GENETIC VARIABILITY FOR SPROUTING ABILITY AND ESTABLISHMENT OF CASSAVA (*Manihot esculenta* Crantz) IN THE NIGERIAN SAVANNA.

By

CHRISTIAN CHUKWUMA OKONKWO

B. Agric (Hons) Crop Production, University of Nigeria, Nsukka.

A thesis Submitted to the PostGraduate School, Ahmadu Bello University, Zaria, In partial fulfilment of the requirements for the award of the degree of Master of Science in Crop Breeding

DEPARTMENT OF PLANT SCIENCE

Faculty of Agriculture

Ahmadu Bello University Zaria,

Nigeria

MARCH, 1998

DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for higher degree.

C.C. Okonkwo (Student) Date 13/9/99

The above declaration is confirmed

Dr. C. A. Echekwu Date 13/09/99

Chairman supervisory Committee.

CERTIFICATION

This thesis entitled "Genetic Variability for Sprouting and Establishment Ability of Cassava (*Manihot esculenta* Crantz) in the Nigerian Savannah" by Christian Chukwuma Okonkwo meets the regulations governing the award of Master of Science degree of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

Dr. C.A. Echekwu — Date 13/09/99
Chairman Supervisory Committee.

Dr.(Mrs) P.E. Olorunju — Date 13/09/99
Member Supervisory committee.

Dr. A.G.O. Dixon (IITA) — Date 13/9/99
Member Supervisory Committee.

Dr. S.O. Alabi — Date 13/09/99
Head, Department of Plant Science.

Prof. S.B. Ojo — Date 04/07/00
Dean, Post graduate School
Ahmadu Bello University, Zaria.

DEDICATION

This thesis is dedicated to my darling wife Lucyfine Oby

and

our lovely son Chris Chukwuma jr.

for their caring love, prayers and support throughout the time of this study.

ACKNOWLEDGMENT

I wish to express my sincere and profound gratitude to the Chairman of my supervisory committee, Dr. C.A. Echekwu for his untiring efforts, valuable suggestions, guidance and encouragement during the course of my study and the write up of the work presented in this thesis. In fact he was more of a friend than a supervisor and his efforts in making me a crop breeder are highly appreciated. I am also, grateful to the other members of my supervisory committee. Dr. (Mrs.) P.E Olorunju will be remembered for her advice, useful criticisms and her motherly role during the course of my study at ABU, Zaria. I am also grateful to Dr. A.G.O. Dixon, cassava breeder at International Institute of Tropical Agriculture (IITA), Ibadan, who introduced me to this work and for his keen interest in the study, and his encouragement and advice to me.

I wish to thank, the IITA for providing me an opportunity for this post graduate study and especially for the financial and material support. My appreciation and thanks also, go to the entire Root and Tuber Improvement Programme of the IITA especially, the Cassava Breeding Unit, for providing me with the cassava germplasm. Dr. R. Asiedu the leader of the programme is recognised for his encouragement and advice. Drs I.J Ekanayake and N. Wanyera are also thanked for their useful suggestions and assistance.

I wish to recognise and acknowledge the overwhelming support and valuable suggestions from Professor U.S. Gupta, Drs. S.O. Alabi, G.O. Bodunde and late Professor C.C. Nwasike. My gratitude also goes to the entire staff of the Department of Plant Science for their assistance to me in one way or the other during the course of my study at the ABU.

I am very grateful to Richardson Okechukwu, Nkechi Okonkwo, Jide Olomola, and Esther Mberu of the TRIP Computer Unit for their special assistance in processing and analysing the data. Messrs, I G. Usuwa, U.C. Okarter, P Iluebbey, J. Ogar and my other

colleagues in TRIP are remembered for their various contributions, assistance and encouragement to the realisation of this project.

To my dear parents Mr. and Mrs. M. O. Okonkwo, I shall always remain most grateful for their love, care, understanding and the good training given to me. The prayers of my younger sisters, brothers and other relatives are appreciated. I wish to express my deep sense of obligation to my dear wife, Lucyfine Oby for her love, care, support and prayers during the course of this work. The concern, care and prayers of my lovely son Chukwuma are gratefully acknowledged. I also appreciate the efforts of my friends and well wishers for their continuous encouragement and to all the others too many to mention here.

Finally, my greatest gratitude and appreciation goes to the Almighty God for giving me the life and strength to finish this work. To God be the glory. I acknowledge with thanks HIS MERCY on me, and my family during the course of this study. May His Holy Name remain Blessed and be Praised Forever, Amen.

ABSTRACT

The studies were carried out to estimate the extent of genetic variability and character relations in cassava (*Manihot esculenta* Crantz) for sprouting and establishment ability. Forty cassava clones comprising: 33 Nigerian cassava land races and 7 IITA improved clones were selected for the study based on their popularity in the 36 states of Nigeria.

The analysis of variance for sprouting ability, establishment ability, cutting characteristics, growth parameters, cassava mosaic disease (CMD) and cassava bacterial blight (CBB) showed highly significant differences (p=0.01) among the genotypes. Combined analysis of variance for sprouting ability, establishment ability, growth parameters,(no of shoots per plot, number of roots per plot, fresh weight of shoot, fresh weight of root, dry weight of shoot, dry weight of root, plant height), CMD and CBB revealed highly significant effects of clones, environments and their interactions (G x E). Locations also differed significantly. Highly significant G x E interactions were observed for all the traits measured. The estimates of genetic variances obtained in this study were comparable among the locations. However kuru location had lower estimates than the other locations.

The genotypic coefficients of variation (GCV) were lower than the phenotypic coefficients of variation (PCV) in all the characters studied thus indicating considerable influence of environment on the expression of these characters. The high GCV values for the characters revealed that the range of variability in the population was large thus suggesting that there is scope for further improvement of these traits through selection. The genetic variances obtained were positive for all the traits studied. Significant genetic differences existed for all the traits studied and varied widely among locations.

From the results, most cassava clones achieved their maximum sprouting potential between 21 and 28 days after planting. Among all the locations, Samaru had the overall best mean performance and Kuru location had the lowest mean performance. The TMS 30572 had the overall best mean performance across the four locations for sprouting and establishment ability. Antiota, TMS 91934, 82/00661, 82/0058, Odungbo, Abachaji, and Oyarugba had mean performance of above 90% sprouting ability and were among the best clones selected for high sprouting ability and establishment potentials. The studies also showed that evaluating for sprouting and supplying should be done between 21 and 28 days after planting.

The forty cassava clones that were involved in the studies showed varying levels of susceptibility to cassava mosaic disease and cassava bacterial blight. Amala, Atu Iwo, Bagi Wawa, Oko Iywo, Olekanga, 2nd Agric were the most resistant clones in the population for CMD, while TMS 81/00110, TMS 82/00058 and TMS 30572 were the resistant clones to CBB.

Correlation coefficients in all the four locations between phenotypic and genotypic correlation showed similar trend and magnitude. Genotypic coefficients of correlation were higher than their corresponding phenotypic correlation coefficients. Highly significant positive genotypic and phenotypic correlation coefficients were observed between sprouting and establishment. Stake fresh weight, stake girth, stake volume, stake bulk density, had significant positive genotypic and phenotypic correlation with sprouting and establishment. Number of shoot, number of roots, fresh weight of shoot, fresh weight of root, dry weight of shoot, dry weight of root and plant height were positively correlated with sprouting and establishment. However, sprouting and establishment correlated significantly, but negatively with number of nodes and pith wood ratio implying that increasing number of nodes of cuttings and pith wood ratio would result in decrease of the sprouting ability of the different genotypes. Similarly, the significant negative correlation between sprouting ability and establishment and pith wood ratio indicated that increasing pith-wood ratio would also result

in decrease of the wood portion of the stakes thus reducing the food reserve in the wood and consequently resulting to poor sprouting and establishment.

Significant but negative phenotypic correlations were observed between sprouting, establishment and CMD and CBB recorded at 3 months after planting. The implication of this observation for breeding could mean that selections aimed at increasing sprouting and establishment abilities would probably lead to decreased pith-wood ratio, decreased CMD, decreased CB**B** and decreased number of nodes, thus these characters could therefore be improved simultaneously.

TABLE OF CONTENTS

Title.....**i**

Declaration ii

Certification iii

Dedication iv

Acknowledgment v

Abstract vii

Table of contents x

List of tables ix

List of appendices xi

CHAPTER ONE

1.0 INTRODUCTION.....1

CHAPTER TWO

2.0 LITERTAURE REVIEW 5

2.1 Sprouting, emergence and establishment of cassava.....5

2.2 Factors affecting sprouting and establishment 5

2.2.1.1 Number iof Nodes per Cutting.....6

2.2.1.2 Fresh Weight of Stakes.....6

2.2.1.3 Thickness of Stakes and Pith Diameter 7

2.2.1.4 Bulk Density of the Stakes 7

2.2.1.5 Length of Cuttings 7

2.2.1.6 Nutrient Content of Stakes 8

2.2.1.7 Storage of Cassava Cuttings 8

2.2.1.8 Incidence of Diseases and Pests 9

2.2.1.9 Age of Mother of Stem 9

2.2.2 Exteral Factors (Evironmental Conditions) 10

2.2.2.1 Tempetarure 10

2.2.2.2 Water and Soil Moisture 10

2.2.2.3 Light 11

2.2.2.4 Time 11

2.3 Genetic Variability for Sprouting Ability and establishment 12

2.4 Correlations 13

CHAPTER THREE

3.0 MATERIALS AND METHODS 16

3.1 Genetic Material 16

3.2 Field Experimentation 16

3.3 Data Collection 18

3.4 Statistical Analaysis 20

3.4.1 Estimates of Variance Components 25

3.4.2 Estimation of Phenotypic and Genotypic Coefficients of Variations 25

3.4.3 Correlation 26

CHAPTER FOUR

4.0 RESULTS 27

4.1 Mean Performance 27

4.1.1 Clonal Differences For Sprouting Ability at 7 Days After Planting (7 DAP) 27

4.1.2 Clonal differences for Sprouting ability at 14 days after planting (14DAP) 28

4.1.3 Clonal Differenve for Sprouting Ability at 21 days 29

4.1.4 Clonal differences for Sprouting ability at 28 days after planting (28 DAP) 30

4.1. 5 Establishment 31

4.1.6 Cutting Characteristic 38

4.1.7 Growth Parameters 41

4.1.8 Disease Incidence 45

4.2 Analsysis of Variance 55

4.3 Estimates of Variance 57

4.3.1 Sprouting per centages 58

4.3.2 Estbalishment 58

4.3.3 Cutting Characteristics 59

4.3.4 Growth Parameter 59

4.3.5 Disease Resistance 60

4.4 Correlations 66

CHAPTER FIVE

5.0 Discussion 73

CHAPTER SIX

6.0 Summary and Conclusion 82

References 85

Appendices 90

LIST OF TABLES

Table 1. Cassava clones used in the study and their States of origin.....17

Table 2. Form of Analysis of variance and covariance for each location.....23

Table 3. Form of analysis of variance and covariance for the combined locations. 24

Table 4. Sprouting percentage and rating of 40 cassava clones evaluated at four locations 7 days after planting (7DAP) in 1994. 33

Table 5. Sprouting percentage and rating of 40 cassava clones evaluated at four locations 14 days after planting (14DAP) in 1994.....34

Table 6. Sprouting percentage and rating of 40 cassava clones evaluated at four locations 21 days after planting (21DAP) in 1994.....35

Table 7. Sprouting percentage and rating of 40 cassava clones evaluated at four locations 28 days after planting (28DAP) in 1994.....36

Table 8. Percentage establishment and rating of 40 cassava clones evaluated at four locations 90 days after planting(90DAP) in 1994 37

Table 9. Mean, standard error of mean, range, phenotypic and genotypic coefficients of variability for the 22 traits of cassava clones grown at Mokwa in 1994.....49

Table 10. Mean, standard error of mean , range, phenotypic and genotypic coefficients of variability for the 22 traits of cassava clones grown at Samaru in 1994.....50

Table 11. Mean, standard error of mean, range, phenotypic and genotypic coefficients of variability for the 22 traits of cassava clones grown at Minjibir in 1994.. 51

KASHIM IBRAHIM LIBR...

Table 12. Mean, standard error of mean, range, phenotypic and genotypic coefficients of variability for the 22 traits of cassava clones grown at Kuru in 1994. 52

Table 13. Mean, standard error of mean, range, phenotypic and genotypic coefficients of variability for the 22 traits of cassava clones grown across different locations in 1994. 53

Table14. Percentage contribution of sources of variation to the total variations for 40 cassava clones grown in 4 locations 55

Table 15. Estimates of genetic variance (σ^2_g), phenotypic variance(σ^2_{ph}) and error variance (σ^2_e)with their standard errors for 22 characters of 40 cassava clones grown at Mokwa. 60

Table 16. Estimates of genetic variance (σ^2_g), phenotypic variance(σ^2_{ph}) and error variance (σ^2_e)with their standard errors for 22 characters of 40 cassava clones at Samaru. 61

Table 17. Estimates of genetic variance (σ^2_g), phenotypic variance(σ^2_{ph}) and error variance (σ^2_e)with their standard errors for 22 characters of 40 cassava clones grown at Minjibir 62

Table 18. Estimates of genetic variance (σ^2_g), phenotypic variance(σ^2_{ph}) and error variance (σ^2_e)with their standard errors for 22 characters of 40 cassava clones at Kuru. 63

Table 19. Estimates of genetic variance (σ^2_g), clone x environmental interaction (σ^2_{gl}) , phenotypic variance(σ^2_{ph}) and error variance (σ^2_e)with their standard errors for 17 characters of 40 cassava clones grown in 4 locations 64

Table 20. Phenotypic and genotypic correlation coefficients between sprouting, establishment ability, and the 17 characters of 40 cassava clones grown at Mokwa in 1994 (n=40). 67

Table 21. Phenotypic and genotypic correlation coefficients between sprouting, establishment ability, and the 17 characters of 40 cassava clones grown Samaru in 1994 (n=40). 68

Table 22. Phenotypic and genotypic correlation coefficients between sprouting, establishment ability, and the 17 characters of 40 cassava clones grown at Minjibir in 1994 (n=40). 69

Table 23. Phenotypic and genotypic correlation coefficients between sprouting, establishment ability, and the 17 characters of 40 cassava clones grown at Kuru in 1994 (n=40). 70

Table 24. Phenotypic and genotypic correlation coefficients between sprouting, establishment ability, and the 17 characters of 40 cassava clones grown in the 4 locations. in 1994 (n=40). 71

LIST OF APPENDICES

Appendix 1a. Mean cutting characteristics of the 40 cassava genotypes grown at Mokwa in 1994 90

Appendix 1b. Mean cutting characteristics of the 40 cassava genotypes grown at Samaru in 1994 91

Appendix 1c. Mean cutting characteristics of the 40 cassava genotypes grown at Minjibir in 1994 92

Appendix 1d. Mean cutting characteristics of the 40 cassava genotypes grown at Kuru in 1994 93

Appendix 1e. Mean cutting characteristics of the 40 cassava genotypes grown across locations in 1994 94

Appendix 2a. Mean performance for growth parameters of the 40 cassava genotypes grown at Mokwa in 1994 95

Appendix 2b. Mean performance for growth parameters of the 40 cassava genotypes grown at Samaru in 1994 96

Appendix 2c. Mean performance for growth parameters of the 40 cassava genotypes grown at Minjibir in 1994 97

Appendix 2d. Mean performance for growth parameters of the 40 cassava genotypes grown at Kuru in 1994 98

Appendix 2e. Mean performance for growth parameters of the 40 cassava genotypes grown in 4 locations in 1994 99

Appendix 3a. Mean severity scores of cassava genotypes to Cassava Mosaic Disease (CMD) and Cassava Bacterial Blight (CBB) at Mokwa in 1994 100

Appendix 3b. Mean severity scores of cassava genotypes to Cassava Mosaic Disease (CMD) and Cassava Bacterial Blight (CBB) at Samaru in 1994 101

Appendix 3c. Mean severity scores of cassava genotypes to Cassava Mosaic Disease (CMD) and Cassava Bacterial Blight (CBB) at Minjibir in 1994 102

Appendix 3d. Mean severity scores of cassava genotypes to Cassava Mosaic Disease (CMD) and Cassava Bacterial Blight (CBB) at Kuru in 1994 103

Appendix 3e. Mean severity scores of cassava genotypes to Cassava Mosaic Disease (CMD) and Cassava Bacterial Blight (CBB) across locations in 1994 104

Appendix 4a. Mean squares of 22 characters of 40 cassava genotypes grown at Mokwa in 1994 105

Appendix 4b. Mean squares of 22 characters of 40 cassava genotypes grown at Samaru in 1994 106

Appendix 4c. Mean squares of 22 characters of 40 cassava genotypes grown at Minjibir in 1994 107

Appendix 4d. Mean squares of 22 characters of 40 cassava genotypes grown at Kuru in 1994 108

Appendix 4e. Combined analysis of variance of 15 characters of 40 cassava clones grown in the four locations 109

Appendix 5.The soil physio-chemical properties of Mokwa, Samaru, Minjibir and Kuru 110

Appendix 6. Weather summary for Mokwa 1994 111

Appendix 7. Weather summary for ABU farm Samaru 1994 112

Appendix 8. Weather summary for Minjibir 1994 113

Appendix 9. Weather summary for Kuru 1994 114

CHAPTER ONE

1.0 INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a perennial shrub belonging to the family *Euphorbiaceae*, the genus comprising of about 123 species. Cassava is the only one with edible tuberous root, and is thus the most economically important *Manihot* species out of 123 reported (Rogers and Appan, 1973.) The crop is variously known as Tapioca, Mandioca and Yuca (Philips, 1974).

Cassava is a native of Latin America, where its widest morphological diversity exists and from where the Portuguese traders introduced it into Africa (Leaky and Wills, 1977). Since the introduction of cassava into Africa, and the crop's steady acceptance and spread among the diverse ethnic groups of the tropical rain forest and adjacent ecological zones, it has been increasingly integrated into the farming systems across the continent (Hahn *et al.* 1979). Cassava is the most important and a major dietary staple food for a large percentage of the populations of sub-Saharan Africa, Asia and Latin America. In the tropical world, cassava ranks fourth in importance as a major food crop in the developing countries after rice, wheat and maize (FAO, 1989). In sub-Saharan Africa, both the tuberous roots and the leaves are consumed. The roots provide over 50% of the daily energy for more than 200 million people in the African Continent (IITA, 1990). They are either eaten raw, boiled with sauce or processed in a number of different ways to make cakes, flours or meal and *gari*. Cassava can also be fermented to produce industrial alcohol, starch and other types of food. Dried cassava pellets or chips are sold in the international markets for starch and animal feeds. The starch is used in many industries such as food processing, pharmaceutical and drugs, textiles, papermaking, adhesives and lubricants. Other chemical products such as alcohol, citric acid, glucose high fructose syrups and monosodium glutamate are obtained from cassava (Berry, 1993 and COSCA, 1994).

Cassava leaves are rich source of protein, eaten as spinach or vegetables by humans in Zaire, Central Africa, Sierra Leone and Liberia. The leaves contribute as much as one-third of the person protein intake from all vegetable in Zaire (FAO, 1971). Cassava production and utilisation have since shifted from being a mere subsistence crop to being a commercial crop wherever it is presently cultivated in Sub- Saharan Africa (Berry, 1993 and COSCA, 1994). The crop has a potential as a famine crop when other crops have failed (Hahn *et al.*, 1979).

Cassava production is concentrated mainly in Africa, South America and South East Asia, with Nigeria, Brazil, Thailand, Zaire and Indonesia as the largest producers. The estimated global production grew from 70 million tonnes in 1960 to 154 million tonnes of fresh roots in 1991 (FAO, 1992). Current world production is about 157 million tonnes from 15.6 million hectares (FAO, 1990).

Current trends indicate that the consumption of cassava is increasing, and that the growing of cassava is expanding to semi-arid areas where cassava was not cultivated 20 years ago. The significant success of this crop to expand to semi-Arid zones can be attributed to its adaptability to varied and often harsh environmental conditions and its versatility in a variety of socio-economic situations. The adoption of drought, disease and pest resistant varieties released by National and International research centres has increased cassava production in many African countries and Nigeria has become since, 1989, the largest cassava producer in the world (FAO, 1991).

Despite the numerous advantages that favour cassava production in the savannah, there are a lot of problems and difficulties associated with cassava growing in the dry zones. In Nigeria, cassava is grown by about 70% of the local farmers and by peasant technology, characterised by inefficient mixed cropping patterns, low inputs and poor cultural and soil management systems. Africa's average cassava root yield of about 7.7 tha^{-1} is still low when compared with the world average of 9-12tha^{-1} (FAO, 1992). The low productivity of cassava in Africa is due to a variety of factors including a host of pests and

diseases which affect the crop, the use of low yielding varieties, inherent low fertility status of the soils and the prevailing farming systems which are essentially low input agricultural systems.

The yield of local cassava varieties on per plant basis might be low when compared to the improved varieties, but the main cause of low yield per unit area of the local varieties could be attributed to poor sprouting and establishment ability of the local varieties.

Sprouting ability of cassava stems is one of the most important agronomic factors in cassava production. It depends upon the quality of the cuttings themselves growth conditions, edaphic and climatic factors. Poor sprouting and low establishment often result to scanty stands, (low plant density) in the field, with increased weed competition, waste of lands, increased cost of labour and inputs especially when cassava is grown as a sole crop. Apart from these intrinsic factors influencing sprouting, establishment and the performance of the plant, some extrinsic factors such as termites, diseases and some environmental conditions (temperature, soil pH, solar radiation, relative humidity and rainfall) also influence sprouting and establishment (Ekanayake, 1993b).

Sprouting and establishment abilities are not direct components of yield but do contribute to yields. In Nigeria, the local farmers cultivate many different genotypes of cassava with distinct morphological characters. Cassava cultivation is also expanding to the semiarid zones where sprouting and establishment are major problems. Most cassava breeding programmes have been primarily based on selections for yield without consciously taking into account the physiological, morphological and quantitative characters which influence sprouting and establishment. It is a fact that the design of effective selection programs is usually dependent on the relative importance of genetic and non-genetic components of variance for characters of interest to breeders.

The present study was therefore designed to:

(1) Estimate the amount of genetic and non-genetic components of variance in Nigerian cassava land races for sprouting and establishment ability.

(2) Investigate relationships between cutting characteristics, growth parameters, cassava mosaic disease (CMD), cassava bacterial blight (CBB), sprouting and establishment ability of cassava cuttings.

(3) Study the effect of environments on sprouting and subsequent establishment ability of cassava cutting.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. Sprouting, Emergence and Establishment of Cassava

Bose *et al.* (1986) defined germination as resumption of growth of the seed embryo. In case of cassava cuttings, germination is referred to as sprouting which is defined as the emergence of the sprout. Sprouting is measured by counting the number of sprouted stakes per day per plot and expressed in percentages (Ekanayake, 1993). Ekanayake (1993) recommended that sprouting percentage could be counted as from 1 week after planting up to 7 weeks after planting.

Establishment is viewed as the successful sprouting and subsequent growth of the cassava plant. It is also the time when the plant had achieved a self subsisting status dependent on the use of the environmental resources after a period, of depending on its internal resources (Medard, 1973). This initial phase of the growth depends on the reserves in the stem cutting (Hunt *et al.*, 1977 and Ghosh *et al.*, 1988). Many workers have measured Establishment. It is expressed as the survival rate, which is the number of plants harvested over the number of plants planted and expressed as percentages (Ekanayake, 1993)

2.2. Factors Affecting Sprouting and Establishment

The factors affecting sprouting and establishment can be divided into two main groups: internal and external factors.

2.2.1. The Internal factors or Cutting Characteristics

The internal factors are the cutting characteristics. These characteristics includes, number of the nodes, fresh weight of stakes, thickness of stakes, stake pith diameter, bulk density of stakes, length of stakes, storage of stakes, nutrient content of the stakes

incidences of diseases and pests and age of mother stakes which affect sprouting and establishment.

2.2.1.1. Number of Nodes per Cutting

A cassava plant may be obtained from a very small cutting with only one bud (CIAT, 1984 and IITA, 1990). However, under field conditions where soil moisture is limited, such cuttings have low possibilities of sprouting and surviving.

Ramanujam and Nair (1987) observed that number of sprouts per stake varied from 3 to 5 per plant and sprout per stake is controlled by node number and quality of the stake in the two clones they studied. The use of five to seven nodes per cutting are considered the best for cassava production (IITA, 1990).

2.2.1.2 Fresh Weight of Stakes.

Cassava is generally established using hardwood from fresh mature stem cuttings (IITA, 1990) and plants established in this way, may differ from those which develop from seeds (Doku, 1969). The use of hard-wood stem cuttings for vegetative propagation allows for considerable variation in the type of cuttings used, methods of planting and the subsequent sprouting and establishment of the plants. According to Toro Atlee (1985) the size, fresh weight and quality of stakes are of importance in cassava production systems. The initial growth phase depends on the fresh weight of stakes which accounts for the subsequent food reserve in the cutting (Hunt *et al.* 1977 and CIAT, 1984). Differences have been found in the speed of sprouting of stakes of different sections of the stem. Heavier stakes from hardwood sprouted faster than those from young upper sections (Leihner 1983; Oka *et al.* 1987; Okeke, 1994). The fresh weight of stakes of cassava stakes used in propagation affects the rate and percentage of sprouting, establishment and final root yield (Toro and Atlee, 1985). Oka *et al.* (1987) stated that fresh weight of stakes positively influenced sprouting.

2.2.1.3 Thickness of Stakes and Pith Diameter

Shoot size is markedly influenced by the size and moisture content of the original cutting. One-bud cuttings produce smaller shoot as diameter and length decrease, (Wholey, 1974). Similarly the production of shoot is decreased by desiccation of the cuttings (CIAT 1978) and this is faster and in thinner and shorter stakes.

Thin cuttings have smaller nutrient reserves and their developed shoots tend to be weak (IITA, 1990). Cuttings selected should have at least half their total diameter occupied by pith. Keating *et al.* (1988) studied effects of stem cutting thickness on subsequent growth and development of cassava. Their results showed that percentage emergence was greater for thicker cuttings than for very thin ones. Ghosh *et al.*, (1988), IITA, (1990) recommended the use of cuttings of 2 to 3 cm diameter for planting.

2.2.1.4 Bulk Density of the Stake

Oka *et al.*, (1987) dealing with *Rayon* 1 and *Rayon* 2, suggested the use of stem bulk density as major character for cutting establishment and survival. In their study with *Rayon* 1 and *Rayon* 2, they reported that stem bulk density was the major determinant for cutting establishment and survival in both dry and rainy seasons in India.

2.2.1.5 Length of Cuttings

Longer cuttings have been associated with improved sprouting percentages and more vigorous shoot growth (Keating *et al*, 1988). Cutting length between 20 and 30 cm is considered optimum (Ghosh *et al.*, 1988). The rapid multiplication technique of cassava gives ways of using shorter cuttings based on the fact that each node is capable of producing a new plant (IITA, 1990). However, special care must be given to such short

cuttings for their successful establishment. Most often they are required to be presprouted before they are transplanted to the field.

2.3.1.6. Nutrient Content of Stakes

The amount of food reserve in the cassava stakes used for planting affects the sprouting and subsequent establishment of the new shoot (Hahn *et al* 1977; CIAT 1978; Keating *et al* 1979). It has been established that the previous year's growth conditions of the cassava cuttings play a major role in the establishment of the cassava cuttings. Keating *et al.* (1979) in their review of work related to sprouting ability of cassava reported that stem cuttings taken from plants grown under high fertilizer regimes sprouted and emerged faster than cuttings taken from plants grown under lower nutrient levels. Keating *et al.* (1979) studied the effect of the pre-harvest fertilization of cassava prior to cutting for planting material on subsequent establishment and root yield. Their study revealed that pre fertilization of the plants six weeks prior to taking cuttings had no effect on emergence from horizontal planting, but significantly reduced time to reach 90% of final emergence from 28 to 18 days. Under adverse conditions, improved emergence rates of cuttings are likely to have beneficial effect on crop establishment. Nutrient status of cassava planting material is likely to affect the succeeding establishment even in situations where post planting nutrition is unfavourable (Keating *et al.,* 1979).

2.2.1.7. Storage of Stakes

Most ofen cassava plants are harvested piece meal and off season. This often results to storage of cuttings before planting. The period during which the plant materials can preserve their viability is related to storage conditions and varietal tolerance to storage (CIAT, 1984 and IITA, 1990).

2.2.1.8. Incidence of Diseases and Pests

Diseases severely affect establishment of cassava cuttings. Cassava Mosaic Disease (CMD), Cassava Bacterial Blight (CBB) and Cassava Anthracnose Disease (CAD) are the most important diseases of cassava in Africa. (IITA, 1990). Cassava anthracnose caused by *Glomerella cingulata* also affect the cassava plant through destruction of the young shoots. It is the most damaging disease of the nodes.

Among the pests, those with serious effects on establishment are termites. Termites attack cassava cuttings, by feeding on propagation materials, roots, swollen roots or growing plants. The most common damage is the loss of the planted cutting. Plant establishment is affected severely especially during prolonged dry periods. Losses in germination as well as death of young plants due to termite feeding has been estimated to be between 15-30 percent (Belloti and Schoonhoven, 1978).

2.2.1.9. Age of Mother Stem

The age of the planting material influences emergence and establishment of cassava. (CIAT, 1984 and IITA, 1990). Emergence was found to be late and the vegetative period much longer in physiologically young material than old ones. However, when cuttings were taken from more than 18 month-old plants, the sprouting buds had reduced viability. This was explained by the fact that the stems were highly lignified, and contained only small amount of food reserves for the sprouting shoots (CIAT, 1984, IITA, 1990). The older plants also harbour more diseases and pests. This adversely affects root and shoot development. Okeke (1994) found that sprouting and establishment were greater when using cuttings taken from the lower and middle portion as compared to when they were taken from upper portions of primary stems. Cuttings taken from 8 to 18 months old plants are considered ideal for planting.(CIAT, 1984 and IITA, 1990).

2.2.2 External Factors or Enviromental Conditions.

External factors are those enviromental conditions such as temperature, water and soil moisture, light and time which affect sprouting and establishment.

2.2.2.1. Temperature

The effects of temperature on sprouting and establishment (early growth) have been studied by several authors (Irikura *et al.*, 1979; Keating and Evenson, 1979; Akparobi, 1992). It has been shown that high temperature favours establishment through its effect on rooting of some crop species. In case of hardwood cuttings, soil temperature has been found beneficial in the induction of roots and causes root development on cuttings before sprouting of buds (Hartmann and Kester, 1983). Akparobi, (1992), in his studies of effects of different temperature regimes on the early growth of four IITA improved cassava varieties, discovered that sprouting of cassava cuttings were significantly affected by air temperature. Early sprouting and growth of cassava was favoured at temperature regimes of between 25 to 35°C. These results confirmed observations made before by Keating and Evenson (1979). However, high temperatures may not be desirable in many other species because they stimulate bud development before root formation and cause increase in water loss from the leaves (Hartmann and Kester, 1983).

