0.38*	-0.32*	0.23	0.22	0.34*	0.35*	0.46**	0.14	0.16	0.30*	0.22	0.30	0.40**	0.12	0.22	
22	HI	0.24	0.17	0.40**	0.37*	0.30	0.21	0.19	0.16	0.49**	0.54**	0.63**	0.60**	0.30*	0.48**	0.51**	0.55**	0.47**	0.66**	-0.32*	0.54**	0.12

PH = Plant height; NL = Number of leaves; LAI = Leaf area index; RDMY = Root dry matter yield; SY = Shoot yield; FRY = Fresh root yield;
NR = Number of roots; HI = Harvest index
MAP = Months after planting

Table 4.54 Correlation coefficient (r) among cassava growth parameters, yield and yield components,and time of harvest in 2008 (n= 37)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	PH 1 MAP																																				
2	PH 2 MAP	0.41																																			
3	PH 3 MAP	0.28	0.74**																																		
4	PH 4 MAP	0.02	0.43	0.74**																																	
5	PH 5 MAP	-0.07	0.50*	0.53*	0.45																																
6	PH 6 MAP	0.24	0.74**	0.87**	0.73**	0.48*																															
7	NL 1 MAP	0.04	0.69**	0.60**	0.58*	0.50*	0.64**																														
8	NL 2 MAP	0.05	0.50*	0.58*	0.66**	0.64**	0.69**	0.70**																													
9	NL 3 MAP	0.22	0.67**	0.78**	0.55*	0.59**	0.81**	0.52*	0.57*																												
10	NL 4 MAP	0.13	0.75**	0.84**	0.66**	0.53*	0.81**	0.68**	0.60**	0.86**																											
11	NL 5 MAP	0.24	0.62**	0.82**	0.68**	0.57*	0.79**	0.52*	0.66**	0.83**	0.77**																										
12	NL 6 MAP	0.36	0.81**	0.77**	0.69**	0.64**	0.78**	0.62**	0.62**	0.80**	0.78**	0.80**																									
13	LAI 2 MAP	-0.08	0.18	0.20	0.39	0.46*	0.37	0.40	0.82**	0.21	0.22	0.35	0.32																								
14	LAI 3 MAP	0.20	0.71**	0.84**	0.65**	0.62**	0.87**	0.56*	0.70**	0.95**	0.85**	0.86**	0.84**	0.38																							
15	LAI 4 MAP	0.24	0.74**	0.83**	0.74**	0.47*	0.80**	0.62**	0.66**	0.79**	0.93**	0.71**	0.79**	0.32	0.85**																						
