EFFECTS OF SOME FIELD PRACTICES ON THE YIELD AND QUALITY OF CASSAVA (*Manihot esculenta* Crantz) PLANTING MATERIAL

By

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ABSTRACT

The use of cassava stems as planting materials is limited by scarcity, poor quality, high cost and inappropriate field techniques (land preparation, planting spacing, and field maintenance). To enhance the supply of stem for planting cassava varieties, the existing production practices were evaluated and techniques for increasing the number and quality of cassava planting materials were investigated.

Seventy-four cassava farms, purposively selected in 11 major cassava growing States in Nigeria were surveyed for percentage missing stands. Twenty-five centimeter long Standard Stakes (SS) of 43 Cassava Mosaic Disease Resistant (CMDR) varieties were cut using secateur, machete, *Okoli*-cutter, hand-held saw and motorized-rotary saw. The cuttings were planted at 100 x 50 cm spacing in a Randomized Completed Block Design (RCBD). The experiment was carried out at Onne and was replicated thrice. Five nationally released varieties out of the 43 CMDR varieties were evaluated in treatment combinations: three node-stake categories, three fertilizer types (400kg/ha each) NPK16:27:10 + Agrolyzer (DAP:21% N + 53% P, 3.2kg/10kg) (F1); NPK15:15:15(F2); NPKSMg 13:9:27:5 (F3) and three planting spacings [80 x 37.5 cm (S1), 80 x 50 cm (S2) and 100 x 50 cm (S3)], in a split-split plot design, three replications at Onne and Ogurugu. Patterns of stake distribution were evaluated in 43 CMDR varieties in a RCBD, four replications at Ibadan, Akure, Onne and Zaria. In all the experiments, the number of nodes, stem weight and diameter per SS were assessed for stem quality. Data on SS yield, quality and percentage missing stands were collected and analyzed using descriptive statistics as well as ANOVA ($P=0.05$).

The percentage missing stands in fields (1-3 months after planting) varied from 18.6 to 32.6%. Mean SS of 5.2 ± 0.3 was obtained from fields planted with SS cut with *Okoli*-cutter, hand-held saw, and motorized-rotary saw while that of secateur was 4.8 ± 0.3. These differences were not significant, but motorized-rotary saw cut faster with less stem damage than others. Spacing (S1 - 10.8 ± 2.2 SS; S2 - 11.85 ± 1.8 and S3 - 7.56 ± 0.5) and number of nodes (2 nodes - 9.9 ± 2; 3 nodes - 8.7 ± 2 and 4 nodes - 11.6 ± 2) did not significantly affect SS yield. Application of fertilizers increased the SS yield by 71.6% (F1), 69.9% (F2) and 80.8% (F3) at Onne and 72.6% (F1), 76.3% (F2) and 83.9% (F3) at Ogurugu. However, there was no significant difference in SS yield under different fertilizer applications at Ogurugu and Onne. There was no significance difference in SS yield at Ibadan, Akure, Onne and Zaria. However, 38.7% of the SS were from the main stem, while 25.8%, 19.3%, 12.8% and 8.5% were from primary, secondary, tertiary and quaternary stems respectively. The mean number of nodes, stem weight and diameter per SS was 12±2.1, 70.1±13.2 (g) and 2.1±0.2 (cm) respectively.

Planting spacing of 80 x 50 cm gave optimum standard stake yields, and could be recommended for stem production. Applying Nitrogen-Phosphorus-Potassium-Sulphur-Magnesium 13:9:27:5:4 fertilizers gave the best standard stake yield. Motorized-chain saw should be used to cut cassava stems.

Keywords: Cassava varieties, Standard stakes, Productivity, Field practices, Missing stands.

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DEDICATION

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CERTIFICATION

We certify that this work was carried out by Marie Octavie Yomeni, of the Department of Agronomy, University of Ibadan, and under our joint supervision in collaboration with the Cassava Breeding Unit, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

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CHAPTER 1

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a major food crop in sub-Sahara Africa. It is primarily a root crop, but the leaves and shoots, which are relatively high in protein, are also often eaten (Manyong *et al.,* 2000). In the early 2000s in Africa, 95 % of total production was used as food and 5 % as feed and industrial raw material (FAO, 1999) and Nigeria produced 32 million tonnes and was the largest producer globally.The total world production of cassava has increased from 217 million tonnes in 2007 to 242 million tonnes in 2009. In 2008, Africa produced about 118.0 million tonnes of cassava roots, which is about 51 % of the world production (FAO, 2009). In 2009, the production increased to 121 million tones of cassava. Cassava ranks first in area planted being the country's main crop and plays an important role in generating income for the rural farmers. To date, Nigeria remains the largest cassava producer (45 million tonnes), followed by Thailand, Brazil, and Indonesia (FAO, 2009).

The roots contain 67 % water and the rest is dry matter that is mainly of starch. Thus, cassava is mainly important for its high carbohydrate content in the roots (Rickard *et al.,* 1991). Over 200 million people in sub-Sahara Africa, get more than half of their calories from foods made from cassava roots. In the 1990s, Nigeria replaced Brazil as the largest cassava producer in the world, while Ghana moved from the eighth to the third largest producer in Africa, after Nigeria and the Democratic Republic of Congo (FAOSTAT, 2000). In 1993, Africa produced about 88 million tonnes of cassava or about 55% of the world's cassava. This output is projected to more than double by 2020 (Scott *et al*., 2000). Trends in cassava production indicate a steady growth over time (growth rate of 2.5 % between 1961 and 1975 and 2.7 % between 1976 and 1998 were recorded across Africa).

Cassava is a major source of income for the farmers (Nweke, 1996). It is a raw material for local industries (Onabolu and Bokanga, 1998; Sanni *et al*., 1998). In Nigeria, during the rapid diffusion of the new IITA's (International Institute of Tropical Agriculture) TMS (Tropical Manioc Selection) varieties, from 1984 to 1992, inflation caused cassava prices to fall by 40 % compared with the period before the rapid diffusion (Nweke, 2004). Cassava has many other benefits (Jones, 1959; Fresco, 1986), being able to grow in sub-optimal conditions of drought and low soil fertility, often encountered in many parts of Africa. Cassava is usually grown on marginal soils. It grows fairly well in poor soils with low pH, and it is relatively resistant to diseases and insect pests. The ultisols which cover more than 70 % of the total land in Eastern Nigeria is the major soil used for the cultivation of crops, especially cassava in many parts of Southeast Nigeria (Mbagwu, 1992). Despite the poor fertility attributes of the soil, it is continuously being used without application of amendments. Few cassava farmers have ready access to the fertilizer service and so are reluctant to use fertilizer when the soil nutrient status is unknown (Henri and Hershey, 2001). When cassava is planted on a fertile soil, it removes large amount of nutrients from the soil. One major consideration in fertilizer recommendation for cassava is that it has a large requirement for potassium (K). A local variety of cassava (Menyok) planted at a spacing of 100 cm x 100 cm in 1996, on soils with low organic matter (1.1 percent), P (Bray 2) very low at 1.56 parts per million (ppm), and K very low at 0.07 meq/100 g, with Ca at 9.7 meq/100 g and Mg at 2.6 meq/100 g (Both very high) indicate that K was a major limiting factor for efficient cassava production on marginal upland Alfisol soils. Application of Nitrogen (N) and Phosphorous (P) only gave the least fresh root yield of 11.88 t/ha. Exclusion of K also resulted in the lowest number of roots per plant at 7.6. Yields showed a curved response to successive increases in K up to 120 kg/ha of K_2O. Separate combinations that added either 30 or 60 kg/ha of K_2O increased yields over the N-P treatment by 55 and 92 %, respectively (Suyamto, 1998)). Yields on many soils are apparently limited by a lack of adequate K. When K level in the soil is low, the response of the crop to N or P fertilizers is poor. On the presence of adequate amounts of K, the crop is able to respond to moderate (though not high) levels of N (Suyamto, 1998). To increase yield potential of cassava, the crop had been reported to respond to good soil fertility and adequate fertilizer (Gomez *et al*., 1980; Howeler, 1996). Farmers do not fertilize cassava because they are content with the minimal yields obtained from using limited inputs or even from their infertile soils.

Fertilizer is not the only factor to consider in achieving high yield in cassava. Cassava production is highly dependent on an adequate supply of good planting materials. However, most farmers still plant what they see or have because of the lack of good planting materials, inability to select for high quality stakes based on scientific criteria and the belief in the traditional method. This always results in very low stem and root yields. There is evidence that the initial use of healthy cuttings is an important factor in the subsequent attainment of good yields (Lozano, 1977). Conversely, cuttings with low vigor and which are infested or infected by pests and pathogens often limit cassava production. Diseases and pests constitute one of the greatest constraints to cassava production in Africa (Theiberge, 1985). The yield losses vary with pests and diseases and the prevailing climatic conditions (Yaninek, 1994) Cassava anthracnose disease, bacterial blight and mosaic disease are the three key diseases that pose a major challenge to cassava production in the rainforest zones of tropical Africa (Hahn *et al*., 1989; Thresh *et al*., 1994). The African cassava mosaic virus (ACMV), which causes mosaic disease (CMD), can reduce cassava yields by over 50% (Ariyo *et al*., 2001). Although the virus is distributed through all cassava producing areas in Africa it has been kept in check through breeding and distribution of resistant germplasm (Thresh *et al*., 1994). However, in many areas farmers still grow local varieties that may be highly susceptible. Even in areas where improved varieties are grown, new variants of virus have been reported resulting from combination of ACMV and the EACMV which could break the resistance currently existing (Otim-Nape *et al*., 2001). Cassava Bacterial Blight (CBB), caused by *Xanthomonas campestris* pv. *Manihotis* affects yields significantly because stems with cankers and blighted leaves wilt ending up in shoot die back. Symptom severity is known to be highest in the humid forest and the forest savanna transition zone (Wydra *et al*., 2001). Varietal resistance has been found to vary in different environments. In many areas farmers do not practice integrated management measures for this important disease and therefore losses could be potentially be high (Hillocks and Wydra, 2002).

In recent years, these cassava diseases have become so important in the extent of damage to plants by reducing the amount of healthy plantable stems available to farmers; that a search for cultivars of cassava resistant to these diseases become necessary. Planting materials from infected stems are usually of poor quality and result in weak plants with low yield. Although in many areas the disease has been kept under control through deployment of resistant germplasm (Hahn *et al*., 1989), continuous monitoring is essential because new strains of the pathogen remain potential threats.

A study conducted by Obilo *et al*. (2010) on the effect of the incidence of cassava anthracnose disease (CAD) on the performance and yield of cassava cultivars showed that cultivar with the largest size of cankers on whole plant, highest fresh weight of infected tubers and stems which led to low yield and less planting materials.

The age of the stem cutting has a profound influence on the root and stem yields. According to Leihner (1984 b), selection of well-developed and well-nourished mature and healthy stems from mother plants, and adequate storage conditions are the first steps towards minimizing detrimental storage effects. Stems for storage should be as long as possible and not cut into stakes as this greatly accelerates dehydration. Green stems are extremely susceptible to attack by soil borne pathogens as well as by sucking insects. They cannot be stored for an interval of 2 to 3 days since they have high water content and tend to dehydrate rapidly. They are also very susceptible to many microorganisms (bacteria and fungi) attack since they are very succulent causing severe rot shortly after planting (Nestel, 1976; Toro *et al.,* 1976).

Optimum population density is required for higher stake yield. Other factors required include control of weeds, pests, diseases, livestock damage and drought/dry spells. Experience in the field of many farmers across several ecologies in Nigeria in some cassava growing areas showed that 25 to 30 % of the planted cuttings are lost in the field (Yomeni, personal communication). Therefore, factors causing missing stands on cassava plots must be identified for each farm and corrected as much as is feasible economically. When stakes do not germinate, the surrounding plant will usually cover over the empty space and compensate for missing plants. Villamayor, 1988 reported that replacement of missing plants is justified only if more than 30 % of plants are missing. He suggested replanting before plants are more than 13 days old. In India, research at CTCRI (1984) found that replanting with 40 cm long stakes produced 50 % higher yield than replanting with normal 20 cm stakes; they suggested replanting at about 15 days. A compensation study has to be carried out to evaluate whether the yield of the available stands has doubled because of the increase in its rectangularity.

Cassava production is constrained by factors such as lack of clean planting materials, low seed multiplication ratio, long maturity periods, low yielding varieties, poor production practices, and pest and disease attack (Obilo *et al*., 2010). Because of the high demand for cassava planting material, there is a need to set up a cassava rapid multiplication scheme. Cassava can be propagated from either stems or botanical seed, but the former is the commonest practice. Propagation of cassava through true seed is feasible but not practicable. Farmers grow cassava using vegetative cuttings or stakes. The number of commercial stakes obtained from a single mother plant in a year ranges from 3 to 30, depending on the growth habit, climate, management and soil conditions (Leihner, 2001). This is considerably less than the propagation rate that can be achieved with other commercial crops that are propagated through true seed or vegetative cuttings. Two to three-node cuttings, pre-sprouted in polythene bags, and planted in the field is a practical method for stem production (Eke-Okoro *et al*., 2005). Ratooning of cassava plot six months after planting (MAP) enables the planting materials to be cut twice a year (Odero *et al*., 2004) in cassava stem multiplication farms. They found that from 1998 to 2004, primary sites have multiplied and distributed over 42 millions stems, enough to establish 4274 ha of land. The use of various tissue culture methods for rapid multiplication of improved cassava clones is a good option because of their very high multiplication ratios and absence of CMV disease. It is, however, often hampered by inadequate number of trained personnel and absence or inadequacy of a unit to immediately execute the multiplication. The method is quite expensive to establish and maintain in a short time, considering the current socio-economic status accorded root vis-à-vis grain crops. Plantlets arising from tissue culture multiplication will be more difficult to handle by most of the target collaborators and pilot farmers that will participate in the program of rapid multiplication. These would also require much more critical training.

In Nigeria, cassava is produced by smallholders who cultivate an average of 1ha per household. However, because of the government promotion of cassava cultivation, farms of 10 ha and above are emerging. These emerging large farms are confronted with several problems including low soil fertility, scarce and expensive planting materials and inappropriate planting techniques. The objectives of this work are to:

1. assess the extent and causes of missing stands in cassava farms;
2. develop practical techniques for rapid multiplication of cassava stems by determining the appropriate stem cutting methods and number of nodes per stake;
3. evaluate the effects of different fertilizers and spacing on cassava stem yield;
4. evaluate the effects of plant spacing and area per stand on the yield of stem;
5. evaluate the pattern of stem cutting distribution among 43 CMDR varieties of cassava;
6. assess the stem yield in trial plots with micro-variability in soil environment using uniformity trial and
7. assess the quality of cassava planting materials obtained from fields.

CHAPTER 2

LITERATURE REVIEW

2.1 Cassava Taxonomy and Origin

Cassava (*Manihot esculenta* Crantz) belongs to the division of Magnoliophyta, class Dicotyledoneae, Sub-class Archichlamideae, Order Euphorbiales, Family Euphorbiaceae, Sub-family Crotonoidea, Tribe Manihotae and genus Manihot. The Manihot comprised a large number of species and has been subdivided into seven sub-genera. Cassava belongs to the sub-genus manihot, which is further divided into six types. Rogers and Appan (1970) identified 75 species within the genus *Manihot*, using taximetric methods.

Botanically, there was a tendency in the literature to assume that cassava has no known ancestry (Allem, 1994 a). However, in 1982, cassava was found grown as a wild population indistinguishable on morphological grounds from the domesticated in the Central Brazillian State of Goais (Allem, 1987). Several publications doubted the findings and raised the possibility that cassava had been regarded as wild material (Bretting, 1990; Heiser, 1990; Bertram, 1993). The conviction was that wild populations of *Manihot flabellifolia* are likely to have led to the genesis of modern commercial and landraces of cassava (Allem, 1994 b). The author (Allem, 1999), recently reaffirmed this position while other studies point to a similar conclusion (Roa *et al.*, 1997; Olsen and Schaal, 1999).

2.2 Cassava breeding and its achievements

Cassava is an out-breeding species with a diploid chromosonal number of 36 (2n=36). Cassava is an ancient crop species and its domestication began about 5000-7000 years BC (Lathrap; 1970; Gibbons, 1990). Domestication of cassava probably began with the selection for large roots, more erect plant type with less branched growth, and the ability to establish easily from stem cuttings. Breeding in this crop had been largely based on mass selection of bulk segregating population of germplasm originated from collection of plants naturally occurring in the wild. Cassava breeding is more time consuming than for annual seed crops. Evaluation of progeny takes longer as clonal propagation is required before replicated field trials can be conducted. Although plant breeding is difficult in cassava, there is a great need for its application to solve very important biotic constraints such as African Cassava Mosaic Virus (ACMV). There is an urgent need to duplicate the existing cassava germplasm collection in order to reduce the risk of loss of valuable genetic material.

Problems in cassava production, processing and utilization in Sub-saharan Africa had been reported (Asiedu *et al.*, 1992) and Bokanga, 1992). The use biotechnology as an alternative to conventional breeding was emphasized. One of the major breakthroughs in cassava was the successful development of plant regeneration systems of cassava by somatic embryogenesis using zygotic embryos (Stamp and Henshaw, 1982) and immature leaf lobes (Stamp and Henshaw, 1987; Taylor *et al.*, 1993). Rapid progress in gene technology has allowed the isolation, sequencing and characterization of gene(s) encoding key enzymes of cyanogenesis (Hughes *et al.*, 1994), especially enzymes involved in linamarin synthesis such as the cytochrome P-450 oxidase (Koch *et al.*, 1994; Anderson *et al.*, 2000). This is expected to make manipulation of cassava cyanogenesis by genetic transformation possible by down regulation via antisense technology (Koch *et al.*, 1994; Bak *et al.*, 1996). A method using a virus-induced cell death system in transgenic model plants has been tested in cassava (Frey *et al.*, 2001). Specific promoters are being isolated from cassava tissues and could be used in gene construction for cassava transformation to enhance and control gene expression (Puonti-Kaerlas *et al.*, 1996b; Verdaguer *et al.*, 1996; Liddle *et al.*, 1997).

2.3 Environmental conditions for cassava growth

Cassava is a crop of the lowland tropics. It does best in a warm, moist climate where mean atmospheric temperatures range from 25-29 ^{o}C, with a soil temperature of about 30 °C. At a temperature below 10 °C the plant stops growing. The crop grows best in areas with an annual well-distributed rainfall of 1000-1500 mm and can tolerate semi-arid conditions with rainfall as low as 500 mm. The crop have a competitive advantage over other crops under drought conditions. Cassava can grow on a wide range of soils, but is best adapted to well-drained, light-textured, deep soils of intermediate fertility. Under high fertility conditions top biomass growth may be enhanced at the expense of root growth. Optimum soil pH is between 4.5 and 6.5. The crop does not grow well in poorly drained soils, gravelly or saline soils, or in soils with a hardpan (Onwueme and Sinha, 1991). However, when moisture availability is low, the cassava plant ceases growth, and sheds some of its older leaves. This behaviour makes cassava a valuable crop in places where, and at times when, the rainfall is low, or uncertain, or both. It is only during the first few weeks after planting that the cassava is unable to tolerate drought to an appreciable extent. Cassava, when planted early has enough moisture for growth and the roots partly mature into the dry season. When planted late, it often experiences water stress during vegetative and roots development stages and the roots mature within the rainy season.

Water stress has negative effects on root yield. El-Sharkawy *et al.* (1998) reported that early and mid-season stress significantly reduce top and root biomass than late or terminal stress which occur during tuber maturity in cassava. Although it is a drought-tolerant crop, growth and yield are decreased by prolonged dry periods. The reduction in storage root yield depends on the duration of the water deficit and is determined by the sensitivity of a particular growth stage to water stress. The critical period for water-deficit effect in cassava is from 1 to 5 months after planting, which is the stage of root initiation and tuberization. Water deficit during at least 2 months of this period can reduce storage root yield from 32 to 60 % (Connor *et al.*, 1981; Porto *et al.*, 1988).

Leaf area is an important limiting factor often because of water shortage or insufficient mineral supply. So there is need for ecological studies on leaf growth and development or for finding genotypes that are able to produce a more extensive leaf area. Cock (1973), found in one variety that leaf area index can be compensated by raising the plant population as high as 20,000 plants/ha with an associated increase in yield.

Temperature is one of the primary factors controlling the rates of cassava growth and development (Cock, 1985; Osiru *et al.*, 1995). The effects of low temperature on storage root development and on dry matter partitioning of selected cassava were assessed by Akparobi *et al.* (2001). They found that the total dry biomass was less at 25-20 ^{o}C and 20-15 ^{o}C than at the ambient (27 – 32 ^{o}C) temperature. Hunt *et al,* (1977) and Manrique (1990) found that higher temperature increased the total biomass of cassava. The ambient conditions were more efficient in allocating dry matter to roots than low temperature, presumably because in the latter, early growth was drastically reduced and root formation was delayed. The cassava at lowland

Ibadan was found to be more efficient in allocating dry matter to roots than that at mid-altitude Jos, which was consistent with reduced growth of cassava under winter conditions (Cock, 1985; Manrique, 1990; Ekanayake *et al.*, 1997). Leaf growth which is characterized by the number of active apices, rate of leaf formation per apex, leaf size and leaf life is an important process in crop growth and development (Irikura *et al.*, 1979). The few studies on cassava leaf development have concentrated on influence of high temperatures. At higher temperatures (24 ^{o}C to 30 ^{o}C), leaf development in cassava takes two weeks and leaf size, generally increases up to four months after planting, but adverse environmental conditions such as water stress and low temperature reduce leaf size (Osiru *et al.*, 1995). Annual conditions of rainfall, temperature, sunshine and relative humidity influence the growth and yield of cassava. Sunshine or light is the most important growth factor as far as temporal factors of crop growth are concerned (Williams and Joseph, 1970; Willey and Roberts, 1976; Simwambana *et al.,* 1995). Eke-Okoro *et al.,* (1999) found in the study of the effects of weather change and planting set on growth and productivity of cassava in South-Eastern Nigeria that differences in the portion of stem used for planting and annual weather conditions were responsible for differences in growth and productivity in cassava.

Weed is also one of the factors that contribute to yield losses. Research have show serious yield losses due to poor weed management practices. In cassava yield losses of 50-90 percent have been reported (Koch *et al.,* 1990; Chikoye *et al.,* 2001) due to the effects of *I. cylindrical.* Hartemink *et al.,* (2000) reported that timing of weeding were important in influencing root number and storage root yield. Delayed weed control depressed both attributes. The critical period for weed competition was 45 day weeding interval, with six weedings in a 14-month of growing crop. Doll and Piedrahita (1976) observed that the critical period of weed competition with cassava was between 60 and 120 days after planting. And that weeds competing for the first 60 days reduced production by 50 % whereas cassava kept weed-free for the first 60 and 120 days produced 76 to 80 % of the maximum yield respectively.

2.4 Cassava yields as influenced by some field practices

Cassava is often grown under low input and low output production systems, particularly when it is grown as a food crop. In general, poor soils show good response to plant population increases, but in rich soils, response to increases in plant population depends on the growth habits of the varieties. Yield in cassava is governed by both environmental and intrinsic factors. The need for standardizing cultural and management practices in selection trials is emphasized, as this will help to reduce the variability due to the environment. Intrinsic factors are those which result from the physical or genetic endowment of a particular clone while physiological characteristics are governed by the genetic make up of a clone. They are also subject to greater or lesser influence by various environmental factors. Nevertheless, attention to a few simple aspects of fields operations can result in a doubling or tripling of output at low cost. The most important field operation for cassava cultivation are the land preparation, selection and the handling of planting material, planting techniques, weed control and soil conservation systems.

2.4.1 Land preparation

Cassava requires a well-prepared land, loose-textured soil to ensure good establishment and minimize weed competition during the early stages of growth and also to allow for root penetration and enlargement. Land preparation practices vary and depend on climate, soil type, topography, vegetation cover and agronomic systems. In a virgin forest where no mechanization is available, no land preparation is required. Small trees, shrubs, vines and branches of large trees are cut down to allow sunlight penetration. These operations must start at the beginning of the dry season. Trees and bushes are piled and burned at the end of the season. When the first rains soften the ground, the soil is loosened with a hoe, planting stick or sharp instrument so that the cassava stakes can be easily planted. These ideal conditions essentially allowed a non-till soil preparation for cassava planting. Grace (1977) reported that the layer of ashes left after burning increases the amount of potash available to the cassava crop.

Where mechanization is available, many cassava growers plow and disk the land to prepare a good seed bed, aerate the soil and control weeds. Ezumah and Okigbo (1980) pointed out that in the humid and sub-humid climates of West Africa, drainage conditions often determine the type of land preparation required, as well as the site of ridges or mounds and the location of crops on them. In Democratic of Congo for example, there was no yield advantage when ridging was compared with flat or untilled plots whenever the field was mulched (Rodriguez, 1980). In an erosion study, Reining (1992) compared mechanized soil preparation (flat, contour, ridges) with a minimum tillage system, where cassava was planted in an existing grass sod by just loosening the soil with a shovel where stakes were to be inserted. Flat and ridges preparations gave no significant root yield differences over 3 growing seasons, while minimum tillage system yielded less than 30% of that obtained in the other two systems. The higher bulk density of the soil under the grass sod and its quick hardening under dry conditions, together with grass competition, were thought to be responsible for the negative result of minimum tillage which however, minimized soil erosion. A number of other researchers reviewed agreed that in most cases, manual or mechanized soil preparation is preferred and that in areas of high rainfall or heavy soils, good drainage must be provided by preparing ridges, beds or mounds (Toro and Atlee, 1980).

There is evidence that soil preparation intensity can be reduced when sustenable practices that can improve soil structure and drainage such as mulching are implemented. Santos (1967) found that the percentage of sprouting and yields of cassava were significantly influenced by the method of land preparation. The method consisting of plow, harrowing and making furrows before planting gave the highest sprouting percentage and the highest yields (17.6 t/ha), while harrowing – plowing – planting gave a yield of 14.9 t/ha. The method consisting of plowing – planting gave a yield of 15.5 t/ha while that of harrowing – punching – hole gave 10.6 t/ha.

2.4.2 Handling and planting of cassava planting material

Cassava production is dependent on an adequate supply of vegetative propagules or stem cuttings. The multiplication rate of these materials is very low 1:10 in comparison with crops grown from the seed (1:300 for cereals), (IITA, 1990). In addition, cassava planting materials are bulky and highly perishable soon after harvest, unless they are carefully stored. Multiplication and distribution of cassava planting materials are expensive, relative to conventional seed services. The yield stability and environmental development of cassava is highly dependent on the quality of the planting material. However, appropriate criteria for selection and handling of cassava planting material have to be considered. The basic considerations for selection and handling of cassava planting materials are described (Lozano and Terry, 1977; Lozano , 1977). There is evidence that the initial use of healthy cuttings is an important factor in the subsequent attainment of good yields. Visual selection of stems for apparently healthy plant is required. Thus, cuttings with low vigor and which are infested or infected by pests and pathogens often limit cassava production. Also, harvesting at appropriate age before the stems are lignified and are infested or infected by diseases are important for selection of viable planting materials. When the stems become too lignified, decreasing sprouting and the presence of undetected pests and diseases is more likely.

Tools to cut the stem into stakes have to be chosen on the basis of the output of the work. But it is recommended that the cutting machine, machetes, secateur and labourers should be disinfected before and after harvest. The machetes or other tools should be very sharp and disinfected with detergent and water. The discarded vegetative material must be removed from the plot and burned to avoid a condusive environment for pest and disease development. Each wound on the stem is a new site of entry for microorganisms that can cause rot or infection during storage or after planting. So, it is very important to avoid bruising or damaging by friction and machete wound during the cutting, transportation and even planting. To avoid bruises during transportation, it is recommended that cardboard or wooden boxes be used during transportation of stems.

Cutting of the stem should be done transversal, not at an angle. When cut is made at a right angle, perimetral and uniform rooting is obtained (Costa and Normanha, 1939; Toro *et al.*, 1976). Stakes treatments are recommended by Lozano *et al.* (1977) for the production of cassava planting material.

The day of cuttings preparation and planting should be as close as possible, so that high vigour, high percentage emergence and sprouting, of stems can be maintained. However, in cassava growing areas with dry, cool or flooded periods, or also due to logistic difficulties, which made planting not feasible, planting material may have to be stored for several months. During storage, the stems gradually deteriorate leading eventually to a total loss of viability. The quality of planting materials to be stored, storage time and conditions can however retard this deterioration.

According to Leihner, (1984 b), selection of well-developed and well-nourished mature and healthy stems from mother plants, and adequate storage conditions are the first steps towards minimizing detrimental storage effects. Mother plants whose stems are to be stored should have a well-balanced nutritional status to ensure good stand establishment after storage. Stems for storage should be as long as possible and not cut into stakes as this greatly accelerates dehydration.

Wholey (1977) studied the changes during storage of cassava planting material and their effects on regeneration. He found that bud dormancy breaks down within a week or so far after detachment of the stem from the growing plant when the process of regeneration begins. However, the majority of buds are induced into the dormant state once a small number of shoots developed from each section. Loss in weight commences within the first week of storage and both moisture and soluble carbohydrates are important components of this loss. A minimum level of 60% moisture in the stakes has been identified as the threshold for satisfactory preservation of viability (Wholey, 1977; Leihner, 1984 b; 1986). Freshly cut cassava stems consist of living tissue that continues to metabolize during storage, losing most soluble carbohydrates for up to 60 days or more after cutting. (Leihner, 1984b; Oka *et al.*, 1987). This means that valuable reserves are being lost, reducing re-sprouting vigour after planting.

Storing cassava stakes under inadequate condition may lead to a drastic loss in viability even under a short duration. Leihner (1984b) reported a drop in percentage sprouting from 100 to 30 % when short stakes were stored for just 15 days at 24 ^{o}C average temperature, under direct exposure to sunlight. Meanwhile, Leihner (1986) reported that stakes stored as long stems under shady condition with 72% average relative humidity and chemical protection gave over 95% sprouting even after 201 days of storage. The improvement of sprouting was reached by re-hydrating stakes for 4 hours in water nutrient solution. Moses *et al.* (2005) also conducted a study on the effect of storage on cassava planting materials. He found that stored planting materials took longer time to sprout after planting than the fresh materials. The delayed sprouting exposes planting materials to infestation and damage especially during the dry spell. Storing cassava cuttings for long period leads to losses in moisture, carbohydrates and nutrients which have been shown to account for overall reduced plant vigour (Leihner, 1983). Nkunika (1980) reported that most weakened plants were particularly susceptible to infestation and damage.

Extensive research has been carried out on storage conditions (Silva, 1970; Correa and Vieira, 1978; Sales and Leihner, 1980; CIAT, 1980, 1982), making it possible to identify practices that keep cassava-planting materials viable for several weeks. Long stems (50-100 cm) should be treated with fungicides and insecticides before storage and kept in a shady place with high relative humidity (70-80 %) and moderate ambient temperature (20-23 ^{o}C). Excessive heat and direct sun accelerate metabolic activity and dehydration. If longer stem storage is envisaged, stored stems may be buried 5-10 cm in the ground with their bottom end allowing root formation below and sprouting of the apical buds above (Leihner, 2001). Stems stored under these conditions may need watering if condition gets overly dry. However, most parts of the buried end of the stem that rooted or sprouted has to be discarded. The cut stakes are then re-treated chemically before planting to provide extra protection and stimulate rooting and sprouting.

2.4.3 Weed control

Weeds cause considerable losses to farmers because they compete with the cassava crop for nutrients, sunlight, water and space. Weeds may also harbour pests and diseases.

Weed control is an important factor required to in obtain high stem and root yields in cassava. In other annual crops, there are critical periods during which weed competition causes significant yield decline. Until the canopy closure, the earliest growth stages are normally the most susceptible, so that keeping crops weed-free during this period is a pre-condition for high productivity. Doll *et al.* (1982) in a study to determine the duration of the critical period for cassava on a fertile soil at a population density of 10,000 plants /ha observed that weed competition during the first 60 days after planting reduced yields by 50 % while weeding after 120 days did not improve tuber yield. Montaldo (1966) and Delgado and Quevedo (1977) suggest that weeding should commence from 3 weeks after planting (WAP) or latest 4-5 WAP and should be repeated as necessary until canopy closure. Doll *et al*. (1982) found that with hand weedings carried out at 30 to 60 days after planting, 77 % of maximum yield could be recovered at a relatively moderate cost. Doll and Piedrahita (1976) tested a number of herbicides in cassava for selectiveness and effectiveness. They classified 18 products as highly selective and 12 as moderate. The substituted urea (diuron, linuron, fluometuron) were found suitable, being classified as moderately selective for cassava, particularly for effective control of broad- leaf weeds. Leihner (1980) examine the weed control effectiveness of intercropping cassava with common beans. Under good weed-control conditions, intercropped cassava yielded 15 % less than the corresponding sole crop; but when no weed control was practiced, a 44 % greater root yield was observed in intercropped compared to sole cropped cassava. These results confirm the excellent cultural weed control potential of intercropping, particularly under marginal low input conditions. In Lampung, Indonesia, best results were obtained with the application of a mixture of paraquat and diuron (3.75 l/ha) at 30 day after planting (Bangun). Research in Thailand indicated best results with the pre-emergence application of 1.56 kg a.i./ha of metolachlor with or without post-emergence spraying with paraquat (0.5 kg a.i./ha) or with fluazifobbutyl (0.38 kg a.i./ha). This produced similar yields weeding costs as twice cultivation with bullocks followed by spot treatment with paraquat (0.5 kg a.i/ha) (Tirawatsakul *et al.,* 1988). Similarly in South Vietnam best results were obtained with application of pre-emergence metolachlor (2.4 l/ha) (Nguyen Huu Hy *et al.,* 2001). An alternative to paraquat is the application of glyphosate (1.5 kg a.i./ha) for post-emergence control of weed. In all cases, it is recommended to use a shield on the sprayer to prevent damage of cassava plants.

In farming system, weed management is faced with many problems including limited financial resources which reduced the range of technologies available to farmers. The traditional way of combating weeds is to abandon the land for natural fallow (Akobundu *et al*., 1999). During long fallow of more than 10 years, vegetation recovers to forests that shade weeds persisting from the previous cropping phase. Also, the population of viable weed seeds in the soil is reduced over time (Akobundu *et al*., 1999). Several studies have shown that the use of cover crops and selected herbicides can suppress weeds, and reduce the weeding frequency (Udensi *et al*., 1999; Akobundu *et al*., 2000; Chikoye *et al*., 2001; 2002).

2.5 Missing stands in cassava farms

Missing stand is defined as the planted spots with no surviving plant. Cassava farms are planted at specific planting spacing. Once a specific spacing has been adopted for the planting, a definite number of stands is expected in one hectare of field. But this is not always so because of missing stands. Cassava production is constrained by many factors in which may have immediate effect on the establishment of the crop (bad cuttings or use of poor quality stakes, flood or inundation or erosion, uncovered stakes after planting under dry weather, skipping of a stand position during planting operation). Some other factors that may affect the crop after establishment include: mechanical damage (faulty manual hoeing operations that unearth or uproot plants during weeding, destruction during trecking in the farm), environmental damage (flood, drying of the stands and stakes which can be due to shallow planting, lodging, high weed competition that causing smoldering of emerging shoots), pests and diseases attack (CMD, CAD, CBB, CBSD, CGM) and livestock or animal damage (cattle, rodents and termite attack).

Experience on many cassava fields in Nigeria showed that missing stands constitute about 25 to 30 % of the plant population after establishment. Is is imperative therefore to identify the factors causing missing stands on cassava plots. A compensation study has to be carried out to evaluate whether the yield of the available stands has double because of the increase in its rectangularity. A study conducted by Mandal *et al*. (1973) on the effect of plant density, fertility level and shoot number on tuber yield and quality of tapioca hybrids showed that the root yield increased with increase in plant number from one to two plants per hill in non-branching variety. CIAT (1976) reported that optimum plant population per unit area depends on the size of the plant and it was found that total root yield increased as the plant population increased. In a study conducted at CIAT in 1976 on two short and 2 tall varieties with different branching characteristics, planted at 2500 and 40,000 plants/ha and harvested at 12 months, it was found that total root yield increased as the plant population increased.

2.6 Techniques for rapid multiplication of cassava stems

The term rapid multiplication, describes a technique developed to overcome the problem of low multiplication ratios in vegetative propagated crops such as cassava. The multiplication ratio for cassava is 1:10. In contrast, a maize plant which yields a cob with about 300 seeds has a multiplication ratio of 1:300 Thus cassava has a low multiplication ratio compared with maize.

Although cassava plants flower and set seed, germination of the seed is difficult under most conditions and is normally of interest only for research purposes. The use of various tissue culture methods for rapid multiplication of improved cassava clones is a good option because of their very high multiplication ratios. It is, however, often hampered by inadequate number of trained personnel and absence or inadequacy of a unit to immediately execute the multiplication. The method is quite expensive to establish and maintain in a short time, considering the current socio-economic status accorded root vis-à-vis grain crops. Plantlets arising from tissue culture multiplication will be more difficult to handle by most of the target collaborators and pilot farmers that will participate in the program of rapid multiplication. These would also require much more critical training. However, African farmers often keep volunteer plants and have sometimes obtained superior varieties in this way. Cassava is normally propagated by means of stem cuttings, which is satisfactory for commercial production but has the disadvantage that the rate of multiplication is slow, giving only ten- to twenty-fold increase per growing cycle. The number of commercial stakes obtained from a single mother plant in a year ranges from 3 to 30, depending on the growth habit, climate, management and soil conditions (Leihner, 2001). This is considerably less than the propagation rate that can be achieved with other commercial crops that are propagated through true seed or vegetative cuttings. For the rapid increase of elite material, it is desirable to use other methods. A number of rapid multiplication techniques have been developed for this purpose.

Wholey and Cock (1973) reported that by adopting a rapid multiplication technique by repeatedly removing shoot tips from two nodes cuttings, one could get 18,000 plantings cuttings from a single plant of cassava in one year under field conditions. Kamalam *et al.* (1977) developed a simple rapid multiplication method that required minimum facility for adoption. This is the induction of two nodes, one node and half node cuttings from a single cassava stem. They found that the use of half node cuttings was efficient. In one year, 647 plants and 3235 stem cuttings of 20 cm long could be developed from a single plant with two stems. Two to three nodes cuttings, pre-sprouted in polythene bags and planted in the field is also a practical method for stem production (Eke-Okoro *et al.*, 2005). Odero *et al.* (2004) adopted two stem harvests system by ratooning the cassava 6 months after planting to enable the stump to grow for another six months to complete its growth cycle at 12 months. They found that for 1998 to 2004, primary sites have multiplied and distributed over 42 millions stems, enough to establish 4274 hectares of land.

2.7 Effects of Soil Fertility on Cassava Production

Yields of cassava vary with soil fertility status of the land. The Ultisols which covers more than 70 % of the total land in Eastern Nigeria and constitute the major soil for the cultivation of crops, including cassava in most parts of Southeast Nigeria (Mbagwu, 1992). The ultisol is characterized by warm, humid climate, B horizon enriched in clay. Despite the poor fertility attributes of the soil, it is continuously being cultivated without delibrate soil fertily management practices. Technically, the first step to efficient fertility management is farm level soil testing to determine crop nutrient requirement. Few cassava farmers have access to this service and can be reluctant to add fertilizer when the soil nutrient status is unknown (Henri and Hershey, 2001). When cassava is planted on a fertile soil, it removes large amount of nutrients from the soil (K, N, Ca, Mg and P) at the time of harvest at 12 MAP. One major consideration in fertilizer recommendation for cassava is that it has a large requirement for potassium (Obigbesan, 1977; CIAT, 1975). Yields on many soils are apparently limited by a lack of adequate potassium. When the potassium level in the soil is low, the response of the crop to nitrogen or phosphorus fertilizers is poor. In the presence of adequate amounts of potassium, the crop is able to respond to moderate (though not high) levels of nitrogen (Onwueme, 1977). To increase yield potential of cassava, the crop had been reported to respond to good soil fertility and adequate fertilizer (Gomez *et al.*, 1980; Howeler, 1996).

Villamayor *et al.* (1992) reported that no significant yield differences due to N, P or K application were observed during the first year (1989-1990) of the long-term fertility trial, but that cultivar VC-1 yielded significantly more than Golden Yellow. Evangelio *et al.* (1995) reported significant differences in yield due to fertilizer levels in the second year until the fourth cropping cycles. The main responses were to K and N application. Cassava yields decreased by about 50 % in the second cropping cycle, but with fertilizer application, yields increased again in the third and the fourth year. Farmers do not fertilize cassava because they are contented with the minimal yields obtained from using limited inputs or even from their infertile soils. The indifference towards low productivity can probably be attributed to the low and unstable prices of cassava roots. However, fertilizer requirement for optimum yield in cassava is determined by the soil fertility status of the farmland, cropping system adopted and the rainfall pattern during the growing season. The major nutrients required by cassava for optimum top growth and root yields are nitrogen (N) and potassium (K), (Obigbesan and Fayemi, 1976; Howeler, 1991). Soils that have low N (<0.10 % total N) and K (<0.15 meq/100 g) will require an additional fertilizer for optimum tuber yield (Kang and Okeke, 1984). Adequate K level in soil stimulate response to N fertilizers but excess amount of both nutrients leads to luxuriant growth at the expense of storage root formation (Rao *et al.,* 1986, Onwueme and Charles, 1994).

Cassava removed substantial amounts of nutrients with the harvested root, the highest being K, followed by N, Ca, Mg and P (Obigbesan, 1977; CIAT, 1982; Pellet and El Sharkawy, 1993). CIAT (1982), in Palmer showed that the variety: M Col 1684 removed a total of 294 Kg N, 34.4 kg P and 302kg K per ha. Without application of fertilizers, soil nutrients are depleted. Yield depressions have been reported in many cases under cassava-based cropping systems (Ikeorgu, 1984; Ambe *et al.*, 1988). Decline in soil fertility is especially serious in tropical regions where the soil lacks adequate plant nutrients and organic matter due to leaching and erosion of top soil by intensive rainfall (Gutteridge and Shelton, 1994). Organic inputs which are often proposed as alternatives to expensive inorganic fertilizers cannot meet crop nutrients demand for large scale production because of their relatively lower nutrient composition; high application rates, high labour requirements and limited availability (Palm *et al.*, 1997).

Cropping systems has influence on fertilizer requirements of cassava. The continuous cropping of cassava leads to fast depletion of major nutrients especially N and K and will require fertilizer supplement to give stable yield (Kang and Okeke, 1994). Farmers seldom cultivate cassava continuously on the same land in South-Western Nigeria, but plant yam as the first crop after a two or three year fallow. Yam is then followed by cassava or maize as s second crop. Yam and cassava extract large amount of soil N and K for top and root development, (Kayode, 1985; Odurukwe, 1986; Norman *et al.,* 1995). Agbaje and Akinlosotu (2004) in a study to evaluate the yield performance of some new cassava varieties to fertilizer when planted late or early found that fertilizer effects on tuber yield was not significant in early-planted cassava. In late-planted cassava, significant reduction in yields was observed from the application of 400 and 800 kg/ha of fertilizer. Incidence of rot was attributed to varietal differences rather than fertilizer rates.

The combined use of organic and inorganic fertilizers will reduce losses by converting inorganic N into organic forms (Kramer *et al.,* 2002). It also reduces the environmental problems that may arise from the use of sole inorganic fertilizers and improves the microbial properties of the soil (Belay *et al.*, 2001). There are evidences from field research that high sustainable yields are possible with integrated use of fertilizers and manure (Raman *et al.*, 1996; Singh, *et al.*, 1999; Bahu *et al.*, 2006). A study conducted to investigate the effects of fertilizer type on the growth and the yield of the cassava in Southwestern of Nigeria show that cassava yields were statistically similar under inorganic and organic fertilizer treatments (Ayoola and Makinde, 2007). Inorganic fertilizer gave an average yield of 11.8 t/ha which was comparable to 11.0 t/ha given by a mixture of inorganic and organic fertilizers.

2.8 Spacing and plant population in cassava fields

Plant population in cassava production depends on variety, soil fertility status, cultural practice and production objective. All these factors accounted for the wide yield variation obtained from different countries and ecological zones within countries. Calderón (1972) working with two varieties in a fertile soil at population from 10,000 to 30,000 plants/ha found that yield increased with population in one of the varieties.

The influence of cropping systems in the traditional agriculture reduced the population of cassava by 50 to 70% depending on the complexity of the intercrop combination. The intercrop can vary from a combination of two to five crops (yams, maize, melons and okra) within the growing season. In such a case, the distance between cassava plants will depend on how much of other intercrops are. Distances between 2-4 m between cassava plants are quite common. It requires some understanding of intercropping and shifting cultivation to appreciate the disadvantage in spacing cassava so widely among the other intercrops. In traditional agriculture, cassava is only rarely grown by itself. When it is, spacing of 80 cm x 100 cm between plants is used.

In a survey dealing with cassava research by 37 Institutions in 11 South and Central American countries, Leihner and Castro (1979) found that sole-cropped cassava is planted at an average density of 11,300 plants/ha, intercropped cassava at a lower density of 8900 plants/ha. In practice, cassava is planted at a time when other intercrops are almost ready for harvesting. Even if the cassava is planted at the same time as the other crops, it invariably out lasts them in the field because of its long growing season. Therefore, the other intercrop components harvested earlier leaving the cassava as the sole crop in the field. Cassava therefore spends the first part of its field life as an intercrop and the second part as a pure stand. While it is an intercrop, the wide spacing of the cassava does not seem to matter, because the intervening spacings are fully occupied. However, when the other crops are harvested, the cassava is unable to spread across the intervening spaces, which are eventually invaded by weeds. Unfortunately, the farmer is so busy harvesting and processing the other crops that he has little time to weed the cassava plot.

Indeed, if the cassava spacing had not been so wide, as it is in ordinary pure stands, weeding would not have been necessary after the first two months. In the widely spaced, intercropped cassava is therefore unable to close canopy and is competes with weeds for the rest of its field life, which may extend a year or more after the other intercrops have been harvested. In this case, yield will definitely be negatively affected. To avoid this type of problem, it is therefore advice that, cassava should be planted as closer as possible or when other intercrops are ready for harvest. Mandal *et al.* (1973) at the Central Crops Research Institute found that the highest root yield was obtained at 12,345 plants/ha for a branched variety and 17,777 plants/ha for a non-branched variety during a 2-year study. Consequently, the requirement of spacing for different types of varieties was ascertained. He also found that with increases in shoot numbers from one to two shoots per plant, root yield increased significantly in both branched and non-branched types.

Considering the production objectives, when root production is the sole aim, densities around 10,000 plants/ha are normally adequate for producing a large number of commercial size roots, which are preferred for fresh consumption. In cases where root size is of no concern, higher planting densities can be used, resulting in a higher total production of small roots. For a combined objective of root and stem production, planting densities at around 20,000 plants/ha are adequate. But when stake production is the sole objective, densities up to 40,000 plants/ha is optimal (Leihner, 1984a). Many authors report that for most cassava genotypes, no significant commercial root yield increased are to be obtained with planting density much greater than 10,000 plants/ha (Tardieu and Fauche, 1961, CIAT, 1977, Castro *et al.*, 1978). When soil fertility status is been taken into consideration, higher populations up to 20,000 plants/ha are recommended when less vigorous genotypes are grown under low fertility soil conditions (Mattos *et al.*, 1973).

Earlier experiments showed that optimum plant populations vary between ecological zones (CIAT, 1973). Also in poor soils, increased population density affected final yield significantly while it does not in rich soils. Silva (1970) reported an optimum population 16,666 to 20,000 plants/ha in soils of good fertility. A population of 16,666 to 20,000 plants/ha in low fertility soils was recommended in Brazil (Normauha and Pereira, 1963; Nunes *et al.,* 1976) even if plants are fertilized and 13,888 plants/ha in fertile soils due to the more vigorous growth in this type of soil. Drumond (1954) found that the best population was 20,000 plants/ha. Santos *et al.* (1972) recommended 10,412 plants/ha for the State of Pernambuco. He also indicated that for the poor soils of the Northeast, 20,000 plants/ha is recommended in contrast with 13,888 for the good fertile soils of the same region. Albuquerque (1970) has recommended after many years of cassava research 10,000 plants/ha for the low fertile soil, 17,777 plants/ha for soils of fertility below average and 4,473 plants/ha for the fertile soils.

Narasimhan and Arjunan (1976) found that by using wider spacing in cassava at 12,345 plants/ha, they could minimize incidence of mosaic. It has been observed that as plant population increases, the total root yield also increases, however, the number of roots per plant, root size and harvest index decrease, while weed control by competition improves. CIAT (1973) with a systematic fan design planted 3 varieties at populations ranging from 2,000 to 80,000 plants/ha. At the seventh month harvest, variety CMC-84 gives the highest yield (18 t/ha) at populations of between 5,000 and 9,000 plants/ha, whereas CMC-49 produced its highest yield (18 t/ha) at between 2,000 and 5,000 plants/ha. The variety Lianera yielded 24 t/ha between 3,000 and 7,000 plants/ha, so it seems that optimum plant density in cassava changes with varieties. The yield decreases at populations larger than optimum because of the weight reduction in roots. Rodriguez *et al*. (1966) recommended much higher populations 13,300 to 20,000 plants/ha. Gurnah (1973) obtained the best root yield at populations of 18,500 plants/ha planted at 60 x 60 cm and observed that spacing above or below 60cm reduced root yield in the forest zone of Ghana. His optimum spacing of 60cm was closer than that of 90cm generally recommended in Ghana (Doku 1969). Takyi (1972) observed that spacing of 90 x 90 cm and 90 x 60 cm on sandy loam in ochrosol at Kwadaso, Ghana, gave significantly higher yield than spacing of 90 cm x 120 cm, but there were few large roots with the closer spacings. Enyi (1970, 1972) used 90 x 120 cm in experiments in cassava in Sierra Leone, but Godfrey-Sam-Aggrey and Bundu (1972) spaced at 120 cm x 120 cm in Sierra Leone. Godfrey-Sam-Aggrey (1978) using a multi-shooted variety in upland soils of Sierra Leone found that increasing plant population to more than 7,000 plants/ha decreased all parameters studied except top/root weight ratio, which increased. The observed effects were attributed to competition for environmental resources, because area of land/plant unit decrease as plant population increased, (Ajoc, 1976; Secreto, 1981; Villamayor and Destriza, 1982).

Caliboso, (1981) did not find any differences in marketable root yield among spacing of 100 x 50 cm, 100 cm x 75 cm and 100 cm x 100 cm, but the trend is in favour of closer spacing. On the other hand, Occiano (1980) and Bansil (1980) found that 75 cm x 75 cm spacing was better than 75 cm x 50 cm or 75 cm x 30 cm or 75 cm x 25 cm spacing. Higher yield was also obtained at 100 cm x 75 cm than at closer spacing of 100 cm x 60 cm, 100cm x 50cm and 100cm x 40cm (Retis and Cerrudo, 1976). Espinas (1979) found 100 cm x 75 cm to have the highest yield compared with 100 cm x 50 cm, 100 cm x 100 cm and 100 cm x 125 cm. The conflicting results are probably due to the differences in variety, soil fertility and climatic conditions. For example, Villamayor and Apilar (1981) found that the yield of Golden Yellow, a short-stature variety was not affected by the population density while the yield of Kadabao variety, a tall-stature one was reduced at a higher population. Studies on plant density and yields conflict both among and within countries. These conditions influence cassava yields, recommendations on plant populations for one variety in a particular environment may not be appropriate else where or with a different variety of cassava.

2.9 Estimating cassava stem yield in a uniformity trial

Uniformity trial involves growing a single crop variety on a field with uniform conditions, that is applying all cultural and management practices as uniformly as possible. All sources of variation except that due to native soil differences are kept constant. At the time of harvest, the planted area is subdivided into small units of the same size and shape (generally referred to as basic units) from which separate measurements of productivity, such as grain yield, are made. Yield differences between these basic units are taken, as a measure of the area's soil heterogeneity. In other words, the produce from each unit is recorded separately. The size of the basic unit is governed mostly by available resources. The smaller the basic units, the more detailed is the measurement of soil heterogeneity (Gomez and Gomez, 1984)

2.10 Some uses of uniformity trial data for management of trials

The usefulness of a uniformity trial lies in the fact that neighbouring units may be amalgamated to form larger plots of various sizes and shapes. The variation in yield over the field due to soil heterogeneity, slight differences in the distribution of manures, errors in weighing and so on, may be calculated for each type of plot formed. The most obvious use of the data is to provide information on the optimum size and shape of plot. In such studies, once the optimum size and shape have been determined, the standard error per plot and the number of replications required to reach a given degree of accuracy in the comparison of the mean treatment yields are also of interest. This type of information is not peculiar to uniformity trial data, but is supplied by every properly designed replicated experiment for the particular type of plot used.

Smith (1938) studied uniformity trial data on shape of plot and derives from them an empirical relation of wide applicability between variance per plot and size of plot.

Uniformity trials can also be used to compare the relative efficiencies of different types of experimental design, and in particular to test whether any newly proposed design seems suitable for a certain crop. Yates (1964), tested the efficiency of a method of arranging variety trials on Parker and Batchelor's uniformity data with oranges. If a trial is intended to provide information on the optimum size and shape of plot as most of the trials are, the smallest unit harvested requires to be somehow smaller than the size of plot likely to be used in practice, so that various shapes of plots may be obtained by amalgamation. In consequence, many trials contain only a few plots of the size which is finally recommended.

The further question whether differences is soil heterogeneity from plot to plot in a field persist year after year is obviously of practical importance. Several trials have been conducted on the same site for a number of years, some with the same crop, for example the trials on Ragi discussed by Lehmann and some with varying crops such as Huntley uniform copping experiment. As a rule, the yields of the same plot in successive years have been found to be positively correlated, whether the same crop followed or a different crop, but the closeness of the correlation has varied considerably. The question on how to adjust the yields of the final experiment for differences shown in the uniformity trial at first caused some difficulty. The analysis of covariance however provides a mean of correction free from any element of arbitrariness, and gave a stimulus to studies on the value of a uniformity trial as a preliminary to field experimentation. With annual agricultural crops, uniformity trials have not in general doubled the precision of subsequent field trials, whereas they entail approximately double the labour of a field trial with no previous uniformity trial, and a year's delay in the experimental results. With perennial plants, such as rubber for example, where each plot consists of the same trees or bushes year after year, the gain in precision is decidedly higher, and preliminary records may often be obtained without much extra labour, or may indeed be part of a standard observational programme. The case for a preliminary uniformity trial is then considerably stronger.

Uniformity trial data have also occasionally been used as a check on the applicability to field experiments of the analysis of variance and the tests of significance based on it. A preliminary requirement for the application of the analysis of variance to be possible is that, the experimental design used should be chosen at random from a set of designs such that, in the absence of any treatment effect, the average treatment mean square over the set should be equal the average error mean square. The repeated use of the same design, however excellent in itself, is condemned on these grounds, and Tedin (1931) has estimated the bias in the Knut Vik Square from a set of uniformity trial data. Results from Eden and Yates (1933) who worked on the uniformity trial show how good an approximation to the tabulated Z distribution is generated by the process of randomization. Large number of uniformity trials has been carried out to testify that uniformity trial data play an important part in modern research on field technique.

2.10.1 Some methods for soil fertility variation and plot size in uniformity trials

Soil fertility contour map: It is a simple but informative representation of soil heterogeneity. The map describes graphically the productivity level by taking the moving averages of yields of units plot and demarcating the regions of same fertility by considering those areas, which have yields of same magnitude. This method of describing variation in fertility has been adopted by large number of workers in India.

Maximum curvature method: In this method basic units of uniformity trials are combined to form new units. The new units are formed by combining columns, rows or both. This combination must be done in such a way that no column or row is left out. For each set of units the coefficient of variation (CV) is computed. A curve is plotted by taking the plot size (in terms of basic units) on X-axis and the CV values on the Y-axis of graph sheet. The point at which the curve takes a turn that is the point of maximum curvature is located by inspection. The value corresponding to the point of maximum curvature will be optimum plot size. Harris (1915, 1920) has shown that adjacent areas are correlated; as such the hypothesis of no correlation is not tenable. He utilizes these criteria for subdividing the field into uniform areas, and suggests the intra-class correlation as a measure of heterogeneity. If this correlation coefficient is in the neighborhood of zero, then the field could be considered as homogeneous field and whatever plot size is adopted, it will not lead to a large experimental error. But these correlation coefficients do not give any idea of plot size.

Smith's index of soil heterogeneity: This index is used to derive optimum plot size and it gives a single value as a quantitative measure of soil heterogeneity in an area. The value of the index indicates the degree of correlation between adjacent experimental plots and it varies between unity and zero. The larger the value of the index the lower is the correlation between adjacent plots, indicating that fertile spots are distributed randomly or in patches. Smith (1938) gave an empirical relation between variance and plot size. He developed an empirical model representing the relationship between plot size and variance of mean per plot. The model is given by the equation:

$$V_x = \frac{V_1}{x^b} \quad \text{or } \log V_x = \log V_1 - b \log x$$

Where x is the number of basic units in a plot, V_x the variance of mean per plot of x units, V_1 is the variance of mean per plot of one unit and b is the characteristics of soil and measure of correlation among contiguous units.

If b = 0, the x units are perfectly correlated and $V_x = V_1$. So there is no gain due to the larger size of plot. Larger area for the purpose of experiment will be used. The values of V_1 and b are determined by the principle of Least Squares.

In summary, uniformity trials, in which no differential treatments are applied, can be used for the following purposes:

- to study the distribution of plot yields with a view to knowing whether the distribution is normal or not.
- to indicate the variability as measured by standard error or coefficient of variation, to be expected for a particular crop in future work.
- to enable values of future yields to be adjusted for initial differences in soil productivity, where each plot has been used for experiments lasting for some years.
- to determine the "best" size and shape of plots when there is blocking, using best in the sense of economy and precision
- to compare different designs for their economic and statistical efficiency.

2.11 Cassava yields as influenced by quality of planting material

Good quality planting material contributes significantly in the determination of root and stem yields. The quality of cassava planting material depends on stem age, thickness, number of nodes per cutting and the size of the stake.

2.11.1 Age of stem cutting

The age of the stem cuttings has a profound influence on the root yield. In other words, the part of the stem from which the cutting is taken has influence on the yield expected from it. The most suitable age of stem cutting has not been determined, but research showed that plantable standard stakes can be obtained from 6 to 18 months after planting (MAP). It is also well known that cuttings from green stems (slightly lignified) will sprout, and can be used for rapid or extra-rapid multiplication of stem. However, they are susceptible to attack by soil borne pathogens as well as by sucking insects. Also, immature herbaceous (green) stem cuttings cannot be stored for more than 2 to 3 days since they have high water content and tend to dehydrate rapidly. They are also very susceptible to many microorganisms (bacteria and fungi) attack since they are very succulent causing severe rot shortly after planting (Eke-Okoro, 2001). It is recommended that planting materials be taken from plants ranging from 8 to 18 MAP. When plants are more than 18 months old, the stems become woody and highly lignified. These stems will contain only small amount of food reserves for the shoots that will sprout from the buds. In this case germinating bud would have reduced viability; present delayed sprouting, and or produce shoot with little vigor. When dealing with younger plant, the part of the stem selected for the cutting should be more lignified. Older stems may also have suffered a greater number of lesions caused by localized pathogens or insects. It is also more difficult to prepare the cutting from older stems.

2.11.2 The diameter of the stem cutting

A practical way of knowing whether a stem is sufficiently mature is to determine the relationship between the diameter of the pith and the stem cutting in a transversal cut. If the diameter of the pith is equal to or less than 50 % of the diameter of the stem, it is sufficiently mature to be used for planting (Lozano *et al.*, 1977).

As a compromise, it is recommended that cuttings should be taken from the middle of the stem where the tissues are relatively mature and likely to be free of mosaic virus. If because of scarcity of planting material, cuttings from tender stem parts are to be used, then, they should first be rooted under ideal condition in a nursery before being transferred to the field. As for the thickness of the stem, it is proportional to the quality of the stem, but not to the pith of the cutting. Any part of the cassava stem can be used as planting material in a commercial operation, but when using thin stems, the germination percentage will be very low and this will drastically affect the plant population which will also affect the stem and root yields. So it is better to avoid thin stems, which have fewer nutrients reserves, and can produce only a few small swollen roots. Depending on variety, tiny stems may be a characteristic of a variety; this will not be compared to the thick stems. It is recommended that the thickness of the stems used for cuttings should not be less than one half the diameter of the thickest part of the stem of the particular variety being used. Neri (1966), found a positive correlation between circumference and yield; the highest yield at 9.5 to 10 cm stem circumference and the lowest at 5.0 cm. Keating and Evanson (1981) found no significant difference in root yield among three diameter sizes used but there was a decline in general plant vigor which is associated with the use of stem cutting from upper regions of the plant. However, stems are thin not because of poor growing conditions, but because of cultural practices such as high density planting, in which case the stems may be thin, but their performance is not affected also, the standard stem thickness is 25mm (Villamayor, 1983 b).

2.11.3 Weight of stem cutting

The influence of weight of stem cutting planted on subsequent cassava yield and the stability of yield was assessed by Okeke (1994). He found that the yield of each cultivar for the three growing seasons did not vary significantly, which suggests that sustainable high root yield appears to be achievable and is greatly aided by the appropriate management of the stake. The stem cutting of 25-cm plantable size has at least 5 to 7 nodes. Each stem node has an auxiliary bud and theoretically, each node can generate one plant. It has been found that cuttings with one to three nodes have low percentages of germination under field conditions (Toro *et al.*, 1976), since they are very short and therefore more susceptible to rapid dehydration and pathogens infestation within a very short time. On the other hand, cuttings with few buds have a greater probability of losing the viability of all their buds during their preparation, transportation and planting. Meanwhile, cuttings with more than ten nodes theoretically have a better chance of conserving their viability because of the greater number of buds. When long cuttings are used, much more propagating material per unit of surface area is required and there is also greater possibility that this material will be affected by localized pathogens and insects. In summary, the stem cuttings used should be 20 to 25-cm long and should have from 5 to 7 nodes and it is important to observe this precaution when dealing with cultivars with long internodes. In such cases, even cuttings that may seem normal in length may contain only one or two nodes.

