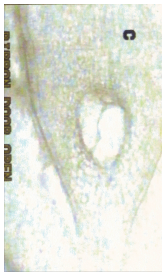

First International Meeting on Cassava Breeding, Biotechnology and Ecology

"Cassava improvement to enhance livelihoods in sub-Saharan Africa and northeastern Brazil"

Brasilia 11-15 November 2006

Organized by the University of Brasilia and The Ministry of Environment, Brasilia, Brazil

Prof. Dr. Nagib Nassar, Convener

Book of Abstracts

Rodomiro Ortiz and Nagib Nassar (eds.)

DEDICATION

To Dr. Sang Ki Hahn

To Dr. S.G. Nair

In recognition for their great contribution to cassava growers and consumers worldwide

First International Meeting on Cassava Breeding, Biotechnology and Ecology

Brasilia, November 2006

Citation

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First International Meeting on Cassava Breeding, Biotechnology and Ecology

General Information

Theme

Cassava improvement to improve livelihoods in sub-Saharan Africa and northeastern Brazil

Venue

Hotel San Marco, Brasilia, Brazil

Call for abstracts for the following sessions (*ID in brackets*)

1. Wild species and landraces to enhance nutritional value (*G, I, D*)
2. Management of reproduction and propagation systems *(B, G)*
3. Biotechnology tools and breeding methods (*B, D, I*)
4. Conservation and evaluation of genetic resources (*G*)
5. Cassava as a feed and for industry (*P*)
6. Ecology and ecosystems (*A*)

Program

Oral presentation and posters on the above subjects. Visit to the living collection of wild *Manihot* species, inter-specific hybrids and cassava landraces at the Univesidade de Brasilia. Visit to cassava plantations and projects around Brasilia

Registration and Abstract Submission

Registration of non Brazilians should reach on or before 30th July 2006. For Brazilians deadline is 31st July 2006. Fees are US$ 150 for non-Brazilian researchers; R$200 for Brazilians. Fees should be deposited in the account of the Fundação Universitaria de

Plenary Lectures (First Day)
[Code in brackets indicate relevant abstract for reference]

Cassava improvement in the tropics: a lesson from sub-Saharan Africa – Sang-Ki Hahn (special conference guest) (*M-01*)

Manipulation of cassava genetic resources for the crop improvement – Nagib Nassar (Brazil) (*G-01*)

Overcoming the challenge of cassava breeding in Asia – S.G. Nair (India) (*I-01*)

Potential of biotechnology and mutagenesis in genetic improvement of cassava – Shri Mohan Jain (Finland) (*B-01*)

Sequencing the cassava genome - a milestone for the Global Cassava Partnership – Claude Fauquet (USA) (*D-01*)

Development of QTL affecting starch content and storage root productivity in two F_1 populations of non-inbred parents in cassava –Wenquan Wang (China) (*D-02*)

Toxicity and detoxification of cassava bitter cultivars – Darna L. Dufour (USA) (*A-01*)

Invited Lectures (Second Day)
[Code in brackets indicate relevant abstract for reference]

Somatic embriogenesis and genetic transformation of Brazilian genotypes of cassava – Francisco Campos (Brazil) (*B-02*)

Comparison of methods for phenotypic adaptability and stability analysis of cassava genotypes for storage roots yield and dry matter content – Marcus Vinícius Kvitschal (Brazil) (*I-07*)

Resíduos de campos e da insustrializacao da mandioca: usos, tratamentos e potencialidade – Marney Pascoli Cereda (Brazil) (*P-01*)

Sistemas locais de conservação da diversidade da mandioca na amazonia – Laure Empraire e Fernando Mathias (Brazil) (*G-03*)

On-farm conservation of cassava diversity: a case from Vale do Ribeira, São Paulo, Brazil – Nevaldo Pironi (Brazil) (*G-05*)

Uncovering local understanding of cassava varietal selection at Koudandeng – Obala, Cameroon – Ntumngia Regina Nchang (*M-02*)

Contents

[1] This topic will be the included in the plenary talk by special conference guest Dr. S.K. Hahn

GENETIC RESOURCES

G-01: Cassava genetic resources and their manipulation for improvement of the crop

Nagib M. A. Nassar
Universidade de Brasilia, Brasilia, Brazil

Cassava wild relatives are perennial and vary in growth pattern from nearly acaulescent subshrubs to small trees. They have been used as a source of useful characters such as high protein content, apomixis, resistance to mealybug and mosaic disease and tolerance to drought. Cultivars ensue from cassava interspecific hybrids with the wild relative *M. glaziovii* are cultivated now in about 4 millions hectares in Nigeria. Indigenous clones are potential source of b-carotene and lycopene. Apomixis genes have been transferred successfully through interspecific hybridization to the crop, and apomictic clones arising from these hybrids are being now grown at the Universidade de Brasilia. Interspecific hybrids produced early have been polyploidized and have their fertility restored. Different useful types of chimera were also produced.

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G-02: Conservation and evaluation of cassava genetic resources

Y. Atoyebi
Nigeria

Effective conservation of genetic resources required a comprehensive understanding of genetics. Most conservation works are been carried out in situ for recalcitrant germplasm and forest species; while ex situ conservation maintains the accession without change as regards its genetic constitution. Most of these ex - situ collections of plant germplasm centre their efforts around a given crop, and most work is conducted at the species or population (accession) level. However, a comprehensive understanding also includes other organizational levels, from ecosystems through cellular and molecular levels, which address issues such as species identity, relatedness, structure and location of desired gene; that existed in both the short- and long-terms, base collection (in the genebank). Depending on the method employed however, it is designed to minimize the possibility of changes accruing through erosion mainly due to the destruction of ecosystems and habitats by human activities. However, with novel biotechnological tools, it is quite easier to know the amount and the extent of the distribution of genetic variation that existed within and inter-species of germplasm, which is a necessary tool for effective conservation strategies. The amount of variation can be very different within species and between different populations of a species and there can be also large differences in the distribution of particular characters or groups of characters. With tissue culture through nodal cutting or meristem, diseases-free cassava plantlet can be conserved *in vitro* in the laboratory for about four weeks, depending on the agar medium, which can later be transferred to the field, after due acclimatization in the chamber. This micro-propagation method can successfully be employed to produce millions of plantlets to be distributed to farmers for increased cassava production. Also application of molecular markers such as simple sequence repeat, Random amplified polymorphism DNA, single Nucleotide polymorphism and diversity array technology are good enough techniques to study plant (cassava) diversity, so as to discover useful genes necessary for crops improvement programs.