16	LAI 5 MAP	0.18	0.70**	0.85**	0.75**	0.62**	0.87**	0.54*	0.73**	0.83**	0.80**	0.89**	0.85**	0.46	0.92**	0.85**																					
17	LAI 6 MAP	0.27	0.80**	0.83**	0.72**	0.73**	0.86**	0.63**	0.73**	0.86**	0.84**	0.77**	0.91**	0.40	090**	0.86**	0.88**																				
18	RDMY 9 MAP	0.24	0.15	0.16	-0.10	0.14	-0.04	-0.02	0.04	0.10	0.15	0.18	0.06	-0.04	0.12	0.20	0.12	0.06																			
19	SY 9 MAP	0.10	0.33	0.30	0.03	0.26	0.22	0.24	0.15	0.35	0.41	0.12	0.12	-0.14	0.30	0.40	0.17	0.30	0.72**																		
20	FRY 9 MAP	-0.02	-0.48*	-0.64**	-0.52*	-0.57*	0.63**	0.49*	-0.40	-0.58*	-0.62**	-0.39	-0.42	-0.02	0.54*	0.59**	-0.52*	-0.65**	-0.13	-0.62*																	
21	NR 9 MAP	-0.21	-0.04	-0.10	0.03	0.22	0.13	-0.10	0.08	0.13	0.17	-0.01	-0.03	0.16	0.07	0.14	0.09	0.17	0.09	0.31	-0.39																
22	HI 9 MAP	-0.40	-0.21	-0.10	-0.12	0.07	-0.29	0.02	0.00	-0.16	-0.09	-0.20	-0.22	-0.09	-0.13	-0.07	-0.16	-0.22	0.51*	0.48*	-0.06	-0.24															
23	RDMY 12 MAP	-0.11	0.02	0.04	-0.11	-0.21	0.01	0.03	0.14	0.04	0.19	-0.02	-0.14	0.07	0.10	0.23	0.02	-0.08	0.60**	0.58*	0.02	0.00	0.64**														
24	SY 12 MAP	0.10	0.42	0.33	0.04	0.20	0.29	0.31	0.25	0.30	0.46	0.12	0.14	-0.01	0.30	0.45	0.19	0.32	0.68**	0.93**	-0.53*	0.29	0.47	0.72**													
25	FRY 12 MAP	-0.07	-0.43	-0.30	-0.21	-0.57*	-0.37	-0.40	-0.19	-0.32	-0.35	-0.12	-0.29	0.00	-0.23	-0.27	-0.19	-0.47*	-0.03	-0.47*	0.79**	-0.53*	0.15	0.30	-0.40												
26	NR 12 MAP	-0.38	-0.22	0.18	0.19	-0.11	0.11	0.06	0.16	-0.03	-0.01	0.02	-0.17	0.15	0.08	-0.02	-0.02	-0.04	0.00	0.08	-0.02	-0.23	0.37	0.37	0.16	0.25											
27	HI 12 MAP	-0.18	-0.40	-0.27	-0.37	-0.08	-0.27	-0.28	-0.20	-0.21	-0.17	-0.31	-0.51*	-0.24	-0.31	-0.29	-0.41	-0.34	0.30	0.47*	-0.21	0.32	0.42	0.39	0.44	-0.23	0.07										
28	RDMY 15 MAP	0.08	0.13	0.08	-0.14	-0.26	0.02	-0.08	0.05	0.09	0.22	0.06	-0.01	0.03	0.16	0.29	0.11	-0.02	0.62**	0.47*	0.18	-0.04	0.45	0.91**	0.61**	0.41	0.23	0.13									