In any production system, size and quality of the stake are of fundamental importance if high yields are expected. The longer the cassava stake used for planting, the greater the yield expected from it (Rodriguez and Sanchez de Bustasmante, 1963; FDAR, 1966; Krochmal, 1969; Silva, 1971; Gurnah, 1974). Both the number and the total weight of tubers realized are increased. As a result, cuttings measuring 40-50 cm give a consistently higher yield than those measuring 15-20 cm. They stated that the greater yield of the longer cutting is probably due to the greater number of nodes from which roots (if they are submerged) or shoots can arise. Also, the longer cutting contains a greater amount of stored food material which the cutting can utilize before it becomes self-sufficient. Indeed, short cuttings reportedly result in a lower percentage sprouting than long cutting and this again contributes to reduced yields per hectare. Even though long cuttings may yield more than shorter ones, practical considerations have dictated the use of shorter cuttings in many cassava growing areas. Long cutting requires a large quantity of planting materials per unit surface area, and this requirement cannot be early met. A cassava plant may be obtained from a very small stake with only one bud, but the possibilities of sprouting under field conditions are very low, under the vagaries of soil moisture (Cock *et al.*, 1976). Celis and Toro, (1974 a, b) reported that the smaller the unburied portion of the stake, the tougher the competition with weeds. When planting long stakes (60 cm long) the plant has higher initial height and hence greater shading of the soil surface, which increases the ability of the cassava plant to compete with weeds. On the other hand a problem may arise when dealing with long stakes, especially if they have to be planted with mechanical planters. Most mechanical planters have been designed to utilize cuttings that are 20 to 30 cm long. Also, if planting has to be done vertically or in inclined position, a disproportionate length of the cutting is left sticking out of the soil, and this can easily be fallen over. Because if the cutting is to be deeply inserted to avoid falling over, rooting and tuber formation will occur at so great a depth that their growth will be impaired and their harvesting will be so difficult.

2.11.4 Length of stem cutting

The length of stakes commonly used by farmers is 15 to 25-cm, which seems appropriate unless a field trial that includes production costs indicates a more convenient size (Toro *et al.*, 1976). It has to be kept in mind that economic aspect as well as practical considerations about handling the stake may affect the size of the propagating material. Several researches have assessed the appropriate size of the planting material to be used. CIAT (1975), working with local varieties in the long stakes planted vertically, obtained the best results with 40 cm stakes without irrigation. Under irrigated condition, CIAT (1979), found 20 cm long stakes as the best stake length. Gonzales (1973) and Rosas (1969), found that 10 cm stakes gave the highest root yield. Silva (1970) reported that 30 cm stakes are superior. Gurnah (1974) found that cassava root yield increased with the number of nodes up to five nodes per stake. An increase in the number of nodes beyond five per stake did not affect the yield. The longer stakes had more buried nodes than did the shorter ones and presumably produced more stems and leaves and subsequently higher yields.

Jeyaseelan (1951) working in Ceylon (Srilanka) with basal and apical stakes, 15 and 30 cm long, and investigating horizontal and vertical planting positions found that best yield were obtained with 30 cm stakes from the basal part planted vertically. Conceição and Sampaio (1973 a), for three years in Bahia, Brazil, used 10, 12, 15, 20 and 30 cm long stakes from twelve month old plants in sandy, clay, loam latosol with 1196 mm of rain and 24 ^{o}C. Stakes were planted horizontally, 10 cm deep. They found that high yields were obtained with 20-25 and 30 cm stakes. Rodriguez and Sanchez (1963), in Misiones Argentina, in a three years study using 30 cm long stakes and two planting positions (inclined and horizontal) and comparing the results with those from 10 cm stakes planted horizontally, found that the 30 cm stakes gave higher yields, as did the inclined position, although the latter made harvesting difficult. Jennings (1970), suggests that long stakes gave higher yields than short ones and recommended 30 and 45 cm long stakes (moderately thick), taken from the basal part of the plant rather than from the terminal parts.

CHAPTER 3

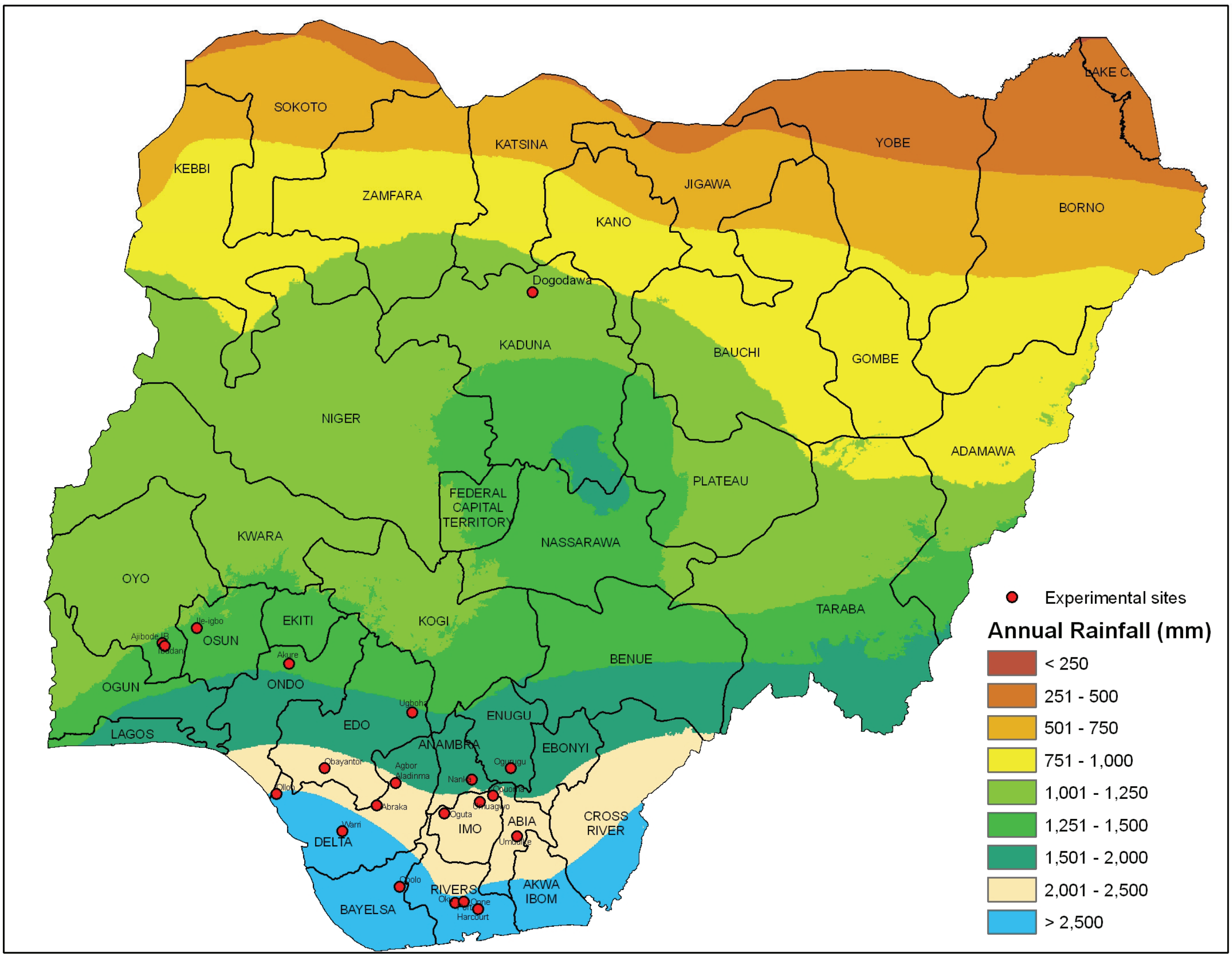
MATERIALS AND METHODS

3. 1 Survey of cassava production system in Southern Nigeria

A survey of levels of missing stands at different growth stages was done in 74 purposively selected cassava farms in 11 States in Southern Nigeria to determine the extent and causes of missing plants in cassava farms. Figure 3.1 shows the map of the locations of the farms visited. Questionnaire was distributed to farmers on visited sites to obtain background information on the farm and the management practices used. A sample of the questionnaire is presented in appendix 1. All the variables observed in the field that influenced the missing stands were described and scored. After obtaining all the information, a thorough assessment of all rows and columns in the farm was undertaking. The numbers of surviving and missing plants per row were counted for each variety. Data were collected at month interval 1 to 12 months after planting (MAP). Data collected were analysed using ANOVA (SAS, 2001) and the descriptive statistics (the mean, standard deviation and the coefficient of variation were calculated). Treatment means with significant differences (P= 0.05) were then compared using DMRT.

3.2 Assessment of stake cutting equipment for cassava stems multiplication

A trial was planted at the Rivers State Institute of Agricultural Research and Training (RIART) annex Onne (4°71'N, 7°09'E) during the 2005/2006 cropping season to: (a) determine the number of plantable stakes per plant for 43 varieties using five cutting tools, (b) evaluate the polarity of the tubers at harvest. The plot was ploughed, harrowed without ridges from 28 to 30 July 2005. Machete was used to cut the planting materials from the field, while secateur, cutlass, hand-held carpenter saw, *okoli*-cutter [2 opposing knives] and motorized-rotary saw were used to cut stems into planting size (20 cm stakes) from 1st to 5th August 2005. Plate 3.1 shows different tools used for the cutting process. Stakes were treated with Basudin 1 % (20 ml of Basudin 1 % into 20 L of water). Stakes were planted on the same day they were cut. Thirty stakes per variety and for each cutting method were planted at inclined direction at about 45 to 60 ^{o}C angle in 3 rows at 100 cm x 50 cm spacing.



Source: Geospatial Unit, International Institute of Tropical Agriculture (IITA), 2009.

Figure 3.1 Map of Nigeria showing the locations visited for the missing stands study.

A mixture of pre-emergence and post- emergence herbicide (200 ml of primextra + 200 ml of gramozone into 20 L of water) was applied from 5th to 8th August 2005. Fertilizer was not applied in the field. The experimental design was split plot with treatments laid out in a Randomized Complete Block Design (RCBD) and replicated twice. The main plots and sub-plots were cutting equipments and varieties respectively. Main plots are plots where the precision of the treatment is sacrified to improve that of the sub-plots. In the sub-plots the precision of the treatment is high. The field layout of the experiment is presented in appendix 2.

At 6 and 12 MAP, the following parameters were measured:

a) Length of stem
b) Stem diameter
c) Number of nodes per stake
d) Root number
e) Root weight
f) Forage weight

The measurement system for the variables studied is shown in table 3.1. Data collected were analyzed using ANOVA statistics.

3.3 Assessment of number of nodes per stake, variety and spacing for stem multiplication.

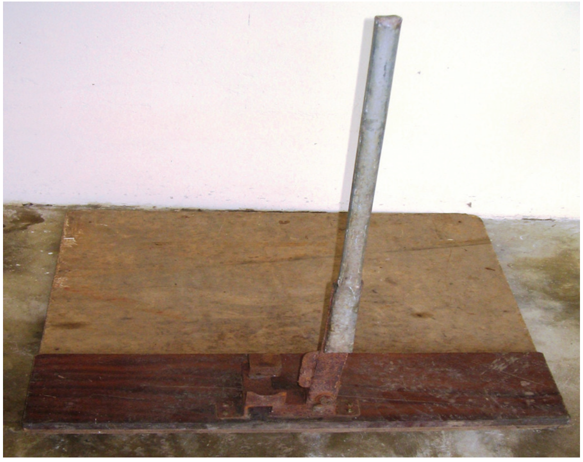
A trial was planted at Block 19 of IITA high rainfall station Onne (4°71'N, 7°09'E), near Port Harcourt during the 2006/2007 cropping season to:

a) assess the effects of : the number of nodes on the sprouting ability of mini-stakes (5-10 cm long) of five cassava varieties and

b) determine the number of plantable stakes obtainable from stems of each variety, when cut at 6 and 12 MAP.

The plot was ploughed and harrowed from 9 to 11 June 2006. Five IITA released cassava varieties (TMS 98/0581, TMS 97/2205, TME 419, TMS 98/0505 and TMS 98/0510) were used. Planting materials were obtained from IITA, Ibadan. Stems were cut into stakes of different number of nodes (2, 3 and 4 nodes-cuttings) and treated with Basudin 1 % (20 ml of Basudin 1 % into 20 L of water). Twenty-two stakes were planted within the rows in a plot. Three spacing combinations were used: 80 cm x 37.5 cm; 80 cm x 50 cm and 100 cm x 50 cm. The layout was a split-split plot experiment in a RCBD with 3 replicates.

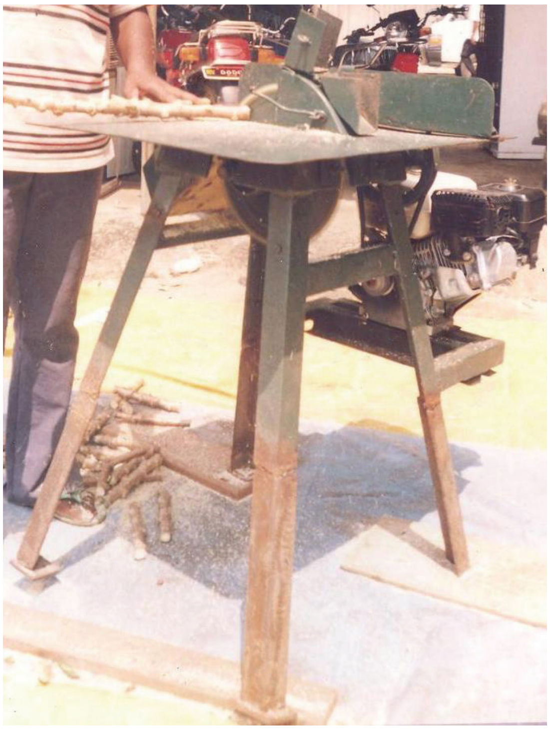
Secateur



Okoli cutter

Hand-held carpenter saw

Matchete/Cutlass



Motorized-rotary saw

Plate 3.1 Tools used to cut the cassava stem into stakes.

Table 3.1 Measurement system for the variables studied.

Variables	Tools for Measurement	Unit	Period of Observation (MAP)
Stem			
Length	Tape rule	cm	6 and 12
Weight	Spring balance	g	6 and 12
Diameter	Veneer calipers	cm	6 and 12
No. of nodes	Counting	number	6 and 12
Roots			
Weight	Spring balance	g	12
Number	Counting	number	12
Size	Tape rule	cm	12

MAP = Month after planting

The main plots were the three spacings, the subplots were the number of node per stake and the sub-subplots were the five varieties. Stakes were planted on flat land by burying horizontally on 16 June 2006. A mixture of pre and post-emergence herbicide (200 ml of primextra + 200 ml of gramozone into 20 L of water) was applied immediately after planting. Fertilizer was not applied in the field. The field layout of the experiment is presented in appendix 3.

The percentage sprouting of each variety was assessed from one to six weeks after planting (WAP). For each variety and each treatment, the number of emerged plants was counted. At 6 MAP (20 January 2007), the number of standard stakes was evaluated in the plot. Four plants per treatment and per variety were considered. For each plant, the total length of the plantable stem for all the stem units was measured at about 3 cm above ground using a tape rule; the diameter was measured using a veneer calipers. At 12 MAP, the number of 25-cm plantable stakes, root and forage yields were measured. All roots were detached from the stumps and weighed. The green portion of the stem including petiole, laminar and top shoot was weighed together as forage. The scale used for the weighing was a 50 kg spring balance. Data collected were analyzed using ANOVA with SAS software package. Means with significant differences were separated using Least Significant Difference (LSD).

3.4 Effect of fertilizers, spacing and variety on cassava productivity in Onne and Ogurugu, Agro- ecologies in Nigeria

Trials were established at: RIART, Onne Rivers State (4°71'N, 7°09'E) which is a humid forest with an annual rainfall of 3016 mm and Ogurugu (6°46'N, 6°55'E), Enugu State which is a Guinea savanna, transition with an annual rainfall of 1700 mm to evaluate the effect of fertilizers on yield (roots, stems and forage) of 5 newly released IITA improved cassava varieties.

The trial at RIART was ploughed and harrowed without ridging between 30 May 2005 and 7 June 2005. Planting materials were cut from IITA fields on 7 June 2005, and cut into planting size. Because of the scarcity of the planting materials, stems were cut into mini-stakes of about six to 10 cm (3–5 nodes) on eight June 2005. Also because of short length of stakes, they were pre-sprouted in a "pre-conditioning room" (45 ^{o}C) for one week (9–17 June 2005) to avoid dehydration. Sprouted materials were removed from the pre-conditioning room on 17 June 2005 and were planted covered on the same day.

Table 3.2 Different plant spacings and their plot sizes used at Onne during the 2006/2007 cropping season.

Row Spacing (cm)	Plant Spacing (cm)	Plot Size (m^2)	Plant Population /ha
100	50	33	20,000
80	50	26.4	25,000
80	37.5	19.8	33,333

At Enugu State, the plot was ploughed and double harrowed without ridges between October 28, and November 1, 2005. Because of the distance between the source of the planting materials (IITA, Onne, Rivers State) and the location of the plot (Ogurugu, Enugu State), planting materials were cut from into 25-cm stakes on 30 October 2005 and were not pre-sprouted. Planting was done at inclined direction in the first week of November 2005. Varieties used were five CMDR varieties (TMS 98/0505; 97/2205; TME 419; 98/0581; 98/0510), one National Check (TMS 30572) and one National Root Crops Research Institute (NRCRI) Umudike resistant variety (NR 8082).

Twelve stem cuttings were planted in each of the 3 rows and the 13 spacing combinations considered by variety (See Table 3.3). One to two MAP (16 August 2005 for RIART plot and on 15 December 2005 for Ogurugu) four types of fertilizers (NPK16:27:10 + AG (DAP: 21 % N + 53 % P: 3.2 kg/10 kg (pre-mixed), NPK 15:15:15, Cotonou fertilizer (NPKSMg 13:9:27:5:4) and the control: no fertilizer) were applied at the rate of 400 kg/ha. The experiment was a split-split plot laid out in a RCBD with three replicates. The main plots were 13 spacing combinations, the sub-plots, 7 varieties and the sub-sub plots 4 types of fertilizers. The field map showing the area (m^2) for each treatment, type of fertilizer and the quantity of nutrient (kg) applied is presented in appendix 4.

At 6 MAP, the standard stakes yield was assessed. Ten plants per treatment were radomly selected and for each plant, the total length of the plantable stem was measured in centimeters using a tape rule and the diameter was measured in centimeters using a veneer calipers.

At 12 MAP in both sites data on number of harvested standard stakes, forage and the root yield were assessed. Data were collected from 3 rows per plot. The plants were separated with a secateur into stem units up to the green-brown point. The total length of the plantable stem was measured in centimeter using a tape rule; the diameter was measured in centimeter using a veneer calipers. The weighing scale was used to measure the stem, forage and root weights after harvest. Data collected were subjected to ANOVA using SAS software. To capture and integrate the response of the cassava to fertilizers at 6 and 12 MAP, there was adoption of a square of the product of 6 and 12 MAP. Means with significant differences were separated using LSD.

3.5 Effects of plant spacing on cassava stems and root yield at Umudike

This experiment had two objectives: (a) to evaluate the effect of plant spacing and area per stand on the cassava root and plantable stem yields and (b) to evaluate the relationship between the *actual* planting spacing [computed from stand geometry data] and cassava yields

The trial was planted at the NRCRI Umudike, Abia State (with annual rainfall of 2200 mm; altitude 120 m; mean annual temperature of 22 to 31 °C; coordinates 5°29' N, 7°24' E. The plot was ploughed and harrowed without ridges from 25 to 29 June 2005. Planting materials were obtained from NRCRI, Umudike and IITA Ibadan.

They were cut into 25-cm stakes with a secateur and planted inclined at about 45 to 60 ^{o}C direction from four to ten July 2005. Varieties planted were: five CMDR varieties (TMS 98/0505; TMS 97/2205; TME 419; TMS 98/0581; TMS 97/0162), one national check (TMS 30572), and one NRCRI Umudike resistant variety (NR 8082). Twelve stem cuttings were planted in each of the 3 rows and 12 spacing combinations considered by variety (Table 3.4). No fertilizer was applied and weeding was done when necessary. The experiment was a split plot laid out in a RCBD with 2 replicates. The main plots were 12 plant spacings and the sub-plots were 7 varieties. The degree of freedom for all treatments was 167 (df = 7 varieties x 12 spacing x 2 reps = 168-1 = 167). Assessment of varieties was done in 24 cases (12 spacings by 2 replicates), while that of spacing was done in 14 cases (7 varieties by 2 replicates).

The field layout of the experiment is shown in appendix 5. At 6 MAP, 17 January 2006 the crop geometry was assessed. For each central row, the distance between each plant at that central row and all its 8 expected neighbors was measured with a tape rule in centimeter to know the real spacing between plants at harvest.

At 12 MAP, the standard stakes, forage and root yields were assessed. Data were collected per plant. Each plant available in each row for all the 3 rows per plot and per variety was harvested. Each plant was cut into stem units up to the green-brown point. The total length of the plantable stem was measured in centimeter using a tape rule. The diameter was measured in centimeter using a veneer calipers, a weighingspring balance was used to measure the stem weight the in grammes while the forage and root weight was measured in grammes using a 50 kg spring balance. Data collected were analyzed using ANOVA with SAS software package. Means with significant differences were separated using LSD.

Table 3.3 Different plot sizes and spacing combination to assess plant population in cassava farms for stem and root production during the 2005/2006 cropping season at Onne and Ogurugu.

Inter-row (r-r) spacing (cm)	Intra-row (p-p) spacing (cm)	Plot Size (m^2)	Area /stands+ (m^2
60	50	10.80	0.30
60	60	12.96	0.36
70	50	12.60	0.35
80	50	14.40	0.40
70	60	15.12	0.42
90	50	16.20	0.45
80	60	17.28	0.48
70	70	17.64	0.49
90	60	19.44	0.54
80	70	20.16	0.56
90	70	22.68	0.63
80	80	23.04	0.64
90	80	25.92	0.72

r-r = row to row spacing; p-p = plant to plant spacing.
Expected treatments: 16; Valid treatments: 13
Spacings: 70 cm x 80 cm; 60 cm x 70 cm; and 60 cm x 80 cm were not considered in the experiment because the spacings within plants are higher than those within rows.
+There were 36 stands/plot.

At 12 MAP, the standard stakes, forage and root yields were assessed. Data were collected per plant. Each plant available in each row for all the 3 rows per plot and per variety was harvested. Each plant was cut into stem units up to the green-brown point. The total length of the plantable stem was measured in centimeter using a tape rule. The diameter was measured in centimeter using a veneer calipers, a weighingspring balance was used to measure the stem weight the in grammes while the forage and root weight was measured in grammes using a 50 kg spring balance. Data collected were analyzed using ANOVA with SAS software package. Means with significant differences were separated using LSD.

3. 6. a Pattern of stakes distribution among 43 CMDR varieties of cassava

Multi-locational trials were planted in 4 locations and 6 sites (Table 3.5) Onne (3 sites), Ibadan (1 site), Akure (1 site) and Zaria (1 site) at 100 cm x 100 cm spacing in a 600 cm x 600 cm plots per variety to: (a) evaluate the characteristics in term of stem distribution of each of the varieties, (b) evaluate the contribution of each stem unit to the total planting materials obtainable from one plant of each variety, and (c) to have a picture of a cassava variety as it is standing in the field. Forty three CMDR varieties were considered. All the fields were laid out in a RCBD with 4 replicates. Stems were treated with Basudin 1 % solution in 20 L of water before planting. No fertilizer was applied. Weeding was done as necessary.

At 12 MAP for each location as specified in the above table, the standard stakes yield obtainable from the plot was measured. A total of 4 plants per variety were assessed for all the 43 varieties planted. Each of the 4 plants were cut at about 3 cm from the ground level, each stem unit was separated from the main stem using secateur. The length of each of the plantable stakes of each stem unit was measured in centimeter using a tape rule. Data collected were used to calculate the mean, standard deviation and the coefficient of variation.

3.6. b Multidimensional analysis for selection of varieties for quality planting materials production.

Multilocational analysis is an analysis that considered many variables often correlated for evaluation. It has to do with checking the variable to variable correlations and remove one variable from each highly correlated pair.

Table 3.4 Different plot sizes and spacing combination for stem production in the 2005/2006 cropping season at Umudike.

Inter-row (r-r) spacing (cm)	Intra-row (p-p) spacing (cm)	Plot Size (m^2)	Area /stands[+] (m^2)
70	50	12.60	0.35
80	50	14.40	0.40
70	60	15.12	0.42
90	50	16.20	0.45
80	60	17.28	0.48
70	70	17.64	0.49
100	50	18.00	0.50
90	60	19.44	0.54
80	70	20.16	0.56
90	70	22.68	0.63
80	80	23.04	0.64
90	80	25.92	0.72

-r = row to row spacing; p-p = plant to plant spacing.
Expected treatments: 16; Valid treatments: 12
Spacings: 100 cm x 80 cm; 100 cm x 70 cm; and 100 cm x 60 cm were not considered in the experiment because the target was to increase the plant density by reducing the plant spacing. While for the spacing 70 cm x 80 cm the spacing within plants was higher that those within rows.
[+]There were 36 stands/plot

Then, consider the ease of practical assessment or measurement of each variable and its correlation coefficient. Finally, compute the relative variation for each variable, pick the most variable ones and select a set of reduced number of variables.

From all the multi-locational trials planted in six locations (Ajibode at Ibadan (DOP: 20th May, 2006), Kate plot (DOP: 3rd March, 2005), Rivers State Institute of Agricultural Research and Training (RIART) (7th June 2005), Demo plot at Onne (DOP: 14th June, 2006), Federal College of Agriculture (FCA) at Akure (DOP: 22th April, 2006) and Dongodawa at Zaria (DOP: 4th August, 2005)) in the south east, south west and north of Nigeria, the number of 25-cm plantable stakes (PS) was assessed. Each of the 4 plants per plot considered was cut into stem units [main stem, primary, secondary, tertiary and other branches] up to the green-brown point. The total length of the plantable stem was measured in centimeter using a tape rule. The number of nodes per 25-cm PS was counted. A 5 kg electronic balance was used to measure the weight of each of the 25-cm PS while a veneer caliper was used to measure its diameter. All roots were counted and weighed using a 50 kg weighing scale. The forage components (leave, top shoot, substandard stems) were collected and weighed using the same 50 kg weighing scale. Data collected were analyzed using descriptive statistics (The mean, standard deviation and the coefficient of variation were calculated).

Multi-Dimensional Analysis (MDA) was used to select varieties that had ability to production high quality planting materials. Only varieties that had their MDA indices greater than that of the mean of the 43 CMDR varieties, and cut across at least four out of the six locations were selected.

3.7 Assessment of stem yield in trial plot with micro-variability in soil environment using uniformity trial

A trial was established in two locations using two varieties, one per location. One in the University of Ibadan campus (TME 7) and one at the International Institute of Tropical Agriculture (IITA), Ibadan (TMS 30572) to: (a) evaluate the differences in yields of cassava planted from same variety, similar stake materials in term of position along the stem and (b) assess the heterogeneity or lack of similarity of soil across the planted portions of the field.

The first plot located at Parry Road had a total area of 0.31 ha (96 m x 32 m). The plot was an 8 year fallow land. Slashing and spot burning were done in the field from

22 to 28 March 2007. Chainsaw was used to fall down trees in the plot on 19 April 2007. Condemned motor tyres were used to burn stumps after the trees have been carried out of the field. This operation was done from 24 April to 27 May 2006. It was a continuous operation because big stumps were burned at least three times to allow quick and easy decay. Manual labors were used to heap the field at 100 cm x 100 cm spacing from 25 April to 23 May 2007.

The planting material was purchased from one of the IITA's contact farmer at Moniya, Ibadan. They were cut from the field on 23 May 2006, cut into 25-cm long on 24 May 2007, and planted on 25 May 2007. The other location was B11b of the IITA Ibadan farm layout (147 m x 20 m). Planting materials was from IITA Ibadan cassava fields. Cutting from the fields was done from 15 to 17 July 2007, were cut into 25-cm long and planted from 18 to 19 July 2007, respectively.

All planting materials were treated with 1 % Basudin (20 ml of Basudin 1 % in 20 L of water) and planted at inclined direction at about 45 to 60 ^{o}C. All stakes were properly numbered from the base of the stem to the top and planted according to their numbers. The plot was subdivided into small units of 100 cm by 100 cm each. The field layout of the experiment is shown in appendix 6. Weeding was done as necessary. For all the locations, the management practices were applied uniformly.

At 6 MAP, specifically on the 29 November 2008 for Parry Road plot and from 28 to 30 January 2008 for IITA plots, a tape rule was used to measure the total plantable stem length for each plant. The basic unit of 100 cm x 100 cm was considered separately from which the yield of the standard stakes was calculated. At 12 MAP, (9th June 2008 for Parry Road plot University of Ibadan and 17–25 August 2008 for IITA plot), the final harvesting was done. A tape rule was used to measure the total plantable stem length for each plant. The green portion of the stem was cut from the plantable part of the stem. The laminar was also separate from the petiole. An electronic weighing balance was used to measure the weight of the stem, stump, forage, laminar and tuber for each plant. Estimation of missing data from missing plant was done using the nearest neighbor analysis method.

Table 3.5 Different locations and date of planting and harvest of the multi-locational trials for the stem quality assessment during the 2006-2007 cassava cropping season.

Location	Latitude /Longitude	Date of planting	Date of harvest	Crop growth period (MWD)
Akan Kate plot, Onne	4°71'N/7°09'E	3 March 2005	7 March 2006	12M1W
Demo plot B22, Onne	4°71'N/7°09'E	14 June 2005	13 June 2006	12M
MLT plot B18, Onne	4°71'N/7°09'E	11 May 2005	17 July 2006	13M1W
FCA, Akure	7°96'N/8°76'E	22 April 2005	25 July 2006	15M3D
Ajibode, Ibadan	6°85'N/2°80'E	20 May 2006	21 June 2007	13M1D
Zaria, Dogodawa	9°16'N/8°26'E	4 August 2005	17 August 2006	12M2W

M = Months; W = Weeks; D = Days

CHAPTER 4

RESULTS

4.1 .1 Missing stands survey in cassava farms

The mean percentage missing stands per site and per variety in 74 cassava fields is presented in appendix 7.1, while the summary table is given in table 4.1. The percentage missing stands varied from 18.6 to 32.6 %, with a mean of 25.6 % and a standard variation of 3.0 %. Varieties that had the percentage missing stands above the average are TMS 98/0510 (32.6 %), TMS 4(2)1425 (29.6 %), TMS 94/0026 (28.3 %), TMS 30572 (27.9 %), NR 8082 (27.1 %) TMS 97/0162 (25.9 %) and TMS 92/0325 (25.8 %). Variety TMS 97/2205 had the lowest percentage missing stands (18.6 %). There was high variation in percentage missing stands at Oku farm (CV = 106.3 %), blocks 8E (101.3 %) and 15A (113.1 %), 9B (104.6 %), Onne Rivers State as well as in Opolo farm (118.9 %), Bayelsa State. Varieties that also showed high variation in percentage missing stands were TMS 96/1569 (109.9 %) and TMS 97/2205 (101.0 %).

The distribution of the frequency of missing cassava stands in 74 farms across 45 varieties is presented in figure 4.1. About 78 % of the 45 varieties studied had a percentage missing stands less than 26 % which is the mean across all varieties. About 4.4 % of the 45 varieties had a percentage missing stands above 30 %.

The description of the intensity of status of the variables studied during the assessment of missing stands in cassava fields and their scores are showed in appendices 7.2 and 7.3.

4.1.2 Correlation and path analysis

The correlation coefficients for all the feasible comparisons are presented in table 4.2. The correlation between days from cutting the cassava stems to planting (DCP) was positive and highly significant ($r = 0.62$) to the number of missing stands. The longer the period from cutting the stems to planting; the more the missing stands.

Table 4.1 Mean percentage of missing cassava stands in 74 farms during the 2006/2007 cropping season in Southwest and Southeast of Nigeria.

S/N	Varieties	Mean (%) missing stands	Total No. of plants observed	Minimum (%)	Maximum (%)	Std. (%)	CV (%)	% of 74 farms with this clone
1	98/0510	32.56	17534	6.64	82.64	19.75	60.65	44.59
2	4(2)1425	29.64	8459	4.88	91.25	23.19	78.25	29.73
3	94/0026	28.31	15481	2.78	74.08	17.52	61.87	48.65
4	30572	27.92	39587	2.78	77.68	18.03	64.59	59.46
5	NR8083	27.05	2109	19.00	40.03	9.87	36.48	5.41
6	97/0162	25.94	15324	2.08	79.86	18.92	72.92	43.24
7	92/0325	25.76	17250	3.47	89.58	16.47	63.96	43.24
8	99/2123	25.47	9979	3.85	68.75	17.41	68.37	33.78
9	NR8082	25.29	10236	10.36	42.64	9.47	37.44	13.51
10	98/0002	25.17	13122	1.39	84.72	19.49	77.44	45.95
11	92/0057	24.74	22433	1.97	94.44	20.02	80.93	58.11
12	92/0326	24.73	16155	2.08	66.67	15.56	62.94	51.35
13	97/4769	24.24	11204	2.78	81.25	18.47	76.19	32.43
14	98/0581	24.22	21985	0.00	90.97	18.15	74.95	52.70
15	99/3073	24.20	10881	0.69	73.61	15.89	65.65	28.38
16	98/2101	24.08	15369	1.39	85.42	18.23	75.73	54.05
17	92/0067	23.77	13610	1.85	85.42	16.95	71.30	47.30
18	96/1642	23.76	16808	1.39	88.19	17.18	72.27	45.95
19	95/0166	23.70	18607	2.78	68.75	16.37	69.10	45.95
20	99/6012	23.49	6216	1.25	83.33	17.62	75.02	31.08
21	97/4779	23.47	17078	1.39	88.89	21.77	92.78	43.24
22	98/0505	23.31	22291	5.21	91.67	16.29	69.88	51.35
23	TME419	22.97	35550	1.78	86.81	15.82	68.86	63.51
24	97/0211	22.77	9308	2.78	95.83	19.97	87.68	36.49
25	96/1632	22.66	10754	1.85	93.06	21.70	95.78	39.19
26	92B/00061	22.60	10337	1.39	74.31	16.07	71.10	44.59
27	96/0603	22.54	11355	3.47	60.94	15.22	67.52	43.24
28	97/3200	21.51	18004	1.45	87.50	20.21	93.99	43.24
29	M98/0068	21.45	9174	0.80	88.89	18.90	88.10	31.08
30	96/1089A	21.21	11876	0.00	94.44	19.91	93.87	39.19
31	91/02324	21.03	14830	0.00	66.67	15.67	74.53	55.41
32	M98/0040	20.90	10683	0.00	58.33	14.19	67.86	33.78
33	95/0289	20.84	10016	1.85	72.22	15.45	74.14	41.89
34	95/0379	20.75	7804	0.00	70.39	18.45	88.91	36.49
35	98/2226	20.56	16618	1.14	51.39	13.94	67.80	41.89
36	82/00058	20.23	8026	1.39	58.93	17.75	87.74	25.68
37	96/1565	20.17	6760	0.00	84.72	19.07	94.52	29.73
38	94/0561	20.12	17071	0.00	90.28	16.11	80.06	45.95
39	96/1569	20.03	5993	1.85	94.44	22.03	109.98	31.08
40	96/0523	20.00	11107	0.00	84.03	18.44	92.20	39.19
41	94/0039	19.97	17675	1.85	60.24	16.51	82.67	43.24
42	M98/0028	19.89	4533	0.00	77.78	17.21	86.52	24.32
43	92B/00068	19.76	20136	0.00	53.90	14.43	73.05	44.59
44	97/4763	19.63	20136	0.00	66.67	17.52	89.22	41.89
45	97/2205	18.64	21426	2.08	95.83	18.82	101.00	50.00
	Mean	23.13	14464.22	2.30	77.72	17.47	76.57	40.78
	Minimum	18.64	2109.00	0.00	40.03	9.47	36.48	5.41
	Maximum	32.56	39587.00	19.00	95.83	23.19	109.98	63.51
	Std.	2.95	7134.76	3.22	14.56	2.71	14.44	11.37
	CV (%)	12.76	49.33	139.84	18.74	15.50	18.86	27.88

Std. = Standard Deviation; CV (%) = Coefficient of Variation.

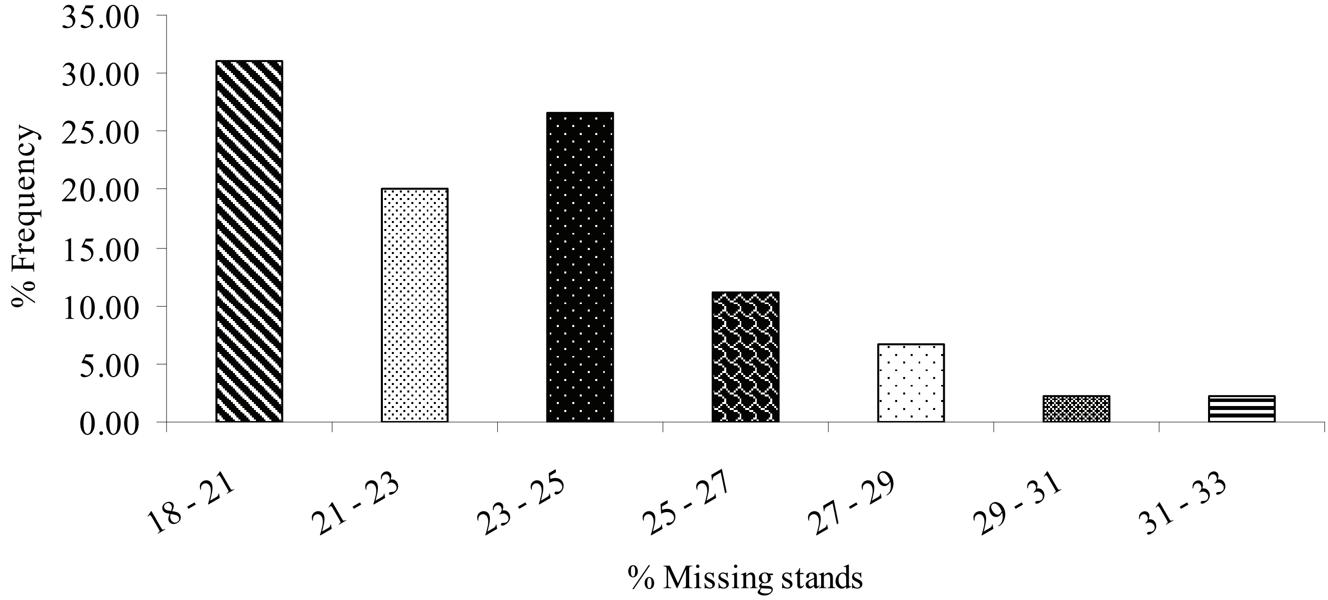


Fig. 4.1 Distribution of the frequency of missing cassava stands across 45 varieties in 74 farms in Southern Nigeria, 2006/2007 cropping season.

Table 4.2 Correlation coefficients between all the variables studied and the missing stands.

Variables	WD	SP	FA	SQ	DCP	PSK	FD	QLP	E	V	F	EB	SoPM	SuPM	TCSt	RPSp	LUE	Missing stands[b]
WD		-0.12	-0.45	-0.44	0.63	-0.1	0.46	-0.47	-0.04	-0.24	-0.36	-0.33	-0.5	-0.39	-0.33	-0.57	-0.57	0.46***
SP			0.14	0.12	-0.05	-0.24	-0.18	0.21	0.06	0.16	0.07	0.28	0.32	0.29	0.12	0.15	0.26	-0.02^{ns}
FA				0.75	-0.57	0.24	-0.72	0.5	0.1	0.47	0.56	0.37	0.73	0.66	0.33	0.78	0.56	-0.35***
SQ					-0.72	0.45	-0.64	0.65	0.16	0.71	0.69	0.45	0.85	0.76	0.46	0.89	0.63	-0.47***
DCP						-0.31	0.42	-0.62	0.06	-0.45	-0.55	-0.32	-0.7	-0.63	-0.34	-0.82	-0.64	0.62***
PSK							-0.11	0.36	0.04	0.38	0.2	0.06	0.33	0.37	0.29	0.41	0.33	-0.31**
FD								-0.37	-0.39	-0.37	-0.59	-0.34	-0.54	-0.46	-0.27	-0.6	-0.45	0.25*
QLP									0.05	0.52	0.39	0.39	0.62	0.81	0.36	0.61	0.52	-0.48***
E										0.08	0.15	0.14	0.1	0.03	0.13	0.12	0.08	0.18^{ns}
V											0.45	0.26	0.52	0.68	0.44	0.6	0.51	-0.40***
F												0.12	0.56	0.47	0.25	0.63	0.4	-0.42***
EB													0.5	0.41	0.12	0.48	0.37	-0.14^{ns}
SoPM														0.81	0.46	0.89	0.71	-0.45***
SuPM															0.5	0.76	0.66	-0.41***
TCSt																0.47	0.48	-0.24*
RPSp																	0.8	-0.51***
LUE																		-0.37***

WD-Weed density; SP-Spacing; FA-Fertilizer application; SQ-Stem quality, DCP-Days from cutting to planting, PSK-Planting Skill, FD-Field Damage, QLP-Quality of land preparation, E-Erosion, V-Variety, F-Fence of the plot; EB-Education background; SoPM-Source of planting materials; SuPM-Supply of planting materials; TCSt-Tools used to cut the stem into stakes; RPSp-Replacement if poor sprouting, LUE-Land use efficiency, b^{***} = significant at 0.1 %, b^{**} = significant at 1 %, b^{*} = significant at 5 %, b^{ns} = not significant at 0.1%.

Other truly significant correlations with the missing stands include weed density (r = 0.46), field damage (r = 0.25).

They were some negative relationship between the missing stands and other variables. Variables negatively correlated with the missing stands were: planting skill (r = -0.31), fertilizer application (r = -0.35), land use efficiency (r = -0.37), stem quality (r = -0.47) and quality of land preparation (r = -0.48).

The direct and indirect effect path coefficients of variables influencing the missing stands in cassava fields are presented in table 4.3. The direct effect of the variables varied from 0.024 to 0.58 while the indirect effects varied from 0.002 to 0.5. The residual effect was 0.47.

4.2 Influence of cutting tools on cassava stems, root and forage production

4.2. a Effect of cutting tools on the number of 25 cm plantable stakes

The mean square values of the analysis of variance for the mean number of 25-cm PS at 6 and 12 MAP are presented in table 4.4. There was a significant difference ($p<0.05$) among the cutting tools used and the varieties, for the number of 25-cm PS at 6 and 12 MAP. But the differences among the cutting tools used were not significant at 12 MAP.

The numbers of 25-cm plantable stakes (PS) at 6 and 12 months after planting (MAP) are presented in tables 4.5, and 4.6. The mean number of 25-cm PS and their standard deviation were 4.50 ± 1.46 (Okoli cutter), 4.83 ± 1.85 (hand-held saw), 4.53 ± 1.55 (machete), 4.05 ± 1.32 (secateur) and 4.72 ± 1.70 (motorized-rotary saw) at 6 MAP and 6.98 ± 2.30 (Okoli cutter), 6.66 ± 2.19 (hand-held saw), 7.14 ± 2.80 (machete), 6.60 ± 1.91 (secateur) and 7.38 ± 2.50 (motorized-rotary saw) at 12 MAP. Across all the cutting tools, the number of 25-cm PS varied from 2 to 8 cuttings ±1.7 and from 6 to 11 cuttings ± 27.21 at 6 and 12 MAP respectively.

4.2. b Effect of cutting tools on the root yield

The mean square values of the analysis of variance for the root and forage yields at 12 MAP are presented in Table 4.7. There was no significant difference among the cutting tools used, for the root yield at 12 MAP while differences among varieties were significant ($p<0.05$). The mean root yield with their standard deviation (Table 4.8) were 29.86 ± 9.31 (Okoli cutter), 27.71 ± 9.27 (hand-held saw), 27.95 ± 10.50 (machete), 27.13 ± 9.92 (secateur) and 28.63 ± 10.86 (motorized-rotary saw) at 12 MAP. The root yield varied from 16.96 to 43.27 t/ha ±6.77 across all the cutting tools.

Table 4.3 Direct (Diagonal) and indirect (Vertical) effect path coefficients of variables influencing the missing stands in 74 cassava fields.

Variables	WD	SP	FA	SQ	DCP	PSK	FD	QLP	E	V	F	EB	SoPM	SuPM	TCSt	RPSp	LUE	SUM
WD	0.091	-0.003	-0.029	-0.255	0.251	0.015	0.066	0.184	-0.009	0.096	0.057	-0.017	0.240	-0.205	0.011	0.083	-0.117	0.460
SP	-0.011	0.024	0.009	0.069	-0.020	0.037	-0.026	-0.082	0.014	-0.064	-0.011	0.014	-0.153	0.153	-0.004	-0.022	0.053	-0.020
FA	-0.041	0.003	0.064	0.434	-0.227	-0.037	-0.103	-0.196	0.023	-0.188	-0.088	0.019	-0.350	0.348	-0.011	-0.114	0.115	-0.350
SQ	-0.040	0.003	0.048	0.579	-0.287	-0.069	-0.092	-0.254	0.036	-0.284	-0.109	0.023	-0.408	0.400	-0.015	-0.130	0.129	-0.470
DCP	0.058	-0.001	-0.037	-0.417	0.398	0.048	0.060	0.243	0.014	0.180	0.087	-0.016	0.336	-0.332	0.011	0.120	-0.131	0.620
PSK	-0.009	-0.006	0.015	0.260	-0.123	-0.154	-0.016	-0.141	0.009	-0.152	-0.032	0.003	-0.158	0.195	-0.010	-0.060	0.068	-0.310
FD	0.042	-0.004	-0.046	-0.370	0.167	0.017	0.144	0.145	-0.089	0.148	0.093	-0.017	0.259	-0.242	0.009	0.088	-0.092	0.250
QLP	-0.043	0.005	0.032	0.376	-0.247	-0.055	-0.053	-0.391	0.011	-0.208	-0.061	0.020	-0.297	0.427	-0.012	-0.089	0.107	-0.480
E	-0.004	0.001	0.006	0.093	0.024	-0.006	-0.056	-0.020	0.227	-0.032	-0.024	0.007	-0.048	0.016	-0.004	-0.018	0.016	0.180
V	-0.022	0.004	0.030	0.411	-0.179	-0.059	-0.053	-0.203	0.018	-0.400	-0.071	0.013	-0.249	0.358	-0.015	-0.088	0.105	-0.400
F	-0.033	0.002	0.036	0.399	-0.219	-0.031	-0.085	-0.153	0.034	-0.180	-0.158	0.006	-0.269	0.248	-0.008	-0.092	0.082	-0.420
EB	-0.030	0.007	0.024	0.260	-0.127	-0.009	-0.049	-0.153	0.032	-0.104	-0.019	0.051	-0.240	0.216	-0.004	-0.070	0.076	-0.140
SoPM	-0.046	0.008	0.047	0.492	-0.279	-0.051	-0.078	-0.243	0.023	-0.208	-0.088	0.025	-0.480	0.427	-0.015	-0.130	0.146	-0.450
SuPM	-0.036	0.007	0.042	0.440	-0.251	-0.057	-0.066	-0.317	0.007	-0.272	-0.074	0.021	-0.388	0.527	-0.016	-0.111	0.135	-0.410
TCSt	-0.030	0.003	0.021	0.266	-0.135	-0.045	-0.039	-0.141	0.030	-0.176	-0.039	0.006	-0.221	0.263	-0.033	-0.069	0.098	-0.240
RPSp	-0.052	0.004	0.050	0.515	-0.327	-0.063	-0.086	-0.239	0.027	-0.240	-0.099	0.024	-0.427	0.400	-0.015	-0.146	0.164	-0.510
LUE	-0.052	0.006	0.036	0.364	-0.255	-0.051	-0.065	-0.203	0.018	-0.204	-0.063	0.019	-0.341	0.348	-0.016	-0.117	0.205	-0.370
Residual effect	0.468																	

WD-Weed density; SP-Spacing; FA-Fertilizer application; SQ-Stem quality, DCP-Days from cutting to planting, PSK-Planting Skill, FD-Field Damage, QLP-Quality of land preparation, E-Erosion, V-Variety, F-Fence of the plot; EB-Education background; SoPM-Source of planting materials; SuPM-Supply of planting materials; TCSt-Tools used to cut the stem into stakes; RPSp-Replacement if poor sprouting, LUE-Land used efficiency.

Table 4.4 Mean square values of the analysis of variance for the mean number of 25-cm plantable stakes per cutting tool at 6 and 12 MAP in 2006 at Onne, Rivers State.

		Mean number of 25-cm plantable stakes per cutting tool at 6 MAP		Mean number of 25-cm plantable stakes per cutting tool at 12 MAP	
Source of Variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square
Replication (Rep)	1	287.94	287.94	15.66	15.66
Variety	42	583.26	13.89^{*}	1602.53	38.16^{**}
Variety*Rep	42	291.30	6.94	509.20	12.12
Cutting Tools (CgT)	4	31.07	7.77^{*}	11.44	2.86^{ns}
CgT*Variety	168	475.30	2.83^{ns}	767.68	4.57^{ns}
Rep*CgT*Variety	172	445.42	2.59	1039.66	6.04
Total	429	2114.28		3946.18	
Grand Mean			4.53		7.00

	6 MAP	12 MAP
	CV (Variety) = 58.15 %	CV (Variety) = 49.73 %
	CV (Cutting Tools) = 35.53 %	CV (Cutting Tools) = 35.11 %
	LSD (Variety) $_{(0.05, 42)}$ = 2.37	LSD (Variety) $_{(0.05, 42)}$ = 3.07
	LSD (Cutting Tools) $_{(0.05, 172)}$ = 1.42	LSD (Cutting Tools) $_{(0.05, 172)}$ = 2.21

b** = Significant at 1 %; b* = Significant at 5 %; b^{ns} = not significant; MAP = Month after planting

Table 4.5 Mean number of 25-cm cassava plantable stakes per cutting tool and per variety at 6 MAP at 100 cm x 50 cm spacing at Onne, Rivers State, Nigeria in the 2005/2006 cropping season.

S/N	Variety	O	S	CT	Sec	E	Mean	Std	CV (%)
1	30572	4.25	7.37	6.98	7.54	4.11	6.05	1.72	28.45
2	4(2)1425	2.22	1.54	3.04	4.02	2.57	2.67	0.93	34.74
3	82/00058	6.08	5.70	8.03	4.81	6.03	6.13	1.18	19.23
4	91/02324	3.86	3.17	3.73	3.25	4.79	3.76	0.65	17.27
5	92/0057	4.94	5.49	4.05	5.43	6.71	5.32	0.97	18.16
6	92/0067	1.85	2.11	2.78	1.98	2.50	2.24	0.39	17.29
7	92/0325	7.29	6.80	5.75	5.15	6.90	6.38	0.89	14.00
8	92/0326	5.71	4.35	3.24	2.73	2.94	3.79	1.24	32.68
9	92B/00061	2.43	5.44	2.95	2.22	4.39	3.48	1.38	39.72
10	92B/00068	3.97	3.38	5.99	3.69	7.05	4.81	1.61	33.49
11	94/0026	4.80	3.38	7.47	4.38	4.16	4.84	1.56	32.28
12	94/0039	3.58	7.45	4.04	4.69	5.01	4.95	1.50	30.32
13	94/0561	2.79	3.44	4.02	3.21	3.82	3.45	0.49	14.20
14	95/0166	4.16	3.03	4.02	4.33	5.75	4.26	0.98	22.92
15	95/0289	4.49	5.67	4.82	2.95	4.31	4.44	0.99	22.17
16	95/0379	4.51	8.03	6.40	5.32	4.37	5.72	1.52	26.60
17	96/0523	3.41	2.32	1.50	2.14	2.91	2.45	0.73	29.87
18	96/0603	3.00	4.25	3.67	4.77	4.47	4.03	0.71	17.51
19	96/1089A	4.71	3.05	3.18	4.06	3.34	3.67	0.70	19.06
20	96/1565	4.38	4.86	5.38	5.09	5.78	5.10	0.53	10.38
21	96/1569	5.02	4.64	4.30	4.40	3.67	4.41	0.50	11.26
22	96/1632	3.24	3.54	2.42	3.55	2.43	3.03	0.57	18.76
23	96/1642	6.69	8.50	3.68	2.59	6.37	5.57	2.39	43.00
24	97/0162	4.87	5.82	4.56	4.57	4.24	4.81	0.61	12.65
25	97/0211	3.22	3.86	3.22	2.54	2.31	3.03	0.62	20.33
26	97/2205	3.88	1.49	3.10	2.26	3.50	2.85	0.97	34.07
27	97/3200	2.90	4.38	5.33	3.28	4.55	4.09	0.99	24.13
28	97/4763	5.86	10.03	8.50	6.65	8.14	7.83	1.63	20.86
29	97/4769	3.66	5.01	4.10	3.60	3.04	3.88	0.73	18.93
30	97/4779	5.61	4.07	3.55	3.49	9.28	5.20	2.44	46.89
31	98/0002	5.08	3.36	2.71	2.56	3.64	3.47	1.00	28.94
32	98/2101	5.38	4.59	6.02	4.97	4.35	5.06	0.66	13.07
33	98/0505	4.32	4.57	4.38	2.74	5.83	4.37	1.10	25.22
34	98/0510	4.90	4.69	6.31	4.58	3.48	4.79	1.01	21.08
35	98/0581	4.69	7.27	3.79	4.93	4.01	4.93	1.38	28.06
36	98/2226	4.41	6.09	6.17	2.79	4.71	4.83	1.39	28.74
37	99/2123	10.24	3.65	4.96	6.29	9.61	6.95	2.88	41.49
38	99/3073	4.40	4.37	5.99	6.84	5.38	5.39	1.06	19.61
39	99/6012	5.64	5.42	4.46	4.12	4.83	4.89	0.63	12.98
40	M98/0028	4.17	5.05	3.68	3.90	4.88	4.33	0.60	13.86
41	M98/0040	3.46	7.19	5.29	4.52	5.44	5.18	1.37	26.43
42	M98/0068	5.47	5.15	3.57	4.16	3.52	4.37	0.90	20.54
43	TME419	4.20	4.38	3.65	3.07	4.04	3.87	0.52	13.52
	Minimum	1.85	1.49	1.50	1.98	2.31	2.24	0.39	10.38
	Maximum	10.24	10.03	8.50	7.54	9.61	7.83	2.88	46.89
	Mean	4.51	4.84	4.53	4.05	4.72	4.53	1.08	23.83
	Std	1.46	1.85	1.55	1.32	1.70	1.18	0.55	9.15
	CV (%)	32.43	38.28	34.31	32.54	35.97	26.04	50.79	38.41
	SE ±	0.23	0.29	0.24	0.20	0.26	0.18	0.08	1.41
	Cutting tools[b]		*						
	Variety		*						
	Cutting tools* Variety		ns						

O=Okoli cutter (2 opposing knives); S=Saw (Hand held carpenter saw); CT=Cutlass (Machete); E=Engine (Motorized rotary saw); Sec=Secateur; b^{ns}=non significant; b^{*}=Significant at 5 %
Std = Standard Deviation; SE = Standard Error; CV = Coefficient of Variation.

Table 4.6 Mean number of standard stakes (25-cm) harvested fron different cassava varieties and cutting tools at 12 MAP at Onne, Rivers State, Nigeria in the 2005/2006 cropping season.

S/N	Variety	O	S	CT	Sec	E	Mean	Std	CV (%)
1	30572	6.61	5.65	6.42	3.59	6.84	5.82	1.33	22.80
2	4(2)1425	4.82	3.86	3.81	3.71	4.03	4.04	0.45	11.12
3	82/00058	4.98	4.14	4.66	5.13	4.03	4.59	0.49	10.71
4	91/2324	5.65	4.90	6.77	6.57	5.61	5.90	0.77	13.03
5	92/0057	6.40	8.21	10.25	8.48	11.33	8.93	1.91	21.39
6	92/0067	5.26	4.69	4.24	6.77	7.26	5.64	1.32	23.33
7	92/0325	9.00	8.68	16.38	8.44	12.31	10.96	3.41	31.14
8	92/0326	8.82	8.15	9.00	8.09	9.25	8.66	0.52	5.99
9	92B/00061	4.27	5.30	5.48	5.91	6.55	5.50	0.84	15.28
10	92B/0068	9.35	3.22	8.02	5.24	5.67	6.30	2.41	38.29
11	94/0026	12.10	6.46	10.86	9.73	7.33	9.30	2.37	25.45
12	94/0039	6.40	10.26	7.86	6.12	8.51	7.83	1.68	21.50
13	94/0561	5.99	5.04	6.51	8.29	8.96	6.96	1.63	23.42
14	95/0166	10.69	11.32	8.77	8.40	8.50	9.53	1.37	14.33
15	95/0289	8.92	10.49	9.03	6.56	8.10	8.62	1.44	16.66
16	95/0379	6.91	8.69	6.03	6.36	9.52	7.50	1.53	20.35
17	96/0523	7.52	8.59	6.68	5.64	5.91	6.87	1.21	17.61
18	96/0603	7.04	8.64	6.14	7.39	6.85	7.21	0.92	12.75
19	96/1089A	5.68	4.17	4.33	4.83	3.94	4.59	0.69	15.05
20	96/1565	7.94	7.86	7.68	10.10	12.94	9.30	2.26	24.33
21	96/1569	3.38	3.90	4.21	3.80	3.20	3.70	0.41	11.07
22	96/1632	5.36	5.52	5.29	5.96	7.10	5.84	0.75	12.77
23	96/1642	4.87	8.16	5.74	6.58	8.69	6.81	1.61	23.60
24	97/0162	7.26	6.55	9.97	7.93	7.64	7.87	1.28	16.30
25	97/0211	8.50	6.87	5.97	6.17	7.67	7.03	1.06	15.04
26	97/2205	7.08	4.17	5.22	7.64	4.93	5.80	1.48	25.52
27	97/3200	6.00	5.55	4.40	4.73	7.57	5.65	1.25	22.10
28	97/4763	10.22	7.10	10.49	7.81	8.52	8.83	1.48	16.82
29	97/4769	2.93	2.96	3.38	3.63	3.46	3.27	0.31	9.55
30	97/4779	3.88	4.70	2.37	3.79	4.35	3.81	0.89	23.33
31	98/0002	5.36	8.51	8.99	5.89	4.59	6.67	1.96	29.46
32	98/02101	3.29	3.49	5.02	6.14	7.70	5.12	1.85	36.14
33	98/0505	7.71	8.18	13.50	5.41	7.99	8.56	2.98	34.82
34	98/0510	7.20	10.35	6.53	5.56	7.53	7.43	1.80	24.19
35	98/0581	7.47	6.67	7.60	5.46	6.29	6.70	0.88	13.15
36	98/2226	10.97	7.05	6.80	7.68	13.82	9.26	3.05	32.91
37	99/2123	10.15	8.66	9.10	9.41	9.76	9.41	0.58	6.12
38	99/3073	5.94	5.28	4.88	4.97	4.02	5.02	0.70	13.88
39	99/6012	9.66	8.15	11.19	11.42	9.99	10.08	1.32	13.07
40	M98/0028	4.88	6.73	7.79	8.64	6.01	6.81	1.47	21.64
41	M98/0040	4.15	3.46	4.34	5.96	8.20	5.22	1.90	36.38
42	M98/0068	8.99	7.74	9.08	9.97	5.74	8.30	1.64	19.73
43	TME419	10.56	6.27	6.17	7.68	9.27	7.99	1.91	23.95
	Minimum	2.93	2.96	2.37	3.59	3.20	3.27	0.31	5.99
	Maximum	12.10	11.32	16.38	11.42	13.82	10.96	3.41	38.29
	Mean	6.98	6.61	7.14	6.69	7.38	6.96	1.42	20.14
	Std	2.30	2.19	2.80	1.91	2.50	1.89	0.73	8.19
	CV (%)	33.01	33.14	39.28	28.60	33.92	27.21	51.09	40.64
	SE ±	0.36	0.34	0.43	0.29	0.39	0.29	0.11	1.26
	Cutting tools[b]		ns						
	Variety		**						
	Cutting tools * Variety		ns						

O=Okoli cutter (2 opposing knives); S=Saw (Hand held carpenter saw); CT=Cutlass (Machete); E=Engine (Motorized rotary saw); Sec=Secateur; b^{ns}=non significant; b^{**}=Significant at 1 %
Std = Standard Deviation; SE = Standard Error; CV = Coefficient of Variation.

Table 4.7 Mean square values of the analysis of variance for the mean root and forage yields (t/ha) per cutting tool at 12 MAP in 2006 at Onne, Rivers State.

		Mean root yield (t/ha) per cutting tool		Mean forage yield (t/ha) per cutting tool	
Source of Variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square
Replication (Rep)	1	272.28	272.28	139.24	139.24
Variety	42	19237.43	458.03 **	450.21	10.72 ^{ns}
Variety*Rep	42	8819.30	209.98	382.81	9.11
Cutting Tools (CgT)	4	374.48	93.62 ^{ns}	8.25	2.06 ^{ns}
CgT*Variety	168	22692.29	135.07 ^{ns}	391.38	2.33 ^{ns}
Rep*CgT*Variety	172	21405.72	124.45	507.05	2.95
Total	429	72801.49		1878.94	
Grand Mean			28.25		3.15

Mean root yield (t/ha) per cutting tool	Mean forage yield (t/ha) per cutting tool
CV (Variety) = 51.29 %	CV (Variety) = 95.82 %
CV (Cutting Tools) = 39.49 %	CV (Cutting Tools) = 54.53 %
LSD (Variety) $_{(0.05, 42)}$ = 13.03	LSD (Variety) $_{(0.05, 42)}$ = 2.71
LSD (Cutting Tools) $_{(0.05, 172)}$ = 9.83	LSD (Cutting Tools) $_{(0.05, 172)}$ = 1.51

b** = Significant at 1 %; b* = Significant at 5 %; b^{ns} = not significant; MAP = Month after planting

Table 4.8 Mean cassava root yield (t/ha) per cutting tool and per variety at 12 MAP at 100 cm x 50 cm spacing at Onne, Rivers State, Nigeria in the 2005/2006 cropping season.