2.2.2.2. Water and Soil Moisture

Water stress is one of the most important environmental variables affecting plant growth and development of cassava. Onwueme (1978) reported that soil moisture was the most important factor for rooting of cuttings especially within the first few days after planting, when the roots were first differentiating from the mass of callus. Onwueme, (1978), Ghosh *et al.*, (1988), observed that cassava cuttings require moist soil for bud

sprouting and establishment and that the most critical period of water requirements for cassava, is the cropsæ establishment period covering about one month from planting.

Daraja (1992) noted that although cassava is relatively drought tolerant, it requires adequate soil moisture for the first 2-3 months after planting. The emphasis on this specific period simply indicates that during the first few weeks after planting, the plant does not always possess that ability to withstand drought (Cock, 1983, Ghosh *et al.*, 1988). According to Bose *et al*. (1986), the drying out of the cutting as a result of excessive water loss before rooting is the main reason for failure of cuttings of some species to root and establish under ordinary propagation facilities. Sprouting rate and survival percentage of sprouts at 2 or 3 months after planting is lower in the dry season than raining season in the major cassava producing areas of Nigeria (IITA, 1993b). IITA (1993b) reported that water deficit stress, higher evaporation demand from the soil and dehydration of plant material, are causes of poor sprouting and establishment of cassava clones in the dry savannah. Effect of water stress on the growth and yield of cassava have been extensively reviewed (Leihner, 1984; Nwosu and Onofeghara, 1992; Daraja, 1992). However, they did not mention any early stress specifically at the planting time.

2.2.2.3. Light

Light as a source of energy in all functions of plant life plays a vital role in establishment of cuttings. According to Bose *et al*, (1986), the number of roots per cutting had been found to be proportional to the amount of daily illumination. This was however estimated to be due to the increase in the amount of carbohydrate reserves

2.2.2.4 Time

Hahn and Keyser (1985) reported that maximum sprouting percentages are achieved between 26 and 28 days after planting. They also reported that plant establishment and canopy development are very slow in cassava plants.

2.3. Genetic Variability for Sprouting Ability and Establishment.

The amount of variability for important economic characters, in the germplasm collection of any crop, sets the limit to progress that can be achieved through selection (Sharma and Sharma, 1989). An assessment of the variability in the germplasm, is therefore required to judge its potential as a base material for genetic improvement (Rao, 1972; Chheda and Fatokun, 1982; Sharma and Sharma, 1989)

Large clonal differences in the rate of sprouting, establishment and a wide range morphological traits, including initial plant vigour, plant height, reactions to pests and diseases and general performance have been widely reported in cassava (CIAT, 1984; Ghosh *et al.*, 1988; IITA, 1990). Woamane (1992) from his work on cassava selection for adaptation to inland valleys, found that the mean percentage of sprouted cutting varied significantly among the 60 genotypes used. Comparing the results he noted no significant differences between sprouting in the inland valleys and the upland. He concluded that the genotypes had high sprouting and establishment percentage in the two environments. Oka *et al.*, (1987) working with Raygong 1 and 3 observed that there was a large difference in the sprouting ability among varieties. He stated that Raygon 1 has relatively higher sprouting ability than Raygon 3 under moisture stress, and that the former produced progenies with high percentage germination rate when used as a parent in a cross. Enyi (1972) noted a great variability among cassava genotypes for the sprouting trait and assumed this was correlated with rooting efficiency.

Great differences have been observed between cassava varieties in their rooting and bud sprouting capacities, the number of nodes per meter of stem and the vigour of the plant produced (CIAT, 1984 and IITA 1990). These varietal dissimilarities are accentuated by storage of cuttings (CIAT, 1984 and IITA 1990). However, despite this existing variability among cassava varieties, Lozano and Booth (1976), noted that the quality of planting

ABUBAKAR IBRAHIM LIBRARY

material, the growth conditions and environmental factors are known to have great influence on the sprouting, establishment ability and the general performance of cassava genotypes. Okeke (1994) showed evidence of varietal differences in the food reserves of cassava stakes and at the various sections of the stem, (the stump, the hardwood, the semi hardwood and the tip shoot). He observed variations in the performance of the sections in terms of their ability to sprout and support early shoot growth. He observed a decrease in food reserve from the hardwood to the semi hardwood and to the tip shoot. He also reported a decreasing gradient of dry matter and potassium in a similar trend in the materials. Cassava genotypes exhibit great variability for carbohydrates, moisture and different hormone concentrations, which are known to affect sprouting of cuttings (Bose *et al.*, 1986).

Hunt et al., (1977) observed that the amount of carbohydrates and moisture status of the stake at the time of planting differed among genotypes and largely influenced the establishment and subsequent growth of the plants. The decrease in the total carbohydrate content of the stakes during the early phase of regeneration of cassava plants indicated that the mother stakes serve as source of energy for the establishing new plant. In a study conducted to assess the relationship between stake characteristics, sprouting ability and establishment, (Ebiyau, 1992) reported significant variability among the genotypes for stake characteristics, sprouting and establishment abilities. Stake characteristics, such as stake fresh weight, volume and bulk densities were implicated as important indicators for sprouting and establishment.

2.4 Correlations

Correlation is a measure of the degree of relationship between variables (Falconer 1960; Steel and Torrie 1984). Progress in breeding for these traits is primarily conditioned by the magnitude, nature, and inter-relations of genotypic and phenotypic correlations in the various plant characters. Estimates of genotypic and phenotypic correlations among

characters are therefore useful in planning and evaluating breeding programmes. A knowledge of the correlations that exist betweem important characters may facilitate the interpretation of results already obtained and can provide the basis for planning of more efficient breeding programmes. Correlations between important and non-important characters may reveal that some of the latter are useful as indicators of one or more of the former. It is important for a plant breeder to know whether the improvement of one character will result in simultaneous changes in other characters. If genotypic correlation between two characters is high, it is advisable to increase the intensity of one by selecting for the character of the other with high heritability

Oka *et al* (1987) in an experiment to investigate the relationship between cutting characteristics and sprouting ability of cassava cuttings in Thailand, reported that establishment expressed as the survival rate of the cuttings was positively correlated with bulk density, volume and fresh weight of the initial cuttings.

Ebiyau, in 1992 studied the relationship between growth, sprouting and establishment characters under field, nursery and glasshouse conditions. Ebiyau, (1992) reported that in all the growing conditions, shoot fresh weight, shoot dry weight, number of roots arising from nodes of the stake and from the based end, correlated positively and significantly with sprouting percent in all the growth conditions. He also noted that stakes qualities such as stake fresh weight, stake volume and density are important indicators of sprouting. Woumane (1994), reported a significant positive correlation ($r = 0.44$) of sprouting ability of cassava cuttings between cassava cuttings grown in the Inland valley systems (I.V.S.) and upland. The number of stands at harvest in the I.V.S had a low but significant correlation with that in the upland ($r = 0.27$). Manga (1994) reported a significant negative correlation ($r = -0.45$) between node number and sprouting suggesting that cuttings with many nodes had low sprouting potential. However, positive correlation was reported between shoot and root parameters. Although a negative association between sprouting and root weight was observed, positive correlation was also observed between

KASIM IBRAHIM LIBRARY

sprouting and establishment. Enyi (1972) observed significant variability among cassava genotypes for the sprouting trait and assumed this was correlated with root efficiency.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Genetic materials

The genetic materials used for the study were obtained from the Cassava Breeding Unit of the International Institute of Tropical Agriculture (IITA) Ibadan. These cassava clones include: 33 Nigerian local land races of cassava representing the most popularly grown clones in Nigeria and 7 improved IITA clones that have been released or recommended for release and are grown extensively in Nigeria. The 40 cassava clones and the States from were they were collected are listed in Table 1.

3.2 Field Experimentation

The experiments were conducted in the field at four locations in Nigeria during the 1994 wet season. These locations were (Mokwa, guinea savanna) (Samaru, northern guinea savanna) (Minjibir, sudan savanna) and (Kuru, mid-altitude woodland savanna).

A randomized complete block design (RCBD) with three replications was used at each location. The plots were single-row ridges spaced 1m x 0.5m apart. Ten uniform sized stakes per clone measuring 25 cm long were planted on each plot 3 days after they were cut from the field. The stakes were planted in a slanting position (45^{-}), burying the two thirds of the stakes in the ground and leaving one-third sticking out. Healthy stems from the selected 40 clones were obtained from 12 months old cassava plants growing in the field for the experiment. A total of 30 cuttings for each cassava clone was planted per location.

The stakes were not treated with any fungicides or insecticides before planting. Fertilizers were not applied and the fields were not irrigated. The plants were also not treated with any chemical in the field. Weeds were controlled through manual hoeing at monthly intervals after planting until harvesting time.

Table 1. Cassava clones used in the study and their States of origin.

S/N	Clones	State of Origin	S/No	Clones	State of Origin
1	Abachaji	Anambra	21	Isunikankiyan	Ogun
2	Adabo Ozi	Kogi	22	Lapai I	Niger
3	Amala	Edo	23	Mokwa 2	Niger
4	Anedo	Ondo	24	Odungbo	Lagos
5	Antiota	Ogun	25	Ojigono	Benue
6	Atu Iwo	Kwara	26	Oko Iyawo	Kwara
7	Bagi wawa	Niger	27	Okonkwo	Jigawa
8	Bakin iri	Yobe	27	Olekanga	Oyo
9	Bakin rogo	Katsina	29	Oyarugba	Oshun
10	Chi ka mutu	Adamawa	30	Panya Akpu	Rivers
11	Dakata uwariya	Kano	31	Rogo Gidan Dawa	Kaduna
12	Dan aziki	Taraba	32	Suleja 4	Nger
13	Dan duala	Plateau	33	2nd Agric	Ondo
14	Dan kporo	Benue	34	TMS 4(2)1425	Oyo
15	Dan waru 1	Kebbi	35	TMS 81/00110	Oyo
16	Darazo rogo	Bauchi	36	TMS 82/00058	Oyo
17	Doya	Borno	37	TMS 82/00661	Oyo
18	Okura	Enugu	38	TMS 30572	Oyo
19	Ewete ihe	Akwa Ibom	39	TMS 50395	Oyo
20	Ilorin rogo	Sokoto	40	TMS 91934	Oyo

3.3. Data collection

Before planting, the following cutting characteristics were assessed and determined:

Number of nodes: The numbers of nodes per 25cm stakes were counted. The total number of stakes was divided by the number of nodes per stake to obtain the number of nodes per stake.

Stem girth: The diameters of all the stakes were measured with a vernier calliper at both ends of each stem cuttings and the mean determined.

Stake pith diameter: This is the total diameters of all the stakes measured with a vernier calliper at both ends of each stem cuttings and the mean determined by dividing by the total number of stakes.

Fresh stake weight: This is the average weight of the total weight of cuttings measured in grams using electronic mettler weighing balance (Model 710).

Stake volume (cm^3): This was determined by water displacement of weight of the cutting in water with a measuring cylinder.

Stakes bulk densities: The were derived by dividing the stakes fresh weight in grammes by the stake volume in cm^3 as:

$$\text{Bulk density } gcm^{-3} = \frac{\text{Stake weight (g)}}{\text{Stake volume } (cm^3)}$$

Pith/wood ratio: This was obtained using the mean pith diameter and stem girth as:

$$PWR = \frac{\text{Pith diameter}}{\text{Stem girth}}$$

The experiment was terminated at 90 DAP. Data from each plot were taken from the ten plants where possible on the following variables.

Sprouting ability of stakes (%): Stands of sprouted stakes were taken from each plot at 7, 14, 21 and 28 days after planting to obtain the number of sprouted stakes in a plot for the calculation of sprouting percentages per plot for the four periods as:

$$\frac{\text{Number of stakes sprouted in a day}}{\text{Number of stakes planted}} \times \frac{100}{1}$$

The values obtained were cumulatively averaged at 7, 14, 21 and 28 days after planting.

Establishment (%): This was done by counting the number of plants that survived 90 DAP and by expressing as a percentage of the total number of stakes planted as follows: The plants were harvested on plot basis by digging the plants up with hoe.

$$\frac{\text{Number of stakes survived}}{\text{Number of stakes planted}} \times \frac{100}{1}$$

Number of shoots per plot: This is the total number of shoots developed on each plant per plot.

Number of Roots per plot: This is the total number of fibrous roots formed at the nodes and the basal portion of the stakes on each plant per plot.

Fresh weight of shoot per plot: This is the fresh weight of shoot per plot measured in grams using a mettler balance model 710.

Fresh weight of root: This is the fresh weight of root per plot was measured with a mettler balance model 710.

Dry weight of shoot: The fresh weight of shoot was measured and oven dried at 65°C for 48 hours for dry weight determination- as:

$$\text{Dry weight of Shoot} = \frac{\text{Oven dry weight of shoot}}{\text{Fresh weight of shoot}} \times \frac{100}{1}$$

Dry weight of root: The fresh weight of root was measured and oven dried at 80 for 48 hours for dry weight determination as:

$$\text{Dry weight of Root} = \frac{\text{Ovendry weight of root}}{\text{Fresh weight of Root}} \times \frac{100}{1}$$

Shoot height: The height of each plant was measured in centimetres with a ruler from the base of the plant to its shoot apex on the tallest branch. This measurement was recorded to the nearest centimetres.

Cassava Mosaic Diseases (CMD) Severity at 1 and 3 months after planting (MAP): These were scored on a scale of 1-5 using IITA, (1990) standard, where 1 = resistant, 2 = moderately resistant, 3 = tolerant, 4 = susceptible and 5 = highly susceptible.

Cassava Bacterial Blight (CBB) Severity at (3MAP): This was scored on a scale of 1-5 using IITA (1990) standard, where 1 = resistant, 2 = moderately resistant, 3 = tolerance, 4 = susceptible and 5 = highly susceptible.

3.4. Statistical Analysis

All data generated for the parameters studied were subjected to statistical analysis using statistical analysis systems (SAS), Version 6.12 1995, computer programmes for linear additive model for randomized complete block design RCBD according to Steele and Torrie, (1984) Singh and Chaudhary, (1985). The data on sprouting and establishment were transformed using acrsine or angular transformation before subjecting them to statistical analysis (Steel and Torrie, 1984). The analysis for each trait was computed on plot means. The cassava clones were treated as fixed effects while the location were treated as random effects.

The form of variance and covariance with the expected mean squares which were used for the estimation of genetic parameters is shown in Table 2. The form of combined analysis of variance and covariance for the four locations usd to estimate the genetic parameters and their interactions with locations for each trait is presented in Table 3 as outlined by Steel and Torrie (1984).

Comparison of the mean performance for sprouting and establishment abilities of the different genotypes were done using the Duncans new multiple range test (DNMRT). The forms of the analysis of variance with expectations of mean squares for the individual and combined analyses are shown in Tables (2 and 3) respectively.

The statistical model for RCBD for each location is given as:

$$X_{ij} = \mu + G_i + B_j + E_{ij}$$

where

X_{ij} = observation of any variable made in the i^{th} genotypes in the j^{th} block.

m = Overall mean.

G_i = Effect of the i^{th} genotype (fixed), in the j^{th} block

i = 1, 2, 3...40

B_j = effect of the i^{th} block (random) j = 1, 2, 3

E_{ij} = random plot error

The statistical linear model for the combined ANOVA was:

$$Y_{ijk} = m + G_i + Ej + B_k(E_j) + (GE)ij + e_{ijk}$$

where

Y_{ijk} = observation of any variable made in the i^{th} genotypes in the k^{th} block for k^{th} environment.

μ = The overall mean.

G_i = The effect of the i^{th} genotype (fixed)i = 1, 2, ... 40

E_j = The effect of the j^{th} environment; (random) J = 1, 2, 3, 4.

$(GE)_{ik}$ = The interaction effect between i^{th} genotype in the j^{th} environment,

$B_k(Ej)$ = The effect of b^{th} block in j^{th} environment (location); K = 1, 2, 3. and

E_{ijk} = The random error effect.

Table 2. Form of Analysis of variance and covariance with the expected mean squares in one location for each trait.

Sources of Variation	d.f	M.S	EMS	EMCP
Rep	(r-1)			
Genotype	(g-1)	M_g	$\sigma_e^2 + r\sigma_g^2$	$\sigma_{e_1 e_2}^2 + r\sigma_{g_1 g_2}^2$
Error	(r-1)(g-1)	M_e	σ_e^2	$\sigma_{e_1 e_2}^2$
Total	(rg-1)			

M_g and M_e = Observed mean squares for genotypes and error respectively.

r = Number of replications

g = Number of genotypes

σ_g^2 = Total genetic variance among genotypes

σ_e^2 = Error variance

$\sigma_{g_1 g_2}^2$ = Genetic covariance for characters 1 and 2

$\sigma_{e_1 e_2}^2$ = Environmental covariance between two traits

Table 3. Form of combined analysis of variance and covariance with the expected mean squares in four locations for each trait

Sources of Variance	Df	MS	EMS	EMCP
Environments (l)	(l-1)			
Reps/Environments	l(r-1)			
Genotype	(g-1)	M_g	$\sigma_e^2 + r\sigma_{gl}^2 + rl\sigma_g^2$	$\sigma_{xy}^2 + r\sigma_{glxgly}^2 + rl\sigma_{gxgy}^2$
Genotype x Environments	(l-1)(g-1)	M_{gl}	$\sigma_e^2 + r\sigma_{gl}^2$	$\sigma_{xy}^2 + r\sigma_{glxgly}^2$
Pooled error	l(r-1)(g-1)	M_e	σ_e^2	σ_{xy}^2

M_g, M_{gl} and M_e = Observed mean squares for genotypes, Genotype x Location interaction and error respectively.

l = Number of locations

r = Number of replications.

g = Number of genotypes

σ_g^2 = Total genetic variance among genotypes

σ_{gl}^2 = Genotype by environmental interaction variance.

σ_{xy}^2 = Error covariance for characters x and y.

σ_{glxgly}^2 = Covariance of genotype by environment for characters x and y

σ_{gxgy}^2 = Genetic covariance for characters x and y

σ_e^2 = Error variance

3.4.1 Estimation of variance components

The components of variance and their standard errors were estimated from the expected mean squares by equating the observed mean squares values of each character, to their expectations as follows:

$$\sigma^2 = M_e \text{ with se } = \frac{\sqrt{2(M_e)^2}}{df + 2}$$

$$\sigma^2_{gl} = \frac{M_{gl} - M_e}{r = 3} \text{ with se } = \sqrt{(\frac{1}{3})^2 [\frac{2(M_{gl})^2}{df + 2} + \frac{2(M_e)^2}{df + 2}]}$$

$$\sigma^2_g = \frac{M_g - M_{gl}}{rl = 12} \text{ with se } = \sqrt{(\frac{1}{12})^2 [\frac{2(M_g)^2}{df + 2} + \frac{2(M_{gl})^2}{df + 2}]}$$

The phenotypic variation among the cassava clones and their standard errors were estimated as:

$$\sigma^2_{ph} = \sigma^2_g + \frac{\sigma^2_e}{r} \text{ with se } = \sqrt{(\frac{1}{3})^2 [\frac{2(M_g)^2}{df + 2}]} \text{ for one location}$$

$$\sigma^2_{ph} = \sigma^2_g + \frac{\sigma^2_{gl}}{l} + \frac{\sigma^2_e}{rl} \text{ with se } = \sqrt{(\frac{1}{12})^2 [\frac{2(M_g)^2}{df + 2}]} \text{ for four locations}$$

3.4.2 Estimation of phenotypic and genotypic coefficents of variation

Phenotypic and genotypic coefficents of variation were computed using the formulae outlined by Singh and Chaudhary (1985) as:

(a) Phenotypic coefficient of variation (P.C.V.)= $\frac{\sqrt{\sigma^2_{ph}}}{\bar{x}} \times 100$

(b) Genotypic coefficient of variation (G.C.V.)= $\frac{\sqrt{\sigma^2_g}}{\bar{x}} \times 100$

Where :

σ^2_{ph} = Phenotypic variance.

σ_g^2 = Genotypic variance.

$\bar{x}$ = Mean of the population.

3.4.3. Correlations

The estimates of genotypic and phenotypic correlation coefficients were estimated for pair of traits measured. The genotypic and phenotypic correlation coefficients were calculated from components of variance and covariance according to (Steel and Torrie 1984; Obi, 1991)

$$r_{gxy} = \frac{\sigma^2_{gxgy}}{\sqrt{\sigma^2_{gx} \times \sigma^2_{gy}}}$$

Where:

σ^2_{gxgy} = Genotypic covariance of characters x and y.

σ^2_{gx} = Genotypic variance of character x.

σ^2_{gy} =Genotypic variace of character y.

r_{gxy} = Correlation coefficient of characters x and y.

The phenotypic correlations were computed using mean squares and mean cross products in the formula:

$$r_{ph} = \frac{\sigma^2_{gxgy}}{\sqrt{\sigma^2_{gx} \times \sigma^2_{gy}}}$$

Where:

r_{ph} = Phenotypic correlation coefficient for characters x and y.

σ^2_{gx} = Phenotypic variance of character x.

σ^2_{gy} = Phenotypic variance of character y.

σ^2_{gxgy} = Phenotypic covariance of characters x and y.

CHAPTER FOUR

4.0 RESULTS

4.1 Mean Performance

For ease of making comparisons, the mean performance information with respect to sprouting percentages of the 40 cassava clones evaluated at the four locations will be presented separately and for the four periods. For each presentation the comparative performance of the clones across the locations is also given.

The results for sprouting percentages are given in Tables 4-8. Clonal differences were observed for these traits at the different locations for the periods and across the four locations. The general mean performance for sprouting percentages ranged from 10.0-100%.

4.1.1 Clonal differences for sprouting ability at 7 Days after planting (7DAP)

Percentage sprouting at Mokwa 7 DAP ranged from 30.0% - 56.7% with the highest percentage sprouting recorded on Antiota (56.7%) and TMS 91934 (53.3%), while the lowest sprouting percentages (30.0%) were recorded on Anedo, Bakin rogo, Chika Mutu, Dakata Uwariya, Dan Dualla, Darazo Rogo, Doya Nganta, Enugu Okura, Ewete Ihe, TMS 82/00058 and Isunikankiyan. At Samaru, sprouting percentage at 7 DAP ranged from 16.7% to 46.7%. Dan Aziki had the highest mean sprouting percentage of 46.7% while Chi ka Mutu and Ojigono (16.7%) each had the lowest mean performance for sprouting.

Antiota also recorded the highest sprouting percentage of 50.0% followed by Odungbo (43.3%) at Minjibir, while Dakata Uwariya and Dan Dualla recorded the lowest value of 13.33%. The range varied from 13.3% to 50.0%. The lowest sprouting percentage ranging from 10.4% to 33.3% was obtained at Kuru location. Odungbo showed high superiority over the other clones with the highest sprouting percentage of 43.3% followed by TMS 91934 (36.7%),while Adabo Ozi and Anedo had the lowest mean performance of 10.0%.

Across the four locations, percentage sprouting varied from 16.7% to 42.5%. The highest percentage sprouting was recorded by Antiota and Odungbo with 42.5% each followed by Dan Aziki (37.5%), while Adabo Ozi, Anedo and Dakata Uwariya had the lowest mean percentage of 16.7% across the four locations.

4.1.2 Clonal differences for sprouting ability at 14 Days after planting (14DAP)

The percentage sprouting for all the clones increased at 14 DAP for all the locations. In most instances the values were more than doubled. At Mokwa sprouting percentage increased to between 43.3% to 90.0%. The highest percentage was recorded on Adabo Ozi (90.0%), while the lowest was recorded on Dakata Uwariya and Darazo rogo (43.3%).

The mean values at Samaru, ranged from 43.3% to 90.0% with Antiota having the highest mean performance of 90.0%. The Ewete Ihe had the lowest mean performance of 43.3%. At Minjibir the results showed similar trend with sprouting percentage ranging from 33.3% to 83.3%. Again Antiota had the highest mean performance of 83.3%, while Dan Dualla had the lowest mean performance of 33.3%.

At Kuru, the trend was a little different. The percentage sprouting at 14 DAP ranged from 33.3% to 70.0% slightly lower than the other locations. The TMS 50395,

KASHIM IBRAHIM LIBRARY

TMS 91934 and Odungbo had the highest mean performance of 70.0%, while Bakin rogo and Dakata Uwariya had the lower mean value of 33.3%.

In the combined data across the locations, the mean percentage for sprouting at 14 DAP, ranged from 44.2 to 78.3%. Antiota had the highest mean value 78.3% followed by TMS 91934 (76.7%) while Bakin rogo and Darazo rogo had the lowest mean performance of 44.2%.

4.1.3 Clonal differences for sprouting ability at 21 Days after planting (21DAP)

At 21 DAP most clones had reached their maximum sprouting potential. At mokwa, the mean values for sprouting ability varied from 43.3% to 100%. Clones such as Abachaji, Adabo Ozi, Antiota, Ilorin rogo, Mokwa-2, Odungbo, Okonkwo local, Oyarugba, Rogo Gidan Dawa, Suleja-4, 2nd Agric, TMS 30572 and TMS 91934 had reached their maximum sprouting percentage of 100.0%, while Dakata Uwariya recorded the lowest sprouting percent of 43.3%.

At Samaru location, Antiota, Mokwa-2, Odungbo, Oyarugba, TMS 82/00661, TMS 30572 and 91934 had also reached their maximum sprouting percent of 100.0%. The lowest mean performance of 63.3% was recorded on Barkin Rogo, Darazo rogo, Doya Nganta, Enugu Okura and Ewete Ihe. Minjibir location showed a similar trend, the average mean performance of the genotypes at 21 DAP varied from 60% to 100.0% with Antiota and TMS 30572 reaching their maximum sprouting of 100.0%. Anedo, Barkin rogo, Doya Nganta, Enugu Okura, Ewete Ihe and Isunikankiyan recorded the lowest mean performance of 60.0% each.

At Kuru location, none of the genotypes recorded 100.0% sprouting. The average mean performance ranged from 50.0 to 93.3% with TMS 91934 having the highest mean performance of 93.3% followed by TMS 30572 with 90.0% sprouting. The lowest mean performance was recorded on Dakata Uwariya with 50.0%.

When all the data across locations were combined, TMS 30572 and TMS 91934 had the highest mean performance of 97.5% each, followed by Antiota and Odungbo with 95.8% each. The lowest mean performance was recorded by Dakata Uwariya that had 57.5% sprouting.

4.1. 4 Clonal differences for sprouting ability at 28 Days after planting (28DAP)

The 28 DAP counts were taken as the final percentage for sprouting ability. At Mokwa, the mean performance of the clones ranged from 50.0 to100.0%. Fifteen clones recorded a maximum sprouting of 100 percent. These clones include. Abachaji, Adabo Ozi, Antiota, Barkin Iri, Ilorin rogo, Mokwa-2, Odungbo, Okonkwo local, Oyarugba, Rogo Gidandawa, Suleja-4, 2nd Agric, TMS 30572, TMS 50395 and TMS 91934. Three clones Bakin Rogo, Dakata Uwariya and Ewete Ihe still had less than 60.0% sprouting at this location 28 DAP.

At Samaru location, the percent sprouting of the clones increased to between 63.3 and 100 percent. Abachaji, Antiota, Dan Waru-1, Mokwa-2, Odungbo, Oyarugba, and TMS 82/00661 had reached 100% sprouting at 28 DAP. The lowest mean performance of 63.3% sprouting was recorded on Enugu Okura. At Minjibir location, the average sprouting percent ranged from 60.0 -100% and Anedo, Barkin Rogo, Dan Duala, Darazo rogo, Enugu Okura, Ewete Ihe, Ojigono and Isunikankiyan had the lowest mean performances of 60.0% each.

The Antiota and TMS 30572. had the maximum sprouting of 100.0% at Kuru location. The average values of sprouting percent ranged from 60.0 to 100.0%. Three clones, Bakin rogo, Dakata Uwariya and Enugu Okura. had the lowest mean performance of 60.0% each When the results were combined across the four locations only two clones TMS 30572 and Antiota recorded a mean sprouting percentage of 100%, while Bakin rogo had the lowest sprouting percent of 60.8%.

4.1.5. Establishment

There were significant differences between all the clones for establishment percentage, which showed similar trends with sprouting percentages. At mokwa, the establishment percentages ranged from 50.0 to 100.0%. with Adabo Ozi, Antiota Odungbo, Rogo Gidan Dawa, TMS 30572 and TMS 50395 having the maximum mean performance of 100.0%. The lowest establishment percentage of 50.0% was recorded on Ewete Ihe.

Two clones TMS 30572 and TMS 50395 had the maximum establishment of 100.0% at Samaru location. The lowest value for establishment (60.0%) was observed on Isunikankiyan, Darazo rogo and Ewete Ihe. Two clones, Ilorin rogo and TMS 30572 also recorded maximum establishment of 100.0% at Minjibir location. Anedo and Isunikankiyan both had a very low establishment of 46.7% at this location.

At Kuru location, Antiota and TMS 91934 had the maximum establishment of 96.7% and Darazo rogo had the lowest mean establishment of 53.3%. Across the four locations, the TMS 30572 and Antiota had the highest mean establishment of 99.2% and 97.5% respectively, followed by Odungbo, which recorded 95.8%. Ewete Ihe had the lowest establishment of 50.0%. Averaged over the four locations, the TMS 30572 had the best overall mean performance of 99.2% for establishment, followed by Antiota with a mean performance of 97.5%. Darazo rogo recorded the lowest mean establishment of 55.0%.

The cassava clones were ranked (Tables 4 to 8) in each location for sprouting and establishment percentage for the four periods they were evaluated. An examination of mean values for sprouting and establishment showed that the genotypes performed differently at the different locations. The genotypes changed position in their ranking in the different locations.

Ranking the genotypes to determine changes in ranking among genotypes 7DAP, indicates that Antiota occupied position one at Mokwa, Minjibir and the data combined across the four locations. It maintained position 2 at Samaru and Kuru locations respectively. Dan Aziki occupied position one at Samaru, and maintained position 3 at the rest of the locations. The ranking for other clones changed from location to location.

For sprouting at 14DAP, only Antiota maintained position 1 in 2 locations (Samaru and Minjibir) and the data combined across the four locations and position 5 at Mokwa. The rest of the genotypes changed positions. Evaluation for sprouting ability at 21DAP showed that three clones the TMS 30572, Antiota and TMS 9193 clones occupied the number position in 3 locations and the data combined across the four locations, while the other clones varied in their positions.

The Antiota and TMS 30572 exhibited their superiority over the other clones by maintained position one in all the fours location and the four locations combined at 28DAP (Table 7). The other clones rankings changed. For establishment ability taken at (90DAP). The TMS 30572 occupied position one in all the locations, while the Antiota maintained positives 2. The rest of the clones changed positions in every other location.