G-03: Sistemas locais de conservação da diversidade da mandioca na Amazônia

Laure Emperaire[1] and Fernando Mathias[2]
[1]*IRD.* [2]*ISA, Brazil*

A mandioca é representada na Amazônia, principalmente na região do Alto Rio Negro, por um imenso leque de variedades. O manejo desta diversidade apóia-se de um lado sobre um conjunto de saberes e práticas extremamente detalhados, e de outro sobre redes de troca de germoplasma. A circulação do germoplasma em redes sociais constitui-se em uma estratégia local de conservação da diversidade agrícola cujas dimensões sociais e ambientais são fundamentais para a manutenção da diversidade local. Esses sistemas agrícolas, produtores de uma importante diversidade agrícola, devem ser objeto de políticas e instrumentos legais de reconhecimento cultural que por um lado os animem e estimulem, respondendo às expectativas e demandas locais, e por outro impeçam a privatização, através de mecanismos de propriedade intelectual, de conhecimentos locais e objetos biológicos (principalmente patentes e registro de cultivares). Nesse sentido, instrumentos ligados ao reconhecimento do patrimônio imaterial e à valorização de produtos locais frutos desses sistemas podem ser passos interessantes para alcançar um sistema sui generis de proteção de conhecimentos ligados a sistemas agrícolas locais e sua diversidade genética associada.

G-04: Dynamic conservation of *Manihot flabellifolia* Pohl

Rui Mendes
Brazil

About 70% of wild species of *Manihot* are from Brazil. They are concentrated at the *Manihot* quadrilateral between 15° and 35º South and 35º and 55º West. They go from small shrubs measuring less than 0.1 m to tall trees or creepers reaching 12 m. Many species are threatened and a small number of plants are growing in this new environment. It is very difficult to keep the *in situ* populations growing far from official conservation areas. Many of these *Manihot* species –which can be used for cassava genetic enhancement, have important traits, such as tolerance and resistance to insects and diseases, and to environmental factors. *M. flabellifolia* is regarded as the gene source of today's cassava cultivars and landraces. A dynamic collection strategy was therefore set up to conserve its germplasm. This collection shows links to natural processes associated to species evolution, thereby making the appearance of new genotypes on the field possible as a result of open pollinated (OP) seeds. Such seeds drop down and can germinate, which leads to new plants from the same species but adapted to the environment where they are growing. Dynamic conservation enables the progressive evolution of a new population. By handling the dynamic collection, it is possible to assess and use this germplasm in the field throughout the years. Plants identified as resistant to insects and diseases could be found more quickly by observing the plants in the field. The biodiversity and genetic resources of *M. flabellifolia* and others *Manihot* species should be preserved by *in situ* and *ex situ* methods.

G-05: Divergência genética entre cultivares de mandioca-de-mesa coletadas no município de Cianorte, região Noroeste do Estado do Paraná

Gisele Cristina Zuin, Pedro Soares Vidigal Filho and Marcus Vinicius Kvitschal
Universidade Estadual de Maringa, Brazil

O objetivo do presente estudo foi avaliar a divergência genética entre 43 cultivares de mandioca-de-mesa coletadas na zona urbana de Cianorte, noroeste do Paraná, mediante a utilização de características botano-agronômicas. A avaliação da divergência foi realizada mediante o emprego do método de otimização de Tocher, com base na distância generalizada de Mahalanobis. A matriz de Mahalanobis indicou que a menor divergência genética foi observada entre os acessos UEM 67 e UEM 71 (0,51%), e entre UEM 71 e UEM 74 (0,75%). Por sua vez, a maior divergência foi observada para as combinações entre os acessos UEM 35 e UEM 173 (55,28%), entre UEM 127 e UEM 173 (54,83%), e entre UEM 85 e UEM 127 (54,25%). O método de otimização de Tocher propiciou a formação de 11 grupos, sendo que o grupo I concentrou o maior percentual de genótipos (46,5%), enquanto que o menor percentual foi observado nos grupos VIII, IX, X e XI (2,32%). A largura de lóbulos foliares (34,03%) e a altura da primeira ramificação (28,93%) foram as características que mais contribuíram para explicação da divergência genética, enquanto que a distância de entrenós (4,32%) e o comprimento de pecíolos (6,88%) foram as características que menos contribuíram.

G-06: On-farm conservation of cassava diversity: A case study from Atlantic Forest, São Paulo State, Brazil

Nivaldo Peroni
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A better understanding of traditional management systems of plant genetic resource is required to enhance on-farm intra-specific diversity. In crop species like cassava, traditional management systems are especially important because of its propagation system. Research on farmers' management practices associated to cassava diversity at species and cultivar levels makes a strong case for studying and developing options for genetic enhancement of local genetic diversity. Using population genetics and ethno-botany within an interdisciplinary structure of participatory research, the diversity and the genetic structure of cassava were evaluated. After sampling 34 households of traditional human communities in the Atlantic Forest, 58 local cultivars were identified as either sweet (*aipim*) or bitter cassava (*mandioca-brava*). The average genetic diversity (H_S= 0.654) ensuing from micro-satellite markers analysis was higher for the sweet than for the bitter cultivars (0.582). The genetic differentiation coefficient (R_{ST}), used to estimate the diversity among the groups, was of 0.057 ($P < 0.001$), which indicates a low divergence between the two cultivar groups. The correlation between the morphological and genetic distances was low, and the congruence was high when ethno-classification and genetic structure were analyzed. The advantages on the use of sweet cultivars, the current socio-economic changes in the use of cassava, and the ecological history of both groups of cultivars were also assessed. Farmers' perception, knowledge and traditional management practices are embedded in their strategies for maintaining autonomy over their livelihood and securing their natural and biological resources. It is important to understand how to guarantee and support the traditional or indigenous crop genetic diversity management practices, which will result in the continued and enhanced generation of new cassava cultivars.

G-07: Phenotypic diversity of cassava in Ethiopia: its implication for food security and the need for biotechnology research

Amsalu Nebiyu
Jimma University College of Agriculture, Department of Horticulture
PO Box 1316, Jimma, Ethiopia

Thirty-six germplasm accessions of cassava representing IITA gene pool and Ethiopian landraces were assessed using qualitative and quantitative characters contributing to morphological diversity at Jimma Agricultural Research Center during 2002-2003 cropping season. The minimum descriptor lists of the International Cassava Germplasm Network and the International Plant Genetic Resources Institute were adopted in the study. Analysis of variance for quantitative characters indicated significant ($P < 0.05$) variations among the accessions for majority of the characters except plant height, number of main stems, stem girth and storage root length. Cluster and distance analyses of quantitative characters based on multivariate analysis pointed out to the existence of six morphologically divergent groups. The clustering pattern of germplasm accessions was found not necessarily related to geographical origin and genetic diversity. The maximum distance was observed between clusters V and VI ($D^2 = 722.93$) while the minimum was between clusters II and I ($D^2 = 33.41$). The present study indicated a considerable amount of variability for most of the characters of interest in cassava for exploitation towards strengthening the food security system of the country. Nevertheless, the need for confirmation of the conventional diversity analysis approaches through advanced tools of biochemical and molecular approaches, and broadening of the genetic base for strengthening cassava improvement strategy are suggested.