S/N	Variety	O	S	CT	Sec	E	Mean	Std	CV (%)
1	30572	27.00	32.75	18.25	25.00	36.75	27.95	7.14	25.56
2	4(2)1425	27.00	28.50	27.50	48.50	30.75	32.45	9.09	28.00
3	82/00058	26.25	25.00	37.75	17.43	22.35	25.76	7.51	29.15
4	91/02324	30.75	16.78	25.00	14.98	23.25	22.15	6.39	28.87
5	92/0057	33.13	30.33	29.50	25.25	31.00	29.84	2.90	9.71
6	92/0067	18.50	17.25	19.00	23.63	18.75	19.43	2.44	12.58
7	92/0325	18.25	32.04	13.58	13.50	47.50	24.97	14.70	58.86
8	92/0326	26.25	18.50	53.50	22.50	41.00	32.35	14.56	45.01
9	92B/00061	34.00	46.50	32.98	36.85	20.85	34.24	9.19	26.85
10	92B/00068	56.50	24.25	31.25	52.00	23.25	37.45	15.72	41.99
11	94/0026	42.76	28.75	36.58	25.75	36.50	34.07	6.81	19.97
12	94/0039	22.00	20.00	21.50	21.50	15.75	20.15	2.57	12.76
13	94/0561	19.90	20.50	28.75	19.58	21.00	21.95	3.84	17.51
14	95/0166	31.00	32.00	60.75	26.50	40.75	38.20	13.62	35.66
15	95/0289	36.00	41.88	32.75	40.25	27.75	35.73	5.72	16.01
16	95/0379	16.75	25.13	18.38	16.50	15.63	18.48	3.85	20.83
17	96/0523	29.75	21.38	12.30	9.00	31.50	20.79	10.08	48.48
18	96/0603	36.50	26.50	22.75	40.50	26.25	30.50	7.58	24.87
19	96/1089A	23.00	21.75	34.50	40.26	35.50	31.00	8.18	26.40
20	96/1565	30.25	36.18	26.50	28.75	31.50	30.64	3.62	11.80
21	96/1569	33.88	29.08	30.08	28.63	34.00	31.13	2.62	8.40
22	96/1632	23.75	37.50	26.75	22.25	33.00	28.65	6.44	22.47
23	96/1642	24.50	17.50	16.25	20.17	24.25	20.53	3.78	18.42
24	97/0162	38.00	33.58	40.50	25.33	22.50	31.98	7.83	24.50
25	97/0211	19.46	18.50	12.15	18.72	15.98	16.96	2.99	17.64
26	97/2101	24.00	27.00	32.75	27.40	36.25	29.48	4.93	16.71
27	97/2205	35.50	18.58	44.25	32.75	22.00	30.62	10.41	33.99
28	97/3200	31.50	30.75	26.25	41.25	39.25	33.80	6.26	18.52
29	97/4763	19.25	39.00	23.50	26.13	20.38	25.65	7.93	30.93
30	97/4769	24.00	29.50	26.25	19.75	14.08	22.72	5.99	26.37
31	97/4779	39.71	39.59	27.88	49.23	48.93	41.07	8.75	21.31
32	98/0002	31.53	44.75	22.26	35.55	28.50	32.52	8.38	25.78
33	98/0505	24.50	26.68	34.50	28.63	27.00	28.26	3.78	13.39
34	98/0510	42.25	16.15	19.64	27.00	21.50	25.31	10.25	40.50
35	98/0581	47.75	51.00	44.50	29.25	32.88	41.08	9.51	23.15
36	98/2226	26.50	17.75	16.60	14.75	26.25	20.37	5.59	27.42
37	99/2123	16.67	9.65	24.00	18.40	18.92	17.53	5.18	29.56
38	99/3073	25.25	31.50	22.00	28.25	20.75	25.55	4.43	17.33
39	99/6012	31.75	20.00	13.15	27.89	19.30	22.42	7.39	32.97
40	M98/0028	32.93	29.25	28.88	34.75	37.00	32.56	3.51	10.77
41	M98/0040	22.75	34.50	22.00	21.50	21.83	24.52	5.60	22.84
42	M98/0068	54.75	29.50	38.25	23.60	70.25	43.27	19.11	44.17
43	TME419	28.13	14.27	26.50	17.25	18.50	20.93	6.06	28.93
	Minimum	16.67	9.65	12.15	9.00	14.08	16.96	2.44	8.40
	Maximum	56.50	51.00	60.75	52.00	70.25	43.27	19.11	58.86
	Mean	29.86	27.71	27.95	27.13	28.63	28.26	7.26	25.51
	Std	9.31	9.27	10.50	9.92	10.86	6.77	3.83	11.09
	CV (%)	31.19	33.46	37.55	36.55	37.95	23.95	52.73	43.48
	SE ±	1.44	1.43	1.62	1.53	1.68	1.04	0.59	1.71
	Cutting tools^{b}		ns						
	Variety		**						
	Cutting tools * Variety		ns						

O=Okoli cutter (2 opposing knives); S=Saw (Hand held carpenter saw); CT=Cutlass (Machete); E=Engine (Motorized rotary saw); Sec=Secateur; b^{ns}=non significant; b^{**}=Significant at 1 % ; Std = Standard Deviation; SE = Standard Error; CV = Coefficient of Variation.

4.2. c Effect of cutting tools on forage yield

There was no significant difference among the cutting tools used and varieties, for the forage yield at 12MAP (Table 4.8).

The mean forage yield with their standard deviation (Table 4.9) were 3.27 ± 1.51 (Okoli cutter), 3.33 ± 1.78 (hand-held saw), 2.99 ± 1.39 (machete), 3.00 ± 1.13 (secateur) and 3.18 ± 1.18 (motorized-rotary saw) at 12 MAP. The forage yield varied from 1.47 to 5.21 t/ha ±1.04 across all the cutting tools. For all the parameters assessed, the interaction was not significant.

4.2. d Evaluation of the polarity of the cassava roots

The polarity of the root presented in table 4.10 shows that an average of 6.53 % of the roots has been formed at the top of the planted stake, while 8.16 % and 85.37 % of the roots have been formed at the middle and at the bottom of the planted stakes respectively.

For all the 43 Cassava Mosaic Disease Resistant (CMDR) varieties assessed, an average of 4,000 roots/ha (with an expected plant population of 20,000 plants/ha) was obtained at the top of the planted stakes, 5,000 roots from the middle and 49,000 roots from the bottom, irrespectively of the cutting tools used. All the varieties showed a strong polarity toward the bottom of the planted stakes (average of 85.4 % of the total tubers obtained per variety). Plate 4.1 showed the smoothness of the stake edges cut with different cutting tools. Stakes cut with secateur had a smoother edge than the one cut with hand-held saw, which is smoother than the one cut with cutlass, Okoli and motorized-rotary saw. Motorized-rotary saw cut faster (one hour to cut stems to plant 1 ha) than cutlass (two hours) and hand-held saw (three hours). However, the secateur gave smoother edge, but it took long time (10 hours) to cut stems to plant one hectare of land. *Okoli* cutter gave broken edge and nine hours to cut stems enough to plant 1 hectare.

4.3 Influence of number of nodes, variety and spacing on stem multiplication

The percentage sprouting of the five CMDR varieties cut at different number of nodes and planted at different spacing is presented in Figure 4.2. Stakes from all the nodes categories started sprouting at the fifth day after planting (DAP), with a percentage of 9.07 % for 2 nodes category, 7.20 % for 3 nodes and 8.80 % for 4 nodes category. At the nineth DAP, half of all the planted stakes sprouted: 53.09 % for 2 nodes category, 51.47 % for 3 nodes and 52.27 % for 4 nodes category. Hundred percent sprouting of stakes for all the stakes-nodes categories were obtained at the 15 DAP. The sprouting ability for all the 43 CMDR varieties and number of nodes were highly and positively associated with the days after planting.

Table 4.9 Mean cassava forage yield (t/ha) per cutting tool and per variety at 12 MAP at 100 cm x 50 cm spacing at Onne, Rivers State, Nigeria in the 2005/2006 cropping season.

S/N	Variety	O	S	CT	Sec	E	Mean	Std	CV (%)
1	30572	6.35	5.20	3.80	4.00	4.43	4.76	1.04	21.88
2	4(2)1425	2.20	2.50	2.40	3.30	3.90	2.86	0.72	25.07
3	82/00058	2.71	2.51	1.38	1.80	3.05	2.29	0.68	29.93
4	91/02324	3.44	4.31	4.19	2.41	4.13	3.70	0.79	21.48
5	92/0057	4.63	2.19	2.13	3.03	3.08	3.01	1.01	33.55
6	92/0067	2.04	1.60	2.18	2.38	2.48	2.13	0.34	16.08
7	92/0325	6.31	4.88	2.95	3.06	3.05	4.05	1.50	37.04
8	92/0326	4.43	3.40	4.83	3.41	4.23	4.06	0.63	15.59
9	92B/00061	2.75	3.33	4.03	2.13	2.76	3.00	0.71	23.83
10	92B/00068	3.15	3.90	3.30	5.78	2.58	3.74	1.23	32.93
11	94/0026	2.63	2.74	1.09	1.81	3.39	2.33	0.89	38.29
12	94/0039	1.46	2.01	1.96	2.55	1.58	1.91	0.43	22.42
13	94/0561	1.83	1.79	2.70	1.40	1.33	1.81	0.55	30.21
14	95/0166	2.35	1.81	3.66	3.23	3.28	2.87	0.76	26.51
15	95/0289	7.50	5.69	2.65	5.05	3.31	4.84	1.93	39.97
16	95/0379	2.24	3.49	2.75	2.20	2.49	2.63	0.53	20.00
17	96/0523	1.50	1.84	1.00	1.21	2.07	1.52	0.44	28.68
18	96/0603	3.11	2.91	2.41	2.49	3.43	2.87	0.43	14.83
19	96/1089A	1.18	1.33	1.21	1.81	1.80	1.47	0.32	21.51
20	96/1565	2.46	3.91	3.74	3.14	2.30	3.11	0.73	23.37
21	96/1569	2.51	1.84	1.41	1.41	1.86	1.81	0.45	24.94
22	96/1632	3.08	4.50	3.28	3.88	3.28	3.60	0.59	16.27
23	96/1642	2.66	2.65	2.46	4.10	3.88	3.15	0.77	24.53
24	97/0162	1.80	1.73	1.74	1.90	0.77	1.59	0.46	29.10
25	97/0211	2.43	3.44	2.83	3.30	2.88	2.97	0.41	13.64
26	97/2101	3.10	3.30	2.65	3.20	3.20	3.09	0.26	8.28
27	97/2205	3.05	3.36	3.57	2.75	2.03	2.95	0.60	20.45
28	97/3200	3.18	1.60	1.73	2.09	3.40	2.40	0.84	34.86
29	97/4763	5.40	3.90	4.60	3.95	4.73	4.52	0.62	13.71
30	97/4769	2.80	2.93	3.33	3.90	6.23	3.84	1.41	36.67
31	97/4779	4.78	2.79	2.83	2.76	4.73	3.58	1.07	30.01
32	98/0002	2.70	2.54	2.43	1.64	2.68	2.40	0.44	18.18
33	98/0505	3.20	4.46	3.13	2.74	3.73	3.45	0.67	19.32
34	98/0510	3.18	11.88	2.45	2.98	2.78	4.65	4.05	87.04
35	98/0581	2.95	2.75	2.68	4.40	3.95	3.35	0.78	23.34
36	98/2226	3.00	2.21	2.5	2.09	3.88	2.74	0.73	26.60
37	99/2123	4.09	5.00	5.56	5.40	5.99	5.21	0.72	13.81
38	99/3073	4.00	4.13	3.00	4.00	2.25	3.48	0.82	23.64
39	99/6012	2.54	1.36	1.65	1.71	1.99	1.85	0.45	24.08
40	M98/0028	3.13	3.88	4.63	4.50	3.30	3.89	0.68	17.48
41	M98/0040	7.88	5.13	4.68	4.75	3.13	5.11	1.73	33.76
42	M98/0068	2.80	4.40	8.65	3.33	5.53	4.94	2.32	47.02
43	TME419	1.91	2.09	2.31	2.05	1.98	2.07	0.15	7.45
	Minimum	1.18	1.33	1.00	1.21	0.77	1.47	0.15	7.45
	Maximum	7.88	11.88	8.65	5.78	6.23	5.21	4.05	87.04
	Mean	3.27	3.33	2.99	3.00	3.18	3.15	0.85	25.98
	Std	1.51	1.78	1.39	1.13	1.18	1.04	0.67	12.86
	CV (%)	46.17	53.32	46.49	37.74	37.00	32.85	78.20	49.48
	SE ±	0.23	0.27	0.21	0.17	0.18	0.16	0.10	1.98
	Cutting tools[b]		ns						
	Variety		ns						
	Cutting tools * Variety		ns						

O=Okoli cutter (2 opposing knives); S=Saw (Hand held carpenter saw); CT=Cutlass (Machete); E=Engine (Motorized rotary saw); Sec=Secateur; b[ns]=non significant; Std = Standard Deviation; SE = Standard Error; CV = Coefficient of Variation.

Table 4.10 Evaluation of polarity of cassava planted at 100 cm by 50 cm spacing at RIART annex, IITA Onne, Nigeria during the 2005/2006 cropping season.

		No. of roots (x1000) for each position/ha*				Percentage (%) of total			Decision
S/N	Variety	Top	Middle	Bottom	Total	Top	Middle	Bottom	
1	30572	4	5	56	65	6.15	7.08	85.95	SPTB
2	4(2)1425	1	3	51	55	2.42	5.70	92.97	"
3	82/0058	4	8	66	78	5.64	10.85	84.87	"
4	91/02324	5	3	54	62	8.39	5.16	87.63	"
5	92/0057	2	3	36	41	6.02	8.29	88.13	"
6	92/0067	1	1	24	26	3.61	3.35	93.04	"
7	92/0325	5	4	28	37	13.9	11.37	74.73	"
8	92/0326	5	4	30	39	12.76	9.48	77.76	"
9	92B/0061	2	3	43	48	4.31	6.67	90.14	"
10	92B/0068	3	3	38	44	6.36	6.67	85.3	"
11	94/0026	5	4	51	60	7.92	7.02	85.06	"
12	94/0039	5	5	57	67	7.26	7.16	84.78	"
13	94/0561	1	3	47	51	1.95	6.51	91.54	"
14	95/0166	2	2	26	30	5.11	5.78	85.56	"
15	95/0289	4	4	42	50	7.27	7.40	85.33	"
16	95/0379	2	5	33	40	4.87	11.41	83.72	"
17	96/0523	5	7	58	70	7.10	10.41	82.50	"
18	96/0603	4	3	60	67	6.27	4.48	90.05	"
19	96/1089A	3	6	75	84	3.34	7.71	88.95	"
20	96/1565	5	6	58	69	7.92	9.08	83.86	"
21	96/1569	4	5	49	58	7.03	7.83	85.14	"
22	96/1632	3	5	48	56	5.82	8.08	86.10	"
23	97/1642	3	2	38	43	7.69	5.08	87.23	"
24	97/0162	3	4	38	45	7.67	9.14	83.19	"
25	97/0211	2	2	25	29	6.71	7.41	85.88	"
26	97/2101	5	7	53	65	7.97	11.03	81.00	"
27	97/2205	4	4	55	63	5.60	6.66	87.74	"
28	97/3200	3	3	63	69	4.37	4.17	91.46	"
29	97/4763	6	11	73	89	6.63	12.3	81.07	"
30	97/4769	3	5	66	74	4.14	6.94	89.73	"
31	97/4779	4	7	75	86	4.17	8.56	87.27	"
32	98/0002	6	5	59	70	7.90	6.95	84.19	"
33	98/0505	4	6	31	41	10.82	13.89	75.28	"
34	98/0510	5	6	34	45	11.47	12.79	75.74	"
35	98/0581	6	6	54	66	8.96	9.57	81.47	"
36	98/2226	2	2	60	64	2.51	3.76	93.73	"
37	99/2123	3	7	39	49	5.56	14.38	80.05	"
38	99/3073	2	4	64	70	3.14	6.29	91.62	"
39	99/6012	6	3	46	55	10.34	5.60	84.06	"
40	M98/0028	4	6	64	74	4.77	8.11	86.13	"
41	M98/0040	4	5	38	47	8.79	11.49	81.28	"
42	M98/0068	5	8	64	77	6.67	10.13	82.51	"
43	TME419	2	4	41	47	3.69	9.23	87.07	"
	Minimum	1.00	1.00	24.00	26.00	1.95	3.35	74.73	
	Maximum	6.00	11.00	75.00	89.00	13.90	14.38	93.73	
	Mean	3.65	4.63	49.07	57.33	6.53	8.16	85.37	
	Std	1.45	1.99	14.11	15.75	2.68	2.69	4.63	
	CV (%)	39.59	42.96	28.75	27.48	41.02	32.90	5.42	
	SE ±	0.22	0.31	2.18	2.43	0.41	0.41	0.71	

Std = Standard Deviation; SE = Standard Error; SPTB = " = Strongly Polar Towards the bottom, CV = Coefficient of Variation; RIART = Rivers State Institute of Agricultural Research and Training; IITA = International Institute of Tropical Agriculture. 1ha* = 20,000 plants.

Secateur
10 hours/person/ha

Hand-held saw
Three hours/person/ha

Machete
Two hours/person/ha

Okoli cutter
Nine hours/person/ha

Motorized-rotary saw
One hours/person/ha

Plate 4.1 Smoothness of cassava stakes' edges cut with different cutting tools and estimated number of hours per person to cut 60 bundles.

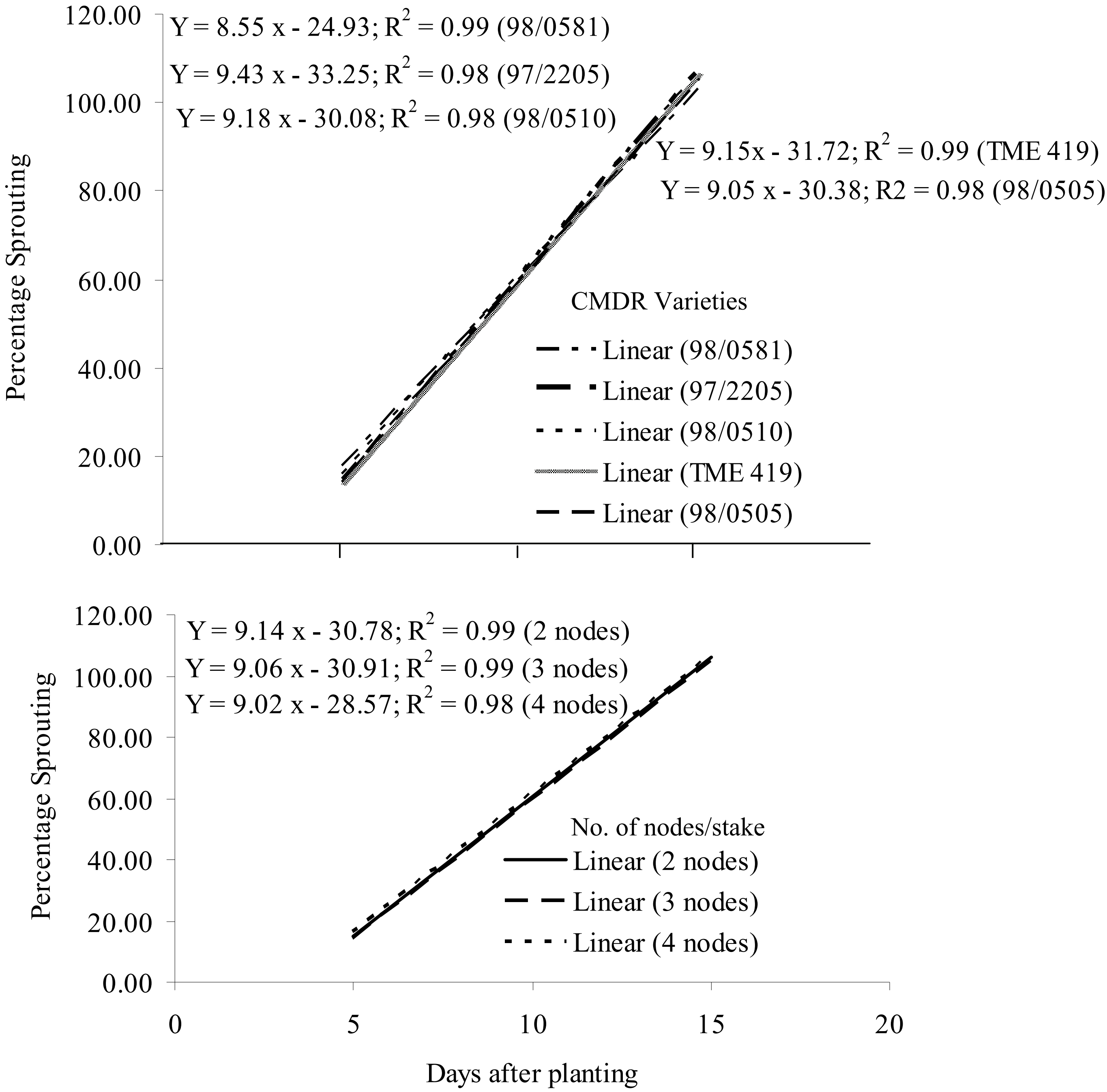


Figure 4.2 Percentage sprouting of 5 CMDR cassava varieties cut at three different numbers of nodes and planted at three different spacing at Onne, Rivers State during the 2006/2007 cropping season.

The days after planting accounted for 98 to 99 % of the total variation in the sprouting ability of these varieties. All the varieties and the number of nodes had positive slopes, in which case the sprouting ability of the cassava increase with the days after planting. The intercepts for all number of nodes and varieties were negative. This means that there will be decrease in the sprouting of cassava if they are cut and not planted.

The mean square values of the analysis of variance for the mean number of 25-cm PS at 6 and 12 MAP are presented in table 4.11 while that of the root and forage yields at 12 MAP are presented in table 4.12. There was significant difference among spacing ($p<0.05$) for the number of 25-cm PS at 6 MAP, root and forage yields at 12 MAP. These differences were not significant at 12 MAP for the number of 25-cm PS. There were significant differences between varieties ($p<0.01$) for all the parameters measured at 12 MAP. The number of nodes per stake was significant ($p<0.01$) only for the number of 25-cm PS at 6 MAP. All the interactions; spacing by number of nodes, spacing by variety, number of nodes by variety and spacing by number of nodes by variety were not significant.

The mean percentage differences (ratio actual yield/expected yield) of the stake production for all spacings and number of nodes per stake were 41.1 % ± 14.86 and 39.1 % ± 14.54 at 6 and 12 MAP respectively (Table 4.13). The mean percentage differences were 41.2 % ± 15.37 for the root yield and 38.0 % ± 15.40 for the forage yield respectively at 12 MAP (Table 4.14).

At 6 MAP, after combining the spacing and the number of nodes per stake, variety TME 419 showed the highest percentage difference for the stake production (49.4 % ± 14.0) (Table 4.15) and the spacing 80 cm x 50 cm, with 4-nodes cuttings (52.7 %).

At 12 MAP, variety TME 419 showed the highest percentage difference for the stake production (47.4 % ± 16.0) and the spacing 80 cm x 50 cm, with 4-nodes cuttings also gave the highest percentage difference (47.0 %) (Table 4.16). For the root yield at 12 MAP spacing 80 cm x 50 cm, with 2-nodes cuttings gave the highest percentage difference of 31.1 and 31.9 % respectively (Figure 4.3). Variety TMS 98/0510 had the highest percentage difference (46.8 %) for the forage yield while planting spacing of 80 cm x 37.5 cm gave the highest percentage difference (49.3 %) (Table 4.17)

Table 4.11 Mean square values of the analysis of variance for the mean number of 25-cm plantable stakes at 6 MAP in 2006 at Onne, Rivers State.

		Mean number of 25-cm plantable stakes at 6 MAP		Mean number of 25-cm plantable stakes at 12 MAP	
Source of Variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square
Spacing	2	57.98	28.99*	450.99	225.49^{ns}
Replication (Rep)	2	19.89	9.95	1521.44	760.72
Spacing*Rep	4	10.62	2.65	249.53	62.38
Node	2	43.76	21.88**	199.24	99.62^{ns}
Spacing*Node	4	11.25	2.81^{ns}	291.48	72.87^{ns}
Spacing*Node*Rep	12	27.05	2.25	784.69	65.39
Variety	4	19.05	4.76*	765.36	191.34**
Spacing* Variety	8	7.32	0.92^{ns}	285.75	35.72^{ns}
Node* Variety	8	11.83	1.48^{ns}	161.06	20.13^{ns}
Spacing*node* Variety	16	40.62	2.54^{ns}	436.74	27.30^{ns}
Rep*Spacing*Node* Variety	72	118.34	1.64	2251.80	31.28
Total	134	367.71		7398.08	
Grand Mean			3.47	10.08	
		CV (Spacing) = 46.95 % CV (Node) = 43.27% CV(Variety) = 36.94 % LSD (Spacing) $_{(0.05, 4)}$ = 0.95 LSD (Node) $_{(0.05, 12)}$ = 0.69 LSD (Variety) $_{(0.05, 72)}$ = 0.69		CV (Spacing) = 78.35 % CV (Node) = 80.22 % CV (Variety) = 55.48 % LSD (Spacing) $_{(0.05, 4)}$ = 4.62 LSD (Node) $_{(0.05, 12)}$ = 3.71 LSD (Variety) $_{(0.05, 72)}$ = 3.03	

b** = Significant at 1 %b* = Significant at 5 % b^{ns} = not significant; MAP = Month after planting

Table 4.12 Mean square values of the analysis of variance for the mean root yield at 12 MAP in 2006 at Onne, Rivers State.

		Mean root yield at 12 MAP		Mean forage yield at 12 MAP	
Source of Variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square
Spacing	2	43583.94	21791.97*	1773.12	886.56*
Replication (Rep)	2	4515.56	2257.78	2102.82	1051.41
Spacing*Rep	4	7767.42	1941.86	410.50	102.62
Node	2	512.99	256.50 ns	27.72	13.86 ns
Spacing*Node	4	12534.36	3133.59*	627.50	156.87*
Spacing*Node*Rep	12	7681.30	640.11	521.89	43.49
Variety	4	20648.49	5162.12**	1942.01	485.50**
Spacing* Variety	8	6046.53	755.82 ns	452.95	56.62 ns
Node* Variety	8	5809.47	726.18 ns	468.45	58.56 ns
Spacing*node* Variety	16	11320.18	707.51 ns	972.78	60.80 ns
Rep*Spacing*Node* Variety	72	37788.94	524.85	3511.09	48.77
Total	134	158209.19		12810.82	
Grand Mean			48.68		10.04

Mean root yield at 12 MAP	Mean forage yield at 12 MAP
CV (Spacing) = 90.52 %	CV (Spacing) = 100.90 %
CV (Node) = 51.97 %	CV (Node) = 65.68 %
CV (Variety) = 47.06 %	CV (Variety) = 69.55 %
LSD (Spacing) $_{(0.05, 4)}$ = 25.79	LSD (Spacing) $_{(0.05, 4)}$ = 5.93
LSD (Node) $_{(0.05, 12)}$ = 11.62	LSD (Node) $_{(0.05, 12)}$ = 3.03
LSD (Variety) $_{(0.05, 72)}$ = 12.41	LSD (Variety) $_{(0.05, 72)}$ = 3.78

b** = Significant at 1 %; b* = Significant at 5 %; b^{ns} = not significant; MAP = Month after planting

Table 4.13 Percentage difference in cassava stake production per plant at 6 and 12 MAP planted at three spacing combinations and three numbers of nodes per stake category at Onne, Rivers State in the 2006/2007 cropping season.

S/N	Stand Spacing (cm x cm)	No. Node/ Stake	Variety	EMN 25-cm PS	AMN 25-cm PS	% Diff. (A/E)	% Surv. Stands	EMN 25-cm PS	AMN 25-cm PS	% Diff. (A/E)	% Surv. Stands
				6 MAP				12 MAP			
1	80 x 37.5	2	TME 419	2.18	0.45	20.5	18.7	7.68	1.06	13.8	18.7
2	80 x 37.5	2	TMS 98/0505	3.84	0.71	18.4	19.1	20.67	3.35	16.2	19.1
3	80 x 37.5	2	TMS 97/2205	2.83	0.41	14.5	15.6	9.98	1.17	11.8	15.6
4	80 x 37.5	2	TMS 98/0581	2.97	0.93	31.4	36.0	13.67	4.73	34.6	36.0
5	80 x 37.5	2	TMS 98/0510	2.39	0.39	16.4	25.9	12.53	3.82	30.5	25.9
6	80 x 37.5	3	TME 419	3.01	1.79	59.4	45.8	5.59	2.42	43.4	45.8
7	80 x 37.5	3	TMS 98/0505	3.48	1.53	44.0	37.3	8.05	2.91	36.1	37.3
8	80 x 37.5	3	TMS 97/2205	2.37	1.03	43.7	38.9	6.95	3.25	46.8	38.9
9	80 x 37.5	3	TMS 98/0581	3.29	1.49	45.2	41.8	8.20	3.53	43.0	41.8
10	80 x 37.5	3	TMS 98/0510	5.04	1.40	27.8	25.8	7.85	1.74	22.2	25.8
11	80 x 37.5	4	TME 419	3.82	2.12	55.5	56.9	8.09	4.64	57.4	56.9
12	80 x 37.5	4	TMS 98/0505	4.27	1.91	44.8	39.6	24.76	6.78	27.4	39.6
13	80 x 37.5	4	TMS 97/2205	4.38	2.89	66.1	69.3	10.69	6.13	57.4	69.3
14	80 x 37.5	4	TMS 98/0581	4.11	2.37	57.5	60.9	8.69	4.80	55.3	60.9
15	80 x 37.5	4	TMS 98/0510	3.71	0.92	24.9	28.4	8.94	2.27	25.4	28.4
16	80 x 50	2	TME 419	3.96	1.76	44.6	44.9	9.15	4.05	44.3	44.9
17	80 x 50	2	TMS 98/0505	3.01	1.07	35.7	35.1	10.37	3.53	34.0	35.1
18	80 x 50	2	TMS 97/2205	2.85	1.00	35.3	35.1	6.31	2.17	34.4	35.1
19	80 x 50	2	TMS 98/0581	2.13	0.76	35.9	33.8	7.74	2.62	33.8	33.8
20	80 x 50	2	TMS 98/0510	3.63	0.60	16.6	16.9	12.77	2.13	16.7	16.9
21	80 x 50	3	TME 419	4.37	2.46	56.3	59.1	9.41	5.33	56.6	59.1
22	80 x 50	3	TMS 98/0505	7.83	2.35	30.0	35.1	18.32	6.18	33.7	35.1
23	80 x 50	3	TMS 97/2205	4.92	1.92	39.0	43.6	12.42	5.24	42.2	43.6
24	80 x 50	3	TMS 98/0581	3.38	1.66	49.2	49.3	9.39	4.68	49.8	49.3
25	80 x 50	3	TMS 98/0510	4.41	1.79	40.6	36.9	10.08	3.79	37.6	36.9
26	80 x 50	4	TME 419	3.39	2.11	62.2	64.9	9.09	5.99	65.9	64.9
27	80 x 50	4	TMS 98/0505	5.01	2.91	58.1	58.2	16.99	7.45	43.9	58.2
28	80 x 50	4	TMS 97/2205	4.10	2.48	60.5	62.7	14.87	6.45	43.4	62.7
29	80 x 50	4	TMS 98/0581	5.16	2.78	53.9	63.1	8.97	5.57	62.2	63.1
30	80 x 50	4	TMS 98/0510	6.05	1.76	29.0	28.0	21.90	4.27	19.5	28.0
31	100 x 50	2	TME 419	1.66	0.58	35.1	34.2	7.75	2.64	34.1	34.2
32	100 x 50	2	TMS 98/0505	1.92	0.55	28.7	33.8	9.97	2.61	26.2	33.8
33	100 x 50	2	TMS 97/2205	2.28	0.81	35.3	37.8	5.34	1.78	33.3	37.8
34	100 x 50	2	TMS 98/0581	2.37	0.72	30.5	31.1	6.21	1.74	28.0	31.1
35	100 x 50	2	TMS 98/0510	2.55	0.47	18.5	21.3	8.43	1.55	18.4	21.3
36	100 x 50	3	TME 419	2.18	1.08	49.5	50.7	6.73	3.36	49.9	50.7
37	100 x 50	3	TMS 98/0505	2.97	1.32	44.4	44.9	9.46	3.80	40.2	44.9
38	100 x 50	3	TMS 97/2205	2.17	0.93	42.7	42.7	5.01	2.16	43.1	42.7
39	100 x 50	3	TMS 98/0581	1.99	0.94	47.3	52.9	5.95	2.87	48.3	52.9
40	100 x 50	3	TMS 98/0510	2.99	0.64	21.4	25.8	6.90	1.88	27.3	25.8
41	100 x 50	4	TME 419	3.52	2.17	61.7	62.7	7.11	4.32	60.7	62.7
42	100 x 50	4	TMS 98/0505	3.44	2.16	62.9	63.6	9.41	5.87	62.4	63.6
43	100 x 50	4	TMS 97/2205	2.51	1.66	66.0	66.2	6.90	4.55	65.9	66.2
44	100 x 50	4	TMS 98/0581	3.49	1.46	42.0	45.3	6.40	2.28	35.6	45.3
45	100 x 50	4	TMS 98/0510	4.09	1.84	44.9	45.3	11.90	5.36	45.1	45.3
	Minimum			1.66	0.39	14.5	15.6	5.01	1.06	11.8	15.6
	Maximum			7.83	2.91	66.1	69.3	24.76	7.45	66.0	69.3
	Mean			3.47	1.45	41.1	41.9	10.08	3.75	39.1	41.9
	Std			1.20	0.73	14.86	14.79	4.43	1.66	14.54	14.79
	CV (%)			34.74	50.60	36.18	35.31	43.95	44.19	37.24	35.31
	Standard Error ±			0.18	0.11	2.24	2.23	0.67	0.25	2.19	2.23

EMN 25-cm PS = Expected Mean Number of 25-cm Plantable Stakes; AMN = Actual Mean Number; A=Actual; E = Expected; % Surv = Percentage survival; Std = Standard Deviation; CV = Coefficient of Variation; Diff.= Difference

Table 4.14 Percentage difference in cassava root and forage production per plant at 12 MAP planted at three spacing combinations and three numbers of nodes per stake category at Onne, Rivers State.

S/N	Stand Spacing (cm x cm)	No. Node/ Stake	Variety	ERt Yld (t/ha)	ARt Yld (t/ha)	% Diff. (A/E)	% Surv. Stands	EFor Yld (t/ha)	AFor Yld (t/ha)	% Diff. (A/E)	% Surv. Stands
1	80 x 37.5	2	TME 419	43.76	7.70	17.6	18.7	6.71	1.07	15.9	18.7
2	80 x 37.5	2	TMS 98/0505	127.82	25.65	20.1	19.1	38.18	5.51	14.4	19.1
3	80 x 37.5	2	TMS 97/2205	73.42	9.71	13.2	15.6	12.85	1.81	14.1	15.6
4	80 x 37.5	2	TMS 98/0581	107.04	37.03	34.6	36.0	13.63	4.81	35.3	36.0
5	80 x 37.5	2	TMS 98/0510	57.15	10.59	18.5	25.9	16.60	3.37	20.3	25.9
6	80 x 37.5	3	TME 419	47.64	25.18	52.9	45.8	7.68	2.43	31.6	45.8
7	80 x 37.5	3	TMS 98/0505	82.15	38.17	46.5	37.3	15.01	3.69	24.6	37.3
8	80 x 37.5	3	TMS 97/2205	28.90	12.52	45.1	38.9	6.90	2.02	29.3	38.9
9	80 x 37.5	3	TMS 98/0581	54.69	27.23	49.8	41.8	12.39	3.20	25.8	41.8
10	80 x 37.5	3	TMS 98/0510	59.39	16.88	28.4	25.8	13.38	3.14	23.5	25.8
11	80 x 37.5	4	TME 419	35.54	21.28	59.9	56.9	5.36	2.82	52.6	56.9
12	80 x 37.5	4	TMS 98/0505	55.77	22.50	40.4	39.6	10.02	4.19	41.8	39.6
13	80 x 37.5	4	TMS 97/2205	51.07	35.49	69.5	69.3	13.05	7.43	56.9	69.3
14	80 x 37.5	4	TMS 98/0581	67.24	39.61	58.9	60.9	14.62	10.59	72.4	60.9
15	80 x 37.5	4	TMS 98/0510	29.70	8.98	30.3	28.4	12.15	2.73	22.5	28.4
16	80 x 50	2	TME 419	50.72	23.26	45.9	44.9	5.00	2.22	44.4	44.9
17	80 x 50	2	TMS 98/0505	60.03	20.94	36.3	35.1	15.14	5.33	35.2	35.1
18	80 x 50	2	TMS 97/2205	38.55	12.53	32.5	35.1	8.62	2.86	33.2	35.1
19	80 x 50	2	TMS 98/0581	61.38	20.15	32.8	33.8	7.07	2.35	33.2	33.8
20	80 x 50	2	TMS 98/0510	44.79	7.21	16.1	16.9	9.69	1.63	16.8	16.9
21	80 x 50	3	TME 419	63.70	35.40	55.6	59.1	7.40	3.87	52.3	59.1
22	80 x 50	3	TMS 98/0505	129.87	42.15	32.5	35.1	26.51	7.99	30.1	35.1
23	80 x 50	3	TMS 97/2205	62.81	24.12	38.4	43.6	9.42	3.56	37.8	43.6
24	80 x 50	3	TMS 98/0581	59.84	29.86	49.9	49.3	8.56	4.20	49.1	49.3
25	80 x 50	3	TMS 98/0510	31.94	10.77	33.7	36.9	8.28	2.70	32.6	36.9
26	80 x 50	4	TME 419	60.79	36.31	59.7	64.9	8.90	4.62	51.9	64.9
27	80 x 50	4	TMS 98/0505	75.43	45.76	60.7	58.2	22.39	10.07	45.0	58.2
28	80 x 50	4	TMS 97/2205	54.34	29.68	54.6	62.7	19.98	8.62	43.1	62.7
29	80 x 50	4	TMS 98/0581	58.84	41.75	71.0	63.1	5.85	4.42	75.6	63.1
30	80 x 50	4	TMS 98/0510	67.41	13.78	20.5	28.0	15.83	3.48	22.0	28.0
31	100 x 50	2	TME 419	30.37	11.06	36.4	34.2	3.12	1.12	35.9	34.2
32	100 x 50	2	TMS 98/0505	19.66	6.77	27.1	33.8	9.29	2.42	26.0	33.8
33	100 x 50	2	TMS 97/2205	9.52	3.27	34.3	37.8	3.83	1.25	32.6	37.8
34	100 x 50	2	TMS 98/0581	23.65	8.24	34.9	31.1	4.19	1.44	34.4	31.1
35	100 x 50	2	TMS 98/0510	6.26	1.19	18.9	21.3	4.14	0.69	16.7	21.3
36	100 x 50	3	TME 419	32.64	15.54	47.6	50.7	3.28	1.57	47.9	50.7
37	100 x 50	3	TMS 98/0505	46.29	19.90	43.0	44.9	11.10	4.71	42.4	44.9
38	100 x 50	3	TMS 97/2205	13.62	5.55	40.8	42.7	3.34	1.46	43.7	42.7
39	100 x 50	3	TMS 98/0581	21.84	11.79	54.0	52.9	3.61	1.90	52.6	52.9
40	100 x 50	3	TMS 98/0510	12.29	3.14	25.6	25.8	4.77	1.30	27.3	25.8
41	100 x 50	4	TME 419	27.22	16.85	61.9	62.7	3.56	2.22	62.4	62.7
42	100 x 50	4	TMS 98/0505	36.01	21.46	59.6	63.6	5.88	3.54	60.2	63.6
43	100 x 50	4	TMS 97/2205	21.06	13.61	64.6	66.2	4.65	3.00	64.5	66.2
44	100 x 50	4	TMS 98/0581	30.96	12.19	39.4	45.3	5.29	2.24	42.3	45.3
45	100 x 50	4	TMS 98/0510	17.71	6.96	39.3	45.3	4.52	1.69	37.4	45.3
	Minimum			6.26	1.19	13.20	15.60	3.12	0.69	14.10	15.60
	Maximum			129.87	45.76	71.00	69.30	38.18	10.59	75.60	69.30
	Mean			48.68	19.77	41.18	41.89	10.04	3.50	37.99	41.89
	Std			27.59	12.13	15.37	14.79	6.89	2.32	15.40	14.79
	CV (%)			56.67	61.37	37.31	35.31	68.63	66.27	40.53	35.31
	Standard Error ±			4.16	1.83	2.32	2.23	1.04	0.35	2.32	2.23

ERtYld= Expected root yield; ARtYld = Actual root yield; t/ha = tones/hectare; A = Actual; E = Expected; EForYld = Expected Forage Yield; AForYld = Actual Forage Yield; % Surv.= Percentage survival; Std = Standard Deviation; CV= Coefficient of Variation; Diff = Difference.

Table 4.15 Effect of spacing, varieties and number of nodes per stake on cassava stake production at 6 MAP at the high rainfall station of IITA Onne, Rivers State, June, 2006-June, 2007.

Stake Spacing (cm x cm)	No. Node /Stake	Cassava varieties TME 419	TMS 98/ 0505	TMS 97/ 2205	TMS 98/ 0581	TMS 98/ 0510	Mini mum	Maxi mum	Mean spacing	Std	CV (%)	SE ±
80 x 37.5	2	20.5	18.4	14.5	31.4	16.4	14.5	31.4	20.2	6.6	32.6	3.3
80 x 37.5	3	59.4	44.0	43.7	45.2	27.8	27.8	59.4	44.0	11.2	25.4	5.6
80 x 37.5	4	55.5	44.8	66.1	57.5	24.9	24.9	66.1	49.8	15.8	31.8	7.9
80 x 50	2	44.6	35.7	35.3	35.9	16.6	16.6	44.6	33.6	10.3	30.5	5.1
80 x 50	3	56.3	30.0	39.0	49.2	40.6	30.0	56.3	43.0	10.1	23.4	5.0
80 x 50	4	62.2	58.1	60.5	53.9	29.0	29.0	62.2	52.7	13.6	25.8	6.8
100 x 50	2	35.1	28.7	35.3	30.5	18.5	18.5	35.3	29.6	6.9	23.2	3.4
100 x 50	3	49.5	44.4	42.7	47.3	21.4	21.4	49.5	41.1	11.3	27.5	5.7
100 x 50	4	61.7	62.9	66.0	42.0	44.9	42.0	66.0	55.5	11.2	20.1	5.6
Minimum		20.5	18.4	14.5	30.5	16.4						
Maximum		62.2	62.9	66.1	57.5	44.9		LSD (Spacing) $_{(0.05, 4)}$ = 0.95				
Mean		49.4	40.8	44.8	43.7	26.7		LSD (Node) $_{(0.05, 12)}$ = 0.69				
Std		14.0	14.2	16.9	9.6	10.2		LSD (Variety) $_{(0.05, 72)}$ = 0.69				
CV (%)		28.3	34.9	37.8	21.9	38.3						
SE ±		5.0	5.0	6.0	3.4	3.6						

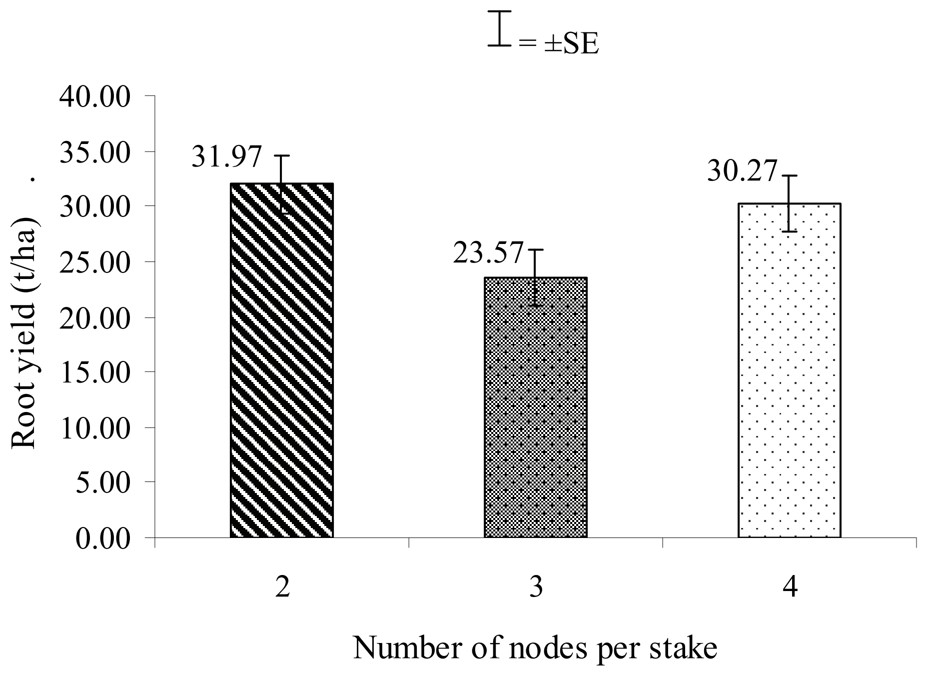
Std = Standard Deviation; SE = Standard Error; CV = Coefficient of Variation;
MAP = Month after planting; cm = centimeter; LSD = Least Significant Difference.
Values indicate number of plantable stakes/plant realized as a percentage of the expected number if there were no missing stands.

Table 4.16 Effect of spacing, varieties and number of nodes per stake on cassava stake production at 12 MAP at the high rainfall station of IITA Onne, Rivers State, June, 2006-June, 2007.

Stake Spacing (cm x cm)	No. Node /Stake	Cassava varieties					Minimum	Maximum	Mean spacing	Std	CV (%)	SE ±
		TME 419	TMS 98/ 0505	TMS 97/ 2205	TMS 98/ 0581	TMS 98/ 0510						
80 x 37.5	2	13.8	16.2	11.8	34.6	30.5	11.8	34.6	21.4	10.4	48.8	5.2
80 x 37.5	3	43.4	36.1	46.8	43.0	22.2	22.2	46.8	38.3	9.8	25.6	4.9
80 x 37.5	4	57.4	27.4	57.4	55.3	25.4	25.4	57.4	44.6	16.6	37.3	8.3
80 x 50	2	44.3	34.0	34.4	33.8	16.7	16.7	44.3	32.6	10.0	30.5	5.0
80 x 50	3	56.6	33.7	42.2	49.8	37.6	33.7	56.6	44.0	9.3	21.0	4.6
80 x 50	4	65.9	43.9	43.4	62.2	19.5	19.5	65.9	47.0	18.5	39.4	9.2
100 x 50	2	34.1	26.2	33.3	28.0	18.4	18.4	34.1	28.0	6.3	22.7	3.2
100 x 50	3	49.9	40.2	43.1	48.3	27.3	27.3	49.9	41.8	9.0	21.5	4.5
100 x 50	4	60.7	62.4	65.9	35.6	45.1	35.6	65.9	53.9	13.0	24.1	6.5
Minimum		13.8	16.2	11.8	28.0	16.7						
Maximum		65.9	62.4	65.9	62.2	45.1		LSD (Spacing) $_{(0.05, 4)}$ = 4.62				
Mean		47.4	35.6	42.0	43.4	27.0		LSD (Node) $_{(0.05, 12)}$ = 3.71				
Std		16.0	13.0	15.3	11.3	9.5		LSD (Variety) $_{(0.05, 72)}$ = 3.03				
CV (%)		33.8	36.5	36.5	26.1	35.1						
SE ±		5.7	4.6	5.4	4.0	3.3						

Std = Standard Deviation; SE = Standard Error; CV = Coefficient of Variation;
MAP = Month after planting; cm = centimeter; LSD = Least Significant Difference

Values indicate number of plantable stakes/plant realized as a percentage of the expected number if there were no missing stands.



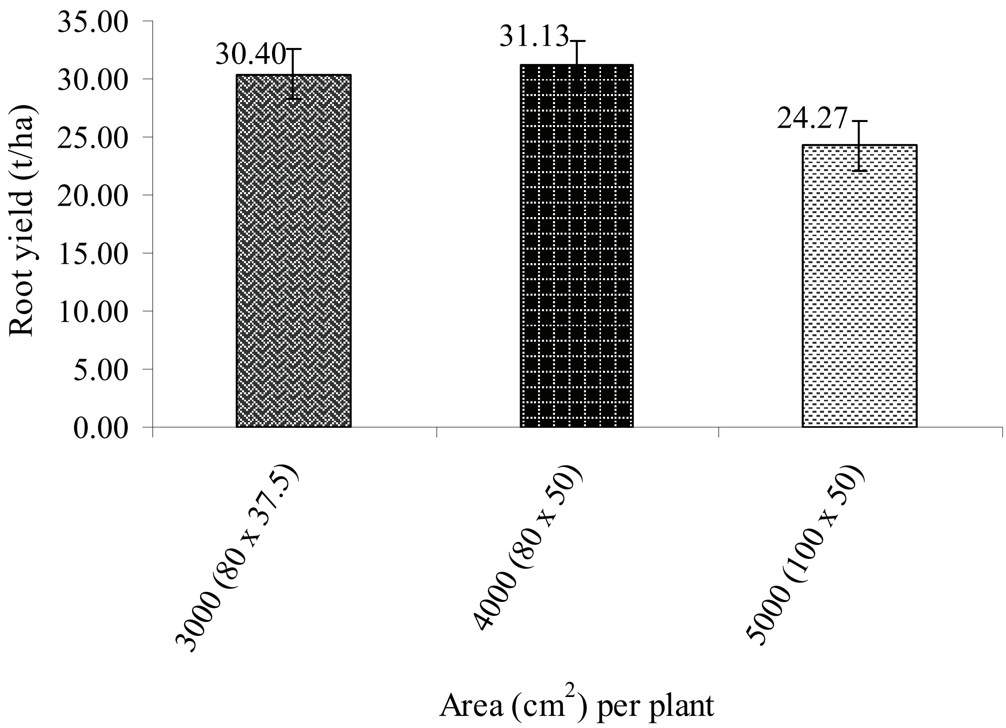


Fig 4.3 Effect of number of node per stake (a) and spacing (b) on the cassava root yield (t/ha) as percentage of the expected root yield if there were no missing stands at12 MAP at the high rainfall station of IITA Onne, Rivers State, June, 2006-June, 2007.

Table 4.17 Effect of spacing and number of node per stake on forage production at12 MAP at the high rainfall station of IITA Onne, Rivers State, during June, 2006-June, 2007.

Stake Spacing (cm x cm)	No. Node /Stake	TME 419	TMS 98/0505	TMS 97/2205	TMS 98/0581	TMS 98/0510	Mini mum	Maxi mum	Mean	Std	CV (%)	SE ±
80 x 37.5	2	15.9	14.4	14.1	35.3	20.3	14.1	35.3	20.0	8.9	44.4	4.4
80 x 37.5	3	31.6	24.6	29.3	25.8	23.5	23.5	31.6	27.0	3.4	12.6	1.7
80 x 37.5	4	52.6	41.8	56.9	72.4	22.5	22.5	72.4	49.3	18.6	37.7	9.3
80 x 50	2	44.4	35.2	33.2	33.2	16.8	16.8	44.4	32.6	9.9	30.5	5.0
80 x 50	3	52.3	30.1	37.8	49.1	32.6	30.1	52.3	40.4	9.9	24.4	4.9
80 x 50	4	51.9	45.0	43.1	75.6	22.0	22.0	75.6	47.5	19.3	40.5	9.6
100 x 50	2	35.9	26.0	32.6	34.4	16.7	16.7	35.9	29.1	7.9	27.2	4.0
100 x 50	3	47.9	42.4	43.7	52.6	27.3	27.3	52.6	42.8	9.6	22.3	4.8
100 x 50	4	62.4	60.2	64.5	42.3	37.4	37.4	64.5	53.4	12.5	23.5	6.3
Minimum		16.1	15.9	14.4	14.1	25.8	16.7					
Maximum		62.6	62.4	60.2	64.5	75.6	37.4	LSD (Spacing) $_{(0.05, 4)}$ = 5.93				
Mean		43.9	43.9	35.5	39.5	46.8	24.3	LSD (Node) $_{(0.05, 12)}$ = 3.03				
Std		14.0	14.0	13.6	15.0	17.5	7.0	LSD (Variety) $_{(0.05, 72)}$ = 3.78				
CV (%)		31.8	31.9	38.1	38.0	37.5	28.7					
SE ±		4.9	4.9	4.8	5.3	6.2	2.5					

Std = Standard Deviation; SE = Standard Error; CV = Coefficient of Variation; cm = centimeter; MAP = Month after planting; LSD = Least Significant Difference

Values indicate forage yield (kg/ha) realize as a percentage of the expected forage yield if there were no missing stands.

4.4 Effect of fertilizers, varieties and spacing on cassava production in Onne and Ogurugu agro-ecologies in Nigeria

4.4.a Location 1. Onne

4.4.a (i) Effect of fertilizers, varieties and spacing on cassava stem production

The analysis of variance for the mean number of 25-cm PS at 6 and 12 MAP is presented in table 4.18. There was significant difference ($p<0.01$) among spacing, variety, fertilizers, interaction spacing*variety, and spacing*fertilizer for the number of 25-cm PS at 6 and 12 MAP. The difference among the interactions variety*fertilizer and spacing*variety*fertilizer was also significant ($p<0.05$) for the number of 25-cm PS at 6 MAP.

The mean number of 25-cm plantable stakes at 6 and 12 MAP are presented in tables 4.19, and 4.20 respectively. The following varieties had the highest mean number of 25-cm plantable stakes across all spacings and fertilizers. These are: 98/0510 (7 cuttings), TME 419 (6 cuttings), 97/2205 (6 cuttings) at 6 MAP and 13 cuttings at 12 MAP for varieties 98/0505, 30572, 98/0510 and NR8082 respectively.

Across all varieties, fertilizer NPKSMgO 13:9:27:5:4 gave the highest mean number of 25-cm plantable stakes (8 cuttings) at 6 MAP at the plant spacings 90 x 60 cm, 90 x 80 cm and 90 x 70 cm. At 12 MAP, fertilizers NPK 16:27:10 + AG, NPK 15:15:15 and NPKSMgO 13:9:27:5:4 gave the highest mean number of 25-cm plantable stakes of 18, 19 and 15 cuttings respectively using the spacing of 90 x 60 cm. Even though fertilizer NPK 15:15:15 had produced 14 cuttings at the plant spacing 60 x 60 cm, fertilizer NPKSMgO 13:9:27:5:4 gave the highest number of plantable stakes almost in all plant spacings (14 cuttings at 80 x 50 cm, 80 x 60 cm, 90 x 70 cm, and 90 x 80 cm).

4.4.a (ii) Effect of fertilizers, varieties and spacing on cassava root production

The analysis of variance for the mean root yield at 12 MAP is presented in table 4.21. There was significant difference ($p<0.01$) among spacing, variety, fertilizers, interaction spacing*variety and variety*fertilizer for root yield at 12 MAP. Interaction spacing*variety*fertilizer was also significant ($p<0.05$).

The mean root yield (t/ha) at 12 MAP is presented is table 4.22. Considering spacing and fertilizer together, varieties NR8082, 98/0505, 98/0510 and 98/0581 had the highest root yield of 57.59 t/ha, 56.42 t/ha, 55.51 t/ha and 51.91 t/ha respectively. Plant spacing 60 x 50 cm had the highest root yield with the fertilizer NPK 15:15:15 (73.15 t/ha), NPKSMgO 13:9:27:5:4 (68.83 t/ha) and NPK 16:27:10 +AG (65.17 t/ha). Fertilizer NPKSMgO 13:9:27:5:4 had high root yield in most of the plant spacing (65.21 t/ha for 70 x 50 cm; 61.39 t/ha for 80 x 50 cm; 60.16 t/ha for 60 x 60 cm and 55.17 t/ha for 90 x 80 cm).

Table 4.18 Mean square values of the analysis of variance for the mean number of 25 cm plantable stakes at 6 MAP and 12 MAP under different fertilizer types at Onne, River State during 2005/2006 cropping season

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square
		6 MAP		12 MAP	
Spacing (SP)	12	485.93	40.49**	879.86	73.32**
Replication (Rep)	2	3.04	1.52	31.35	15.67
SP*Rep	24	94.23	3.93	403.00	16.79
Variety (Var)	6	580.07	96.68**	738.98	123.16**
SP*Var	72	906.92	12.60**	2502.38	34.76**
SP*Var*Rep	156	617.08	3.96**	1815.42	11.64
Fertilizer (Fert)	3	1619.60	539.87	6354.22	2118.07**
SP*Fert	36	110.37	3.07**	837.94	23.28**
Var*Fert	18	58.25	3.24*	261.86	14.55**
SP*Var*Fert	216	458.94	2.12	1429.73	6.62*
Rep*SP*Var*Fert	546	955.01	1.75	2801.73	5.13
Total	1091	5889.44		18056.49	
Grand Mean			5.43		12.21

6 MAP [CV (Spacing) = 36.51 %; CV (Variety) = 36.65 %; CV(Fertilizer) = 24.36%]
12 MAP [CV (Spacing) = 33.56 %; CV (Variety) = 27.94%; CV (Fertilizer) = 18.55 %]
b** = Significant at 1 %; b* = Significant at 5 %; b^{ns} = not significant; MAP = Month after planting

Table 4.19 Mean number of 25-cm plantable stakes at 6 MAP under different types of fertilizers and spacing at Onne, Rivers State during the 2005/2006 planting season.

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV%	SE±
90 x 80	F1	8.83	7.09	6.57	5.80	8.22	5.68	7.92	5.68	8.83	7.16	1.22	16.99	0.50
	F2	6.31	6.99	5.07	7.23	8.13	6.64	6.69	5.07	8.13	6.72	0.93	13.90	0.38
	F3	8.85	6.40	9.07	5.16	9.00	5.78	9.09	5.16	9.09	7.62	1.76	23.11	0.72
	F4	4.41	3.68	3.60	2.33	3.86	3.74	2.71	2.33	4.41	3.48	0.71	20.47	0.29
80 x 80	F1	8.01	5.38	8.39	5.05	8.68	7.41	7.60	5.05	8.68	7.22	1.44	19.92	0.59
	F2	4.90	5.01	6.29	9.51	7.27	4.90	6.19	4.90	9.51	6.30	1.67	26.59	0.68
	F3	7.93	6.34	7.68	6.61	6.87	4.95	7.78	4.95	7.93	6.88	1.05	15.30	0.43
	F4	2.99	3.58	3.08	2.47	3.42	2.32	4.09	2.32	4.09	3.13	0.62	19.92	0.25
90 x 70	F1	4.60	8.17	6.37	5.52	7.99	6.47	3.83	3.83	8.17	6.14	1.62	26.48	0.66
	F2	6.41	7.97	7.27	5.56	5.16	6.46	4.28	4.28	7.97	6.16	1.26	20.47	0.51
	F3	7.12	9.98	6.85	7.11	8.68	8.29	5.00	5.00	9.98	7.57	1.59	20.97	0.65
	F4	2.92	6.44	4.39	2.73	3.88	3.72	3.05	2.73	6.44	3.88	1.28	32.94	0.52
80 x 70	F1	6.98	8.55	5.90	4.84	5.96	5.37	4.24	4.24	8.55	5.98	1.43	23.98	0.59
	F2	5.05	8.25	6.42	4.93	6.80	6.76	4.04	4.04	8.25	6.04	1.43	23.74	0.59
	F3	7.42	10.17	7.43	5.34	8.16	6.54	4.95	4.95	10.17	7.14	1.77	24.77	0.72
	F4	3.60	4.24	3.84	2.68	3.50	4.93	3.32	2.68	4.93	3.73	0.71	19.09	0.29
70 x 70	F1	6.61	7.06	6.53	5.54	6.84	5.96	3.80	3.80	7.06	6.05	1.12	18.52	0.46
	F2	4.85	6.27	5.89	3.84	5.96	7.11	5.41	3.84	7.11	5.62	1.05	18.70	0.43
	F3	5.97	9.10	5.91	5.49	6.59	5.75	5.45	5.45	9.10	6.32	1.28	20.28	0.52
	F4	2.80	4.54	3.59	3.25	4.59	4.01	2.66	2.66	4.59	3.63	0.78	21.52	0.32
90 x 60	F1	5.47	8.95	7.35	4.13	9.46	4.22	4.84	4.13	9.46	6.35	2.24	35.23	0.91
	F2	6.34	9.07	6.49	6.08	8.75	4.35	4.76	4.35	9.07	6.55	1.80	27.53	0.74
	F3	8.38	10.36	9.48	7.33	10.64	5.48	6.39	5.48	10.64	8.29	1.99	23.96	0.81
	F4	3.61	6.08	5.19	2.52	6.80	2.15	3.78	2.15	6.80	4.30	1.77	41.07	0.72
80 x 60	F1	5.21	5.00	8.43	4.94	7.95	4.33	3.82	3.82	8.43	5.67	1.79	31.58	0.73
	F2	4.55	6.85	7.63	4.93	9.09	4.37	4.52	4.37	9.09	5.99	1.87	31.24	0.76
	F3	8.90	7.00	9.78	6.21	10.16	4.24	3.87	3.87	10.16	7.16	2.56	35.69	1.04
	F4	3.21	4.08	5.20	2.76	5.62	2.18	2.77	2.18	5.62	3.69	1.32	35.66	0.54

Table 4.19 Mean number of 25-cm plantable stakes at 6 MAP under different types of fertilizers and spacing at Onne, Rivers State during the 2005/2006 planting season (Contd).