Table 4. Sprouting percentage and ranking of 40 cassava clones evaluated in four locations, 7 days after planting (7DAP) in 1994

	Percentage sprouting at 7 DAP														
	Mokwa			Samaru			Minjibir			Kuru			Across locations		
Clones	mean		rank	mean		rank	mean		rank	mean		rank	mean		rank
Abachaji	43.3	bcde	14	30.0	abcd	14	30.0	cde	7	20.0	cdef	22	30.8	defghij	19
Adabo ozi	50.0	abc	3	43.3	ab	2	23.3	defg	22	10.0	f	39	31.7	cdefghi	16
Amala	40.0	cdef	18	30.0	abcd	14	23.3	defg	22	13.3	ef	34	26.7	ghijklm	26
Anedo	30.0	f	29	16.7	d	37	20.0	efg	28	10.0	f	39	19.7	n	39
Antiota	57.7	a	1	40.0	ab	2	50.0	a	1	33.3	bc	3	44.0	a	1
Atu Iwo	40.0	cdef	18	30.0	abcd	14	20.0	efg	28	20.0	cdef	22	27.5	fghijkl	24
Bagi Wawa	40.0	cdef	18	33.3	abcd	14	23.3	defg	22	26.7	bcde	9	30.8	defghij	19
Bakin Iri	33.3	ef	28	23.3	bcd	26	23.3	defg	22	13.3	ef	34	23.3	klmn	34
Bakin Rogo	30.0	f	29	20.0	cd	33	20.0	efg	28	13.3	ef	34	20.8	lmn	37
Chi ka muta	30.0	f	29	16.7	d	37	20.0	efg	28	13.3	ef	34	20.0	mn	38
Dakata uwariya	30.0	f	29	20.0	cd	33	13.3	g	39	13.3	ef	34	19.2	n	39
Dan Aziki	50.0	abc	3	46.7	a	1	36.7	bc	3	26.7	bcde	9	40.0	ab	3
Dan Duala	30.0	f	29	30.0	abcd	14	13.3	g	39	23.3	bcdef	17	24.2	jklmn	32
Dan Kporo	46.7	abcd	6	43.3	ab	2	30.0	cde	7	26.7	bcde	9	36.7	bcd	5
Dan Waru-1	40.0	cdef	18	30.0	abcd	14	26.7	cdef	18	26.7	bcde	9	30.8	defghij	19
Darazo Rogo	30.0	f	29	20.0	cd	33	20.0	efg	28	23.3	bcdef	17	23.3	klmn	34
Doya Nganta	30.0	f	29	30.0	abcd	14	23.3	defg	22	16.7	def	31	25.0	ijklmn	30
Emugu Okura	30.0	f	29	33.3	abcd	14	20.0	efg	28	20.0	cdef	22	25.8	hijklmn	28
Ewete Ihe	30.0	f	29	23.3	bcd	26	20.0	efg	28	20.0	cdef	22	23.3	klmn	34
Ilorin Rogo	46.7	abcd	6	40.0	ab	2	20.0	efg	28	30.0	bcd	7	34.2	bcdef	8
Isunikankiyan	30.0	f	29	26.7	bcd	26	16.7	fg	38	23.3	bcdef	17	24.2	jklmn	32
Lapai-1	36.7	def	24	36.7	abc	12	26.7	cdef	18	16.7	def	31	29.2	efghij	22
Mokwa-2	46.7	abcd	6	23.3	bcd	26	30.0	cde	7	26.7	bcde	9	31.7	cdefghi	16
Odungbo	46.7	abcd	6	43.3	ab	2	43.3	ab	2	46.7	a	1	45.0	a	1
Ojigono	43.3	bcde	14	16.7	d	37	20.0	efg	28	20.0	cdef	22	25.0	ijklmn	30
Oko Iyawo	43.3	bcde	14	20.0	cd	33	33.3	defg	22	23.3	bcdef	17	27.5	fghijkl	24
Okonkwo Local	36.7	def	24	16.7	d	37	30.0	cde	7	20.0	cdef	22	25.8	hijklmn	28
Olekanga	40.0	cdef	18	40.0	ab	2	30.0	cde	7	20.0	cdef	22	32.5	cdefgh	13
Oyarugba	46.7	abcd	6	30.0	abcd	14	36.7	bc	3	33.3	bc	3	36.7	bcd	5
Panya Akpu	36.7	def	24	36.7	abc	12	30.0	cde	7	33.3	bc	3	34.2	bcdef	8
Rogo Gidan Dawa	40.0	cdef	18	43.3	ab	2	20.0	efg	28	26.7	bcde	9	32.5	cdefgh	13
Suleja-4	46.7	abcd	6	40.0	ab	2	33.3	bcd	5	33.3	bc	3	38.3	bc	4
2ND Agric	43.3	bcde	14	33.3	abcd	14	26.7	cdef	18	23.3	bcdef	17	31.7	cdefghi	16
TMS 4(2)1425	30.0	f	29	33.3	abcd	14	26.7	cdef	18	16.7	def	31	26.7	ghijklm	26
TMS 81/00110	36.7	def	24	43.3	ab	2	30.0	cde	7	20.0	cdef	22	32.5	cdefgh	13
TMS 82/00058	30.0	f	29	23.3	bcd	26	30.0	cde	7	30.0	bcd	7	28.3	efghijk	23
TMS 82/00661	46.7	abcd	6	43.3	ab	2	30.0	cde	7	20.0	cdef	22	35.0	cbde	12
TMS 30572	50.0	abc	3	30.0	abcd	14	30.0	cde	7	26.7	bcde	9	34.2	bcdef	8
TMS 50395	46.7	abcd	6	26.7	bcd	26	33.3	bcd	5	26.7	bcde	9	33.3	bcdefg	11
TMS 91934	53.3	ab	2	26.7	bcd	26	30.0	cde	7	36.7	ab	2	36.7	bcd	5

Means in the same column with the same letter(s) are not statistical different from each other using DNMRT (P=0.05)

Table 5. Sprouting percentage and ranking of 40 cassava clones evaluated in four locations 14 days after planting (14DAP) in 1994

	Percentage sprouting at 14 DAP											
	Mokwa		Samaru		Minjibir		Kuru		Across locations	
Clones	mean	rank	mean	rank	mean	rank	mean	rank	mean	rank
Abachaji	70.0	cdefg 18	63.3	defghi 23	66.7	abcd 9	43.3	defg 27	60.8	fghijk 22
Adabo ozi	90.0	a 1	73.3	abcdef 13	60.0	bcdef 21	33.3	g 38	64.2	defghi 20
Amala	66.7	defg 23	50.0	hji 37	60.0	bcdef 21	46.7	cdefg 18	56.7	ijklmn 26
Anedo	73.3	bcdef 12	56.7	fghij 29	36.7	gh 37	43.3	defg 27	52.5	klmno 30
Antiota	80.0	abcd 5	90.0	a 1	83.3	a 1	60.0	abcd 8	78.3	a 1
Atu Iwo	66.7	defg 23	63.3	defghi 23	46.7	efgh 31	40.0	efg 34	54.2	jklmn 29
Bagi Wawa	73.3	bcdef 12	80.0	abcd 4	60.0	bcdef 21	46.7	cdefg 18	65.0	defgh 17
Bakin Iri	73.3	bcdef 12	66.7	cdefgh 20	60.0	bcdef 21	43.3	defg 27	60.8	fghijk 22
Bakin Rogo	46.7	ij 37	56.7	fghij 29	40.0	gh 37	33.3	g 38	44.2	o 35
Chi ka muta	60.0	fghi 30	60.0	efghij 26	46.7	efgh 31	43.3	defg 27	52.5	klmno 30
Dakata uwariya	43.3	j 38	53.3	ghij 32	50.0	defgh 29	33.3	g 38	45.0	o 35
Dan Aziki	76.7	abcde 10	80.0	abcd 4	70.0	abc 6	46.7	cdefg 18	68.3	bcdef 6
Dan Duala	50.0	hij 36	60.0	efghij 26	33.3	h 40	46.7	cdefg 18	47.5	on 39
Dan Kporo	70.0	cdefg 18	76.7	abcde 10	66.7	abcd 9	63.3	abc 5	69.2	bcdef 6
Dan Waru-1	83.3	abc 4	80.0	abcd 4	63.3	bcde 17	46.7	cdefg 18	68.3	bcdef 6
Darazo Rogo	43.3	j 38	50.0	hij 37	43.3	fgh 34	40.0	efg 34	44.2	o 35
Doya Nganta	70.0	cdefg 18	73.3	abcdef 13	50.0	defgh 29	43.3	defg 27	59.2	ghijkl 24
Enugu Okura	60.0	fghi 30	53.3	ghij 32	40.0	gh 37	36.7	fg 36	47.5	on 39
Ewete Ibe	43.3	j 38	43.3	j 40	46.7	efgh 31	46.7	cdefg 18	45.0	o 35
Ilorin Rogo	80.0	abcd 5	73.3	abcdef 13	60.0	bcdef 21	56.7	abcde 11	67.5	cdefg 12
Isunkankiyan	56.7	ghij 33	53.3	ghij 32	43.3	fgh 34	46.7	cdefg 18	50.0	mno 34
Lapai-1	80.0	abcd 5	70.0	bcdefg 17	63.3	bcde 17	46.7	cdefg 18	65.0	defgh 17
Mokwa-2	80.0	abcd 5	66.7	cdefgh 20	73.3	ab 2	50.0	bcdefg 15	67.5	cdefg 12
Odungbo	70.0	cdefg 18	80.0	abcd 4	76.7	ab 2	70.0	a 1	74.2	abc 3
Ojigono	66.7	defg 23	53.3	ghij 32	43.3	fgh 34	43.3	defg 27	51.7	lmno 32
Oko Iyawo	66.7	defg 23	56.7	fghij 29	53.3	cdefg 27	50.0	bcdefg 15	56.7	hijklm 26
Okonkwo Local	70.0	cdefg 18	53.3	ghij 32	66.7	abcd 9	46.7	cdefg 18	59.2	ghijkl 24
Olekanga	73.3	bcdef 12	73.3	abcdef 13	70.0	abc 6	43.3	defg 27	65.0	defgh 17
Oyarugba	63.3	efgh 28	80.0	abcd 4	73.3	ab 2	66.7	ab 4	70.8	abcde 5
Panya Akpu	66.7	defg 23	76.7	abcde 10	66.7	abcd 9	63.3	abc 5	68.8	bcdef 6
Rogo Gidan Dawa	86.7	ab 2	66.7	cdefgh 20	60.0	bcdef 21	56.7	abcde 11	67.5	cdefg 12
Suleja-4	76.7	abcde 10	80.0	abcd 4	63.3	bcde 17	50.0	bcdefg 15	67.5	cdefg 12
2ND Agric	80.0	abcd 5	70.0	bcdefg 17	66.7	abcd 9	60.0	abcd 8	69.2	bcdef 6
TMS 4(2)1425	56.7	ghij 33	60.0	efghij 26	53.3	cdefg 27	36.7	fg 36	51.7	lmno 32
TMS 81/00110	60.0	fghi 30	70.0	bcdefg 17	66.7	abcd 9	53.3	abcdef 14	62.5	fghi 21
TMS 82/00058	56.0	ghij 33	46.7	ij 39	66.7	abcd 9	56.7	abcde 11	56.7	hijklm 26
TMS 82/00661	63.3	efgh 28	86.7	ab 2	66.7	abcd 9	60.0	abcd 8	69.2	bcdef 6
TMS 30572	73.3	bcdef 12	83.3	abc 3	70.0	abc 6	63.3	abc 5	72.5	abcd 4
TMS 50395	73.3	bcdef 12	63.3	defghi 23	63.3	bcde 17	70.0	a 1	67.5	cdefg 12
TMS 91934	86.7	ab 2	76.7	abcde 10	73.3	ab 2	70.0	a 1	76.7	ab 2

Means in the same column with the same letter(s) are not statistical different from each other using DNMRT (P=0.05)

Table 6. Sprouting percentage and ranking of 40 cassava clones evaluated in four locations 21 days after planting (21DAP) in 1994

	Percentage sprouting at 21 DAP																	
	Mokwa			Samaru			Minjibir			Kuru			Across locations		
Clones	mean		rank	mean		rank	mean		rank	mean		rank	mean		rank
Abachaji	93.3	abc	16	93.3	abc	12	86.7	cde	12	83.3	abc	5	89.2	bcdef	10
Adabo ozi	100.0	a	1	93.3	abc	12	86.7	cde	12	70.0	cdefg	18	87.5	cdef	13
Amala	86.7	cde	23	66.7	ef	32	76.7	fgh	25	70.0	cdefg	18	75.0	jkl	28
Anedo	80.0	efg	27	70.0	def	30	60.0	jk	32	63.3	efgh	33	68.3	lm	32
Antiota	100.0	a	1	100.0	a	1	100.0	a	1	83.3	abc	5	95.8	ab	3
Atu Iwo	83.3	def	26	80.0	bcdef	25	66.7	jk	32	60.0	efgh	33	72.5	jkl	28
Bagi Wawa	93.3	abc	16	96.7	ab	8	80.0	efg	22	63.3	defgh	28	83.3	efghi	19
Bakin Iri	96.7	ab	13	86.7	abcd	19	70.0	hi	28	56.7	fgh	37	77.5	ijk	26
Bakin Rogo	56.7	ijk	35	63.3	f	37	60.0	jk	32	53.3	gh	39	58.3	n	36
Chi ka muta	73.3	gh	31	80.0	bcdef	25	66.7	ij	31	66.7	cdefgh	26	71.7	kl	30
Dakata uwariya	43.3	l	40	66.7	ef	32	70.0	hi	28	50.0	h	40	57.5	n	36
Dan Aziki	96.7	ab	13	66.7	abc	12	86.7	cde	12	83.3	abc	5	90.0	cde	11
Dan Duala	60.0	j	36	93.3	ef	32	56.7	k	40	70.0	cdefg	18	63.3	mn	34
Dan Kporo	96.7	ab	13	96.7	abc	12	93.3	abc	4	90.0	ab	2	93.3	abc	5
Dan Waru-1	93.3	abc	16	63.3	ab	8	80.0	efg	22	70.0	cdefg	18	85.0	defgh	18
Darazo Rogo	60.0	j	36	66.7	ef	32	60.0	jk	32	60.0	efgh	33	60.8	n	36
Doya Nganta	76.7	fgh	29	63.3	f	37	73.3	ghi	27	63.3	defgh	28	77.5	ijk	26
Enugu Okura	63.3	ij	34	96.7	f	37	60.0	jk	32	60.0	efgh	33	61.7	n	36
Ewete Ihe	50.0	kl	39	63.7	f	37	60.0	jk	32	70.0	cdefg	18	60.8	n	36
Ilorin Rogo	100.0	a	1	93.3	abc	12	93.3	abc	4	76.7	abcde	12	90.8	abcd	7
Isunikankiyan	60.0	j	36	66.7	ef	32	60.0	jk	32	63.3	defgh	28	62.5	mn	34
Lapai-1	93.3	abc	16	83.3	abcde	24	83.3	def	17	70.0	cdefg	18	82.5	fghi	22
Mokwa-2	100.0	a	1	100.0	a	1	93.3	abc	4	70.0	cdefg	18	90.8	abcd	7
Odungbo	100.0	a	1	100.0	a	1	93.3	abc	4	90.0	ab	2	95.8	ab	3
Ojigono	86.7	cde	23	70.0	def	30	60.0	jk	32	63.3	defgh	28	70.0	l	31
Oko Iyawo	90.0	bcd	20	86.7	abcd	19	76.7	fgh	25	63.3	defgh	28	79.2	ghij	23
Okonkwo Local	100.0	a	1	86.7	abcd	19	93.3	abc	4	73.3	bcdef	17	88.3	cdef	13
Olekanga	90.0	bcd	20	90.0	abc	12	86.7	cde	12	66.7	cdefgh	27	83.3	efghi	19
Oyarugba	100.0	a	1	100.0	a	1	93.3	abc	4	80.0	abcd	10	93.3	abc	5
Panya Akpu	80.0	efg	27	86.7	abcd	19	83.3	def	17	83.3	abc	5	83.3	efghi	19
Rogo Gidan Dawa	100.0	a	1	93.3	abc	12	90.0	bcd	10	76.7	abcde	12	90.0	cde	11
Suleja-4	100.0	a	1	96.7	ab	8	90.0	bcd	10	76.7	abcde	12	90.8	abcd	7
2ND Agric	100.0	a	1	80.0	bcdef	25	86.7	cde	12	76.7	abcde	12	85.8	defg	17
TMS 4(2)1425	70.0	hi	33	76.7	cdef	29	70.0	hi	28	56.7	fgh	37	68.3	lm	32
TMS 81/00110	73.3	gh	31	86.7	abcd	19	83.3	def	17	70.0	cdefg	18	78.3	hijk	24
TMS 82/00058	76.7	fgh	29	80.0	bcdef	25	80.0	efg	22	76.0	abcde	12	78.3	hijk	24
TMS 82/00661	86.7	cde	23	100.0	a	1	83.3	def	17	80.0	abcd	10	87.5	cdef	13
TMS 30572	100.0	a	1	100.0	a	1	100.0	a	1	90.0	ab	2	97.5	a	1
TMS 50395	90.0	bcd	20	96.7	ab	8	83.3	def	17	83.3	abc	5	88.3	cdef	13
TMS 91934	100.0	a	1	100.0	a	1	96.7	ab	3	93.3	a	1	97.5	a	1

Means in the same column with the same letter(s) are not statistical different from each other using DNMRT (P=0.05)

Table 7. Sprouting percentage and ranking of 40 cassava clones evaluated in four locations 28 days after planting (28DAP) in 1994

	Percentage sprouting at 28 DAP																	
	Mokwa			Samaru			Minjibir			Kuru			Across locations					
Clones	mean		rank	mean		rank	mean		rank	mean		rank	mean		rank			
Abachaji	100.0	a	1	100.0	a	1	90.0	bcd	11	90.0	abcd	5	95.0	abcd	7			
Adabo ozi	100.0	a	1	96.7	ab	11	90.0	bcd	11	83.3	bcdef	15	92.5	bcdef	12			
Amala	90.0	bcd	21	70.0	ef	33	80.0	efg	22	80.0	cdefg	18	80.0	kl	24			
Anedo	80.0	efg	27	70.0	ef	33	60.0	i	33	70.0	fghi	32	70.0	nop	33			
Antiota	100.0	a	1	100.0	a	1	100.0	a	1	100.0	a	1	100.0	a	1			
Atu Iwo	83.3	def	26	83.0	bcde	27	70.0	h	28	70.0	fghi	32	76.7	lm	29			
Bagi Wawa	93.3	abc	19	100.0	a	1	80.0	efg	22	76.7	defgh	23	87.5	fghi	18			
Bakin Iri	100.0	a	1	86.7	abcd	23	70.0	h	28	63.3	hi	36	80.0	lk	24			
Bakin Rogo	56.7	jkl	38	66.7	f	38	60.0	i	33	60.0	i	38	60.8	r	40			
Chi ka muta	73.3	gh	32	83.3	bcde	27	70.0	h	28	80.0	cdefg	18	76.7	lm	29			
Dakata uwariya	53.3	kl	39	70.0	ef	33	70.0	h	28	60.0	i	38	63.3	qr	36			
Dan Aziki	96.7	ab	16	93.3	ab	11	90.0	bcd	11	86.7	abcde	10	91.7	cdefg	14			
Dan Duala	60.0	jk	35	70.0	ef	33	60.0	i	33	73.3	efghi	26	65.0	pqr	35			
Dan Kporo	96.7	ab	16	93.3	ab	11	93.3	abc	8	93.3	abc	4	94.2	abcde	10			
Dan Waru-1	93.3	abc	19	100.0	a	1	80.0	efg	22	80.0	cdefg	18	88.3	efgh	17			
Darazo Rogo	60.0	jk	35	70.0	ef	33	60.0	i	33	63.3	hi	36	63.3	qr	36			
Doya Nganta	80.0	efg	27	96.7	ab	11	73.3	gh	27	73.3	efghi	26	80.8	lkj	28			
Enugu Okura	63.3	ij	34	63.3	f	38	60.0	i	33	60.0	i	38	61.7	qr	36			
Ewete Ihe	50.0	l	40	66.7	f	38	60.0	i	33	70.0	fghi	32	61.7	qr	36			
Ilorin Rogo	100.0	a	1	96.7	ab	11	100.0	a	1	76.7	defgh	23	93.3	bcde	11			
Isunikankiyan	60.0	jk	35	73.3	def	31	60.0	i	33	73.3	efghi	26	66.7	opq	34			
Lapai-1	96.7	ab	16	83.3	bcde	27	83.3	def	17	80.0	cdefg	18	85.8	hij	20			
Mokwa-2	100.0	a	1	100.0	a	1	100.0	a	1	83.3	bcdef	15	95.8	abc	4			
Odungbo	100.0	a	1	100.0	a	1	93.3	abc	8	90.0	abcd	5	95.8	abc	4			
Ojigono	86.7	cde	24	73.3	def	31	60.0	i	33	73.3	efghi	26	73.3	mn	31			
Oko Iyawo	90.0	bcd	21	90.0	abc	20	76.7	fgh	26	73.3	efghi	26	82.5	ijk	22			
Okonkwo Local	100.0	a	1	93.3	ab	11	96.7	ab	5	90.0	abcd	5	95.0	abcd	7			
Olekanga	90.0	bcd	21	90.0	abc	20	86.7	cde	15	80.0	cdefg	18	86.7	ghi	19			
Oyarugba	100.0	a	1	100.0	a	1	96.7	ab	5	86.7	abcde	10	95.8	abc	4			
Panya Akpu	80.0	efg	27	90.0	abc	20	83.3	def	17	86.7	abcde	10	85.0	hijk	21			
Rogo Gidan Dawa	100.0	a	1	96.7	ab	11	90.0	bcd	11	86.7	abcde	10	93.3	bcdef	12			
Suleja-4	100.0	a	1	96.7	ab	11	93.3	abc	8	90.0	abcd	5	95.0	abcd	7			
2ND Agric	100.0	a	1	86.7	abcd	23	86.7	cde	15	83.3	bcdef	15	89.2	defgh	16			
TMS 4(2)1425	70.0	hi	33	76.7	cdef	30	70.0	h	28	66.7	ghi	35	70.8	no	32			
TMS 81/00110	76.7	fgh	31	86.7	abcd	23	83.3	def	17	73.3	efghi	26	80.0	kl	24			
TMS 82/00058	80.0	efg	27	86.7	abcd	23	80.0	efg	22	76.7	defgh	23	80.8	jkl	23			
TMS 82/00661	86.7	cde	24	100.0	a	1	83.3	def	17	90.0	abcd	5	90.0	cdefgh	15			
TMS 30572	100.0	a	1	100.0	a	1	100.0	a	1	100.0	a	1	100.0	a	1			
TMS 50395	100.0	a	1	96.7	ab	11	83.3	def	17	86.7	abcde	10	91.7	cdefg	14			
TMS 91934	100.0	a	1	100.0	a	1	96.7	ab	5	96.7	ab	3	98.3	ab	3			

Means in the same column with the same letter(s) are not statistical different from each other using DNMRT (P=0.05)

Table 8. Percentage establishment and ranking of 40 cassava clones evaluated in four locations 90 days after planting (90DAP) in 1994

	Establishment																	
	Mokwa			Samaru			Minjibir			Kuru			Across locations					
Clones	mean		rank	mean		rank	mean		rank	mean		rank	mean		rank			
Abachaji	96.7	ab	8	96.7	ab	5	80.0	defg	13	76.7	cdef	20	87.5	defgh	9			
Adabo ozi	100.0	a	1	90.0	abc	8	80.0	defg	13	73.3	defg	23	85.8	efghi	13			
Amala	86.7	bcd	19	70.0	def	30	80.0	defg	13	80.0	bcde	15	79.2	jkl	24			
Anedo	73.3	e	30	70.0	def	30	46.7	l	39	66.7	fgh	33	64.2	op	33			
Antiota	100.0	a	1	96.7	ab	5	96.7	ab	3	96.7	a	1	97.5	ab	2			
Atu Iwo	80.0	cde	22	83.3	bcd	24	70.0	ghi	27	70.0	efgh	27	75.8	lm	27			
Bagi Wawa	86.7	bcd	19	93.3	abc	8	76.7	efgh	18	76.7	cdef	20	83.3	ghij	19			
Bakin Iri	80.0	cde	22	80.0	cde	28	66.7	hji	29	63.3	ghi	35	72.5	mn	28			
Bakin Rogo	56.7	fg	35	66.7	ef	33	53.3	kl	35	60.0	hi	36	59.2	pq	34			
Chi ka Muta	73.3	e	30	70.0	def	30	60.0	ijk	30	73.3	defg	23	69.2	no	31			
Dakata uwariya	53.3	fg	35	66.7	ef	33	56.7	jkl	32	60.0	hi	36	59.2	pq	34			
Dan Aziki	80.0	cde	22	93.3	abc	8	83.3	cdef	10	86.7	abc	7	85.8	efghi	13			
Dan Duala	53.3	fg	35	63.3	f	36	50.0	kl	35	63.3	ghi	35	57.5	q	37			
Dan Kporo	96.7	ab	8	93.3	abc	8	90.0	abcd	5	86.7	abc	7	91.7	cde	5			
Dan Waru-1	86.7	bcd	19	90.0	abc	8	73.3	fgh	22	80.0	bcde	15	82.5	hijk	21			
Darazo Rogo	53.3	fg	35	60.0	f	36	53.3	kl	35	53.3	i	40	55.0	q	37			
Doya Nganta	76.7	de	28	88.3	bcd	24	60.0	ijk	30	70.0	efgh	27	72.5	mn	28			
Enugu Okura	53.3	fg	35	63.3	f	36	53.3	kl	35	60.0	hi	36	57.5	q	37			
Ewete Ihe	50.0	g	40	60.0	f	36	56.7	jkl	32	66.7	fgh	33	58.3	q	37			
Ilorin Rogo	96.7	ab	8	86.7	abc	8	100.0	a	1	70.0	efgh	27	88.3	defgh	9			
Isunikankiyan	60.0	f	34	60.0	f	36	46.7	l	39	70.0	efgh	27	59.2	pq	34			
Lapai-1	96.7	ab	8	83.3	bcd	24	73.3	fgh	22	80.0	bcde	15	83.3	ghij	19			
Mokwa-2	90.0	abc	14	86.7	abc	8	80.0	defg	13	83.3	bcd	10	85.0	fghij	16			
Odungbo	100.0	a	1	100.0	a	1	93.3	abc	4	90.0	ab	2	95.8	abc	3			
Ojigono	73.3	e	30	66.7	ef	33	56.7	jkl	32	70.0	efgh	27	66.7	o	32			
Oko Iyawo	90.0	abc	14	90.0	abc	8	76.7	efgh	18	73.3	defg	23	82.5	hijk	21			
Okonkwo Local	90.0	abc	14	90.0	abc	8	86.7	bcde	7	90.0	ab	2	89.2	defgh	9			
Olekanga	90.0	abc	14	90.0	abc	8	80.0	defg	13	80.0	bcde	15	85.0	fghij	16			
Oyarugba	96.7	ab	8	100.0	abc	8	83.3	cdef	10	83.3	bcd	10	90.8	cdef	7			
Panya Akpu	80.0	cde	22	90.0	a	1	73.3	fgh	22	80.0	bcde	15	80.8	ijkl	23			
Rogo Gidan Dawa	100.0	a	1	86.7	abc	8	90.0	abcd	5	83.3	bcd	10	90.0	def	8			
Suleja-4	90.0	abc	14	90.0	abc	8	76.7	efgh	18	86.7	abc	7	85.8	efghi	13			
2ND Agric	100.0	a	1	86.7	abc	8	83.3	cdef	10	83.3	bcd	10	88.3	defgh	9			
TMS 4(2)1425	70.0	e	30	80.0	cde	28	70.0	ghi	27	70.0	efgh	27	72.5	mn	28			
TMS 81/00110	76.7	de	28	83.3	bcd	24	76.7	efgh	18	73.3	defg	23	77.5	klm	26			
TMS 82/00058	80.0	cde	22	86.7	abc	8	73.3	fgh	22	76.7	cdef	20	79.2	jkl	24			
TMS 82/00661	80.0	cde	22	96.7	ab	5	73.3	fgh	22	90.0	ab	2	85.0	fghij	16			
TMS 30572	100.0	a	1	100.0	a	1	100.0	a	1	96.7	a	1	99.2	a	1			
TMS 50395	100.0	a	1	100.0	a	1	86.7	bcde	7	83.3	bcd	10	92.5	bcd	4			
TMS 91934	96.7	ab	8	93.3	abc	8	86.7	bcde	7	90.0	ab	2	91.7	cde	5			

Means in the same column with the same letter(s) are not statistical different from each other using DNMRT (P=0.05)

4.1.6. Cutting Characteristics.

The mean values of node number, stake girth, pith girth, stake weight, stake volume, bulk density and pith-wood ratio of the cassava genotypes are presented in appendices 1a-1e for Mokwa, Samaru, Minjibir Kuru and for the combined data across the four locations respectively. Genotypes differ significantly at ($P < 0.05$) in all the cutting characteristics of the 25cm stakes measured.

The highest number of nodes at Mokwa location was recorded on Dan Dualla (15.7) followed by Ewete Ihe (14.9) while Adabo Ozi had the lowest number of nodes of 7.5. The mean value for number of nodes ranged from 7 to 15 with a mean value of approximately 12 nodes. At Samaru location, the mean number of nodes ranged from 9 for TMS 82/00058 to approximately 15 for Bakin rogo, while the mean value of number of nodes varied from 9 to 82/00058 to 15.5 for Darazo rogo at Minjibir location. Darazo rogo (14.5) and Chika ka Mutu (14.3) had the highest number of nodes at Minjibir station, while the lowest number were observed on TMS 50395 with 10 nodes and TMS 82/00058 had approximately 9 nodes. At Kuru location, Doya Nganta and Darazo rogo recorded the highest number of nodes of approximately 15, while Rogo Gidan Dawa and TMS 91934 had the lowest number of nodes of 10 and 8.1 respectively.

At Mokwa location, Ilorin rogo had the highest stake girth of approximately 2.1cm, followed by Rogo Gidan Dawa with 2.0cm. Panya Akpu had the lowest stake girth of 1.1cm, At Samaru location, the stake girth varied from 1.0 to 2.0cm with Oyarugba and Dan waru-1, having the highest stake girth of 2.0cm. Bakin rogo and Dan Dualla had the lowest stake girth of 1.2cm each at Minjibir. It varied from 1.9 to 2.0 cm for Minjibir location. Ilorin rogo had the highest mean value of 2.0 while Enugu Okura recorded the lowest value of 1.1cm. Olekanga and Oyarugba had the

highest mean value of approximately 2.0cm for stake girth each at Kuru location. Dakata Uwariya and Darazo rogo had the lowest value of approximately 1.1cm each.