29	SY 15 MAP	0.22	0.44	0.40	0.10	0.18	0.37	0.29	0.25	0.36	0.50*	0.20	0.21	0.03	0.37	0.52*	0.27	0.36	0.73**	0.90**	-0.51*	0.29	0.38	0.71**	0.96**	-0.36	0.13	0.38	0.64**								
30	FRY 15 MAP	-0.11	-0.42	-0.36	-0.33	-0.44	-0.44	-0.41	-0.29	-0.41	-0.44	-0.09	-0.30	0.01	-0.34	-0.45	-0.25	-0.55*	-0.01	0.58*	0.86**	-0.48*	0.07	0.09	-0.50*	0.86**	0.17	-0.25	0.25	-0.47*							
31	NR 15 MAP	0.23	0.15	0.45	0.44	0.57*	0.33	0.15	0.50*	0.47	0.39	0.41	0.41	0.39	0.46	0.44	0.44	0.53*	-0.06	0.05	-0.36	0.04	-0.06	-0.16	0.00	-0.25	0.02	0.03	-0.15	0.04	-0.29						
32	HI 15 MAP	-0.15	-0.19	-0.23	-0.48*	-0.38	-0.27	-0.31	-0.30	-0.21	-0.06	-0.23	-0.43	-0.28	-0.23	-0.13	-0.28	-0.41	0.55*	0.44	0.17	0.12	0.46*	0.78**	0.52*	0.28	0.06	0.60**	0.72**	0.52*	0.21	-0.45					
33	RDMY 18 MAP	0.00	-0.05	-0.22	-0.36	-0.40	-0.31	-0.11	-0.12	-0.19	-0.09	-0.13	-0.17	-0.03	-0.17	-0.10	-0.23	-0.31	0.34	0.07	0.61**	-0.39	0.42	0.69**	0.25	0.63**	0.25	0.01	0.78**	0.21	0.58*	-0.27	0.55*				
34	SY 18 MAP	0.02	0.29	0.16	-0.09	-0.04	0.08	0.13	0.10	0.15	0.32	0.03	0.08	-0.04	0.18	0.33	0.06	0.13	0.66**	0.70**	-0.08	0.02	0.55*	0.88**	0.84**	0.05	0.26	0.29	0.86**	0.81**	-0.10	-0.15	0.67**	0.67**			
35	FRY 18 MAP	-0.10	-0.34	-0.49*	-0.40	-0.51*	-0.50*	-0.28	-0.29	-0.40	-0.43	-0.30	-0.26	-0.05	-0.38	-0.42	-0.40	-.526*	-0.10	-0.47	0.88**	-0.51*	0.20	0.22	-0.35	0.79**	0.16	-0.27	0.35	-0.37	0.82**	-0.32	0.17	0.78**	0.13		
36	NR 18 MAP	-0.11	-0.33	-0.37	-0.26	-0.27	-0.42	-0.16	-0.02	-0.41	-0.38	-0.16	-0.20	0.23	-0.33	-0.40	-0.32	-0.40	-0.20	-0.62**	0.84**	-0.56*	0.08	0.06	-0.48*	0.74**	0.18	-0.18	0.11	0.48*	0.78**	-0.10	0.06	0.58*	-0.05	0.79**	
37	HI 18 MAP	0.09	-0.07	-0.26	-0.49*	-0.28	-0.39	-0.16	-0.15	-0.28	-0.17	-0.24	-0.26	-0.06	-0.26	-0.19	-0.31	-0.39	0.21	-0.04	0.52*	-0.47*	0.38	0.48*	0.09	0.51*	-0.14	0.25	0.51*	0.08	0.46	-0.11	0.58*	0.71**	0.42	0.54*	0.60**