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV%	SE±
70 x 60	F1	5.15	6.15	7.51	5.89	9.66	4.02	6.23	4.02	9.66	6.37	1.80	28.25	0.73
	F2	5.84	5.65	7.00	4.28	8.87	5.39	5.18	4.28	8.87	6.03	1.49	24.78	0.61
	F3	6.09	6.67	8.84	6.87	9.30	7.79	4.68	4.68	9.30	7.18	1.60	22.35	0.65
	F4	3.48	3.31	4.15	3.18	6.09	3.37	2.36	2.36	6.09	3.71	1.18	31.72	0.48
60 x 60	F1	3.49	6.56	7.70	5.89	7.62	3.96	6.48	3.49	7.70	5.95	1.66	27.87	0.68
	F2	4.55	7.32	6.42	5.87	5.88	3.25	5.76	3.25	7.32	5.58	1.32	23.65	0.54
	F3	4.42	7.81	7.52	4.33	10.36	7.12	5.16	4.33	10.36	6.68	2.19	32.76	0.89
	F4	2.67	4.64	2.94	3.31	2.92	2.31	3.67	2.31	4.64	3.21	0.77	23.88	0.31
90 x 50	F1	3.97	4.17	5.47	6.45	7.82	3.37	6.12	3.37	7.82	5.34	1.59	29.77	0.65
	F2	4.15	3.57	5.91	7.36	6.92	4.16	6.04	3.57	7.36	5.44	1.49	27.32	0.61
	F3	3.66	5.37	5.64	7.23	8.27	5.22	6.52	3.66	8.27	5.99	1.50	25.08	0.61
	F4	2.00	2.12	3.96	3.97	3.56	1.39	3.60	1.39	3.97	2.94	1.07	36.38	0.44
80 x 50	F1	4.84	3.27	5.66	6.60	5.84	4.39	5.39	3.27	6.60	5.14	1.09	21.14	0.44
	F2	4.29	4.24	5.30	6.51	6.47	2.82	5.08	2.82	6.51	4.96	1.32	26.54	0.54
	F3	3.69	5.20	6.86	8.01	6.37	3.77	7.10	3.69	8.01	5.86	1.68	28.66	0.69
	F4	3.16	1.64	3.45	5.30	4.16	2.03	3.24	1.64	5.30	3.28	1.24	37.68	0.50
70 x 50	F1	2.94	3.73	5.67	6.84	4.84	3.22	4.25	2.94	6.84	4.50	1.40	31.03	0.57
	F2	2.69	4.20	4.42	7.47	6.57	3.34	4.19	2.69	7.47	4.70	1.72	36.55	0.70
	F3	3.85	4.38	4.94	6.21	6.25	4.01	4.89	3.85	6.25	4.93	0.97	19.75	0.40
	F4	1.89	1.77	3.25	5.15	2.74	2.22	1.94	1.77	5.15	2.71	1.20	44.29	0.49
60 x 50	F1	4.73	3.37	5.57	5.42	7.08	2.75	4.23	2.75	7.08	4.74	1.46	30.77	0.59
	F2	3.71	3.70	4.82	6.76	6.85	3.10	4.70	3.10	6.85	4.81	1.49	31.00	0.61
	F3	3.10	4.40	5.54	5.79	5.56	6.06	4.11	3.10	6.06	4.94	1.09	22.01	0.44
	F4	2.01	2.22	3.38	2.95	3.29	1.59	2.60	1.59	3.38	2.58	0.67	26.12	0.27
Minimum		1.89	1.64	2.94	2.33	2.74	1.39	1.94						
Maximum		8.90	10.36	9.78	9.51	10.64	8.29	9.09						
Mean		4.86	5.73	5.99	5.34	6.76	4.51	4.81						
Std		1.89	2.23	1.73	1.64	2.07	1.71	1.55						
CV%		38.98	38.82	28.79	30.66	30.57	37.93	32.17						
SE±		0.27	0.31	0.24	0.23	0.29	0.24	0.22						

F1 = NPK 16:27:10 + Agrolyzer (DAP:21 %N + 53 %P, 3.2 kg/10kg); F2 = NPK 15:15:15; F3 = NPKSMgO 13:9:27:5:4; F4 = No fertilizer; CV =Coefficient of variation; SE = Standard error; Std = Standard deviation.

Table 4.20 Mean number of 25-cm plantable stakes under different types of fertilizers and spacing at 12MAP at Onne, Rivers State during the 2005/2006 planting season.

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
90 x 80	F1	12.70	16.07	10.43	12.92	12.60	10.63	13.36	10.43	16.07	12.67	1.88	14.84	0.77
	F2	14.41	14.65	12.23	14.44	15.00	9.55	15.08	9.55	15.08	13.62	2.04	14.95	0.83
	F3	14.40	12.88	13.57	14.75	14.76	10.76	19.44	10.76	19.44	14.37	2.64	18.39	1.08
	F4	9.18	9.20	8.08	9.70	10.05	6.79	10.41	6.79	10.41	9.06	1.25	13.76	0.51
80 x 80	F1	11.53	16.99	11.87	13.85	13.31	12.77	13.99	11.53	16.99	13.47	1.81	13.44	0.74
	F2	13.09	12.94	10.16	14.85	13.65	13.31	14.55	10.16	14.85	13.22	1.53	11.59	0.63
	F3	11.60	12.55	11.22	13.99	14.05	10.33	16.72	10.33	16.72	12.92	2.17	16.82	0.89
	F4	6.77	9.72	7.37	9.90	9.63	7.15	10.66	6.77	10.66	8.74	1.58	18.11	0.65
90 x 70	F1	15.64	14.38	12.70	10.79	14.21	14.52	13.30	10.79	15.64	13.65	1.57	11.50	0.64
	F2	18.92	14.41	12.97	12.40	11.76	14.13	12.08	11.76	18.92	13.81	2.46	17.84	1.01
	F3	15.54	14.51	13.60	10.54	13.85	17.86	13.76	10.54	17.86	14.24	2.21	15.53	0.90
	F4	11.37	8.99	8.59	7.47	9.20	10.54	7.20	7.20	11.37	9.05	1.52	16.75	0.62
80 x 70	F1	14.60	12.29	11.04	8.39	12.87	9.56	11.78	8.39	14.60	11.50	2.08	18.05	0.85
	F2	15.79	15.19	10.15	12.54	11.56	10.99	9.87	9.87	15.79	12.30	2.36	19.20	0.96
	F3	13.31	14.24	11.90	8.67	10.52	9.73	10.81	8.67	14.24	11.31	1.97	17.40	0.80
	F4	9.22	9.83	9.61	5.47	8.77	6.07	6.84	5.47	9.83	7.97	1.80	22.63	0.74
70 x 70	F1	14.89	13.86	13.42	13.13	13.21	16.56	12.39	12.39	16.56	13.92	1.39	10.00	0.57
	F2	12.10	12.23	14.23	14.70	16.32	13.18	14.50	12.10	16.32	13.89	1.50	10.80	0.61
	F3	11.57	14.01	13.01	13.03	14.94	13.31	14.14	11.57	14.94	13.43	1.07	8.00	0.44
	F4	8.70	8.00	10.37	9.51	9.43	10.14	9.24	8.00	10.37	9.34	0.81	8.68	0.33
90 x 60	F1	12.39	19.68	13.03	27.20	15.01	13.14	23.28	12.39	27.20	17.67	5.82	32.94	2.38
	F2	14.11	19.14	11.28	26.52	21.99	12.89	25.73	11.28	26.52	18.81	6.21	33.03	2.54
	F3	14.72	16.89	10.95	18.30	13.03	12.23	16.26	10.95	18.30	14.63	2.68	18.32	1.09
	F4	6.93	5.40	6.19	9.31	5.61	5.51	9.07	5.40	9.31	6.86	1.68	24.44	0.68
80 x 60	F1	17.44	15.00	13.03	13.82	11.73	10.70	12.35	10.70	17.44	13.44	2.25	16.74	0.92
	F2	11.60	15.44	11.64	17.38	13.82	11.37	12.33	11.37	17.38	13.37	2.30	17.22	0.94
	F3	14.52	14.00	10.19	14.50	16.07	12.22	19.63	10.19	19.63	14.45	2.96	20.52	1.21
	F4	5.32	8.25	7.53	8.01	8.52	5.56	7.59	5.32	8.52	7.25	1.29	17.74	0.53

Table 4.20 Mean number of 25-cm plantable stakes under different types of fertilizers and spacing at 12MAP at Onne, Rivers State during the 2005/2006 planting season (Contd).

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
70 x 60	F1	11.37	13.15	12.15	13.34	17.75	12.25	10.85	10.85	17.75	12.98	2.28	17.59	0.93
	F2	12.11	13.15	10.26	12.02	19.65	10.99	9.68	9.68	19.65	12.55	3.34	26.63	1.37
	F3	11.96	14.31	12.59	12.00	15.89	10.53	13.25	10.53	15.89	12.93	1.76	13.57	0.72
	F4	7.50	7.27	6.96	6.90	10.51	6.44	5.35	5.35	10.51	7.28	1.59	21.85	0.65
60 x 60	F1	10.87	16.38	14.29	14.26	20.71	13.45	19.00	10.87	20.71	15.57	3.38	21.74	1.38
	F2	12.61	18.60	8.81	15.15	18.83	11.55	13.54	8.81	18.83	14.16	3.67	25.90	1.50
	F3	11.22	15.80	13.15	12.35	15.71	11.52	14.45	11.22	15.80	13.46	1.90	14.11	0.78
	F4	7.04	11.33	9.27	9.28	10.17	7.57	7.84	7.04	11.33	8.93	1.53	17.19	0.63
90 x 50	F1	15.43	17.76	11.71	16.61	12.82	10.97	16.57	10.97	17.76	14.55	2.69	18.46	1.10
	F2	14.34	14.64	11.70	19.08	12.23	13.00	12.86	11.70	19.08	13.98	2.48	17.77	1.01
	F3	16.83	11.60	12.47	16.28	11.54	11.89	13.47	11.54	16.83	13.44	2.23	16.61	0.91
	F4	8.46	4.60	6.44	8.99	7.19	7.61	7.47	4.60	8.99	7.25	1.44	19.82	0.59
80 x 50	F1	13.78	11.26	13.06	13.74	14.02	11.74	13.80	11.26	14.02	13.06	1.11	8.53	0.45
	F2	16.13	11.81	13.59	11.31	13.55	11.25	11.17	11.17	16.13	12.69	1.85	14.55	0.75
	F3	15.55	12.50	14.61	13.40	15.97	13.16	13.50	12.50	15.97	14.10	1.30	9.21	0.53
	F4	6.98	7.53	8.96	7.46	7.66	7.11	7.88	6.98	8.96	7.66	0.65	8.54	0.27
70 x 50	F1	12.36	11.56	12.88	14.68	12.30	11.58	13.14	11.56	14.68	12.64	1.08	8.52	0.44
	F2	11.54	12.46	12.26	13.88	13.54	12.33	13.77	11.54	13.88	12.83	0.90	7.02	0.37
	F3	13.11	10.11	14.00	14.02	11.53	11.22	11.44	10.11	14.02	12.21	1.51	12.38	0.62
	F4	6.10	6.13	8.11	9.44	6.37	7.15	8.24	6.10	9.44	7.36	1.28	17.34	0.52
60 x 50	F1	12.65	13.09	10.53	13.84	12.07	11.73	14.08	10.53	14.08	12.57	1.24	9.89	0.51
	F2	10.88	13.24	10.28	17.08	14.15	10.92	14.30	10.28	17.08	12.98	2.44	18.84	1.00
	F3	14.29	11.44	10.12	18.80	12.57	11.11	12.74	10.12	18.80	13.01	2.88	22.16	1.18
	F4	8.44	7.74	7.11	9.14	6.30	6.57	8.60	6.30	9.14	7.70	1.08	14.04	0.44
	Minimum	5.32	4.60	6.19	5.47	5.61	5.51	5.35						
	Maximum	18.92	19.68	14.61	27.20	21.99	17.86	25.73						
	Mean	12.19	12.66	11.07	13.06	12.86	10.87	12.76						
	Std	3.14	3.46	2.23	4.23	3.52	2.69	3.98						
	CV (%)	25.78	27.35	20.19	32.37	27.35	24.72	31.21						
	SE ±	0.44	0.48	0.31	0.59	0.49	0.38	0.56						

F1 = NPK 16:27:10 + Agrolyzer (DAP:21 %N + 53 %P, 3.2 kg/10kg); F2 = NPK 15:15:15; F3 = NPKSMgO 13:9:27:5:4; F4 = No fertilizer; CV =Coefficient of variation; SE = Standard error; Std = Standard deviation.

Table 4.21 Mean square values of the analysis of variance for the mean root and forage yields (t/ha) at 12 MAP under different fertilizer types at Onne, River State during 2005/2006 cropping season

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square
		Root		Forage	
Spacing (SP)	12	30414.36	2534.53**	4435.24	369.60**
Replication (Rep)	2	479.09	239.55	12.32	6.16
SP*Rep	24	7171.15	298.80**	298.86	12.45
Variety (Var)	6	38006.00	6334.33**	3733.45	622.24**
SP*Var	72	92914.48	1290.48**	3945.18	54.79**
SP*Var*Rep	156	55435.24	355.35**	1540.08	9.87
Fertilizer (Fert)	3	106697.93	35565.98**	2479.93	826.64**
SP*Fert	36	4699.23	130.53^{ns}	406.06	11.28**
Var*Fert	18	5913.81	328.55**	295.56	16.42**
SP*Var*Fert	216	28663.69	132.70*	1136.55	5.26**
Rep*SP*Var*Fert	546	58133.84	106.47	2162.50	3.96
Total	1091	428528.84		20445.72	
Grand Mean			50.72		7.71

Root [CV (Spacing) = 34.08 %; CV (Variety) = 37.17 %; CV (Fertilizer) = 20.34 %]
Forage [CV (Spacing) = 45.76 %; CV (Variety) = 40.75 %; CV (Fertilizer) = 25.81 %]
b** = Significant at 1 %, b* = Significant at 5 %, b^{ns} = not significant; MAP = Month after planting

Table 4.22 Mean root yield (t/ha) under different types of fertilizers and spacing at 12MAP at Onne, Rivers State during the 2005/2006 planting season

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
90 x 80	F1	33.19	57.06	39.55	47.81	41.63	29.20	87.89	29.20	87.89	48.05	19.82	41.26	8.09
	F2	41.02	56.10	48.30	47.24	52.82	29.78	88.08	29.78	88.08	51.91	18.12	34.91	7.40
	F3	52.34	58.74	50.46	54.17	57.14	27.44	85.88	27.44	85.88	55.17	17.13	31.04	6.99
	F4	23.52	32.10	25.15	27.76	26.35	15.00	63.75	15.00	63.75	30.52	15.55	50.95	6.35
80 x 80	F1	24.97	63.54	62.50	52.78	56.55	52.17	73.07	24.97	73.07	55.08	15.12	27.46	6.17
	F2	37.76	58.59	66.28	68.66	71.05	33.33	78.39	33.33	78.39	59.15	17.21	29.10	7.03
	F3	28.26	47.37	49.13	50.08	64.27	42.71	84.11	28.26	84.11	52.27	17.63	33.72	7.20
	F4	15.91	37.05	31.77	35.18	36.40	21.51	54.45	15.91	54.45	33.18	12.37	37.28	5.05
90 x 70	F1	64.25	26.64	39.79	33.70	56.00	60.70	48.88	26.64	64.25	47.14	14.22	30.16	5.80
	F2	56.16	34.86	36.57	45.59	54.30	62.50	41.31	34.86	62.50	47.33	10.54	22.28	4.30
	F3	80.69	30.43	38.69	36.02	57.04	65.08	48.63	30.43	80.69	50.94	17.89	35.12	7.30
	F4	35.04	17.37	27.27	21.70	26.46	33.09	25.79	17.37	35.04	26.67	6.11	22.89	2.49
80 x 70	F1	53.60	41.34	32.17	28.57	63.00	59.35	47.52	28.57	63.00	46.51	13.18	28.34	5.38
	F2	66.90	44.47	39.60	42.06	60.46	44.34	43.54	39.60	66.90	48.77	10.49	21.51	4.28
	F3	62.30	44.87	58.48	42.01	64.17	52.17	44.04	42.01	64.17	52.58	9.20	17.50	3.76
	F4	32.67	24.12	28.79	20.25	22.50	22.80	32.45	20.25	32.67	26.22	5.04	19.23	2.06
70 x 70	F1	70.07	31.50	56.52	40.59	78.62	55.05	43.99	31.50	78.62	53.76	16.62	30.92	6.79
	F2	55.96	31.22	63.62	60.60	77.69	44.79	57.01	31.22	77.69	55.84	14.66	26.26	5.99
	F3	62.24	36.56	71.72	43.83	80.09	60.15	51.11	36.56	80.09	57.96	15.31	26.42	6.25
	F4	28.74	22.11	35.62	27.85	40.65	27.89	33.85	22.11	40.65	30.96	6.14	19.83	2.51
90 x 60	F1	50.92	37.62	44.22	76.00	53.05	39.51	62.06	37.62	76.00	51.91	13.56	26.12	5.53
	F2	34.83	49.41	40.36	71.50	74.39	49.72	74.69	34.83	74.69	56.41	16.84	29.86	6.88
	F3	37.62	35.41	49.95	79.01	65.43	38.86	54.65	35.41	79.01	51.56	16.20	31.42	6.61
	F4	25.37	28.52	34.70	44.13	28.51	16.82	36.98	16.82	44.13	30.72	8.82	28.71	3.60
80 x 60	F1	39.60	38.34	45.80	56.77	56.17	58.22	50.77	38.34	58.22	49.38	8.28	16.76	3.38
	F2	35.25	36.70	53.32	68.42	55.55	46.75	62.50	35.25	68.42	51.21	12.46	24.34	5.09
	F3	53.29	37.75	66.86	79.29	83.26	59.24	61.60	37.75	83.26	63.04	15.49	24.56	6.32
	F4	23.51	24.25	35.78	38.43	36.37	31.20	29.17	23.51	38.43	31.24	5.94	19.00	2.42

Table 4.22 Mean root yield (t/ha) under different types of fertilizers and spacing at 12MAP at Onne, Rivers State during the 2005/2006 planting season (Contd).

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
70 x 60	F1	30.66	53.08	49.40	48.17	64.26	67.66	60.38	30.66	67.66	53.37	12.45	23.33	5.08
	F2	41.16	34.62	48.63	61.80	62.33	70.63	56.45	34.62	70.63	53.66	12.79	23.83	5.22
	F3	35.73	44.71	68.14	53.37	70.50	69.20	53.41	35.73	70.50	56.44	13.43	23.80	5.48
	F4	20.48	24.78	34.63	29.06	36.11	42.30	35.13	20.48	42.30	31.78	7.45	23.44	3.04
60 x 60	F1	33.19	50.48	66.13	61.73	65.74	68.94	71.39	33.19	71.39	59.66	13.49	22.61	5.51
	F2	42.22	37.92	47.43	70.99	57.01	77.11	69.71	37.92	77.11	57.48	15.46	26.89	6.31
	F3	41.00	54.85	65.95	64.07	64.82	65.76	64.66	41.00	65.95	60.16	9.28	15.43	3.79
	F4	26.20	26.78	47.37	37.96	39.14	44.32	38.02	26.20	47.37	37.11	8.05	21.69	3.29
90 x 50	F1	52.14	42.66	54.75	72.18	51.35	53.54	74.87	42.66	74.87	57.36	11.74	20.47	4.79
	F2	77.18	47.98	44.32	84.61	56.11	60.21	47.89	44.32	84.61	59.76	15.56	26.04	6.35
	F3	66.50	38.18	32.39	72.64	69.99	68.52	70.44	32.39	72.64	59.81	16.94	28.32	6.92
	F4	34.32	25.51	26.94	51.75	45.59	34.98	43.09	25.51	51.75	37.45	9.76	26.06	3.98
80 x 50	F1	59.87	43.56	50.49	67.70	55.01	65.60	79.83	43.56	79.83	60.29	12.03	19.96	4.91
	F2	50.69	42.47	46.41	67.83	48.76	72.65	72.60	42.47	72.65	57.35	13.14	22.91	5.36
	F3	57.72	41.67	52.06	89.37	51.81	84.03	53.10	41.67	89.37	61.39	18.01	29.33	7.35
	F4	29.77	26.87	34.01	52.18	34.19	47.97	47.96	26.87	52.18	38.99	10.12	25.96	4.13
70 x 50	F1	54.89	51.72	61.56	85.72	52.34	58.74	77.90	51.72	85.72	63.27	13.32	21.06	5.44
	F2	52.97	52.26	49.40	79.76	50.07	67.28	72.23	49.40	79.76	60.57	12.32	20.35	5.03
	F3	56.57	46.42	62.80	93.45	59.76	71.32	66.16	46.42	93.45	65.21	14.71	22.56	6.01
	F4	34.09	34.44	38.49	54.56	35.20	47.41	44.42	34.09	54.56	41.23	7.82	18.96	3.19
60 x 50	F1	68.63	53.98	51.65	68.98	80.84	73.70	58.40	51.65	80.84	65.17	10.79	16.56	4.40
	F2	69.95	56.88	60.02	90.18	75.55	91.91	67.53	56.88	91.91	73.15	13.70	18.74	5.59
	F3	79.33	56.55	47.46	93.25	76.11	71.11	57.96	47.46	93.25	68.83	15.76	22.90	6.43
	F4	48.00	35.07	36.76	42.28	43.94	45.01	45.21	35.07	48.00	42.32	4.73	11.16	1.93
	Minimum	15.91	17.37	25.15	20.25	22.50	15.00	25.79						
	Maximum	80.69	63.54	71.72	93.45	83.26	91.91	88.08						
	Mean	45.95	40.53	47.12	56.42	55.51	51.91	57.59						
	Std	16.65	11.37	12.28	19.66	15.41	17.96	16.01						
	CV (%)	36.24	28.05	26.06	34.85	27.76	34.60	27.80						
	SE ±	2.33	1.59	1.72	2.75	2.16	2.51	2.24						

F1 = NPK 16:27:10 + Agrolyzer (DAP:21 %N + 53 %P, 3.2 kg/10kg); F2 = NPK 15:15:15; F3 = NPKSMgO 13:9:27:5:4; F4 = No fertilizer;
CV =Coefficient of variation; SE = Standard error; Std = Standard deviation.

4.4.a (iii) Effect of fertilizers, varieties and spacing on cassava forage production

The analysis of variance for the mean forage yield at 12 MAP is presented in table 4.21. There was significant difference ($p<0.01$) among spacing, variety, fertilizers, interaction spacing*variety, spacing*fertilizer, variety*fertilizer and spacing*variety*fertilizer for forage yield at 12 MAP.

The mean forage yield (t/ha) at 12 MAP is presented is table 4.23. Considering spacing and fertilizer together, varieties 98/0505 and 98/0510 had the highest forage yield of 10.15 t/ha and 9.90 t/ha respectively. Plant spacing of 60 x 50 cm had the highest forage yield with the fertilizer NPK 16:27:10 +AG (12.37 t/ha), NPK 15:15:15 (12.29 t/ha) and NPKSMgO 13:9:27:5:4 (11.84 t/ha). Plant spacing 90 x 60 cm also had high forage yield of 11.64 t/ha (NPK 16:27:10 + AG) and 11.15 t/ha (NPK 15:15:15). Fertilizer NPK 16:27:10 + AG and NPK 15:15:15 had high forage yield of 11.27 t/ha and 11.09 t/ha with the plant spacing of 60 x 60 cm.

4.4.b Location 1. Ogurugu

4.4.b (i) Effect of fertilizers, varieties and spacing on cassava stem production

The analysis of variance for the mean number of 25-cm PS at 6 and 12 MAP is presented in table 4.24. There was significant difference ($p<0.01$) among spacing, variety, fertilizers, interactions spacing*variety, spacing*fertilizer variety*fertilizer and spacing*variety*fertilizer for the number of 25-cm PS at 6 and 12 MAP.

The mean number of 25-cm plantable stakes at 6 and 12 MAP are presented in tables 4.25, and 4.26 respectively. The highest mean numbers of 25-cm plantable stakes across all spacings and fertilizers were obtained from varieties 97/2205 (7 cuttings), 98/0510 (6 cuttings), NR8082 (5 cuttings), at 6 MAP and 30572 (13 cuttings), TME 419, 98/0510, and NR8082 each having 12 cuttings at 12 MAP.

At 6 MAP, across all varieties, plant spacing of 90 x 70 cm had the highest mean number of 25-cm plantable stakes with the fertilizers NPK 15:15:15 (7 cuttings), NPK 16:27:10 + AG (6 cuttings) and NPKSMgO 13:9:27:5:4 (6 cuttings). Plant spacing 80 x 70 cm also had the highest mean number of 25-cm plantable stakes with the fertilizers NPK 15:15:15 (6 cuttings) at 6 MAP.

At 12 MAP, the highest mean number of 25-cm plantable stakes was 14 cuttings and was obtained from fertilizers NPK 16:27:10 + AG and NPK 15:15:15 at 90 x 80 cm and 70 x 70 cm plant spacings, NPKSMgO 13:9:27:5:4 at 80 x 80 cm, and NPK 16:27:10 + AG, NPKSMgO 13:9:27:5:4, NPK 15:15:15 at 90 x 70 cm and 80 x 70 cm.

Table 4.23 Mean forage yield (t/ha) under different types of fertilizers and spacing at 12MAP at Onne, Rivers State during the 2005/2006 planting season.

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
90 x 80	F1	3.99	10.42	2.45	5.63	6.81	2.69	9.95	2.45	10.42	5.99	3.25	54.31	1.33
	F2	5.65	9.72	2.62	7.20	7.33	4.26	9.38	2.62	9.72	6.59	2.60	39.46	1.06
	F3	5.08	8.34	2.66	7.64	5.22	3.43	8.10	2.66	8.34	5.78	2.29	39.63	0.94
	F4	3.09	5.92	1.54	4.19	3.86	1.45	6.12	1.45	6.12	3.74	1.88	50.15	0.77
80 x 80	F1	2.61	14.84	7.08	6.68	6.22	4.79	5.78	2.61	14.84	6.86	3.82	55.74	1.56
	F2	2.71	10.57	6.13	7.74	7.25	3.44	4.97	2.71	10.57	6.12	2.70	44.23	1.10
	F3	2.87	7.53	4.36	7.76	7.52	4.08	5.94	2.87	7.76	5.72	1.97	34.49	0.81
	F4	1.69	5.80	2.73	4.31	4.07	2.38	3.91	1.69	5.80	3.56	1.38	38.93	0.57
90 x 70	F1	5.89	4.33	4.95	3.97	6.97	6.55	6.83	3.97	6.97	5.64	1.23	21.79	0.50
	F2	7.62	5.19	3.30	3.86	4.62	5.00	5.86	3.30	7.62	5.06	1.41	27.85	0.58
	F3	6.20	4.49	3.79	4.83	6.24	6.16	6.23	3.79	6.24	5.42	1.03	18.97	0.42
	F4	4.23	3.31	2.12	2.68	3.19	3.84	4.20	2.12	4.23	3.37	0.79	23.38	0.32
80 x 70	F1	6.38	5.24	3.22	3.69	11.94	3.87	5.94	3.22	11.94	5.76	2.98	51.75	1.22
	F2	7.97	6.56	3.96	2.92	7.91	4.40	5.54	2.92	7.97	5.61	1.96	35.02	0.80
	F3	5.77	7.32	2.72	4.51	8.10	5.63	5.01	2.72	8.10	5.58	1.78	31.93	0.73
	F4	3.89	3.67	2.74	4.29	4.38	3.90	3.51	2.74	4.38	3.77	0.55	14.60	0.22
70 x 70	F1	7.96	5.26	5.40	5.31	8.07	8.00	7.09	5.26	8.07	6.73	1.36	20.16	0.55
	F2	6.30	5.63	7.14	3.99	10.52	6.29	6.71	3.99	10.52	6.65	1.98	29.77	0.81
	F3	6.87	6.09	8.06	4.10	8.41	5.37	6.48	4.10	8.41	6.48	1.49	23.04	0.61
	F4	4.58	3.58	4.50	2.94	5.40	3.34	4.57	2.94	5.40	4.13	0.86	20.94	0.35
90 x 60	F1	10.53	13.57	5.99	21.91	12.54	7.28	9.69	5.99	21.91	11.64	5.26	45.18	2.15
	F2	7.20	12.48	5.81	25.82	9.05	5.35	12.35	5.35	25.82	11.15	7.08	63.48	2.89
	F3	8.22	7.69	7.67	21.79	12.37	4.59	8.72	4.59	21.79	10.15	5.62	55.33	2.29
	F4	3.51	4.72	2.76	10.60	5.77	2.20	7.07	2.20	10.60	5.23	2.91	55.69	1.19
80 x 60	F1	7.58	7.52	5.75	9.69	9.37	6.41	7.12	5.75	9.69	7.63	1.45	18.97	0.59
	F2	7.16	6.70	6.17	7.52	9.58	5.88	7.87	5.88	9.58	7.27	1.24	17.07	0.51
	F3	8.26	7.10	7.23	8.37	11.00	7.19	8.47	7.10	11.00	8.23	1.36	16.54	0.56
	F4	2.58	3.98	3.93	5.93	6.74	4.47	4.81	2.58	6.74	4.63	1.37	29.62	0.56

Table 4.23 Mean forage yield (t/ha) under different types of fertilizers and spacing at 12MAP at Onne, Rivers State during the 2005/2006 planting season (Contd).

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
70 x 60	F1	6.08	10.93	5.55	10.63	12.27	8.73	7.49	5.55	12.27	8.81	2.57	29.19	1.05
	F2	7.69	10.48	4.99	14.66	9.34	8.60	7.84	4.99	14.66	9.08	2.99	32.88	1.22
	F3	6.26	9.14	5.49	11.61	11.11	7.87	7.86	5.49	11.61	8.48	2.30	27.13	0.94
	F4	3.69	6.76	3.13	6.81	7.47	5.00	5.63	3.13	7.47	5.50	1.65	30.01	0.67
60 x 60	F1	7.10	13.28	6.79	12.67	17.82	7.15	14.07	6.79	17.82	11.27	4.31	38.21	1.76
	F2	8.11	12.60	6.53	13.55	14.94	8.43	13.47	6.53	14.94	11.09	3.31	29.81	1.35
	F3	7.25	9.82	6.80	11.94	12.98	5.28	12.81	5.28	12.98	9.56	3.14	32.88	1.28
	F4	5.16	7.32	3.96	9.54	8.52	3.47	8.06	3.47	9.54	6.57	2.37	36.08	0.97
90 x 50	F1	11.41	16.92	3.43	11.52	13.56	7.31	11.50	3.43	16.92	10.81	4.34	40.15	1.77
	F2	16.87	15.27	5.19	17.42	16.41	6.97	6.25	5.19	17.42	12.05	5.60	46.43	2.28
	F3	10.78	10.21	3.26	12.79	13.53	6.99	9.51	3.26	13.53	9.58	3.52	36.74	1.44
	F4	4.77	5.09	2.44	9.98	11.12	3.07	7.96	2.44	11.12	6.35	3.38	53.29	1.38
80 x 50	F1	10.68	10.77	5.80	12.06	15.44	6.38	9.84	5.80	15.44	10.14	3.30	32.59	1.35
	F2	9.60	8.82	6.01	14.90	16.79	9.35	7.77	6.01	16.79	10.46	3.91	37.32	1.59
	F3	9.22	8.56	6.11	12.31	13.56	9.99	7.95	6.11	13.56	9.67	2.56	26.45	1.04
	F4	6.23	4.07	4.05	9.17	10.30	4.35	5.21	4.05	10.30	6.20	2.56	41.26	1.04
70 x 50	F1	11.34	12.90	5.86	16.58	10.13	8.25	10.62	5.86	16.58	10.81	3.40	31.47	1.39
	F2	7.23	11.67	5.52	17.83	11.17	8.55	8.09	5.52	17.83	10.01	4.06	40.58	1.66
	F3	6.93	10.27	5.16	18.30	11.69	6.54	9.17	5.16	18.30	9.72	4.41	45.37	1.80
	F4	4.33	6.73	4.25	12.66	8.40	5.06	6.75	4.25	12.66	6.88	2.96	42.98	1.21
60 x 50	F1	14.34	14.31	6.01	15.83	17.80	10.34	7.97	6.01	17.80	12.37	4.34	35.09	1.77
	F2	12.46	14.60	6.91	17.10	17.31	9.54	8.11	6.91	17.31	12.29	4.24	34.47	1.73
	F3	13.33	12.03	4.95	18.78	14.58	9.62	9.56	4.95	18.78	11.84	4.39	37.08	1.79
	F4	6.62	6.84	3.98	9.47	8.06	6.79	5.91	3.98	9.47	6.81	1.71	25.08	0.70
	Minimum	1.69	3.31	1.54	2.68	3.19	1.45	3.51						
	Maximum	16.87	16.92	8.06	25.82	17.82	10.34	14.07						
	Mean	7.00	8.60	4.79	10.15	9.90	5.88	7.65						
	Std	3.19	3.54	1.65	5.65	3.87	2.21	2.40						
	CV (%)	45.60	41.24	34.47	55.61	39.12	37.63	31.35						
	SE ±	0.45	0.50	0.23	0.79	0.54	0.31	0.34						

F1 = NPK 16:27:10 + Agrolyzer (DAP:21 %N + 53 %P, 3.2 kg/10kg); F2 = NPK 15:15:15; F3 = NPKSMgO 13:9:27:5:4; F4 = No fertilizer;
CV =Coefficient of variation; SE = Standard error; Std = Standard deviation.

Table 4.24 Mean square values of the analysis of variance for the mean number of 25 cm plantable stakes at 6 MAP and 12 MAP under different fertilizer types at Ogurugu, Enugu State during 2005/2006 cropping season

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square
		6MAP		12MAP	
Spacing (SP)	12	547.67	45.64*	1282.42	106.87**
Replication (Rep)	2	2.60	1.30	7.70	3.85
SP*Rep	24	100.06	4.17	418.28	17.43
Variety (Var)	6	3136.40	522.73*	826.87	137.81**
SP*Var	72	1254.46	17.42*	1127.37	15.66**
SP*Var*Rep	156	360.62	2.31	891.84	5.72
Fertilizer (Fert)	3	1110.56	370.19*	4157.52	1385.84**
SP*Fert	36	182.91	5.08*	172.10	4.78**
Var*Fert	18	521.75	28.99*	96.26	5.35**
SP*Var*Fert	216	1287.11	5.96*	978.29	4.53**
Rep*SP*Var*Fert	546	971.39	1.78	1477.00	2.71
Total	1091	9475.55		11435.64	
Grand Mean		3.93			11.44

6MAP [CV (Spacing) = 51.96 %; CV (Variety) = 38.67 %; CV (Fertilizer) = 33.95 %]
12MAP [CV (Spacing) = 36.49 %; CV (Variety) = 20.91 %; CV (Fertilizer) = 14.39 %]
b** = Significant at 1 %; b* = Significant at 5 %; b^{ns} = not significant; MAP = Month after planting

Table 4.25 Mean number of 25-cm plantable stakes at 6 MAP under different types of fertilizers and spacing at Ogurugu, Enugu State during the 2005/2006 planting season.

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV%	SE±
90 x 80	F1	6.93	3.92	2.73	3.15	6.67	4.03	4.13	2.73	6.93	4.51	1.65	36.55	0.67
	F2	6.08	3.27	3.21	2.39	6.88	3.17	4.01	2.39	6.88	4.14	1.68	40.51	0.69
	F3	7.01	3.64	3.41	2.96	7.75	3.46	6.57	2.96	7.75	4.97	2.04	41.04	0.83
	F4	3.31	2.03	1.83	2.36	2.71	1.93	2.43	1.83	3.31	2.37	0.52	21.78	0.21
80 x 80	F1	4.87	3.70	3.07	2.53	4.46	3.87	5.38	2.53	5.38	3.98	1.00	25.06	0.41
	F2	6.34	2.82	2.76	2.84	6.09	2.89	4.13	2.76	6.34	3.98	1.60	40.15	0.65
	F3	6.48	3.27	2.71	2.43	5.30	4.71	4.85	2.43	6.48	4.25	1.49	35.03	0.61
	F4	3.30	1.64	1.65	1.64	3.63	1.61	2.55	1.61	3.63	2.29	0.87	38.20	0.36
90 x 70	F1	13.51	3.90	1.01	1.75	10.25	3.04	5.72	1.01	13.51	5.60	4.65	83.00	1.90
	F2	17.43	5.40	1.23	1.50	11.55	2.22	7.37	1.23	17.43	6.67	6.03	90.32	2.46
	F3	13.43	6.09	1.10	2.15	6.61	2.82	10.91	1.10	13.43	6.16	4.63	75.16	1.89
	F4	6.43	2.17	0.56	1.17	2.52	1.82	4.25	0.56	6.43	2.70	2.01	74.49	0.82
80 x 70	F1	9.46	5.47	0.86	0.97	6.36	2.87	7.33	0.86	9.46	4.76	3.29	69.09	1.34
	F2	11.34	2.73	1.15	1.35	10.93	2.43	10.93	1.15	11.34	5.84	4.93	84.40	2.01
	F3	10.41	3.69	1.15	1.04	9.68	2.54	9.72	1.04	10.41	5.46	4.29	78.48	1.75
	F4	8.00	1.89	0.63	0.77	4.81	2.24	3.57	0.63	8.00	3.13	2.61	83.39	1.07
70 x 70	F1	10.29	4.98	1.63	1.71	4.58	2.83	6.12	1.63	10.29	4.59	3.03	65.96	1.24
	F2	8.26	5.23	1.39	1.60	8.35	2.84	7.46	1.39	8.35	5.02	3.09	61.47	1.26
	F3	12.87	2.79	0.79	1.43	6.43	2.41	5.81	0.79	12.87	4.65	4.20	90.35	1.71
	F4	6.94	2.40	0.55	1.18	2.90	1.55	4.06	0.55	6.94	2.80	2.17	77.43	0.88
90 x 60	F1	5.47	5.90	3.46	4.79	6.48	4.11	4.97	3.46	6.48	5.03	1.03	20.57	0.42
	F2	6.50	4.87	3.33	3.67	7.23	2.86	5.09	2.86	7.23	4.79	1.64	34.17	0.67
	F3	5.79	5.70	3.31	5.53	6.92	3.71	5.19	3.31	6.92	5.17	1.25	24.27	0.51
	F4	3.29	2.86	2.16	2.27	2.79	2.38	3.65	2.16	3.65	2.77	0.55	19.92	0.23
80 x 60	F1	6.93	3.88	3.09	4.12	5.73	3.53	5.75	3.09	6.93	4.72	1.42	30.08	0.58
	F2	6.97	4.87	2.95	4.52	4.73	2.93	5.15	2.93	6.97	4.59	1.39	30.26	0.57
	F3	7.22	6.40	3.38	4.83	5.69	2.91	4.86	2.91	7.22	5.04	1.55	30.71	0.63
	F4	3.62	3.05	1.59	2.71	3.48	1.96	3.03	1.59	3.62	2.78	0.76	27.23	0.31

Table 4.25 Mean number of 25-cm plantable stakes at 6 MAP under different types of fertilizers and spacing at Ogurugu, Enugu State during the 2005/2006 planting season (Contd).

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV%	SE±
70 x 60	F1	4.24	4.37	2.67	4.98	6.68	3.86	4.45	2.67	6.68	4.46	1.21	27.19	0.50
	F2	4.98	4.29	2.76	2.81	7.11	3.45	4.97	2.76	7.11	4.34	1.53	35.34	0.63
	F3	6.39	4.33	2.84	3.27	7.48	3.74	6.39	2.84	7.48	4.92	1.81	36.81	0.74
	F4	2.87	2.76	1.81	2.00	3.41	2.34	3.21	1.81	3.41	2.63	0.60	22.90	0.25
60 x 60	F1	3.60	5.63	3.03	4.25	5.90	3.55	4.87	3.03	5.90	4.41	1.10	24.92	0.45
	F2	4.93	5.05	3.32	3.65	6.52	3.18	6.01	3.18	6.52	4.67	1.32	28.39	0.54
	F3	6.49	4.84	2.77	3.23	6.93	3.55	5.47	2.77	6.93	4.75	1.63	34.28	0.67
	F4	2.27	3.45	2.06	1.87	3.38	2.17	3.45	1.87	3.45	2.66	0.72	27.16	0.30
90 x 50	F1	7.33	2.67	1.88	1.18	8.88	2.88	1.94	1.18	8.88	3.82	3.01	78.76	1.23
	F2	12.93	2.69	1.12	1.34	2.34	2.71	6.54	1.12	12.93	4.24	4.23	99.82	1.73
	F3	1.44	4.68	1.48	1.51	6.28	2.33	9.09	1.44	9.09	3.83	2.98	77.80	1.22
	F4	1.07	2.70	0.69	0.74	0.88	1.71	1.22	0.69	2.70	1.29	0.71	55.41	0.29
80 x 50	F1	7.92	1.24	1.57	1.52	8.32	2.13	2.91	1.24	8.32	3.66	3.10	84.68	1.26
	F2	6.52	3.88	1.22	2.47	1.77	2.31	6.59	1.22	6.59	3.54	2.21	62.63	0.90
	F3	3.85	2.15	1.26	1.13	8.69	1.49	8.28	1.13	8.69	3.83	3.31	86.27	1.35
	F4	1.53	0.99	1.03	0.99	1.19	1.03	1.77	0.99	1.77	1.22	0.31	25.64	0.13
70 x 50	F1	8.69	1.78	1.55	1.43	3.55	1.57	2.62	1.43	8.69	3.03	2.61	86.26	1.07
	F2	1.70	1.68	1.31	1.49	1.76	2.02	7.99	1.31	7.99	2.56	2.40	93.61	0.98
	F3	7.24	2.31	1.03	1.31	9.72	1.89	7.85	1.03	9.72	4.48	3.65	81.46	1.49
	F4	1.31	1.17	0.70	0.82	0.97	1.09	1.15	0.70	1.31	1.03	0.21	20.72	0.09
60 x 50	F1	6.92	1.27	1.62	2.39	2.53	1.99	2.25	1.27	6.92	2.71	1.91	70.40	0.78
	F2	4.06	1.77	1.34	1.23	2.67	1.35	6.34	1.23	6.34	2.68	1.90	71.02	0.78
	F3	9.69	3.81	1.45	2.18	13.32	1.18	7.03	1.18	13.32	5.52	4.66	84.29	1.90
	F4	2.39	1.12	1.05	0.87	0.83	0.80	1.69	0.80	2.39	1.25	0.59	47.14	0.24
	Minimum	1.07	0.99	0.55	0.74	0.83	0.80	1.15						
	Maximum	17.43	6.40	3.46	5.53	13.32	4.71	10.93						
	Mean	6.52	3.45	1.89	2.27	5.63	2.58	5.17						
	Std	3.54	1.48	0.93	1.24	2.95	0.89	2.34						
	CV (%)	54.29	42.80	49.16	54.79	52.34	34.63	45.26						
	SE±	0.50	0.21	0.13	0.17	0.41	0.12	0.33						

F1 = NPK 16:27:10 + Agrolyzer (DAP:21 %N + 53 %P, 3.2 kg/10kg); F2 = NPK 15:15:15; F3 = NPKSMgO 13:9:27:5:4; F4 = No fertilizer;
CV =Coefficient of variation; SE = Standard error; Std = Standard deviation.

Table 4.26 Mean number of 25-cm plantable stakes under different types of fertilizers and spacing at 12MAP at Ogurugu, Enugu State during the 2005/2006 planting season.

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
90 x 80	F1	12.42	14.92	17.16	16.29	15.60	12.96	11.44	11.44	17.16	14.40	2.15	14.91	0.88
	F2	12.22	14.99	13.57	15.71	13.04	13.04	12.75	12.22	15.71	13.62	1.27	9.30	0.52
	F3	10.69	14.33	13.04	13.04	13.80	11.71	14.57	10.69	14.57	13.02	1.41	10.80	0.57
	F4	8.01	11.27	9.16	9.73	9.96	10.00	9.89	8.01	11.27	9.72	0.98	10.11	0.40
80 x 80	F1	11.88	13.29	12.88	13.94	12.98	13.03	13.65	11.88	13.94	13.09	0.66	5.03	0.27
	F2	12.84	12.82	13.64	12.92	14.79	12.48	13.11	12.48	14.79	13.23	0.77	5.83	0.32
	F3	11.51	13.55	12.01	13.04	16.15	12.44	17.00	11.51	17.00	13.67	2.11	15.40	0.86
	F4	7.29	8.70	8.49	7.69	10.71	9.51	10.28	7.29	10.71	8.95	1.28	14.28	0.52
90 x 70	F1	12.82	13.88	20.50	12.72	12.03	13.26	12.33	12.03	20.50	13.93	2.96	21.21	1.21
	F2	12.66	14.87	16.27	13.53	13.09	13.31	14.59	12.66	16.27	14.05	1.26	8.99	0.52
	F3	13.02	15.69	16.91	12.48	13.71	11.51	13.32	11.51	16.91	13.80	1.88	13.59	0.77
	F4	9.39	11.24	11.54	9.96	9.17	8.46	9.11	8.46	11.54	9.84	1.15	11.71	0.47
80 x 70	F1	12.21	14.11	15.40	12.67	13.59	12.30	16.65	12.21	16.65	13.85	1.67	12.10	0.68
	F2	13.86	18.27	14.40	13.39	15.18	13.69	13.43	13.39	18.27	14.60	1.73	11.87	0.71
	F3	13.60	15.02	13.12	11.11	14.60	12.78	17.76	11.11	17.76	14.00	2.09	14.95	0.85
	F4	9.77	8.41	10.41	7.33	10.95	8.16	10.38	7.33	10.95	9.34	1.37	14.67	0.56
70 x 70	F1	12.48	15.40	13.49	13.70	12.86	12.14	14.77	12.14	15.40	13.55	1.19	8.82	0.49
	F2	13.69	13.65	16.38	12.60	12.22	12.26	14.24	12.22	16.38	13.58	1.46	10.79	0.60
	F3	13.80	15.77	17.35	12.19	13.57	9.70	11.94	9.70	17.35	13.47	2.54	18.84	1.04
	F4	9.71	9.60	9.76	6.68	9.30	6.41	7.39	6.41	9.76	8.41	1.51	18.02	0.62
90 x 60	F1	8.96	10.55	11.88	12.00	12.84	8.73	12.34	8.73	12.84	11.04	1.66	15.01	0.68
	F2	10.64	13.45	12.69	11.60	13.21	9.55	13.85	9.55	13.85	12.14	1.60	13.16	0.65
	F3	9.51	11.57	12.27	11.40	16.09	9.16	12.63	9.16	16.09	11.80	2.30	19.48	0.94
	F4	5.53	6.56	9.92	8.48	8.96	6.87	9.72	5.53	9.92	8.00	1.70	21.18	0.69
80 x 60	F1	9.32	13.17	11.38	9.72	10.55	9.72	13.16	9.32	13.17	11.00	1.62	14.75	0.66
	F2	10.58	11.30	11.16	10.07	13.98	10.38	13.50	10.07	13.98	11.57	1.55	13.40	0.63
	F3	8.86	11.21	13.17	10.76	12.06	10.82	12.10	8.86	13.17	11.28	1.37	12.11	0.56
	F4	5.27	7.87	10.04	9.84	6.96	7.34	9.49	5.27	10.04	8.12	1.76	21.73	0.72

Table 4.26 Mean number of 25-cm plantable stakes under different types of fertilizers and spacing at 12MAP at Ogurugu, Enugu State during the 2005/2006 planting season (Contd).

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
70 x 60	F1	11.45	15.98	13.07	10.30	13.73	11.54	13.89	10.30	15.98	12.85	1.91	14.85	0.78
	F2	12.63	14.07	12.94	11.46	13.75	12.32	13.65	11.46	14.07	12.98	0.92	7.10	0.38
	F3	12.09	15.14	12.04	11.35	14.79	11.69	14.55	11.35	15.14	13.09	1.65	12.60	0.67
	F4	8.15	8.85	7.76	5.52	10.93	8.14	9.58	5.52	10.93	8.42	1.68	19.91	0.68
60 x 60	F1	10.46	13.32	11.18	14.10	12.79	8.90	11.29	8.90	14.10	11.72	1.80	15.33	0.73
	F2	13.08	11.90	10.83	13.20	12.87	9.16	12.78	9.16	13.20	11.97	1.50	12.49	0.61
	F3	11.47	12.44	11.36	13.00	12.45	11.58	12.51	11.36	13.00	12.12	0.64	5.25	0.26
	F4	6.55	6.57	9.51	8.70	9.80	5.45	8.50	5.45	9.80	7.87	1.67	21.25	0.68
90 x 50	F1	9.72	15.83	9.50	11.84	8.63	9.82	9.84	8.63	15.83	10.74	2.44	22.75	1.00
	F2	7.68	14.95	11.42	8.49	9.02	12.29	8.27	7.68	14.95	10.30	2.67	25.90	1.09
	F3	6.39	20.12	10.08	13.03	11.73	7.90	8.50	6.39	20.12	11.11	4.58	41.21	1.87
	F4	5.49	9.89	3.54	4.12	6.05	3.77	3.99	3.54	9.89	5.26	2.24	42.59	0.92
80 x 50	F1	11.84	13.21	11.42	12.67	11.60	12.41	12.17	11.42	13.21	12.19	0.63	5.17	0.26
	F2	11.59	13.00	15.75	11.25	13.19	11.86	14.07	11.25	15.75	12.96	1.59	12.24	0.65
	F3	10.94	15.59	11.88	13.18	11.13	9.60	12.32	9.60	15.59	12.09	1.91	15.82	0.78
	F4	6.83	9.73	7.39	8.19	5.42	4.80	6.71	4.80	9.73	7.01	1.66	23.63	0.68
70 x 50	F1	11.52	16.28	12.37	11.38	12.58	11.82	12.64	11.38	16.28	12.66	1.67	13.23	0.68
	F2	9.07	14.16	14.66	12.35	12.91	11.53	12.51	9.07	14.66	12.45	1.84	14.77	0.75
	F3	11.91	11.89	12.38	10.55	12.95	11.03	11.74	10.55	12.95	11.78	0.80	6.79	0.33
	F4	6.48	9.09	6.53	6.54	9.57	6.27	7.70	6.27	9.57	7.45	1.37	18.37	0.56
60 x 50	F1	11.19	19.28	10.96	10.97	10.80	9.67	11.27	9.67	19.28	12.02	3.25	27.01	1.33
	F2	13.07	11.60	10.05	11.13	10.34	11.33	11.49	10.05	13.07	11.29	0.98	8.68	0.40
	F3	11.59	12.23	10.28	11.68	10.09	10.25	11.12	10.09	12.23	11.03	0.84	7.62	0.34
	F4	6.55	8.31	5.18	6.60	6.03	5.61	6.58	5.18	8.31	6.41	1.00	15.56	0.41
	Minimum	5.27	6.56	3.54	4.12	5.42	3.77	3.99						
	Maximum	13.86	20.12	20.50	16.29	16.15	13.69	17.76						
	Mean	10.39	12.86	11.92	11.08	11.83	10.20	11.79						
	Std	2.45	3.02	3.11	2.54	2.52	2.45	2.73						
	CV (%)	23.62	23.45	26.09	22.95	21.32	23.99	23.17						
	SE ±	0.34	0.42	0.44	0.36	0.35	0.34	0.38						

F1 = NPK 16:27:10 + Agrolyzer (DAP:21 %N + 53 %P, 3.2 kg/10kg); F2 = NPK 15:15:15; F3 = NPKSMgO 13:9:27:5:4; F4 = No fertilizer;
CV =Coefficient of variation; SE = Standard error; Std = Standard deviation.

4.4.b (ii) Effect of fertilizers, varieties and spacing on cassava root production

The analysis of variance for the mean root yield at 12 MAP is presented in table 4.27. There was significant difference ($p<0.01$) among spacing, variety, fertilizers, interaction spacing*variety, spacing*fertilizer variety*fertilizer and spacing*variety*fertilizer for root yield at 12 MAP.

The mean root yield (t/ha) at 12 MAP is presented is table 4.28. Considering spacing and fertilizer together, varieties NR8082, 30572 and 98/0581 had the highest root yield of 35.98 t/ha, 29.37 t/ha, and 26.11 t/ha respectively. Plant spacing 70 x 70 cm had the highest root yield with the fertilizer NPK 15:15:15 (35.01 t/ha), NPKSMgO 13:9:27:5:4 (33.41 t/ha). Plant spacing 60 x 60 cm also had high root yield with the fertilizers NPK 15:15:15 (33.28 t/ha), NPK 16:27:10 + AG (32.83 t/ha), NPKSMgO 13:9:27:5:4 (32.88 t/ha).

4.4.b (iii) Effect of fertilizers, varieties and spacing on cassava forage production

The analysis of variance for the mean forage yield at 12 MAP is presented in table 4.27. There was significant difference ($p<0.01$) among spacing, variety, fertilizers, interaction spacing*variety, spacing*fertilizer, variety*fertilizer and spacing*variety*fertilizer for forage yield at 12 MAP.

The mean forage yield (t/ha) at 12 MAP is presented is table 4.29. Considering spacing and fertilizer together, the following varieties had the highest forage yield NR 8082 (3.83 t/ha), 98/0510 (3.53 t/ha), 97/2205 (3.18 t/ha) and 30572 (3.13 t/ha). Plant spacing of 60 x 50 cm had the highest forage yield with the fertilizers NPK 16:27:10 +AG (5.01 t/ha), NPK 15:15:15 (4.26 t/ha) and NPKSMgO 13:9:27:5:4 (4.19 t/ha). Plant spacing 70 x 50 cm also had high forage yield of 4.12 t/ha (NPK 16:27:10 + AG) and 4.04 t/ha (NPKSMgO 13:9:27:5:4).

Fertilizer NPK 16:27:10 + AG and NPK 15:15:15 had high forage yield of 11.27 t/ha and 11.09 t/ha with the plant spacing of 60 x 60 cm.

4.4.c Pair comparison of all the fertilizer types at Onne and their effects on cassava stem, root and forage production

Pair comparison of all the fertilizer types showed significant difference ($p<0.01$) for the number of 25-cm PS at 6 MAP, except the pair "premix NPK 16:27:10 + Agrolyzer (DAP: 21: % N + 53 % P, 3.2 kg/10 kg) with NPK 15:15:15" which was not significant for all the parameters measured (Table 4.30).

Table 4.27 Mean square values of the analysis of variance for the mean root and forage yields (t/ha) at 12 MAP under different fertilizer types at Ogurugu, Enugu State during 2005/2006 cropping season

Source of Variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square
		Root		Forage	
Spacing (SP)	12	20549.21	1712.43**	550.05	45.84**
Replication (Rep)	2	133.19	66.59	0.38	0.19
SP*Rep	24	1822.20	75.93	24.22	1.01
Variety (Var)	6	37425.89	6237.65**	808.76	134.79**
SP*Var	72	24291.10	337.38**	404.61	5.62**
SP*Var*Rep	156	4773.54	30.60	113.05	0.72
Fertilizer (Fert)	3	17007.23	5669.08**	114.63	38.21**
SP*Fert	36	1469.39	40.82**	58.75	1.63**
Var*Fert	18	1515.36	84.19**	70.51	3.92**
SP*Var*Fert	216	8005.79	37.06**	368.78	1.71**
Rep*SP*Var*Fert	546	6363.47	11.65	174.45	0.32
Total	1091	123356.38		2688.20	
Grand Mean			25.04		2.80

Root [CV (Spacing) = 34.80 %; CV (Variety) = 22.09 %; CV (Fertilizer) = 13.63 %]
Forage [CV (Spacing) = 35.89 %; CV (Variety) = 30.30 %; CV (Fertilizer) = 20.20 %]
b** = Significant at 1 %, b* = Significant at 5 %, b^{ns} = not significant; MAP = Month after planting

Table 4.28 Mean root yield (t/ha) under different types of fertilizers and spacing at 12MAP at Ogurugu, Enugu State during the 2005/2006 planting season.

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
90 x 80	F1	21.40	33.05	21.54	26.06	23.21	23.27	35.79	21.40	35.79	26.33	5.79	21.98	2.36
	F2	22.22	28.56	17.08	25.27	27.35	25.66	35.90	17.08	35.90	26.01	5.78	22.24	2.36
	F3	21.84	34.38	16.52	29.11	20.80	29.82	43.33	16.52	43.33	27.97	9.15	32.70	3.73
	F4	12.98	23.56	12.46	19.23	8.46	17.63	28.00	8.46	28.00	17.47	6.80	38.91	2.78
80 x 80	F1	28.02	28.44	15.63	26.48	15.76	29.00	39.66	15.63	39.66	26.14	8.35	31.94	3.41
	F2	28.78	29.39	20.18	26.53	19.77	27.39	42.02	19.77	42.02	27.72	7.42	26.76	3.03
	F3	29.08	36.14	17.52	27.56	17.91	33.13	53.99	17.52	53.99	30.76	12.43	40.42	5.08
	F4	18.74	22.15	12.86	16.15	10.78	20.27	28.64	10.78	28.64	18.51	6.00	32.42	2.45
90 x 70	F1	30.91	30.54	17.43	27.65	24.99	37.07	38.47	17.43	38.47	29.58	7.19	24.31	2.94
	F2	25.73	32.10	15.63	28.36	24.85	33.43	46.34	15.63	46.34	29.49	9.45	32.03	3.86
	F3	31.83	36.38	18.30	31.74	23.31	34.02	38.92	18.30	38.92	30.64	7.32	23.89	2.99
	F4	20.24	24.88	9.12	20.85	17.17	25.35	26.73	9.12	26.73	20.62	6.09	29.51	2.48
80 x 70	F1	29.34	34.39	18.03	32.72	32.36	31.32	51.68	18.03	51.68	32.83	9.93	30.25	4.05
	F2	26.91	38.94	18.87	30.27	33.33	32.17	42.70	18.87	42.70	31.88	7.81	24.49	3.19
	F3	30.11	38.68	17.44	28.01	34.59	29.78	45.73	17.44	45.73	32.05	8.91	27.80	3.64
	F4	19.72	28.39	11.29	19.98	22.75	24.85	34.76	11.29	34.76	23.11	7.39	31.99	3.02
70 x 70	F1	27.87	45.93	17.86	33.82	19.81	30.09	50.88	17.86	50.88	32.32	12.40	38.37	5.06
	F2	24.98	45.40	17.02	37.26	32.70	27.98	59.76	17.02	59.76	35.01	14.17	40.46	5.78
	F3	28.63	36.42	18.43	32.59	36.59	32.23	48.98	18.43	48.98	33.41	9.23	27.62	3.77
	F4	21.53	25.63	6.50	25.53	26.59	23.75	38.86	6.50	38.86	24.06	9.53	39.62	3.89
90 x 60	F1	22.99	31.80	13.43	25.39	27.55	32.30	38.69	13.43	38.69	27.45	8.05	29.34	3.29
	F2	26.88	31.73	12.80	19.10	21.29	25.21	35.74	12.80	35.74	24.68	7.75	31.42	3.17
	F3	25.86	38.39	12.14	20.09	22.64	26.73	38.68	12.14	38.68	26.36	9.59	36.39	3.92
	F4	17.57	26.68	7.83	13.24	16.97	21.19	29.43	7.83	29.43	18.99	7.49	39.45	3.06
80 x 60	F1	22.45	29.40	12.58	23.28	20.14	36.51	43.12	12.58	43.12	26.78	10.37	38.71	4.23
	F2	19.80	33.70	10.94	20.83	16.58	31.52	59.07	10.94	59.07	27.49	16.07	58.44	6.56
	F3	24.56	31.87	15.30	18.98	20.44	32.39	52.12	15.30	52.12	27.95	12.43	44.49	5.08
	F4	12.94	17.89	4.17	12.60	15.54	27.45	34.98	4.17	34.98	17.94	10.24	57.10	4.18

Table 4.28 Mean root yield (t/ha) under different types of fertilizers and spacing at 12MAP at Ogurugu, Enugu State during the 2005/2006 planting (Contd).