The highest pith diameter at Mokwa was recorded on Oyarugba (0.71cm) and Enugu Okura (0.97cm) while Bakin rogo and Lapai-1 recorded the lowest value of 0.42 cm each. Enugu Okura also had the highest mean value of 0.71cm at Samaru and Atu Iwo had the lowest pith diameter of 0.48cm. The Oyerugba and Okonkwo local had the highest pith diameter of 0.63cm at Minjibir station, while Atu Iwo had the lowest pith girth of 0.47cm. At Kuru, pith diameter ranged from 0.41 to 0.68cm, with a mean value of 0.5cm with Suleja-4 having the highest of 0.68cm and Bakin rogo had the lowest pith diameter of 0.41cm.

The stake fresh weight at Mokwa ranged from 55.9 to 109.7g. Rogo Gidan Dawa had the highest stake fresh weight of 109.7g followed by Odungbo with 109.3g. Isunikakiyan had the lowest weight of approximately 56 g. At Samaru, the fresh weight of stakes varied from 60.6 to 109.5g with the heaviest being Adabo Ozi (109.5g) followed Dan Kporo (107.2g). Bakin rogo recorded the lowest weight of 60.6g. Abachaji (104.8g) and Enugu Okura (56.6g) were the highest and the lowest, respectively at Minjibir location. At Kuru location Antiota had the highest stake fresh weight of 105.0g followed by Abachaji with 102.8g, while Doya Nganta had the lowest stake fresh weight of 59.7g.

At Mokwa location, Antiota had the highest stake volume of 103cm^3 followed by Dan Kporo with stake volume of 100.cm^3 while the lowest stake volume of 65.6cm^3 was recorded on TMS 4(2)1425. At Mokwa stake volume ranged from 65.6 to 103cm^3 with mean value of 84.1cm^3. The Adabo Ozi of 109.0cm^3 and TMS 4(2)1425 of 67.8cm^3

were the highest and lowest stake volumes, respectively at Samaru location, while the overall mean value was 85.8cm^3. At Minjibir, stake volume ranged from 69.0cm^3 for Ewete Ihe to 105.7cm^3 for Antiota. The highest stake volume was recorded on Oyarugba (121.3 cm^3) followed by Abachaji (03.67cm^3) and the lowest stake volume of 63.60cm^3 was observed on Oko Iyawo at Kuru location.

The bulk densities of the genotypes varied greatly among the clones. At Mokwa location, the bulk density ranged from 0.82 gcm^{-3}to 1 1gcm^{-3} with 2nd Agric having the highest value of 1.1 gcm^{-3} followed by Bakin Iri of 1.03gcm^{-3}. The Ewete Ihe and Enugu Okura had the lowest bulk density of 0.82gcm^{-3} each. The TMS 50395 had the highest mean bulk density of 1.03gcm^{-3} at Samaru location, followed by Antiota with 1.02gcm^{-3} while Ewete Ihe and Enugu Okura again had the lowest mean value of 0.82gcm^{-3} each. At Minjibir, the highest mean bulk density was recorded on Ilorin rogo (1.0gcm^{-3}) followed by Adabo Ozi (1.0gcm^{-3}). and Enugu Okura (0.74gcm^{-3}) had the lowest mean value. The Antiota (1.04gcm^{-3}) and TMS 82/00661 (1.02gcm^{-3}) had the highest bulk density while Doya Nganta had the lowest value of 0.65gcm^{-3} at Kuru.

The highest pith-wood ratio at Mokwa was obtained on Ewete Ihe (0.48cm). While the lowest pith-wood ratio was recorded on Rogo Gidan Dawa (0.27cm). The highest pith-wood ratio at Samaru was obtained on Dakata uwariya (0.47cm) while Odungbo, TMS82/00661 and TMS 91934 had the lowest value of 0.30cm each. At Minjibir the highest mean value of 0.45cm was recorded on Anedo, Bakin rogo, Darazo rogo and Isunikankiyan. The TMS 30572 had the lowest mean value of 0.31 cm. At kuru, Anedo (0.47cm) and Rogo Gidan Dawa (0.30cm) had the highest and lowest mean performance for pith-wood ration, respectively.

4. 1. 7. **Growth Parameters.**

The mean values of number of shoots per plot, number of roots, fresh weight of shoot, fresh weight of root, dry weight of shoot, dry weight of root and plant height are presented in Appendices 2a-2d for Mokwa, Samaru, Minjibir, and Kuru. The combined data across the four locations is also presented in Appendix 2e. Significant differences were observed among the cassava genotypes used in this study for the various growth parameters measured.

At Mokwa, the TMS 91934 had the highest mean number of shoots per plot of 24.7 followed by Dan Kporo (23.7) while Ewete Ihe had the lowest mean value of 11.7. The number of shoots per plot varied from 11.7 to 24.7 with a mean value of 18.8. The TMS 91934 also recorded the highest mean shoot number per plot of 19.7 at Samaru, while the lowest mean shoot number per plot was obtained on TMS 81/00110 and Bagi Wawa which had approximately 11 shoot number per plot. The overall mean value recorded was 14 with thirty genotypes having means value equal or greater than the overall mean. The mean value for number of shoots varied from 9 for Anedo to 23.7 for TMS 91934 at Mijibir station. Oyarugba had the highest mean number of shoots per plot of 22.7 followed by TMS 91934 with 20.7 at Kuru location, while Ewete Ihe had the lowest mean value of 8.7.

When the data were combined for all the locations, 91934 had the highest mean for number of shoots per plot of approximately 22 shoots/plot. Ewete Ihe had the lowest mean value of 11.The mean for the genotypes were approximately 16 per plot.

Among the growth parameters considered, the number of roots per plot varied remarkably among the genotypes. At Mokwa, it varied from 34.7 for Darazo rogo to

158.3 for TMS 30572, with a mean of 74.1. The TMS 50395 had the highest number of roots per plot of 135 at Samaru location, while Dakata Uwariya had the lowest number of roots per plot of 44. The mean root number per plot ranged from 26.3 for Bakin rogo to 136.7 for TMS 30572 at Minjibir location with a mean of 66.7. At Kuru location, Odugbo had the highest root number of 93.7 followed by Antiota and TMS 91934 with a mean of 89.3 each while Ojigono had the lowest number of roots of 40.0.

Across the four locations, the mean root number per plot ranged from 39 to 118 with TMS 30572 having the highest number of roots per plot of 118. Enugu Okura had the lowest mean value of 61.Twenty-one out of the forty cassava genotypes had mean values equal or greater than the overall mean of 71.

The mean fresh weight of shoots was highly variable among the genotypes. At Mokwa, the mean for fresh shoot weight ranged from 138g for Ewete Ihe to 1008.3g for Rogo Gidan Dawa with an overall mean of 651g. Twenty-one out of the forty genotypes had mean values higher than the overall mean. The highest mean for fresh weight was recorded on Antiota 6053g at Samaru location, while Anedo had the lowest fresh weight of shoot 144g.

At Minjibir, the mean fresh weight of shoots ranged from 1245.1g for TMS 30572 to 149 for Enugu Okura. Generally, very low mean fresh weight of shoots was obtained at Kuru location. It varied from 23.9 to 412.7g with a mean of 109.00g TMS 30572 had the highest mean value of 412.7 while Dakata Wariya had the lowest mean value of 23.9g. Combining the data across the four locations the fresh weight of shoot ranged from 138.2g for Ewete Ihe to 812g for TMS 30572, with a mean value of 430.5g and

twenty two out of the forty genotypes had the mean values equal or greater than the overall mean.

Remarkable differences were observed among the cassava genotypes for fresh root weight. At Mokwa, the fresh weight of root ranged from 3g to 18.7g with a mean of 7.8g. Adabo Ozi had the highest root fresh weight of 18.7g followed by TMS 50395 while Ojigono and Dan Dualla had the lowest root fresh weight of 3.0g and 2.3g respectively. The highest and lowest root fresh weight of 22.9g and 4.98g were recorded on Odungbo and Darazo rogo, respectively at Samaru location with a mean of 9.98g. At Minjibir location, fresh weight of roots ranged from 2.1g to 18.4g for Dan Dualla and Ilorin rogo respectively. At Kuru location, root fresh weight varied from 3.6g to 15.7g with mean value 7.9g. 2nd Agric recorded the highest mean of 15.7g followed by Dankporo with 13.7g while Isunikankiyan had the lowest root fresh weight of 3.6g. The combined data across locations, showed that Antiota had the highest root fresh weight of 14.95g followed by TMS 30572 with 14.52g and the lowest root fresh weight was obtained from Darazo Rogo (3.47g).

Generally, Mokwa location had the highest mean dry weight shoot, which ranged from 44.4g to 524.7g and with a mean of 236.9g. The highest dry shoot weight was recorded on Dan Kporo and the lowest on Ewete Ihe. At Samaru, Antiota had the highest dry shoot weight of 201.9g while Darazo rogo had the lowest mean of 26.4g. At Minjibir, the shoot dry weight ranged from 26.9g for Ewete Ihe to 411.9g for Dan Kporo, with a mean of 191g.

At Kuru location, the highest shoot dry weight of 93.4g was recorded on TMS 30572 and the lowest of 5.9g on Dakata Uwariya. Combing the data across the four locations, the shoot dry weight ranged from 53.1 to 242.3g. The TMS 30572 had the highest mean shoot dry weight of 242.3g and Ojigono had the lowest mean shoot dry weight of 53.1g.

At Mokwa, the root dry weight ranged from 0.30 to 6.3g, with a mean of 2.2g. The TMS 50372 gave the highest root dry weight, while Dan Dualla gave the lowest mean root dry weight. The highest and lowest root dry weight of 11.9g and 0.64g at Samaru location, were recorded on Antiota and Darazo rogo, respectively with a mean of 2.9g. At Minjibir location, the root dry weight varied from 0.3g for Dan Dualla to 4.3g for Okonkwo local with a mean of 5.3g. At Kuru location, Antiota gave the highest mean root dry weight of 4.1g followed by TMS 30572 (4.0g), while Darazp rogo gave the lowest rood dry weight of 0.55g. For data combined for the four locations, Odungbo gave the highest root dry weight of 5.9g followed by Abachaji while Darazo rogo had the lowest mean root dry weight of 0.56g.

The mean plant height was highly variable among the cassava genotypes with the tallest and shortest genotypes being 67.cm and 37.8 for Panya Akpu and Anedo, respectively for Mokwa location. At Samaru location, Rogo Gidan Dawa (58.5cm) was the tallest clone follwed by Suleja-4 (60.1), while Anedo (37.4cm) was the shortest clone. The tallest clone at Minjibir location was Okonkwo Local (63.3cm) followed by TMS 30572 (60.4) while Enugu Okura (34.5cm) was the shortest of all the clones. The genotypes generally were shortest at Kuru, when compared with the other locations. The tallest clone was TMS 81/00110 (40.8cm), while the shortest was Bakin Iri (22.7cm).

KASHIM IBRAHIM

Combing the data across the four locations, the mean length for the clones ranged from 34.5 cm for Anedo to 54.6cm for TMS 81/00110 with an overall mean of 46.7cm.

4 .1. 8. Disease Incidence

The results of cassava mosaic disease (Appendices 3a-3e) show the mean value of Cassava mosaic disease (CMD) and Cassava bacterial blight (CBB) scores taken at one month and three months after planting for Mokwa, Samaru, Minjibir, Kuru and across the four locations combined, respectively. The differences among the cassava clones with respect to CMD and CBB expression were significant at ($P<0.05$). CMD severity ratings one month after planting (1MAP) ranged from 1.3 to 5.0 at Mokwa location. Anedo was the most susceptible and had the highest severity score of 5.0. Six clones, Amala, Atu Iwo, Bagi Wawa, Lapai, Oko Iyawo, Olekanga and 2nd Agric were the most resistant clones with the lowest severity score of 1.3 (as shown in appendix 3a).

CMD (1MAP) varied from 1.0 to 4.0 for Samaru location. Adabo Ozi, Chi ka Mutu, Dakata Uwariya and Darazo rogo were the most susceptible clones with the highest severity score of 4.0. Amala had the lowest severity score of 1.0 although not significantly different from Atu Iwo, Bagi Wawa, Lapai, Oko Iyawo, Olekanga and 2nd Agric, which had severity score of 1.33 each. These clones were therefore the most resistant clones in the population as shown in (appendix 3b). At Minjibir, CMD 1MAP severity scores ranged from 1.3 to 4.7, with Dakata Uwariya having the highest disease score of 4.7, followed by Isunikankiyan with 4.3. The Amala, Atu Iwo, Bagi Wawa, Lapai-1, Oko Iyawo and 2nd Agric consistently recorded the lowest mean score of 1.3 as shown in (appendix 3a).

At Kuru location, Mokwa-2 had the highest of 4.7 followed by Dakata Uwariya and Isunikankiyan, which recorded high severity score of 4.3 each, while Bagi Wawa had the lowest score of 1.0. The mean severity score for CMD 1 MAP, averaged over the four locations showed that Dakata Uwariya with a score of 4.3 followed by Darazo rogo (4.2), were the most susceptible clones in the population. Lapai-1, Oko Iyawo, 2nd Agric, scored 1.33 each while Amala, Atu Iwo and Bagi Wawa scored 1.3 each consistently show resistance to CMD as shown in (appendix 3e).

The mean scores for CMD 3MAP did not vary much from the severity scores one month after planting, rather there was a progressive increase in the disease scores from one month to three month scores. At Mokwa location, CMD severity 3 month after planting ranged from 1.33 to 5.00. Anedo still was the most susceptible and had the highest severity score of 5.0, while six clones-Amala, Atu Iwo, Bagi Wawa, Lapai-1, Oko Iyawo, Olekanga and 2nd Agric were consistently the most resistant clones with the lowest severity score of 1.3.

CMD (3 MAP) varied from 1.0 to 4.3 at Samaru, with Adabo Ozi, having the highest severity score of 3.2, while Amala had the lowest severity score of 1.0. CMD 3 MAP severity score ranged from 1.3 to 4.7, with Dakata Uwariya having the highest disease score of 4.7. Amala, Atu Iwo, Bagi Wawa, Lapai-1, Oko Iyawo and 2nd Agric recorded the lowest mean score of 1.3 at Minjibir location.

At Kuru location, Mokwa-2 and Dakata Uwariya recorded the highest of 4.7, while Amala, Atu Iwo, Bagi Wawa, Lapai-1, Oko Iyawo, Olekanga and 2nd Agric were consistently the most resistant clones with the lowest severity score of 1.3. The mean

score for CMD 3MAP combined over four locations showed that Anedo and Dakata Uwariya with approximate scores of 4.7 followed by Darazo rogo (4.1), were the most susceptible clones. While Lapai-1, Oko Iyawo, 2nd Agric with scores of 1.3 each and Amala, Atu Iwo and Bagi Wawa (1.3) each showing resistance to CMD.

In terms of resistance to CBB 3MAP, most of the genotypes were comparable. The highest severity score for cassava bacterial blight was recorded on clone Anedo and Dan Dualla (4.3) while the clones TMS 81/00110, TMS 82/00058, TMS 81/00661, Atu Iwo and Dan Kporo were most resistant clones with a score of 2.0 each at Mokwa location. CBB severity score ranged from 4.0 to 1.7 with an average mean score of 2.7. CBB scores varied remarkably among the genotypes ranging from 2.3 for TMS 4(2)1425, TMS 81/00110, TMS 82/0058, TMS 82/00661 to approximately 4.7 for Darazo rogo at the Minjibir. Four clones, Dakata Uwariya, Dan Dualla, Darazo rogo, and Enugu Okura had the highest susceptibility score of 4.0 at Kuru.

Darazo rogo with approximate score of 4.2 followed by Anedo (3.9) were the most susceptible clones, while TMS 82/00110 and TMS 81/00661with scores of 2.0 each were the most resistant clone to CBB in the combined data across the four locations. Generally, all the clones showed symptoms of CBB.

Tables 9-12 show a summary of the basic statistics for the twenty-two characters measured, including the grand means, with their respective standard errors, ranges, the genotypic and phenotypic coefficients of variations for the 40 genotypes evaluated at each of the four locations (Mokwa, Samaru, Minjibir and Kuru locations). A similar

table for the combined data across the four locations is presented in table 13. Significant variations were observed among the cassava clones for all the characters measured. Wide ranges in the means were also observed for all the characters in the single locations and across the four locations combined. However, the ranges in the means observed did not differ much among the locations.

The means, ranges, the genotypic coefficients of variations (GVC) and phenotypic coefficients of variations (PVC) though varying widely in values followed the same pattern for the characters considered in the four locations. The standard errors were much lower than their respective means. PVCs were higher than their corresponding genotypic components for all the characters studied.

At Mokwa, (Table 9), wide class ranges were observed on sprouting and establishment for the four they were evaluated. Relatively high genotypic coefficients of variation were observed for root fresh weight (48.0%) shoot fresh weight (35.1%) shoot dry weight (45.1%) root dry weight (74.0%), CMD (1MAP) (35.9%), CMD 3 MAP (34.5%) and Stake girth (20.9%). At Samaru, (Table 10), higher genotypic coefficients of variation were observed for, root fresh weight (41.5%) shoot fresh weight (38.8%) shoot dry weight (44.8%) root dry weight (92.8%). CMD 3MAP (29.2%) establishment (14.2%) and stake girth (15.0%). At Minjibir, (Table 11) wide class ranges were observed on all the characters measured Relatively higher genotypic coefficients of variation were observed for Establishment (19.1%), shoot dry weight (49.3%) root dry weight (63.3%), CMD 1MAP (28.9%) and CMD 3MAP 33.4%.

At Kuru, (Table 12) high genotypic coefficients of variation were observed for root fresh weight (31.5%), shoot fresh weight (62.9%), shoot dry weight (59.8%), root dry weight (50.2%), and CMD 3 MAP (35.1%). Combined data across the locations, (Table 13) showed relatively, higher genotypic coefficients of variation for root fresh weight (36.5%), shoot fresh weight (33.7%), shoot dry weight (37.9%), CMD 1MAP (33.7%) and CMD 3 MAP (33.2%).

Table 9. Mean, standard error of mean, range, phenotypic and genotypic coefficients of variability for the 22 traits of cassava clones grown at Mokwa in 1994

Character	mean°SE	Range	GCV	PCV
Sprouting 7 DAP	39.67°0.82	20 - 50	24.55	26.66
Sprouting 14 DAP	58.167°1.31	30 - 90	19.16	20.80
Sprouting 21 DAP	85.000°1.35	40 - 100	18.82	19.09
Sprouting 28 DAP	86.167°1.25	50 - 100	18.22	18.45
Establishment	82.333°1.30	50 - 100	18.92	19.28
Number of nodes	12.080°0.15	8 - 18.2	13.97	14.42
Stake girth	1.488°0.03	1 - 2.31	21.15	21.50
Stake pith girth	0.527°0.01	0.4 - 0.82	14.70	15.49
Stake fresh weight	84.070°1.48	53.7 - 118.5	19.51	19.60
Stake volume	87.030°1.18	61.8 - 118	14.26	14.41
Bulk density	0.952°0.01	0.02 - 1.15	5.75	8.14
Pith-wood ratio	0.363°0.01	0.24 - 0.51	15.09	15.90
Number of shoots	18.783°0.24	8 - 27	17.19	17.95
number of roots	74.100°2.16	27 - 183	35.14	36.20
Fresh weight shoot	651.117°13.42	103 - 1123	37.96	39.15
Fresh weight root	7.838°0.44	2.2 - 19.9	47.97	50.09
Dry weight of shoot	236.289°4.18	13.08 - 614.9	45.09	49.31
Dry weight of root	2.293°0.25	0.3 - 7.1	73.98	74.75
Plant height	54.132°0.78	26.9 - 72	9.75	12.70
CMD 1 MAP	2.975°0.09	1 - 5	39.06	40.63
CMD 3 MAP	2.942°0.09	1 - 5	34.43	36.55
CBB 3 MAP	3.058°0.06	2 - 5	24.56	27.36

Table 10. Mean, standard error of mean, range, phenotypic and genotypic coefficients of variability for the 22 traits of cassava clones grown at Samaru in 1994.

Character	mean°SE	Range	GCV	PCV
Sprouting 7 DAP	30.83°1.13	10 - 60	22.72	29.25
Sprouting 14 DAP	46.75°1.31	40 - 100	22.70	25.76
Sprouting 21 DAP	85.17°1.35	40 - 100	13.94	15.22
Sprouting 28 DAP	87.42°1.25	50 - 100	12.86	13.88
Establishment	83.42°1.30	50 - 100	14.22	15.16
Number of nodes	11.75°0.15	9 - 16	12.94	13.31
Stake girth	1.55°0.03	1.11 - 2.48	15.65	16.43
Stake pith girth	0.57°0.01	0.42 - 0.83	5.60	7.23
Stake fresh weight	83.67°1.48	60 - 118	19.02	19.19
Stake volume	85.77°1.18	65 - 115	14.62	14.80
Bulk density	0.97°0.01	0.8 - 1.19	5.64	5.95
Pith-wood ratio	0.37°0.01	0.22 - 0.51	12.02	12.99
Number of shoots	14.11°0.24	9 - 23	12.32	14.71
number of roots	81.93°2.16	34 - 179	25.45	26.75
Fresh weight shoot	322.72°13.42	77 - 754	38.80	41.28
Fresh weight root	9.98°0.44	2.66 - 24.5	41.45	43.88
Dry weight of shoot	86.58°4.18	18.67 - 256.6	44.82	47.84
Dry weight of root	2.91°0.25	0.3 - 14.4	92.83	94.11
Plant height	51.58°0.78	30 - 71	10.46	12.81
CMD 1MAP	2.58°0.09	1 - 5	33.53	35.04
CMD 3MAP	2.60°0.09	1 - 5	31.46	33.26
CBB 3MAP	2.65°0.06	1 - 4	21.21	22.41

Table 11. Mean, standard error of mean, range, phenotypic and genotypic coefficients of variability for the 22 traits of cassava clones grown at Minjibir in 1994.

Character	mean°SE	Range	GCV	PCV
Sprouting 7 DAP	26.33°0.84	10 - 50	24.79	28.49
Sprouting 14 DAP	59.08°1.30	30 - 90	18.56	20.52
Sprouting 21 DAP	79.33°1.25	50 - 100	16.10	16.49
Sprouting 28 DAP	80.42°1.30	50 - 100	16.80	17.13
Establishment	73.83°1.40	30 - 100	19.42	19.92
Number of nodes	12.00°0.14	8.6 - 15.6	10.91	11.75
Stake girth	1.50°0.02	1.02 - 2.18	14.64	15.34
Stake pith girth	0.56°0.01	0.42 - 0.73	5.65	7.29
Stake fresh weight	78.34°1.27	50.8 - 115	17.31	17.50
Stake volume	84.02°0.91	65 - 115	11.06	11.36
Bulk density	0.93°0.01	0.72 - 1.1	7.62	7.87
Pith-wood ratio	0.38°0.00	0.27 - 0.49	8.32	9.61
Number of shoots	16.83°0.36	6 - 24	19.97	21.10
number of roots	66.71°2.35	19 - 194	33.20	35.18
Fresh weight shoot	639.18°29.64	23 - 16.85	43.88	46.30
Fresh weight root	7.14°0.35	1.2 - 18.7	51.28	52.46
Dry weight of shoot	191.11°10.70	24.3 - 531.1	49.29	53.17
Dry weight of root	5.92°3.49	0.15 - 421	63.13	76.04
Plant height	48.57°0.78	30.3 - 69.2	13.71	15.21
CMD 1MAP	2.79°0.09	1 - 5	33.81	34.79
CMD 1MAP	2.60°0.09	1 - 5	36.77	37.76
CBB 3MAP	2.85°0.07	2 - 5	22.33	23.98

Table 12. Mean, standard error of mean, range, phenotypic and genotypic coefficients of variability for the 22 traits of cassava clones grown at Kuru in 1994.

Character	mean°SE	Range	GCV	PCV
Sprouting 7 DAP	23.08°0.90	10 - 50	28.78	33.89
Sprouting 14 DAP	49.92°1.15	20 - 80	18.28	20.93
Sprouting 21 DAP	71.67°22	40 - 100	13.07	15.12
Sprouting 28 DAP	79.42°1.11	60 - 100	12.55	13.57
Establishment	76.67°1.06	50 - 100	12.97	13.75
Number of nodes	12.31°0.17	1.11 - 17.8	11.23	12.79
Stake girth	1.44°0.03	0.69 - 2.1	17.39	18.12
Stake pith girth	0.53°0.01	0.37 - 0.78	10.26	11.84
Stake fresh weight	76.91°1.39	35.5 - 115.5	19.24	19.47
Stake volume	82.67°1.10	45 - 125	13.56	13.96
Bulk density	0.93°0.01	0.48 - 1.08	9.04	9.46
Pith-wood ratio	0.38°0.01	0.26 - 0.65	8.37	10.80
Number of shoots	15.25°0.33	8 - 25	18.67	20.41
number of roots	61.56°1.75	19 - 115	24.05	26.65
Fresh weight shoot	109.016.71	14.5 - 438	62.91	64.59
Fresh weight root	7.93°0.39	1.6 - 22.2	31.58	40.33
Dry weight of shoot	27.53°1.77	4.16 - 132.73	59.77	63.65
Dry weight of root	1.60°0.10	0.22 - 6.52	50.21	55.77
Plant height	32.37°0.57	17.8 - 48	13.83	15.92
CMD 1MAP	2.88°0.10	1 - 5	34.46	35.85
CMD 1MAP	2.90°0.11	1 - 5	38.24	39.75
CBB 3MAP	2.89°0.06	2 - 4	20.11	21.74

Table 13. Mean, standard error of mean, range, phenotypic and genotypic coefficients of variability for the 22 traits of cassava clones grown across different locations in 1994.

Character	mean°SE	Range	GCV	PCV
Sprouting 7 DAP	27.48°0.48	10 - 60	21.02	23.40
Sprouting 14 DAP	58.48°0.68	20 - 100	14.99	16.39
Sprouting 21 DAP	80.290.71	40 - 100	14.33	14.96
Sprouting 28 DAP	83.35°0.66	50 - 100	14.11	14.59
Establishment	79.06°0.68	30 - 100	15.47	15.92
Number of shoots	16.24°0.18	6 - 27	15.26	16.27
number of roots	71.08°1.16	19 - 194	27.29	28.44
Fresh weight shoot	430.51°14.62	14.5 - 1685	33.71	37.99
Fresh weight root	8.22°0.20	1.2 - 24.5	36.45	39.25
Dry weight of shoot	135.38°5.66	4.16 - 641.9	37.93	43.31
Dry weight of root	3.18°0.88	0.15 - 421	5.45	117.09
Plant height	46.66°0.54	17.8 - 72	9.80	11.02
CMD 1 MAP	2.81°0.05	1 - 5	33.71	34.53
CMD MAP	2.760.05	1 - 5	33.27	34.27
CBB 3 MAP	2.86°0.04	1 - 5	19.67	20.88

4.2. Analysis of variance

The mean squares from the analysis of variance of 22 characters for Mokwa, Samaru, Minjibir and Kuru locations are presented in Appendices 4a, 4b, 4c, and 4d respectively. The combined analysis of variance of 15 characters for the four environments is also presented in appendix 4e. The cassava clones were significantly different at (P=0.01) for all the characters (Appendices 4a to 4d) measured in the individual locations and in the four locations combined. The results were generally similar and showed the same trend for the four locations. Mokwa location had the highest entry mean squares followed by Minjibir, Samaru, and Kuru location had the lowest entry mean square. The location effects were significant for all the parameters studied indicating that the locations were different. There were also significant genotype x environment observed among the genotypes for all the characters measured in the environments.

A partition of total sum of squares into various components of the sources of variations is shown in Table 14. The cassava genotypes exhibited high proportion of genetic variance for all the characters. The percentage contribution of genotypic sources of variation was generally higher than the location sources of variation except for plant height. The variations due to genotypes were higher than the variation due to genotypes x location interactions for all the traits except dry weight of shoot. The variations due to genotypes were also higher than the error sources of variation except dry weight of root. However, the error sources of variation contributed higher percentage variation more than the genotype x location interactions sources of variation except for sprouting at 21DAP, establishment, and

fresh weight of root. The replication in location had the lowest percentage contribution in all the cases.

Table 14. Percentage contribution of sources of variation to the total variations for 40 cassava clones grown in 4 locations.

	Percentage contribution due to				
	Location	Rep(loc)	Genotype	G x E	Error
			df		
Character	3	8	39	117	312
Sprouting 7 DAP	27.39	2.80	28.28	16.48	24.90
Sprouting 14 DAP	22.04	0.85	37.12	18.33	21.68
Sprouting 21 DAP	12.46	0.97	57.80	14.32	14.45
Sprouting 28 DAP	5.77	0.41	68.59	13.28	11.94
Establishment	6.91	1.35	69.43	11.32	10.98
Number of shoots	12.25	1.37	65.29	10.26	10.82
Number of roots	9.98	1.78	38.13	22.21	27.90
Fresh weight shoot	62.45	0.29	13.49	14.81	8.95
Fresh weight root	5.81	3.19	35.91	24.63	30.46
Dry weight of shoot	55.79	1.40	14.47	15.54	12.79
Dry weight of root	5.78	0.90	51.40	32.68	9.23
Plant height	51.73	1.40	18.19	1.22	16.47
CMD 1MAP	2.09	0.63	69.40	11.43	16.46
CMD 1MAP	2.04	1.21	67.55	12.80	16.40
CBB 3MAP	2.77	4.47	49.26	19.91	23.59

4.3 Estimates of variance components

Estimates of variance components were obtained from individual locations and are presented in Tables 15, 16, 17, and 18 for Mokwa, Samaru, Minjibir and Kuru respectively. Estimates of the variance components were also obtained from the combined analysis of variance for the four environments.

Table 19 shows the estimates of genetic variance (σ_g^2), phenotypic variance (σ_{ph}^2), genotype x environment interaction variance (σ_{gl}^2), and error variance (σ^2), with their standard errors for the combined analysis of variance. The combined analysis variance provided unbiased estimates of the genetic variance components. The bias due to environmental effects has been removed since the experiment was grown in four different environments. Since the estimates of variance components are linear functions of the mean squares, the variances of such estimates can be written as a function of the variance of the mean squares contributing to the estimates. Consequently, all the mean squares in the study showed signigicant differences from zero and hence gave significant estimates of genetic variance. All the estimates of variances components were positive in this study. All traits showed positive genetic estimates and were larger than their respective standard errors

KASIM IBRAHIM LIBR

Estimates of genotype x environment interaction variance (σ_{gl}^2) were relatively smaller compared to those of genetic variances. The genetic variances were however, higher than their environmental variances, with the execption of sprouting percent at 7DAP at Mokwa which had higher environmental variances than the genetic variances. The genetic variances were lower than their respective phenotypic variances. The

estimates of σ^2_{xl} were positive for all traits, and at least four times larger than their respective standard errors. Phenotypic and error variance estimates were positive for all the traits. They had relatively low standard errors when compared to genotypic variances.