G-08: Evaluación de rendimiento y calidad en el Banco de Germplasma de yuca del INIA-Anzoátegui

L. Vaccarino, J. Montilla and D. Torres
INIA-Anzoátegui, El Tigre, Estado Anzoátegui

El Banco de Germoplasma de yuca representa una importante reserva de variabilidad genética de evaluación con fines de selección y mejoramiento para la obtención de nuevos cultivares. Las 60 entradas pertenecientes al Banco de Germoplasma de yuca se vienen evaluando bajo criterios morfológicos, moleculares, fitosanitarios, productivos y de calidad. Esta línea de investigación tiene como finalidad evaluar y mantener estos recursos fitogenéticos con el objetivo de incrementar el rendimiento y la calidad de las raíces. Las entradas fueron plantadas en parcelas individuales de 36 m^2, con una densidad de 10,000 plantas ha^{-1}. Las prácticas empleadas para su manejo, correspondieron a las recomendadas por el INIA para la localidad. A los 12 meses, durante los ciclos de plantación 2001-2002, 2002-2003 y 2003-2004, se evaluaron el peso de las raíces por planta (kg), la materia seca y el contenido de almidón (%). Se obtuvieron promedios y valores de medidas de dispersión de las diferentes variables evaluadas. Los resultados obtenidos durante evaluaciones de tres años, señalaron que las entradas 9807RN, Negrita-D, CM-523-7, 9836C y Cachipo presentaron altos pesos de raíces (2.63 kg, 2.32 kg, 2.21 kg, 2.16 kg y 2,09 kg respectivamente). No obstante la más alta materia seca se encontró en las entradas INIA-2000, Tres Brinco, Cachipo, Blanquita, y Lancetilla II (38.7%, 36.5%, 35.2%, 35.2%, y 35.1%, respectivamente). Las entradas seleccionadas, serán utilizadas para el inicio de un programa de evaluación y selección multi-local.

G-09: Transfer to, and preliminary evaluation of the CIAT cassava core collection in Thailand

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In 2001, CIAT and the Department of Agriculture of Thailand agreed to establish a duplicate of the CIAT cassava core collection, presently held in trust for FAO at CIAT headquarters in Colombia, for safe keeping and utilization in Thailand. Thus, from 2002 to 2005, the Rayong Field Crops Research Center (RFCRC) got 12 batches of *in vitro* plants with two tissue culture tubes of each clone. RFCRC has now received the total core collection of 628 accessions, which comprises most of the genetic variability of the crop. After arrival in Thailand, these plants have been sub-cultured and all accessions are being preserved at RFCRC. For the *in vitro* collection, ten plants of each clone are being maintained in tissue culture. After multiplication, the remaining plants have been transferred to the greenhouse, and then, after hardening, to the field. Currently, 115 accessions have been evaluated in the field for yield and other traits. Of these, 25 accessions were identified with very high yield, 8 accessions with high starch content, 30 accessions with good resistance to diseases (mainly cassava bacterial blight or CBB), and 13 accessions with good resistance to pests (mainly red spider mite). A total of 8 accessions had more than 30% crude protein leaf content. In the short term, the beneficial effects generated by the new germplasm can directly benefit the many small cassava farmers in the country.

G-10: Amino acids profile in cassava and an interspecific hybrid

Marcelo Vale de Souza and Nagib M. A. Nassar
Universidade de Brasilia, Brasilia, Brazil

Cassava roots have low protein content (0.7-2%). Amino-acids such as lysine and methionine are also low, whereas some research reports indicated the absence of methionine. The amino-acid profile of a cassava common cultivar and an interspecific hybrid -namely ICB 300, were analyzed by the computerized apparatus Hitachi L-8500. The interspecific hybrid has 10-times more lysine and 3-times more methionine than the common cassava cultivar: lysine content was 0.010 g per 100 g in the common cassava cultivar while it reached 0.098 in the interspecific hybrid. Methionine in the common cassava cultivar was 0.014 g per 100 g whereas it reached 0.041 g per 100 g in the interspecific hybrid. Total amino acid content in the common cassava cultivar was 0.254 g per 100g viz. a viz. 1.664 g per 100g in the interspecific hybrid. This genetic variability of the amino acid profile and quantity indicates the feasibility of selecting interspecific hybrids that are rich in both crude protein and amino acids.

G-11: Carotenoids in cassava indigenous clones and an interspecific hybrid*

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Vitamin A deficiency results in progressive eye damage. It is a serious problem in the northern and northeastern Brazil. Screening of some cassava clones and interspecific hybrids for its precursors revealed high level of lutein and trans-β-carotene in roots of the indigenous Brazilian clone UnB 400, which is popularly known by Amarela. Its roots reach 236 and 1.24 mg g^{-1} respectively combined with an excellent palatibility. The leaves of an interspecific hybrid of cassava with *M. oligantha* had 9108 mg kg^{-1} viz. a viz. 780 mg kg^{-1} lutein of common cassava cultivars.

G-12: Incidencia de enfermedades en el banco de germoplasma de yuca del INIA-Anzoátegui

Jenny Chirinos, Luis Vaccarino and Joan Montilla
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El banco de gemoplasma de yuca representa una importante fuente de variabilidad genética, el cual puede ser evaluado y empleado con fines de selección y mejoramiento para la obtención de cultivares adecuados a los requerimientos del sector productivo de la zona. Las enfermedades es uno de los factores que mayor daño causan a este cultivo. En este Banco de Germoplasma de yuca se vienen evaluando desde hace tres año la incidencia y severidad de las enfermedades presentes con el fin de seleccionar aquellos materiales tolerantes a las mismas. Se evaluaron 60 materiales, los cuales han sido sembrados en parcelas de 36 m^2 c/u, con una separación de 1 m entre hilera y 1 m entre plantas. Las evaluaciones se realizaron quincenalmente por un período de 36 meses. Las enfermedades que tuvieron mayor incidencia y severidad fueron añublo bacteriano (*Xanthomonas axonopodis* pv. *manihotis)* con un 90% de incidencia, mancha parda (*Cercoporidium henningsis)* con 50% y el añublo pardo (*Cercospora viscosae*) con 20%. En conclusión se encontró que todos los cultivares fueron susceptibles a la bacteriosis, pero los mas tolerantes fueron 98102 spc, 165-7, 9804rr, 988 spc, y 9852 s.