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
70 x 60	F1	28.69	43.77	13.76	28.52	33.55	34.85	39.14	13.76	43.77	31.75	9.62	30.30	3.93
	F2	25.87	40.68	16.73	21.78	27.64	30.72	48.86	16.73	48.86	30.33	11.07	36.52	4.52
	F3	28.73	42.77	15.48	23.94	21.99	33.88	44.56	15.48	44.56	30.19	10.82	35.85	4.42
	F4	20.16	22.97	5.84	14.26	20.91	21.32	32.83	5.84	32.83	19.76	8.26	41.79	3.37
60 x 60	F1	23.32	40.71	14.22	31.98	27.69	33.23	58.67	14.22	58.67	32.83	14.11	42.96	5.76
	F2	36.07	35.48	15.09	26.97	26.66	32.19	60.50	15.09	60.50	33.28	13.96	41.95	5.70
	F3	29.98	42.19	14.90	32.89	29.55	33.73	46.93	14.90	46.93	32.88	10.23	31.10	4.17
	F4	17.05	27.15	7.28	16.53	21.87	20.96	36.84	7.28	36.84	21.10	9.25	43.84	3.78
90 x 50	F1	15.12	26.71	14.46	23.85	17.22	18.79	23.09	14.46	26.71	19.89	4.71	23.66	1.92
	F2	11.93	22.07	16.64	14.57	15.83	20.60	16.12	11.93	22.07	16.82	3.47	20.63	1.42
	F3	13.80	28.73	13.77	24.56	14.17	20.06	14.62	13.77	28.73	18.53	6.08	32.83	2.48
	F4	6.86	15.92	6.67	7.58	6.67	13.80	10.53	6.67	15.92	9.72	3.81	39.21	1.56
80 x 50	F1	12.66	23.40	20.30	21.69	15.03	17.71	22.11	12.66	23.40	18.99	3.99	21.01	1.63
	F2	11.12	16.89	18.82	19.90	25.88	19.76	19.11	11.12	25.88	18.78	4.38	23.30	1.79
	F3	9.34	29.51	26.35	19.99	16.37	18.67	14.00	9.34	29.51	19.17	6.96	36.29	2.84
	F4	6.16	14.07	43.33	16.04	8.09	10.22	9.63	6.16	43.33	15.36	12.79	83.23	5.22
70 x 50	F1	21.85	33.62	22.79	22.31	26.73	22.04	29.78	21.85	33.62	25.59	4.63	18.09	1.89
	F2	16.77	23.77	17.73	26.57	29.95	23.56	29.23	16.77	29.95	23.94	5.18	21.64	2.12
	F3	26.54	27.01	29.73	22.68	31.74	25.19	33.11	22.68	33.11	28.00	3.71	13.24	1.51
	F4	10.34	14.82	14.95	12.58	19.59	16.87	16.67	10.34	19.59	15.12	3.02	19.99	1.23
60 x 50	F1	18.30	15.23	24.89	36.78	21.05	22.64	29.66	15.23	36.78	24.08	7.26	30.14	2.96
	F2	23.26	13.75	20.72	24.22	22.78	23.51	26.38	13.75	26.38	22.09	4.05	18.32	1.65
	F3	27.77	21.57	22.09	33.90	20.77	22.93	25.91	20.77	33.90	24.99	4.66	18.63	1.90
	F4	13.19	9.87	13.32	16.80	16.08	19.00	19.83	9.87	19.83	15.44	3.53	22.85	1.44
	Minimum	6.16	9.87	4.17	7.58	6.67	10.22	9.63						
	Maximum	36.07	45.93	43.33	37.26	36.59	37.07	60.50						
	Mean	21.71	29.37	16.13	23.84	22.15	26.11	35.98						
	Std	7.10	8.87	6.40	6.72	6.96	6.33	13.12						
	CV (%)	32.70	30.21	39.70	28.20	31.43	24.23	36.48						
	SE ±	0.99	1.24	0.90	0.94	0.97	0.89	1.84						

F1 = NPK 16:27:10 + Agrolyzer (DAP:21 %N + 53 %P, 3.2 kg/10kg); F2 = NPK 15:15:15; F3 = NPKSMgO 13:9:27:5:4; F4 = No fertilizer;
CV =Coefficient of variation; SE = Standard error; Std = Standard deviation.

Table 4.29 Mean forage yield (t/ha) under different types of fertilizers and spacing at 12MAP at Ogurugu, Enugu State during the 2005/2006 planting season

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
90 x 80	F1	2.23	2.95	1.67	4.58	5.94	1.46	2.88	1.46	5.94	3.10	1.62	52.32	0.66
	F2	2.08	2.72	1.62	4.32	4.83	1.78	3.35	1.62	4.83	2.96	1.26	42.58	0.51
	F3	2.15	2.65	1.29	2.97	3.68	1.91	4.46	1.29	4.46	2.73	1.08	39.73	0.44
	F4	1.84	2.34	0.89	1.99	3.33	1.04	2.41	0.89	3.33	1.98	0.84	42.37	0.34
80 x 80	F1	2.53	3.11	1.52	4.04	5.01	1.86	3.47	1.52	5.01	3.08	1.22	39.78	0.50
	F2	2.44	3.25	1.12	5.52	4.41	1.78	3.35	1.12	5.52	3.12	1.52	48.50	0.62
	F3	2.63	4.19	1.09	4.00	4.64	2.08	5.02	1.09	5.02	3.38	1.46	43.23	0.60
	F4	1.94	2.59	0.74	2.77	3.58	1.17	2.52	0.74	3.58	2.19	0.98	44.61	0.40
90 x 70	F1	3.63	2.21	1.45	3.47	3.57	1.62	4.01	1.45	4.01	2.85	1.06	37.10	0.43
	F2	4.40	2.97	1.42	2.84	5.47	1.35	4.30	1.35	5.47	3.25	1.56	47.91	0.64
	F3	3.97	2.79	1.42	3.26	4.49	1.40	3.23	1.40	4.49	2.94	1.18	40.14	0.48
	F4	2.99	1.57	1.18	2.55	2.73	1.18	2.94	1.18	2.99	2.16	0.82	37.88	0.33
80 x 70	F1	3.39	2.80	1.68	4.08	3.78	1.31	3.82	1.31	4.08	2.98	1.10	36.86	0.45
	F2	2.95	2.99	1.71	4.29	4.21	1.36	3.79	1.36	4.29	3.04	1.16	38.11	0.47
	F3	3.98	3.40	1.57	3.26	4.52	1.32	6.28	1.32	6.28	3.48	1.71	49.21	0.70
	F4	2.69	2.52	1.34	2.22	3.41	1.05	3.30	1.05	3.41	2.36	0.90	38.33	0.37
70 x 70	F1	4.27	5.50	1.48	4.09	4.59	1.84	3.95	1.48	5.50	3.67	1.47	40.06	0.60
	F2	3.47	3.06	1.49	4.30	4.20	2.04	5.70	1.49	5.70	3.47	1.44	41.43	0.59
	F3	4.83	4.52	2.36	3.66	4.16	1.66	4.30	1.66	4.83	3.64	1.19	32.60	0.48
	F4	2.10	2.04	1.05	3.24	3.54	1.29	3.27	1.05	3.54	2.36	1.00	42.45	0.41
90 x 60	F1	1.36	1.15	0.79	3.42	2.54	1.44	2.76	0.79	3.42	1.92	0.98	50.93	0.40
	F2	1.80	1.66	0.75	3.30	2.10	1.42	2.65	0.75	3.30	1.95	0.83	42.64	0.34
	F3	1.76	1.63	1.24	3.44	2.38	1.03	2.84	1.03	3.44	2.04	0.88	42.90	0.36
	F4	1.49	1.37	0.45	2.22	2.02	0.59	2.39	0.45	2.39	1.50	0.77	51.05	0.31
80 x 60	F1	1.10	1.44	0.77	2.11	1.49	0.96	1.79	0.77	2.11	1.38	0.47	34.34	0.19
	F2	1.61	2.07	0.71	1.85	2.27	1.48	2.91	0.71	2.91	1.84	0.69	37.31	0.28
	F3	1.54	2.04	1.09	1.55	1.66	0.87	2.83	0.87	2.83	1.65	0.64	38.95	0.26
	F4	1.52	1.75	0.49	0.93	1.32	0.81	1.79	0.49	1.79	1.23	0.50	40.40	0.20

Table 4.29 Mean forage yield (t/ha) under different types of fertilizers and spacing at 12MAP at Ogurugu, during the 2005/2006 planting season (Contd).

Spacing (cm x cm)	Fertilizer types	TMS 97/2205	TMS 30572	TME 419	TMS 98/0505	TMS 98/0510	TMS 98/0581	NR 8082	Minimum	Maximum	Mean	Std	CV (%)	SE ±
70 x 60	F1	1.99	2.76	1.20	2.65	2.95	1.36	2.51	1.20	2.95	2.20	0.70	31.71	0.29
	F2	1.72	3.17	1.05	2.66	2.38	1.56	2.34	1.05	3.17	2.12	0.72	33.95	0.29
	F3	1.80	3.25	1.07	1.94	2.85	1.39	2.42	1.07	3.25	2.10	0.78	37.12	0.32
	F4	1.86	1.21	0.53	1.29	3.82	1.12	2.36	0.53	3.82	1.74	1.08	62.19	0.44
60 x 60	F1	1.88	2.23	1.07	3.19	4.83	1.11	3.82	1.07	4.83	2.59	1.42	54.64	0.58
	F2	2.97	2.24	1.34	3.64	3.65	1.29	3.73	1.29	3.73	2.69	1.08	40.11	0.44
	F3	2.71	2.25	1.59	2.64	3.65	1.72	2.73	1.59	3.65	2.47	0.70	28.37	0.29
	F4	2.52	1.60	0.55	2.65	4.48	0.81	2.89	0.55	4.48	2.21	1.35	61.17	0.55
90 x 50	F1	3.61	5.44	0.98	2.79	2.92	2.02	4.84	0.98	5.44	3.23	1.55	48.06	0.63
	F2	2.77	6.01	1.00	1.51	2.48	1.32	5.16	1.00	6.01	2.89	1.96	67.71	0.80
	F3	3.02	1.83	1.37	2.96	3.25	1.25	3.43	1.25	3.43	2.44	0.93	38.07	0.38
	F4	2.74	1.51	1.35	1.34	1.42	1.43	2.74	1.34	2.74	1.79	0.65	36.38	0.27
80 x 50	F1	4.44	4.88	1.68	1.77	3.80	1.80	5.18	1.68	5.18	3.36	1.57	46.69	0.64
	F2	4.23	4.88	2.09	1.59	3.83	1.88	6.03	1.59	6.03	3.51	1.69	48.32	0.69
	F3	3.78	5.36	2.81	1.90	2.83	2.03	3.97	1.90	5.36	3.24	1.22	37.63	0.50
	F4	3.65	2.29	5.35	2.15	2.93	1.56	3.51	1.56	5.35	3.06	1.26	41.10	0.51
70 x 50	F1	4.61	6.52	1.65	3.25	3.61	2.87	6.36	1.65	6.52	4.12	1.81	43.92	0.74
	F2	4.33	4.14	1.02	3.37	3.02	2.53	6.61	1.02	6.61	3.57	1.74	48.54	0.71
	F3	8.60	3.32	2.28	2.54	3.95	2.36	5.26	2.28	8.60	4.04	2.27	56.17	0.93
	F4	5.64	2.45	2.55	1.89	7.26	1.70	3.60	1.70	7.26	3.58	2.10	58.71	0.86
60 x 50	F1	5.00	9.16	2.11	3.91	3.88	2.37	8.63	2.11	9.16	5.01	2.83	56.57	1.16
	F2	7.76	4.82	2.08	2.98	3.78	2.47	5.90	2.08	7.76	4.26	2.04	47.98	0.83
	F3	6.69	5.31	2.66	4.88	2.83	2.30	4.68	2.30	6.69	4.19	1.63	38.92	0.67
	F4	4.20	3.10	2.00	2.07	3.10	2.15	4.30	2.00	4.30	2.99	0.98	32.74	0.40
Minimum		1.10	1.15	0.45	0.93	1.32	0.59	1.79						
Maximum		8.60	9.16	5.35	5.52	7.26	2.87	8.63						
Mean		3.18	3.13	1.46	2.92	3.53	1.57	3.83						
Std		1.59	1.59	0.78	1.02	1.16	0.49	1.40						
CV (%)		49.94	50.75	53.77	34.83	32.84	31.29	36.57						
SE ±		0.22	0.22	0.11	0.14	0.16	0.07	0.20						

F1 = NPK 16:27:10 + Agrolyzer (DAP:21 %N + 53 %P, 3.2 kg/10kg); F2 = NPK 15:15:15; F3 = NPKSMgO 13:9:27:5:4; F4 = No fertilizer;
CV =Coefficient of variation; SE = Standard error; Std = Standard deviation.

Table 4.30 Mean square values of the analysis of variance for the mean number of 25-cm plantable stakes at 6 and 12 MAP, root and forage yields for each fertilizer type at 12 MAP at Onne, during the 2005/2006 cropping season.

Interaction among fertilizer types	Degree of Freedom	No. 25-cm plantable stakes at 6 MAP		No. 25-cm plantable stakes at 12 MAP		Mean root yield (t/ha)		Mean forage yield (t/ha)	
		Sum of Square	Mean Square	Sum of Square	Mean Square	Sum of Square	Mean Square	Sum of Square	Mean Square
F with Cntl	1	1491.06	1491.06^{**}	6341.07	6341.07^{**}	105104.56	105104.56^{**}	2414.37	2414.37^{**}
F2 with F3	1	110.15	110.15^{**}	11.19	11.19^{ns}	418.57	418.57^{*}	42.43	42.43^{**}
F3 with F4	1	1445.07	1445.07^{**}	3961.68	3961.68^{**}	81128.59	81128.59^{**}	1258.44	1258.44^{**}
F1 with F3	1	80.31	80.31^{**}	8.32	8.32^{ns}	1593.04	1593.04^{**}	55.08	55.08^{**}
F1 with F4	1	844.05	844.05^{**}	4333.16	4333.16^{**}	59984.80	59984.80^{**}	1840.08	1840.08^{**}
F2 with F4	1	757.28	757.28^{**}	4393.88	4393.88^{**}	69892.42	69892.42^{**}	1762.10	1762.10^{**}
F1 with F2	1	2.35	2.35^{ns}	0.21	0.21^{ns}	378.45	378.45^{ns}	0.82	0.82^{ns}

F= Fertilizer, F1 = NPK 16:27:10 + Agrolyzer (DAP: 21 % N + 53 % P, 3.2 kg / 10 kg); F2 = NPK 15:15:15; F3 = NPKSMgO 13:9:27:5:4; Cntl = Control = No fertilizer

There was significant difference among each fertilizer type compared with the control. At 12 MAP the differences between NPK 15:15:15 and NPKSMgO 13:9:27:5:4 were not significant for the number of 25-cm PS. But these differences were significant for the root yield ($p<0.05$) and the forage yield ($p<0.01$). There were no significant differences between NPK 16:27:10 + Agrolyzer (DAP: 21 % N + 53 % P, 3.2 kg/10kg) and NPKSMgO 13:9:27:5:4 for the number of 25-cm PS. These differences were significant for the root yield and forage yields ($p<0.01$)

4.4.d Pair comparison of all the fertilizer types at Ogurugu and their effects on cassava stem, root and forage production

Pair comparison of all the fertilizer types showed significant difference ($p<0.01$) for the number of 25-cm PS at 6 MAP, except the pair "premix NPK 16:27:10 + Agrolyzer (DAP: 21: % N + 53 % P, 3.2 kg/10 kg) with NPK 15:15:15" which was not significant for all the parameters measured (Table 4.31). There was significant difference among each fertilizer type compared with the control. At 12 MAP the differences between NPK 15:15:15 and NPKSMgO 13:9:27:5:4 were not significant for the number of 25-cm PS and for the forage yield. But these differences were significant for the root yield ($p<0.01$). There were no significant differences between NPK 16:27:10 + Agrolyzer (DAP: 21 % N + 53 % P, 3.2 kg/10kg) and NPKSMgO 13:9:27:5:4 for the number of 25-cm PS and forage yield. These differences were significant for the root yield ($p<0.05$).

4.4.e The percentage increase in the cassava stem, root and forage production due to fertilizer application

Taking all the fertilizer types together and varieties on the other hands, the mean number of 25-cm PS (from 6 to 12 MAP), forage and root yields for each fertilizer types and for each variety are presented in figures 4.4 and 4.5. Varieties 98/0505 and 98/0510 responded well to fertilizer treatments and for all parameters measured (8 and 9 cuttings, 10 t/ha for forage and 50 t/ha for root yield) at Onne. Fertilizers were more effective at Onne than Ogurugu for all the parameters studied. There was no significant difference among the fertilizer types for the number of 25-cm PS at 12 MAP at Onne and Ogurugu and for the forage yield at Ogurugu. However, NPKSMgO 13:9:27:5:4 fertilizer had the highest number of 25-cm PS (9 stakes) at Onne and Ogurugu (8 stakes) and the highest root yield (58.1 t/ha) at Onne and (27.93 t/ha) at Ogurugu. The highest forage yield was obtained with the premix (NPK 15:15:15 + Agrolyzer) fertilizer at Onne (8.8 t/ha) and Ogurugu (3.04 t/ha).

Table 4.31 Mean square values of the analysis of variance for the mean number of 25-cm plantable stakes at 6 and 12 MAP, root and forage yields for each fertilizer type at 12 MAP at Ogurugu, during the 2005/2006 cropping season.

Interaction among fertilizer types	Degree of Freedom	No. 25-cm plantable stakes at 6 MAP		No. 25-cm plantable stakes at 12 MAP		Mean root yield (t/ha)		Mean forage yield (t/ha)	
		Sum of Square	Mean Square	Sum of Square	Mean Square	Sum of Square	Mean Square	Sum of Square	Mean Square
F with Cntl	1	1057.26	1057.26**	4152.42	4152.42**	16815.50	16815.50**	113.49	113.49**
F2 with F3	1	28.79	28.79**	4.86	4.86^{ns}	191.28	191.28**	0.09	0.09^{ns}
F3 with F4	1	940.08	940.08**	2668.04	2668.04**	12766.58	12766.58**	68.12	68.12**
F1 with F3	1	48.58	48.58**	0.46	0.46^{ns}	56.26	56.26*	1.07	1.07^{ns}
F1 with F4	1	561.24	561.24**	2738.76	2738.76**	11127.80	11127.80**	86.30	86.30**
F2 with F4	1	639.84	639.84**	2900.59	2900.59**	9832.48	9832.48**	73.12	73.12**
F1 with F2	1	2.57	2.57^{ns}	2.32	2.32^{ns}	40.06	40.06^{ns}	0.55	0.55^{ns}

F1 = NPK 16:27:10 + Agrolyzer (DAP: 21 % N + 53 % P, 3.2 kg / 10 kg); F2 = NPK 15:15:15; F3 = NPKSMgO 13:9:27:5:4;
Cntl = Control = No fertilizer

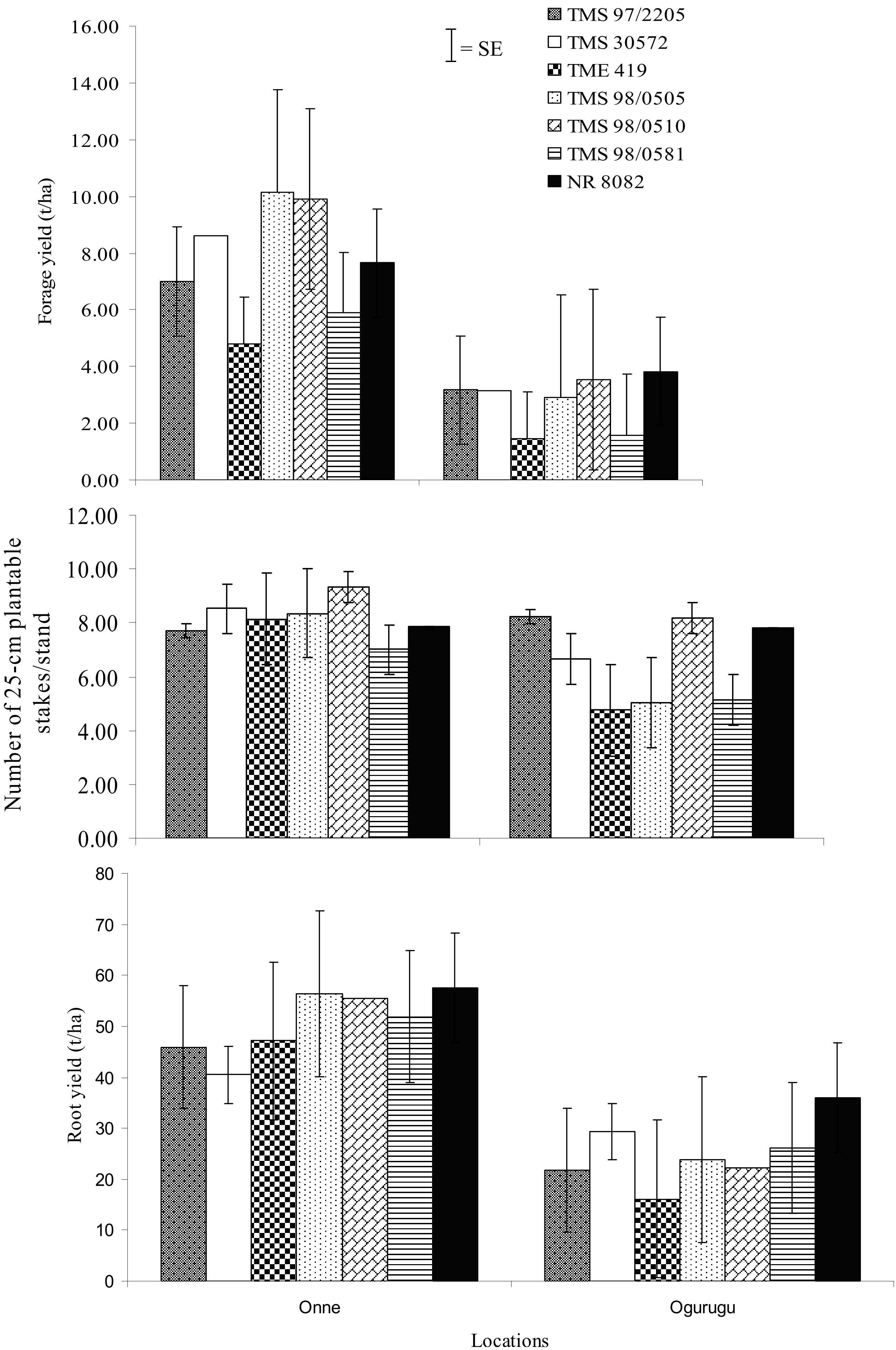


Fig 4.4 Mean number of 25-cm plantable stakes from 6 to 12 MAP, root and forage yields (t/ha) for each variety at 12 MAP at Onne, and Ogurugu during the 2005/2006 planting

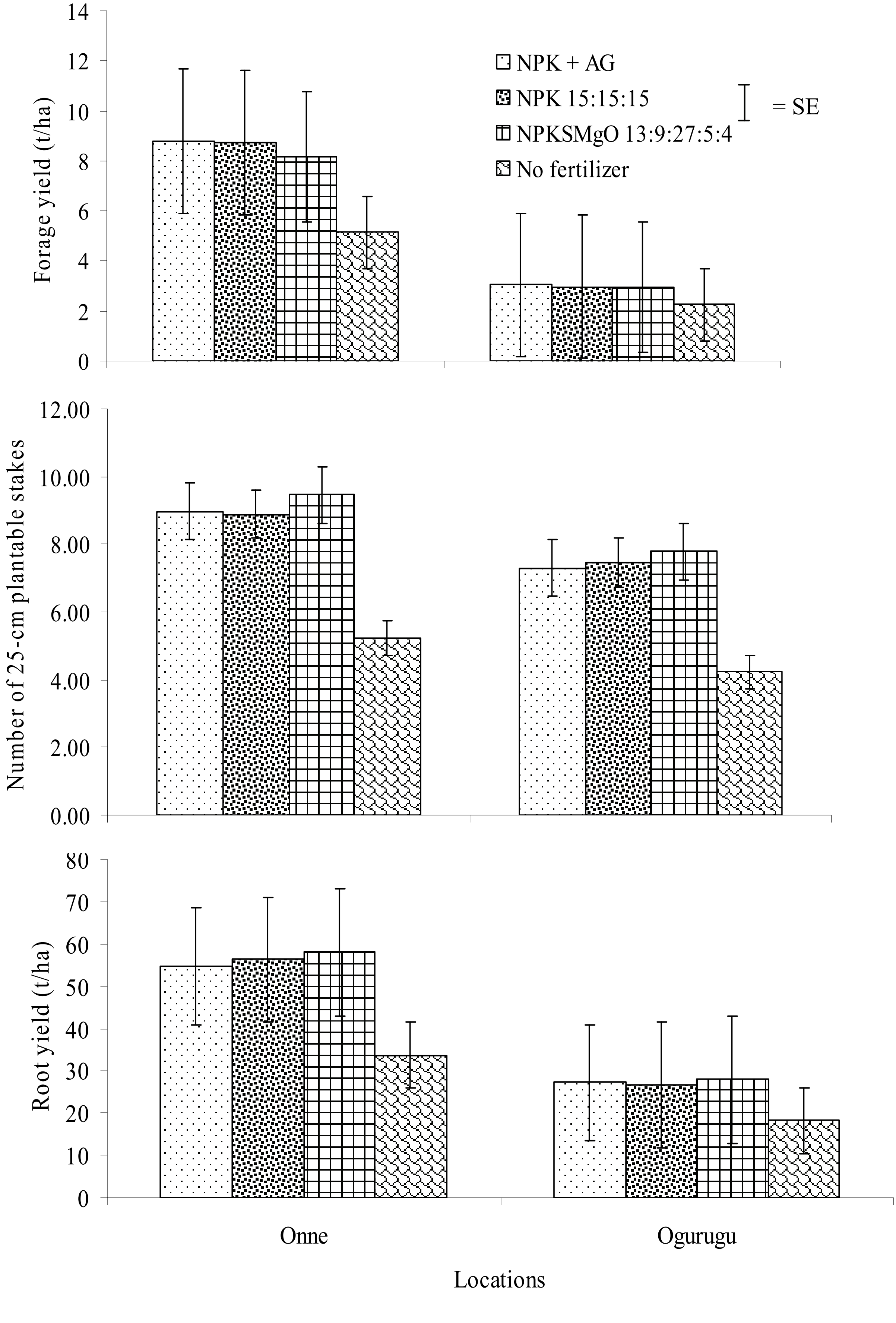


Fig 4.5 Mean number of 25-cm plantable stakes from 6 to 12 MAP, root and forage yields (t/ha) for each fertilizer type at 12 MAP at Onne, and Ogurugu during the 2005/2006 planting season.

The percentage increase due to fertilizer for all the parameters measured is showed in table 4.32. For the number of 25-cm PS at 12 MAP, there was an increase of 71.6 % due to the premix “NPK 16:27:10 + Agrolyzer”, 69.9 % due to NPK 15:15:15 fertilizer and 80.8 % due to NPKMgO 13:9:27:5:4 fertilizers at Onne. This increase was 72.6 % (NPK 16:27:10 + Agrolyzer), 76.3 % (NPK 15:15:15) and 83.9 % (NPKMgO 13:9:27:5:4) at Ogurugu. The percentage increase in root yield due to fertilizer application was 62.1 % (premix “NPK 16:27:10 + Agrolyzer”) 67.1 % (NPK 15:15:15) and 72.3 % (NPKMgO 13:9:27:5:4) at Onne and 49.4 % (premix “NPK 16:27:10 + Agrolyzer”) 46.5 % (NPK 15:15:15) 53.0 % (NPKMgO 13:9:27:5:4) at Ogurugu. For the forage yield at 12 MAP, the increase due fertilizer was of 71.5 % (premix “NPK 16:27:10 + Agrolyzer”), 67.0 % (NPK 15:15:15) and 59.3 % (NPKMgO13:9:27:5:4) at Onne and 35.6 % (NPK 16:27:10 + Agrolyzer), 32.6 % (NPK 15:15:15) and 31.7 % (NPKMgO 13:9:27:5:4) at Ogurugu.

4.5 Effects of plant spacing on cassava stems and root yields Umudike

The mean square values of the analysis of variance of the expected and actual number of 25-cm PS, root and forage yields are showed in tables 4.33 and 4.34. There was significant difference ($p<0.01$) among varieties for all the parameters measured at 12 MAP. Differences among spacings were significant ($p<0.01$) only for the expected and the actual root yield. Interaction between spacing and variety was significant ($p<0.01$) for the root yield only.

The expected plant populations from different plant spacings of cassava for stem production at Umudike are showed in table 4.35. The relationship between different plant populations and the different plant spacing is presented in figure 4.6. The plant population increased as the planting spacing decreased. The plant population varied from 13,889 plants/ha (90 cm x 80 cm) to 28,571 plants/ha (70 cm x 50 cm).

Variation among varieties for the expected and actual mean number of 25-cm cassava plantable stake, root and forage yields (t/ha) at different planting spacings at 12 MAP is shown in figure 4.7. From this generalized pattern and for all the parameters measured, the actual yield obtained was lower than the expected yield. The mean expected and actual numbers of 25-cm PS obtained per stand were 17 and 12 stakes respectively. For all the parameters measured, the slope (b) of the regression equation was negative. This was an indication that the ability to produce stems roots and forage decreased with an increase in plant spacing.

Table 4.32 Percentage increase in mean number of 25-cm plantable stake, forage and root yields (t/ha) due to application of different fertilizer types at 12 MAP at Onne and Ogurugu during the 2005/2006 planting season.

Fertilizer Types	Onne			Ogurugu		
	No.of 25-cm PS (%)	Root yield (%)	Forage yield (%)	No. of 25-cm PS (%)	Root yield (%)	Forage yield (%)
NPK 16:27:10 + Agrolyzer (DAP: 21%N + 53 % P, 3.2kg/10 kg)	71.57	62.14	71.54	72.58	49.42	35.63
NPK 15:15:15	69.91	67.06	70.18	76.31	46.47	32.59
NPKSMgO 13:9:27:5:4	80.76	72.25	59.26	83.92	53.04	31.70

MAP = Month after planting; PS = Plantable stakes, No = Number, cm = centimeter

Table 4.33 Mean square values of the analysis of variance for the mean expected cassava root and forage yields (t/ha) and the number of 25-cm plantable stakes (PS) per variety and for each spacing at 12 MAP at Umudike during 2005/2006 cropping season.

		Root yield		Forage yield		No. of 25-cm PS	
Source of Variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square	Sum of Square	Mean Square
Replication (Rep)	1	31.06	31.06	116.42	116.42	673.72	673.72
Spacing (SP)	11	8162.22	742.02**	254.28	23.12^{ns}	1576.72	143.34^{ns}
Spacing*Rep	11	1061.16	96.47	118.56	10.78	1241.20	112.84
Variety (Var)	6	12428.43	2071.41**	135.32	22.55**	1212.62	202.10**
SP*Var	66	4939.57	74.84^{ns}	124.33	1.88^{ns}	865.31	13.11^{ns}
Rep*SP*Var	72	8030.07	111.53	183.36	2.55	1146.84	15.93
Total	167	34652.50		932.28		6716.41	
Grand Mean			42.68		4.55		16.86
		CV (Spacing) = 23.01 % CV (Variety) = 24.74 %		CV (Spacing) = 72.16 % CV (Variety) = 35.10 %		CV (Spacing) = 63.00 % CV (Variety) = 23.67 %	

b** = Significant at 1 %; b* = Significant at 5 %; b^{ns} = not significant; MAP = Month after planting

Table 4.34 Mean square values of the analysis of variance for the mean actual cassava root and forage yields (t/ha) and the number of 25-cm plantable stakes (PS)per variety and for each spacing at 12 MAP at Umudike, Abia State during 2005/2006 cropping season.

		Root yield		Forage yield		No. of 25-cm PS	
Source of Variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square	Sum of Square	Mean Square
Replication (Rep)	1	174.62	174.62	73.42	73.42	600.43	600.43
Spacing (SP)	11	4054.07	368.55^{**}	101.71	9.25^{ns}	1072.9	97.54^{ns}
Spacing*Rep	11	696.85	63.35	62.92	5.72	900.84	81.90
Variety (Var)	6	4890.48	815.08^{**}	68.70	11.45^{**}	1347.40	224.57^{**}
SP* Var	66	4367.44	66.17^{**}	57.72	0.87^{ns}	734.06	11.12^{ns}
Rep*SP*Var	72	4092.17	56.84	105.32	1.46	1058.00	14.69
Total	167	18275.64		469.78		5713.60	
Grand Mean			28.45		3.07		12.28
		CV (Spacing) = 27.98 % CV (Variety) = 26.50 %		CV (Spacing) = 77.90 % CV (Variety) = 30.36 %		CV (Spacing) = 73.70% CV (Variety) = 31.21 %	

b^{**} = Significant at 1 %; b^{*} = Significant at 5 %; b^{ns} = not significant; MAP = Month after planting

Table 4.35 Expected plant populations from different types of planting spacing of cassava for stem production at Umudike during 2006/2007 cropping season.

Row to row (r-r) spacing (cm)	Plant to plant (p-p) spacing (cm)	Area /stand (m^2)	Rectangularity (p-p)/(r-r)	Plot Size (m^2)	Expected plant population/ha	Ratio to common practice
70	50	0.35	1.40	12.60	28,571	1.43
80	50	0.40	1.60	14.40	25,000	1.25
70	60	0.42	1.17	15.12	23,810	1.19
90	50	0.45	1.80	16.20	22,222	1.11
80	60	0.48	1.33	17.28	20,833	1.04
70	70	0.49	1.00	17.64	20,408	1.02
100	50	0.50	2.00	18.00	20,000	1.00
90	60	0.54	1.50	19.44	18,518	0.93
80	70	0.56	1.14	20.16	17,857	0.89
90	70	0.63	1.29	22.68	15,873	0.79
80	80	0.64	1.00	23.04	15,625	0.78
90	80	0.72	1.13	25.92	13,889	0.69

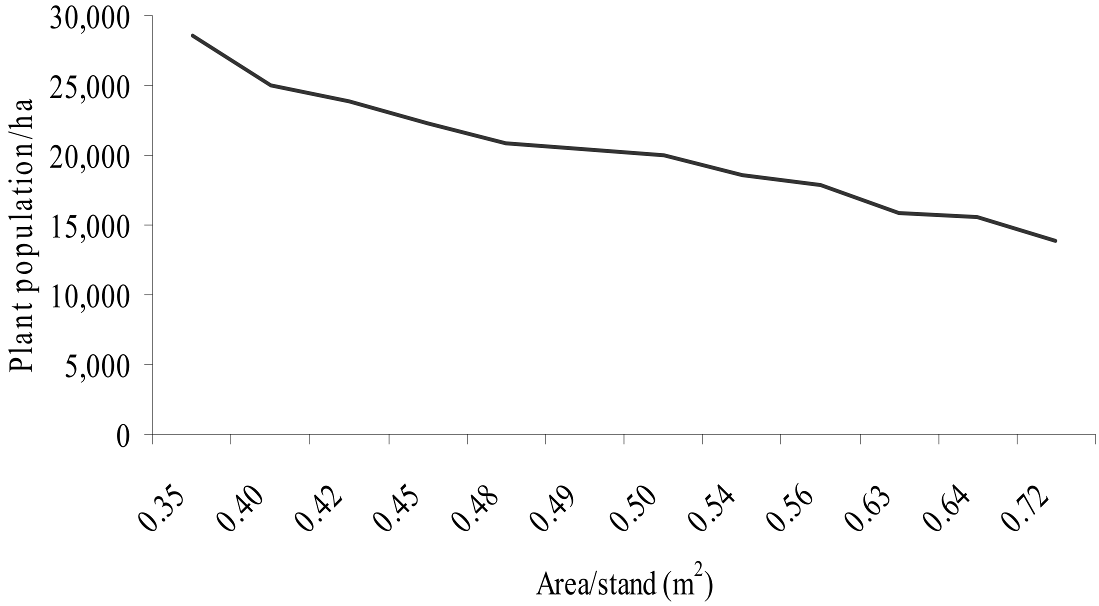


Figure 4.6 Relationship between different plant populations with different types of plant spacing.

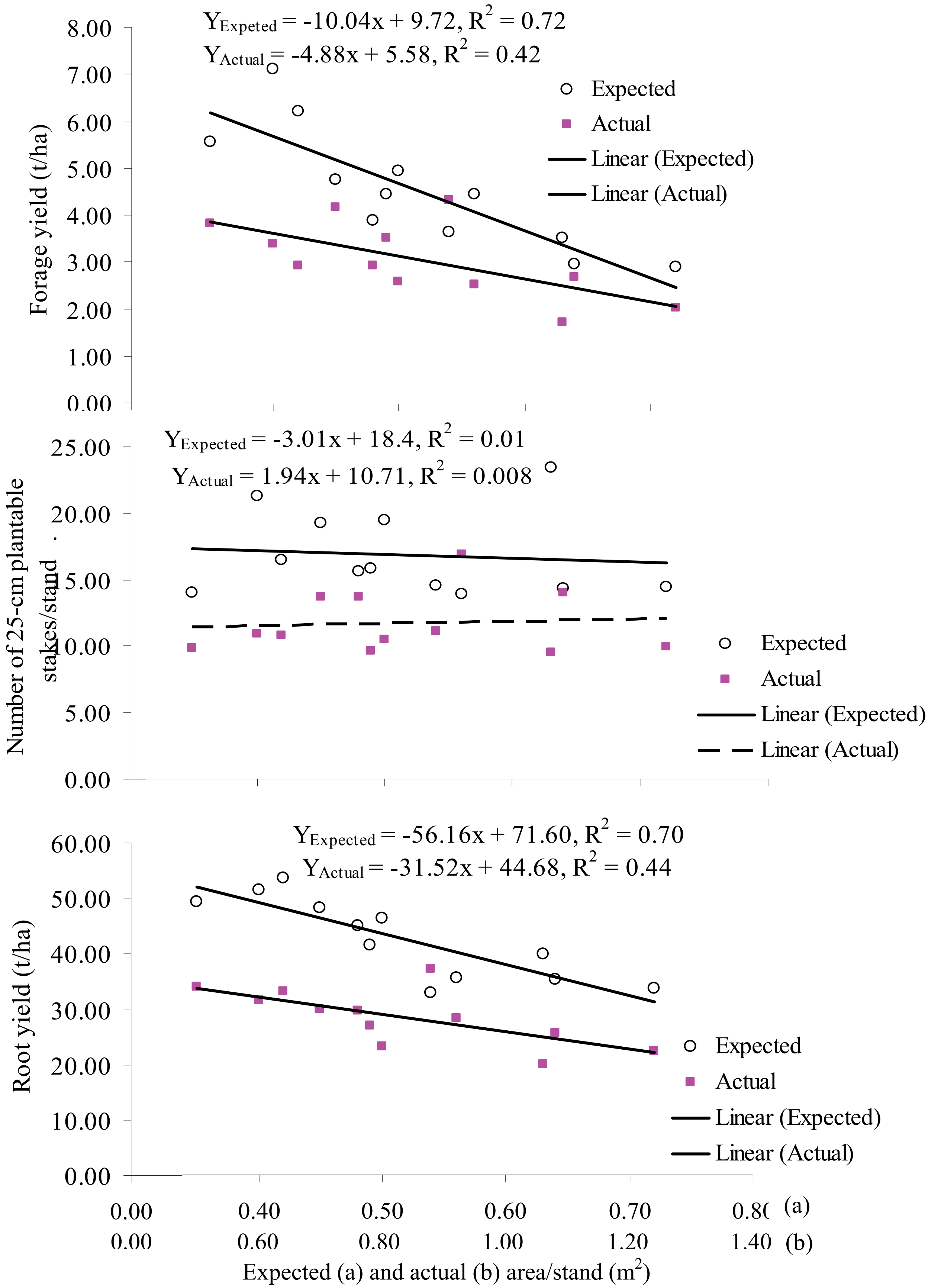


Fig 4.7 Variation among varieties for the expected and actual mean number of 25-cm cassava plantable stake, root and forage yields (t/ha) at different planting spacings at 12 MAP at Umudike, Abia State during 2005/2006 cropping season.
Each data point is the average of seven CMDR varieties

The coefficients of determination R^2 were 0.70 and 0.72 for the expected root and forage yields. This means that the equation was able to account for 70 and 72 % of the total variation in the expected root and forage yields. Only 42 and 44 % of the total variation in the actual forage and root yields were accounted for by the equation. For the production of both actual and expected plantable stakes, the equation accounted for only 0.8 and 10 % of the total variation in the yield when spacing is considered. This is an indication that plantable stakes production is not highly related to the plant spacing.

The yield of all the parameters measured (plantable stakes per plant, root and forage) decreased with the increase in plant spacing. Therefore there is no compensation in cassava production.

4.6 Pattern of stake cutting distribution among the 43 CMDR varieties of cassava

The mean number of 25-cm PS per stem unit for the 43 CMDR cassava varieties is presented in Table 4.36. All the varieties had planting materials up to the secondary branch of the cassava plant. Twenty two varieties had plantable stakes up to their quaternary branches. They were: TMS 98/0510 (5.01), TMS 94/0561 (4.62), TMS 95/0166 (4.35), TMS 96/1642 (4.08), TMS 94/0026 (3.45), TMS 99/3073 (3.30), TMS 98/2101 (3.06), TMS 92B/00068 (2.06), TMS 97/0211 (1.85), TMS 91/02324 (1.81), TMS 96/1632 (1.75), TMS 92/0326 (1.44), TMS 92/0057 (1.24), TMS 96/1089A (1.11), TMS 98/0002 (0.98), TMS 98/0505 (0.97), TMS 97/3200 (0.76), TMS 95/0379 (0.68), TMS 92/0325 (0.62), TMS 95/0289 (0.61), TMS 96/0603 (0.25), TMS 30572 (0.13). Varieties TMS 96/0523, TMS 99/6012, TMS M98/0028, and TME 419 did not have planting materials up to their tertiary branch. Twenty eight varieties had majority of the plantable material at the main stem while fifteen varieties had majority of the plantable material at the primary branch. The mean number of plantable material from the all stem unit was 7.84 from the main stem, 5.40 from the primary branch, 4.06 from the secondary branch, 2.79 from the tertiary branch and 2.00 from the quaternary branch.

On the order hand, the higher percentage of the total planting material was from the main stem (38.7 %), followed by the primary branch (25.8 %), then the secondary branch (19.3 %), the tertiary (12.8 %) and the quaternary branch (8.5 %) (Table 4.37). Nine varieties had more than 50 % of their total planting material from the main stem. They are M98/0028 (81.8 %), TMS 97/0162 (75.5 %), TME 419 (71.86 %), TMS 99/6012 (70.31 %), TMS 96/0523 (64.7 %), TMS 98/0581 (58.3 %), TMS 95/0289 (57.8 %), TMS 98/2226 (53.2 %) and TMS 92B/00061 (50.2 %).

Table 4.36 Mean number of 25-cm plantable stakes per stem branching level for 43 cassava varieties planted at 100 cm x 100 cm in 6 locations* in Nigeria during the 2006/2007 cropping season.

S/N	Variety	Main	Primary	Secondary	Tertiary	Quaternary	Total
1	30572	4.45	6.64	6.37	2.62	0.13	20.21
2	4(2)1425	2.65	3.69	2.64	1.31	-	10.29
3	82/00058	5.13	4.72	1.59	0.63	-	12.07
4	91/02324	8.50	2.67	4.28	3.29	1.81	20.55
5	92/0057	11.77	4.88	2.72	3.11	1.24	23.72
6	92/0067	7.95	3.84	4.46	0.74	-	16.99
7	92/0325	14.52	11.32	4.95	2.29	0.62	33.70
8	92/0326	11.04	2.45	3.45	5.84	1.44	24.22
9	92B/00061	8.89	3.62	2.04	3.17	-	17.72
10	92B/00068	7.87	4.36	2.54	1.74	2.06	18.57
11	94/0026	7.86	9.72	7.46	3.55	3.45	32.04
12	94/0039	8.56	5.23	5.11	2.75	-	21.65
13	94/0561	4.18	6.82	5.65	4.07	4.62	25.34
14	95/0166	6.20	4.55	5.52	2.63	4.35	23.25
15	95/0289	9.34	2.73	1.89	1.61	0.61	16.18
16	95/0379	4.13	5.46	4.64	1.17	0.68	16.08
17	96/0523	12.55	5.26	1.59	-	-	19.40
18	96/0603	9.30	3.06	6.95	3.09	0.25	22.65
19	96/1089A	6.91	4.12	5.60	2.49	1.11	20.23
20	96/1565	11.11	6.04	2.13	2.98	-	22.26
21	96/1569	5.87	5.42	3.50	2.99	-	17.78
22	96/1632	7.26	3.12	7.09	2.82	1.75	22.04
23	96/1642	6.10	7.11	3.91	3.06	4.08	24.26
24	97/0162	13.88	3.53	0.67	0.32	-	18.40
25	97/0211	6.62	6.91	4.42	3.43	1.85	23.23
26	97/2205	3.22	8.42	6.55	2.97	-	21.16
27	97/3200	7.15	6.36	4.37	3.52	0.76	22.16
28	97/4763	12.00	5.94	5.09	2.32	-	25.35
29	97/4769	5.72	5.02	2.14	0.95	-	13.83
30	97/4779	9.40	7.01	4.97	2.47	-	23.85
31	98/0002	3.33	6.75	5.98	3.46	0.98	20.50
32	98/0505	3.88	6.19	5.29	4.20	0.97	20.53
33	98/0510	4.33	6.16	4.15	3.85	5.01	23.50
34	98/0581	11.04	3.92	2.05	1.92	-	18.93
35	98/2101	7.22	7.58	5.84	5.15	3.06	28.85
36	98/2226	15.78	7.23	3.22	3.43	-	29.66
37	99/2123	5.28	7.31	4.90	2.75	-	20.24
38	99/3073	3.02	8.69	4.31	3.11	3.30	22.43
39	99/6012	12.92	4.45	1.00	-	-	18.37
40	M98/0028	9.68	1.55	0.61	-	-	11.84
41	M98/0040	5.43	4.09	5.94	1.51	-	16.97
42	M98/0068	4.91	6.16	5.36	5.58	-	22.01
43	TME419	10.09	2.18	1.77	-	-	14.04
	n	7.84	5.40	4.06	2.79	2.0	
Minimum		2.65	1.55	0.61	0.32	0.13	
Maximum		15.78	11.32	7.46	5.84	5.01	
Mean		7.84	5.40	4.06	2.79	2.00	
Standard Deviation		3.37	2.08	1.86	1.25	1.52	
CV(%)		43.03	38.57	45.69	44.82	75.67	
SE±		0.52	0.32	0.29	0.19	0.23	

CV = Coefficient of Variation, SE =Standard Error. **-** = Do not have, n = number of observations,
* = Blocks 4B, 18, 22 of the International Institute of Tropical Agriculture Onne, Federal College of Agriculture Akure, Ajibode Ibadan, and Dogodawa, Zaria.
Very low (0 < x < 3.3), low (3.3 < x < 6.3), medium (6.3 < x < 10), high (10 < x < 13.3), very high x > 13.3

Table 4.37 Mean percentage of the total number of 25-cm plantable stakes per stem branching level for 43 cassava varieties planted at 100 cm x 100 cm in 6 locations* in Nigeria during the 2006/2007 cropping season.

S/N	Variety	Main	Primary	Secondary	Tertiary	Quaternary	Total
1	30572	22.02	32.86	31.52	12.96	0.64	100
2	4(2)1425	25.75	35.86	25.66	12.73	-	100
3	82/00058	42.50	39.11	13.17	5.22	-	100
4	91/02324	41.36	12.99	20.83	16.01	8.81	100
5	92/0057	49.62	20.57	11.47	13.11	5.23	100
6	92/0067	46.79	22.60	26.25	4.36	-	100
7	92/0325	43.09	33.59	14.69	6.80	1.84	100
8	92/0326	45.58	10.12	14.24	24.11	5.95	100
9	92B/00061	50.17	20.43	11.51	17.89	-	100
10	92B/00068	42.38	23.48	13.68	9.37	11.09	100
11	94/0026	24.53	30.34	23.28	11.08	10.77	100
12	94/0039	39.54	24.16	23.60	12.70	-	100
13	94/0561	16.50	26.91	22.30	16.06	18.23	100
14	95/0166	26.67	19.57	23.74	11.31	18.71	100
15	95/0289	57.73	16.87	11.68	9.95	3.77	100
16	95/0379	25.68	33.96	28.86	7.28	4.23	100
17	96/0523	64.69	27.11	8.20	-	-	100
18	96/0603	41.06	13.51	30.68	13.64	1.10	100
19	96/1089A	34.16	20.37	27.68	12.31	5.49	100
20	96/1565	49.91	27.13	9.57	13.39	-	100
21	96/1569	33.01	30.48	19.69	16.82	-	100
22	96/1632	32.94	14.16	32.17	12.79	7.94	100
23	96/1642	25.14	29.31	16.12	12.61	16.82	100
24	97/0162	75.43	19.18	3.64	1.74	-	100
25	97/0211	28.50	29.75	19.03	14.77	7.96	100
26	97/2205	15.22	39.79	30.95	14.04	-	100
27	97/3200	32.27	28.70	19.72	15.88	3.43	100
28	97/4763	47.34	23.43	20.08	9.15	-	100
29	97/4769	41.36	36.30	15.47	6.87	-	100
30	97/4779	39.41	29.39	20.84	10.36	-	100
31	98/0002	16.24	32.93	29.17	16.88	4.78	100
32	98/0505	18.90	30.15	25.77	20.46	4.72	100
33	98/0510	18.43	26.21	17.66	16.38	21.32	100
34	98/0581	58.32	20.71	10.83	10.14	-	100
35	98/2101	25.03	26.27	20.24	17.85	10.61	100
36	98/2226	53.20	24.38	10.86	11.56	-	100
37	99/2123	26.09	36.12	24.21	13.59	-	100
38	99/3073	13.46	38.74	19.22	13.87	14.71	100
39	99/6012	70.33	24.22	5.44	-	-	100
40	M98/0028	81.76	13.09	5.15	-	-	100
41	M98/0040	32.00	24.10	35.00	8.90	-	100
42	M98/0068	22.31	27.99	24.35	25.35	-	100
43	TME419	71.87	15.53	12.61	-	-	100
		43	43	43	39	22	
Minimum		13.46	10.12	3.64	1.74	0.64	
Maximum		81.76	39.79	35.00	25.35	21.32	
Mean		38.70	25.87	19.32	12.83	8.55	
Standard Deviation		17.32	7.68	8.02	4.87	6.05	
CV(%)		44.76	29.67	41.52	37.96	70.78	
SE±		2.67	1.18	1.24	0.75	0.93	

CV = Coefficient of Variation, SE =Standard Error, **-** = Do not have, n = number of observations.

*= Blocks 4B, 18, 22 of the International Institute of Tropical Agriculture Onne, Federal College of Agriculture Akure, Ajibode Ibadan, and Dogodawa, Zaria.

Very low (0 < x < 16), low (16 < x < 32), medium (32 < x < 49), high (49 < x < 66), very high x > 66

The number of stem level obtained from each variety is showed in table 4.38. This table showed that each of the 43 CMDR varieties had an average of 2 main stems, 3 primary branches, 4 secondary branches, 5 tertiary branches and 7 quaternary branches. The pattern of branching and number of 25-cm plantable stakes from each level of branching is showed in figure 4.8.

4.7 Assessment of the stem yield in trial plots with micro-variability in soil environment using uniformity trial

4.7.1 Soil Characteristics

The analysis of soil revealed highly to moderate acidic soil in both locations after harvesting of the cassava crop (Table 4.39 and Table 4.40). There is a slight difference among the different blocks on which soil samples were taken. A part from manganese (Mn), zinc (Zn), copper (Cu) and iron (Fe) that their concentration increased after harvest in both locations, all other nutrients (organic carbon, available P, Ca, Mg, K, Na, Zn, Cu and CEC) concentration reduced after harvest. About 84 % of Na was used during the cassava growth at Parry Road as compared to 12 % used at IITA. For NPK, the reduction was 7.1 % (at Parry) and 4.9 % (at IITA) for the N, 38.3 % and 56.2 % for available P and 0 % and 18.0 % for K. Soil available P was about 10 folds higher at International Institute of Tropical Agriculture (IITA) than at Parry Road, University of Ibadan. Both Parry Road and IITA soils had higher concentration of Ca and K while Parry Road soil had the highest concentration of Mn. Soils from IITA and Parry Road were Loamy Sand.

4.7.2 Distribution of the stem and root yields across the field

The distribution of the number of 25-cm PS per plant at 6 and 12 MAP and the root yield for the two cassava varieties TME 7 and TMS 30572 are shown in figures 4.9, 4.10 and 4.11. Ninety five (1) and five (2) percent information were considered. The distribution of all the parameters measured showed a positive skewness except for the root yield of the variety TMS 30572 (-0.0042 at 95 % and -0.81 at 5 %). The kurtosis was positive only when considering 5 % of the information for the number of 25-cm PS per plant of TME 7 at 6 and 12 MAP (0.83 and 2.80), TMS 30572 at 12 MAP (2.80) and the root yield of TME 7 at 12 MAP (10.82). The coefficients of variation at 95 % information were 51.68 %, 42.50 % (stem yield of TME 7 at 6 and 12 MAP), 53.19 %, 41.51 % (stem yield of TMS 30572 at 6 and 12 MAP) and 52.13 %, 35.02 % (root yield TME 7 and TMS 30572 at 12 MAP).

Considering 95 % of the information, the stem yield varied from 0 to 12 stakes per plant with a mean of 5 stakes per plant and standard deviation of 2.59 stakes per plant and from 1 to 24 stakes per plant with a mean of 12 stakes per plant and a standard deviation of 4.73 for TME 7 at 6 and 12 MAP.

Table 4.38 Mean number of stem level obtained per variety for 43 cassava varieties planted at 100 cm x 100 cm in 6 locations* in Nigeria during the 2006/2007 cropping season.

S/N	Variety	Main	Primary	Secondary	Tertiary	Quaternary	Total number of stem levels
1	30572	1	3	5	6	2	5
2	4(2)1425	2	3	3	6	-	4
3	82/00058	1	4	4	1	-	4
4	91/02324	2	3	3	4	5	5
5	92/0057	2	3	3	4	3	5
6	92/0067	2	3	4	4	-	4
7	92/0325	2	4	4	5	5	5
8	92/0326	2	2	4	5	7	5
9	92B/00061	2	3	3	8	-	4
10	92B/00068	2	3	4	4	4	5
11	94/0026	2	3	4	5	11	5
12	94/0039	2	3	4	4	-	4
13	94/0561	2	3	4	5	11	5
14	95/0166	2	4	7	4	12	5
15	95/0289	2	2	3	5	4	5
16	95/0379	2	3	4	3	7	5
17	96/0523	2	2	5	-	-	3
18	96/0603	2	2	5	4	2	5
19	96/1089A	2	3	5	3	8	5
20	96/1565	2	3	3	5	-	4
21	96/1569	2	3	5	7	-	4
22	96/1632	2	3	7	7	11	5
23	96/1642	2	3	3	7	8	5
24	97/0162	2	2	2	2	-	4
25	97/0211	2	4	4	5	8	5
26	97/2205	2	4	5	4	-	4
27	97/3200	2	4	4	5	4	5
28	97/4763	2	4	5	8	-	4
29	97/4769	2	3	3	3	-	4
30	97/4779	2	4	5	5	-	4
31	98/0002	2	3	4	4	4	5
32	98/0505	2	3	5	4	3	5
33	98/0510	1	3	5	4	9	5
34	98/0581	2	3	4	3	-	4
35	98/2101	2	4	5	5	2	5
36	98/2226	2	4	4	6	-	4
37	99/2123	2	3	4	4	-	4
38	99/3073	2	4	5	6	15	5
39	99/6012	2	3	6	-	-	4
40	M98/0028	2	2	4	-	-	4
41	M98/0040	2	3	4	6	-	4
42	M98/0068	2	3	5	9	-	4
43	TME419	1	3	5	-	-	4
	n	43	43	43	39	22	
	Minimum	1.44	1.83	1.75	1.00	2.00	
	Maximum	2.30	4.15	6.81	9.43	15.00	
	Mean	1.85	3.09	4.26	4.91	6.68	
	Standard Deviation	0.25	0.57	0.99	1.69	3.70	
	CV (%)	13.33	18.33	23.25	34.48	55.48	
	SE±	0.04	0.09	0.15	0.26	0.57	

CV = Coefficient of Variation, SE =Standard Error, **-** = Do not have, n = number of observations, * = Blocks 4B, 18, 22 of the International Institute of Tropical Agriculture Onne, Federal College of Agriculture Akure, Ajibode Ibadan, and Dogodawa, Zaria.

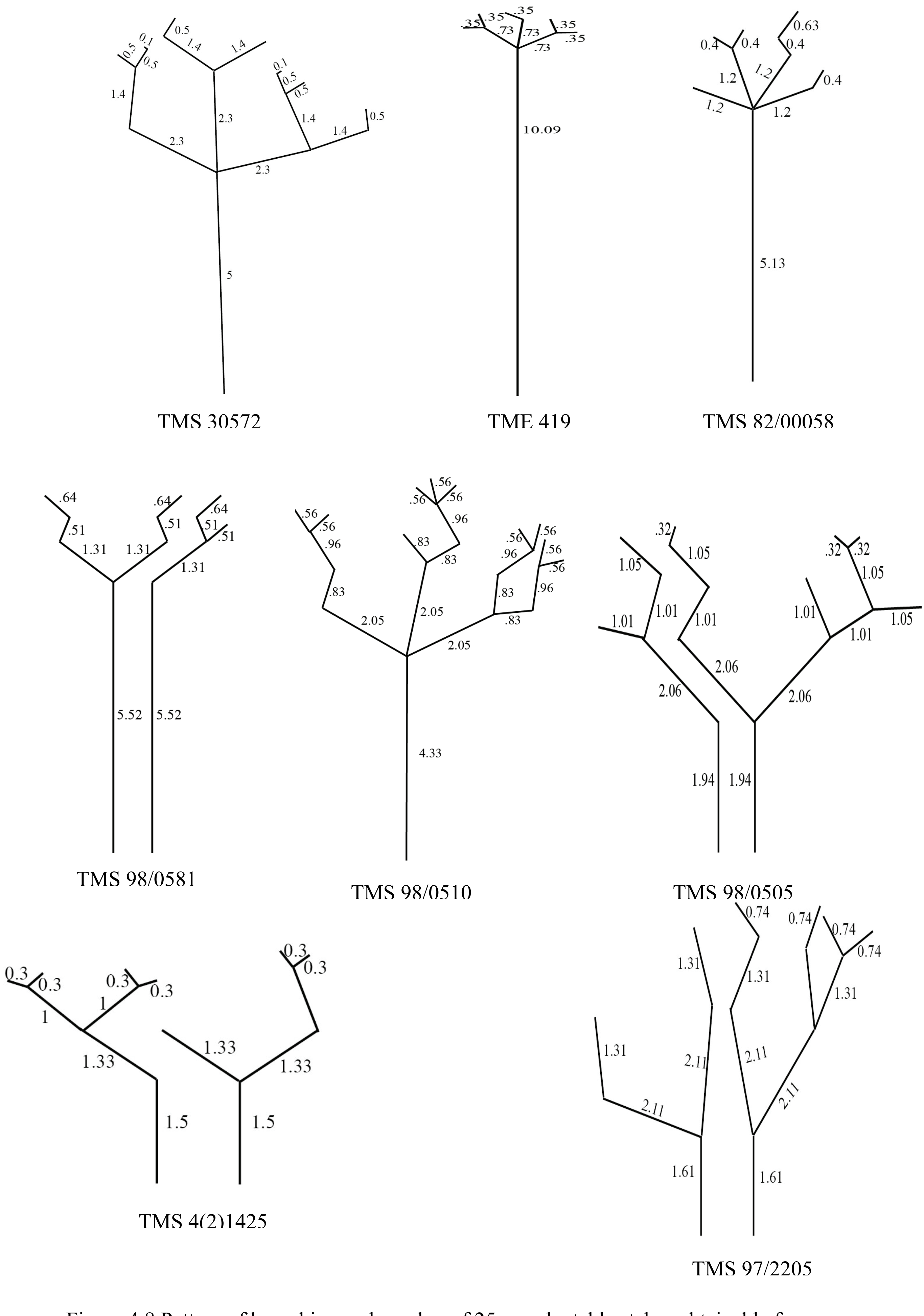


Figure 4.8 Pattern of branching and number of 25-cm plantable stakes obtainable from each level of branching.

Table 4.39 Soil physico chemical properties of a uniformity trial before and after planting at the University of Ibadan, during the cropping season 2007/2008.

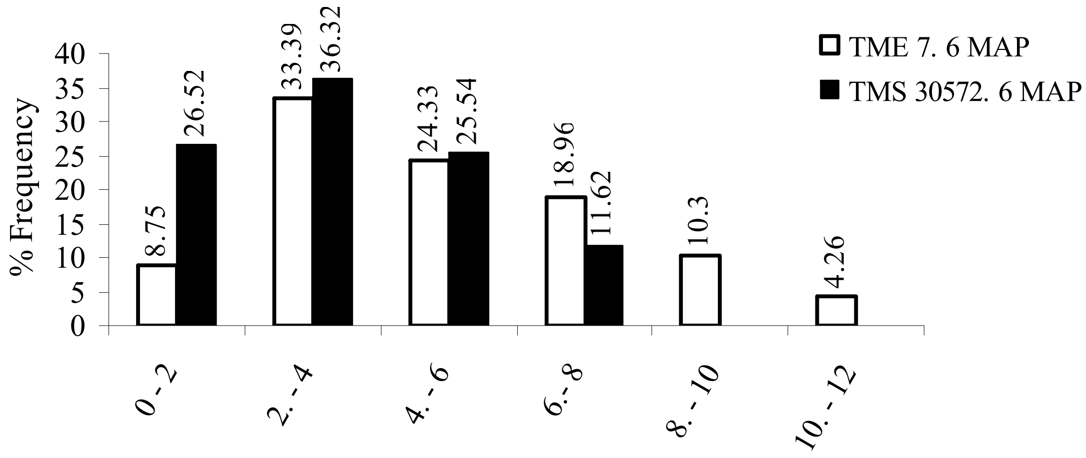
	Parry Road UI before planting				Parry Road UI after planting				
Soils properties	Block 1	Block 2	Block 3	Block 4	Block 1	Block 2	Block 3	Block 4	% Red uction
pH (H_2O)	5.93	5.65	5.78	5.80	5.33	5.30	5.68	6.23	2.76
pH (KCl)	5.10	4.95	5.08	5.08	4.38	4.48	4.98	5.10	6.34
Organic Carbon	1.23	1.27	1.16	0.94	0.94	0.93	1.23	1.14	7.83
Total N	0.30	0.30	0.28	0.23	0.23	0.22	0.30	0.28	7.14
Avalaible P	8.68	6.25	14.68	11.36	1.91	2.42	10.72	10.21	38.28
Ca (cmol/kg)	1.86	1.79	2.52	2.62	2.27	2.47	1.53	1.57	10.91
Mg (cmol/kg)	0.70	0.71	0.80	0.83	0.76	0.81	0.69	0.75	1.32
K (cmol/kg)	0.41	0.41	0.47	0.53	0.48	0.50	0.41	0.41	0.00
Na (cmol/kg)	4.94	0.23	0.25	0.28	0.25	0.22	0.20	0.23	84.51
Mn (mg/kg)	108.75	105.71	126.47	124.89	94.55	123.70	155.64	135.02	-9.24
Fe (mg/kg)	94.53	91.19	100.17	93.78	97.44	88.48	101.61	106.36	-3.74
Zn (mg/kg)	2.82	2.68	2.90	2.71	3.08	3.05	2.28	2.80	-1.08
Cu (mg/kg)	0.97	0.88	0.85	1.06	1.09	0.96	0.80	0.81	2.13
CEC	4.05	4.64	4.63	4.55	4.25	4.44	3.17	3.16	15.88
Based saturation	78.95	67.22	86.64	92.82	86.81	88.74	89.04	93.63	-10.00
Clay (g/kg)	143.00	173.00	143.00	143.00	200.50	153.00	148.00	143.00	0.00
Silt (g/kg)	129.00	136.50	106.50	104.00	96.50	121.50	141.50	181.50	0.00
Sand (g/kg)	728.00	690.50	750.50	753.00	703.00	725.50	710.50	675.50	0.00
Textural calssification	Loamy Sand				Loamy Sand				

IITA = International Institute of Tropical Agriculture

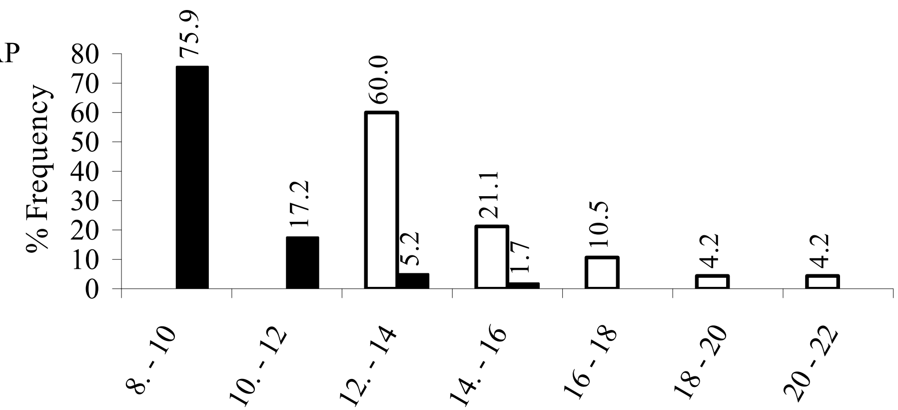
Table 4.40 Soil physico chemical properties of a uniformity trial before and after planting at IITA, Ibadan, during the cropping season 2007/2008.