4.3.1 Sprouting percentages

The individual location analysis revealed that the major component of the phenotypic variance were attributable to the genetic variances (Table 16-18), with the exception of sprouting percentage 7 days after planting at Samaru and Kuru locations which had higher environmental variances than the genetic variance. Sprouting percent at 14, 21 and 28 days after planting all have large estimates of genetic variance. The corresponding values for these characters for genotype x environmental variance and phenotypic variance were also very high.

4.3.2. Establishment

The proportion of the genetic components of the phenotypic variance was generally large in both individual locations and the combined analysis (Tables 15-19). The highest genetic estimate of 270.47 of the phenotypic variance was obtained from Mokwa location, and the lowest was about (135.76) the phenotypic variance from Kuru location. The genetic variance, vaied widely in relation to the phenotypuc variance in both individual location and combined analysis. Enviromnetal variances was very low compared to the genetic variance. Estimates obtained varied from 27.76% in Mokwa location to 57.29% in Samaru location. The GxE variances were also generally lower than the genetic and environmental variances contributing obly about 1.43% of the phenotypic variance in the combined analysis.

4.3.3 Cutting Characteristics

The estimates of variance components for cutting characteristics and their standard are also shown in (Tables 15-18). All the cutting characteristic showed positive genetic estimates. The genetic variances were larger than their respective environmental variances. The phenotypic variance were largely attributed to genetic variances. The estimates did not vary much from the individual locations. Relatively high genetic variances were obtained fro stake fresh weight, stake volume and number of nodes per stakes (Tables 15-18). However, very low variance component estimates were obtained for stake girth, pith girth, bulk density and pith-wood ratio.

4.3.4 Growth parameters

Estimates in the different location were comparable in magnitude. Corresponding mean squares of the genetic variances were significantly differences at (P=0.01) for all characters in the population and in all the locations and combined analysis. Again, all estimates were positive and greater than their standard errors. The growth parameters exhibited higher genetic variance than the cutting characteristics. High proportion of the phenotypic variances were attributable to the genetic variances. Fresh and dry weight of shoot exhibited extra ordinary large variances in all the location and combined location. (Tables 15-19). The enviromental variances were generally lower than the genetic variances and in the combined analysis, GxE interaction variances were lower than their corresponding genetic and environmental variances. Highly significant (P=0.01) genotype-environmental interactions (GxE) were also observed among the clones for the growth parameters in the population.

4.3.5 Disease resistance

Positive genetic variance estimates, were obtained for the disease ratings. In all the locations, and across the four locations combined, estimates of genotypic variances were higher than the environmental variances. Genetic variance contributed high proponderance of the phenotypic variance. GxE interaction variance was lower than the environmental and genetic variances. Generally the disease ratings had low estimates in location and across the locations combined.

Table 15. Estimates of genetic variance (σ_g^2), phenotypic variance (σ_{ph}^2) and error variance (σ_e^2) for 22 characters of 40 cassava genotypes grown at Mokwa.

Character	σ_g^2	σ_{ph}^2	σ_e^2
Sprouting 7 DAP	53.056°13.90	81.582 °13.82	28.526°4.51
Sprouting 14 DAP	124.167°32.53	190.898 ° 16.27	66.731°10.55
Sprouting 21 DAP	255.812°58.15	248.118 °58.14	22.308°3.53
Sprouting 28 DAP	246.49655.98	265.214 °55.82	18.718°12.92
Establishment	242.714°55.67	270.470 °55.65	27.756°4.39
Number of nodes	2.848°0.67	3.405 °0.67	0.557°0.09
Stake girth	0.099°0.02	0.109 °0.02	0.010°0.00
Stake pith girth	0.006°0.00	0.008 °0.00	0.002°0.00
Stake fresh weight	269.070°59.92	275.993 °59.92	6.923°1.09
Stake volume	153.943°34.76	164.27 °34.76	10.330°1.63
Bulk density	0.003°0.00	0.012 °0.00	0.009°0.00
Pith-wood ratio	0.003°0.00	0.004 °0.00	0.001°0.00
Number of shoots	10.428°2.52	13.256 °2.51	2.828°0.45
number of roots	678.019°159.03	802.36 °158.90	124.340°19.66
Fresh weight shoot	61102.33°14363.92	72733.63 °14350.8	11631.30°1839.07
Fresh weight root	14.136°3.41	17.968 °3.40	3.832°0.61
Dry weight of shoot	11350.82°3019.03	18078.56 °2998.45	6677.737°1055.84
Dry weight of root	2.878°0.65	3.058 °0.65	0.180°0.03
Plant height	27.828°10.89	86.240 °10.45	58.412°9.24
CMD 1MAP	1.350°0.32	1.684 °0.32	0.334°0.05
CMD 3MAP	1.026°0.26	1.417 °0.26	0.391°0.06
CBB 3MAP	0.564°0.16	0.972 °0.15	0.408°0.06

Table 16. Estimates of genetic variance (σ_g^2), phenotypic variance (σ_{ph}^2) and error variance (σ_e^2) for 22 characters of 40 cassava genotypes grown at Samaru.

Character	σ_g^2	σ_{ph}^2	σ_e^2
Sprouting 7 DAP	49.081°18.67	145.85 °17.96	96.773°15.30
Sprouting 14 DAP	112.585°32.43	209.85 °32.03	97.265°15.38
Sprouting 21 DAP	140.919°37.36	222.351 °37.12	81.432°12.88
Sprouting 28 DAP	126.325°32.70	189.21 °32.53	62.885°9.94
Establishment	140.726°35.43	198.012 °35.30	57.286°9.06
Number of nodes	2.309°0.54	2.716 °0.54	0.407°0.06
Stake girth	0.059°0.01	0.077 °0.01	0.018°0.00
Stake pith girth	0.001°0.00	0.003 °0.00	0.002°0.00
Stake fresh weight	253.315°56.98	267.251 °56.97	13.936°2.20
Stake volume	157.356°35.58	168.55 °35.58	11.194°1.77
Density	0.003°0.00	0.004 °0.00	0.001°0.00
Pith-wood ratio	0.002°0.00	0.003 °0.00	0.001°0.00
Number of shoots	3.020°0.97	6.889 °0.95	3.869°0.61
Number of roots	434.847°106.29	570.87 °106.05	136.027°21.51
Fresh weight shoot	15679.72°3932.81	77662.45 °3919.22	61985.729°80.08
Fresh weight root	17.117°4.25	23..313 °4.24	6.196°0.98
Dry weight of shoot	1505.771°380.26	2134.13°378.81	628.362°99.35
Dry weight of root	7.303°1.66	7.908°1.66	0.605°0.10
Plant height	29.088°9.91	72.741 °9.64	43.653°6.90
CMD 1MAP	0.750°0.18	0.958 °0.18	0.208°0.03
CMD 1 MAP	0.669°0.17	0..905°0.17	0.236°0.04
CBB 3MAP	0.316°0.08	0.426 °0.08	0.110°0.02

Table 17. Estimates of genetic variance (σ_g^2), phenotypic variance (σ_{ph}^2) and error variance (σ_e^2) for 22 characters of 40 cassava genotypes grown at Minjibir.

Character	σ_g^2	σ_{ph}^2	σ_e^2
Sprouting 7 DAP	42.628°12.62	83.632 °12.43	41.004°6.48
Sprouting 14 DAP	120.278°32.74	200.489 °32.47	80.171°12.68
Sprouting 21 DAP	163.141°37.80	186.88 °37.78	23.739°3.75
Sprouting 28 DAP	182.415°41.95	204.722 °41.93	22.308°3.53
Establishment	205.577°47.79	237.65 °47.76	32.073°5.07
Number of nodes	1.716°.42	2.533 °0.42	0.817°0.13
Stake girth	0.048°0.01	0.062 °0.01	0.014°0.00
Stake pith girth	0.001°0.00	0.003 °0.00	0.002°0.00
Stake fresh weight	183.903°41.51	195.963 °41.50	12.060°1.91
Stake volume	86.359°20.14	100.68 °20.13	14.321°2.26
Bulk density	0.005°0.00	0.006 °0.00	0.001°0.00
Pith-wood ratio	0.001°0.00	0.006 °0.00	0.001°0.00
Number of shoots	11.296°2.79	15.236 °2.78	3.940°0.62
number of roots	490.356°122.02	671.569 °121.64	181.213°28.67
Fresh weight shoot	78656.25°19392.12	105408.29 °19340.8	26752.044229.87
Fresh weight root	13.401°3.10	15.28 °3.10	1.879°0.30
Dry weight of shoot	8872.682°2291.94	13231.07 °2280.40	4358.383689.12
Dry weight of root	11.277°133.57	1464.147 °109.45	1452.870229.72
Plant height	44.343°12.16	75.023 °12.05	30.680°4.85
CMD 1 MAP	0.891°0.21	1.049 °0.21	0.158°0.02
CMD 3MAP	0.914°0.21	1.063 °0.21	0.149°0.02
CBB 3MAP	0.405°0.10	0.591 °0.10	0.186°0.03

Table 18. Estimates of genetic variance (σ_g^2), phenotypic variance (σ_{ph}^2) and error variance (σ_e^2) for 22 characters of 40 cassava genotypes grown at Kuru.

Character	σ_g^2	σ_{ph}^2	σ_e^2
Sprouting 7 DAP	44.145°13.78	95.277°13.51	51.132°8.085
Sprouting 14 DAP	83.269°24.44	160.79 °24.10	77.521°12.257
Sprouting 21 DAP	87.778°26.34	176.581 °25.92	88.803°14.041
Sprouting 28 DAP	99.316°25.80	149.89 °25.66	50.577°7.997
Establishment	98.803°24.62	135.762 °24.54	36.923°5.838
Number of nodes	1.91°0.55	3.615 °0.55	1.705°0.270
Stake girth	0.063°0.02	0.099 °0.02	0.016°0.003
Stake pith girth	0.003°0.00	0.006°0.00	0.003°0.000
Stake fresh weight	218.861°49.53	234.993 °49.52	16.134°2.551
Stake volume	125.612°29.44	148.323 °29.41	22.711°3.591
Bulk density	0.007°0.00	0.009°0.00	0.002°00
Pith-wood ratio	0.001°0.00	0.003°0.00	0.002°0.000
Number of shoots	8.103°2.15	12.849 °2.14	4.746°0.750
Number of roots	219.104°59.96	369.217 °59.44	150.113°23.735
Fresh weight shoot	4703.371°1095.63	5465.98°1094.89	762.611°120.579
Fresh weight root	6.265°2.34	18.122 °2.26	11.857°.875
Dry weight of shoot	270.85°68.07	379.703 °67.83	108.853°17.211
Dry weight of root	0.643°0.18	1.094 °0.18	0.451°0.071
Plant height	20.048°5.95	39.563 °5.86	19.515°3.086
CMD 1MAP	0.987°0.24	1.231 °0.24	0.244°0.039
CMD 1 MAP	1.23°0.29	1.758 °0.29	0.297°0.047
CBB 3MAP	0.338°0.09	0.509 °0.09	0.171°0.027

Table 19. Estimates of genetic variance (σ^2_g), genotype x environmental interaction (σ^2_{gl}), phenotypic variance (σ^2_{ph}) and error variance (σ^2_e) for 22 characters of 40 cassava genotypes grown across locations

Character	σ^2_g	σ^2_{ph}	σ^2_{gl}	σ^2_e
Sprouting 7 DAP	33.369 ° 12.92	101.623 ° 6.46	13.859°309.26	4.359°4.34
Sprouting 14 DAP	76.827 ° 28.68	190.497 ° 14.34	33.248°1198.98	0.422°6.42
Sprouting 21 DAP	132.308 ° 45.03	215.984 ° 22.52	29.605°1022.38	4.071°4.32
Sprouting 28 DAP	138.337 ° 46.18	202.260 ° 23.09	25.301°409.39	8.622°3.08
Establishment	149.523 ° 44	210.465 ° 24.72	22.432°529.07	8.51°3.07
Number of shoots	6.148 ° 2.18	12.058 ° 1.09	2.064°104.09	.846°0.31
Number of roots	376.323 ° 127.54	603.529 ° 63.77	79.258°1995.90	47.948°11.81
Fresh weight shoot	21066.92 ° 8353.78	51370.63 ° 4176	18968.5°1747074	1336.13°904.72
Fresh weight root	8.981 ° 3.25	18.671 ° 1.63	3.749°37.99	.941°0.47
Dry weight of shoot	2636.556 ° 1123.37	8443.365 ° 561.69	2863.475°230208.6	2943.334°234.9
Dry weight of root	0.03 ° 9.88	369.111 ° 4.94	5.555°93.15	363.526°29.01
Plant height	20.919 ° .26	68.392 ° 4.13	9.408°2427.29	38.065°3.04
CMD 1MAP	0.896 ° 0.29	1.230 ° 0.15	0.098°0.71	0.236°0.02
CMD 1MAP	0.843 ° 0.28	1.228 ° 0.14	0.117°0.88	0.268°0.02
CBB 3MAP	0.317 ° 0.11	0.625 ° 0.06	0.089°0.71	0.219°0.02

4.4. Correlations

In order to determine the relationships existing between sprouting, establishment cutting characteristics and the growth parameters, their phenotypic and genotypic coeficients were computed. All possible phenotypic and genotypic correlations among the charactersmeasured were computed. Only the relationships beteen sprouting and establishment abilities with the other characters were presented. The correlation coeficients are presented in tables 20-24. Genotypic correlation coefficients were higher than their corresponding phenotypic correlatition coefficients. The phenotypic and genotypic correlations, generally depicted similar trends in magnitude and direction in all the locations and across the four lcoations and hence only the estimates of genotypic correlation across the four locations were discussed for purposes of clarity and avoudance of repetitions. However, slight differences existed in the magnitude of correlation coefficients exhibited by the difference locations. The Kuru location has the lowest correlation coefficients when compared to Mokwa, Samaru and Minjibri and the data conbined across the locations.

As expected, establishment exhibited high and positive correlation with sprouting percents for the four periods sprouting percentages were taken. The correlation coefficients ranged form (r =0.73) for 7 days after planting to (r =0.97) for 28 days after planting. High positive correlation (Table 24) were observed between the sprouting and the cutting characteristics for example, high correlation was observed between sprouting and stake fresh weight (r = 0.66**), bulk density (r =0.64**) and stake volume (r =0.37*). Sprouting percent at 28 days after planting was also postive correlated with growth parameters, for example, Sprouting percent at 28 days after planting had high correlation with number of roots (r = 0.59**), fresh weight of root (r = 0.52**), dry weight of shoot (r = 0.53**) plant height (r =

0.49**) and dry wieght of root (0.46**). However, negative correlation coefficients were observed between sprouting percent and node number (r = -0.50**), pith-wood ratio (r = -0.38*) and cassava bacterial blight 3 months after planting (r= -0.57**).

Establishment exhibited high and positive correlation with stake fresh weight (r = 0.58**), bulk density (r = 0.56**), stake volume (r = 0.43**) and stake girth (r = 0.38*). However, negative correlations were exhibited between establishment and the following cutting characteristics: node number (r = -51**) pith diameter, (r = -0.31*) and pith-wood ratio (r = -0.37*).

Among the growth parameters, high correlation coefficient was observed between establishment and number of root (r = 0.60**), frsh weight of shoot (r = 0.37*). Establishment was negatively correlated with Cassava mosaic disease scored three months after planting (r = -0.32*) and cassava bacterial blight scored three months after planting (r = -0.43).

Table 20. Phenotypic and genotypic correlation coefficients between sprouting ability, establishment, cutting characteristics and growth parameters of 40 cassava clones grown at Mokwa in 1994 (n = 40).

	spt7		spt14		spt21		spt28		estab	
	ph	g	ph	g	ph	g	ph	g	ph	g
spt14	0.59*	0.76**								
spt21	0.68**	0.88**	0.79**	0.95**						
spt28	0.68**	0.87**	0.77**	0.95**	0.98**	0.99**				
estab	0.67**	0.86**	0.72**	0.92**	0.90**	0.95**	0.92**	0.97**		
nnd	0.28**	0.50**	-0.29**	-0.55**	-0.44**	-0.57**	-0.48**	-0.60**	-0.48**	-0.60**
stgt	0.11*	0.20**	0.24**	0.40**	0.25**	0.31**	0.25**	0.30**	0.38**	0.42**
ptgt	0.17^{ns}	0.18^{ns}	0.11^{ns}	0.23^{ns}	0.15^{ns}	0.19^{ns}	0.13^{ns}	0.17^{ns}	0.08^{ns}	0.06^{ns}
stwt	0.36**	0.52**	0.32**	0.48**	0.49**	0.53**	0.52**	0.55**	0.49**	0.54**
stvol	0.29**	0.45**	0.29**	0.32**	0.35**	0.40**	0.38**	0.42**	0.36**	0.42**
bd	0.19*	0.55**	0.25**	0.59**	0.34**	0.62**	0.31**	0.63**	0.31**	0.63**
pwr	-0.10*	-0.28**	-0.25**	-0.28**	-0.31**	-0.41**	-0.32**	-0.42**	-0.27**	-0.39**
nostm	0.34**	0.61**	0.32**	0.61**	0.53**	0.65**	0.53**	0.65**	0.56**	0.65**
nort	0.32**	0.50**	0.36**	0.48**	0.44**	0.52**	0.46**	0.54**	0.42**	0.67**
fwtsht	0.04^{ns}	0.06^{ns}	0.24**	0.44**	0.34**	0.42**	0.37**	0.44**	0.44**	0.50**
fwtrt	0.24^{ns}	0.45**	0.26**	0.47**	0.33**	0.42**	0.35**	0.46**	0.45**	0.54**
dwtsht	0.17^{ns}	0.44**	0.26**	0.56**	0.30**	0.51**	0.29**	0.51**	0.34**	0.55**
dwtrt	0.26^{ns}	0.42**	0.24**	0.37**	0.33**	0.37**	0.36**	0.41**	0.46**	0.52**
pltht	0.25 ^{ns}	0.35**	0.24^{ns}	0.38*	0.19^{ns}	0.40*	0.21^{ns}	0.43**	0.27^{ns}	0.44**
cmd1	-0.19^{ns}	-0.35**	-0.15^{ns}	-0.25*	-0.28*	-0.33**	-0.30*	-0.34**	-0.35**	-0.39**
cmd3	-0.22^{ns}	-0.38**	-0.27^{ns}	-0.35**	-0.28*	-0.39**	-0.29 ^{ns}	-0.40*	-0.37**	-0.47**
cbb3	-0.24^{ns}	-0.39**	-0.24^{ns}	-0.29*	-0.23*	-0.33**	-0.26 ^{ns}	-0.36**	-0.33**	-0.47**

*, ** = Statistically significant at 5% and 1% probability levels, respectively.

SPT 7 - SPT 28: Sprouting percentages at 7, 14, 21, 28 days after planting, ESTAB: Establishment, NND: number of nodes, STGT: Stem girth, PTGT: Pith girth, STWT: stem weight, STVOL: stem volume, BD: bulk density, PWR: Stake pith-wood ratio, NOSTM: number of stem, NORT: number of roots, FWTSHT: fresh weight of shoot, FWTRT: fresh weight of root, DWTSHT: dry weight of shoot, DWTRT: dry weight of root, PLTHT: plant height.

Table 21. Phenotypic and genotypic correlation coefficients between sprouting ability, establishment, cutting characteristics and growth parameters of 40 cassava clones grown at Samaru in 1994 (n=40).

	spt7		spt14		spt21		spt28		estab	
	ph	g	ph	g	ph	g	ph	g	ph	g
spt14	0.59**	0.80**								
spt21	0.41*	0.62**	0.72**	0.93**						
spt28	0.36*	0.58**	0.68**	0.87**	0.96**	1.00**				
estab	0.39**	0.64**	0.65**	0.86**	0.85**	0.99**	0.87**	0.96**		
nnd	-0.18*	-0.38**	-0.18**	-0.27**	-0.23**	-0.38**	-0.29**	-0.38**	-0.28**	-0.42**
stgt	0.12*	0.25**	0.20**	0.42**	0.30**	0.51**	0.29**	0.47**	0.31**	0.47**
ptgt	0.10ns	0.31*	-0.03ns	-0.02ns	0.02ns	0.04ns	0.01ns	-0.01ns	-0.01ns	0.03ns
stwt	0.13*	0.33**	0.29**	0.51**	0.39**	0.59**	0.42**	0.59**	0.34**	0.47**
stvol	0.19ns	0.23**	0.20**	0.41**	0.28**	0.45**	0.36**	0.47**	0.39**	0.50**
bd	0.11*	0.23**	0.30**	0.56**	0.41**	0.59**	0.45**	0.51**	0.47**	0.60**
pwr	-0.01*	-0.23**	-0.26**	-0.52**	-0.36**	-0.61**	-0.36**	-0.59**	-0.40**	-0.58**
nostm	0.02ns	0.07ns	0.13ns	0.20*	0.17*	0.31**	0.35**	0.35**	0.24**	0.34**
nort	0.04*	0.36**	0.25**	0.47**	0.44**	0.60**	0.46**	0.59**	0.56**	0.66**
fwtsht	0.14ns	0.42**	0.20**	0.49**	0.26**	0.48**	0.24**	0.44**	0.28**	0.49**
fwtrt	0.09ns	0.25**	0.12**	0.42**	0.23**	0.45**	0.24**	0.42**	0.36**	0.50**
dwtsht	0.05ns	0.45**	0.17**	0.53**	0.24**	0.48**	0.21**	0.44**	0.25**	0.50**
dwtrt	0.06ns	0.19**	0.09*	0.31**	0.16**	0.31**	0.17**	0.30**	0.23**	0.36**
pltht	0.30*	0.68**	0.23*	0.26*	0.24*	0.34**	0.25*	0.37**	0.27*	0.40**n
CMD1	-0.20ns	-0.01ns	-0.09ns	-0.18ns	-0.11ns	-0.15ns	-0.10ns	-0.12sn	-0.21ns	-0.32*
CMD3	-0.11ns	-0.24ns	-0.06ns	-0.10ns	-0.03ns	-0.09ns	-0.02ns	-0.05ns	-0.13ns	-0.24ns
cbb3	-0.22ns	-0.35*	-0.17ns	-0.19ns	-0.19ns	-0.25ns	-0.17ns	-0.21ns	-0.25ns	-0.34*

*, ** = Statistically significant at 5% and 1% probability levels, respectively.

SPT 7 - SPT 28: Sprouting percentages at 7 14, 21, 28 days after planting, ESTAB: Establishment, NND: number of nodes, STGT: Stem girth, PTGT: Pith girth, STWT: stem weight, STVOL: stem volume, BD: bulk density, PWR: Stake pith-wood ratio, NOSTM: number of stem, NORT: number of roots, FWTSHT: fresh weight of shoot, FWTRT: fresh weight of root, DWTSHT: dry weight of shoot, DWTRT: dry weight of root, PLTHT: plant height, CMDS!: cassava mosaic virus severity 1map, African cassava mosaic virus severity 3map,CBBS3: Cassava bacterial blight severity 3map.

Table 22. Phenotypic and genotypic correlation coefficient between sprouting ability, establishment, cutting characteristics and growth parameters of 40 cassava clones grown at Minjibir in 1994 (n=40).

	spt7		spt14		spt21		spt28		estab	
	ph	g	ph	g	ph	g	ph	g	ph	g
spt14	0.74**	0.96**								
spt21	0.65**	0.82**	0.84**	0.99**						
spt28	0.56**	0.83**	0.75**	0.92**	0.91**	0.97**				
estab	0.55**	0.80**	0.75**	0.94**	0.87**	0.98**	0.90**	1.03**		
nnd	-0.11**	-0.41**	-0.23**	-0.48**	-0.28**	-0.42**	-0.26**	-0.46**	-0.24**	-0.39**
stgt	0.16**	0.35**	0.25**	0.49**	0.37**	0.50**	0.44**	0.59**	0.36**	0.50**
ptgt	0.06*	0.33*	0.11*	0.40**	0.12**	0.31**	0.18**	0.45**	0.11*	0.35**
stwt	0.19**	0.38**	0.28**	0.42**	0.40**	0.45**	0.44**	0.53**	0.34**	0.40**
stvol	0.10**	0.26**	0.13**	0.22**	0.22**	0.28**	0.26**	0.36**	0.25**	0.30**
bd	0.14*8	0.38**	0.34**	0.54**	0.44**	0.53**	0.49**	0.48**	0.44**	0.53**
pwr	-0.18**	-0.36**	-0.19**	-0.54**	-0.33**	-0.53**	-0.35**	-0.55**	-0.32**	-0.54**
nostm	0.21**	0.47**	0.32**	0.54**	0.35**	0.52**	0.39**	0.56**	0.37**	0.47*
nort	0.11**	0.45**	0.26**	0.54**	0.39**	0.56**	0.42**	0.60**	0.41**	0.56**
fwtsht	0.19**	0.35**	0.20**	0.56**	0.35**	0.58**	0.40**	0.62**	0.39**	0.63**
fwtrt	0.19**	0.28**	0.21**	0.43**	0.38**	0.49**	0.44**	0.55**	0.45**	0.56**
dwtsht	0.16**	0.36**	0.21**	0.43**	0.33**	0.55**	0.36**	0.50**	0.33**	0.53**
dwtrt	0.05^{ns}	0.13^{ns}	-0.04^{ns}	0.19^{ns}	0.11^{ns}	0.15^{ns}	0.17^{ns}	0.29^{ns}	0.13^{ns}	0.31^{ns}
pltht	0.11*	0.38**	0.14**	0.46**	0.23**	0.42**	0.23**	0.44**	0.24**	0.49**
CMD1	-0.19^{ns}	-0.31*	-0.31*	-0.38*	-0.25^{ns}	-0.40**	-0.25^{ns}	-0.39^{ns}	-0.37*	-0.39*
CMD3	-0.13*	-0.34**	-0.22**	-0.42**	-0.23**	-0.30**	-0.22**	-031**	-0.32**	-0.42**
cbb3	-0.11*	-0.32**	-0.21*	-0.48**	-0.27**	-0.37**	-0.27**	-0.39**	-0.29**	-0.43**

*, ** = Statistically significant at 5% and 1% probability levels, respectively.

SPT 7 - SPT 28: Sprouting percentages at 7 14, 21, 28 days after planting, ESTAB: Establishment, NND: number of nodes, STGT: Stem girth, PTGT: Pith girth, STWT: stem weight, STVOL: stem volume, BD: bulk density, PWR: Stake pith-wood ratio, NOSTM: number of stem, NORT: number of roots, FWTSHT: fresh weight of shoot, FWTRT: fresh weight of root, DWTSHT: dry weight of shoot, DWTRT: dry weight of root, PLTHT: plant height.

KASHIM IBRAHIM LIBRARY

Table 23. Phenotypic and genotypic correlation coefficient between sprouting ability, establishment, cutting characteristics and growth parameters of 40 cassava clones grown at Kuru in 1994 (n=40).

	spt7		spt14		spt21		spt28		estab	
	ph	g	ph	g	ph	g	ph	g	ph	g
spt14	0.63**	0.91**								
spt21	0.49**	0.91**	0.81*	0.89**						
spt28	0.40*	0.73**	0.60**	0.83**	0.81**	0.97**				
estab	0.40*	0.71**	0.57**	0.83**	0.69**	0.93**	0.89**	0.97**		
nnd	-0.14*	-0.31**	-0.14**	-0.37**	-0.21**	-0.57**	-0.25**	-0.51**	-0.23**	-0.55**
stgt	0.05^{ns}	0.18**	0.18^{ns}	0.26**	0.22*	0.30**	0.29**	0.35**	0.30**	0.34**
ptgt	0.01^{ns}	0.16^{ns}	0.19^{ns}	0.25**	0.23ns	0.27**	0.23*	0.29**	0.28*	0.31**
stwt	0.07*	0.32**	0.13**	0.32**	0.27**	0.55**	0.32**	0.52**	0.26**	0.42**
stvol	0.10^{ns}	0.26**	0.13*	0.22**	0.25**	0.46**	0.27**	0.42**	0.29*	0.38**
bd	0.09^{ns}	0.20**	0.10*	0.28**	0.18**	0.40**	0.24**	0.40**	0.26**	0.40**
pwr	-0.01^{ns}	-0.22**	-0.06^{ns}	-0.22*	-0.09^{ns}	-0.26**	0.16^{ns}	-0.28**	-0.23^{ns}	-0.32**
nostm	0.08*	0.47**	0.15**	0.37**	0.26**	0.50**	0.32**	0.57**	0.31**	0.54**
nort	0.15**	0.51**	0.19**	0.53**	0.33**	0.59**	0.72**	0.61**	0.47**	0.59**
fwtsht	0.08^{ns}	0.15*	0.07*	0.20**	0.15**	0.47**	0.28**	0.42**	0.30**	0.48**
fwtrt	0.03^{ns}	0.17**	0.09*	0.43**	0.14*	0.66**	0.18*	0.57**	0.18*	0.57**
dwtsht	0.04^{ns}	0.16**	0.19*	0.35**	0.13**	0.55**	0.24**	0.56**	0.32**	0.57**
dwtrt	0.05^{ns}	0.10*	0.09*	0.25**	0.14**	0.55**	0.21**	0.51**	0.22**	0.40**
pltht	0.05^{ns}	0.07*	0.14*	0.29**	0.12*	0.42**	0.11*	0.44**	0.11*	0.42**
CMD1	0.06^{ns}	0.02^{ns}	-0.09^{ns}	-0.12^{ns}	0.04^{ns}	-0.04^{ns}	-0.09^{ns}	-0.12^{ns}	-0.20^{ns}	-0.25^{ns}
CMD3	-0.05^{ns}	-0.05^{ns}	0.18^{ns}	-0.12^{ns}	-0.15^{ns}	-0.06^{ns}	-0.14^{ns}	-0.13^{ns}	-0.25^{ns}	-0.28^{ns}
cbb3	-0.01^{ns}	-0.19^{ns}	-0.19^{ns}	-0.32**	-0.26^{ns}	-0.35**	-0.30*	-0.37**	-0.40*	-0.48**

*, ** = Statistically significant at 5% and 1% probability levels, respectively.

SPT 7 - SPT 28: Sprouting percentages at 7 14, 21, 28 days after planting, ESTAB: Establishment, NND: number of nodes, STGT: Stem girth, PTGT: Pith girth, STWT: stem weight, STVOL: stem volume, BD: bulk density, PWR: Stake pith-wood ratio, NOSTM: number of stem, NORT: number of roots, FWTSHT: fresh weight of shoot, FWTRT: fresh weight of root, DWTSHT: dry weight of shoot, DWTRT: dry weight of root, PLTHT: plant height.