PH = Plant height; NL = Number of leaves; LAI = Leaf area index; RDMY = Root dry matter yield; SY = Shoot yield; FRY = Fresh root yield;

NR = Number of roots; HI = Harvest index

MAP = Months after planting

Table 4.55 Correlation coefficient (r) among cassava growth parameters, yield and yield components,and time of harvest in 2009 (n= 37)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1 PH 1 MAP																																				
2 PH 2 MAP	0.73**																																			
3 PH 3 MAP	0.74**	0.91**																																		
4 PH 4 MAP	0.65**	0.84**	0.92**																																	
5 PH 5 MAP	0.72**	0.83**	0.84**	0.87**																																
6 PH 6 MAP	0.64**	0.78**	0.79**	0.87**	0.94**																															
7 NL 1 MAP	0.70**	0.52*	0.54*	0.54*	0.64**	0.58*																														
8 NL 2 MAP	0.74**	0.70**	0.65**	0.57*	0.65**	0.53*	0.35																													
9 NL 3 MAP	0.71**	0.55*	0.59**	0.55*	0.64**	0.49*	0.60**	0.57*																												
10 NL 4 MAP	0.60**	0.56*	0.70**	0.76**	0.78**	0.71**	0.54*	0.50*	0.72**																											
11 NL 5 MAP	0.63**	0.74**	0.74**	0.79**	0.80**	0.74**	0.61**	0.64**	0.72**	0.86**																										
12 NL 6 MAP	0.64**	0.69**	0.75**	0.71**	0.69**	0.59**	0.55*	0.75**	0.65**	0.74**	0.80**																									
13 LAI 2 MAP	0.71**	0.82**	0.81**	0.82**	0.84**	0.78**	0.49*	0.86**	0.58*	0.68**	0.76**	0.81**																								
14 LAI 3 MAP	0.53*	0.44	0.51*	0.48*	0.62**	0.56*	0.27	0.54*	0.64**	0.65**	0.43	0.54*	0.65**																							
15 LAI 4 MAP	0.60**	0.67**	0.81**	0.86**	0.84**	0.80**	0.47	0.57*	0.60**	0.90**	0.75**	0.74**	0.82**	0.76**																						
16 LAI 5 MAP	0.60**	0.74**	0.74**	0.74**	0.84**	0.76**	0.50*	0.73**	0.65**	0.68**	0.73**	0.79**	0.88**	0.76**	0.79**																					
17 LAI 6 MAP	0.50*	0.62**	0.69**	0.65**	0.67**	0.61**	0.34	0.71**	0.50*	0.52*	0.50*	0.76**	0.82**	0.75**	0.71**	0.87**																				
18 RDMY 9 MAP	-0.36	-0.02	0.05	0.12	-0.21	-0.18	-0.20	-0.39	-0.28	-0.06	-0.16	-0.10	-0.16	-0.25	0.04	-0.21	-0.10																			
19 SY 9 MAP	-0.22	-0.03	0.06	0.20	-0.02	-0.06	0.05	-0.24	0.03	0.25	0.13	0.15	0.03	-0.06	0.26	-0.02	-0.05	0.77**																		
20 FRY 9 MAP	-0.44	0.00	0.01	0.07	-0.14	-0.05	-0.47	-0.37	-0.44	-0.30	-0.35	-0.41	-0.18	-0.13	-0.08	-0.11	-0.02	0.67**	0.23																	
21 NR 9 MAP	0.23	0.27	0.32	0.17	0.07	0.08	-0.10	0.12	-0.14	0.02	-0.11	-0.01	0.13	0.24	0.17	0.11	0.19	0.13	-0.30	0.38																
22 HI 9 MAP	-0.01	-0.04	0.04	0.03	-0.18	-0.24	0.09	-0.08	-0.13	0.10	0.00	0.16	-0.08	-0.33	0.03	-0.33	-0.22	0.60**	0.61**	-0.08	-0.01															
23 RDMY 12 MAP	-0.31	-0.07	0.03	0.10	-0.22	-0.20	-0.03	-0.35	-0.20	-0.12	-0.17	-0.05	-0.17	-0.29	-0.02	-0.18	-0.04	0.92**	0.73**	0.55*	-0.06	0.57*														