Soils properties	IITA before planting Block 1	Block 2	Block 3	Block 4	IITA after planting Block 1	Block 2	Block 3	Block 4	% Red uction
pH (H_2O)	5.30	5.75	6.00	5.85	5.80	5.85	5.80	6.15	3.37
pH (KCl)	4.35	4.40	5.05	4.95	4.80	4.85	4.85	5.20	5.04
Organic Carbon	1.78	1.80	1.34	1.46	1.06	1.94	1.71	1.84	4.17
Total N	0.44	0.44	0.32	0.36	0.26	0.47	0.43	0.45	4.88
Avalaible P	32.12	26.14	29.43	8.62	14.94	8.68	9.07	7.24	56.24
Ca (cmol/kg)	3.03	3.28	4.20	1.28	3.94	1.30	1.19	1.37	35.27
Mg (cmol/kg)	0.93	0.97	1.04	0.70	0.99	0.65	0.70	0.71	16.67
K (cmol/kg)	0.50	0.50	0.59	0.41	0.56	0.32	0.38	0.40	18.00
Na (cmol/kg)	0.23	0.25	0.32	0.19	0.31	0.19	0.20	0.21	12.00
Mn (mg/kg)	86.23	87.71	95.36	89.57	93.54	89.40	92.48	93.04	-2.59
Fe (mg/kg)	92.68	113.10	93.75	111.26	119.35	97.09	123.33	97.26	-2.69
Zn (mg/kg)	3.20	3.15	4.26	2.55	3.07	4.23	2.51	3.29	-2.53
Cu (mg/kg)	1.00	1.13	1.43	1.03	1.07	1.64	1.08	1.06	-6.25
CEC	5.38	5.70	6.44	2.86	6.20	2.76	2.66	2.88	29.84
Based saturation	92.68	113.10	93.75	111.26	119.35	97.09	123.33	97.26	-2.69
Clay (g/kg)	88.00	88.00	108.00	118.00	68.00	78.00	98.00	98.00	0.00
Silt (g/kg)	154.00	174.00	134.00	164.00	114.00	84.00	124.00	114.00	0.00
Sand (g/kg)	758.00	738.00	758.00	718.00	818.00	838.00	778.00	788.00	0.00
Textural calssification	Loamy Sand				Loamy Sand				

IITA = International Institute of Tropical Agriculture



(1) Field range (95 %) of the number of 25-cm plantable stakes/stand at 6 MAP at 12 MAP at IITA and UI



(2) Field range (5%) of the number of 25-cm plantable stakes/stand at 6 MAP at 12 MAP at IITA and UI

(1) TME 7 (6 MAP): N = 2252; Mean = 5.02; Min = 0; Max = 12; Skew = 0.42; Kurtosis = - 0.36; CV (%) = 51.68; Std = 2.59; t_{cal} = 91.83

TMS 30572 (6 MAP): N = 2240; Mean = 2.30; Min = 0; Max = 5.96; Skew = 0.213; Kurtosis = - 0.011; CV (%) = 53.19; Std = 1.22; t_{cal} = 88.98

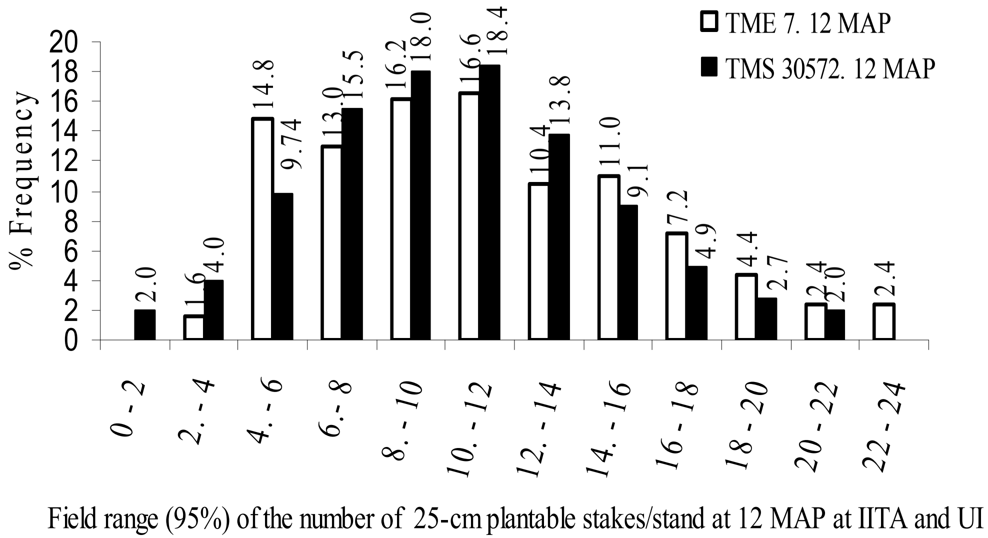
(2) TME 7 (6 MAP): N = 95; Mean = 14.29; Min = 12.04; Max = 20.52; Skew = 1.30; Kurtosis = 0.83; CV (%) = 16.05; Std = 2.29 t_{cal} = 60.73

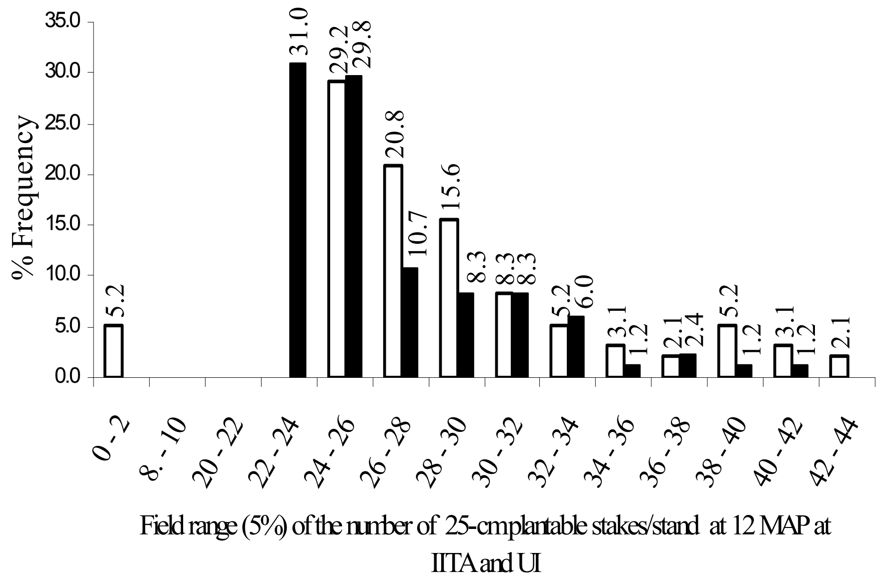
TMS 30572 (6 MAP): N = 10; Mean = 6.88; Min = 6.15; Max = 7.76; Skew = 0.24; Kurtosis = - 1.69; CV (%) = 9.22; Std = 0.63; t_{cal} = 34.30

The mean number of 25-cm plantable stakes per plant at 6 MAP at Parry Road and IITA was 5 and 2 cuttings respectively.

MAP = month after planting, IITA = International Institute of Tropical Agriculture, N = Population sample, Std = Standard deviation, Min = minimum; Max = Maximum, CV = coefficient of variation, t_{cal} = t value calculated for the t test.

Fig. 4.9 Distribution of number of 25-cm plantable stakes per plant of two cassava varieties (TME 1 and TMS 30572) at 6 MAP at Parry Road Plot, University of Ibadan, and at IITA, Ibadan.





(1) TME 7 (12 MAP): N = 2251; Mean = 11.12; Min = 1.28; Max = 23.88; Skew = 0.50; Kurtosis = - 0.37; CV (%) = 42.50; Std = 4.73; t_{cal} = 111.75

TMS 30572 (12 MAP): N = 2166; Mean = 10.25; Min = 0; Max = 21.88; Skew = 0.22; Kurtosis = - 0.084; CV (%) = 41.51; Std = 4.25; t_{cal} = 112.13

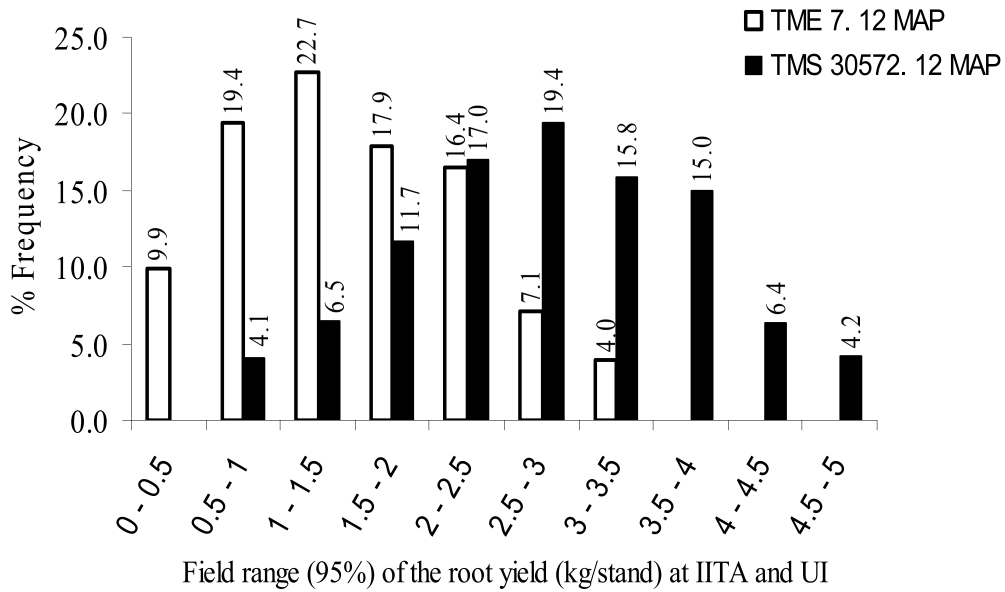
(2) TME 7 (12 MAP): N = 96; Mean = 28.0; Min = 1.28; Max = 49.96; Skew = -1.04; Kurtosis = 4.28; CV (%) = 29.44; Std = 8.24; t_{cal} = 33.38

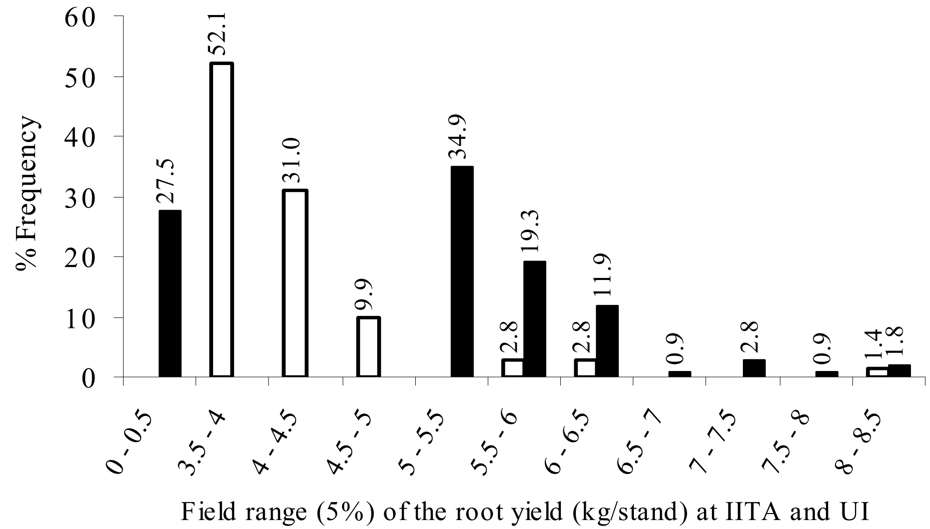
TMS 30572 (12 MAP): N = 84; Mean = 26.56; Min = 22.12; Max = 42.68; Skew = 1.59; Kurtosis = 2.80; CV (%) = 15.47; Std= 4.11; t_{cal} = 59.26

The mean number of 25-cm plantable stakes per plant at 12 MAP at Parry Road and IITA was 12 and 11 cuttings respectively.

MAP = month after planting, IITA = International Institute of Tropical Agriculture, N = Population sample, Std = Standard deviation, Min = minimum; Max = Maximum, CV = coefficient of variation, t_{cal} = t value calculated for the t test.

Fig. 4.10 Distribution of number of 25-cm plantable stakes per plant of two cassava varieties (TME 1 and TMS 30572) at 12 MAP at Parry Road Plot, University of Ibadan, and at IITA, Ibadan.





(1) TME 7 (12 MAP): N = 2276; Mean = 1.50; Min = 0.05; Max = 3.49; Skew = 0.34; Kurtosis = - 0.63; CV (%) = 52.13; Std = 0.78; t_{cal} = 91.52.

TMS 30572 (12 MAP): N = 2141; Mean = 2.81; Min = 0.52; Max = 5.00; Skew = -0.0042; Kurtosis = - 0.52; CV (%) = 35.02; Std = 0.98 t_{cal} = 132.12

(2) TME 7 (12 MAP): N = 71; Mean = 4.17; Min = 3.53; Max = 8.11; Skew = 2.87; Kurtosis = 10.82; CV (%) = 18.11; Std = 0.76; t_{cal} = 46.54

TMS 30572 (12 MAP): N = 109; Mean = 4.26; Min = 0.14; Max = 8.38; Skew = -0.80; Kurtosis = - 0.97; CV (%) = 58.15; Std = 2.48; t_{cal} = 17.95

The mean root yield at 12 MAP at Parry Road and IITA was 1.59 and 2.87 kg/plant respectively.

MAP = month after planting, IITA = International Institute of Tropical Agriculture, N = Population sample, Std = Standard deviation, Min = minimum; Max = Maximum, CV = coefficient of variation, t_{cal} = t value calculated for the t test.

Fig 4.11 Distribution of root yield (kg/plant) of two cassava varieties(TME 1 and TMS 30572) at 12 MAP at Parry Road Plot, University of Ibadan, and at IITA, Ibadan.

The root yield of TME 7 varied from 0.05 to 3.49 kg/plant with a mean of 1.50 kg/plant and a standard deviation of 0.78 at 12 MAP. For the variety TMS 30572, the stem yield varied from 0 to 6 stakes per plant with a mean of 3 stakes per plant and a standard deviation of 1.22 at 6 MAP and from 0 to 22 stakes per plant with a mean of 11 stakes per plant and a standard deviation of 4.25 at 12 MAP. The root yield varied from 0.52 to 5 kg/plant with a mean of 2.81 kg/plant and a standard deviation of 0.98 at 12 MAP.

For 5 % information, the stem yield varied from 12 to 21 stakes per plant with a mean of 14 stakes per plant and standard deviation of 2.29 (TME 7, 6 MAP) and from 1 to 50 stakes per plant with a mean of 28.0 stakes per plant and a standard deviation of 8.24 (TME 7 12 MAP). For the same variety, the root yield varied from 3.53 to 8.11 kg/plant with a mean of 4.17 kg/plant and a standard deviation of 0.76 at 12 MAP. For the variety TMS 30572, the stem yield varied from 6.15 to 7.76 stakes per plant with a mean of 6.88 stakes per plant and a standard deviation of 0.63 at 6 MAP and from 22.12 to 42.68 stakes per plant with a mean of 26.56 stakes per plant and a standard deviation of 4.11 at 12 MAP. The root yield varied from 0.14 to 8.38 kg/plant with a mean of 4.26 kg/plant and a standard deviation of 2.48 at 12 MAP.

4.7.3 Test for randomness of missing stands observed in all the sections of the field

The observed and expected percentage missing stands in an 8 rows by 3 columns plot for the stem and root yields for the two cassava varieties (TME 7 and TMS 30572) are presented in tables 4.41, 4.42 and 4.43. The observed number of missing stands was 189 plants, 194 plants and 195 plants out of 2496 plants for the number of 25-cm PS (6 and 12 MAP) and the root yield at 12 MAP for the variety TME 7. For the variety TMS 30572, the observed number of missing stands was 295 plants, 221 plants and 224 plants out of 2250 plants for the number of 25-cm PS (6 and 12 MAP) and root yield at 12 MAP. There was no significance difference among stakes position positions on the number of missing stand for all the parameters measured. The mean square values of the analysis of variance for the percentage of missing stands on the stem and root yield are showed in tables 4.44 and 4.45.

The Chi squares calculated were 16.48 and 12.37 for the number of 25-cm PS of TME 7 at 6 and 12 MAP, 13.30 and 22.49 for number of 25-cm PS of TMS 30572 at 6 and 12 MAP.

Table 4.41 Observed percentage missing stands in an 8 row x 3 column plot* for the number of 25-cm plantable stakes per plant at 6 and 12 MAP for TME 7 and TMS 30572 cassava varieties at Parry road, UI, and IITA, Ibadan during the 2007/2008 cropping season.

	6 MAP								12 MAP							
	TME 7 No. 25-cm PS Parry Road				TMS 30572 No. 25-cm PS IITA				TME 7 No. 25-cm PS Parry Road				TMS 30572 No. 25-cm PS IITA			
	C1	C2	C3	M% MS	C1	C2	C3	M% MS	C1	C2	C3	M% MS	C1	C2	C3	M% MS
R1	6.48	5.56	6.25	6.10	2.78	6.48	5.21	4.82	5.56	6.48	8.33	6.79	3.70	6.48	4.17	4.78
R2	3.70	9.26	5.21	6.06	2.78	10.19	14.58	9.18	4.63	2.78	4.17	3.86	2.78	6.48	12.50	7.25
R3	8.33	7.41	8.33	8.02	8.33	13.89	17.71	13.31	9.26	6.48	6.25	7.33	5.56	8.33	17.71	10.53
R4	2.78	3.70	12.50	6.33	6.48	11.11	12.50	10.03	3.70	4.63	11.46	6.60	2.78	7.41	6.25	5.48
R5	12.04	8.33	9.38	9.92	7.41	7.41	18.75	11.19	12.04	9.26	7.29	9.53	8.33	2.78	12.50	7.87
R6	16.67	13.89	19.79	16.78	17.59	13.89	18.75	16.74	13.89	14.81	20.83	16.51	12.96	12.04	9.38	11.46
R7	6.48	3.70	4.17	4.78	12.96	15.74	20.83	16.51	7.41	0.93	6.25	4.86	11.11	11.11	15.63	12.62
R8	1.85	0.93	6.25	3.01	6.48	18.52	16.67	13.89	9.26	4.63	7.29	7.06	4.63	17.59	12.50	11.57
Sum	58.33	52.78	71.88	61.00	64.81	97.22	125.00	95.68	65.74	50.00	71.88	62.54	51.85	72.22	90.63	71.57

MAP = Month after planting; IITA = International Institute of Tropical Agriculture; PS = Plantable Stakes, M%MS = Mean percentage missing stands.
*The plot has been subdivided into 8 rows (R1, R2, R3, R4, R5, R6, R7 and R8) and 3 columns (C1, C2, and C3).

Table 4.42 Observed percentage missing stands in an 8 row x 3 column plot* the root yield (kg/plant) at 12 MAP for TME 7 and TMS 30572 cassava varieties at Parry road, UI, and IITA, Ibadan during the 2007/2008 cropping season.

	Rt Wt TME 7, Parry Road				Rt Wt TMS 30572, IITA			
	C1	C2	C3	M% MS	C1	C2	C3	M% MS
R1	5.56	4.63	8.33	6.17	4.63	6.48	5.21	5.44
R2	4.63	3.70	3.13	3.82	2.78	6.48	12.50	7.25
R3	9.26	7.41	6.25	7.64	5.56	8.33	18.75	10.88
R4	3.70	3.70	11.46	6.29	3.70	7.41	6.25	5.79
R5	12.04	10.19	7.29	9.84	7.41	3.70	11.46	7.52
R6	14.81	14.81	20.83	16.82	12.96	10.19	9.38	10.84
R7	7.41	0.93	6.25	4.86	11.11	12.04	16.67	13.27
R8	9.26	5.56	7.29	7.37	3.70	18.52	12.50	11.57
Sum	66.67	50.93	70.83	62.81	51.85	73.15	92.71	72.57

MAP = Month after planting; IITA = International Institute of Tropical Agriculture;
Rt Wt = Root weight; M%MS = Mean percentage missing stands
*The plot has been subdivided into 8 rows (R1, R2, R3, R4, R5, R6, R7 and R8) and 3 columns (C1, C2, and C3).

Table 4.43 Expected number of missing stands in an 8 rows x 3 columns plot for the root and forage yields at 6 and 12 MAP for TME 7 and TMS 30572 cassava varieties at Parry road, UI, and IITA, Ibadan during the 2007/2008 cropping season.

Ho: All sections of the plot have unequal percentage missing stands.

	No. 25-cm PS, 6 MAP						No. 25-cm PS, 12 MAP						Root Weight (kg/plant), 12 MAP					
	TME 7, Parry Road			TMS 30572, IITA			TME 7, Parry Road			TMS 30572, IITA			TME 7, Parry Road			TMS 30572, IITA		
	5.83	5.27	7.18	3.27	4.90	6.30	7.14	5.43	7.80	3.47	4.83	6.06	6.55	5.00	6.96	3.89	5.48	6.95
	5.79	5.24	7.14	6.22	9.33	12.00	4.06	3.08	4.43	5.25	7.32	9.18	4.05	3.10	4.31	5.18	7.31	9.27
	7.67	6.94	9.46	9.02	13.52	17.39	7.71	5.86	8.42	7.63	10.63	13.34	8.11	6.19	8.61	7.77	10.97	13.90
	6.05	5.47	7.46	6.80	10.19	13.10	6.93	5.27	7.58	3.97	5.53	6.94	6.67	5.10	7.09	4.13	5.83	7.39
	9.48	8.58	11.68	7.58	11.37	14.62	10.02	7.62	10.95	5.70	7.94	9.97	10.44	7.98	11.09	5.38	7.58	9.61
	16.05	14.52	19.77	11.34	17.01	21.87	17.36	13.20	18.98	8.30	11.56	14.51	17.85	13.64	18.97	7.75	10.93	13.85
	4.57	4.14	5.64	11.19	16.78	21.57	5.11	3.89	5.59	9.14	12.73	15.97	5.16	3.94	5.48	9.48	13.38	16.95
	2.88	2.60	3.55	9.41	14.11	18.14	7.42	5.64	8.11	8.39	11.68	14.66	7.82	5.97	8.31	8.27	11.67	14.79
χ^2_{cal}			16.48			13.30			12.37			22.49			13.19			22.14
$\chi^2_{tab,df\ 14,\ 0.05}$			23.68			23.68			23.68			23.68			23.68			23.68
Remarks			+			+			+			+			+			+

MAP = Month after planting; IITA = International Institute of Tropical Agriculture; PS = Plantable Stakes; χ^2_{cal} = Chi-square calculated; Rt Wt = Root weight
$\chi^2_{tab,df\ 14,\ 0.05}$ = Chi-square tabulated at 14 degree of freedom and at $P < 0.05$; + = Accept Ho.

Table 4.44 Mean square values of the analysis of variance for the transformed percentage missing stands on the number of 25-cm plantable stakes (PS) at 6 and 12 MAP, root yield (kg/plant) at 12 MAP of the variety TMS 30572 in 2008 at IITA Ibadan.

		Number of 25-cm PS at 6 MAP		Number of 25-cm PS at 12 MAP		Root yield (kg/plant) at 12 MAP	
Source of variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square	Sum of Square	Mean Square
Replication (Rep)	5	4.19	0.84	2.88	0.58	2.36	0.47
Stake Position (SP)	3	0.22	0.073 ^{ns}	0.14	0.045 ^{ns}	0.13	0.042 ^{ns}
SP*Rep	15	0.84	0.056	1.82	0.12	1.78	0.12
Total	23	5.25		4.84		4.27	
Grand Mean		1.10		0.80		0.83	

Number of 25-cm PS at 6 MAP [CV (SP) = 24.56 %];
Number of 25-cm PS at 12 MAP [CV (SP) = 26.52 %];
Root yield (kg/plant) at 12 MAP [CV (SP) = 26.52 %];
b^{ns} = not significant; MAP = Month after planting;
IITA = International Institute of Tropical Agriculture

Table 4.45 Mean square values of the analysis of variance for the transformed percentage missing stands on the number of 25-cm plantable stakes (PS) at 6 and 12 MAP, root yield (kg/plant) at 12 MAP of the variety TME 1 in 2008 at Parry Road, UI, Ibadan.

		Number of 25-cm PS at 6 MAP		Number of 25-cm PS at 12 MAP		Root yield (kg/plant) at 12 MAP	
Source of variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square	Sum of Square	Mean Square
Replication (Rep)	3	4.67	1.56	5.81	1.94	2.97	0.99
Stake Position (SP)	3	0.14	0.046 ns	1.75	0.58 ns	2.19	0.73 ns
SP*Rep	8	10.80	1.35	3.64	0.52	7.69	0.96
Total	14	15.54		10.35		12.94	
Grand Mean		0.23		0.48		0.40	

Number of 25-cm PS at 6 MAP [CV (SP) = 86.96 %];
Number of 25-cm PS at 12 MAP [CV (SP) = 158.66 %];
Root yield (kg/plant) at 12 MAP [CV (SP) = 213.60 %];
b^{ns} = not significant; MAP = Month after planting; UI = University of Ibadan

The chi squares calculated for the root yield were 13.19 (TME 7) and 22.14 (TMS 30572). The chi square tabulated for all the parameters at 14 degree of freedom and at $p<0.05$ was 23.68. For both stem and root yields at 6 and 12 MAP and in all the sections of the plot, the chi square tabulated was greater than the chi square calculated. This leads to the acceptance of the null hypothesis which was that all sections of the plot have unequal percentage missing stands.

4.7.4 Effect of stake positions on the stem and root yields

The stake position does not have influence on stakes generated at 6 and 12 MAP. There was no significant difference between stake positions for the number of 25-cm PS at 6 and 12 MAP and root yield at 12 MAP. The mean square values of the analysis of variance for the effect of stake positions on the stem and root yield are showed in tables 4.46 and 4.47.

TME 7 had 5-6 stakes/plant and TMS had about 2 stakes per plant at 6 MAP. Variety TME 7 produced an average of 6 stakes/plant from planted stakes obtained from the bottom, and top-middle of the stem, 5 stakes/plant from that from the bottom-middle, and the top of the stem (Table 4.48). At 12 MAP, the same variety had 12 stakes/plant from the bottom, bottom-middle, and top-middle and 11 stakes/plant from the top (Table 4.48). Variety TMS 30572 gave 2 stakes/plant from planted stakes obtained from the bottom, bottom-middle, top-middle and top of the stem at 6 MAP and 11 stakes/plant at 12 MAP from planted stakes obtained from the bottom, bottom-middle, top-middle and top of the stem. For the root yield, variety TME 7 had 1.66 kg/plant from the bottom, 1.47 kg/plant from the bottom-middle, 1.57 kg/plant from the top-middle and 1.55 kg/plant from the top at 12 MAP. Variety TMS 30572 had 2.89 kg/plant from the bottom, 2.81 kg/plant from the bottom-middle, 2.88 kg/plant from the top-middle and 2.91 kg/plant from the top at 12 MAP.

The percentage of bottom (Table 4.48). was 100.7 % for the number of 25-cm PS of the bottom-middle of TMS 30572 at 6 MAP, 101.7 % and 101.1 % for the bottom-middle and the top for the stem yield of TMS 30572 at 12 MAP. For the root yield, the percentage of bottom over the top was 100.7 % at 12 MAP. For the variety TME 7, the percentage of bottom was 93.7 %, 99.4 % and 88.4 % for the number of 25-cm PS at 6 MAP of the bottom-middle, top-middle, and top respectively and 95.6 %, 99.9 %, and 89.6 % for the number of 25-cm PS at 12 MAP of the bottom-middle, top-middle, and top respectively. For the root yield, the percentage of the bottom was 88.8 %, 94.9 % and 93.7 % for the root yield at 12 MAP of the bottom-middle, top- middle, and top respectively.

Table 4.46 Mean square values of the analysis of variance for effect of cassava stake positions on the number of 25-cm plantable stakes (PS) at 6 and 12 MAP, root yield (kg/plant) at 12 MAP of the variety TME 7 in 2008 at Parry Road, UI, Ibadan.

		Number of 25-cm PS/plant at 6 MAP		Number of 25-cm PS/plant at 12 MAP		Root yield (kg/plant) at 12 MAP	
Source of Variation	Degree of Freedom	Sum of Square	Mean Square	Sum of Square	Mean Square	Sum of Square	Mean Square
Replication (Rep)	3	22.02	7.34	56.13	18.71	0.56	0.19
Stake Position (SP)	3	1.15	0.38^{ns}	4.34	1.45^{ns}	0.070	0.023^{ns}
SP*Rep	9	5.36	0.60	21.07	2.34	0.16	0.018
Total	15	28.53		81.54		0.79	
Grand Mean		5.37		11.73		1.56	

Number of 25-cm PS/plant at 6 MAP [CV (SP) = 11.48 %];
Number of 25-cm PS/plant at 12 MAP [CV (SP) = 10.27 %];
Root yield (kg/plant) at 12 MAP [CV (SP) = 9.72 %]; b^{ns} = not significant;
MAP = Month after planting; UI = University of Ibadan

Table 4.47 Mean square values of the analysis of variance for effect of cassava stake positions on the number of 25-cm plantable stakes (PS) at 6 and 12 MAP, root yield (kg/plant) at 12 MAP of the variety TMS 30572 in 2008 at IITA, Ibadan.

Source of Variation	Degree of Freedom	Number of 25-cm PS/plant at 6 MAP		Number of 25-cm PS/plant at 12 MAP		Root yield (kg/plant) at 12 MAP	
		Sum of Square	Mean Square	Sum of Square	Mean Square	Sum of Square	Mean Square
Replication (Rep)	5	2.21	0.44	174.40	34.88	2.31	0.46
Stake Position (SP)	3	0.018	0.0059^{ns}	0.22	0.075^{ns}	0.033	0.011^{ns}
SP*Rep	15	0.22	0.015	4.56	0.30	0.22	0.015
Total	23	2.45		179.18		2.56	
Grand Mean		2.31		10.85		2.87	

Number of 25-cm PS/plant at 6 MAP [CV (SP) = 3.33 %];
Number of 25-cm PS/plant at 12 MAP [CV (SP) = 2.52 %]
Root yield (kg/plant) at 12 MAP [CV (SP) = 3.65 %]; b^{ns} = not significant;
MAP = Month after planting; IITA = International Institute of Tropical Agriculture

Table 4.48 Effect of cassava stake positions and the percentage of the bottom over other cassava stake positions on the number of 25-cm plantable stakes at 6 and 12 MAP and root yield (kg/plant) at Parry Road, UI and IITA, Ibadan during the 2007/2008 cropping season.

Cassava Stake Position	TME 7 (Parry Road, UI)					TMS 30572 (IITA, Ibadan)				
	Mean	Std	CV (%)	SE ±	% bottom	Mean	Std	CV (%)	SE ±	% bottom
25-cm PS 6 MAP										
Bottom	6.00	1.29	22.86	0.64	100.00	2.00	0.29	12.60	0.12	100.00
Bottom-Middle	5.00	1.28	24.33	0.64	93.66	2.00	0.34	14.33	0.14	100.72
Top-Middle	6.00	1.95	34.87	0.98	99.38	2.00	0.40	17.70	0.16	97.71
Top	5.00	1.41	28.37	0.71	88.33	2.00	0.35	15.36	0.14	98.64
LSD $_{(0.05)}$	1.23					0.15				
25-cm PS 12 MAP										
Bottom	12.00	2.70	22.17	1.35	100.00	10.79	3.28	30.37	1.34	100.00
Bottom-Middle	12.00	2.19	18.79	1.09	95.51	10.97	3.10	28.23	1.26	101.65
Top-Middle	12.00	3.16	25.98	1.58	99.92	10.72	2.72	25.40	1.11	99.41
Top	11.00	1.90	17.41	0.95	89.56	10.91	2.84	26.03	1.16	101.14
LSD $_{(0.05)}$	2.45					0.68				
Root yield (kg/plant) 12 MAP										
Bottom	1.66	0.31	18.86	0.16	100.00	2.89	0.32	10.98	0.13	100.00
Bottom-Middle	1.47	0.20	13.50	0.10	88.84	2.81	0.45	15.87	0.18	97.29
Top-Middle	1.57	0.26	16.63	0.13	94.87	2.88	0.35	12.24	0.14	99.54
Top	1.55	0.18	11.90	0.09	93.67	2.91	0.28	9.59	0.11	100.69
Grand mean	1.56					2.87				
LSD $_{(0.05)}$	0.21					0.15				
Stake position^{b}	ns									

MAP = Month after planting; IITA = International Institute of Tropical Agriculture; PS = Plantable Stakes/plant; CV = Coefficient of variation; Std = Standard deviation; SE = Standard error; b^{ns} = non significant.

4.8 Determination of cassava stakes quality index from different varieties.

The mean number of 25-cm PS per plant, the stem diameter, the stem weight, number of nodes per 25-cm PS, the root and forage yields for all the 43 CMDR varieties in six locations (Ajibode at Ibadan, Kate plot, Rivers State Institute of Agricultural Research and Training (RIART), Demo plot at Onne, Federal College of Agriculture (FCA) at Akure and Dongodawa at Zaria) are presented in appendices 8.1, 8.2, 8.3, 8.4, 8.5 and 8.6.

The number of 25-cm PS in all the locations and for the 43 CMDR varieties varied from 8 (TMS 4(2)1425) to 21 stakes (TMS 96/2226) with a mean of 15 stakes and a standard deviation of 3.03. For the number of nodes per 25-cm PS per plant, it varied from 10 (TMS 96/1089A) to 17 nodes (M98/0028) per 25-cm PS with a mean of 12 nodes and a standard deviation of 1.41. The stem weight varied from 63.51 (TMS 97/4779) to 92.98 g (TMS 97/4769) per 25-cm PS, with a mean of 77.87 g and a standard deviation of 9.42. The stem diameter varied from 1.67 (TMS 97/2205) to 2.13 cm (TMS 94/0039) per 25-cm PS, with a mean of 1.88 cm and a standard deviation of 0.13. The root and forage yields varied from 17.56 (TMS 30572) to 52.74 t/ha (TMS 97/0162) with a mean of 30.06 t/ha and a standard deviation of 7.63 and from 2.53 (TMS 98/0510) to 10.60 t/ha (TMS 91/02324) with a mean of 5.59 t/ha and a standard deviation of 2.13 respectively. Only sixteen varieties out of the 43 in trial were selected for the ability to produce high quality planting materials across at least four out of the six locations in Nigeria. Results for the Multi-Dimensional Analysis (MDA) for the selected varieties with good ability to produce high quality planting materials across at least four out of the six locations in Nigeria are presented in table 4.49. The mean MDA indice across the 43 CMDR varieties used for the seletion was 9.21 (Ajibode at Ibadan), 8.61 (Kate plot at Onne), 8.99 (RIART at Onne), 9.45 (Demo plot at Onne), 9.33 (FCA at Akure) and 9.20 (Dongodawa at Zaria).

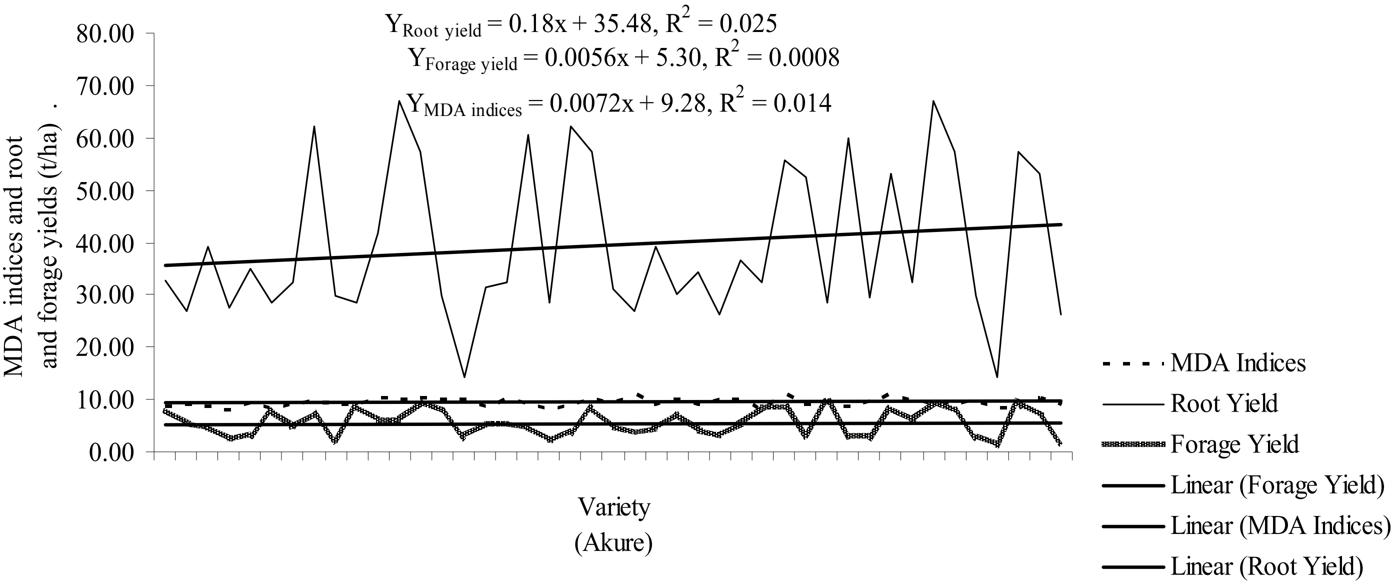
The effects of quality stakes on root and forage yields of 43 CMDR varieties in six locations are shown in figure 4.12.The figure showed that varieties accounted only for from 0.0005 % (RIART at Onne) to 9.9 % (Demo at Onne) of the variation in root yield, from 0.08 % (FCA at Akure) to 3.6 % (RIART at Onne) of the variation in forage yield. This was an indication that the ability to get high root and forage yield was not captured by the quality of stem since all the cuttings used were standard.

Table 4.49 Recommended varieties with good ability to produce quality planting materials across 6 locations in Nigeria during the 2006/2009 cropping season.

		MDA indices use for selection* per location						No. Locations out of six where this variety was selected
S/N	Variety	Ajibode, Ibadan	Kate, Onne	RIART, Onne	FCA Akure	Dogodawa Zaria	Demo Onne	
1	92/0057	10.13		9.93	-	10.89	11.16	4
2	92/0325	10.98	11.22	10.75	-	10.27	-	4
3	92/0326	10.31		9.47	9.75	10.05	10.38	5
4	92B/00068	-	10.97	9.27	-	9.83	10.47	4
5	94/0039	-	11.46	9.91	10.13		9.51	4
6	95/0166	-	9.72	10.97	10.15	10.44	12.37	5
7	95/0289	9.70		9.36	10.00		9.25	4
8	96/0523	-	10.39	9.98	10.11	11.39	10.85	5
9	96/1565	9.69	8.88	9.24	-		9.66	4
10	97/4763	10.10	8.63	10.39	9.89	10.69	-	5
11	98/0510	9.59	8.91	10.31	-	9.89	11.07	5
12	98/0581	-	8.89	8.98	9.75	9.76	9.90	5
13	98/2101	-	9.98	9.02	10.99	-	10.88	4
14	98/2226	9.51	11.87	9.58	9.70	-	9.58	5
15	99/2123	10.77	9.54	10.51	9.48	-	-	4
16	99/3073	10.97	8.63	-	9.51	11.03	-	4
	Mean of the 43 varieties	9.21	8.61	8.99	9.45	9.33	9.20	

MDA = Multi-dimension Analysis, RIART = Rivers State Institute of Agricultural Research and Training, FCA = Federal College of Agriculture.

*Only varieties that had their MDA indices greater than the one of the mean of the 43 varieties were selected per location.
- = MDA indices lower than the one of the mean of the 43 cassava varieties in that location.



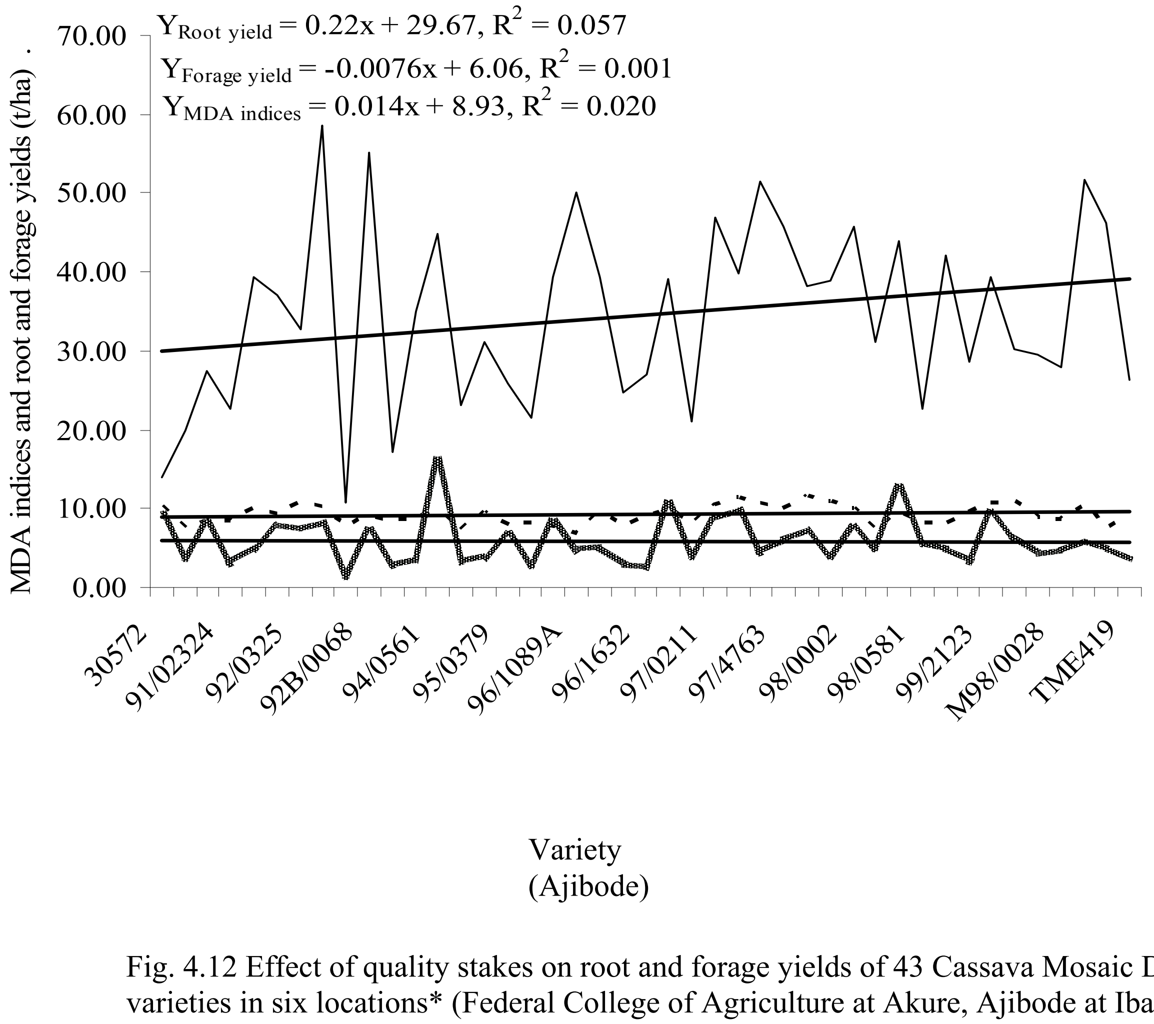
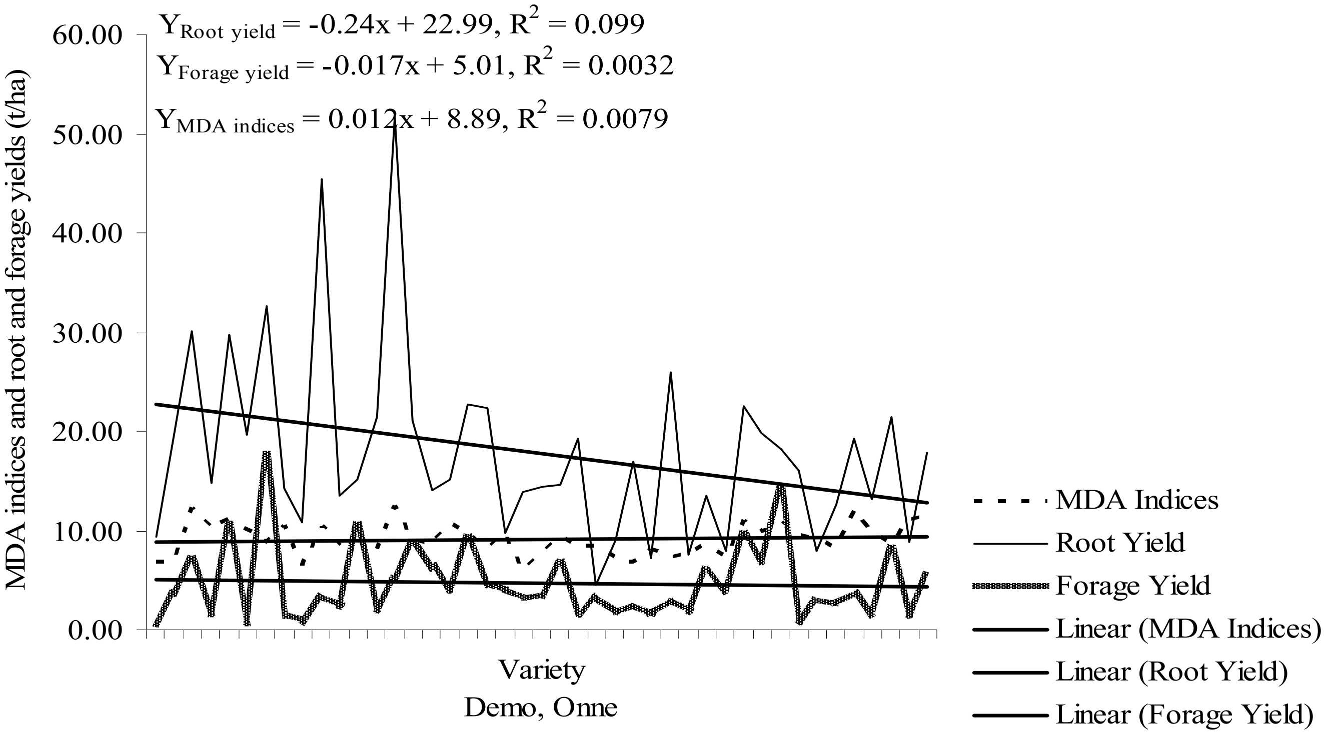
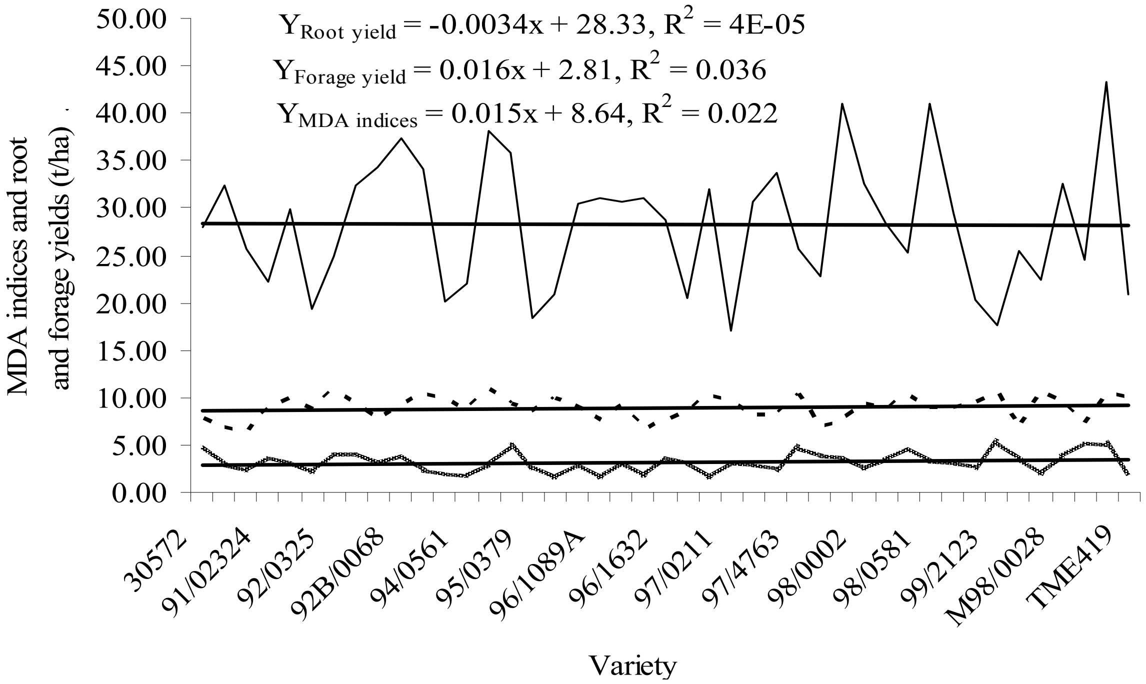


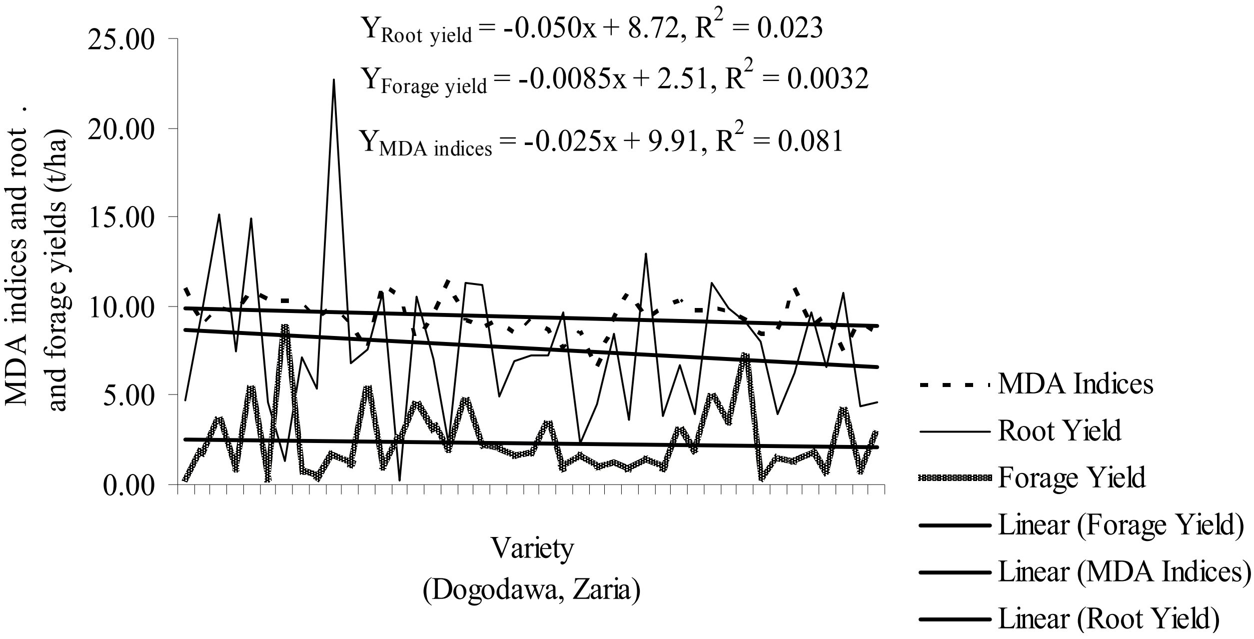
Fig. 4.12 Effect of quality stakes on root and forage yields of 43 Cassava Mosaic Disease Resistant varieties in six locations* (Federal College of Agriculture at Akure, Ajibode at Ibadan,…..).
*See other locations below.





(Rivers State Institute of Agricultural Research and Training (RIART), Onne)

Fig. 4.12 Effect of quality stakes on root and forage yields of 43 Cassava Mosaic Disease Resistant varieties in six locations* (…., RIART and Demo at Onne,…) (Contd.).
*See other locations above and below.



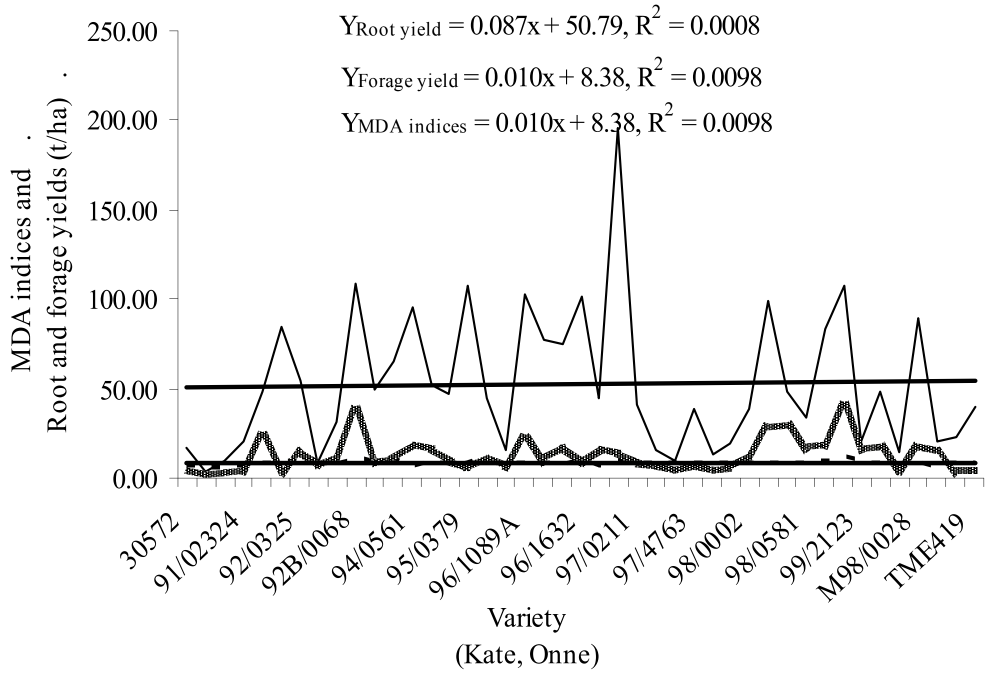


Fig. 4.12 Effect of quality stakes on root and forage yields of 43 Cassava Mosaic Disease Resistant varieties in six locations* (…., Dogodawa at Zaria and Kate plot at Onne) (Contd.). *See other locations above.

CHAPTER 5

DISCUSSION

A better understanding of the current cassava production practices and factors that influenced cassava productivity are prerequisites for the development of improved and new techniques in cassava stem and root production. The new system will enhance the supply of high quality stem required for massive cultivation of cassava for planting cassava.

Fields survey showed that seventeen variables including: days from cutting to planting of stem, plant spacing, planting skill, weed density, field damage, erosion, quality of cassava planting material and non application of fertilizer were responsible for the low stem and root yields obtained in cassava farms. Perez *et al.*, (2009) identified the same factors in addition to the low growth rate of planting materials as significant in influencing wide variation in plant densities across farms. A correlation analysis showed that weed density, plant spacing, days from cutting the stem to planting, field damage and erosion were highly and positively correlated with the missing stands. In which case as the weed density, day from cutting the stem to planting, field damage and erosion increased, the missing stands increased. The stem quality and planting skill were highly and negatively correlated with the missing stands. This means that, as the stem quality and planting skill increased the missing stands decreased.

Evaluations with a uniform plant stand are fundamental for efficient selections in cassava (*Manihot esculenta* Crantz) breeding. However, it is difficult to correct data of missing plants. The effect of missing stands on plot yield may not be noticeable when there are one or two missing plants. The compensatory growth of neighboring plants usually helps to reduce differences in total plot yield (Perez *et al.,* 2009). However, as the proportion of missing plants increases, the compensatory growth of the remaining plants is not enough to correct the total plot yield (Mead 1968; Gomez and De Datta, 1972; James *et al.,* 1973; Kamidi, 1995). The relationship between plant density and crop yield has been reported (Willey and Heath 1969; Vencovsky and Cruz. 1991; Verones *et al.*, 1995; Schmildt *et al.,* 2001). Perez *et al.,* (2009) also found that for every genotype, mean plot yields decreased as the number of missing plant increased.

The direct and indirect effects helped to understand the nature of the cause and effect of the missing stands. Missing stand can be the results of weed density, days from cutting the stem to planting, stem quality, erosion, planting skill, field damage quality of land preparation and the land use efficiency. The residual effect of 0.468 indicated that all the seventheen variables had contributed about 53 % to the missing stands and 47 % of the causes of missing stands were due to residual effects.

The non significant difference observed among the tools used to cut the stem may be due to the fact that these tools did not affect the sprouting of the planted stakes. However, these tools may affect the cassava production in the sense that some stakes may be damaged or have bruise. Also, depending on the tools the cut surface of the stakes may be slanted which will expose the stakes to micro-organisms attack. Sinthuprama, (1980) reported that slanted cut increased tissue exposure to dehydration. The important factor for sprouting of cassava stems is its quality after cutting. Moreover, the number of stakes produced per hour using these tools is also very important. Cassava production required intensive labour [Akhir and Sukra, 2002 (81 man-day/ha), Fermont *et al.,* 2010 (287 man-day/ha), Onweueme and Charles, (1994) (150-200 man-day/ha)], therefore, there is a need to adopt some techniques to reduce the production cost. Akhir and Sukra, 2002; Lungkapin *et al.,* 2007 had designed and tested a stem cutter (Mardi) which can cut all diameters and varieties of cassava stems in horizontal plane with minimum power. Test results was satisfactory indicated that the best cutting quality was obtained when a 60 teeth circular saw was operated at more than 1,200 revolution per minute cutting speed and less than 50 revolution per minute cam shaft speed. The designed unit exhibited higher capacity and efficiency upon uniform feeding rate. It should be noted that these designs though very good may not be available to our farmers and if it is it would not be affordable. Akhir and Sukra, 2002 also reported that the preparation of stem cuttings could be done manually using simple tools such as hand saw or a motorized-chain saw.

Considering the extent of damage stems and the time to prepare stem for a hectare of land, tools used in this study could be ranked as follows: motorized-rotary saw, hand-held saw, secateur, machete and *Okoli* cutter. A very strong polarity towards the bottom of the planted stakes observed in tubers of all varieties may be due to the slanted planting position. When stakes cut with a sharp angle is planted inclined, it allows the localization of the roots in one area of the soil and consequently the grouping of the roots together, easing the harvest (Vincent, 2009). According to some authors, slanting is the best because allows rapid sprouting of the cuttings (Okeke, 1989; Oguzor, 2007) and also gives high root and stem yields (Sinthuprama and Tiraporn, 1984; Tongglum *et al.,* 1990).

The assessment of the effect of number of nodes per stakes on the sprouting ability of cassava showed that sprouting occurred 5 – 15 days after planting. These results were consistent with the previous findings (Vincent, 2009). Sprouting is influenced by position of the stake. Stakes with four nodes gave the highest number of 25-cm plantable stakes. This may be due to the fact that stakes with 4 nodes are longer and heavier than that of 2 and 3 nodes, consequently more food storage. Differences in weight of cuttings affect their food reserve (Okeke, 1994, Eke-Okoro, 2002). Shorter cuttings have low percentage of sprouting in the field due to rapid dehydration. Also there is possibility to have more than three shoots from the stakes with 4 nodes. These results were in line with that of Marianne *et al.,* (2007) who found a positive correlation between number of nodes and the number of stems produced by the stakes. Villamayor *et al.,* 1992 also supported the fact long stakes perform better than short ones when planted horizontally.