Table 24. Phenotypic and genotypic correlation coefficient between sprouting ability, establishment, cutting characteristics and growth parameters of 40 cassava clones grown in the 4 locations. in 1994 (n=40).

	spt7		spt14		spt21		spt28		estab	
	ph	g	ph	g	ph	g	ph	g	ph	g
spt14	0.63**	0.85**								
spt21	0.55**	0.80**	0.78*	0.93**						
spt28	0.49*	0.74**	0.70**	0.91**	0.81**	0.97**				
estab	0.48*	0.73**	0.66**	0.80**	0.79**	0.93**	0.89**	0.97**		
nnd	-0.14*	-0.41**	-0.14**	-0.43**	-0.31**	-0.51**	-0.32**	-0.50**	-0.33**	-0.51**
stgt	0.07ns	0.26**	0.18ns	0.39**	0.28*	0.39**	0.39**	0.43**	0.27**	0.38**
ptgt	0.08ns	0.24ns	0.09ns	0.25**	0.13ns	0.27**	0.13*	0.29**	0.18*	0.31**
stwt	0.27*	050**	0.37**	055**	0.50**	0.64**	0.55**	0.66**	0.48**	0.58**
stvol	0.21ns	0.42**	0.24*	0.39**	0.35**	0.50**	0.27**	0.37**	0.32*	0.43**
bd	0.07ns	0.36**	0.20*	0.50**	0.28**	0.53**	0.34**	0.54**	0.36**	0.56**
pwr	-0.04ns	-0.29**	-0.12ns	-0.32*	-0.23ns	-0.36**	0.26ns	-0.38**	-0.13ns	-0.37**
nostm	0.08*	0.29**	0.18**	0.39**	0.28**	0.45**	0.30**	0.51**	0.31**	0.50**
nort	0.15**	0.47**	0.27**	0.50**	0.40**	0.51**	0.44**	0.59**	0.47**	0.60**
fwtsht	0.05ns	015*	0.17*	0.35**	0.25**	0.49**	0.34**	0.50**	0.37**	0.53**
fwtrt	0.06ns	0.30**	0.19*	0.43**	0.24*	0.53**	0.28*	0.52**	0.28*	0.53**
dwtsht	0.04ns	0.29**	0.20*	0.35**	0.28**	0.50**	0.24**	0.53**	0.33**	0.51**
dwtrt	0.07ns	0.35*	0.09*	0.25**	0.11**	0.45**	0.14**	0.46**	0.18**	0.37**
pltht	0.21	0.50*	0.24*	0.41**	0.24*	0.46**	0.27*	0.49**	0.26*	0.48**
CMD1	0.06ns	0.10ns	-0.09ns	-0.15ns	0.10ns	-0.17	-0.10ns	-0.14ns	-0.31ns	-0.25ns
CMD3	-0.11ns	-0.23ns	0.13ns	-0.22ns	-0.15ns	-0.18ns	-0.13ns	-0.07ns	-0.23ns	-0.32**
cbb3	-015ns	-0.28ns	-0.17ns	-0.31**	-0.20 ns	-0.32**	0.32*	0.57**	-0.29*	-0.43**

*, ** = Statistically significant at 5% and 1% probability levels, respectively.

SPT 7 - SPT 28: Sprouting percentages at 7 14, 21, 28 days after planting, ESTAB: Establishment, NND: number of nodes, STGT: Stem girth, PTGT: Pith girth, STWT: stem weight, STVOL: stem volume, BD: bulk density, PWR: Stake pith-wood ratio, NOSTM: number of stem, NORT: number of roots, FWTSHT: fresh weight of shoot, FWTRT: fresh weight of root, DWTSHT: dry weight of shoot, DWTRT: dry weight of root, PLTHT: plant height.

CHAPTER FIVE

5.0 DISCUSSION

The result of the present investigation (ie the means, ranges and genotypic and phenotypic coefficients of variability for the different traits) (Tables 9-13) and the mean squares of variation among genotypes for sprouting ability and establishment (Appendixes 4a-4e) showed considerable variability for these traits. The phenotypic means of the different genotypes also showed wide ranges of variation for sprouting ability at 7, 14, 21, 28, days after planting, establishment, cutting characteristics and growth parameters. The genotypes also showed significant differents for CMD and CBB. The genotypes also showed differential performance in the four locations and across the four locations combined.

These significant differences in the clones for these characters indicate considerable variability in the Nigerian cassava landraces. CIAT (1984); Cock (1985); IITA (1990) Manga (1994), Woumane (1994) have reported variability among cassava genotypes for sprouting traits.

These significant differences observed in the clones for these characters indicate considerable variability in the Nigerian cassava landraces. CIAT (1984); Cock (1985), IITA (1990) Manga (1994) Woumane, (1994) have reported variability among cassava genotypes for sprouting traits. The significant differences can be supported by the fact that cassava genotypes of different origins were used in the study. Some of the genotypes were introductions, some improved clones while others were landraces or traditional cultivars, resulting from natural selections in the farmers' fields and from farmers' selections over a long period of time for different food quality traits. The sprouting obtained in the various locations is similar to the report of Hahn and Keyser (1985) who obtained maximum

sprouting between 26 and 27 DAP after planting. The late sprouting rate in Kuru station could be attributed to low temperature, Keating and Evenson (1979) and Akparobi (1992) reported that sprouting of cassava cuttings were significantly affected by air temperature. They also indicated that early sprouting and growth of cassava was favoured at a temperature region of 25 to 35°C, which was far higher, than the temperature of 20 to 25°C recorded in Kuru during the period of the experiment as shown in (Appendix 9).

The wide ranges in values obtianed and the magnitudes of the genotypic coefficients of variation are suggestive of the presence of an appreciable amount of genetic variability for these characters in the clones. The high Phenotypic coefficients of variations (PCV) and the genotypic coefficients of variation (GCV) observed for sprouting and establishment suggest better scope for these characters in future breeding programmes. Phenotypic coefficients of variations were higher than the genotypic coefficients of variation for all the characters studied. This indicates considerable environmental influences on the expression of these characters. CIAT (1984); Cock (1985), and IITA (1990) reported similar results. This result is also in agreement with the findings of Birdar (1978) and Manga (1994), who in their different experiments reported high genotypic coefficients of variation for Sprouting measured at 7, 14, and 30 days after planting, fresh weight of shoot, fresh weight of root, dry weight of shoot, dry weight of root, plant height.The high genotypic coefficients of variation for Sprouting at 7 days after planting, sprouting 14 DAP, fresh weight of shoot, fresh weight of root, dry weight of shoot, dry weight of root, plant height., CMD 1MAP, CMD 3MAP and CBB3 with high differences between PCV and GCV are therefore likely to be more influenced by the interplay of environmental factors. However, stake fresh weight, stake volume, bulk density and pith-wood ratio and number of shoot per plant exhibited low differences between phenotypic and genotypic coefficients of variation indication that the

environment had little influence upon these plant characters. Generally, the high degree of both PCV and GCV exhibited by these characters indicate the existence of high levels of genetic variability. The characters therefore offer better scope for selection in crop improvement programmes.

The analysis of variance (Appendices 4a to 4d) showed highly significant differences for all the traits measured in the single locations. The combined analysis of variance of 15 characters for four environments also showed highly significant differences for all the traits measured and are presented in table 4e of the appendix. Partitioning of the variances into its components revealed that a large proportion of the phenotypic variance of sprouting percent at four periods and establishment was attributable to the genotypic variance among the genotypes.

Highly significant differences (P=0.01) were observed among clones for all of the characters measured in the four environments. Estimates genetic variances as well as phenotypic and environmental variances were computed to study available variability in the populations. The genetic variation of the materials used in this is reflected in the differences in performance among the clones.

Estimates of genetic effects accounted for a reasonable amount of these variance components. The estimates of genetic and phenotypic variances (Tables 16-20) were positive for all the traits and had low standard errors. Genetic components of variance were larger in magnitude than those for environmental components, implying that these characters are highly heritable and a high response from selection for these characters is possible. In this study, all characters exhibited considerable genetic variability as shown by the differences in the wide magnitude between genetic and phenotypic variances. The large ratios of genotypic

to phenotypic variance between the genotypes for sprouting ability and establishment and the growth parameters indicate that these character were highly inherited and the differences between the genotypes are real. Similar trends were observed by Biradar *et al* (1978) and Manga, (1994).

Locations differed significantly for all the characters measured. The variations in mean performance for sprouting and establishment and the growth parameters for the 40 clones over locations may be attributed to environmental factors particularly rainfall distribution, soil temperature, variation in soil types, and major diseases at the test sites.

The study indicated that sprouting and establishment abilities in cassava genotypes are sensitive to environment and their interaction, making it necessary to evaluate them over locations. Therefore, a study of the genetic variability for sprouting and establishment in cassava in different locations would give more precision. Environment was a major source of variation and therefore it is important for breeders to decentralise selection procedure in order to produce varieties with adaptation to specific agroecologies.

The combined analysis of variance provided unbiased estimates of the genetic and genotype x location variance components, since the experiment was conducted in four difference environments. Significant genotypes x environmental interactions were also observed among the genotypes for all the characters. The differential performance of the cassava clones in different locations and across locations for sprouting ability, establishment as shown in the ranking of the genotypes (Tables 4-8) and other characters in this study indicate the presence of genotype x location interaction. The interaction variances were high indicating that locations are more important sources of variation. This shows that the environments play a great role in determining sprouting ability and establishment.

However, GxE interactions as manifested by differences in performance of genotypes among different environments, in the present study, depended more on genotypes than environment and therefore should be partly heritable. The GxE in this study was mainly due to genotype effect which in this study contributed the highest percentage sources of variation for all the traits studied (Table 14).

The four locations used in this study provided contrasting environmental conditions to detect the existence of G x E interaction. High significant GxE interaction has been reported in cassava. Cock, (1987) and IITA (1991). The highly significant GxE interactions indicated that phenotypic expression of the clones would vary in different environments, with years and over loations.

Cockerham (1963) indicated that a large interaction component of variances could be as a result of the genetic variance being large in one environment than the other and this could be true in this investigation. Singh and Singh (1977) reported that genetic variances are greatly biased by the environmental influence. In the present study, all traits had relatively low G x E interaction variances when compared with their respect phenotypic and environmental variances. The additive genetic variances appeared to be the major sources of variation in the traits studied. The genetic variances estimated from the present study, represent the total genetic variances because it was not possible to separate it into its various component parts (additive, dominance and epistasis) as a result the experimental materials and the design used.

As it has been mentioned in chapter three under literature review, that certain characteristics have been to known to have some influence on sprouting and establishment in

cassava. Data were taken on the cutting characteristics and growth parameters to investigate their relationship with sprouting percentage and establishment. These are presented as correlations in Tables 21-25. Although both genotypic and phenotypic correlations were measured, the more important genotypic correlations were presented and discussed. The degree of phenotypic and genotypic correlation between characters is an important factor especially in economic and complex characters such as sprouting and establishment. Steel and Torrie (1984) state that correlations are a measure of the intensity of association between variable. Plant breeders are interested in the quantitative inheritance of correlated characters, since selections usually involve the changing of two or more traits simultaneously. The selection for one character results in a progress for all positively correlated characters but in a retrogress for all negatively correlated characters.

For this reason, the phenotypic and genotypic correlation coefficients between sprouting, establishment cutting characteristics, growth parameters and the two important diseases were measured. The genotypic correlation coefficients were higher than their corresponding phenotypic coefficients. The higher genotypic correlations than phenotypic ones observed among the characters studied indicate an inherent association between them. According to Nandpuri *et al*, (1973), higher genotypic correlations than phenotypic may be possibly be due to modifying or masking effect of environment in the expression of the characters under study.

The positive and significant phenotypic and genotypic correlations obtained between sprouting ability and establishment and cutting characteristics (stem girth, stem weight, stem volume and bulk density) suggest that selection for these characters will result in improved sprouting ability and establishment. Strong positive correlation ($r = 0.84$ $r = 0.82$ $r = 0.80$)

between stake bulk density, stake fresh weight and number of roots respectively, suggests that they are useful indicators of sprouting and establishment. The strong positive correlation between stake bulk density and stake fresh weight with sprouting may be related to the amount and distribution of food reserves in the stakes. Stakes with high food reserves will support more sprouting.

Establishment correlated with number of roots, weight of stake and roots. The number of roots produced per plant varies with genotypes and may be related to the nutrient status and rooting ability of the clones. Manga (1994) observed that shoot and root numbers were highly correlated, suggesting that assessment of root development at early stage can be made on the above found growth. Therefore getting rid of difficulties in monitoring root development at the early stages, (Ekanayake, 1993). Selecting genotypes that will give uniform establishment is important. Therefore selection for high establishment and high root number could be used for identifying high yielding genotypes. Poor plant stand is synonymous to pod yield.

Similarly highly positive and significant phenotypic and genotypic correlations were observed between sprouting, establishment and growth parameters, (number of stems, number of roots, fresh weight of shoot and fresh weight of root. Dry weight of shoot, dry weight of roots and plant height). These correlations indicate that sprouting ability and establishment are closely associated with cutting characteristics and growth parameters, thus the possibility of simultaneous improvement of these traits by a single selection programme. In his several studies (Ebiyau, 1992), however, showed either negative, positive or no association between sprouting and shoot weight, and other characters thus making it difficult to use it in direct selection.

KASU

The positive significant phenotypic association between sprouting, establishment and fresh weight of stem, stem volume, bulk density confirms the earlier funds of Oka *et al.*, (1987) and Ebiyau (1992). Positive correlations between stem girth and sprouting potential was reported by CIAT (1984) and IITA (1990). The significant positive correlation also observed between establishment, number of roots and fresh weight of shoot and roots corroborated with the previous results of Manga, (1994) and Ekanayeke (1993). The implication of these observations is that, selection for any of the characters should also ultimately lead to increase in sprouting.

On the other hand, sprouting and establishment correlated significantly and negatively with number of nodes and pith-wood ratio corroborating the earlier findings of Manga (1994) who reported a significant negative phenotypic correlation (r= -0.45) between number of nodes and sprouting at 30 DAP. From the present findings, increasing number of nodes of cutting resulted in a decrease of the sprouting ability of the different genotypes. This may be attributed to the inherent competition occurring among the nodes, site of the meristematic tissues of buds and forerunners of new shooots. Each dominant bud willing to sprout will attract the limited amount of available reserves, which possibly result in delaying the sprouting process of the cutting and may even lead to the failure of the cutting to regenerate a new plant in case of stem physiology (Hartman and Kester, 1983).

Similarly, the negative correlation between pith-wood ratio and sprouting and establishment indicated that increasing pith-wood ratio also decreases the wood portion of the stem thus reducing the food reserve in the wood, consequently resulting to poor sprouting and establishment.

Significant negative phenotypic and genotypic correlations were observed between sprouting, establishment and cassava mosaic disease and cassava bacterial blight recorded at 3 MAP. Manga, (1994), reported negative correlation (r = -0.84) between sprouting and number of nodes. This result also agrees the findings of CIAT (1984) and IITA (1990) which reported that stem cuttings exposes the crop to wide range of environmental hazard, pets and diseases during the early stages of establishment. These diseases which are caused by systemic organisms can be transmitted with the stakes through successive generations, thus resulting in poor sprouting and establishment. The observed significant negative correlations between number of nodes and pith-wood ratio, Cassava mosaic disease one month after planting and Cassava bacterial blight is not unexpected. The implication of this observation for breeding is that selection aimed at increasing sprouting would probably lead to decreased pith-wood ratio, cassava mosaic disease, cassava bacterial blight and number of nodes, thus both characters could therefore be improved simultaneously.

CHAPTER SIX

6.0 SUMMARY AND CONCLUSIONS

In order to obtain necessary information that could be potentially useful for the genetic improvement of sprouting and establishment in cassava, the following studies were carried out.

- ñ Assessment of the extent genetic variability in Nigerian cassava landraces for sprouting and establishment ability.
- ñ Investigate relationship between cutting characteristics, growth parameters, CMD and CBB sprouting and establishment ability of cassava stakes.
- ñ Study the effect of environments of sprouting and subsequent establishment ability of cassava genotypes.

The study involved a total of 40 cassava clones consisting of 33 Nigerian local landraces and 7 improved cassava clones from the International Institute of Tropical Agriculture. The experiment was conducted in 1994 in four locations: Mokwa (southern guinea savanna), Samaru (north guinea savanna), Minjibir (sudan savanna) and Kuru (mid altitude woodland savanna). A randomized complete block design (RCBD) with three replications was used at each location. Data were collected on the plants for number of nodes, stake diameter, pith girth, stake weight, stake volume, stake bulk density, pith-wood ratio, number of shoot per plant, number of roots, fresh weight of shoot, and root, dry weight of shoot and root and plant height, cassava mosaic disease and cassava bacterial blight. Analysis of variance and covariance were performed on the four locations and for the combined data across the four locations for the characters. Analysis for each trait was computed on plot mean basis.

A summary of the findings and conclusions derived from these investigations are as follows:

Remarkable differences were observed among the cassava genotypes used in this study for the various characters that were measured. On the basis of performance of individual cultivars for sprouting, establishment and their components, TMS 30572 and Antiota had the best overall mean performance across the four locations. Other good genotypes in the population include Dan Kporo, Odungbo, Oyarugba, Rogo Gidan Dawa, TMS 50395, TMS 91943, Abachaji, Amala, Bagi Wawa, Dan Aziki, Dan waru-1, Ilorin rogo, Lapai-1, Mokwa-2, Oko Iyawo, Okonkwo local, Olekanga, Panya Akpu, Suleja-4, 2nd Agric, TMS 82/00058 and TMS 82/00661. The high percentage of sprouting potential exhibited by these clones indicate that these genotypes have good sprouting potential and could be used as parent materials to improve sprouting ability and establishment. Maximum sprouting percentages among the genotypes in the different locations were achieved between 21 and 28 DAP.

The forty cassava clones that were involved in the study showed varying levels of susceptibility to Cassava mosaic disease and Cassava bacterial blight. Amala, Atu Iwo, Bagi Wawa, Oko Iyawo, Olekanga and 2nd Agric were the most resistant clones in the population for cassava mosaic disease, while TMS 81/00110, TMS 82/00058 and TMS 30572 were the most resistant clone to cassava bacterial blight.

Genotypic coefficient of variation was lower than phenotypic in all the characters studied indicating considerable influence of environment on the expression of the characters. The high genetic variance (GCV), for the characters revealed that the range of variability in the population was large thus suggesting that there is scope for further improvement of these

traits through selection. The variation observed within each trait was highly significant. Population means were significantly different for each trait. Highly significant differences were also observed for locations. Most genetic variance estimates were associated with small standard errors indicating that the estimates were different from zero. The estimates of genetic variances obtained in the study varied widely from location to location and there was also a significant genotype by environmental interaction for all the characters measured.

Highly significant and positive genotypic and phenotypic correlation coefficients were observed between sprouting and establishment. Stake fresh weight, stem volume, bulk density were positively correlated with sprouting and establishment. Number of shoot, root number, fresh weight of shoots, dry weight of roots, and plant, height were also positively correlated with sprouting and establishment. Negative correlations were observed between sprouting, establishment, cassava mosaic disease, cassava bacterial blight, node number and pith-wood ratio.

REFERENCES

Akparobi, S.O. (1992). *Effect of Different Temperature Rregimes on the Early Growth of Four Improved Cassava Varieties (Manihot esculenta* Crantz). Unpublished M.Sc. Thesis. Department of Agronomy, University of Ibadan, Ibadan, Nigeria. 67pp.

Belloti, A.C. and A. Van Schoonhoven (1978). *Cassava Pests and Their Control.* Cassava information centre *CIAT Series* 09EC-2 November, 71pp.

Berry, S.S. (1993). Socio-economic Aspect of Cassava Cultivation and Use in Africa: Implications for the development technology.COSCA working paper No 8. Collaborative Study of Cassava in Africa. International Institute of Tropical Agriculture, Ibadan. 33pp.

Biradar, R.S., P.G. Rajendran and N. Hrishi (1978). Genetic variability and Correlation Studies in Cassava (*M. Esculenta* Crantz). *Journal of Root Crops* 4 (1): 7-10.

Bose, T.K., S.K. Mitra and M.K. Sadhu (1986). *Propagation of Tropical and Subtropical Horticultural Crops.* Naya Prokash 206 Bidhan Savani Calcutta 700 006 India 612pp.

Chheda, H.R. and C.A. Fatokun (1982) Numeric Analysis of Variations Patterns in Okra (*Abelmoschus esculenta* (L.) Moench). *Botanical Gazette* 143: 253-261.

CIAT (1984). *Selection and Preparation of Ccassava Cuttings for Planting. Study Guide* 1984.

CIAT (Centro Internacional de Agricultura Tropical) (1978). Cassava Program, Annual Report, for 1977. CIAT, AF 6713 Cali, Colombia.

Cock, J.H. (1985). *New Potential for a Neglected Crop.* West view press Inc. Boulder Frederick A Praeger, Publisher Book. 191pp London.

Cock, J.H. and M.A. El. Sharkaway (1987). The Physiological Characteristics for Cassava Selection. *Experimental Agriculture*. 24: 443-448.

Cockerham, C.C. (1963). Estimates of Genetic Variance. In Hanson, W.D and Robinson, H.F. (ed) Statistical *Genetic and Plant Breeding* NAS-NRC pub/. 982 Washington D.C. pp 53-94.

COSCA (1994). Collaborative Study of Cassava in Africa. Cassava varietal needs of farmers and the potential for production growth in Africa. Working paper No 10.

Daraja, Y.B. (1992). *Effect of Mulching, Water Stress and Quality of Planting Materials on the Establishment and Early Growth of Cassava (Manihot esculenta* Crantz). Unpublished M.Sc. thesis. University of Ibadan. October, 1992 115pp

Doku, E.V. (1969). *Cassava in Ghana*. Accra, Ghana University Press 44 pp.

Ebiyau, J. (1992). *Variability in Sprouting Rate Establishment of Cassava Genotypes and Response to Three Shoot Disease*. Unpublished M.Sc. thesis Department of Agronomy. University of Ibadan 125pp

Ekanayake, I.J. (1992). *Procedures for the Growth Analysis of Cassava*. TRIP methodology paper No. 1. International Institute of Tropical Agriculture and Tuber Improvement Program Ibadan.

Ekanayake, I.J. (1993b). Root and Tuber Improvement Programme *Archival Report* (1989-1993) part III. Tissue culture, plant physiology and biochemistry. International Institute of Tropical Agriculture, Ibadan, Nigeria.

Enyi, B.A.C. (1972a). Effect of Shoot Number and Time of Planting on Growth, Development and Yield of Cassava *(Manihot esculenta* Crantz). *Journal of Horticultural Science 47:457-466*

Falconer, D.S. (1960) Introduction to Quantitative Genetics. The Ronald Press Company. News report 365pp.

FAO (Food and Agricultural Organization off United Nations) (1989) Utilization of Tropical Foods: Roots and Tubers Rome, FAO.

FAO (Food and Agricultural Organization off United Nations) (1990).. Production Year Book. FAO, Rome Italy, vol. 44.

FAO (Food and Agricultural Organization off United Nations) (1991). Food Outlook. FAO, Rome Italy, May 1991.

FAO) (Food and Agricultural Organization off United Nations) (1992. Production yearbook. FAO, Rome, Italy. 1992.

FAO (Food and Agricultural Organization off United Nations). (1971). Annual Report

Ghosh, S.P. T. Ramamijan, J.S. Jos, S.N. Moorthy and R.G. Nair (1988). *Tuber Crops* Oxford and IBH Publishing Co. Ltd., New Delhi 403pp.

Hahn S.K. and J. Keyser (1985) Cassava a Basic Food in Africa. *Out look on Agriculture* 14: 95 -100

Hahn, S.K., E.R. Terry, K. Leuschner, I.O. Akobundu, and R. Lal (1979). Cassava Improvement in Africa. *Field Crop Research* 2: 193-226.

Hartman, H.T. and D.E. Kester, (1983) *Plant Propagation. Principles and Practice*, 4th edition. Prentice-Hall. Inc Englewood cliffs, New Jersey 07632. 729p

Hunt, L.A. D.W Wholey And J.H Cock, (1977). Growth Physiology of Cassava (*Manihot esculenta Crantz) Field Crops Abstracts* 30 (2) 77-91.

Ibrahim, A.E.; D.M. Teksony, D.B. Egli and D.A. Van san Ford (1992). Water Content and Germination of Immature Wheat Kernels. *Seed Science and Technology* 20:39-46.

IITA (1990). *Cassava in Tropical Africa*: A Reference Manual. International Institute of Tropical Agriculture, Ibadan, Nigeria. Pages 52-60.

IITA (1993). Root and Tuber Improvement Programme *Archival Report* (1989-1993) part III. Tissue Culture, Plant Physiology and Biochemistry International Institute of Tropical Agriculture, Ibadan, Nigerian.

IITA (International Institute of Tropical Agriculture) (1990). Annual report.

Keating, B., A. Evenson and D. Edwards (1979). Effect of Pre-fertilization on Emergence of Stem Cuttings of Cassava (*Manihot esculenta* Crantz) Prior to Cutting for Planting Materials, on Subsequent Establishment and Root Yield. In: *Proceedings of the fifth International Symposium of Tropical Root Crops held in Manila*, Philippines 17-21 September 1979.

Keatings B.A. and J.P. Evenson, (1979) Effect of Soil Temperature on Sprouting and Sprout Elongation of Stem Cuttings of Cassava (*Manihot esculenta* Crantz) *Field Crop Research 2:241-251.*

Keatings B.A. and J.P. Evenson, (1979). Effects of Stem Cutting Thickness on Subsequent Growth and Development of Cassava (*Manihot esculenta* Crantz). *East African Forestry. Journal* 1981 53(3) 145-149.

Leaky, L.A. and Wills F.B. (1977). *Food Crops of the Lowland Tropics*. Oxford University Press. 243pp.

Leihner, D. (1984). Cassava Planting Material Conditions for Its Production. *Cassava Newsletter*, 8: 1-11

Lozano, J.C. and R.H. Booth, (1976). *Diseases of Cassava (Manihot esculenta Crantz)*. Series DE-5, June 1976. CIAT (Centro Internacional de Agricultura Tropical).

Manga A (1994) *Sprouting and Establishment of Cassava*. Unpublished Msc thesis, Department of Agronomy University of Ibadan Ibadan, Nigeria 248pp.

Medard, R. (1973). Morphoenese du Manioc, (*Manihot esculenta* Crantz) Euphorbiaceae Crotonoides Etudes descriptive. *Adansonia Serie* 2 13(4): 483-494.

Nandapuri , B.S.,S. Singh and T Lal (1973. Studies on Genetic Variability and Correlation. *Journal of Research* 10: 316-321.

Nwosu, L.A. and F.A. Onofeghara, (1992). Critical Water Stress Levels Affecting the Growth of Cassava Proceedings of the 4th symposium ISTRC-AB 1992 pp. 163-168.

Obi, I.U. (1991). *Introduction to Covariance Analysis* (with worked Examples) Optimal Computr solutions LTD 75 Agbani Road Enugu 32pp

Oka, M.J. Limsila, S. Sarakarn (1987) Relationship Between Characteristics and Germination Ability of Cuttings in Cassava (*Manihot esculenta* Crantz) *JARQ* 2(1): 70-75.

Okeke, J.E. (1994). Productivity and Yield Stability in Cassava (*Manihot esculenta* Crantz) as Affected by Stake Weight. *Journal of Agric Sci*. Cambridge vol. 122pp

Onwueme, I.C. (1978). *The TropicalTtuber Crops, Yam, Cassava, Sweet Potato and Cocoyam*. Chistester, John Willey and sons, New York, 234pp.

Philips, T.P. (1974). *Cassava Utilization and Protein Markets*. Ottawa. IDCR-020e 182p.

Ramanijam T. and G.M. Nair (1987). Certain Physiological Changes Associated with Sprouting Cassava Stakes. *Journal of Root Crops* 13 (1): 77-82.

Rao, T.S. (1972). Notes on the Natural Variability for Some Qualitative and Quantitative Character in Okra (*Abelmoschus esculenta* (L.) Moench.). *Indian Journal of Agricultural Science*. 42: 437-438.

Rogers, D.J. and Appan, S.C. (1973). Manihot and Manihotoides (Euphorbiaceae). A computer-assisted study monograph 13. Organization for Flora Neotropica. Hafner Press, New York. 272pp.

Sharma, K.C. and R.K. Sharma (1989). Variation and Character Associations of Grain Yield and Its Component Character in Coriander. *Indian Journal of Genetics* 49: 135-139.

Singh A and Singh H.N. (1977). Notes on Heritability, Genetic Advance and Minimum Number of Genes in Chili *Indian Journal. of Agric Sc*. 47 (5): 260-262.

Singh, R.K. and B.D. Choudhary (1985). Biometrical Methods in Quantitative Genetic Analysis. Kalzanin Publishers Ludhiana, India 296pp.

Steel, R.G. and J.H. Torrie (1984). *Principles and Procedures of Statistics. - A Biometrical Approach* 2nd edition McGraw-Hill Book Company. New York. 633pp.

Toro, M.J.C. and Atlee F.B. (1985). Agronomic Practices for Cassava Production. A Literature Review. In: *Cassva Research, Production and Utilization*. Cock, H. and J.A. Reyes (eds.). CIAT, Colombia: 207-214.

Wholey, D.W. (1974). Rapid Propagation of Cassava. Unpublished Ph.D. Thesis University of West Indies, St. Augustine, Trinidad. 160pp.

Wouamane, M. (1994). Cassava (*Manihot esculenta* Crantz) Selection for Adaptation to Inland Valleys. Unpublished M.Sc. Thesis Department of Agronomy, University of Ibadan, Nigeria. 96pp.