24 SY 12 MAP	-0.16	-0.03	0.06	0.15	-0.07	-0.12	0.17	-0.25	0.09	0.11	0.06	0.18	-0.04	-0.19	0.12	-0.08	-0.05	0.72**	0.90**	0.12	-0.43	0.63**	0.79**													
25 FRY 12 MAP	-0.42	0.03	0.04	0.05	-0.16	-0.05	-0.46	-0.34	-0.49*	-0.33	-0.32	-0.40	-0.19	-0.20	-0.11	-0.13	-0.04	0.62**	0.12	0.96**	0.42	-0.09	0.51*	0.03												
26 NR 12 MAP	-0.13	0.29	0.15	0.16	-0.02	0.08	-0.26	0.12	-0.42	-0.35	-0.08	0.00	0.15	-0.31	-0.17	0.06	0.17	0.21	-0.20	0.48*	0.34	-0.09	0.13	-0.18	0.53*											
27 HI 12 MAP	-0.22	-0.31	-0.20	-0.16	-0.35	-0.38	0.02	-0.37	-0.22	-0.09	-0.25	-0.22	-0.31	-0.39	-0.13	-0.50*	-0.38	0.67**	0.67**	0.12	-0.14	0.83**	0.71**	0.68**	0.07	-0.24										
28 RDMY 15 MAP	-0.39	-0.11	-0.02	0.04	-0.26	-0.24	-0.10	-0.40	-0.23	-0.13	-0.18	-0.07	-0.22	-0.29	-0.05	-0.20	-0.07	0.94**	076**	0.55*	-0.09	0.57*	0.98**	0.81**	0.52*	0.11	0.68**									
29 SY 15 MAP	-0.16	-0.14	-0.02	0.06	-0.14	-0.21	0.19	-0.31	0.11	0.12	-0.01	0.11	-0.14	-0.18	0.07	-0.17	-0.12	0.69**	0.88**	0.05	-0.41	0.68**	0.77**	0.97**	-0.05	-0.33	0.76**	0.79**								
30 FRY 15 MAP	-0.41	-0.03	-0.02	-0.04	-0.25	-0.13	-0.50*	-0.34	-0.55*	-0.41	-0.39	-0.44	-0.25	-0.26	-0.20	-0.19	-0.10	0.55*	0.01	0.92**	0.48*	-0.10	0.45	-0.06	0.98**	0.57*	0.04	0.46	-0.13							
31 NR 15 MAP	0.27	0.56*	0.54*	0.53*	0.28	0.21	0.27	0.37	0.44	0.40	054*	0.56*	0.53*	0.20	0.42	0.41	0.43	0.43	0.44	0.10	0.17	0.32	0.39	0.39	0.09	0.25	0.17	0.37	0.32	0.02						
32 HI 15 MAP	-0.46	-0.48*	-0.41	-0.35	-0.58*	-0.58*	-0.21	-0.49*	-0.37	-0.31	-0.44	-0.29	-0.46	-0.48*	-0.32	-0.59**	-0.44	0.70**	0.70**	0.17	-0.21	0.78**	0.74**	0.74**	0.11	-0.15	0.90**	0.75**	0.79**	0.09	0.12					
33 RDMY 18 MAP	-0.56*	-0.14	-0.09	-0.08	-0.34	-0.23	-0.57*	-0.44	-0.55*	-0.33	-0.40	-0.33	-0.29	-0.22	-0.14	-0.23	-0.05	0.75**	0.31	0.89**	0.29	0.11	0.66**	0.23	0.91**	0.43	0.24	0.69**	0.17	0.89**	0.10	0.33				
34 SY 18 MAP	-0.32	-0.13	-0.01	0.08	-0.14	-0.14	-0.01	-0.39	-0.08	0.02	-0.13	0.00	-0.11	-0.12	0.11	-0.12	-0.01	0.81**	0.88**	0.36	-0.32	0.52*	0.85**	0.92**	0.27	-0.13	0.69**	0.87**	0.90**	0.16	0.29	0.74**	0.47*			
35 FRY 18 MAP	-0.47*	-0.09	-0.07	-0.09	-0.32	-0.21	-0.57*	-0.36	-0.56*	-0.44	-0.42	-0.45	-0.30	-0.29	-0.25	-0.24	-0.11	0.56*	0.02	0.91**	0.43	-0.09	0.47*	-0.04	0.97**	0.57*	0.06	0.47*	-0.10	0.98**	0.01	0.12	0.92**	0.19		
36 NR 18 MAP	-0.57*	-0.39	-0.35	-0.39	-0.47*	-0.46	-0.82**	-0.26	-0.38	-0.32	-0.53*	-0.41	-0.33	0.07	-0.20	-0.31	-0.07	0.31	0.03	0.52*	0.32	-0.01	0.16	-0.11	0.48*	0.07	0.10	0.21	-0.09	0.47*	-0.04	0.24	0.59**	0.12	0.53*	
37 HI 18 MAP	-0.57*	-0.41	-0.40	-0.40	-0.54*	-0.42	-0.65**	-0.57*	-.705**	-0.48*	-0.54*	-0.63**	-0.62**	-0.49*	-0.47	-0.57*	-0.51*	0.37	-0.10	0.62**	0.43	0.04	0.20	-0.22	0.69**	0.37	0.10	0.24	-0.21	0.77**	-0.32	0.18	0.69**	-0.05	0.78**	0.47*