Planting spacings of 80 cm x 37.5 cm and 80 cm x 50 cm gave the higher stem yield. This may be due to the high plant population compare to the planting spacing of 100 cm x 50 cm, that is with high plant population, there are a greater number of stems. Villamoyor and Apilar (1981) also reported that stakes can be produced in large quantity by adopting a high population density. These results were in line with that of Villamayor *et al.* (1992) and Evangelio and Ladera (1998). The percentage differences (ratio actual yield / expected yield) of the stake and root production were greater than 1. This means that the actual yield was lower than the expected yield. This is probably due to missing stands that led to reduction in plant population at harvest (Perez *et al.,* 2009). It can be recommended that to meet up with the targeted plant population at harvest narrow spacing should be used at the initial stage to get a high plant population.

On the other hands, application of fertilizers had increased the stem and root yields for the two locations. These results corroborate the findings of Gomez *et al*. (1980), Wilson and Ovid (1994), Howeler (1996), Agbaje .and Akinlosotu, (2004) and Anthony *et al.* (2009) that to increase the yield potential of cassava, there is need for good soil fertility and adequate fertilizer. However, fertilizer requirement for optimum stem and root yields in cassava is determined by soils fertility status of the plot, cropping system, the rainfall pattern during the growing season, weed management, but not influenced by variety, pest and disease pressure and harvest age (Anneke M. Fermont *et al.,* 2010). Fertilization modifies the nutritional status of the cassava stakes (Okeke, 1994) and consequently affects the productivity of subsequent crops. It is therefore recommended that optimum levels of fertilization should be established specifically for producing high and quality stem and root yields (Molina *et al.,* 1995). For the root yield in the two locations, fertilizer NPKSMgO 13:9:27:5:4 had the higher value. This may be due to the high concentration of potassium, knowing that potassium is a best sure fertilizer for cassava. The high potassium need for cassava was also reported by Adekayode and Adeola (2009) who found a positive correlation between the increasing rates of potassium fertilizer with the cassava yield. Hagens and Sittibusaya (1990) reported that without adequate K fertilization, cassava yields declined after several years of continuous cropping due to K depletion. Howeler (1991) supported the idea by stressing that cassava requires some application of N and K fertilizer for maximum root and stem yields. Fertilizers [NPK 16:27:10 + Agrolyzer (DAP: 21 % N + 53 % P, 3.2 kg/10 kg)] and NPK 15:15:15 gave the higher forage yield. This may be due to the high level of N fertilizer. The major nutrients required by cassava for optimum top growth and tuber yields are nitrogen and potassium Obigbesan and Fayemi, (1976), Howeler (1991). These findings confirmed the results of the study of Onwueme and Charles (1994), Wilson and Ovid (1994) who reported that adequate K levels in soil stimulate the response to N fertilizers, but excess amount of both nutrients leads to luxuriant growth at the expense of tuber formation.

The actual stem and root yields obtained from all planted spacings were lower than the expected yields. While the actual planted spacings measured at harvest were wider than the initial ones. This may be due to experimental error, in the sense that the targeted planting spacing was obtained at the planting stage. On the other hand, some cuttings may have shifted from the initial planted areas or did not sprout. Another reason may be that the sprouted cuttings died, due to certain factors (weather, mechanical damage, diseases, etc.). Several factors could have contributed to these losses: climatic and/or agronomic factors. Cock, (1985); Osiru *et al.* (1995) reported that the temperature is one of the primary factors controlling the rates of cassava growth and development. Annual conditions of rainfall, temperature, sunshine and relative humidity influence the growth and yield of cassava. Sunshine or light is the most important growth factor as far as temporal factors of crop growth are concerned (Simwambana *et al.* 1995; Eke-Okoro *et al.,* 1999). The method of planting had also been emphasized by Okeke (1989), Oguzor, (2007). Okechukwu (2009) also reported that diseases are limiting factors to cassava performance. There are also evidences from field research that high sustainable yields are possible with the integrated use of fertilizers and manure (Raman *et al.*, 1996; Singh, *et al.*, 1999; Bahu *et al.*, 2006). Lozano (1977), Eke-Okoro, (2002) recommended the use of quality planting material; which is the most crucial factors that determine the cassava productivity.

Differences between varieties were significant for all the variables studies. This does not mean that some varieties were not good, but the differences may be due to other treatments such as spacings. Plant spacings were strongly associated with the root and forage yield. However, it was observed that the stem, root and forage yields decreased as the plant spacing increased. This was a good indication that cassava does not compensate for the the missing stands. This result was in line with the findings of Nguyen *et al.,* (2007) who stated that narrower spacing gave higher cassava yield that the wider spacing. As mentioned earlier, some authors (Mead 1968; Gomez and De Datta, 1972; James *et al.,* 1973; Ramidi, 1995) also found out that as the proportion of missing plants increases, the compensatory growth of the remaining plants is not enough to correct the total plot yield. Consideration has to be made with the type of variety and spacing to be used, and also the production objective. If the only objective is the production of stakes, high density (40,000 plants/ha) can be used, and when some stakes do not germinate, the surrounding plants will grow and their yield will compensate for the missing ones (Leihner, 2002). When planting for root yield, spacing of 90 cm x 90 cm is recommended (Begun and Paul, 2003). When chosen the planting consideration has to be done on the branching habit of the variety. High branching to be planted on wider space and low branching on narrow spacing.

The number of 25-cm plantable stakes varied from one stem unit to another on the same cassava plant. This may be due to the variations of the morphological characteristics of cassava. Cassava plant height can varied from 1 to 4 m and plant type ranges from highly branching to non-branching and erect types. Variety TMS 98/2226 that had the highest number of 25-cm plantable stakes at its main also had produced stem up to its tertiary branching. Varieties such as TME 419, M98/0028 and TMS 96/0523 can only produce planting material up to their secondary branching. This was due to their morphological characteristic (Erect and high branching type). These findings confirmed the results of Ceballos and de la Cruz, (2002). Cassava plant architecture influences the amount of planting material that the mother plant can produce. It was observed that the number of branches per plant and stem number per unit area affected the stake number.

There was a trend that the number of stakes increased with the number of stem obtained per stem unit. Stake number can also be affected by the plant height. These findings supported the results of the study of Villamayor and Apilar (1981) and Villamayor, (1987). These observations also accord with the literature in showing that the architecture of the cassava stem system, in particular the extent of branching, is the most important determinant of asexual fecundity ion cassava, because the extent of branching affects the distribution of stem across diameter classes (Oka *et al.,* 1987, Keating *et al.,* 1988 Jennings, 1995 and Marianne *et al.*, 2007). However, the extent of branching of cassava plants is affected by many factors including propagation practices and environmental conditions, but it also shows high variability when such factors are controlled (Okogbenin, 2003). The extent of branching and the number of stem per plant can be used as criteria for varietals selection for stem production, taking into consideration the planting spacing.

In the uniformity trial, parameter such as stem and root yields for the variety TME 7 and TMS 30572 showed a positive skew and negative kurtosis. Skewness is the degree of asymmetry of a distribution while Kurtosis is the degree of peakedness of a distribution. Visual examination of the data seems to suggest a substantial deviation from the normal distribution. The negative kurtosis simply signified that the distribution is platykurtic. As the frequency distribution increased, the number of plants having high root and stem yield increased and reach a peak where they will start decrease and even reach zero. Since only one variety was planted at the time at a particular field and had received the same treatment, the difference in yield may be attributed to variation in the part of the stakes planted, the number of missing stands in blocks or in soil heterogeneity.

Analysis of variance for the effect of stakes position from the stem on the root and stem yields was not significant. This means that variation in the root and stem yield could not be attributed to the position of the stakes from the stem. However, the percentage of bottom (ratio of the yield of the Top, Top-Middle, Bottom-Middle over the Bottom) was less than 100 %, which means that the bottom part of the stem is produce higher yields than those taken from the bottom-middle, top-middle and top. These same observations were made by Tongglum *et al.* (1987) and Chankam (1994). Stakes derived from the lower and middle part of the stem had significantly higher germination rates than those derived from the upper part of the stem (George *et al.*, 2001). There is a weight and diameter gradient in cassava stem from the base to the shoot tip. Cuttings of the same length from different parts of the stem may differ in weight. Differences in weight of cutting result in differences in food reserves (Okeke, 1994), and it is on this that the initial growth of the plant depends. The diameter gradient along the stem can also affect the cassava yields (Lozano, 1977) because in most cases, the ratio pith/wood from the top of the stem is greater than 50 %.

Poor quality planting material is often associated with marginal growth and productivity of cassava. Assessment of number of nodes, stem weight (g) and diameter (cm) per 25-cm plantable stake is necessary for good quality cassava planting and high root and stem yields. Results from this study showed that the minimum number of nodes per 25-cm PS was 7. These observations accord with the literature that recommends 5 to 7 nodes per plantable stakes (Cock *et al.*, 1976; Lozano *et al.*, 1977). However, the higher number of nodes on the stake the greater possibility to have more number of stems per plant (Marianne *et al.,* 2007). The mean plantable stake weight obtained (78 g) was lesser but not too far from that obtained by Okeke (88 g) (1994) and Oke-Okoro (88 g) (2001). Differences may be due to the fact that cassava varieties do not have the same characteristics, and also the part of the stem where the stakes have being cut matters. As mentioned earlier, there is a weight gradient in cassava stem from the base to the top of the cassava plant. This applies to the diameter. Different parts of the cassava stem had different diameters, and varieties had different characteristics. The mean diameter obtained from this study (20.1 mm) falls within the range (20-30 mm) recommended by Lozano (1977). The basic is that as a general rule, the diameter of the pith should be less than 50 % of the stem diameter in cross-section. It is also important to note that the stem diameter and the stem length together determine the mass of the planting material. Thus increase in the mass of the planting material may lead to increased yield in the plant. The effect of plantable stakes on root and forage yields was not observed. The ability to produce root and forage was not due to the quality of stakes, but the potential of variety planted.

CHAPTER 6

SUMMARY AND CONCLUSIONS

Despite the increase in the quantity of cassava produced annually, demand for the planting of this crop has continued to exceed supply due to lack of understanding of factors that determine stem production in Nigeria. Therefore, to enhance the supply of stem for planting cassava varieties, survey and multi-locational trials were conducted during 2005-2008 to evaluate the existing production practices and develop new techniques for increasing the number and quality of cassava plantable stakes.

Survey was done in 74 purposively selected cassava farms to evaluate the agronomic practices and assess the percentage missing stands in cassava fields. Different cutting tools were assessed in order to determine which could be the best to be used for stakes preparation. The plant spacing to be used for stem production and the necessity of applying fertilizers for increasing cassava yield were evaluated in a split-split plot design in two locations. Pattern of stakes distribution were evaluated in 43 CMDR varieties in a randomized complete block design in four locations. Cassava varieties TME 7 and TMS 30572 were assessed in a uniformity trial to estimate the stem yield grown in heterogeneous soils. The number of nodes, stem weight and diameter per 25-cm plantable stakes were assessed in six locations to evaluate the stem quality and the effect of quality stems on root and forage yields. The findings in this study are summarized as follows:

1. An average of 23 plants was missing for every 100 plants planted. Factors such as weed density, day from cutting the stem to planting, livestock damage and erosion were positively correlated with the missing stands while stem quality, planting spacing, fertilizer application, planting skill, quality of land preparation and the land use efficiency were negatively correlated with the missing stands. Control of these factors will help to reduce the occurrence of missing stands and increase the cassava stake and root yields.
2. Tools such as motorized-rotary saw cut faster than hand-held saw, Okoli cutter, machete and secateur with minimal nodes damage. Secateur cut slower than all the tools evaluated in this study, but gave a smoother stake edge. For these reasons,

motorized-chain saw could be recommended for commercial cassava production while secateur could be used for subsistence farming.

3. Tubers of all the 43 CMDR varieties planted showed a very strong polarity towards the bottom of the planted stakes. This was due to the slanted planting position and it an advantage because it ease the harvest
4. In the field planted with the five nationally released cassava varieties where stakes were cut at different number of nodes (two, three and four), sprouting occurred 5 to 15 days after planting the cassava stakes irrespectively to the number of nodes per stake.
5. Stakes with four nodes gave the highest stem yield because of the high probability of having more than one sprouted shoot.
6. The percentage difference of stake, root and forage production (actual yield/expected yield) due to missing stands was as low as 11.8 %, 13.2 % and 14.1 % respectively.
7. Considering each parameter separately, planting spacing of 80 cm x 50 cm and 80 cm x 37.5 cm gave the highest number of 25-cm plantables stakes, root and forage yield. By combining the effect of planting spacing with the number of nodes, the combination of 80 cm x 50 cm with stakes with four nodes gave the highest stem and forage yields.
8. There was no significant difference among the three types of fertilizers applied at Onne and Ogurugu. However, application of fertilizers increased the stem yield by 71.6 % (premix “NPK 16:27:10 + Agrolyzer”), 69.9 % (NPK 15:15:15) 80.8 % (NPKMgO 13:9:27:5:4) at Onne and 72.6 % (NPK 16:27:10 + Agrolyzer), 76.3 % (NPK 15:15:15) and 83.9 % (NPKMgO 13:9:27:5:4) at Ogurugu.
9. There was no significance difference among spacing and interaction and spacing by variety for both expected and actual stem and forage yields, but these differences were significant for both actual and expected root yields. It was observed that the stem, root and forage yields decreased as the planting spacing increased. This was a good indication that cassava does not compensate for the the missing stands.
10. Among the 43 CMDR varieties, plantable stakes were from the main stem, primary, secondary, tertiary and quaternary stem. Only varieties TMS 96/0523, TMS 99/6012, TMS M98/0028 and TME 419 did not have plantable stakes at their tertiary branches.

11. The effect of plantable stakes on root and forage yields could not be observed due to environmental errors such as small or unequal slope in the field, squares not perfect. The ability to produce root and forage cannot be captured by the quality of stakes, but the genetic potential of the variety where standard stakes were used in the trial.

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APPENDICES

Appendix 1 QUESTIONNAIRES FOR CASSAVA PRODUCERS.

SECTION 1: PERSONAL DATA

1. Sex (a) Male (b) Female
2. State of Origin:________________________________
3. Local Government Area: ________________________
4. Town/Village: __________________________________
5. Marital Status: (a) Single (b) Married (c) Widow (d) Separated

   (e) Divorced (f) Others (specify)

4. Religion (a) Christianity (b) Islam (c) Traditional (d) Others (specify)
5. Age (tick the one that applies)

   a) Less than 20 years (b) 20-29 years (c) 30-39 years (d) 40-50 years

   (e) More than 50 years

Farm size: ____

Farm Location:_____________________________________

Major Occupation: (a) Farming (b) Tailoring (c) Trading (d) Lecturer

(e) Combination (f) Others (specify)

Education Background

(a) No formal education

(b) Some primary

(c) Finished Primary Six

(d) Some Secondary

(e) Others (specify)

Do you grow cassava for (a) Home consumption? (b) Commercial? (c) Both?

(d) Others (specify)

How long have you been producing cassava? _________________________

Have you ever attended any training on cassava production? ______________

Do you belong to any co-operative society? ____________________________

Who owns the farm? Private or Community farm? ______________________

If community farm what is your position, Staff or Manager? ______________

SECTION 2: PRODUCTION INPUT SUPPLY

How long have you been growing cassava commercially? _______________

Has there been an increase or decrease in price ___________, profit ___________

What varieties of cassava do you plant? List__________, ___________, _____

Which of the varieties do you plant most and why? ____________________

____

Where do you get your planting materials?

(a) Personal farm
(b) Local market
(c) Research Institute
(d) Private Farmer
(e) Others (specify) ____

How regular is the supply?

(a) Very regular
(b) Regular
(c) Moderate
(d) Not regular
(e) Scarce

What was the nature of the land before this present planting, continuous cropping, fallow or virgin land? ______________________________________

How did you obtain the initial fund for your farm work?

(a) Personal saving

(b) Relatives/Friends

(c) Cooperative/Association

(d) Private Money Lender

(e) Bank

(f) Others (specify) ____

24. How do you get information on how to improve your cassava crop?

(a) State ADP Staff

(b) Extension Staff of a University

(c) Older farmers

(d) Personal experience

25. Where do you get labour?

(a) Family (b) Hired (c) Others (specify) ______________________________

26. How good/effective are your labours? Skill labours? Unskilled labours? Others?

27 How many man-days did you use to plant your cassava farm?

28 What is the average cost for one man-day work in your location? _______________

29. What are your inputs in cassava production?

____

____

30. When do you usually plant cassava?

____

Cassava production activities and time they are carried out.

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Land preparation Planting Weeding 1st 2nd 3rd 4th Fertilizer application Insecticide application Manure application Re-heaping Harvesting Other activities (specify)												

31. Why don't you plant at other times? ____

____

32. Does fertilizer application increase yields of cassava tubers? ________________

33. What things destroy your crops? ____

34. What do you do about them? ____

____

35. How are weeds suppressed? ______________________________________

Production

36 How long did you keep your cassava stems before planting them to the field?

1 day? 2 days? 3-5 days? Beyond one week? 1 month? 2 months? 3 months? Others (specify) ______________________________

37. Did you treat the cassava planting material before planting? ___________________

38. Which tool (s) did you use to cut the stem into stakes? Secateur? Matchete? Others?

Specify ____

39. How is your cassava crop planted?

(a) Direct planting of stem cuttings into the soil

(b) Pre-sprouting of the cutting before planting

(c) Others (specify)____

40. What was the planting spacing used? 1m x 1 m? 1m x 0.5 m? Irregular? Others?

____

41. Which tool (s) did you use to plant your cassava in the field? Rope? Stick? Pace?

None? Others? ____

42. Did you spray pre-emergence herbicide after planting? _______________________

43. How many times did you weed your farm? ____________________________

44. How did you weed your farm? Manual? Chemical? Both (Integrated)? ___________

45. Did you apply any fertilizer? If yes which type? ____________________

46. What percentage establishes

No. Planted	No. Died	% Establishment
Direct seeding		
Seedling transplant		

47. Do you make heaps? Ridges? Flat? _____________________________________

48. Do you mix cassava with other crops? List the crops___________________

49. Do you grow cassava for (a) Home consumption? (b) Commercial? (c) Both?

(d) Others (specify)_______________________________________

50. In what way do you achieve this?

(a) by selling cassava stems

(b) by selling cassava tubers

(c) Others (specify)

51. Why do you do (a)

(b)

or (c) in question 24?

52. When you have poor sprouting in your farm, how do you handle it?

(a) Replacement

(b) Nothing

(c) Plant other crops

(d) Others (specify)

53. What are the causes of poor sprouting in your farm?

(a) Termite infestation

(b) Old age of plant

(c) Use of immature stems

(d) Drought

(e) Flood

(f) Bad planting

(g) Poor land preparation

54. How do you prevent poor germination?

(a) Matching the weather with planting

(b) Close spacing

(c) Treating the stem with chemical

(d) Others (specify)

Harvesting/Storage/Sales

55. What month do you harvest your roots/stems?

Roots ________________________

Stems __________________________

56. What quantity of tubers do you obtain from your field? ________________________

57 What quantity of Stems do you produce from your field? ____________________

58. How long do you store the roots? ___________________________________

59. How long do you store the roots before sales? _______________________

60. How long do the tubers/leaves remain with you on farm? ____________________

61. Who are your buyers?

    (a) Traders m/f

    (b) Transporters m/f

    (c) Retailers m/f

    (d) Middle men/women

    (e) Wholesale m/f

    NB: m = Male; f = Female

62. How do you determine your prices? _________________________________

63. What is the sales difference between irrigated and rain fed tubers/leaves?

    ____

64. How do you harvest tubers/leaves?

65. How often do you harvest your tubers/leaves?

63. Who does the harvesting, m/f?

67. Please list seven most important problems facing cassava producers.

    Rank in order of importance.

    a)

    b)

    c)

    d)

    e)

    f)

    g)

68. How do you assess the future prospects of cassava producers?

Appendix 2 Field Layout showing 43 varieties of cassava planted in 2 replicates each of which received 5 treatments [Okoli-cutter; HandSaw; Matchete; Secateur; Engine (Motorized saw)] during the 2005/2006 cropping season at Onne.

Rep 2

V5	V42	V40	V3	V37	V11	V7	V35	V2	V23	V41	V28	V13	V33	V38
V34	V21	V9	V32	V15	V31	V25	V6	V26	V12	V29	V19	V39	V1	
V27	V24	V22	V20	V18	V17	V16	V14	V10	V8	V43	V4	V36	V30	

150 cm

Rep 1

		V43	V42	V41	V40	V39	V38	V37	V36	V35	V34	V33	V32	V31
V30	V29	V28	V27	V26	V25	V24	V23	V22	V21	V20	V19	V18	V17	V16
V15	V14	V13	V12	V11	V10	V9	V8	V7	V6	V5	V4	V3	V2	V1

550 cm

200 cm

Appendix 3 Field Layout of a split-split design showing the number of nodes per stake, spacings and the varieties.

Row to row by plant to plan spacing	Number of nodes per stake	Varieties planted in their different positions																	
100 cm x 50 cm	3 – nodes	V1	V2	V3	V4	V5	2 - 3	V5	V1	V2	V3	V4	4 - 5	V1	V4	V2	V3	V5
	4 - nodes	V1	V3	V4	V5	V2	4 - 5	V4	V5	V1	V2	V3	2 - 3	V4	V3	V5	V1	V2
	2- nodes	V1	V2	V4	V5	V3	3 - 4	V3	V1	V2	V5	V4	3 - 4	V2	V1	V3	V4	V5
80 cm x 50 cm	3 - nodes	V1	V2	V4	V3	V5	4 - 5	V3	V4	V1	V2	V5	2 - 3	V2	V1	V4	V5	V3
	4- nodes	V1	V2	V5	V3	V4	2 - 3	V5	V1	V4	V2	V3	3 - 4	V5	V4	V3	V1	V2
	2- nodes	V2	V3	V4	V5	V1	3 - 4	V5	V3	V1	V2	V4	4 -5	V5	V4	V1	V2	V3
80 cm x 37.5 cm	4 - nodes	V2	V3	V4	V1	V5	3 - 4	V1	V2	V3	V4	V5	2 - 3	V1	V2	V3	V4	V5
	3- nodes	V2	V3	V1	V4	V5	2 - 3	V4	V1	V2	V3	V5	4 - 5	V2	V1	V4	V5	V3
	2 -nodes	V3	V1	V2	V4	V5	4 - 5	V4	V2	V1	V3	V5	3 - 4	V2	V1	V3	V4	V5
		REP I						REPII						REPIII				

Appendix 4 Field map showing the area (m^2) for each treatment, type of fertilizer and the quantity of nutrient (kg) applied at Onne and Ogurugu.

Plot size = 388.08 m^2 (Plant to plant = 0.8; Row to Row 0.9, 0.8 and 0.7 for each type of fertilizer)

No Fertilizer
NPKSMgO:13:9:27:5:4 N=2.018 kg K=3.479 kg MgO=0.466 kg P=0.615 kg S=0.205 kg
NPK 15:15:15 N=2.328 kg P=1.024 kg K=1.932 kg
NPK 16:27:10 N=2.484 kg P=1.844 kg K=1.288 kg

Plot size = 288.96 m^2 (Plant to plant = 0.8; Row to Row 0.9, 0.8, 0.7 and 0.6 for each type of fertilize)

No Fertilizer
NPKSMgO: 13:9:27:5:4 N=1.502 kg K=2.590 kg MgO=0.347 kg P=0.458 kg S=0.153 kg
NPK 15:15:15 N=1.734 kg P=0.763 kg K=1.439 kg
NPK 16:27:10 N=1.849 kg P=1.373 kg K=0.959 kg

Plot size = 365.4 m^2 (Plant to plant = 0.5; Row to Row 0.9, 0.8, 0.7 and 0.6 for each type of fertilizer)

No Fertilizer
NPKSMgO: 13:9:27:5:4 N=1.90 kg K=3.275 kg MgO=0.438 kg P=0.579 kg S=0.193 kg
NPK 15:15:15 N=2.192 kg P=0.965 kg K=1.819 kg
NPK 16:27:10 N=2.338 kg P=1.736 kg K=1.213 kg

Plot size = 438.4 m^2 (Plant to plant = 0.6; Row to Row 0.9, 0.8, 0.7 and 0.6 for each type of fertilizer)

No Fertilizer
NPKSMgO: 13:9:27:5:4 N=2.280 kg K=3.930 kg MgO=0.526 kg P=0.694 kg S=0.231 kg
NPK 15:15:15 N=2.630 kg P=1.157 kg K=2.183 kg
NPK 16:27:10 N=2.856 kg P=2.083 kg K=1.455 kg

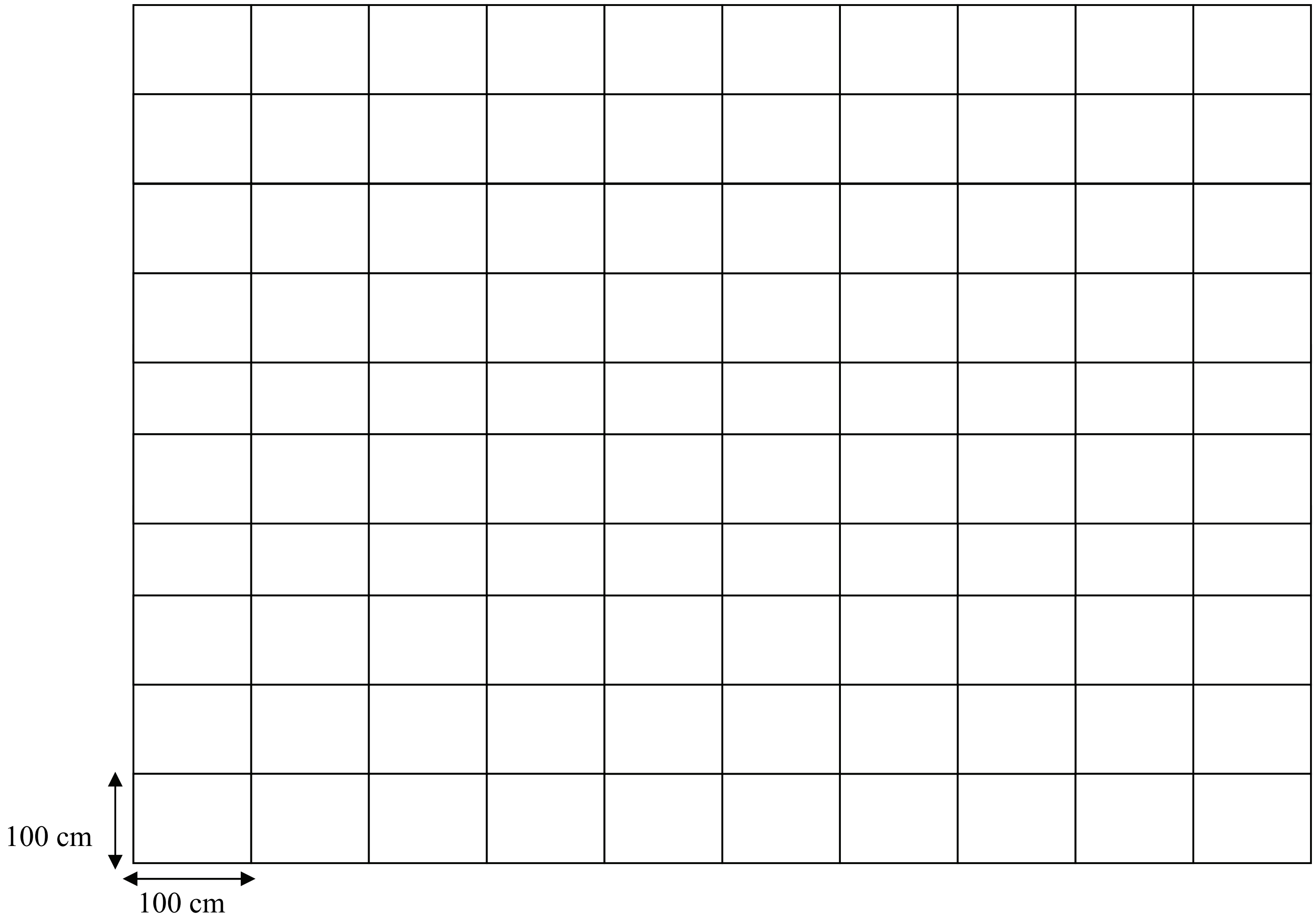
Appendix 5 Field Layout showing the different spacing combinaisons at Onne during the 2005/2006 season.

	100 cm x 50 cm	90 cm x 50 cm	90 cm x 70 cm	80 cm x 50 cm	70 cm x 50 cm	70 cm x 60 cm	80 cm x 60 cm	70 cm x 70 cm	90 cm x 60 cm	80 cm x 80 cm	80 cm x 70 cm	90 cm x 80 cm
V6 →												
V2 →												
V3 →												
V1 →												
V5 →												
V7 →												
V4 →												

200 cm

	80 cm x 50 cm	70 cm x 60 cm	70 cm x 70 cm	80 cm x 70 cm	90 cm x 60 cm	90 cm x 80 cm	80 cm x 80 cm	70 cm x 50 cm	100 cm x 50 cm	80 cm x 60 cm	90 cm x 70 cm	90 cm x 50 cm
V7 →												
V6 →												
V5 →												
V4 →												
V3 →												
V2 →												
V1 →												

Appendix 6 Layout of the uniformity trial for each variety planted at 100 cm by 100 cm for each location during the 2008/2009 cropping season.



Appendix 7.1 Percentage of missing cassava stands in 74 farms during the 2006/2007 cropping season in Southwest and Southeast of Nigeria.

S/N	Farm No. Location Varieties	1 Onne 8C	2 Onne 8D	3 Onne Oku 1	4 Onne Oku 2	5 Onne 8E	6 Onne 15A	7 Onne 12C	8 Onne 15B	9 Onne 10C	10 Onne 9B	11 P/H UST1	12 P/H UST2
1	30572	11.81	-	2.78	8.92	14.12	50.56	-	-	-	-	24.07	-
2	4(2)1425	10.42	17.61	19.44	23.68	7.18	91.25	4.88	-	18.75	-	62.04	-
3	82/00058	4.86	-	1.85	4.80	5.56	11.54	-	-	1.39	6.48	31.71	-
4	91/02324	6.25	-	10.19	3.43	42.36	17.32	-	14.38	0.00	10.19	6.25	14.58
5	92/0057	2.78	-	12.04	6.00	9.03	18.85	27.21	13.93	13.89	12.04	16.67	20.24
6	92/0067	4.86	31.18	17.59	8.97	11.11	28.69	23.55	-	3.47	1.85	36.81	20.00
7	92/0325	3.47	-	9.26	18.87	4.17	21.61	-	13.57	11.81	9.26	40.97	20.12
8	92/0326	2.08	8.82	7.41	-	7.64	16.66	5.15	-	6.94	2.78	16.67	36.23
9	92B/00061	2.78	33.10	28.70	-	1.39	9.05	-	6.06	2.08	1.85	40.28	15.05
10	92B/00068	8.33	-	5.56	10.48	10.42	11.73	3.74	-	0.00	6.48	18.06	14.34
11	94/0026	29.17	-	23.15	15.24	15.97	5.41	3.05	2.78	15.28	18.52	33.33	13.19
12	94/0039	27.08	-	1.85	9.01	4.86	-	-	6.89	11.11	20.37	7.64	9.15
13	94/0561	6.94	-	5.56	32.50	0.00	-	-	-	22.92	15.74	11.11	5.99
14	95/0166	6.94	-	6.48	7.69	21.53	-	25.94	14.50	3.47	2.78	11.11	17.75
15	95/0289	6.94	-	1.85	7.69	2.08	10.60	9.90	24.03	2.78	36.11	18.75	13.37
16	95/0379	4.86	16.22	1.85	12.86	6.25	26.75	14.90	-	0.69	3.70	13.89	19.61
17	96/0523	1.39	-	19.44	16.67	1.39	-	-	6.76	0.00	0.93	15.28	2.97
18	96/0603	6.25	-	14.81	28.05	3.47	4.65	3.56	-	4.17	6.48	14.58	19.83
19	96/1089A	9.72	6.11	13.89	-	1.39	12.52	7.52	-	2.78	0.00	23.61	41.67
20	96/1565	6.25	10.67	8.33	23.08	0.00	6.11	-	-	3.47	4.63	18.75	30.77
21	96/1569	8.16	3.85	9.26	9.76	2.08	4.40	-	-	8.33	1.85	-	-
22	96/1632	-	11.32	1.85	-	6.94	-	-	5.97	10.42	5.56	24.31	8.39
23	96/1642	-	-	13.89	50.00	1.39	2.54	-	-	6.25	-	13.19	26.77
24	97/0162	-	28.10	13.89	12.95	2.08	11.46	10.19	12.16	11.81	-	14.58	12.77
25	97/0211	-	-	6.48	4.65	4.86	-	10.90	-	10.42	-	12.50	25.00
26	97/2205	-	-	7.41	32.76	2.08	-		10.53	5.56	-	12.50	4.16
27	97/3200	-	12.61	6.48	7.47	3.47	11.14	1.45	-	-	-	2.78	9.91
28	97/4763	-	-	0.93	-	1.39	-		4.00	-	-	3.47	5.57
29	97/4769	-	17.98	15.74	17.39	2.78	7.49	12.07	-	-	-	18.06	19.30
30	97/4779	-	-	88.89	56.76	3.47	-	-	-	-	-	10.42	14.17
31	98/0002	-	53.30	20.37	27.03	1.39	31.86	-	2.83	-	-	22.92	26.85
32	98/0505	-	-	10.19	14.29	5.56	-	-	10.91	-	-	25.69	20.73
33	98/0510	-	14.42	14.81	37.63	18.75	7.05	6.64		-	-	31.25	14.64
34	98/0581	-	-	21.30	44.87	11.81	-		13.23	-	-	20.14	7.83
35	98/2101	-	-	23.15	51.09	6.25	61.35		3.97	-	-	6.25	15.77
36	98/2226	-	-	1.85	4.26	6.94	13.42	5.46	-	-	-	6.94	8.13
37	99/2123	-	-	24.07	38.89	16.67	8.46	4.01	-	-	-	23.61	17.06
38	99/3073	-	-	18.52	17.57	18.75	-		-	-	-	19.44	8.18
39	99/6012	-	8.25	9.26	8.14	8.33	1.25	13.25	-	-	-	43.75	21.43
40	M98/0028	-	8.06	8.33	0.00	11.11	3.57	33.56	-	-	-	26.39	19.87
41	M98/0040	-	12.18	20.37	19.51	3.47	-	11.28	-	-	-	28.47	13.18
42	M98/0068	-	34.45	6.48	12.92	6.94	-	-	-	-	-	9.03	0.80
43	TME419	-	12.59			12.50	1.78	-	-	-	-	18.75	19.44
44	NR8082	-	-	-	-	-	-	-	-	-	-	-	-
45	NR8083	-	-	-	-	-	-	-	-	-	-	-	-
	Mean	8.16	17.94	13.23	19.08	7.65	17.55	11.34	9.79	7.11	8.38	20.38	16.28
	Minimum	1.39	3.85	0.93	0.00	0.00	1.25	1.45	2.78	0.00	0.00	2.78	0.80
	Maximum	29.17	53.30	88.89	56.76	42.36	91.25	33.56	24.03	22.92	36.11	62.04	41.67
	Std.	7.18	12.57	14.06	14.82	7.75	19.85	8.99	5.63	6.20	8.76	12.17	8.73
	CV (%)	87.99	70.10	106.28	77.68	101.32	113.07	79.29	57.54	87.13	104.55	59.69	53.64

Std = Standard Deviation; CV (%) = Coefficient of Variation; P/H = Port Harcourt; - = Not planted

Appendix 7.1 Percentage of missing cassava stands in 74 farms during the 2006/2007 cropping season in Southwest and Southeast of Nigeria (Contd).

S/N	Farm No. Location Varieties	13 Bayelsa Opolo	14 Ugbo ha 1	15 Ugbo ha 2	16 Onne 22	17 Onne Police	18 Ibadan Ajibode	19 Obayantor Div. Heri.	20 Ibadan BS9	21 Ibadan BS10	22 Ibadan BS11A
1	30572	11.51	43.16	61.74	17.19	-	25.05	39.07	33.33	23.44	14.58
2	4(2)1425	-	-	-	8.70	-	38.46	-	-	-	-
3	82/00058	-	-	-	28.26	-	30.97	33.55	-	-	-
4	91/02324	2.08	-	-	7.00	17.11	48.22	57.33	14.06	9.38	3.47
5	92/0057	-	-	52.50	13.95	-	40.99	59.25	-	-	-
6	92/0067	1.85	-	-	12.50	-	25.84	40.60	-	41.67	-
7	92/0325	-	-	-	21.88	32.47	35.82	38.64	-	-	-
8	92/0326	-	50.62	-	29.00	20.32	36.29	19.09	42.19	57.81	-
9	92B/00061	3.47	-	-	10.42	41.30	39.19	43.48	-	-	-
10	92B/00068	-	-	-	9.38	-	36.73	34.92	-	-	-
11	94/0026	36.11	-	50.83	53.13	34.06	31.80	34.11	53.13	46.88	-
12	94/0039	11.81	-	60.24	4.17	18.52	39.02	46.79	-	-	-
13	94/0561	19.44	-	-	5.00	12.53	18.28	-	-	-	-
14	95/0166	2.78	-	-	21.59	5.82	27.12	40.33	68.75	59.38	-
15	95/0289	1.85	-	-	26.09	-	34.81	44.69	10.94	7.81	-
16	95/0379	2.78	-	-	0.00	-	28.18	47.21	-	-	-
17	96/0523	4.86	-	-	3.13	-	27.87	43.00	-	-	-
18	96/0603	10.42	-	-	8.33	-	11.95	26.67	60.94	35.94	-
19	96/1089A	4.86	-	-	7.29	-	24.81	43.60	-	-	-
20	96/1565	2.08	-	-	9.90	-	37.30	-	-	-	-
21	96/1569	2.08	-	-	11.46	-	33.50	-	-	-	-
22	96/1632	7.64	-	-	10.00	-	29.36	-	-	-	-
23	96/1642	4.86	-	-	11.36	-	33.82	-	17.19	40.63	-
24	97/0162	-	-	-	9.01	40.08	50.59	-	-	-	-
25	97/0211	2.78	-	-	3.13	25.98	52.85	24.89	-	-	-
26	97/2205	6.94	-	-	13.02	-	35.10	32.99	-	-	-
27	97/3200	4.86	-	-	6.25	-	29.32	41.67	-	-	-
28	97/4763	0.00	-	-	5.43	-	21.45	39.04	-	-	-
29	97/4769	-	-	-	4.35	-	28.55	43.02	-	-	-
30	97/4779	1.39	-	-	3.03	15.09	22.03	53.94	-	-	-
31	98/0002	1.39	30.78	-	8.82	27.12	62.14	-	-	-	-
32	98/0505	-	13.89	-	5.21		36.42	27.13	-	-	-
33	98/0510	-	-	-	22.92	58.95	17.72	47.75	71.88	54.69	-
34	98/0581	4.86	41.67	-	8.33		29.03	27.40	18.75	39.06	-
35	98/2101	1.39	-	-	8.44	22.70	37.87	44.23	29.69	32.81	-
36	98/2226	6.94	-	-	1.14		35.25	35.91	39.06	25.00	-
37	99/2123	23.61	-	-	17.71		64.47	42.51	-	-	-
38	99/3073	0.69	-	-	9.09		44.00	-	-	-	-
39	99/6012	-	-	-	31.52		37.52	34.24	-	-	-
40	M98/0028	-	-	-	7.29		26.79	-	-	-	-
41	M98/0040	-	-	-	7.61	12.13	29.13	35.44	-	-	-
42	M98/0068	6.25	35.16		4.35		18.90	35.74	-	-	-
43	TME419	-	-	-	15.22	20.61	35.43	48.17	-	-	-
44	NR8082	-	-	-	-	-	-	-	-	-	-
45	NR8083	-	-	-	-	-	-	-	-	-	-
	Mean	6.61	35.88	56.33	12.13	25.30	33.72	39.59	38.32	36.50	9.03
	Minimum	0.00	13.89	50.83	0.00	5.82	11.95	19.09	10.94	7.81	3.47
	Maximum	36.11	50.62	61.74	53.13	58.95	64.47	59.25	71.88	59.38	14.58
	Std.	7.85	12.76	5.46	10.05	13.48	10.80	8.99	21.46	16.69	7.86
	CV (%)	118.88	35.56	9.69	82.86	53.29	32.04	22.72	55.99	45.72	87.03

Std = Standard Deviation; CV (%) = Coefficient of Variation; Div. Her. = Divine Heritage; - = Not planted

Appendix 7.1 Percentage of missing cassava stands in 74 farms during the 2006/2007 cropping season in Southwest and Southeast of Nigeria (Contd).

S/N	Farm No. Location Varieties	23 Ibadan BS11B	24 Ibadan BS12F	25 Ibadan BS12T	26 Ibadan BS15F	27 Onne RIART	28 Warri site 1	29 Warri Site 2	30 Warri Site 3	31 FCA 1	32 FCA 2
1	30572	-	-	20.83	3.33	51.78	-	-	-	15.26	38.51
2	4(2)1425	51.92	77.08	-	-	-	-	-	-	-	-
3	82/00058	-	-	-	-	-	-	-	-	-	-
4	91/02324	-	13.89	5.56	11.67	-		40.88		27.71	35.36
5	92/0057	14.06	-	-	-	-	-	-	-	26.72	40.00
6	92/0067	-	-	-	-	-	-	-	-	17.34	44.10
7	92/0325	-	-	-	-	-	-	-	-	32.83	43.12
8	92/0326	33.82	-	20.83	-	-	-	-	-	14.49	42.62
9	92B/00061	-	-	-	-	-	37.89	-	-	27.43	42.74
10	92B/00068	-	-	-	-	-	-	-	-	32.32	-
11	94/0026	-	-	-	-	-	-	-	63.47	22.00	40.54
12	94/0039	-	-	-	-	-	-	-	-	10.81	45.08
13	94/0561	-	-	-	-	-	-	-	-	19.11	33.46
14	95/0166	-	-	-	-	-	-	-	-	18.86	-
15	95/0289	-	-	-	-	-	-	-	-	22.73	40.37
16	95/0379	-	-	-	-	-	-	70.39	-	10.40	34.59
17	96/0523	-	-	-	-	-	-	-	-	25.47	39.22
18	96/0603	-	-	-	-	-	-	-	-	29.66	28.21
19	96/1089A	-	-	-	-	-	-	-	-	21.27	44.89
20	96/1565	-	-	-	-	-	-	-	-	32.97	41.77
21	96/1569	-	-	-	-	-	-	-	-	26.69	30.75
22	96/1632	-	-	-	-	-	-	-	-	52.38	40.09
23	96/1642	-	-	-	-	-	-	-	-	36.69	50.45
24	97/0162	-	-	-	-	-	-	-	76.66	19.65	39.43
25	97/0211	-	-	-	-	-	35.02	-	-	24.36	33.60
26	97/2205	-	-	-	-	61.52	24.32	-	-	12.01	29.53
27	97/3200	-	-	-	-	-	3.62	-	-	20.98	36.05
28	97/4763	-	-	-	-	-	-	-	-	41.74	41.97
29	97/4769	-	-	-	-	-	55.13	-	-	34.20	46.42
30	97/4779	-	-	-	-	-	-	-	-	25.70	38.99
31	98/0002	-	-	-	-	-	47.28	-	-	12.20	63.72
32	98/0505	-	-	-	-	59.24	-	-	-	24.16	40.21
33	98/0510	-	-	-	-	68.24	-	-	-	15.41	-
34	98/0581	-	-	-	-	76.98	-	-	-	41.30	29.27
35	98/2101	-	-	-	-	-	-	-	-	40.52	37.89
36	98/2226	-	-	-	-	-	-	-	-	43.16	35.56
37	99/2123	-	-	-	-	-	-	-	-	22.25	39.59
38	99/3073	-	-	-	-	-	-	-	-	39.81	36.19
39	99/6012	-	-	-	-	-	-	-	-	22.90	34.41
40	M98/0028	-	-	-	-	-	-	-	-	18.03	-
41	M98/0040	-	-	-	-	-	7.19	-	-	21.64	-
42	M98/0068	-	-	-	-	-	25.00	-	-	26.92	42.86
43	TME419	20.51	-	-	-	50.75	-	-	-	27.51	31.43
44	NR8082	-	-	-	-	42.64	-	-	-	-	-
45	NR8083	-	-	-	-	-	-	-	-	-	-
	Mean	30.08	45.49	15.74	7.50	58.74	29.43	55.64	70.06	25.79	39.25
	Minimum	14.06	13.89	5.56	3.33	42.64	3.62	40.88	63.47	10.40	28.21
	Maximum	51.92	77.08	20.83	11.67	76.98	55.13	70.39	76.66	52.38	63.72
	Std.	16.73	44.69	8.82	5.89	11.57	18.08	20.87	9.33	9.79	6.65
	CV (%)	55.61	98.24	56.04	78.57	19.69	61.44	37.50	13.31	37.95	16.94

Std = Standard Deviation; CV (%) = Coefficient of Variation; FCA = Federal College of Agriculture; - = Not planted

Appendix 7.1 Percentage of missing cassava stands in 74 farms during the 2006/2007 cropping season in Southwest and Southeast of Nigeria (Contd).

	Farm No.	33	34	35	36	37	38	39	40	41	42	43
	Location	FCA	Onne	Oguta	Oguta	Onne	Onne	Onne	Ferdi	Ferdi	F/P	Ogu
S/N	Varieties	3	12B	NSM1	NSM 2	Kate	20	20B	nand 1	nand 2	I/U	rugu1
1	30572	77.68	70.26	19.76	35.04	22.45	2.78	-	33.85	39.34	61.96	13.67
2	4(2)1425	-	52.84	22.64	20.80	24.49	-	-	-	-	-	-
3	82/00058	-	15.38	-	-	38.78	-	-	-	-	-	-
4	91/02324	66.67	-	-	30.80	18.37	29.86	12.41	-	-	-	-
5	92/0057	94.44	-	-	32.96	18.37	-	-	-	-	76.00	
6	92/0067	85.42	-	-	34.56	16.33	-	-	-	-	-	-
7	92/0325	89.58	-	17.20	-	22.45	-	-	38.04	-	-	-
8	92/0326	66.67	-	17.13	-	18.37	20.14	-	-	-	-	-
9	92B/00061	74.31	-	-	32.80	16.33	-	24.64	-	-	-	-
10	92B/00068	46.53	-	-	29.42	18.37	-	-	-	-	-	-
11	94/0026	47.92	-	-	-	24.49	-	-	-	-	74.08	-
12	94/0039	49.31	-	-	-	20.41	-	-	-	-	-	-
13	94/0561	90.28	28.21	-	-	32.65	6.94	6.42	-	-	-	-
14	95/0166	54.17	-	-	-	12.24	-	-	-	40.82	-	-
15	95/0289	72.22	-	-	-	20.41	4.86	-	-	-	-	-
16	95/0379	62.50	-	-	-	20.41	-	-	-	-	-	-
17	96/0523	84.03	-	-	27.52	26.53	-	-	-	-	-	-
18	96/0603	56.94	-	-	34.32	14.29	-	25.97	-	-	-	-
19	96/1089A	94.44	51.76	17.27	-	14.29	14.58	-	37.20	-	-	-
20	96/1565	84.72	-	-	-	14.29	-	-	-	-	-	-
21	96/1569	94.44	55.93	-	-	16.33	-	-	-	-	-	-
22	96/1632	93.06	79.44	-	33.04	12.24	11.11	-	-	-	-	-
23	96/1642	88.19	-	21.60	-	10.20	-	-	-	42.42	-	-
24	97/0162	79.86	-	-	-	18.37	-	-	-	39.76	-	-
25	97/0211	95.83	-	-	-	14.29	7.64	-	-	40.81	-	-
26	97/2205	95.83	-	25.28	-	20.41	4.86	-	40.42	41.00	-	9.29
27	97/3200	87.50	-	20.88	-	20.41	36.11	-	40.86	39.31	-	-
28	97/4763	66.67	-	19.60	31.20	12.24	54.17	-	-	43.63	-	-
29	97/4769	81.25	-	-	-	18.37	-	-	-	42.27	-	-
30	97/4779	86.11	-	-	34.00	28.57	-	-	-	-	-	-
31	98/0002	84.72	-	-	37.60	20.41	50.69	-	-	-	-	-
32	98/0505	91.67	-	22.48	-	18.37	-	30.40	-	-	-	14.86
33	98/0510	82.64	27.65	19.52	-	28.57	-		-	-	-	18.66
34	98/0581	90.97	-	-	36.72	16.33	34.72		-	-	-	5.75
35	98/2101	85.42	65.34	-	30.32	22.45	18.75	15.69	-	-	-	-
36	98/2226	51.39	-	-	33.68	12.24	-	-	-	-	-	-
37	99/2123	68.75	36.36	-	26.00	14.29	26.39	-	-	-	-	-
38	99/3073	73.61	-	-	33.36	16.33	35.42	-	-	-	-	-
39	99/6012	83.33	-	-	24.88	26.53	3.47	-	-	-	-	-
40	M98/0028	77.78	-	-	-	22.45	-	-	-	-	-	-
41	M98/0040	58.33	34.43	-	-	24.49	25.69	17.33	-	-	-	-
42	M98/0068	88.89	22.04	-	29.76	20.41	2.78		-	-	-	-
43	TME419	86.81	34.62	21.60	-	10.20	11.81	19.40	-	-	-	6.67
44	NR8082	-	-	10.36	-	-	-	-	-	-	-	20.97
45	NR8083	-	-	19.76	-	-	-	-	-	-	-	-
	Mean	77.83	44.17	19.65	31.44	19.51	20.14	19.03	38.07	41.04	70.68	12.84
	Minimum	46.53	15.38	10.36	20.80	10.20	2.78	6.42	33.85	39.31	61.96	5.75
	Maximum	95.83	79.44	25.28	37.60	38.78	54.17	30.40	40.86	43.63	76.00	20.97
	Std.	14.72	19.87	3.53	4.16	5.98	15.93	7.80	2.82	1.49	7.61	5.85
	CV (%)	18.92	44.98	17.98	13.23	30.66	79.08	41.00	7.41	3.63	10.77	45.60

Std = Standard Deviation; CV (%) =Coefficient of Variation; F/P.I/U=Faculty plot Ile Ugbo; Umu = Umuagwo; - = Not planted; FCA = Federal College of Agriculture

Appendix 7.1 Percentage of missing cassava stands in 74 farms during the 2006/2007 cropping season in Southwest and Southeast of Nigeria (Contd).

S/N	Farm No. Location Varieties	44 Umu Moca1	45 Umu Moca2	46 Umu Moca3	47 Umu Moca 4	48 Onne 13A	49 Onne 13B	50 Ogur ugu 2	51 NSM Affor	52 NSM Agbor	53 NSM Ollor	54 Abia Isiyi
1	30572	23.63	-	-	-	17.00	-	18.08	33.29	29.25	26.81	34.78
2	4(2)1425	12.12	27.14	-		-	16.01	-	-	-	-	-
3	82/00058	9.51	23.33	-	-	-	10.68	-	-	-	-	-
4	91/02324		30.08	-	-	10.42	12.16	-	-	-	-	-
5	92/0057	11.58	14.80	16.33	17.67	28.43	4.43	-	-	-	-	-
6	92/0067	29.04	30.00	-	-	6.81	-	-	-	-	-	-
7	92/0325	33.74	24.00	19.75	17.60	11.51	18.91	-	-	-	-	-
8	92/0326	20.57	15.67	-	-	21.44	20.72	-	-	-	-	-
9	92B/00061	14.26	16.00	29.00	-	-	15.89	-	-	-	-	-
10	92B/00068	31.45	-	-	4.00	12.68	7.67	-	-	-	-	-
11	94/0026	18.88	20.00	-	-	6.77	-	-	-	-	-	-
12	94/0039	16.56	-	-	-	48.67	-	-	-	-	-	-
13	94/0561	18.68	28.78	45.67	18.67	6.39	19.64	-	-	-	-	-
14	95/0166	16.16	22.25	-	-		30.87	-	-	-	-	-
15	95/0289	-	-	-	-	27.01	24.40	-	-	-	-	-
16	95/0379	16.21	-	-	-	13.62	10.16	-	-	-	-	-
17	96/0523	22.07	23.00	-	6.00		-	-	-	-	-	-
18	96/0603	36.99	18.00	37.00	-	11.70	14.25	-	-	-	-	-
19	96/1089A	21.19	21.00	-	-	8.97	-	-	-	-	-	-
20	96/1565	-	-	-	-		26.85	-	-	-	-	-
21	96/1569	19.53	-	10.00	-	4.69	-	-	-	-	-	-
22	96/1632	14.52	23.67	-	-		5.70	-	-	-	-	-
23	96/1642	21.90	23.23	28.00	15.00	18.66	13.01	-	-	-	-	-
24	97/0162	27.83	-	-	6.67	40.54	28.21	-	-	-	-	-
25	97/0211	24.32	-	16.86	6.08	31.05	23.81	-	-	-	-	-
26	97/2205	6.64	8.50	-	-	5.57	6.38	9.28	-	-	-	-
27	97/3200	2.47	-	29.80	3.00	4.99	-	-	-	-	-	-
28	97/4763	30.87	-	-	-	-	6.37	-	-	-	-	-
29	97/4769	24.15	22.92	-	-	-	9.51	-	-	-	-	-
30	97/4779	17.02	19.33	-	-	-	3.10	-	-	-	-	-
31	98/0002	17.77	25.00	-	-	9.40	15.31	-	-	-	-	-
32	98/0505	28.34	26.25	20.40	7.25	7.60	9.16	24.86	-	-	-	-
33	98/0510	37.43	-	-	-	43.56	-	26.74	-	-	-	-
34	98/0581	26.46	-	-	-	12.78	-	8.65	-	-	-	-
35	98/2101	24.75	25.00	-	-	19.06	6.33	-	-	-	-	-
36	98/2226	26.82	15.83	-	-		14.05	-	-	-	-	-
37	99/2123	21.80	-	-	5.75	11.40	4.40	-	-	-	-	-
38	99/3073	23.97	23.00	-	-	16.73	-	-	-	-	-	-
39	99/6012	10.35	22.00	-	-	-	-	-	-	-	-	-
40	M98/0028	21.88	-	19.60	7.00	-	27.34	-	-	-	-	-
41	M98/0040	11.52	14.63	25.60	0.00	-	-	-	-	-	-	-
42	M98/0068	17.43	-	-	-	14.34	-	-	-	-	-	-
43	TME419	23.50	19.72	35.43	4.50	4.73	10.24	10.96	37.24	16.00	-	-
44	NR8082	-	-	-	-	-	18.07	27.69	33.20	33.48	16.55	-
45	NR8083	-	-	-	-	-	-	-	29.40	19.00	40.03	-
	Mean	21.07	21.27	25.65	8.51	16.43	14.45	18.04	33.28	24.43	27.80	34.78
	Minimum	2.47	8.50	10.00	0.00	4.69	3.10	8.65	29.40	16.00	16.55	34.78
	Maximum	37.43	30.00	45.67	18.67	48.67	30.87	27.69	37.24	33.48	40.03	34.78
	Std.	7.94	4.93	9.86	6.06	11.96	7.94	8.47	3.20	8.28	11.77	
	CV (%)	37.69	23.17	38.45	71.23	72.78	54.95	46.96	9.61	33.89	42.36	0.00

Std =Standard Deviation; CV (%)=Coefficient of Variation;NSM=Nigerian Starch Mill;Umu=Umuagwo; - = Not planted

Appendix 7.1 Percentage of missing cassava stands in 74 farms during the 2006/2007 cropping season in Southwest and Southeast of Nigeria (Contd).

S/N	Farm No. Location Varieties	55 Abraka Okpue	56 Nanka Ezeilo	57 Onne 10B	58 Onne 8A	59 Onne 21A	60 Onne 8B	61 Onne 5A	62 Onne 14	63 Onne 13C	64 Onne 21B
1	30572	-	39.45	-	-	-	-	10.81	-	-	-
2	4(2)1425	-	-	-	-	-	-	23.00	-	-	-
3	82/00058	-	-	-	-	-	-	9.89	-	-	-
4	91/02324	24.41	33.95	9.76	-	37.56	32.00	26.19	-	-	18.55
5	92/0057	13.54	48.59	7.24	-	30.29	27.59	9.11	19.42	30.08	12.99
6	92/0067	10.27	-	21.61	-	15.67	27.08	18.54	-	-	10.85
7	92/0325	-	-	-	-	-	44.13	-	28.69	-	-
8	92/0326	29.59	-	14.57	43.70	-	43.17	42.78	23.62	-	-
9	92B/00061	25.94	-	-	-	-	-	-	26.48	14.42	14.72
10	92B/00068	20.57	53.90	39.41	-	-	25.34	19.55	7.97	-	13.77
11	94/0026	-	-	-	-	-	16.67	19.31	42.76	-	22.16
12	94/0039	-	-	10.56	-	-	45.64	5.32	5.37	27.39	16.94
13	94/0561	-	-	16.14	-	-	-	20.17	16.61	26.09	-
14	95/0166	-	30.57	-	19.81	-	46.25	27.69	27.23	26.54	12.56
15	95/0289	13.56	-	-	-	-	18.54	29.81	29.44	24.84	-
16	95/0379	42.86	-	-	-	-	-	-	-	-	-
17	96/0523	-	-	-	-	-	37.24	-	10.26	-	-
18	96/0603	-	39.21	-	-	-	46.33	-	27.08	-	-
19	96/1089A	-	-	8.24	-	-	-	26.92	-	-	-
20	96/1565	-	-	-	-	-	31.17	-	10.63	-	-
21	96/1569	-	-	-	-	-	-	-	-	35.86	-
22	96/1632	-	-	-	-	-	37.08	13.57	-	15.11	-
23	96/1642	-	-	16.18	-	-	22.35	19.17	10.36	24.56	13.80
24	97/0162	-	-	15.32	-	-	32.50	23.46	17.61	23.08	14.75
25	97/0211	-	-	-	-	-	45.57	-	-	-	-
26	97/2205	-	-	6.32	-	-	18.05	11.25	5.24	-	11.00
27	97/3200	22.98	-	5.21	-	-	37.50	15.35	22.94	-	-
28	97/4763	-	-	3.27	-	11.36	22.07	11.29	18.12	21.84	12.60
29	97/4769	-	-	7.81	-	-	-	-	-	26.75	-
30	97/4779	-	-	8.52	24.26	13.07	26.25	15.88	11.88	11.71	7.97
31	98/0002	26.30	-	9.97	25.24	19.73	-	13.24	10.53	23.75	5.38
32	98/0505	-	-	7.81	10.71	34.85	21.88	12.76	18.28	23.98	20.86
33	98/0510	12.50	-	14.39	-	-	-	-	-	44.74	-
34	98/0581	15.46	-	8.81	24.14	-	30.20	14.93	21.24	33.82	18.53
35	98/2101	-	37.52	5.70	-	11.46	18.78	7.39	9.28	10.18	19.51
36	98/2226	-	-	8.03	-	16.47	39.00	22.36	10.41	20.89	26.56
37	99/2123	-	-	-	-	-	-	-	47.28	-	-
38	99/3073	25.75	-	-	-	-	-	-	22.21	-	-
39	99/6012	-	-	-	-	-	-	-	25.10	-	36.31
40	M98/0028	-	-	-	-	-	-	-	19.01	-	-
41	M98/0040	-	54.71	-	-	-	-	-	25.07	-	-
42	M98/0068	-	22.46	-	-	-	-	-	-	-	-
43	TME419	12.46	49.11	5.27	22.36	32.33	37.14	24.62	20.38		8.11
44	NR8082	-	24.54	-	-	-	-	-	-	-	-
45	NR8083	-	-	-	-	-	-	-	-	-	-
	Mean	21.16	39.46	11.37	24.32	22.28	31.90	18.31	19.68	24.51	15.90
	Minimum	10.27	22.46	3.27	10.71	11.36	16.67	5.32	5.24	10.18	5.38
	Maximum	42.86	54.71	39.41	43.70	37.56	46.33	42.78	47.28	44.74	36.31
	Std.	8.96	11.15	7.73	9.88	10.34	9.83	8.25	9.98	8.36	7.06
	CV (%)	42.36	28.25	67.95	40.63	46.40	30.80	45.07	50.70	34.12	44.44

Std. = Standard Deviation; CV (%) = Coefficient of Variation; - = Not planted

Appendix 7.1 Percentage of missing cassava stands in 74 farms during the 2006/2007 cropping season in Southwest and Southeast of Nigeria (Contd).