G-13: Indigenous cassava clones as a new source of lycopene

Osmindo Rodrigues Pires Junior[1], Carla Simone Vizzotto[1], Carlos Alberto Schwartz[1] and Nagib M.A. Nassar[2]

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Indigenous cassava clones acquired through their domestication a large diversity in relation to many economic traits such as high content of carotenoids and excellent palatability among other characters. One of these clones, which has been grown by indigenous Brazilian farmers and now being maintained in the Universidade de Brasilia gene bank, showed a high level of lycopene content (5 mgm per kilogram viz. a viz. zero in common cultivars, and 12-20 mgm kg^{-1} in tomato, a lycopene- rich crop). This is the first report of a cassava clone rich in lycopene.

G-14: Genetic variability of cassava germplasm from an *in situ* mini-bank in a Yawalapiti village

Larissa Lemos Mendanha Cavalcante, Fábio de Oliveira Freitas and Ana Yamaguishi Ciampi

Embrapa Recursos Genéticos e Biotecnologia, Brazil

Cassava is the staple food of the Yawalapiti tribe, living in the Parque Indígena do Xingu (the State of Mato Grosso, in the south of Brazilian Amazonia), and is present in great variety in the village. This research portrays a grower who cultivates a distinct form of the crop, which forms the base of a ritual dedicated to the "cassava spirit" (kukurro). The plantation is prepared with two large mounds of earth where all the cassava types are kept. With such a variety of cassava types concentrated in a small area, the potential for recombination is increased, where the mounds form an *in situ* mini-genebank. RAPD (Random Amplified Polymorphic DNA) is a type of molecular marker that permits analysis of genetic variability in natural populations and genebanks. This research used RAPD to analyse the genetic variability of the cassava in this indigenous collection. Leaf material was collected from five individual offspring from cassava seed and two samples of a plant from each of the two mounds under vegetative propagation. After the extraction and quantification of the cassava DNA, the samples were amplified by PCR, using RAPD primers. The analysis of the polymorphism of the RAPD markers showed a similarity of 80% among the individuals from vegetative propagation and 50% among the individual offspring from seed. These preliminary results indicate that the genebank will have to be enriched. However, for a more representative sampling, a new collection and analysis are underway.

BREEDING

I-01: Overcoming challenges for cassava improvement in Asia

S.G. Nair
Central Tuber Crops Research Institute, Trivandrum, India

Cassava is cultivated in a wide range of agro-climatic zones in Asia varying from the tropical equatorial region in Indonesia and Malaysia to the semi-temperate region of Guandong in southern China. In India, the crop is generally cultivated in the tropical belt, where the annual rainfall varies from 600 to 3000 mm. Cassava is predominantly cultivated as a rainfed crop in India as in the rest of Asia. However, in the plains of Tamil Nadu in India, cassava is grown as an irrigated crop and has recorded the highest yields. Biotic stresses are minor in Asia, except in India where cassava mosaic disease (CMD) caused by Indian Cassava Mosaic Virus (ICMV) has become rampant leading to reduction in yield and starch turnover under severe symptom expression. Cassava is utilized in food, feed, and as raw materials for the industry in Asia. In Indonesia and southern India, especially in Kerala, it is consumed in raw form. It is used in processed form (sago and starch) throughout the country. The largest share (60%) of the tuberous root produced in Asia is used as animal feed and as raw materials for the industry. More recently the demand for cassava leaves increased because the feed industry uses instead of imported legumes such as alfalfa, thereby reducing production cost through import substitution. The challenges for cassava crop improvement in Asia refer to production, processing and utilization, and genetic enhancement undertakings should aim:

- Breeding stable cultivars in starch content and yield across seasons and locations
- Selecting suitable cultivars to specific location and cropping systems
- Developing diseases resistant cultivats with better yield, starch content and culinary qualities
- Enhancing nutrient content by incorporating protein and carotene, and reducing cyanogens
- Releasing new cultivars for the processing industry having easy pealability, less post-harvest deterioration, and native starch qualities suitable for different value addition processes

I-02: Recent trends in cassava breeding in India

S G. Nair* and M. Unnikrishnan
Central Tuber Crops Research Institute, Trivandrum, India

Cassava along with maize, sugarcane and rice, constitute the most important sources of energy in the diet of tropical countries in the world. Cassava is rapidly emerging as a crop of considerable importance in India. Kerala and Tamil Nadu account for about 80% of the total acreage of the crop in India. India possesses the highest national tuberous root yield in the world (27.6 t ha^{-1}). It is cultivated in an area of 0.2 million ha producing 5.5 million t of tuberous roots. Besides being important in human diet in Kerala, cassava provides cheap nutritious feed for livestock as well. Its tuberous roots have innumerable industrial uses also, particularly for starch extraction. Though cassava is under cultivation in India for more than one and a half century, systematic research in this crop was lagging until about 1940 when certain research projects were started in the Department of Botany of the University of Travancore. In 1951, cassava research was considerably expanded under a scheme jointly funded by the Indian Council of Agricultural Research and the Government of Travancore-Cochin. During the third 5-year plan, the Tuber Crops Research Institute was established in 1963 by the Government of India for intensification of research on the improvement of root and tuber crops. The approaches to cassava breeding at Central Tuber Crops Research Institute (CTCRI) in Trivandrum involved the use of familiar tools of introduction, assay, selection, intervarietal, and interspecific hybridization, production of chromosomal races, genome approach, mutation breeding, tissue culture. A diverse improvement program considering the requirements of farmers, consumers and industry is actively underway on this root crop at the Institute. Cultivar improvement tools in this program include intervarietal hybridization, combining ability tests, heterosis breeding, triploidy. Early maturing clones, resistance to cassava mosaic disease (CMD), high b-carotene content, and producing cassava from true seeds are among the important targets of cassava breeding in India. *Manihot caerulescens* appears as a new promising source of resistance to CMD.