PH = Plant height; NL = Number of leaves; LAI = Leaf area index; RDMY = Root dry matter yield; SY = Shoot yield; FRY = Fresh root yield;

NR = Number of roots; HI = Harvest index

MAP = Months after planting

CHAPTER 5

DISCUSSION

The two cassava varieties used in this study were improved varieties. These varieties exhibited different responses to the various treatments in the trials.

The TMS 30572 grew faster than TMS 92/0326 at both locations although significant height differences were only recorded in 2007. In contrast, leaf production and LAI in TMS 92/0326 were greater than those of TMS 30572. These disparities could be attributed to inherent varietal differences in these cassava varieties earlier reported by (IITA, 1990, Dixon *et al*., 2010) that TMS 30572 has the ability to grow fast and establish canopy early to suppress weeds while TMS 92/0326 produces multiple sprouts and produces wider leaf lobes. Similarly, higher fresh, dry root and shoot yields obtained from TMS 92/0326 at the two locations and in both years could be attributed to higher leaf production and leaf area which resulted in increased photosynthetic ability, manufacture of assimilates and subsequent partitioning to the roots. This corroborates the report of Ekanayake (1993) and Githunguri *et al*. (1998) on the relationship between LAI and root yield in cassava.

Fertilizer application caused marked improvements on growth and yield of cassava in all the trials in the study which is in line with the reported work of Obigbesan (1999) and IITA (2005) on cassava response to fertilizer application in Ibadan. The two cassava varieties used responded well to fertilizer application. In all the experiments, stem elongation, leaf production and development were increased when fertilizer was applied compared with the treatments without fertilizer (control) probably due to adequate supply of nutrients to the plants as well as the crop's prompt response to applied fertilizer. The growth and yield response obtained by the application of NPK 15-15-15 at 600 kg/ha were similar to that obtained by the application of OF at 2.5 to 6.0 t/ha in all the trials and at both locations. The increased cassava LAI caused by the application of OF compared with NPK and control could be attributed to the availability of both macro and micro nutrients for good shoot development. Similar finding on the application of NPK 20-10-10 and micro nutrient fertilizers had earlier been reported by Ano and Ikwelle (1998).

Fresh root yields obtained with the application of OF at 2.5 t/ha were higher than that of control by 40.0% and 33.6% in 2008 and 2009 respectively, thus confirming the efficacy of 2.5 t/ha OF as a possible substitute for the frequently used mineral fertilizer in cassava production. However, the rate of 2.5 t/ha identified to be optimum for cassava in this study was higher than 1.5 t/ha OF rate recommended by Zebarth *et al.* (2005) for a shorter maturity crop, sweet potato.

The residual effect of OF application was positive on the growth and yield of cassava in this study. The values of growth parameters and root yield obtained from residues of applied OF at 2.5 to 6.0 t/ha were significantly higher than those of NPK and no fertilizer treatments. Furthermore, the residues of applied OF favoured the elongation of stem in TMS 30572 than TMS 92/0326 cassava variety. Shorter plants recorded in NPK treatments similar to control could have been as a result of low soil nutrient due to plant uptake by previous crop which left little or no fertilizer residue to support another cropping season. In some cases, growth parameters obtained with residues of applied fertilizer were higher than those obtained during the first year with fertilizer. This finding could have been due to the prolonged effect of OF in soil which corroborates the report of Eneji *et al.* (1996) on the slow release of nutrient from the organic portion of applied OF.

The yields of cassava root obtained with the residue of applied OF were also similar to those obtained at fresh application in the first season of planting, thus indicating the efficacy of OF at 2.5 t/ha in supporting optimum yields of cassava root in two cropping seasons. This could have been due to the continuous and slow release of essential nutrients from the previously applied OF which sustained the growth and optimum yields of cassava for two cropping seasons. In contrast, nutrients in residues of NPK 15-15-15 fertilizer application at 600 kg/ha was inadequate to support the production of optimum yield of cassava for two consecutive cropping seasons. This corroborates the findings of Titiloye (1982), Makinde (2007), Olowokere (2009) and Ayeni (2010) on residual effects of organic and organomineral fertilizers on crops.

Obigbesan (1999) and Adeoye *et al.* (2008) also reported on the short-term effects of mineral fertilizers in soils.