S/N	Farm No. Location Varieties	65 Onne 9	66 Onne Cont.6	67 Onne Cont. 5	68 Onne 7C	69 Onne 10A	70 Onne 14B	71 Onne 12	72 Onne Cont. 4	73 Ogur ugu3	74 Onne 6	Mean missing stands
1	30572	-	13.22	44.41	-	-	6.25	-	26.58	17.00	-	27.65
2	4(2)1425	-	-	-	-	21.67	-	-	-	-	-	29.40
3	82/00058	-	-	-	-	-	58.93	-	56.94	-	-	20.31
4	91/02324	-	-	-	12.37	-	-	-	38.03	-	-	20.84
5	92/0057	14.55	54.58	51.63	1.97	-	12.21	-	14.91	-	-	25.22
6	92/0067	19.16	48.20	50.20	16.79	-	-	-	19.53	-	-	23.64
7	92/0325	9.97	-	-	-	19.72	33.93	-	37.13	-	-	25.81
8	92/0326	24.30	-	-	10.95	-	28.83	-	-	-	-	24.60
9	92B/00061	-	-	25.91	10.39	-	-	-	18.34	-	-	22.35
10	92B/00068	22.66	-	12.17	29.41	-	4.58	-	50.00	-	-	20.13
11	94/0026	32.71	-	-	11.32	-	6.45	-	34.54	-	-	28.31
12	94/0039	11.59	-	-	6.05	4.00	16.11	-	20.82	-	-	19.96
13	94/0561	9.19	-	16.37	12.63	-	23.60	-	32.24	-	-	20.45
14	95/0166	22.43	-	-	14.57	-	-	-	38.63	-	-	23.51
15	95/0289	-	-	-	-	20.94	-	-	36.66	-	-	20.38
16	95/0379	11.63	-	-	-	37.00	-	-	30.70	-	-	21.16
17	96/0523	6.44	49.49	25.77	7.67	-	24.11	-	21.39	-	-	19.80
18	96/0603	20.40	-	-	-	-	-	-	20.77	-	-	22.81
19	96/1089A	-	-	-	5.96	-	-	-	27.35	-	-	21.40
20	96/1565	-	-	-	-	11.40	-	-	28.70	-	-	19.86
21	96/1569	8.41	-	-	16.67	-	-	-	46.59	-	-	19.43
22	96/1632	5.92	-	37.72	-	15.00	18.57	-	27.16	-	-	22.71
23	96/1642	38.08	-	-	34.17	-	11.80	-	26.27	-	-	23.93
24	97/0162		-	47.02	7.46	-	-	-	42.23	-	-	25.94
25	97/0211	8.60	-	-		-	-	-	22.57	-	-	22.77
26	97/2205	-	-	-	6.35		8.20	-	28.95	11.75	3.51	18.64
27	97/3200	30.53	-	-	-	-	-	-	70.33	-	-	21.05
28	97/4763	10.28	9.61	-	8.51	-	8.30	-	41.67	-	-	19.74
29	97/4769	-	-	-	-	19.06	-	-	7.18	-	-	23.97
30	97/4779	26.64	7.83	20.59	3.33	-	11.76	-	39.32	-	-	23.85
31	98/0002	-	-	-	11.32	-	-	-	9.52	-	-	24.99
32	98/0505	-	30.97	46.98	-	-	-	-	19.29	18.89	21.50	23.70
33	98/0510	17.69	-	53.59	43.98	-	-	-	36.83	30.72	13.73	32.56
34	98/0581	21.50	-	19.14	8.75	0.00	-	-	20.97	14.59	10.95	23.76
35	98/2101	25.50	12.65	21.57	7.68	-	20.41	-	19.05	-	-	24.27
36	98/2226	-	-	-	10.65	-	24.11	-	35.89	-	-	20.25
37	99/2123	-	-	-	-	-	3.85	-	27.62	-	-	26.35
38	99/3073	18.38	-	-	-	-	-	-	7.15	-	-	24.20
39	99/6012	-	-	-	-	-	16.07	-	17.97	-	-	23.65
40	M98/0028	-	-	-	-	-	-	-	-	-	-	19.45
41	M98/0040	9.18	-	-	-	-	-	-	-	-	-	20.90
42	M98/0068	-	-	-	-	-	-	-	9.49	-	-	20.98
43	TME419	7.66	23.04	39.87	5.78	15.41		26.96	40.15	17.90	14.21	23.14
44	NR8082	-	-	-	-	-	-	-	-	25.44	-	26.10
45	NR8083	-	-	-	-	-	-	-	-	-	-	27.05
	Mean	17.34	27.73	34.20	12.70	16.42	17.79	26.96	29.47	19.47	12.78	23.13
	Minimum	5.92	7.83	12.17	1.97	0.00	3.85	26.96	7.15	11.75	3.51	23.03
	Maximum	38.08	54.58	53.59	43.98	37.00	58.93	26.96	70.33	30.72	21.50	22.89
	Std.	8.98	18.74	14.46	9.92	10.23	13.16		13.57	6.51	6.49	22.95
	CV (%)	51.82	67.57	42.28	78.12	62.29	73.96	0.00	46.05	33.44	50.75	99.21

Std. = Standard Deviation; CV (%) = Coefficient of Variation; Cont. = Contour; - = Not planted

Appendix 7.2 Description of the intensity of status of the variables studied for missing stands in cassava fields.

1	Weed Density (WD) (% weeding)	[0-10[	[10-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9
2	Spacing (SPg) (m^2)	[0-0.35[	[0.35-0.45[	[0.45-0.55[	[0.55-0.65[	[0.65-0.75[	[0.75-0.85[	[0.85-0.95[	[0.95-1[	>1.0
		1	2	3	4	5	6	7	8	9
3	Fertilizer application(FA) (% of the quantity applied)	[0-20[	[20-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
	(Number of bags applied in the farm)	0	1	2	3	4	5	6	7	8
		1	2	3	4	5	6	7	8	9
4	Stem quality(StQ)*: Age(StQA)*(% of Brown portion)	[0-20[	[20-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9
5	Health (StQH)* (Disease) (% incidence)	0	]1-30]	]30-40]	]40-50]	]50-60]	]60-70]	]70-80]	]80-90]	]90-100]
		1	2	3	4	5	6	7	8	9
6	Length (StQL)* (cm)	]0-10]	]10-15]	]15-20]	]20-25]	]25-30]	]30-35]	]35-40]	]40-45]	>45 cm
		1	2	7	9	8	6	4	3	1
7	Diameter (StQD)* (mm)	]0-10]	]10-15]	]15-20]	]20-25]	]25-30]	]30-35]	]35-40]	>40 mm	
		1	2	3	7	9	8	8	1	
8	Pith-wood ratio (StQPWR)* (%)	]0-20]	]20-30]	]30-40]	]40-50]	]50-60]	]60-70]	]70-80]	]80-90]	]90-100]
		4	3	2	1	3	5	7	8	9
9	Cut surface (StQCS)* (% smooth and transverse)	[0-20[	[20-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9
10	Days from cut stem to planting (DCP) (No of days)	1	2	3	4	5	6	>6 days		
		1	2	4	6	7	8	9		
11	Planting orientation (PO) (% inclined)	[0-20[	[20-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9
12	Planting depth /Part of stem buried (PD) (ratio)	0	1/2	1/3	2/3	3/4	>1			
		1	2	5	9	8	-1			
13	Percent of *reversed* stake (PRS) (%)	0	]1-30]	]30-40]	]40-50]	]50-60]	]60-70]	]70-80]	]80-90]	]90-100]
		1	2	3	4	5	6	7	8	9
14	Termite infestation (TI) (%)	0	[1-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9
15	Livestock damage (LD) (%)	0	[1-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9

WD, SPg, StQH, DCP, PRS, StQPWR, TI, LD, RD, E = the lower the value of the trait the better (1); FA, StQA, StQL, StQD, , StQCS, PO, PD, QLP, PFL, V, F, EB, SoPM, SuPL, TSt, TCSt, TP, PSp, LUE = the higher the value of the trait the better (9), *= component of the stem quality

Appendix 7.2 Description of the intensity of status of the variables studied for missing stands in cassava fields (Contd).

16	Rodent damage (RD) (%)	0	[1-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9
17	Quality of land preparation (QLP) (% clean)	[0-20[	[20-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9
18	Pattern of field layout (PFL) (% straight planting)	[0-20[	[20-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9
19	Erosion (E)	0	[20-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9
20	Variety (V)	unknown	local	Local and improved	improved					
		1	5	7	9					
21	Fence of the plot (F).	none	Partly fenced	Totally fenced						
		1	5	9						
22	Education background (EB)	none	primary	secondary	1st degree	2nd degree	3rd degree			
		1	3	5	7	8	9			
23	Source of planting materials (SoPM)	Local ma rket (1)	Private farmers (2)	Personal farm (3)	Research Institute (4)	(1,2) or 1,3) or (2,3)	(1,4)	(2,4)	(3,4)	(1,2,3,4)
		1	5	8	9	2	3	6	7	4
24	Supply of planting materials (SuPL)	Scarce	Regular	Very regular						
		2	7	9						
25	Treatment of cassava stem (TSt)	never	occasionally	Always						
		1	5	9						
26	Tools used to cut stem into stakes (TCSt) (% sharp)	[0-20[	[20-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		Knees	Okoli	Machete on wood	Machete into soil	Hand saw	Secateu r	Engine		
27		1	2	4	5	7	8	9		
	Tools used to plant in the field (TP) (% acceptability)	none	pacing	stick	rope	Planter				
		1	5	7	8	9				
28	Replacement if poor sprouting (PSp) (%replacement)	[0-20[	[20-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9
29	Land use efficiency (LUE) (% use)	[0-20[	[20-30[	[30-40[	[40-50[	[50-60[	[60-70[	[70-80[	[80-90[	[90-100[
		1	2	3	4	5	6	7	8	9

WD, SPg, StQH, DCP, PRS, StQPWR, TI, LD, RD, E = the lower the value of the trait the better (1), FA, StQA, StQL, StQD, , StQCS, PO, PD, QLP, PFL, V, F, EB, SoPM, SuPL, TSt, TCSt, TP, PSp, LUE = the higher the value of the trait the better (9), *= component of the stem quality.

Appendix 7.3 Scores of variables observed during the assessment of missing stands in cassava fields.

S/N	Location/Site	WD	SP	FA	StQA	StQH	StQL	StQD	StQPWR	StQCS	DCP	PO	PD	PRS	TI	LD	RD	QLP	PFL	E	V	F	EB	SoPM	SuPM	TSt	TCSt	TP	RPSp	LUE
1	Block 8a Trial	1	8	9	9	1	9	9	1	9	2	9	9	1	1	1	1	9	9	3	9	9	8	9	9	9	8	8	9	9
2	Block 8a Inter	2	8	9	8	1	9	9	1	9	2	8	8	1	1	1	1	9	9	1	9	9	8	9	9	5	8	8	9	9
3	Oku farm Trial	3	8	1	9	1	9	9	1	9	2	9	9	2	3	4	2	9	9	1	9	1	7	9	9	5	8	8	9	9
4	Oku farm Mult	4	4	1	8	1	8	8	2	9	2	9	8	1	4	3	3	9	7	1	9	1	7	9	9	9	8	8	6	6
5	Block 8b MLT	1	4	9	9	2	8	9	3	9	2	9	9	1	1	1	1	9	9	1	9	9	8	9	9	9	8	8	7	7
6	Block 13a Mult	2	4	9	8	2	9	9	3	8	2	8	8	2	2	1	1	9	9	1	9	9	8	9	9	9	8	8	8	8
7	Block 12	2	8	9	8	3	9	9	1	9	2	8	8	1	1	1	1	9	9	4	9	9	9	9	9	9	8	8	9	9
8	Block 13b	1	8	9	9	2	9	8	1	9	2	9	9	1	1	1	1	9	9	3	9	9	9	9	9	9	8	8	9	9
9	Block 10b	3	8	9	8	3	9	8	1	9	2	8	8	1	1	1	1	9	9	2	9	9	9	9	9	9	8	8	9	9
10	Block 9	1	8	9	8	2	8	9	1	9	2	8	8	1	1	1	1	9	9	1	9	9	9	9	9	9	8	8	9	9
11	Block 22 Demo	1	4	1	9	1	8	9	1	9	2	9	9	1	1	1	1	9	9	3	9	9	9	9	9	9	8	8	9	9
12	Police station	5	8	1	8	1	9	9	1	9	2	8	8	2	3	1	1	9	9	1	9	1	8	9	9	9	8	8	6	6
13	BS 9 Trial	1	8	9	8	1	9	8	1	9	2	8	8	1	2	3	1	9	9	1	9	1	9	9	9	9	7	8	9	9
14	BS 10 Trial	1	8	9	9	1	9	8	1	9	2	9	9	1	1	1	1	9	9	1	9	1	9	9	9	9	7	8	9	9
15	BS 11 Trial	2	8	9	8	1	9	9	1	9	2	8	8	1	1	1	2	9	9	1	9	1	9	9	9	9	7	8	9	9
16	BS 11 Mult.	3	4	9	9	3	9	8	1	7	3	9	9	1	1	1	3	9	9	1	9	1	9	9	9	9	7	8	9	8
17	BS 12 Front.	2	4	9	9	2	8	8	1	8	2	9	9	1	2	1	2	9	9	1	9	1	9	9	9	9	7	8	9	8
18	BS 12 Tail Trial	2	8	9	9	1	8	9	1	8	2	9	9	1	2	1	2	9	9	1	9	1	9	9	9	9	7	8	9	9
19	BS 15 Front	1	4	9	8	1	9	9	1	9	2	8	8	1	2	1	3	9	9	1	9	1	9	9	9	9	7	8	9	7
20	RIART Spacing	1	3	9	9	1	9	9	1	9	2	9	9	1	1	1	1	9	9	6	9	1	9	9	9	9	8	8	9	9
21	Block 12b B.Pit	1	8	9	9	2	9	8	1	9	2	8	8	1	1	1	1	9	9	4	9	9	9	9	9	9	8	8	9	6
22	Akan Kate Trial	1	1	9	9	3	9	8	1	9	2	8	8	1	1	1	1	9	9	3	9	9	7	9	9	9	8	8	8	9
23	Block 20 Inters.	2	8	9	8	1	8	9	1	9	2	8	8	1	1	1	1	9	9	1	9	9	8	9	9	9	8	8	8	8
24	Block 20 B. pit2	3	8	9	8	2	8	9	1	9	2	9	9	1	1	1	1	9	9	1	9	9	8	9	9	9	8	8	8	8
25	Spacing/Agroly	2	1	9	9	1	9	9	1	8	3	9	9	1	2	1	1	9	9	1	9	1	9	9	9	9	8	8	9	9
26	Block 13a Mult.	2	4	9	8	1	9	9	1	9	2	8	8	1	1	1	1	9	9	2	9	9	8	9	9	9	8	8	9	8

WD-Weed density; SPg-Spacing; FA-Fertilizer application; StQ-Stem quality[StQA-Age; StQH-Health; StQL-Length; StQD-Diameter; StQPWR-Pith-wood ratio; StQCS-Cut surface], DCP-Days from cut to plant, PO-Planting orientation, PD- Planting depth, PRS-Percentage of reversed stakes, TI-Termite infestation, LD-Livestock damage, RD-Rodent damage, QLP-Quality of land preparation, PFL-Pattern of field layout, E-Erosion, V-Variety, F-Fence of the plot; EB-Education background; SoPM-Source of planting materials; SuPM-Supply of planting materials; TSt-Treatment of cassava stems; TCSt-Tools used to cut the stem into stakes; TP-Tools used to plant in the field; RPSp-Replacement if poor sprouting, LUE-Land used efficiency. WD, SPg, StQH, DCP, PRS, StQPWR, TI, LD, RD, E = the lower the value of the trait the better (1); FA, StQA, StQL, StQD, , StQCS, PO, PD, QLP, PFL, V, F, EB, SoPM, SuPL, TSt, TCSt, TP, PSp, LUE = the higher the value of the trait the better (9), *= component of the stem quality

Appendix 7.3 Scores of variables observed during the assessment of missing stands in cassava fields (Contd).

S/N	Location/Site	WD	SP	FA	StQA	StQH	StQL	StQD	StQPWR	StQCS	DCP	PO	PD	PRS	TI	LD	RD	QLP	PFL	E	V	F	EB	SoPM	SuPM	TSt	TCSt	TP	RPSp	LUE
27	Block 13b Mult.	1	4	9	8	2	9	8	1	9	2	8	8	2	1	1	1	9	9	3	9	9	8	9	9	9	8	8	9	7
28	Spacing/Agroly	1	1	9	9	1	9	8	1	9	3	9	9	1	1	1	1	9	9	1	9	1	9	9	9	9	8	8	9	9
29	Block 10b Mult.	2	4	9	9	2	9	9	1	9	2	9	9	2	1	1	2	9	9	2	9	9	8	9	9	9	8	8	9	8
30	Block 8A Mult.	2	4	9	9	2	8	9	1	9	2	9	9	1	1	1	2	9	9	1	9	9	8	9	9	9	5	8	9	7
28	Spacing/Agroly	1	1	9	9	1	9	8	1	9	3	9	9	1	1	1	1	9	9	1	9	1	9	9	9	9	8	8	9	9
29	Block 10b Mult.	2	4	9	9	2	9	9	1	9	2	9	9	2	1	1	2	9	9	2	9	9	8	9	9	9	8	8	9	8
30	Block 8A Mult.	2	4	9	9	2	8	9	1	9	2	9	9	1	1	1	2	9	9	1	9	9	8	9	9	9	5	8	9	7
31	Block 21A Mult.	1	4	9	9	2	9	8	3	9	2	8	9	2	1	1	2	9	9	1	9	9	8	9	9	9	4	8	9	8
32	Block 8B Mult.	2	4	9	9	2	9	9	2	8	2	7	8	3	1	1	2	9	9	1	9	9	8	9	9	9	8	8	9	7
33	Block 5A Mult.	3	4	9	9	2	9	9	3	9	2	8	9	2	1	1	2	9	9	1	9	9	8	9	9	9	8	8	9	7
34	Block 14 Mult.	3	4	9	8	2	9	9	3	8	2	7	9	3	1	1	1	9	9	3	9	9	8	9	9	9	8	8	9	8
35	Block 13C Mult.	1	4	9	9	2	9	8	2	8	2	7	9	1	1	1	1	9	9	4	9	9	8	9	9	9	4	8	9	8
36	Block 21B Mult.	2	4	9	8	2	9	8	2	8	2	9	8	1	1	1	2	9	9	1	9	9	8	9	9	9	4	8	9	9
37	Block 9 Mult.	3	4	9	9	2	8	9	2	8	2	8	8	3	1	1	1	9	9	1	9	9	8	9	9	9	4	8	9	9
38	Contour 6 Mult.	2	4	9	8	2	8	8	2	9	3	9	9	2	1	1	1	9	9	1	9	9	8	9	9	9	4	8	8	7
39	Contour 5 Mult.	2	4	9	9	2	9	8	3	8	3	8	8	2	1	1	1	9	9	1	9	9	8	9	9	9	8	8	8	8
40	Block 7C Mult.	1	4	9	9	2	9	9	3	9	2	8	8	3	1	1	1	9	9	2	9	9	8	9	9	9	8	8	9	8
41	Block 10A Mult.	3	4	9	8	2	9	8	3	9	2	8	9	1	1	1	1	9	9	2	9	9	8	9	9	9	2	8	9	7
42	Block 14B Mult.	3	4	9	8	2	9	8	2	9	2	8	8	1	1	1	1	9	9	1	9	9	8	9	9	9	2	8	9	8
43	Block 12 demo	1	4	1	9	1	8	9	1	8	2	9	8	1	1	1	2	9	9	3	9	9	9	9	9	9	8	8	9	9
44	Contour 4 Mult.	2	4	9	9	2	8	8	2	9	3	8	9	1	1	1	1	9	9	1	9	9	8	9	9	9	8	8	9	8
45	Spacing/Agroly.	1	1	9	9	1	9	8	1	8	3	9	8	1	1	1	1	9	9	1	9	1	9	9	9	9	8	8	8	9
46	Block 6 Demo	1	3	1	9	1	9	9	1	8	1	9	9	1	1	3	3	9	9	1	9	9	9	9	9	9	8	8	9	9
47	UST Trial	2	8	1	9	1	9	8	1	9	3	8	9	1	1	1	3	9	9	1	9	1	9	6	7	9	5	8	7	9
48	UST Mult.	4	5	1	8	1	9	6	2	9	3	7	9	4	1	3	4	8	6	1	9	1	9	6	7	5	4	8	6	7
49	Ajibode Mult.	3	5	1	7	3	9	5	3	8	5	5	9	3	1	4	5	9	9	1	9	1	9	6	7	1	4	8	5	6

WD-Weed density; SPg-Spacing; FA-Fertilizer application; StQ-Stem quality[StQA-Age; StQH-Health; StQL-Length; StQD-Diameter; StQPWR-Pith-wood ratio; StQCS-Cut surface], DCP-Days from cut to plant, PO-Planting orientation, PD- Planting depth, PRS-Percentage of reversed stakes, TI-Termite infestation, LD-Livestock damage, RD-Rodent damage, QLP-Quality of land preparation, PFL-Pattern of field layout, E-Erosion, V-Variety, F-Fence of the plot; EB-Education background; SoPM-Source of planting materials; SuPM-Supply of planting materials; TSt-Treatment of cassava stems; TCSt-Tools used to cut the stem into stakes; TP-Tools used to plant in the field; RPSp-Replacement if poor sprouting, LUE-Land used efficiency. WD, SPg, StQH, DCP, PRS, StQPWR, TI, LD, RD, E = the lower the value of the trait the better (1); FA, StQA, StQL, StQD, , StQCS, PO, PD, QLP, PFL, V, F, EB, SoPM, SuPL, TSt, TCSt, TP, PSp, LUE = the higher the value of the trait the better (9), *= component of the stem quality

Appendix 7.3.: Scores of variables observed during the assessment of missing stands in cassava fields (Contd).

S/N	Location/Site	WD	SP	FA	StQA	StQH	StQL	StQD	StQPWR	StQCS	DCP	PO	PD	PRS	TI	LD	RD	QLP	PFL	E	V	F	EB	SoPM	SuPM	TSt	TCSt	TP	RPSp	LUE
50	Div.Heri.Farms	7	9	1	6	2	9	6	2	8	6	6	8	5	5	1	5	7	7	1	9	1	7	6	7	1	4	8	3	6
51	FCA Mult.	5	4	5	5	4	8	6	2	6	6	6	8	4	3	1	2	8	7	1	9	1	7	4	9	5	8	8	4	5
52	FCA Mult.	6	4	5	6	3	8	5	2	7	6	7	9	5	3	1	4	8	6	1	9	1	7	5	9	5	8	8	5	7
53	FCA Trial	3	8	1	6	2	9	6	1	6	6	6	9	2	2	1	3	9	9	1	7	1	7	6	9	5	8	8	4	9
54	NSM. Mult.	3	4	6	5	3	9	6	2	9	3	7	9	3	1	1	1	9	7	5	7	1	8	8	9	5	9	9	8	8
55	NSM. Trial	2	8	8	6	3	9	7	1	8	4	8	6	3	1	1	1	9	9	4	9	1	8	8	9	5	5	9	7	9
56	MOCA Student 1	2	8	1	6	2	6	6	2	8	3	7	5	2	3	2	1	9	8	1	9	1	7	2	7	1	4	7	3	7
57	MOCA School	2	9	1	6	2	9	6	2	6	3	8	6	3	3	3	1	9	7	1	7	1	7	6	7	1	4	7	4	6
58	MOCA Farmers	4	8	1	6	2	8	7	2	8	3	7	6	4	2	4	4	9	7	1	5	1	7	4	2	1	4	1	4	5
59	MOCA Student 2	1	8	1	5	3	8	6	2	7	3	7	7	5	2	2	3	9	7	1	7	1	7	3	2	1	4	5	4	6
60	NSM Mult.Afor	2	9	7	6	3	9	5	3	5	3	8	6	3	3	1	1	9	8	1	7	1	9	8	9	5	5	7	5	7
61	NSM.Agbor	1	9	6	6	4	9	6	2	6	4	8	6	3	1	1	1	9	8	1	7	1	9	8	9	5	4	7	5	6
62	NSM Mult.Olloh	3	9	6	7	4	9	6	3	6	3	7	5	4	2	1	1	9	8	1	7	1	9	8	9	5	4	7	5	5
63	Isiyi Farms	3	9	1	6	3	6	5	3	7	3	7	7	3	3	1	4	6	7	1	7	1	9	3	2	1	4	1	4	6
64	Okpue Farms	1	8	1	8	2	9	8	1	6	7	8	4	4	5	1	3	9	9	1	9	1	8	6	7	1	9	9	3	6
65	Opolo Mult	1	8	1	8	1	7	8	1	8	3	8	8	2	1	1	2	6	9	1	9	1	5	3	2	1	8	1	4	6
66	Ugboha Mult. 1	3	9	1	7	3	6	5	2	7	5	7	8	4	3	3	2	7	7	1	7	1	7	2	2	1	4	1	3	5
67	Ugboha Mult. 2	3	9	1	6	3	7	7	3	8	5	7	7	4	2	3	2	7	7	1	7	1	7	2	2	1	4	1	2	5
68	C.of Educ. Warri 1	5	9	1	8	2	6	5	2	7	8	6	8	3	1	1	3	8	6	3	7	1	8	4	2	5	4	7	2	4
69	C.of Edu. Warri 2	5	9	1	7	2	7	6	2	8	8	7	7	4	1	1	2	6	6	4	7	1	8	4	2	5	4	7	3	4
70	C.of Edu. Warri 3	6	9	1	7	2	7	7	2	7	8	6	8	3	1	1	2	7	6	5	9	1	8	4	2	5	4	7	2	5
71	Ferdinand Site 1	3	9	3	6	4	8	6	3	8	5	7	6	3	1	3	3	5	7	1	7	1	7	7	2	1	5	7	5	7
72	Ferdinand Site 2	2	9	4	5	3	5	7	2	7	5	7	5	4	1	3	3	5	7	1	5	1	7	8	2	1	5	7	6	8
73	Faculty plot	7	9	1	4	3	5	6	3	8	7	6	4	3	1	3	3	5	6	1	7	1	7	1	2	1	4	5	2	4
74	Rev.Ezeilo	3	9	1	5	2	7	7	3	7	5	5	5	4	3	1	2	6	7	1	7	1	9	6	2	1	4	7	4	5

WD-Weed density; SPg-Spacing; FA-Fertilizer application; StQ-Stem quality[StQA-Age; StQH-Health; StQL-Length; StQD-Diameter; StQPWR-Pith-wood ratio; StQCS-Cut surface], DCP-Days from cut to plant, PO-Planting orientation, PD- Planting depth, PRS-Percentage of reversed stakes, TI-Termite infestation, LD-Livestock damage, RD-Rodent damage, QLP-Quality of land preparation, PFL-Pattern of field layout, E-Erosion, V-Variety, F-Fence of the plot; EB-Education background; SoPM-Source of planting materials; SuPM-Supply of planting materials; TSt-Treatment of cassava stems; TCSt-Tools used to cut the stem into stakes; TP-Tools used to plant in the field; RPSp-Replacement if poor sprouting, LUE-Land used efficiency. WD, SPg, StQH, DCP, PRS, StQPWR, TI, LD, RD, E = the lower the value of the trait the better (1); FA, StQA, StQL, StQD, , StQCS, PO, PD, QLP, PFL, V, F, EB, SoPM, SuPL, TSt, TCSt, TP, PSp, LUE = the higher the value of the trait the better (9), *= component of the stem quality.

Appendix 8.1 Mean number of 25-cm plantable stakes per plant for 43 Cassava Mosaic Disease Resistant varieties in six locations.

S/N	Variety	Ajibode	Kate O.	RIART O.	Akure	Zaria	Demo O.	Mean	Sdt	CV (%)	SE ±
1	30572	28.73	9.36	5.82	25.13	11.57	15.67	16.05	9.09	56.62	4.06
2	4(2)1425	6.66	3.62	4.04	12.35	8.53	11.37	7.76	3.66	47.11	1.64
3	82/00058	16.00	4.52	4.59	16.61	8.54	26.02	12.71	8.41	66.16	3.76
4	91/02324	8.13	4.72	5.90	23.59	8.86	12.81	10.67	6.92	64.87	3.09
5	92/0057	21.12	10.95	8.93	28.73	10.72	18.67	16.52	7.71	46.65	3.45
6	92/0067	14.57	10.13	5.64	20.14	7.75	13.39	11.94	5.23	43.80	2.34
7	92/0325	28.62	30.56	10.96	20.00	8.53	14.96	18.94	9.14	48.26	4.09
8	92/0326	22.22	8.73	8.66	25.12	6.89	20.76	15.40	8.15	52.93	3.64
9	92B/00061	14.38	8.16	5.50	20.26	5.85	11.95	11.02	5.71	51.81	2.55
10	92B/00068	19.50	15.59	6.30	21.42	11.14	24.48	16.40	6.79	41.39	3.04
11	94/0026	10.53	22.67	9.30	31.88	9.54	16.38	16.72	9.06	54.20	4.05
12	94/0039	19.36	21.37	7.83	24.43	6.79	17.18	16.16	7.26	44.95	3.25
13	94/0561	35.18	6.72	6.96	26.47	14.62	18.98	18.15	11.21	61.74	5.01
14	95/0166	9.40	23.63	9.53	31.52	7.66	16.81	16.43	9.52	57.98	4.26
15	95/0289	15.27	13.04	8.62	16.18	8.72	15.73	12.93	3.47	26.84	1.55
16	95/0379	10.22	10.90	7.50	22.04	8.73	15.24	12.44	5.39	43.34	2.41
17	96/0523	19.62	24.28	6.87	29.25	8.42	12.76	16.87	8.99	53.30	4.02
18	96/0603	11.82	9.68	7.21	26.28	7.27	14.87	12.85	7.19	55.92	3.21
19	96/1089A	15.57	5.33	4.59	16.61	9.48	9.31	10.15	5.03	49.54	2.25
20	96/1565	11.52	17.28	9.30	24.48	10.14	21.54	15.71	6.37	40.56	2.85
21	96/1569	12.42	11.23	3.70	29.47	6.06	9.69	12.09	9.12	75.38	4.08
22	96/1632	7.13	16.98	5.84	25.14	7.64	13.75	12.75	7.45	58.48	3.33
23	96/1642	22.13	12.21	6.81	36.16	8.53	19.90	17.62	10.94	62.06	4.89
24	97/0162	11.05	21.69	7.87	19.23	6.81	15.67	13.72	6.11	44.55	2.73
25	97/0211	25.66	8.94	7.03	31.50	11.87	16.61	16.94	9.76	57.60	4.36
26	97/2205	34.07	8.60	5.65	24.42	8.83	11.67	15.54	11.21	72.14	5.01
27	97/3200	27.26	12.26	8.83	25.65	7.15	6.85	14.67	9.35	63.73	4.18
28	97/4763	20.89	13.41	3.27	32.46	13.93	19.28	17.21	9.69	56.34	4.33
29	97/4769	18.32	12.01	3.81	10.90	7.57	9.94	10.42	4.84	46.44	2.16
30	97/4779	32.33	6.34	6.67	33.23	14.64	12.67	17.65	12.17	68.96	5.44
31	98/0002	28.63	17.89	5.12	25.79	14.74	18.36	18.42	8.36	45.37	3.74
32	98/0505	10.26	9.96	8.56	20.28	10.79	8.00	11.31	4.52	39.97	2.02
33	98/0510	10.38	11.60	7.43	28.28	8.95	25.33	15.33	9.04	59.00	4.04
34	98/0581	10.70	16.25	6.70	25.21	8.44	16.45	13.96	6.81	48.79	3.05
35	98/2101	11.62	21.89	5.80	36.15	4.82	19.25	16.59	11.81	71.19	5.28
36	98/2226	28.25	30.06	9.26	30.66	7.54	19.59	20.89	10.48	50.14	4.68
37	99/2123	18.72	23.29	9.41	27.68	6.91	19.43	17.57	8.00	45.50	3.58
38	99/3073	24.18	13.61	5.02	35.43	12.81	18.17	18.20	10.55	57.96	4.72
39	99/6012	15.41	8.15	10.08	23.82	6.89	20.96	14.22	7.03	49.41	3.14
40	M98/0028	13.42	3.64	6.81	12.78	5.01	10.66	8.72	4.14	47.43	1.85
41	M98/0040	19.34	4.88	5.22	12.82	6.06	11.68	10.00	5.70	57.02	2.55
42	M98/0068	17.83	10.38	8.30	35.14	9.27	14.39	15.88	10.08	63.46	4.51
43	TME419	9.54	12.01	7.99	19.94	8.19	19.47	12.86	5.50	42.75	2.46
	Minimum	6.66	3.62	3.27	10.90	4.82	6.85	7.76	3.47	26.84	1.55
	Maximum	35.18	30.56	10.96	36.16	14.74	26.02	20.89	12.17	75.38	5.44
	Mean	17.86	13.22	6.96	24.76	8.91	15.97	14.61	7.84	53.29	3.50
	Std.	7.71	6.95	1.89	6.68	2.51	4.53	3.03	2.31	10.04	1.03
	CV (%)	43.17	52.56	27.21	26.98	28.13	28.37	20.74	29.45	18.84	29.45
	SE±	1.18	1.06	0.29	1.02	0.38	0.69	0.46	0.35	1.53	0.16

RIART =River State Institute of Agricultural Research and Technology, CV = Coefficient of Variation, SE = Standard Error, Std = Standard deviation, O = Onne.

Appendix 8.2 Assessment of stem weight (g) per 25-cm plantable stakes per plant for 43 Cassava Mosaic Disease Resistant varieties in six locations for cassava stake quality.

S/N	Variety	Ajibode	Kate O.	RIART O.	Akure	Zaria	Demo O.	Mean	Sdt	CV (%)	SE ±
1	30572	65.51	91.21	81.94	70.97	75.17	48.33	72.19	14.70	20.37	6.58
2	4(2)1425	50.33	80.80	66.41	198.46	53.77	54.98	84.13	57.12	67.89	25.54
3	82/00058	78.13	83.33	37.28	82.86	80.87	76.77	73.21	17.79	24.30	7.95
4	91/02324	84.89	83.16	90.15	84.23	60.20	91.95	82.43	11.44	13.88	5.12
5	92/0057	120.69	85.07	62.14	85.49	58.30	87.98	83.28	22.36	26.85	10.00
6	92/0067	91.16	86.74	67.20	99.89	69.86	69.99	80.81	13.63	16.86	6.09
7	92/0325	105.54	77.99	76.59	97.72	77.34	69.21	84.07	14.19	16.88	6.34
8	92/0326	134.35	91.20	56.27	86.54	60.20	65.98	82.42	29.11	35.32	13.02
9	92B/00061	62.88	98.41	63.44	96.27	52.17	39.54	68.78	23.78	34.57	10.64
10	92B/00068	95.31	96.61	93.37	88.07	44.96	48.60	77.82	24.25	31.16	10.84
11	94/0026	66.49	83.43	86.47	84.10	48.92	37.82	67.87	20.57	30.31	9.20
12	94/0039	72.12	76.54	86.94	79.50	41.95	73.05	71.68	15.51	21.64	6.94
13	94/0561	65.33	92.51	109.08	88.70	65.44	50.44	78.58	21.76	27.69	9.73
14	95/0166	76.60	72.49	98.91	85.16	75.72	102.97	85.31	12.88	15.10	5.76
15	95/0289	140.91	85.70	78.51	110.32	48.17	80.11	90.62	31.63	34.90	14.14
16	95/0379	88.22	90.31	95.44	90.59	57.25	56.11	79.65	17.96	22.54	8.03
17	96/0523	57.61	78.14	67.40	88.27	73.24	85.71	75.06	11.53	15.35	5.15
18	96/0603	70.03	84.84	71.10	87.96	69.95	81.14	77.50	8.13	10.49	3.64
19	96/1089A	40.87	90.31	90.23	98.46	63.99	64.97	74.80	21.92	29.31	9.80
20	96/1565	142.36	83.54	64.95	89.81	44.54	59.30	80.75	34.37	42.56	15.37
21	96/1569	50.10	84.22	71.62	83.17	59.96	36.91	64.33	18.85	29.31	8.43
22	96/1632	116.16	72.12	59.13	94.02	55.41	56.55	75.57	24.65	32.62	11.02
23	96/1642	102.36	70.76	82.78	79.68	31.86	69.03	72.74	23.30	32.03	10.42
24	97/0162	73.14	74.14	71.89	71.59	30.61	68.30	64.94	16.94	26.08	7.57
25	97/0211	108.44	91.91	110.13	73.74	28.79	54.94	77.99	32.01	41.04	14.32
26	97/2205	40.17	94.33	94.21	85.30	41.16	41.72	66.15	27.73	41.92	12.40
27	97/3200	122.15	88.50	65.35	95.56	66.17	44.65	80.39	27.37	34.04	12.24
28	97/4763	100.73	84.66	166.76	72.57	53.83	46.02	87.43	43.68	49.97	19.54
29	97/4769	270.74	86.28	84.29	83.64	71.37	61.53	92.98	39.27	42.24	17.56
30	97/4779	67.31	85.12	51.24	75.40	52.25	49.72	63.51	14.77	23.25	6.60
31	98/0002	89.27	75.48	148.23	87.22	46.47	61.86	84.75	35.02	41.32	15.66
32	98/0505	66.74	78.83	89.32	98.92	55.13	60.11	74.84	17.19	22.96	7.69
33	98/0510	116.53	80.50	98.75	72.21	72.97	71.60	85.43	18.38	21.52	8.22
34	98/0581	66.38	82.03	87.21	93.14	66.35	94.06	81.53	12.52	15.36	5.60
35	98/2101	104.09	73.87	91.35	77.77	75.03	88.07	85.03	11.75	13.82	5.25
36	98/2226	68.93	73.68	73.55	87.55	55.92	71.84	71.91	10.15	14.11	4.54
37	99/2123	162.39	83.79	87.49	71.73	53.52	59.20	86.35	39.55	45.80	17.69
38	99/3073	104.49	70.52	46.04	72.42	58.30	47.62	66.57	21.62	32.48	9.67
39	99/6012	86.32	71.40	56.97	101.15	54.45	99.72	78.34	20.57	26.26	9.20
40	M98/0028	84.97	88.37	64.54	89.98	71.48	84.46	80.63	10.23	12.69	4.58
41	M98/0040	95.94	78.21	59.84	74.18	34.65	79.82	70.44	21.00	29.82	9.39
42	M98/0068	54.96	97.54	100.01	76.45	52.70	102.82	80.75	22.85	28.30	10.22
43	TME419	123.22	83.50	86.35	73.94	48.62	92.46	84.68	24.36	28.76	10.89
	Minimum	40.17	70.52	37.28	70.97	28.79	36.91	63.51	8.13	10.49	3.64
	Maximum	270.74	98.41	166.76	198.46	80.87	102.97	92.98	79.50	72.50	35.55
	Mean	92.67	83.30	81.18	88.02	57.19	67.16	77.87	23.22	29.16	10.39
	Std.	39.93	7.55	23.95	19.73	13.29	18.51	7.34	13.15	13.31	5.88
	CV (%)	43.09	9.07	29.50	22.41	23.24	27.56	9.42	56.63	45.63	56.63
	SE±	6.09	1.15	3.65	3.01	2.03	2.82	1.12	2.01	2.03	0.90

RIART =River State Institute of Agricultural Research and Technology, CV = Coefficient of Variation, SE = Standard Error, Std = Standard deviation, O = Onne.

Appendix 8.3 Assessment of number of nodes per 25-cm plantable stakes per plant for 43 Cassava Mosaic Disease Resistant varieties in six locations for cassava stake quality.

S/N	Variety	Ajibode	Kate O.	RIART O.	Akure	Zaria	Demo O.	Mean	Sdt	CV (%)	SE±
1	30572	12.07	6.65	9.78	10.85	18.76	2.65	10.13	5.42	53.55	2.43
2	4(2)1425	16.11	8.84	10.38	10.90	18.61	4.64	11.58	5.05	43.61	2.26
3	82/00058	13.11	8.33	8.72	10.75	17.30	6.87	10.85	3.83	35.31	1.71
4	91/02324	16.85	10.59	12.04	8.49	20.45	5.90	12.39	5.39	43.53	2.41
5	92/0057	13.56	10.05	12.01	8.91	26.80	7.30	13.10	7.07	53.92	3.16
6	92/0067	14.56	13.95	15.06	10.09	24.66	9.69	14.67	5.41	36.87	2.42
7	92/0325	13.64	11.33	12.60	13.56	20.80	5.81	12.96	4.82	37.21	2.16
8	92/0326	12.36	12.58	12.64	14.21	26.14	6.57	14.08	6.47	45.93	2.89
9	92B/00061	12.12	12.72	11.31	12.24	29.56	4.37	13.72	8.36	60.96	3.74
10	92B/00068	12.18	14.79	14.43	12.61	22.83	6.47	13.89	5.30	38.19	2.37
11	94/0026	16.43	10.71	14.17	12.14	18.08	6.60	13.02	4.14	31.83	1.85
12	94/0039	13.59	11.17	14.03	14.37	17.24	6.27	12.78	3.73	29.19	1.67
13	94/0561	7.66	7.19	8.98	14.19	19.27	3.27	10.09	5.71	56.57	2.55
14	95/0166	10.57	10.50	15.22	11.74	24.02	9.10	13.53	5.54	40.99	2.48
15	95/0289	10.25	9.59	11.02	18.45	13.05	5.35	11.29	4.33	38.35	1.94
16	95/0379	12.43	9.18	8.87	10.95	20.38	6.17	11.33	4.91	43.35	2.20
17	96/0523	10.44	12.45	18.62	12.84	20.86	10.77	14.33	4.35	30.35	1.95
18	96/0603	12.85	7.88	12.29	10.42	18.21	6.07	11.29	4.27	37.80	1.91
19	96/1089A	8.23	11.06	10.29	10.81	13.33	6.78	10.08	2.30	22.77	1.03
20	96/1565	13.94	9.80	9.66	10.76	16.35	5.49	11.00	3.77	34.26	1.69
21	96/1569	14.16	14.76	9.38	12.84	19.03	3.87	12.34	5.19	42.07	2.32
22	96/1632	16.69	13.51	9.56	12.04	22.53	4.96	13.22	6.03	45.63	2.70
23	96/1642	11.37	7.80	9.93	13.23	22.48	4.56	11.56	6.13	53.02	2.74
24	97/0162	15.04	11.03	15.63	15.75	20.15	4.94	13.76	5.20	37.80	2.33
25	97/0211	12.48	12.70	12.32	10.62	16.29	5.35	11.63	3.59	30.91	1.61
26	97/2205	16.93	11.60	12.05	10.48	4.36	5.94	10.23	4.54	44.38	2.03
27	97/3200	11.12	9.67	6.40	14.76	19.34	6.75	11.34	4.98	43.92	2.23
28	97/4763	14.09	11.15	20.89	11.45	19.97	4.02	13.60	6.27	46.11	2.80
29	97/4769	16.06	9.85	9.81	14.55	21.10	5.84	12.87	5.45	42.39	2.44
30	97/4779	14.43	14.41	8.60	14.38	12.45	5.71	11.66	3.69	31.61	1.65
31	98/0002	11.39	8.50	13.83	10.37	17.36	3.93	10.90	4.59	42.10	2.05
32	98/0505	10.25	13.47	7.88	13.74	18.90	6.77	11.83	4.47	37.79	2.00
33	98/0510	15.93	12.37	11.79	10.69	18.21	5.20	12.36	4.50	36.42	2.01
34	98/0581	12.84	9.97	12.45	13.92	19.77	5.25	12.37	4.77	38.58	2.13
35	98/2101	11.34	12.39	14.61	13.24	22.13	6.61	13.39	5.08	37.96	2.27
36	98/2226	9.42	9.49	10.14	12.25	16.80	4.18	10.38	4.12	39.71	1.84
37	99/2123	12.60	8.17	8.58	13.37	20.03	5.00	11.29	5.27	46.70	2.36
38	99/3073	15.23	12.27	8.96	8.59	17.17	4.41	11.10	4.71	42.41	2.11
39	99/6012	13.42	10.31	14.66	12.53	21.20	5.98	13.02	5.04	38.69	2.25
40	M98/0028	14.87	17.03	16.23	14.64	27.39	9.42	16.60	5.92	35.66	2.65
41	M98/0040	16.54	11.13	9.57	15.48	18.70	6.25	12.95	4.73	36.54	2.12
42	M98/0068	6.92	10.26	15.24	11.47	18.71	9.21	11.97	4.30	35.91	1.92
43	TME419	11.62	10.92	14.50	16.26	17.47	8.16	13.16	3.53	26.85	1.58
	Minimum	6.92	6.65	6.40	8.49	4.36	2.65	10.08	2.30	22.77	1.03
	Maximum	16.93	17.03	20.89	18.45	29.56	10.77	16.60	8.36	60.96	3.74
	Mean	12.97	10.98	11.98	12.46	19.49	6.01	12.32	4.94	40.18	2.21
	Std.	2.50	2.23	3.02	2.14	4.29	1.74	1.41	1.05	7.81	0.47
	CV (%)	19.29	20.32	25.20	17.15	22.03	29.03	11.48	21.28	19.44	21.28
	SE±	0.38	0.34	0.46	0.33	0.65	0.27	0.22	0.16	1.19	0.07

RIART =River State Institute of Agricultural Research and Technology, CV = Coefficient of Variation, SE = Standard Error, Std = Standard deviation, O = Onne.

Appendix 8.4 Assessment of stake diameter per 25-cm plantable stakes per plant for 43 Cassava Mosaic Disease Resistant varieties in six locations for cassava stake quality.

S/N	Variety	Ajibode	Kate O.	RIART O	Akure	Zaria	Demo O.	Mean	Sdt	CV (%)	SE±
1	30572	2.09	1.10	1.95	2.05	1.90	1.66	1.79	0.37	20.64	0.17
2	4(2)1425	1.76	0.99	1.89	2.17	1.58	1.65	1.67	0.39	23.56	0.18
3	82/00058	1.68	1.07	1.93	3.12	1.86	2.76	2.07	0.75	36.11	0.33
4	91/02324	1.71	1.27	2.25	1.86	1.75	3.13	1.99	0.64	32.05	0.29
5	92/0057	1.68	1.37	2.54	2.32	1.59	2.64	2.02	0.54	26.75	0.24
6	92/0067	2.09	0.92	2.21	2.14	1.96	2.08	1.90	0.49	25.65	0.22
7	92/0325	1.71	1.17	2.04	2.06	1.83	2.06	1.81	0.35	19.07	0.15
8	92/0326	1.74	1.10	2.18	1.97	2.11	2.33	1.91	0.44	23.20	0.20
9	92B/00061	1.67	1.27	2.02	2.15	1.56	1.64	1.72	0.32	18.66	0.14
10	92B/00068	1.62	1.97	2.03	2.23	1.41	2.23	1.92	0.34	17.51	0.15
11	94/0026	1.83	1.18	2.14	2.03	1.48	1.93	1.76	0.36	20.69	0.16
12	94/0039	1.64	2.96	2.17	2.54	1.46	2.01	2.13	0.56	26.24	0.25
13	94/0561	1.65	1.36	1.97	2.21	1.46	2.03	1.78	0.34	19.10	0.15
14	95/0166	1.89	1.16	2.01	2.04	1.93	3.17	2.03	0.65	31.74	0.29
15	95/0289	2.45	1.10	1.98	2.18	1.69	2.19	1.93	0.48	24.87	0.21
16	95/0379	1.97	1.49	1.89	2.02	1.70	1.96	1.84	0.20	11.15	0.09
17	96/0523	1.87	1.09	2.15	2.03	3.26	2.19	2.10	0.70	33.15	0.31
18	96/0603	1.77	1.10	2.23	2.14	1.80	2.31	1.89	0.45	23.73	0.20
19	96/1089A	1.79	1.81	2.03	2.17	1.47	2.16	1.90	0.27	14.07	0.12
20	96/1565	2.10	1.19	2.05	1.97	2.12	2.02	1.91	0.36	18.79	0.16
21	96/1569	1.87	1.15	2.04	2.01	1.70	1.72	1.75	0.33	18.61	0.15
22	96/1632	1.73	1.21	2.13	1.98	1.67	1.99	1.79	0.33	18.53	0.15
23	96/1642	2.26	1.33	2.00	1.89	1.65	2.02	1.86	0.32	17.40	0.14
24	97/0162	1.71	1.10	2.53	2.15	1.56	1.84	1.81	0.49	27.16	0.22
25	97/0211	1.88	1.31	2.14	2.23	1.38	2.02	1.83	0.39	21.45	0.18
26	97/2205	1.75	1.15	1.82	2.05	1.48	1.79	1.67	0.32	18.93	0.14
27	97/3200	1.90	1.09	1.94	1.98	1.93	1.91	1.79	0.34	19.13	0.15
28	97/4763	1.89	1.22	1.97	1.89	1.38	1.90	1.71	0.32	18.87	0.14
29	97/4769	2.12	0.99	1.93	2.15	1.40	1.77	1.73	0.45	26.23	0.20
30	97/4779	1.60	1.34	2.07	2.23	1.35	2.04	1.77	0.39	22.12	0.18
31	98/0002	1.72	1.19	1.89	2.03	1.40	2.21	1.74	0.39	22.28	0.17
32	98/0505	1.83	1.55	1.94	2.05	1.58	1.75	1.78	0.20	11.14	0.09
33	98/0510	2.14	1.64	3.00	1.62	1.82	2.51	2.12	0.55	25.88	0.25
34	98/0581	2.33	1.37	2.05	1.92	1.91	2.35	1.99	0.36	18.15	0.16
35	98/2101	1.80	1.22	2.01	2.03	1.93	2.48	1.91	0.41	21.45	0.18
36	98/2226	1.92	2.45	2.17	1.54	1.67	2.50	2.04	0.40	19.61	0.18
37	99/2123	2.12	1.24	3.12	1.74	1.63	2.08	1.99	0.64	32.18	0.29
38	99/3073	1.95	1.35	1.86	1.72	2.39	2.10	1.90	0.35	18.52	0.16
39	99/6012	1.89	1.18	2.32	2.14	1.66	3.45	2.11	0.77	36.41	0.34
40	M98/0028	1.67	0.98	2.14	2.15	1.60	2.07	1.77	0.46	25.78	0.20
41	M98/0040	1.98	1.22	2.06	2.23	1.69	2.00	1.86	0.36	19.40	0.16
42	M98/0068	2.33	1.28	1.97	2.03	1.64	2.20	1.91	0.39	20.30	0.17
43	TME419	2.79	1.17	2.34	1.60	1.69	2.33	1.99	0.60	30.22	0.27
	Minimum	1.60	0.92	1.82	1.54	1.35	1.64	1.67	0.20	11.14	0.09
	Maximum	2.79	2.96	3.12	3.12	3.26	3.45	2.13	0.77	36.41	0.34
	Mean	1.90	1.31	2.12	2.06	1.72	2.17	1.88	0.43	22.71	0.19
	Std.	0.25	0.38	0.26	0.25	0.33	0.40	0.13	0.14	5.97	0.06
	CV (%)	13.24	28.81	12.41	12.29	19.14	18.37	6.76	31.39	26.27	31.39
	SE±	0.04	0.06	0.04	0.04	0.05	0.06	0.02	0.02	0.91	0.01

RIART =River State Institute of Agricultural Research and Technology, CV = Coefficient of Variation, SE = Standard Error, Std = Standard deviation, O = Onne.

Appendix 8.5 Assessment of root yield (t/ha) for 43 Cassava Mosaic Disease Resistant varieties in six locations for cassava stake quality.

S/N	Variety	Ajibode	Kate O.	RIART O	Akure	Zaria	Demo O.	Mean	Sdt	CV (%)	SE±
1	30572	13.90	16.71	27.95	32.69	4.71	9.41	17.56	10.79	61.47	4.83
2	4(2)1425	19.80	3.50	32.45	27.00	9.80	19.60	18.69	10.68	57.13	4.78
3	82/00058	27.50	9.78	25.76	39.31	15.08	30.16	24.60	10.65	43.31	4.76
4	91/02324	22.60	20.00	22.15	27.50	7.43	14.86	19.09	7.03	36.82	3.14
5	92/0057	39.25	48.89	29.84	34.94	14.88	29.76	32.93	11.35	34.47	5.08
6	92/0067	37.10	84.33	19.43	28.56	4.57	19.62	32.27	27.71	85.88	12.39
7	92/0325	32.75	54.19	24.97	32.38	1.32	32.68	29.71	17.05	57.37	7.62
8	92/0326	58.50	8.87	32.35	62.25	7.08	14.16	30.53	24.82	81.27	11.10
9	92B/00061	10.80	32.00	34.24	29.75	5.38	10.77	20.49	12.84	62.64	5.74
10	92B/00068	55.10	108.33	37.45	28.56	22.69	45.39	49.59	31.02	62.56	13.87
11	94/0026	17.10	49.87	34.07	41.63	6.77	13.55	27.17	17.18	63.23	7.68
12	94/0039	35.00	64.94	20.15	67.06	7.54	15.08	34.96	25.67	73.43	11.48
13	94/0561	44.80	95.67	21.95	57.19	10.72	21.44	41.96	31.37	74.77	14.03
14	95/0166	23.20	51.49	38.20	29.75	0.25	51.67	32.43	19.46	60.03	8.70
15	95/0289	31.00	46.67	35.73	14.13	10.50	21.00	26.50	13.79	52.05	6.17
16	95/0379	25.80	108.00	18.48	31.31	7.03	14.06	34.11	37.19	109.02	16.63
17	96/0523	21.60	44.53	20.79	32.44	2.35	15.06	22.79	14.48	63.53	6.48
18	96/0603	39.40	16.17	30.50	60.69	11.31	22.62	30.11	18.03	59.87	8.06
19	96/1089A	50.00	102.22	31.00	28.56	11.15	22.30	40.87	32.63	79.84	14.59
20	96/1565	39.25	77.86	30.64	62.13	4.90	9.80	37.43	28.69	76.64	12.83
21	96/1569	24.60	74.67	31.13	57.19	6.89	13.79	34.71	26.18	75.44	11.71
22	96/1632	27.00	101.90	28.65	31.19	7.24	14.47	35.08	34.02	96.99	15.21
23	96/1642	39.20	44.67	20.53	27.00	7.26	14.52	25.53	14.39	56.36	6.44
24	97/0162	21.00	195.24	31.98	39.31	9.63	19.27	52.74	70.57	133.82	31.56
25	97/0211	46.90	40.73	16.96	30.25	2.25	4.51	23.60	18.68	79.15	8.35
26	97/2205	39.80	16.17	30.62	34.19	4.52	9.05	22.39	14.46	64.60	6.47
27	97/3200	51.40	9.67	33.80	26.38	8.49	16.97	24.45	16.41	67.12	7.34
28	97/4763	45.80	39.11	25.65	36.44	3.62	7.23	26.31	17.47	66.40	7.81
29	97/4769	38.10	13.67	22.72	32.44	12.97	25.94	24.30	10.03	41.28	4.49
30	97/4779	38.90	19.70	41.07	55.69	3.81	7.61	27.80	20.62	74.18	9.22
31	98/0002	45.80	38.67	32.52	52.63	6.71	13.42	31.62	18.13	57.34	8.11
32	98/0505	31.10	99.00	28.26	28.56	4.00	8.00	33.15	34.26	103.33	15.32
33	98/0510	43.90	48.39	25.31	59.94	11.24	22.48	35.21	18.41	52.30	8.23
34	98/0581	22.60	34.11	41.08	29.50	9.89	19.78	26.16	11.09	42.40	4.96
35	98/2101	42.20	82.78	29.48	53.25	9.07	18.14	39.15	26.65	68.07	11.92
36	98/2226	28.60	107.22	20.37	32.44	8.05	16.09	35.46	36.22	102.15	16.20
37	99/2123	39.40	20.00	17.53	67.06	3.97	7.94	25.98	23.60	90.83	10.55
38	99/3073	30.10	48.89	25.55	57.19	6.28	12.57	30.10	19.91	66.16	8.90
39	99/6012	29.60	14.22	22.42	29.75	9.61	19.22	20.80	8.14	39.12	3.64
40	M98/0028	27.80	89.22	32.56	14.13	6.56	13.12	30.56	30.34	99.28	13.57
41	M98/0040	51.80	21.11	24.52	57.19	10.76	21.52	31.15	18.75	60.19	8.38
42	M98/0068	46.10	23.25	43.27	53.25	4.39	8.78	29.84	20.63	69.12	9.22
43	TME419	26.40	39.78	20.93	26.38	4.63	17.92	22.67	11.59	51.12	5.18
	Minimum	10.80	3.50	16.96	14.13	0.25	4.51	17.56	7.03	34.47	3.14
	Maximum	58.50	195.24	43.27	67.06	22.69	51.67	52.74	70.57	133.82	31.56
	Mean	34.48	52.70	28.26	39.51	7.61	17.80	30.06	21.47	68.65	9.60
	Std.	11.51	39.22	6.77	14.61	4.15	9.40	7.63	11.29	20.86	5.05
	CV (%)	33.38	74.42	23.95	36.97	54.58	52.84	25.38	52.59	30.39	52.59
	SE±	1.76	5.98	1.03	2.23	0.63	1.43	1.16	1.72	3.18	0.77

RIART =River State Institute of Agricultural Research and Technology, CV = Coefficient of Variation, SE = Standard Error, Std = Standard deviation, O = Onne.

Appendix 8.6 Assessment of forage yield (t/ha) for 43 Cassava Mosaic Disease Resistant varieties in six locations for cassava stake quality.

S/N	Variety	Ajibode	Kate O.	RIART O	Akure	Zaria	Demo O.	Mean	Sdt	CV (%)	SE±
1	30572	9.10	3.12	4.76	7.75	0.27	0.55	4.26	3.66	85.81	1.63
2	4(2)1425	3.68	1.42	2.86	5.19	1.80	3.60	3.09	1.38	44.66	0.62
3	82/00058	7.98	2.56	2.29	4.44	3.47	6.95	4.61	2.36	51.05	1.05
4	91/02324	2.86	3.83	3.70	2.31	0.82	1.65	2.53	1.18	46.52	0.53
5	92/0057	5.05	23.33	3.01	3.31	5.30	10.60	8.43	7.79	92.39	3.48
6	92/0067	7.70	3.87	2.13	7.82	0.38	0.75	3.78	3.32	87.95	1.49
7	92/0325	7.37	14.44	4.05	4.50	8.80	17.61	9.46	5.48	57.87	2.45
8	92/0326	7.9	5.60	4.06	7.00	0.75	1.50	4.47	2.91	65.07	1.30
9	92B/00061	1.403	11.33	3.00	2.13	0.48	0.96	3.22	4.07	126.62	1.82
10	92B/00068	7.1	37.22	3.74	8.38	1.63	3.26	10.22	13.46	131.74	6.02
11	94/0026	2.85	8.83	2.33	5.75	1.13	2.26	3.86	2.89	74.84	1.29
12	94/0039	3.4	9.75	1.91	5.88	5.25	10.49	6.11	3.41	55.84	1.53
13	94/0561	16.00	17.56	1.81	9.38	0.99	1.97	7.95	7.50	94.31	3.35
14	95/0166	3.22	15.76	2.87	7.82	2.54	5.08	6.22	5.07	81.60	2.27
15	95/0289	3.80	8.33	4.84	3.06	4.35	8.70	5.51	2.40	43.56	1.07
16	95/0379	6.74	4.79	2.63	5.06	3.18	6.36	4.80	1.65	34.40	0.74
17	96/0523	2.65	10.61	1.52	5.19	2.00	4.00	4.33	3.36	77.63	1.50
18	96/0603	8.16	6.33	2.87	4.44	4.59	9.19	5.93	2.41	40.70	1.08
19	96/1089A	4.80	22.22	1.47	1.94	2.22	4.44	6.18	7.98	129.01	3.57
20	96/1565	5.05	9.69	3.11	3.88	2.02	4.04	4.63	2.68	57.79	1.20
21	96/1569	2.80	16.67	1.81	8.38	1.55	3.09	5.71	5.92	103.53	2.65
22	96/1632	2.59	7.24	3.60	4.43	1.74	3.48	3.85	1.90	49.42	0.85
23	96/1642	10.50	16.00	3.15	3.44	3.30	6.60	7.16	5.19	72.38	2.32
24	97/0162	3.80	12.80	1.59	4.19	0.85	1.69	4.15	4.44	106.86	1.98
25	97/0211	8.70	6.70	2.97	7.00	1.64	3.27	5.05	2.79	55.33	1.25
26	97/2205	9.50	5.71	2.95	3.88	0.85	1.69	4.10	3.15	76.83	1.41
27	97/3200	4.40	3.58	2.40	3.06	1.16	2.32	2.82	1.12	39.80	0.50
28	97/4763	5.94	6.61	4.52	5.19	0.72	1.45	4.07	2.43	59.65	1.09
29	97/4769	7.10	3.54	3.84	8.38	1.44	2.88	4.53	2.65	58.49	1.18
30	97/4779	4.10	4.46	3.58	8.38	0.88	1.75	3.86	2.62	67.86	1.17
31	98/0002	7.50	11.56	2.40	3.13	2.97	5.93	5.58	3.54	63.36	1.58
32	98/0505	4.97	27.78	3.45	9.38	2.00	4.00	8.60	9.72	113.13	4.35
33	98/0510	12.60	29.17	4.65	2.79	4.80	9.60	10.60	9.80	92.41	4.38
34	98/0581	5.50	16.33	3.35	2.94	3.47	6.93	6.42	5.09	79.32	2.28
35	98/2101	4.80	17.93	3.09	8.00	7.12	14.24	9.20	5.73	62.28	2.56
36	98/2226	3.20	39.44	2.74	5.88	0.43	0.86	8.76	15.16	173.06	6.78
37	99/2123	9.40	15.33	5.21	9.38	1.40	2.79	7.25	5.15	71.06	2.30
38	99/3073	6.50	16.77	3.48	7.82	1.25	2.50	6.39	5.65	88.51	2.53
39	99/6012	4.20	4.56	1.85	3.06	1.76	3.53	3.16	1.17	37.00	0.52
40	M98/0028	4.51	16.67	3.89	1.25	0.81	1.61	4.79	6.01	125.47	2.69
41	M98/0040	5.70	14.50	5.11	9.38	4.07	8.15	7.82	3.82	48.88	1.71
42	M98/0068	4.80	4.08	4.94	6.75	0.77	1.53	3.81	2.26	59.19	1.01
43	TME419	3.50	4.06	2.07	2.04	2.69	5.38	3.29	1.30	39.42	0.58
	Minimum	1.40	1.42	1.47	1.25	0.27	0.55	2.53	1.12	34.40	0.50
	Maximum	16.00	39.44	5.21	9.38	8.80	17.61	10.60	15.16	173.06	6.78
	Mean	5.89	12.14	3.15	5.43	2.32	4.63	5.59	4.45	74.94	1.99
	Std.	2.94	9.06	1.04	2.44	1.89	3.77	2.13	3.12	30.76	1.39
	CV (%)	49.90	74.58	32.85	44.91	81.40	81.40	38.16	69.99	41.04	69.99
	SE±	0.45	1.38	0.16	0.37	0.29	0.58	0.33	0.48	4.69	0.21

RIART =River State Institute of Agricultural Research and Technology, CV = Coefficient of Variation, SE = Standard Error, Std = Standard deviation, O = Onne.