APPENDICES

Appendix 1a Mean cutting characteristics of the 40 cassava genotypes grown at Mokwa in 1994

Genotype	number of nodes	stake girth	pith diameter	stake weight	stake volume	bulk density	pith wood
Abachaji	10.93	1.92	0.51	118.07	116.67	0.69	0.26
Adabo Ozi	10.80	1.95	0.64	107.80	105.33	1.03	0.33
Amala	11.93	1.69	0.55	85.43	87.50	0.97	0.33
Anedo	13.17	1.16	0.52	77.10	82.37	0.94	0.45
Antiota	10.87	1.76	0.51	112.10	109.00	1.03	0.29
Atu Iwo	13.33	1.11	0.43	75.77	84.13	0.90	0.38
Bagi Wawa	12.53	1.67	0.55	82.83	83.83	0.99	0.33
Bakin Iri	13.00	1.78	0.55	91.60	88.6	1.03	0.31
Bakin rogo	17.07	1.12	0.42	64.27	77.10	0.83	0.38
Chika mutu	14.33	1.12	0.43	72.50	80.97	0.90	0.38
Dakata Uwar'	14.73	1.22	0.52	68.83	79.33	0.87	0.43
Dan aziki	11.80	1.82	0.54	88.77	92.47	0.96	0.30
Dan dualla	15.07	1.09	0.43	63.77	77.10	0.82	0.39
Dan Kporo	11.80	1.73	0.54	101.10	101.67	1.00	0.31
Danwaru-1	11.47	1.21	0.52	92.63	94.20	0.98	0.43
Darazo Rogo	13.53	1.27	0.46	63.63	80.30	0.85	0.37
Doya	13.27	1.25	0.50	77.07	68.60	0.96	0.40
Okura	12.67	1.85	0.79	57.82	77.27	0.85	0.42
Ewete Ihe	14.87	1.17	0.56	63.03	111.67	0.82	0.48
Ilorin Rogo	10.50	2.05	0.57	114.83	67.67	1.03	0.28
Isun	14.50	1.32	0.58	55.90	81.63	0.82	0.44
Lapai-1	11.27	1.24	0.42	81.10	98.23	0.99	0.35
Mokwa-2	10.60	1.79	0.56	99.57	105.33	1.01	0.36
Odungbo	10.73	1.35	0.47	107.27	79.60	1.02	0.35
Ojigono	12.17	1.30	0.54	78.37	79.60	0.98	0.42
Oko Iyawo	12.67	1.47	0.55	78.13	79.47	0.99	0.38
Okonkwo local	10.50	1.82	0.52	88.30	87.43	1.01	0.28
Olekanga	11.63	1.46	0.57	80.97	82.00	0.99	0.39
Oyarugba	10.23	1.93	0.71	99.70	99.17	1.01	0.37
Panya Akpu	11.97	1.08	0.43	75.40	77.27	0.98	0.4
Rogo Gidan Dawa	9.33	2.20	0.55	107.73	106.33	1.02	0.25
Sulaje-4	10.57	1.83	0.64	97.17	97.00	1.00	0.35
2nd Agric	10.33	1.70	0.54	83.82	79.37	1.06	0.32
TMS 4(2)1425	13.93	1.31	0.47	61.30	65.57	0.93	0.36
TMS 81/00110	11.47	1.33	0.51	65.00	71.43	0.91	0.39
TMS 82/00058	11.40	1.23	0.47	73.53	79.03	0.93	0.38
TMS 82/00661	12.20	1.28	0.49	88.20	88.70	0.99	0.38
TMS 30572	10.37	1.56	0.53	85.67	86.43	0.99	0.34
TMS 50395	8.77	1.21	0.47	91.77	92.60	0.99	0.39
TMS 91934	10.93	1.17	0.43	84.93	83.13	1.02	0.37
Mean	12.08	1.49	0.53	84.07	87.03	0.95	0.36
CV %	6.18	6.76	8.85	3.13	3.69	9.94	7.53
LSD(0.05)	1.21	0.16	0.08	4.28	5.22	0.15	0.04

Appendix 1b. Mean cutting characteristics of the 40 cassava genotypes grown at Samaru in 1994

Genotype	number of nodes	stake girth	pith diameter	stake weight	stake volume	bulk density	pith wood
Abachaji	11.03	1.75	0.58	105.87	104.00	1.02	0.33
Adabo Ozi	9.70	1.67	0.61	109.53	109.00	0.01	0.36
Amala	11.93	1.50	0.57	69.90	77.93	0.9	0.38
Anedo	12.07	1.26	0.55	70.10	78.73	0.90	43.00
Antiota	11.07	1.94	0.60	112.50	105.00	1.07	0.31
Atu Iwo	14.60	1.23	0.48	77.13	81.83	0.94	0.39
Bagi Wawa	12.67	1.38	0.53	104.97	104.00	1.01	0.39
Bakin Iri	11.67	1.33	0.53	74.40	78.23	0.95	0.40
Bakin rogo	15.00	1.20	0.53	60.63	70.17	0.86	0.44
Chika mutu	13.50	1.56	0.58	79.97	88.50	0.90	0.38
Dakata Uwar'	14.37	1.22	0.57	71.27	79.77	0.89	0.47
Dan aziki	10.73	1.61	0.61	87.00	86.10	1.01	0.38
Dan dualla	14.30	1.20	0.52	62.83	73.73	0.85	0.43
Dan Kporo	11.47	1.74	0.60	107.23	107.00	1.00	0.35
Danwaru-1	10.50	1.99	0.55	105.50	104.67	1.01	0.27
Darazo Rogo	13.63	1.28	0.57	71.13	76.43	0.93	0.44
Doya	13.50	1.32	0.55	97.17	81.40	0.97	0.42
Okura	11.73	1.65	0.71	64.83	76.00	0.85	0.43
Ewete Ihe	14.37	1.26	0.55	63.67	77.57	0.82	0.43
Ilorin Rogo	11.50	1.75	0.56	90.50	90.38	1.00	0.32
Isun	13.83	1.29	0.59	73.43	81.37	0.9	0.46
Lapai-1	10.90	1.39	0.52	69.77	71.43	0.98	0.38
Mokwa-2	10.70	1.75	0.59	107.13	108.00	0.99	0.34
Odungbo	10.67	2.22	0.56	111.73	103.33	1.08	0.27
Ojigono	12.63	1.35	0.56	67.50	70.53	0.96	0.41
Oko Iyawo	12.50	1.47	0.58	71.87	72.37	0.99	0.39
Okonkwo local	10.93	1.51	0.56	81.57	80.93	1.01	0.37
Olekanga	11.37	1.50	0.61	75.47	76.40	0.99	0.40
Oyarugba	9.97	2.00	0.64	98.17	97.17	1.01	0.32
Panya Akpu	10.27	1.57	0.49	79.10	97.27	1.00	0.32
Rogo Gidan Dawa	9.97	1.53	0.56	98.17	97.17	1.01	0.37
Sulaje-4	10.40	1.80	0.60	96.43	94.57	1.02	0.34
2nd Agric	12.40	1.46	0.55	71.87	74.70	0.96	0.37
TMS 4(2)1425	10.33	1.39	0.52	65.60	67.77	0.97	0.38
TMS 81/00110	9.90	1.58	0.61	77.00	78.67	0.98	0.38
TMS 82/00058	9.27	1.42	0.55	74.63	76.33	0.98	0.39
TMS 82/00661	10.43	1.49	0.51	88.47	87.97	0.01	0.35
TMS 30572	9.79	1.89	0.55	107.17	103.3	1.03	0.29
TMS 50395	12.10	1.88	0.61	74.97	72.87	1.03	0.32
TMS 91934	12.20	1.76	0.49	88.13	86.40	1.02	0.28
Mean	11.75	1.55	0.57	83.67	85.77	0.97	0.37
CV %	5.43	8.64	8.44	4.46	3.90	3.21	8.17
LSD(0.05)	1.02	0.22	0.08	6.07	5.44	0.05	0.05

Appendix 1c. Mean cutting characteristics of the 40 cassava genotypes grown at Minjibir in 1994

Genotype	number of nodes	stake girth	pith diameter	stake weight	stake volume	bulk density	pith wood
Abachaji	10.63	1.86	0.63	104.80	105.33	1.00	0.34
Adabo Ozi	10.13	1.73	0.59	102.80	101.67	1.01	0.34
Amala	13.57	1.49	0.56	69.00	76.40	0.90	0.38
Anedo	13.53	1.19	0.53	69.00	83.23	0.76	0.45
Antiota	10.40	1.89	0.58	63.53	105.67	1.04	0.31
Atu Iwo	12.67	1.29	0.47	68.40	75.43	0.91	0.37
Bagi Wawa	12.97	1.40	0.54	77.50	81.43	0.95	0.39
Bakin Iri	12.37	1.37	0.58	68.83	76.23	0.90	0.43
Bakin rogo	13.50	1.19	0.54	66.03	78.77	0.84	0.45
Chika mutu	14.30	1.32	0.50	74.23	81.10	0.92	0.38
Dakata Uwar'	13.80	1.42	0.54	63.50	72.90	0.87	0.38
Dan aziki	10.47	1.57	0.56	87.10	87.50	0.99	0.36
Dan dualla	14.00	1.93	0.52	65.00	81.83	0.80	0.44
Dan Kporo	11.40	1.71	0.55	98.93	99.00	1.00	0.32
Danwaru-1	11.17	1.58	0.56	78.00	87.47	0.89	0.36
Darazo Rogo	14.53	1.15	0.52	67.40	78.30	0.86	0.45
Doya	13.27	1.32	0.56	70.23	82.57	0.85	0.43
Okura	13.87	1.14	0.49	56.63	76.40	0.74	0.43
Ewete Ihe	13.40	1.31	0.55	59.33	69.00	0.86	0.42
Ilorin Rogo	11.67	1.10	0.63	91.77	90.43	1.02	0.32
Isun	13.80	1.18	0.53	59.83	71.17	0.84	0.45
Lapai-1	11.17	1.51	0.66	71.40	79.60	0.90	0.37
Mokwa-2	11.87	1.67	0.57	100.40	104.33	0.96	0.34
Odungbo	11.50	1.79	0.63	99.17	99.77	0.99	0.35
Ojigono	13.37	1.25	0.54	62.33	75.17	0.83	0.43
Oko Iyawo	12.57	1.39	0.56	70.00	75.50	0.93	0.40
Okonkwo local	11.90	1.82	0.63	79.70	79.87	1.00	0.35
Olekanga	12.80	1.34	0.51	74.70	75.63	0.99	0.38
Oyarugba	10.90	1.87	0.69	90.43	90.23	1.00	0.37
Panya Akpu	10.63	1.45	0.52	73.07	82.30	0.89	0.36
Rogo Gidan Dawa	10.33	1.41	0.54	91.03	91.57	0.99	0.39
Sulaje-4	10.93	1.65	0.58	90.67	90.27	1.01	0.35
2nd Agric	11.20	1.63	0.63	76.77	79.30	0.97	0.39
TMS 4(2)1425	12.30	1.42	0.53	70.00	76.77	0.91	0.37
TMS 81/00110	10.93	1.60	0.58	74.03	77.90	0.95	0.36
TMS 82/00058	8.97	1.49	0.55	78.77	81.10	0.97	0.36
TMS 82/00661	11.27	1.50	0.56	78.67	85.10	0.92	0.37
TMS 30572	10.83	1.77	0.53	83.9	84.63	0.99	0.31
TMS 50395	10.00	1.60	0.62	81.40	83.97	0.97	0.38
TMS 91934	11.27	1.40	0.54	85.03	85.97	0.99	0.39
Mean	12.00	1.45	0.56	78.34	84.02	0.93	0.38
CV %	7.53	7.83	7.89	4.43	4.50	2.37	7.18
LSD(0.05)	1.47	0.19	0.07	5.65	6.15	0.04	0.04

Appendix 1d. Mean cutting characteristics of the 40 cassava genotypes grown at Kuru in 1994

Genotype	number of nodes	stake girth	pith diameter	stake weight	stake volume	bulk density	pith wood
Abachaji	10.70	1.79	0.57	102.83	103.67	0.99	0.32
Adabo Ozi	11.83	1.59	0.55	93.70	101.4	0.93	0.35
Amala	12.07	1.51	0.55	67.90	76.00	0.89	0.37
Anedo	13.70	1.18	0.55	72.00	75.83	0.96	0.47
Antiota	10.73	1.73	0.54	105.33	101.67	1.04	0.31
Atu Iwo	13.83	1.26	0.46	66.93	74.50	0.90	0.36
Bagi Wawa	13.47	1.42	0.45	73.50	80.80	0.91	0.32
Bakin Iri	13.90	1.21	0.55	69.17	75.07	0.92	0.46
Bakin rogo	13.07	1.17	0.41	61.83	70.97	0.87	0.35
Chika mutu	13.53	1.15	0.51	74.13	79.80	0.93	0.44
Dakata Uwar'	13.93	1.06	0.47	63.73	75.27	0.84	0.44
Dan aziki	11.33	1.41	0.51	85.17	86.27	0.99	0.36
Dan dualla	13.33	1.14	0.47	65.70	79.67	0.82	0.41
Dan Kporo	11.50	1.71	0.56	97.33	97.67	1.00	0.33
Danwaru-1	10.83	1.09	0.47	70.23	79.83	0.88	0.46
Darazo Rogo	15.87	1.06	0.45	64.17	75.60	0.85	0.43
Doya	15.00	1.31	0.52	39.70	71.27	0.56	0.39
Okura	12.70	1.44	0.54	64.90	80.67	0.80	0.37
Ewete Ihe	12.40	1.41	0.52	61.00	70.43	0.87	0.37
Ilorin Rogo	14.27	1.32	0.46	89.30	93.80	0.95	0.35
Isun	12.67	1.51	0.59	64.53	69.70	0.93	0.39
Lapai-1	11.40	1.50	0.59	70.70	77.60	0.91	0.39
Mokwa-2	12.60	1.74	0.63	78.50	78.10	1.01	0.36
Odungbo	10.63	1.67	0.61	100.00	99.30	1.01	0.37
Ojigono	13.77	1.34	0.55	60.50	69.67	0.87	0.41
Oko Iyawo	12.57	1.24	0.46	53.50	63.60	0.86	0.37
Okonkwo local	12.77	1.71	0.56	83.70	84.17	0.99	0.33
Olekanga	12.77	1.99	0.63	75.57	78.10	0.97	0.32
Oyarugba	13.70	1.95	0.62	111.83	121.33	0.92	0.32
Panya Akpu	10.60	1.22	0.48	77.00	78.93	0.97	0.39
Rogo Gidan Dawa	10.00	1.13	0.49	88.67	89.67	0.99	0.30
Sulaje-4	10.23	1.95	0.68	88.33	90.10	0.98	0.35
2nd Agric	11.93	1.29	0.59	74.33	76.17	0.98	0.46
TMS 4(2)1425	12.20	1.26	0.50	71.73	79.87	0.90	0.40
TMS 81/00110	12.50	1.63	0.54	72.94	76.93	0.95	0.33
TMS 82/00058	12.40	1.46	0.52	75.87	79.50	0.96	0.36
TMS 82/00661	10.83	1.27	0.52	84.17	82.67	1.02	0.41
TMS 30572	10.70	1.67	0.67	95.80	94.77	1.01	0.40
TMS 50395	12.57	1.70	0.60	79.83	85.37	0.93	0.35
TMS 91934	7.44	1.57	0.46	80.51	81.00	0.99	0.30
Mean	12.31	1.44	0.53	76.91	82.67	0.93	0.38
CV %	10.61	8.75	10.96	5.22	5.76	4.45	13.21
LSD(0.05)	2.12	0.21	0.10	6.53	7.75	0.07	0.08

Appendix 1e. Mean cutting characteristics of the 40 cassava genotypes grown in 4 locations in 1994

Genotype	number of nodes	stake girth	pith diameter	stake weight	stake volume	bulk density	pith wood
Abachaji	10.83	1.83	0.57	107.89	107.42	0.93	0.31
Adabo Ozi	10.63	1.73	0.60	103.46	104.35	0.99	0.35
Amala	12.38	1.55	0.56	73.06	79.46	0.92	0.36
Anedo	13.12	1.20	0.54	70.93	80.04	0.89	0.45
Antiota	10.77	1.82	0.56	109.68	105.33	1.05	0.30
Atu Iwo	13.61	1.22	0.46	72.06	78.98	0.91	0.38
Bagi Wawa	12.91	1.47	0.52	84.70	87.52	0.97	0.36
Bakin Iri	12.73	1.42	0.55	76.00	79.53	0.95	0.40
Bakin rogo	14.66	1.17	0.47	63.19	74.25	0.85	0.41
Chika mutu	13.92	1.29	0.50	75.21	82.59	0.91	0.40
Dakata Uwar'	14.21	1.23	0.53	66.83	76.82	0.87	0.43
Dan aziki	11.08	1.60	0.55	87.01	88.08	0.99	0.35
Dan dualla	14.18	1.16	0.48	64.32	78.21	0.82	0.42
Dan Kporo	11.54	1.72	0.56	101.15	101.33	1.00	0.33
Danwaru-1	10.99	1.47	0.52	86.59	91.54	0.94	0.38
Darazo Rogo	14.39	1.19	0.50	66.53	76.38	0.87	0.42
Doya	13.76	1.30	0.53	66.54	78.88	0.84	0.41
Okura	12.74	1.52	0.63	61.05	75.42	0.81	0.41
Ewete Ihe	13.76	1.29	0.55	61.76	73.57	0.84	0.43
Ilorin Rogo	11.98	1.78	0.56	96.60	96.57	1.00	0.32
Isun	13.70	1.32	0.57	63.43	72.48	0.87	0.43
Lapai-1	11.18	1.41	0.52	73.24	77.57	0.95	0.37
Mokwa-2	11.44	1.74	0.61	96.40	97.17	1.00	0.35
Odungbo	10.88	1.76	0.57	104.54	101.93	1.03	0.33
Ojigono	12.98	1.31	0.55	67.18	73.74	0.91	0.42
Oko Iyawo	12.58	1.39	0.54	68.29	72.73	0.94	0.39
Okonkwo local	11.52	1.72	0.57	83.32	83.10	1.00	0.33
Olekanga	12.14	1.57	0.58	76.68	78.03	0.98	0.37
Oyarugba	11.20	1.94	0.67	100.03	101.98	0.99	0.34
Panya Akpu	10.87	1.33	0.48	76.14	79.44	0.96	0.37
Rogo Gidan Dawa	9.91	1.57	0.54	96.40	96.18	1.00	0.37
Sulaje-4	10.53	1.81	0.63	93.22	92.98	1.00	0.35
2nd Agric	11.47	1.52	0.58	76.70	77.38	0.99	0.38
TMS 4(2)1425	12.19	1.34	0.50	67.16	72.49	0.93	0.38
TMS 81/00110	11.20	31.53	0.56	72.25	76.23	0.95	0.37
TMS 82/00058	10.51	1.40	0.52	75.70	78.99	0.96	0.37
TMS 82/00661	11.18	1.38	0.52	84.88	86.11	0.99	0.38
TMS 30572	10.42	1.72	0.57	93.13	92.28	1.01	0.34
TMS 50395	10.86	1.60	0.57	81.99	83.70	0.98	0.36
TMS 91934	10.46	1.48	0.48	84.65	84.13	0.01	0.33
Mean	12.03	1.50	0.55	80.75	84.87	0.94	0.37
CV %	7.76	8.04	9.07	4.34	4.51	5.83	9.36
LSD(0.05)	0.75	0.10	0.04	2.81	3.07	0.04	0.03

Appendix 2a. Mean performance for growth parameters of the 40 cassava genotypes grown at Mokwa in 1994

Genotype	Number of stems	Number of Roots	Fresh weight of shoot	Fresh weight of root	Dry weight of shoot	Dry weight of root	Plant height
Abachaji	22.33	102.67	585.00	13.27	153.50	4.40	56.57
Adabo Ozi	22.00	104.00	650.00	18.73	350.08	6.23	67.03
Amala	17.00	65.33	698.33	9.07	257.27	2.20	56.3
Anedo	16.33	56.33	483.00	4.13	118.49	0.60	37.83
Antiota	22.33	91.67	911.00	11.87	311.57	3.40	60.63
Atu Iwo	16.67	63.67	750.67	6.87	194.62	2.47	56.87
Bagi Wawa	20.67	69.67	848.00	6.96	235.40	1.49	52.17
Bakin Iri	18.33	65.00	879.00	5.78	270.25	1.56	47.77
Bakin rogo	12.67	40.33	337.67	3.54	142.21	0.55	47.3
Chika mutu	17.33	63.00	425.67	5.313	105.83	1.33	46.97
Dakata Uwar'	14.33	41.00	497.67	2.94	139.67	0.42	50.20
Dan aziki	19.33	64.00	434.67	8.16	275.32	1.52	60.77
Dan dualla	14.67	39.67	231.67	2.33	61.97	0.30	40.73
Dan Kporo	23.67	97.67	836.00	10.33	524.67	2.70	56.43
Danwaru-1	20.33	71.00	576.33	5.66	298.59	1.76	53.57
Darazo Rogo	12.67	34.67	329.67	2.43	109.19	0.40	46.3
Doya	17.33	65.00	578.00	6.44	148.11	1.09	54.97
Okura	13.67	37.33	553.33	4.04	144.25	0.59	52.33
Ewete Ihe	11.67	34.67	138.33	4.617	44.40	0.89	52.07
Ilorin Rogo	23.00	95.67	838.67	7.79	417.20	2.19	60.37
Isun	12.67	44.00	320.67	3.78	67.59	0.51	54.23
Lapai-1	19.67	71.00	874.33	7.78	377.20	2.47	55.6
Mokwa-2	21.00	86.67	434.67	8.16	294.35	2.38	54.93
Odungbo	23.33	112	960.00	9.93	248.15	5.12	57.83
Ojigono	18.33	53.67	283.00	3.00	108.86	0.42	43.67
Oko Iyawo	20.67	70.33	816.33	7.89	235.15	2.27	47.5
Okonkwo local	19.67	94.33	463.33	9.16	138.53	1.60	46.43
Olekanga	19.33	74.67	865.33	10.31	288.81	2.17	50.10
Oyarugba	22.33	90.33	765.67	9.63	242.49	3.61	52.30
Panya Akpu	17.67	65.33	903.67	7.66	296.35	1.60	67.07
Rogo Gidan Dawa	20.67	115.00	1038.33	18.37	505.53	5.53	59.83
Sulaje-4	22.33	82.33	1034.00	8.70	352.65	2.61	64.43
2nd Agric	21.67	94.00	961.33	8.43	380.40	5.26	49.03
TMS 4(2)1425	17.33	50.33	343.33	4.88	149.12	1.48	57.17
TMS 81/00110	17.67	58.67	434.00	5.94	158.02	1.30	62.60
TMS 82/00058	18.67	66.00	640.33	5.46	216.63	1.30	63.43
TMS 82/00661	17.33	60.33	456.33	6.46	182.77	1.24	60.00
TMS 30572	21.33	158.33	1007.33	13.21	375.97	5.37	54.70
TMS 50395	18.67	112.00	895.67	14.93	236.85	6.33	59.67
TMS 91934	24.67	102.33	964.33	9.55	292.96	3.05	47.57
Mean	18.78	74.1	651.12	7.84	236.29	2.29	54.13
CV %	8.95	15.05	16.56	24.97	34.58	18.49	14.12
LSD(0.05)	2.73	18.13	175.31	3.18	132.83	0.69	12.42

Appendix 2b. Mean performance for growth parameters of the 40 cassava genotypes grown at Samaru in 1994

Genotype	Number of stems	Number of Roots	Fresh weight of shoot	Fresh weight of root	Dry weight of shoot	Dry weight of root	Plant height
Abachaji	18.33	113.00	303.33	19.53	88.88	9.73	53.47
Adabo Ozi	14.33	99.67	399.00	11.67	110.72	2.50	57.50
Amala	12.33	60.00	22.33	7.41	51.44	1.39	52.47
Anedo	14.00	60.67	144.00	6.77	39.67	0.94	37.40
Antiota	14.67	109.67	605.33	20.43	201.88	11.87	53.90
Atu Iwo	12.67	84.33	377.00	5.63	96.02	1.07	50.30
Bagi Wawa	11.33	94.00	360.33	11.27	97.64	2.88	54.00
Bakin Iri	14.67	73.67	559.67	7.71	138.18	1.26	45.60
Bakin rogo	11.67	52.67	329.00	5.90	62.73	1.49	41.37
Chika mutu	12.00	63.33	193.33	9.35	53.97	1.29	47.80
Dakata Uwar'	13.00	44.00	154.27	6.18	37.29	1.58	49.67
Dan aziki	16.00	102.33	345.00	10.57	88.07	2.20	58.97
Dan dualla	12.67	43.67	182.00	6.57	44.66	1.35	38.33
Dan Kporo	13.67	94.00	291.67	10.83	69.78	2.14	56.23
Danwaru-1	15.67	93.33	397.67	9.17	91.85	1.53	51.67
Darazo Rogo	11.67	56.33	110.93	4.98	26.36	0.64	43.33
Doya	17.67	68.67	218.33	6.35	59.07	1.08	48.63
Okura	11.67	54.67	173.00	6.60	44.32	1.01	51.87
Ewete Ihe	12.00	61.33	129.67	6.91	34.23	0.98	55.73
Ilorin Rogo	14.67	93.00	547.67	9.78	147.48	3.81	61.77
Isun	12.67	58.00	205.00	5.05	57.87	0.82	52.90
Lapai-1	13.33	90.33	322.33	9.69	90.07	1.86	52.47
Mokwa-2	14.67	79.33	256.00	9.77	67.89	2.31	47.00
Odungbo	15.00	114.33	445.67	22.90	159.47	11.73	58.17
Ojigono	17.67	114.33	142.67	4.58	31.16	1.76	39.30
Oko Iyawo	13.67	44.33	382.33	10.9	99.72	2.25	47.50
Okonkwo local	17.00	90.33	275.33	8.26	62.27	1.30	50.90
Olekanga	12.00	79.67	386.33	12.27	90.05	2.36	45.93
Oyarugba	15.33	89.67	302.00	15.37	74.60	4.05	43.17
Panya Akpu	16.33	91.00	270.67	6.92	70.64	2.03	66.03
Rogo Gidan Dawa	12.33	75.33	267.00	7.96	69.49	2.65	58.50
Sulaje-4	12.33	82.00	506.33	8.92	139.25	3.63	60.13
2nd Agric	16.00	77.00	231.00	11.70	58.33	2.98	51.47
TMS 4(2)1425	14.33	65.67	420.33	9.43	108.79	1.80	53.93
TMS 81/00110	11.33	78.67	298.00	7.50	76.83	1.56	60.37
TMS 82/00058	12.67	87.33	392.33	8.39	92.03	1.99	55.60
TMS 82/00661	15.00	107.33	525.00	15.67	151.96	6.02	51.47
TMS 30572	14.33	103.00	585.33	15.73	159.45	5.56	56.57
TMS 50395	14.33	135.33	420.33	16.6	141.83	6.54	55.73
TMS 91934	19.67	97.67	321.33	8.05	77.23	2.48	45.87
Mean	14.11	81.93	322.72	9.98	86.58	2.91	51.58
CV %	13.94	14.23	24.40	24.94	28.95	26.72	12.81
LSD(0.05)	3.20	18.96	127.98	4.05	40.75	1.26	10.74

Appendix 2c. Mean performance for growth parameters of the 40 cassava genotypes grown at Minjibir in 1994

Genotype	Number of stem	Number of Roots	Fresh weight of shoot	Fresh weight of root	Dry weight of shoot	Dry weight of root	Plant height
Abachaji	18.67	81.00	771.00	9.23	248.90	3.72	45.87
Adabo Ozi	18.00	81.33	845.00	8.57	358.00	3.47	53.20
Amala	12.67	56.33	691.70	8.87	191.97	3.42	48.87
Anedo	9.33	33.00	238.70	2.43	66.57	0.32	39.70
Antiota	21.67	89.33	915.30	12.93	360.20	4.92	53.63
Atu Iwo	16.67	64.00	66.97	6.87	174.58	2.59	40.83
Bagi Wawa	17.00	68.00	701.00	6.07	232.63	2.40	46.40
Bakin Iri	14.67	51.33	507.00	4.30	125.97	0.56	39.90
Bakin rogo	11.67	26.33	160.00	2.30	43.53	0.35	39.07
Chika mutu	15.00	50.33	377.00	3.07	108.60	0.48	42.30
Dakata Uwar'	16.00	42.33	157.00	3.07	37.40	0.41	48.93
Dan aziki	20.33	78.67	784.00	9.97	268.90	2.60	46.70
Dan dualla	12.33	35.33	220.00	2.13	71.17	0.30	42.90
Dan Kporo	21.00	89.67	841.70	10.00	411.07	3.77	50.93
Danwaru-1	17.00	64.33	470.00	4.33	129.03	2.37	44.80
Darazo Rogo	10.33	37.00	156.30	2.80	63.33	0.41	49.37
Doya	13.33	51.00	166.40	4.73	56.70	0.66	47.03
Okura	13.33	28.67	149.00	3.17	26.94	0.49	34.50
Ewete Ihe	13.67	36.33	232.70	3.13	40.70	0.47	41.27
Ilorin Rogo	20.22	88.00	1021.70	18.4	285.37	7.43	38.60
Isun	10.67	30.67	253.00	2.57	74.53	0.43	54.47
Lapai-1	17.33	69.00	764.00	6.53	266.83	1.18	45.73
Mokwa-2	18.33	69.33	672.00	8.60	191.73	3.12	58.90
Odungbo	23.33	99.33	913.30	10.73	199.33	4.64	60.63
Ojigono	15.00	50.67	311.00	2.83	54.53	0.44	37.57
Oko Iyawo	15.33	66.00	738.30	8.13	182.97	2.44	46.40
Okonkwo local	20.00	81.33	935.30	8.13	278.93	4.28	63.27
Olekanga	18.33	73.67	799.70	9.83	217.60	2.84	58.37
Oyarugba	22.33	103.67	832.30	10.17	206.80	4.06	51.50
Panya Akpu	18.67	64.00	872.00	7.37	245.03	3.03	43.87
Rogo Gidan Dawa	14.33	62.00	1043.30	8.03	267.67	3.60	55.47
Sulaje-4	18.33	76.33	931.30	8.17	320.00	2.35	56.93
2nd Agric	17.33	79.33	763.30	7.07	234.73	2.44	55.93
TMS 4(2)1425	17.33	64.67	607.30	6.50	175.53	1.83	40.23
TMS 81/00110	17.67	69.00	775.70	7.03	251.67	1.47	54.60
TMS 82/00058	18.00	65.00	659.30	5.37	190.90	2.28	46.73
TMS 82/00661	15.00	69.33	837.30	6.97	274.37	3.60	58.60
TMS 30572	21.33	136.67	1245.70	16.5	340.53	6.28	60.43
TMS 50395	18.33	85.33	771.00	10.13	192.50	2.69	53.03
TMS 91934	23.67	100.67	766.70	10.13	216.60	4.17	45.30
Mean	16.83	66.71	693.18	7.14	191.11	5.92	48.57
CV %	11.79	20.19	25.60	19.20	34.54	64.83	11.40
LSD(0.05)	3.23	21.89	265.87	2.23	107.31	61.96	9.00

Appendix 2d. Mean performance for growth parameters of the 40 cassava genotypes grown at Kuru in 1994