Plant growth and yield were affected by location. The leaf production and LAI, fresh root, dry matter production as well as shoot yield was higher at Oluana location than those obtained at Ajibode in 2007 and 2008. This could have been as a result differences in the soil nutrient content of the soils in the two locations. The analysis of the soil collected from the sites showed that the organic carbon and primary nutrients content were higher at Oluana than Ajibode soil. The role of N, P and K in increasing cassava root yield has been reported (Obigbesan, 1999; Howeler, 2002).

The interaction of location and variety, location and fertilizer, variety and fertilizer as well as location and variety and fertilizer were not significant for the growth and yield parameters in this trial.

Evidently, harvesting cassava at the time of full maturity is crucial in obtaining high yield and good quality root tubers. Cassava tuber yield of both varieties increased with delay in time of harvest up to 15 MAP in both years of the trial but further delay up to 18 MAP did not result in significant increase in root yield. Increase of 42.3% in fresh root yield obtained as a result of the delay of harvesting from 12 to 15 MAP as well as from 15 - 18 MAP was probably due to partitioning of assimilates in favour of the root tubers and accumulation within these periods. Similar findings on higher yields obtained due to prolonged harvest beyond 12 MAP have been reported (Ngeve, 1985; Nweke *et al*., 1994; Alleman and Dugmore, 2004; Okpara *et al*, 2010).

About 17.4% reduction in fresh root yield observed in TMS 92/0326 with delay in harvest up to 18 MAP was due to bacteria rot disease which affected the cassava tubers, but the reason for this was not clear in this experiment. The significant increase in fresh tuber yields of the two varieties with OF and NPK application compared with the control at 15 MAP indicated the importance and positive response of cassava to fertilizer application. Many research findings have also indicated that cassava responds well to fertilizer application (Adeoye *et al*., 1991; Obigbesan, 1999, and Okpara *et al*., 2010). Lawal (2008) working on response of yam to OF and NPK also made similar observation. However, compared with inorganic fertilizer, NPK, OF application gave a better result in TMS 30572 especially when harvest was delayed up to 18 MAP. This finding is an indication of the efficacy of OF in cassava production especially when harvest is prolonged beyond 12 MAP. It could be attributed to the long term effect of the organic portion of OF in soil. Similar results have been reported by Adeoye *et al*. (1991) and Lawal (2008) on yams, cassava and other crops. They all asserted that combination of organic and inorganic fertilizer on crop production performed equally and in some cases better than the use of organic or inorganic alone. However, the relatively poor performance of control plots can be attributed to low nutrient status in the plots that failed to sustain optimum yield of cassava.

The positive relationship between root yield of cassava and shoot weight, root dry matter production, number of roots, number of leaves per plant at 3 to 4 MAP and leaf area index (LAI) at 3 to 6 MAP in the first year of the study was an indication that the parameters contributed significantly to the root yield. This was probably due to enhancement of photosynthesis, increasing the production of assimilates and subsequent partitioning and distribution in favour of the root tubers. However, the negative correlation of plant height at 3 MAP with fresh root yield within the same period indicated that this parameter reduced fresh root yield due to high demand of assimilates by the growing shoot to the detriment of tuber formation. Furthermore, in 2008, number of leaves per plant at 3, LAI at 4 and 6 MAP, root dry matter production, fresh shoot weight, number of roots and harvest index all contributed to fresh root yield of cassava. Similar results on contributions of leaf area and shoot weight to root yield in cassava have been reported (Cock, 1985; Osiru *et al*. (1995); Ekanayake (1996) and Eke-Okoro, 2001).

The root dry matter production, fresh shoot weight and harvest index resulting from residues of applied fertilizer contributed significantly to fresh root yield of cassava in 2008 and 2009. Similarly, in 2009, plant height at 4 and 5 MAP, number of leaves per plant and LAI each at 4 to 6 MAP also had positive relationship with fresh root yield of cassava. This result indicated that these parameters made significant contributions to yield probably by enhancing the production of assimilates which was partitioned in favour of the root tubers during this active period of growth. Similar result on sink distribution in cassava has been reported (Ekanayake, 1993).