I-03: Breeding cassava for better nutrition

Chris Okon-Abraham

Nigeria

Although cassava is a major food crop, its scientific breeding began only recently compared with other crops. Significant progress has been achieved, particularly in Asia where cassava is used mainly for industrial processes and no major biotic constraints affect its productivity. Cassava breeding faces several limitations that need to be addressed. The heterozygous nature of the crop and parental lines used to generate new segregating progenies makes it difficult to identify parents with good breeding values. Breeding so far has been mainly based on a mass phenotypic recurrent selection. There is very little knowledge on the inheritance of traits of agronomic relevance. Several approaches have been taken to overcome the constraints in the current methodologies for the genetic improvement of cassava. Evaluations at early stages of selection allow for estimates of general combining ability effect or breeding values of parental lines. Inbreeding by sequential self-pollination facilitates the identification of useful recessive traits, either already present in the *Manihot* gene pool or induced by mutagenesis. In the past an emphasis was given to breeding cassava with white roots. However, considerable efforts were recently invested in measuring the variability for its carotenoids contents in roots and leaves from thousands of clones, along with other relevant information. It was found that high levels of carotenoids (more than 1 and 96 mg/100 g of fresh root or leaf tissue, respectively) could be found in certain clones. High levels of carotenoids were associated with yellow coloration, which facilitates the selection for high nutritional value. Clones with yellow roots, low cyanide level, and excellent cooking quality have been identified. Carotenoids levels in cassava roots were measured in different plants of the same clone and different roots of the same plant, and different sections of the same roots. The environmental effect on cassava was also measured. This research showed that the high-carotene trait is fairly stable. Stability of carotenes upon different root processing methods was also measured. Boiling cassava roots will eliminate the cyanide present in them but will retain about 60% of the original levels of carotenoids. Furthermore, a detailed study of the quality of carotenoids in the roots revealed that more than 90% is ß-carotene. This particular pigment has the largest capacity to be turned into vitamin A by the human body. The high-carotene trait also seems to delay or reduce the onset of post-harvest physiological deterioration (PPD) of the roots. PPD is a natural process that spoils cassava roots one or two days after harvest. The short post-harvest storage life of cassava is a characteristic that limits the marketability of the roots and a delayed or reduced PPD would encourage farmers to grow yellow-rooted cassava clones. The nutritional value of cassava foliage can also be exploited. In addition to the high levels of carotenoids, it has excellent amounts of protein and minerals but it shows a low bioavailability. With the knowledge generated by cassava breeders, high carotenes is combined with good agronomic characteristics. Within five years elite cassava genotypes with yellow roots will be ready for testing and eventual cultivar release using a farmers'

participatory approach. Simultaneously new crosses will be made to further increase the concentration of carotenes or to improve relevant agronomic characteristics.

I-04: Improving the nutritional quality of cassava roots to improve the livelihoods of farmers in northeast Brazil

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The ability of cassava to withstand biotic and abiotic stresses is a major contribution for food security in subsistence-farming systems, particularly in marginal environments. This project is a part of the HarvestPlus Challenge Program of the Consultative Group on International Agriculture, whose overall objective is to improve the nutritional quality of the most relevant crops for developing areas of the world. The target populations are the poor rural and urban people, particularly those living in marginal lands. Within this context cassava is an important commodity in the tropical region of the word, including northeast Brazil. The overall objective of this project is to identify and produce new cassava cultivars with high nutritional value, good agronomic characteristics –including tolerance to drought, adaptation to the semi-arid conditions in northeast Brazil, and acceptable to farmers. In addition to the benefits for Brazil this bred-germplasm will also contribute to improve the diets of populations in Latin America, Africa and Asia by introducing cassava germplasm with enhanced carotene, Fe and Zn contents in their roots.

I-05: Screening of cassava landraces for root carotenoid content

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A total of 1800 accessions from the germplasm bank at *Embrapa Cassava and Tropical Crop Fruits* were evaluated to identify those with high carotenoids in their roots. The first selection was based on the color chart that helped to identify high color intensity associated to high-carotene content; i.e., accessiones with root color intensity scores ranging between 5 (yellow) to 8 (pinkish). As result of this first screening, a total of 72 landraces from the germplasm bank of *Embrapa Cassava and Crop Fruits* were selected. Samples from these landraces were taken for carotenoid quantification, which was made with a spectrophotometer. An average of 6,6µg/g of total carotenoids of fresh roots and a wide genetic variation ranging from 0,63µg/g to 15,51µg/g of total carotenoids was observed in the fresh root samples. Seventeen out of the 72 samples showed carotenoid concentrations higher than 10µg/g including the two genotypes with pinkish roots.

I-06: Seventy years of cassava improvement in Tanzania

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Cassava was recorded first in Zanzibar (Tanzania Island) in 1799. The crop became more important in 20th century. To date cassava is the second most important staple food in Tanzania. Cassava breeding started in the 1930s at Amani in Tanzania, to develop cultivars resistant to both cassava mosaic disease and cassava brown streak disease; however, these biotic stresses are still threatening cassava production in the country. Cassava research at Amani developed clone 5318/34 from intercrossing rubber species with cassava hybrids. Clone 58308 selected in Nigeria from 5318/34 seeds, became parent of many IITA (International Institute of Tropical Agriculture) derived cassava clones including TMS 30572 and TMS 4(2)1425, which are popular cultivars in Nigeria. From 1994, the Tanzanian National Cassava Programme has continued to expand its genetic base through introductions from IITA and CIAT (Centro Internacional de Agricultura Tropical), and further hybridization. Major successes have been the release of cultivars for humid lowlands and semi-arid areas and control of cassava mealybug. Cassava production in Tanzania has doubled in the last four decades; however, constraints to production are frequent drought, declining soil fertility, inadequate supply of quality stems, low adoption rate of improved cultivars, pests such as cassava green mites and termites, poor crop husbandry, poor farm implements and lack of incentives for increased production. Demand for cassava as food, animal feed and industrial raw material has increased over the last 10 years and is expected to expand. Research needs to date includes: breeding and selection for quality aspects, drought resistance, use of biotechnology tools to complement conventional breeding, approaches to increased productivity, processing and marketing issues, and dissemination of technologies.

I-07: Progress in cassava breeding in Zambia

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Cassava is becoming increasingly important in Zambia. It is the second staple for the country and is crucial for crop diversification, food security and is being explored as a raw material for industrial uses. Organized cassava research did not start until the early 80's when the crop was threatened by the mealybug. The mealybug pest prompted government to invest on cassava improvement to arrest the pest problem and improve the crop in general. The focus for crop improvement has been on high and stable dry root yield, early maturity, tolerance to pests and diseases, root quality characteristics preferred by farmers and participatory selection.

I-08: Plant health assessment of seven cassava cultivars in southern Burkina Faso

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Burkina Faso is a Sahelian country of West Africa where cassava's farming is developing with government and some international organizations support. In order to afford a large diffusion of this crop in the country, some experiments about adaptation of cultivars and their selection with growers are led by the Environment and Agricultural Research Institute of Burkina Faso (INERA) in partnership with the International Institute of Tropical Agriculture (IITA). During the crop year 2005-2006, a trial was carried out by the INERA in two southern locations of the country to assess the rate of resumption and the plant health of a local cassava cultivar and six improved cultivars that are spreading in the country. The evaluation of cassava cultivars' rate of resumption was carried out with all cultivars flat planted and to bulk 10 days after plantation. The results indicate that the rates of recovery vary according to the cultivars and the mode of plantation. Cassava bacterial disease, cassava green mite and termite's damages were also recorded in both locations. This research showed the importance (incidence and severity) of these diseases and insects pests that varied according to the cultivar, the location, and the growing period.