Genotype	Num-ber of stem	Num-ber of Roots	Fresh weight of shoot	Fresh weight of root	Dry weight of shoot	Dry weight of root	Plant height
Abachaji	18.00	66.00	173.00	10.03	26.70	3.61	36.13
Adabo Ozi	16.33	65.00	161.00	11.57	23.80	2.16	39.37
Amala	13.33	46.67	181.33	9.00	36.23	1.73	28.10
Anedo	11.00	39.33	76.40	8.33	20.56	1.24	23.03
Antiota	20.67	89.33	247.33	14.57	63.57	4.04	38.47
Atu Iwo	14.33	67.67	107.00	8.30	26.88	1.76	31.67
Bagi Wawa	14.67	68.33	119.00	9.70	30.37	1.75	34.73
Bakin Iri	12.00	43.33	57.40	5.17	17.46	0.84	31.47
Bakin rogo	12.67	42.00	49.73	4.70	12.73	0.74	22.73
Chika mutu	13.00	67.33	70.27	4.73	18.33	0.70	33.23
Dakata Uwar'	11.33	33.67	23.90	4.87	5.87	0.86	27.53
Dan aziki	17.33	70.33	129.67	9.37	35.06	2.06	34.93
Dan dualla	13.00	42.67	51.00	4.37	11.73	0.71	31.67
Dan Kporo	18.33	77.67	192.67	13.77	49.74	2.89	38.50
Danwaru-1	14.00	50.33	65.97	5.00	14.53	1.41	24.73
Darazo Rogo	10.00	29.67	57.03	3.67	14.28	0.55	24.73
Doya	16.33	55.67	49.23	5.27	13.87	0.83	25.93
Okura	12.00	35.67	38.07	4.90	10.45	0.74	23.93
Ewete Ihe	8.67	45.00	51.97	5.53	11.43	0.52	25.90
Ilorin Rogo	15.00	57.67	71.83	11.60	17.70	2.20	28.67
Isun	11.67	43.67	44.67	3.60	10.67	0.57	36.43
Lapai-1	16.67	73.00	91.43	9.53	22.58	1.91	35.20
Mokwa-2	15.33	74.67	99.63	5.30	25.86	1.05	33.20
Odungbo	20.00	93.67	170.00	10.20	47.18	1.94	35.83
Ojigono	17.33	14.00	62.50	4.57	17.95	0.77	29.6
Oko Iyawo	14.33	65.67	105.97	7.73	26.40	1.36	29.13
Okonkwo local	17.67	62.33	161.00	4.23	63.40	0.73	34.83
Olekanga	13.67	63.33	103.8	6.93	24.61	1.31	32.70
Oyarugba	22.67	81.33	136.03	10.9	40.29	2.12	39.73
Panya Akpu	15.33	76.67	71.37	9.13	19.26	1.70	35.40
Rogo Gidan Dawa	19.00	68.67	48.30	5.73	11.07	1.24	32.20
Sulaje-4	17.00	70.00	87.83	7.70	19.70	1.30	33.20
2nd Agric	13.67	87.67	125.67	15.67	33.12	2.70	34.00
TMS 4(2)1425	15.67	49.67	82.33	7.97	21.73	1.59	29.70
TMS 81/00110	13.67	58.00	103.97	9.53	27.16	1.78	40.80
TMS 82/00058	15.33	62.00	100.8	5.90	26.52	1.24	39.87
TMS 82/00661	14.00	68.67	151.07	7.57	44.74	1.45	38.57
TMS 30572	19.33	74.00	412.67	12.63	93.40	4.01	36.77
TMS 50395	15.00	62.67	75.37	9.80	20.19	2.00	36.20
TMS 91934	20.67	89.33	152.33	10.07	44.29	1.78	25.93
Mean	15.25	61.56	109.00	7.93	27.53	1.60	32.37
CV %	14.29	19.9	25.33	43.44	37.89	42.03	13.65
LSD(0.05)	3.54	19.92	44.89	5.60	16.96	1.09	7.18

Appendix 2e. Mean performance for growth parameters of the 40 cassava genotypes grown in 4 locations in 1994

Genotype	Number of stems	Number of Roots	Fresh weight of shoot	Fresh weight of root	Dry weight of shoot	Dry weight of root	Plant height
Abachaji	19.33	90.67	458.1	13.02	129.52	5.37	48.01
Adabo Ozi	17.67	87.50	513.8	12.64	210.65	3.59	54.28
Amala	13.83	57.08	448.4	8.56	134.23	2.18	46.43
Anedo	12.67	47.33	235.5	5.42	61.32	0.78	34.49
Antiota	19.83	95.00	669.8	14.95	234.31	6.06	51.66
Atu Iwo	15.08	69.92	476.1	6.92	123.03	1.97	44.92
Bagi Wawa	15.92	75.00	507.1	8.50	149.01	2.13	46.92
Bakin Iri	14.92	58.33	500.8	5.74	137.96	1.05	41.18
Bakin rogo	12.17	40.33	196.6	4.11	65.30	0.78	37.62
Chika mutu	14.33	61.00	266.6	5.62	71.68	0.95	42.58
Dakata Uwar'	13.67	40.25	208.2	4.26	55.06	0.82	44.08
Dan aziki	18.25	78.83	423.3	9.52	166.84	2.10	50.34
Dan dualla	13.17	40.33	171.2	3.85	47.38	0.66	38.41
Dan Kporo	19.17	89.75	540.5	11.23	263.89	2.88	50.53
Danwaru-1	16.75	69.75	377.5	6.04	133.51	1.77	43.69
Darazo Rogo	11.17	39.42	163.5	3.47	53.29	0.56	40.93
Doya	16.17	60.08	253.4	5.70	69.44	0.92	44.14
Okura	12.67	39.08	228.4	4.68	56.49	0.71	40.66
Ewete Ihe	11.50	44.33	138.2	4.55	32.69	0.71	43.74
Ilorin Rogo	18.17	83.58	620.00	11.89	216.94	3.91	47.35
Isun	11.92	44.08	205.80	3.75	52.67	0.59	49.51
Lapai-1	16.75	75.83	513.00	8.39	179.17	1.85	47.25
Mokwa-2	17.33	77.50	365.60	7.96	144.96	2.22	48.51
Odungbo	20.42	104.83	622.30	13.44	163.54	5.86	53.12
Ojigono	17.08	48.17	199.80	3.75	53.13	0.85	37.53
Oko Iyawo	16.00	73.08	510.70	8.26	136.06	2.08	42.63
Okonkwo local	18.58	79.42	458.80	7.45	135.76	36.6	48.86
Olekanga	15.53	75.33	538.80	9.84	155.27	2.17	46.78
Oyarugba	20.67	96.00	509.00	11.52	141.04	3.46	46.68
Panya Akpu	17.00	74.25	529.40	7.77	157.87	2.09	53.09
Rogo Gidan Dawa	16.58	80.25	599.20	10.02	213.44	3.26	51.50
Sulaje-4	17.50	77.67	639.90	8.37	207.90	2.47	53.68
2nd Agric	17.17	84.50	520.30	10.69	176.65	3.35	47.61
TMS 4(2)1425	16.08	57.58	363.30	7.20	113.79	1.68	45.26
TMS 81/00110	15.08	66.08	402.90	7.50	128.42	1.53	54.59
TMS 82/00058	16.17	70.08	448.20	6.28	131.52	1.70	51.41
TMS 82/00661	15.33	76.42	492.40	9.16	163.46	3.08	52.16
TMS 30572	19.08	118.00	812.80	14.52	242.34	5.30	52.12
TMS 50395	16.58	98.83	540.60	12.86	147.84	4.39	51.16
TMS 91934	22.17	97.50	551.20	9.45	157.77	2.87	41.17
Mean	16.24	71.08	430.51	8.22	135.38	3.18	46.66
CV %	12.07	17.11	24.73	29.64	40.08	59.95	13.22
LSD(0.05)	1.58	9.77	85.53	2.00	43.58	15.32	4.96

Appendix 3a. Mean severity scores of cassava genotypes to cassava mosaic disease (CMD) and Cassava bacterial blight (CBB) damage at Mokwa in 1994

Genotype	CMD (1MAP)	CMD (3MAP)	CBB (3MAP)
Abachaji	2.67	3.00	2.33
Adabo Ozi	2.67	2.67	2.67
Amala	1.00	1.33	2.0 0
Anedo	5.00	5.00	4.33
Antiota	2.00	2.00	3.00
Atu Iwo	1.00	1.33	2.00
Bagi Wawa	1.00	1.33	2.33
Bakin Iri	2.33	3.00	4.00
Bakin rogo	4.67	5.00	5.00
Chika mutu	4.33	3.67	4.00
Dakata Uwar'	4.00	4.33	3.33
Dan aziki	3.33	3.00	3.33
Dan dualla	4.33	4.33	4.33
Dan Kporo	2.67	3.00	2.00
Danwaru-1	4.33	3.67	3.33
Darazo Rogo	4.67	4.67	4.00
Doya	4.67	4.67	4.33
Okura	3.00	3.00	3.33
Ewete Ihe	3.00	3.00	4.33
Ilorin Rogo	2.67	2.67	2.33
Isun	4.67	4.33	3.33
Lapai-1	1.00	1.33	2.33
Mokwa-2	4.33	4.00	4.33
Odungbo	2.00	2.00	3.00
Ojigono	3.00	3.00	3.00
Oko Iyawo	1.33	2.00	3.33
Okonkwo local	4.00	3.67	3.67
Olekanga	1.33	1.33	2.33
Oyarugba	4.00	3.33	3.67
Panya Akpu	4.00	3.00	2.67
Rogo Gidan Dawa	3.00	3.00	3.00
Sulaje-4	3.00	3.33	2.67
2nd Agric	1.00	1.33	2.33
TMS 4(2)1425	2.67	2.33	2.33
TMS 81/00110	2.67	2.67	2.00
TMS 82/00058	2.67	2.00	2.00
TMS 82/00661	2.33	2.33	2.00
TMS 30572	2.00	2.00	2.33
TMS 50395	3.00	2.33	2.67
TMS 91934	3.67	3.67	3.00
MEAN	2.96	2.94	3.06
CV %	19.43	21.63	20.88
LSD(0.05)	0.94	1.02	1.04

Appendix 3b. Mean severity scores of cassava genotypes to cassava mosaic disease (CMD) and Cassava bacterial blight (CBB) damage at Samaru in 1994

Genotype	CMD (1MAP)	CMD (3MAP)	CBB (3MAP)
Adabo Ozi	4.00	4.33	3.67
Amala	1.00	1.00	2.00
Anedo	3.33	3.67	3.67
Antiota	2.00	2.33	2.67
Atu Iwo	1.00	1.33	2.00
Bagi Wawa	1.33	1.67	1.67
Bakin Iri	2.67	2.67	2.67
Bakin rogo	3.33	3.33	3.33
Chika mutu	4.00	4.00	3.00
Dakata Uwar'	4.00	3.00	3.00
Dan aziki	3.67	3.33	3.33
Dan dualla	3.00	3.00	3.00
Dan Kporo	2.33	3.00	2.67
Danwaru-1	3.00	3.00	3.00
Darazo Rogo	4.00	3.67	4.00
Doya	3.00	3.00	3.00
Okura	2.67	2.67	2.67
Ewete Ihe	3.00	2.00	2.00
Ilorin Rogo	2.67	3.00	2.00
Isun	3.00	3.00	3.33
Lapai-1	1.00	1.33	2.33
Mokwa-2	3.00	2.67	2.67
Odungbo	2.33	2.67	2.67
Ojigono	3.67	3.33	3.00
Oko Iyawo	1.00	1.00	2.00
Okonkwo local	3.33	3.33	3.33
Olekanga	1.33	1.00	2.00
Oyarugba	3.33	3.33	3.00
Panya Akpu	2.67	3.00	3.00
Rogo Gidan Dawa	3.00	3.33	3.00
Sulaje-4	1.67	1.67	2.00
2nd Agric	1.00	1.00	2.00
TMS 4(2)1425	200	2.00	2.00
TMS 81/00110	2.33	2.67	2.00
TMS 82/00058	2.33	2.67	2.33
TMS 82/00661	2.67	2.00	2.00
TMS 30572	2.33	2.00	2.00
TMS 50395	2.00	2.00	2.00
TMS 91934	3.00	3.00	3.00
MEAN	2.58	2.60	2.65
CV %	17.64	18.67	12.53
LSD(0.05)	0.74	0.79	0.54

Appendix 3c. Mean severity scores of cassava genotypes to cassava mosaic disease (CMD) and Cassava bacterial blight (CBB) damage at Minjibir in 1994

Genotype	CMD (1MAP)	CMD (3MAP)	CBB (3MAP)
Adabo Ozi	3.00	2.33	2.33
Amala	1.00	1.00	2.00
Anedo	4.00	4.00	4.00
Antiota	2.67	2.00	2.67
Atu Iwo	1.00	1.00	2.33
Bagi Wawa	1.00	1.33	2.33
Bakin Iri	3.00	3.00	3.67
Bakin rogo	3.67	3.33	3.00
Chika mutu	3.67	4.00	3.67
Dakata Uwar'	4.67	4.67	4.00
Dan aziki	3.00	2.33	2.33
Dan dualla	3.33	3.33	3.33
Dan Kporo	3.00	2.33	2.33
Danwaru-1	2.67	2.67	3.00
Darazo Rogo	4.00	4.00	4.67
Doya	3.00	3.00	3.00
Okura	3.00	3.67	3.33
Ewete Ihe	3.67	4.00	4.00
Ilorin Rogo	3.00	3.00	3.00
Isun	4.33	4.00	3.33
Lapai-1	1.00	1.00	2.33
Mokwa-2	3.33	3.00	3.00
Odungbo	2.67	2.00	3.33
Ojigono	3.33	3.33	4.00
Oko Iyawo	1.33	1.33	2.33
Okonkwo local	3.33	3.00	3.33
Olekanga	1.00	1.00	2.00
Oyarugba	2.67	3.00	2.67
Panya Akpu	3.00	3.00	3.00
Rogo Gidan Dawa	3.67	3.00	3.00
Sulaje-4	3.33	2.67	2.67
2nd Agric	1.00	1.00	2.33
TMS 4(2)1425	3.00	2.00	2.00
TMS 81/00110	2.67	2.00	2.00
TMS 82/00058	2.00	1.67	2.00
TMS 82/00661	2.00	2.00	2.00
TMS 30572	2.67	2.00	2.33
TMS 50395	2.67	2.33	2.33
TMS 91934	3.33	3.00	2.67
MEAN	2.79	2.60	2.85
CV	14.23	14.86	15.14
LSD(0.05)	0.65	0.63	0.70

Appendix 3d Mean severity scores of cassava genotypes to cassava mosaic disease (CMD) and Cassava bacterial blight (CBB) damage at Kuru in 1994

Genotype	CMD (1MAP)	CMD (3MAP)	CBB (3MAP)
Adabo Ozi	3.33	3.33	2.67
Amala	1.00	1.00	2.67
Anedo	4.00	4.00	3.67
Antiota	2.67	2.33	3.00
Atu Iwo	1.00	1.00	2.33
Bagi Wawa	1.00	1.00	2.67
Bakin Iri	3.00	3.33	3.67
Bakin rogo	3.00	2.67	3.00
Chika mutu	3.00	4.00	3.00
Dakata Uwar'	4.33	4.67	4.00
Dan aziki	3.33	3.00	2.67
Dan dualla	3.67	3.67	4.00
Dan Kporo	3.00	3.33	2.67
Danwaru-1	3.67	3.67	3.00
Darazo Rogo	4.00	4.00	4.00
Doya	3.33	3.67	3.33
Okura	3.33	3.67	4.00
Ewete Ihe	3.67	3.67	3.00
Ilorin Rogo	3.00	3.33	3.00
Isun	4.33	4.67	3.67
Lapai-1	1.00	1.00	2.33
Mokwa-2	4.67	4.67	3.33
Odungbo	2.67	2.00	3.00
Ojigono	3.67	3.67	3.33
Oko Iyawo	1.00	1.00	2.00
Okonkwo local	3.67	4.33	3.67
Olekanga	1.00	1.00	2.00
Oyarugba	3.33	4..00	3.00
Panya Akpu	3.33	3.67	3.00
Rogo Gidan Dawa	3.67	3.33	3.00
Sulaje-4	3.00	2.67	2.33
2nd Agric	1.00	1.00	2.33
TMS 4(2)1425	2.67	2.33	2.33
TMS 81/00110	2.33	2.00	2.00
TMS 82/00058	2.67	2.00	2.00
TMS 82/00661	2.67	2.33	2.00
TMS 30572	2.00	2.00	2.00
TMS 50395	2.67	2.33	2.00
TMS 91934	3.67	3.67	3.00
MEAN	2.88	2.9	2.89
CV %	17.15	18.78	14.3
LSD(0.05)	0.80	0.89	0.67

Appendix 3e. Mean severity scores of cassava genotypes to cassava mosaic disease (CMD) and Cassava bacterial blight (CBB) damage grown in 4 locations in 1994.

Genotype	CMD (1MAP)	CMD (3MAP)	CBB (3MAP)
Adabo Ozi	3.25	3.17	2.83
Amala	1.00	1.08	2.17
Anedo	4.08	4.17	3.92
Antiota	2.33	2.17	2.83
Atu Iwo	1.00	1.17	2.17
Bagi Wawa	1.08	1.33	2.25
Bakin Iri	2.75	3.00	3.33
Bakin rogo	3.67	3.58	3.75
Chika mutu	3.75	3.92	3.42
Dakata Uwar'	4.25	4.17	3.58
Dan aziki	3.33	2.92	2.92
Dan dualla	3.58	3.58	3.38
Dan Kporo	2.75	2.92	2.42
Danwaru-1	3.42	3.25	3.08
Darazo Rogo	4.17	4.08	4.17
Doya	3.50	3.58	3.42
Okura	3.00	3.25	3.33
Ewete Ihe	3.12	3.17	3.33
Ilorin Rogo	2.83	3.00	2.58
Isun	4.08	4.00	3.42
Lapai-1	1.00	1.17	2.33
Mokwa-2	3.83	3.58	3.33
Odungbo	2.42	2.17	3.00
Ojigono	4.42	3.33	3.33
Oko Iyawo	1.17	1.33	2.42
Okonkwo local	3.58	3.58	3.50
Olekanga	1.17	1.17	2.08
Oyarugba	3.33	3.42	3.08
Panya Akpu	3.25	3.17	2.92
Rogo Gidan Dawa	3.33	3.17	3.00
Sulaje-4	2.75	2.58	2.42
2nd Agric	1.00	1.08	2.25
TMS 4(2)1425	2.58	2.17	2.17
TMS 81/00110	2.50	2.33	2.00
TMS 82/00058	2.42	2.08	2.08
TMS 82/00661	2.42	2.17	2.00
TMS 30572	2.25	2.00	2.17
TMS 50395	2.58	2.25	2.25
TMS 91934	3.42	3.33	2.92
MEAN	2.85	2.79	2.92
CV %	18.62	19.47	16.18
LSD(0.05)	0.43	0.44	0.38

Appendix 4a. Mean squares of 22 characters of 40 cassava genotypes grown at Mokwa in 1994

	Mean squares due to		
	REP	GENOTYPE	ERROR
	2	39	78
Character	---------- df ----------		
Sprouting 7 DAP	20.83	187.69**	28.53
Sprouting 14 DAP	30.83	439.23**	66.73
Sprouting 21 DAP	30.00	789.74**	22.31
Sprouting 28 DAP	3.33	758.21**	81.72
Establishment	50.83	755.90**	27.76
Number of nodes	0.34NS	9.10**	0.56
Stake girth	0.018NS	0.31**	0.01
Stake pith girth	0.001NS	0.02**	0.002
Stake fresh weight	5.171NS	813.97**	6.92
Stake volume	1.78NS	472.16**	10.33
Bulk density	0.016NS	0.019**	0.009
Pith-wood ratio	0.0002NS	0.008**	0.0007
Number of shoots	62.71**	34.11**	2.83
number of roots	167.43NS	2158.40**	124.34
Fresh weight shoot	11801.63NS	194938.30**	11631.30
Fresh weight root	1.74NS	46.24*	3.83
Dry weight of shoot	22514.30*	40730.19**	6677.74
Dry weight of root	0.14NS	8.81**	0.18
Plant height	609.43**	142.00**	58.41
CMD 1MAP	0.98	4.38**	0.33
CMD 3MAP	2.41**	3.47**	0.39
CBB 3MAP	5.43**	2.10**	0.42

Appendix 4b. Mean squares of 21 characters of 40 cassava genotypes grown at Samaru in 1994

	Mean squares due to		
	REP	GENOTYPE	ERROR
	2	39	78
Character	df		
Sprouting 7 DAP	525.833	244.017**	96.774
Sprouting 14 DAP	40.00	435.021**	97.265
Sprouting 21 DAP	90.833	504.188**	81.432
Sprouting 28 DAP	80.833	441.859**	62.885
Establishment	465.833	479.466**	57.286
Number of nodes	3.909**	7.334**	0.407
Stake girth	0.0130NS	0.196**	0.018
Stake pith girth	0.008NS	0.006**	0.002
Stake fresh weight	59.196NS	773.880**	13.936
Stake volume	23.566NS	483.262	11.194
Bulk density	0.001NS	0.011**	0.001
Pith-wood ratio	0.001NS	0.008**	0.001
Number of shoots	1.758NS	12.930**	3.869
number of roots	4.608NS	1440.568**	136.027
Fresh weight shoot	6131.120NS	53237.726**	6198.57
Fresh weight root	4.846NS	57.547**	6.196
Dry weight of shoot	16.954NS	5145.675**	628.362
Dry weight of root	0.698NS	22.515**	0.605
Plant height	64.106NS	130.919**	43.653
CMD 1MAP	0.558NS	2.457**	0.208
CMD 3MAP	0.475NS	2.243**	0.236
CBB 3MAP	0.700NS	1.059**	0.11

Appendix 4c. Mean squares of 21 characters of 40 cassava genotypes grown at Minjibir in 1994

	Mean squares due to		
	REP	GENOTYPE	ERROR
	2	39	78
Character	df		
Sprouting 7 DAP	200.83	168.889**	41.004
Sprouting 14 DAP	373.33	441.004**	80.171
Sprouting 21 DAP	140.83	513.162**	23.739
Sprouting 28 DAP	63.33	569.551**	22.307
Establishment	115.83	648.803**	32.073
Number of nodes	0.24NS	5.664**	0.817
Stake girth	0.087NS	0.159**	0.014
Stake pith girth	0.04**	0.006**	0.002
Stake fresh weight	3.12NS	563.768**	12.06
Stake volume	3.81NS	273.399**	14.321
Bulk density	0.00NS	0.016**	0.0005
Pith-wood ratio	0.00NS	0.005**	0.005
Number of shoots	24.01NS	37.829**	3.94
number of roots	82.80NS	1652.379**	181.313
Fresh weight shoot	104846.39NS	262720.79**	26752.04
Fresh weight root	0.84NS	42.082**	1.879
Dry weight of shoot	43168.47**	30976.43**	4358.38
Dry weight of root	1406.21NS	1486.70NS	1452.87
Plant height	6.99NS	163.708**	30.68
CMD 1MAP	0.51NS	2.832**	0.158
CMD 3MAP	0.18NS	2.892**	0.149
CBB 3MAP	0.08NS	1.401**	0.186

Appendix 4d. Mean squares of 21 characters of 40 cassava genotypes grown at Kuru in 1994

	Mean squares due to		
	REP	GENOTYPE	ERROR
	2	39	78
Character	df		
Sprouting 7 DAP	205.833	183.568**	51.132
Sprouting 14 DAP	43.333	327.329**	77.521
Sprouting 21 DAP	303.333	352.137**	88.803
Sprouting 28 DAP	60.833	348.526**	50.577
Establishment	93.333	333.333**	36.923
Number of nodes	3.412	7.434**	1.705
Stake girth	0.005	0.205**	0.016
Stake pith girth	0.004	0.012**	0.003
Stake fresh weight	61.511	672.718**	16.134
Stake volume	6.571	399.547**	22.711
Bulk density	0.010	0.021**	0.002
Pith-wood ratio	0.003	0.007**	0.002
Number of shoots	22.575	29.056**	4.746
number of roots	162.608	807.425**	150.113
Fresh weight shoot	1532.051	14872.723**	762.611
Fresh weight root	49.163	30.652**	11.857
Dry weight of shoot	127.758	921.404**	108.853
Dry weight of root	2.365	2.379	0.451
Plant height	6.904	79.66**0	19.515
CMD 1MAP	0.133	3.206**	0.244
CMD 3MAP	0.100	3.986	0.297
CBB 3MAP	0.008	1.186**	0.171

Appendix 4e. Combined analysis of variance of 15 characters of 40 cassava clones grown in the four locations.

	Mean squares due to				
	Location	Rep(Loc)	GENOTYPE	G x E	ERROR
	3	8	39	117	312
Character	----------	----------	--df--	----------	----------
Sprouting 7 DAP	1466.875**	238.333	496.362**	95.935**	54.359
Sprouting 14 DAP	5687.431	121.875	1102.089	180.166	80.422
Sprouting 21 DAP	4849.722	141.25	1730.577	142.885	54.071
Sprouting 28 DAP	1941.875	52.083	1774.567	114.525	38.622
Establishment	2509.653	181.458	1900.08	105.807	38.51
Number of shoots	493.785**	27.763	83.814***	10.038**	3.846
Number of roots	9467.550**	104.363	4901.602**	385.722**	147.948
Fresh weight shoot	8287500.42	31077.80	321044.63**	68241.64**	11336.13
Fresh weight root	180.179	14.177	124.956	17.188	5.941
Dry weight of shoot	1092027.24	16456.87	43172.43	11533.76	2943.33
Dry weight of root	434.932	352.353	379.831	380.193	363.526
Plant height	11514.23	171.856	317.319	66.288	38.065
CMD 1MAP	3.372**	0.544	11.287**	0.53	0.236
CMD 1MAP	4.152**	0.79	10.736	0.618	0.268
CBB 3MAP	3.381**	1.554	4.293	0.485	0.219

Appendix 5 The soil physio-chemical properties of Mokwa, Samaru, Minjibir and Kuru location.

Soil characteristics	Mokwa	Samaru	Minjibir	Kuru
Texture Class:				
Clay %	8.0	8.33	3.1	8.53
Silt %	10.5	47.00	10.5	40..32
Sand %	81.5	44.67	86.5	51.26
Chemical properties:				
pH (H_2O) 1:1	5.9	7.13	6.47	5.70
Organic C (%)	0.65	1.74	1.21	
Nitrogen % (Kjel)	0.04	0.05	0.02	0.08
C/N ratio	17.00	17..3	18.2	
Available P (Bray-1)	5.28	2.76	6.21	1.70
Exchange calcium (meq/100 soil)	1.93	2.11	1.20	2.10
Magnesium (Meq/100g soil)	0.35	0.81	0.61	2.71
Potassuim (Meq/100 Soil)	0.15	0.22	0.07	0.16
Soduim Cmol(+)/kg	0.23	0.26	0.29	0.28
Copper (ppm)	0.53	0.56	0.58	0.49
Zinc	16.87	23.0	21.5	20..51
Manganese Acid Cmol(+)/kg	0.38	0.41	0.41	0.37
exchangeable Acid	0.33	0.35	0.38	0.36
ECEC	2.98	21..50	22.33	23.2

Appendix 6 Mean monthly weather summary for Mokwa 1994

Month	Temperature °C max	min	mean	Total rainfall mm	rainfall Days	Sunshine mean hr	RH mean %	Total evaporation mm	Wind speed mean km/hr	Solar radiation mJ m2/day	Soil temp (°C) at 30 cm depth
January	37	15	26	0	0	7	21	293	3	15	27
February	40	19	30	0	0	7	17	394	3	16	30
March	42	25	33	0	0	8	30	410	3	17	34
April	39	25	32	52	3	6	44	293	3	18	35
May	35	23	29	116	8	6	56	294	3	17	31
June	33	22	28	150	17	5	60	297	3	15	28
July	32	22	27	120	23	5	68	206	3	10	28
August	30	22	26	263	21	4	79	183	3	11	27
September	32	25	29	287	19	5	78	194	3	17	27
October	34	20	27	197	12	6	68	209	3	15	27
November	36	17	26	7	3	7	44	279	3	16	27
December	36	13	24	0	0	7	32	325	3	16	26

Appendix 7 Mean monthly weather summary for ABU farm Samaru 1994

Month	Temperature °C max	min	mean	Total rainfall mm	rainfall Days	Sunshine mean hr	RH mean %	Total evaporation mm	Wind speed mean km/hr	Solar radiation mJ m2/day	Soil temp (°C) at 30 cm depth
January	30	14	22	0	0	7	19	288	4	16	-
February	32	16	24	0	0	6	13	390	4	17	-
March	37	20	29	-	-	6	26	405	4	23	-
April	36	22	29	20	8	6	36	290	8	20	-
May	34	22	28	120	8	7	41		8	18	-
June	31	20	25	232	12	3	53	293	8	19	-
July	29	20	25	169	9	6	64	200	8	15	-
August	27	20	24	216	21	4	78	182	6	9	-
September	29	19	24	83	16	5	75	183	4	11	-
October	31	19	25	69	10	7	65	205	3	18	-
November	30	13	22	0	0	9	38	270	5	19	-
December	27	11	19	0	0	6	23	334	8	14	-

Appendix 8. Mean monthly weather summary for Minjibir 1994

Month	Temperature °C max	min	mean	Total rainfall mm	rainfall Days	Sunshine mean hr	RH mean %	Total evaporation mm	Wind speed mean km/hr	Solar radiation mJ m2/day	Soil temp (°C) at 30 cm depth
January	30	13	21	0	0	7	17	175	2	20	27
February	32	15	23	0	0	7	13	201	2	23	28
March	39	18	29	0	0	7	11	310	1	26	33
April	39	24	31	10	4	6	20	277	3	23	35
May	38	25	32	48	8	7	24	275	2	23	32
June	38	25	32	130	10	7	32	252	3	21	31
July	33	23	28	161	16	6	42	201	3	18	30
August	30	21	26	250	18	6	52	177	2	18	31
September	33	22	27	133	16	6	46	207	2	19	30
October	35	22	28	38	4	7	39	228	1	20	31
November	33	14	24	0	0	8	25	189	2	20	40
December	28	12	20	0	0	7	22	169	3	20	29

Appendix 9. Mean monthly weather summary for Kuru 1994

Month	Temperature °C max	min	mean	Total rainfall mm	rainfall Days	Sunshine mean hr	RH mean %	Total evaporation mm	Wind speed mean km/hr	Solar radiation mJ m2/day	Soil temp (°C) at 30 cm depth
January	22	12	17	0	0	5	78	293	3	19	22
February	24	14	19	0	0	6	74	314	3	19	22
March	28	26	27	0	0	6	82	386	3	19	27
April	24	18	21	133	13	5	90	171	3	16	26
May	24	18	21	218	17	6	72	96	2	15	23
June	22	17	20	188	25	4	92	61	3	15	21
July	20	17	19	275	17	4	93	53	3	13	21
August	20	17	19	304	24	4	94	37	3	10	18
September	21	17	19	216	16	4	88	55	3	10	23
October	24	16	20	54	8	5	66	110	3	17	24
November	24	13	18	0	0	5	62	227	3	19	23
December	21	12	16	0	0	-	80	314	3	19	22

Appendix 10

BIOGRAPHY

Name: Christian Chukwuma Okonkwo.

Date of birth: 15th July 1960 at Makurudi, Nigeria.

Business Address: International Institute of Tropical Agriculture (IITA)
PMB 5320 Oyo Road,
Ibadan, Nigeria.
Phone (243) 02-2412626 Extension 2319.

Home Address: No 10 Ibiam street, Uwani Enugu
Enugu State.

Institutions Attended:	From	To	**Certificate / Degree Obtained**
Central School Olo. Ezeagu LGA Enugu	1971	1975	First School leaving Certificate (FSLC).
Community Sec. School Olo Ezeagu LGA. Enugu.	1975	1979	West African School Certificate (WASC).
University of Nigeria, Nssuka.	1979	1984	Bachalor of Agriculture (B.Agric. Hons)

Posts Held: Teacher , Kano Ministry of Education 1985 -1989.
Research Assistance IITA 1989 to Date.

Year of Admission for graduate studies: 1993

Admission Number : Msc/Agric 5394/ 92-93.