The number of leaves per plant at 3 and 4 MAP, leaf area index at 3 to 6 MAP and fresh shoot weight had negative relationship with fresh root yield when cassava was harvested at 9 MAP in 2008. This was probably due to the fact that more assimilates were apportioned to the growing shoot at this point leading to reduction in assimilates translocated to the roots before this time of harvest. Plant height at 5 MAP, LAI at 6 MAP in 2008 as well as number of leaves per plant produced at 3 MAP in 2009, all had a negative relationship with fresh root yield at 12 MAP, indicating that these parameters reduced the fresh root yield of cassava at this time of harvest. This was probably due to the high demand of photosynthates for vegetative growth to the detriment of the root tubers. The shoot yield, LAI at 6 MAP, plant height at 3, 5 and 6 MAP, LAI at 6 MAP all at 18 months harvest in 2008 as well as number of leaves per plant at 3 MAP at 18 months harvest reduced fresh root yield. This could have resulted from the delay in harvest time which made extra demand of assimilates for shoot growth finding. Similar result on partitioning of assimilates in favour of cassava shoot with age of the plant has been reported (Githunguri *et al*., 1998; Osiru *et al*., 1995).

CHAPTER 6

SUMMARY AND CONCLUSIONS

Cassava is one of the most important food crops and a popular crop in the farming systems of most Nigerian farmers. The performance and productivity of the crop is influenced by the fertility status of the soil and the harvesting time. Chemical fertilizers are detrimental to soil health, effects do not last in soil and may not be readily available at peak periods of need, therefore the need to explore cheaper, sustainable and readily available nutrient sources for the production of this important arable crop. Furthermore, the information on the optimum rate of organomineral fertilizer to apply as well as the suitable time to harvest cassava in Southwestern Nigeria is scarce.

Field experiments were conducted between 2007 and 2009 at Ajibode and Oluana in Ibadan to determine the effects of fertilizer treatments (types and rate) and harvesting time on yield of cassava (*Manihot esculenta* Crantz). Five rates of organomineral fertilizer (1.5, 2.5, 3.5, 4.5 and 6.0 t/ha) as well as NPK 15:15:15 at 600 kg/ha and no-fertilizer as controls were evaluated on the performance of cassava. The residual effects of the fertilizers on the performance of the same test crop were investigated. Four periods of harvesting (9, 12, 15 and 18 months after planting) were also investigated to determine the optimum period of harvest. The experiments were evaluated using a split-plot arrangement in a randomized complete block design (RCBD) and replicated three times.

The major findings of the study are summarized as follows:

1. Use of organomineral fertlizer proved to be effective in supporting cassava growth and increasing root yield.
2. Application of 2.5 t organomineral fertilizer per hectare was appropriate in producing optimum cassava root tuberous yield.

3. Application of 2.5 t organomineral fertilizer per hectare was effective in producing similar yield as the application of NPK 15:15:15 at the rate of 600 kg/ha.
4. The fresh root yield of TMS 92/0326 was higher than that of TMS 30572 at 12 months after planting
5. One application of 2.5 t of organomineral fertilizer per hectare was effective in producing optimum yield of cassava root tubers in two cropping seasons.
6. The best time to harvest TMS 30572 and TMS 92/0326 was 15 MAP for optimum yields.
7. Leaving root tubers of cassava varieties on the farm up to 18 MAP did not bring appreciable increase in yield but promoted high losses from tuber rot disease especially in respect of TMS 92/0326.
8. Organomineral fertilizer application had more positive effects on cassava growth and yield up to 18 MAP than NPK.

From the above observations, it could be concluded that:

One application of organomineral fertilizer at 2.5 t/ha can support optimum crop yield of cassava for two seasons of production.

The optimum time to harvest TMS 30572 and TMS 92/0326 is 15 MAP (depending on the soil fertility) for optimum dry matter yields.

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