I-09: Evaluación de enfermedades en ocho cultivares de yuca en cuatro localidades del estado de Anzoátegui

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En la zona oriental el cultivo de yuca involucra pequeños y medianos productores, con una importante participación de indígenas Kariñas. Basado en lo antes señalado, se establece la necesidad de validar, parte del referencial tecnológico disponible, haciendo énfasis en la evaluación de germoplasma promisorios del cultivo. Para esto, durante los años 2002, 2003 y 2004, se establecieron ensayos de evaluación de cultivares en las localidades Mucura, Melones, Santa Cruz de Cachipo y Las Bombitas. En cada sitio se determinó la incidencia y severidad de las enfermedades presentes. El diseño de experimento fue de bloques completos al azar con ocho tratamientos y tres repeticiones. Los clones evaluados fueron: Querepa, Venezuela 7, Cacho é Venao, Llavitera, Pata de Paloma, 9803rn, INIA 2000 y un testigo local. La bacteriosis (*Xanthomonas campestris* pv. *manihotis*), la mancha parda (*Cercosporidium henningsis*) y añublo pardo (*Cercospora viscosae*) fueron las enfermedades detectadas durante la evaluación, siendo la primera la de mayor importancia en tanto en incidencia como en severidad. Se observaron diferencias significativas para los efectos: cultivar, localidad e interacción localidad x cultivar. La prueba de medias para localidad indica que Las Bombitas fue donde se presento la menor incidencia de la bacteriosis alcanzados un nivel de 18%, seguido por Mucura con un 30%. Melones y Santa Cruz de Cachipo presentaron igual comportamiento (40%).Los cultivares que fueron tolerantes a la bacteriosis fueron el 9810cus (9%), Pata é Palota (22%), y Cacho de Venado (20%).

I-10: Comparison of methods for phenotypic adaptability and stability analysis of cassava genotypes for storage roots yield and dry matter content

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The cassava crop shows a strong and significant genotype x environment (G x E) interaction effect, which makes selection difficult. Breeders have available many methods for analyses of genotype yield adaptability and stability to help in the difficult task of identifying superior cultivars in the presence of significant G x E interaction. However, they frequently have difficulty in choosing the most suitable method for use in different situations. Thus, the phenotypic adaptability and stability methods of Eberhart and Russel (1966), Eskridge (1990), Lin and Binns (1988), Annicchciarico (1992) and AMMI analysis were compared using storage roots yield and dry matter content data of eight cassava genotypes in eight environments, assessed in northwest Paraná, Brazil. A high degree of association among the methods applied was observed, except for AMMI analysis. The $A_i(\%)$ parameter of the AMMI analysis correlated positively and negatively with S^2_{di} and r^2 from the Eberhart and Russel (1966) analysis, respectively, just for the dry matter content trait. This probably occurred because of better fit of the linear model to the dry matter content than storage roots yield data. All methodologies can be used efficiently as a supplementary tool to help the breeder in the selection of superior and stable cassava genotypes.

I-11: Storage roots yield stability of cassava clones in northwestern region of Paraná State – Brazil using the AMMI analysis

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High stability and adaptability of storage roots yield are very desirable attributes for cassava clones. The aim of this research was therefore to evaluate the genotype environment interaction (G x E) and the stability of cassava clones of Instituto Agronômico de Campinas (89-IAC generation). A subset of eight cassava genotypes was chosen from storage roots yield performance trials, witch were arranged in a randomized complete block design with four replications, in two counties (Araruna and Maringá) in the Northwestern region of Paraná State, during 5-agricultural-year period (1997-2001). The G x E interaction was evaluated by using joint variance analysis and the stability and adaptability were verifying by using the AMMI analysis. Significant interaction of G x E ($P<0.05$) for storage roots yield was revealed by joint analysis. The genotypes IAC 153 (26.77 t ha^{-1}), Fibra (26.46 t ha^{-1}), IAC 190 (25.33 t ha^{-1}) and IAC 184 (24.24 t ha^{-1}) presented the highest storage roots yield averages. However, Fibra and IAC 153 genotypes showed high G x E effect while IAC 184 and IAC 190 genotypes were considering as the most stable genotype beyond it had presented high storage roots yield averages. The results had indicated that AMMI analysis was an efficient tool in the evaluation of phenotypic adaptability and stability of cassava clones, indicating that IAC 190 clone was the most promising one.

I-12: Estabilidade de produção de cultivares de mandioca-de-mesa coletadas nas Regiões Norte, Noroeste e Oeste do Paraná

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O presente trabalho teve como objetivo avaliar a estabilidade fenotípica de 14 cultivares de mandioca-de-mesa coletadas nas regiões Norte, Noroeste e Oeste do Estado do Paraná. Os experimentos foram instalados nos municípios de Maringá (2001/2002 e 2002/2003) e de Campo Mourão (2003/2004 e 2004/2005), região Noroeste do Paraná, perfazendo um total de quatro ambientes. O delineamento experimental utilizado foi o de blocos completos casualizados, com três repetições, sendo avaliadas as características produção de raízes tuberosas e índice de colheita. A análise da estabilidade foi realizada mediante a aplicação das metodologias propostas por Lin e Binns (1988), Eskridge (1990) e Annicchiarico (1992). A cultivar Fécula Branca, seguida pelas cultivares Branca 3, Amarela da Rama Branca, Amarela de São Domingos, Caipira e Quarenta Quilos, foi a que apresentou maior estabilidade de produção de raízes tuberosas para todas as metodologias aplicadas. Para a característica índice de colheita, a cultivar Caipira foi a que apresentou maior estabilidade, merecendo destaque também para as cultivares Fécula Branca, Amarela 2, Branca 1, Quarenta Quilos, Amarela 1 e Guaíra. Considerando a produção de raízes tuberosas, o índice de colheita, além de outras características agronômicas importantes para a mandioca-de-mesa, tais como teor de HCN, tempo de cozimento, teor de amido nas raízes tuberosas, e resistência às doenças, as cultivares Fécula Branca, Caipira, Branca 1 e Amarela 2 são indicadas para cultivo na região Noroeste do Paraná.

I-13: Strategies to develop and identify cassava clones with novel starch types

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Cassava is an important food security crop. It is also becoming an important source of raw material for different industries: as a source of energy in the feed industry, as a source of starch and, more recently, for ethanol production. To consolidate the industrial uses of cassava, an increased emphasis in the search for value-added traits, while maintaining or enhancing its productivity, has recently been given by the cassava-breeding project at CIAT. For the starch industry, different approaches to produce cassava roots with novel starch types have been initiated. Inbreeding has been introduced to cassava genetic improvement because it offers many advantages, including a facilitated identification of useful recessive traits. Ongoing research for the production of doubled-haploid lines will reduce the time required to reach full homozygosity. Plants from irradiated seed in a mutation-breeding project have been evaluated in the field and many self-pollinations have been made to implement the TILLING system specifically targeting the waxy starch trait. Waxy starch will also be produced through gene silencing using genetic transformation. Conventional recurrent selection methods have also began for a divergent selection searching to increase or reduce amylose content in the starch from the roots. Novel starch types are also sought through crosses with related *Manihot* species. Finally, CIAT has set up a high capacity root-quality laboratory to routinely screen the roots of the thousands of new genotypes generated every year. As a result several mutations, including a cassava clone with waxy starch have been produced and identified.

I-14: Mejoramiento genético de la yuca en Venezuela durante la última década y perspectivas actuales

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En Venezuela, la yuca es cultivada en una superficie cercana a 1 hectárea por agricultor. Las estadísticas disponibles señalan que el área plantada con yuca nacionalmente y los rendimientos registrados se han incrementado entre 1.995 y 2.005, en 15 y 8%, respectivamente, alcanzando 45,000 ha cultivadas y 12.5 t ha $^{-1}$ de rendimiento nacional. Estos incrementos se han debido más al mejoramiento en las practicas culturales que a la incorporación de cultivares seleccionados. Las actividades de mejoramiento genético se centraron en la colecta, introducción y caracterización del germoplasma, aplicación de la selección masal estratificada (Occidente) y poli-cruzamientos (Oriente), y evaluación de progenies de semillas sexuales recibidas del CIAT. Actualmente el Ministerio de Ciencia y Tecnología, a través de sus instituciones adscritas (INIA e IDEA) iniciaron programas de selección y mejoramiento genético, que incluye: i. Sistema Nacional de Curaduría de Germoplasma; ii. Identificación, introducción y cruzamiento de clones promisorios; iii. Selección de clones nacionales e introducidos para un amplio rango de ambientes; iv. Plan Nacional de Semillas; v. Centros de Manejo y Multiplicación Masiva, vía *in vitro* e incorporación de sistemas de inmersión temporal, y vi. Estudios de diversidad genética y exploración de grupos de ligamientos para detección de resistencia a problemas sanitarios. Es conveniente resaltar que a este trabajo se han sumado un gran número de instituciones que incluyen a las universidades (Central de Venezuela, Los Andes, Guayana, Oriente, Zulia, Simón Bolívar y Ezequiel Zamora) así como instituciones del Sector privado como Agropecuaria Mandioca, Yuquitas Dora, Lapporto CA, CONVACA y FEDEPORCINA, entre otras.

I-15: Evaluación de clones elites de yuca en Venezuela

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Durante el año 2001, fueron introducidos en Venezuela, los clones: BRA 383, CM 3306-4, CM 507-37, CM 6740-7, CM 4843-1, CM 523-7, CM 7514-7, CM 6119-5, CM 4574-7, PER 183, CM 7514-8, CM 5306-8, SM 909-25, CM 8027-3, CM 6438-14, SM 805-15, CM6921-3, TAI-8, CM 7073-7, SM 1565-15, considerados clones elites del programa de Mejoramiento CLAYUCA/CIAT. Estos clones fueron evaluados en dos localidades del centro y cuatro localidades del oriente del país, con el objeto de identificar su potencialidad y comportamiento agronómico, para cada región. Resultados preliminares han permitido identificar al clon: CM6740-7, con rendimientos de: 86 t ha^{-1} en Maracay-2004(a), 59 t ha^{-1} en Maracay(b)-2004, 25 t ha^{-1} en El Tigre-2004, 29 t ha^{-1} en El Tigre-2005, 30 t ha^{-1} en El Tigre-2006 y 29 t ha^{-1} en Puerto Ordaz-2006. Igualmente destacó el clon SM909-25, con rendimientos de: 85; 13, 41; 29; y, 31 t ha^{-1} en Maracay(a)-2004, El Tigre-2004, El Tigre-2005, El Tigre-2006, y Puerto Ordaz-2006, respectivamente. Ambos clones además de tener altos rendimientos, han sido altamente favorecidos por los agricultores en evaluaciones participativas. Cabe destacar, que el clon CM6740-7 tiene bajos tenores de HCN (dulce), mientras que le clon SM909-25 muestra contenidos moderados a altos de HCN (amargo), Con lo cual los clones introducidos ofrecen excelentes alternativas tanto para la industria como para el consumo directo.

I-16: A strategy for cassava breeding

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Cassava is a monoecious crop species. Each inflorescence has male flowers in the top and female flowers in the bottom. Protogyny occurs in each branch. Both self- and cross-pollinations occur naturally in cassava. Several species of wasps and bees are the main pollinators. There is no cross- and self-incompatibility, but male sterility occurs. A strong inbreeding depression together with vegetative reproduction maintains a high level of heterozygosity, such as in allogamous species. We propose the adaptation and application of the reciprocal recurrent selection method for cassava breeding. This strategy allows the exploration of all types of genetic variances and has the main objective to improve the heterotic response between two populations (A and B). The A population is used as a tester of B population and *vice versa*. In each cycle, plants from the A population with the more vigorous progenies when crossed with B population are selected and recombined. The same procedure is applied to the plants from the B population. Thus, two new populations are obtained in each cycle, and, eventually, they can be released as new cultivars. Besides, in advanced cycles, the bred-populations can be used for successive selfing generations to develop lines, selecting better lines according to their combining ability, crossing these lines, and obtaining new commercial hybrids. A third advantage applied to any cycle of reciprocal recurrent selection of cassava breeding is that every time a superior cross is found, it can be fixed through vegetative propagation, and a new clone can be released. The identification of heterotic groups can be facilitated by using molecular markers, such as RAPD, AFLP, SSR and SCAR. This strategy can be useful for the development of new breeding populations and commercial hybrids in cassava.

I-17: Rayong 9 – A new Thai cassava cultivar with improved starch and ethanol yields

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Rayong 9 is a newly released Thai cassava cultivar bred by the Department of Agriculture, under the Ministry of Agriculture and Cooperatives of Thailand. It has been selected since 1992 from the cross between CMR31-19-23 and OMR29-20-118 at Rayong Field Crops Research Center. After seedling selection, single row selection, preliminary yield trials at 2 locations, and standard yield trials at 3 locations, it was selected for regional yield trials at 8 locations, and for farmers' field yield trials at 14 locations, where it had had an average starch yield of 7.6 t ha^{-1} with the average starch content of 24.4 %. The average ethanol yield in laboratory trials and at the factory was 208 l t^{-1} of 12 months old fresh roots, which was 16.3 % higher than that of Rayong 90, the former highest ethanol yield cultivar in Thailand. This newly developed cultivar was officially released in 2005. It also has a good plant type, producing good quality stakes with a high rate of germination as well as a large number of stakes from each plant. It is expected to be a good cassava cultivar for the ethanol industry.

I-18: Cassava trial in Maracanã, Uiramutã, Roraima, Brazil

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Maracanã is a small macuxi indigenous community of Uiramutã, northeastern Roraima (Brazil). From June 2003 to December 2004, a cassava trial was conducted using seven plants per row with 1m x 1m spacing in 3 replicates. The soil had a pH of 6.5, 12.13, 2.28 and 0 cmolc dm^{-3} of Ca, Mg and Al, respectively as well as 0.97 and 284.74 mg dm^{-3} of P and K and 55.8 g/dm3 of organic matter. The trial was fertilized with 300 kg ha^{-1} of N-P-K (4-28-20) at planting. There were two harvests: 12 and 18 months after planting. In the first harvest, cultivars RR-0033 (EMBRAPA collection), Anita (community's collection), RR-0002, RR-0064 and RR-0065 (EMBRAPA collection) had following root yields (for flour purposes): 37, 36, 30, 28 and 25 t ha^{-1} respectively. The root yield for fresh table use was 25, 22, 19, 19 and 18 t ha^{-1} for RR-0073, Mx Retroi (Malacacheta indigenous community's collection), RR-0067, Aciolina (EMBRAPA collection) and Juriti (community's collection), respectively. In the second harvest the following root yields (for flour purposes) were recorded: 86.667, 65.714, 62.857, 60, 58.571 and 47.143 t ha^{-1} for RR-0064, Iracema sn, RR-0002, RR-0033, RR-0065 (EMBRAPA collection) and Anita (community's collection), respectively. The best cultivars for fresh table root yield were Mx retrói, RR-0067 (EMBRAPA collection) and Juriti (community's collection) whose root yields were 91.667, 90 and 55.714 t ha^{-1} whereas Roraima's yield was 13 t roots ha^{-1}.

BIOTECHNOLOGY – CELL BIOLOGY

B-01: Plant tissue culture and induced mutations in genetic improvement of cassava

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Cassava is a tropical root crop, requiring at least 8 months of warm weather to produce a crop. The average yield in Ghana is 7 to 10 t ha^{-1}, which is far below that of India (23-25 t ha^{-1}) or Thailand (37 t ha^{-1}). The poor yield in Ghana and other cassava growing countries is probably due to: poor fertilization, drought, heavily infected of planting material with African Cassava Mosaic (ACMV) and other viruses, and poor quality cultivars. There is a lack of proper supply of improved cassava planting material to the growers. Plant tissue culture refers to growing and multiplication of cells, tissues and organs of plants on defined solid or liquid media under aseptic and controlled environment. Micropropagation technique for rapid shoot proliferation is primarily achieved from any part of the plant such as shoot tip, tiny stem cuttings, roots, and auxiliary buds. The process of micropropagation is usually divided into several stages: prepropagation, initiation of explants, subculture of explants for proliferation, shooting and rooting, and hardening. It is critical to select proper genotypes and grow mother plants under the controlled environment, and determine the maximum number of subcultures before initiating new fresh cultures. By failing to do so, *in vitro* grown plants will show somaclonal variation in the field. It could become a major economic problem for the cassava growers. Normally, commercial companies use extensively micropropagation in large-scale plant multiplication. However, the high cost of *in vitro* plant production, low volumes produce, labour intensive, and somaclonal variation hinder the rise in the profits of commercial enterprises, and therefore it is highly desirable to modify the techniques to overcome these problems for the supply of high quality planting material to small and commercial cassava growers. Somatic embryogenesis is an ideal technique for clonal propagation of woody and fruit plants and genetic gain can now be captured through it. Formation of embryos from somatic cells by a process of resembling zygotic embryogenesis in one of the most features of plants and offers a potentially large-scale propagation system for superior clones. It has several additional advantages such as the ability to produce large number of plants, potential for automation, the opportunities for synthetic seed, long-term storage (‘cryopreservation’), packaging, direct delivery systems and genetic manipulations. Normally, the initiation of embryogenic cultures is done by culturing immature zygotic embryos, or sometimes with mature zygotic embryos, and off shoots. The maintenance of embryogenic cultures is critical for preventing somaclonal variation, and therefore, regular subcultures are done. Also, it is critical to cryopreserve immediately after embryogenic cultures are initiated to prevent variation and preservation of elite germplasm. Abscisic acid (ABA) is added in the culture medium for the maturation of somatic embryos, which look like zygotic embryos. Well developed somatic embryos are germinated to regenerate plants (somatic seedlings), and finally are acclimatised and transfer to the field. In conifers, somatic emblings are being field tested by few commercial companies in North America. Somatic embryogenesis is highly genotypic dependent, and it would be useful to modify the culture medium accordingly.

For large-scale production of somatic embryos, 'bioreactor' system works well, *e.g*. 'temporary immersion system' (RITA bioreactor). The low cost of production of somatic embryos and high germination rate are highly desirable for large-scale production in a bioreactor. This system has not yet been tried in cassava. Nuclear applications in food and agriculture have contributed greatly in enhancing agriculture production of seed and vegetatively propagated crops. Even though nuclear technology has benefited greatly agriculture, still it has a great potential in genetic improvement of cassava and other crops. More than 2300 mutant cultivars have officially been released in many countries (http://www-mvd.iaea.org). Both chemical and physical mutagens are used to induce mutations. Among them, gamma rays and ethyl-methane sulphonate (EMS) are widely used for mutation induction. Fine embryogenic cell suspension cultures are most suitable for inducing mutations by transferring to the filter paper and plated on the agarised culture medium for gamma irradiation. Initially LD_{50} dose is determined, which is used as an optimal dose for mutation induction. Irradiated cells are further cultured to the fresh medium for the development, maturation, and germination of mutated somatic embryos. This approach provides mutated somatic seedlings in a short period of time and also prevents chimerism problem which otherwise requires to multiply plants up to M1V4 generation for chimera dissociation. Alternatively, shoot tip or bud wood can be irradiated and multiply plants up to M1V4 generation for producing pure mutants by dissociation of chimerism. A mutant cassava cultivar 'Tek Bankye' has been released by the Ghanaians. This cultivar has an excellent cooking quality and is very popular among growers. It is however susceptible to ACMV. There is no availability of cassava mutant resistant to ACMV and requires utmost attention on the development of disease resistant mutants. Cassava has a potential of using as a bio-energy crop for the production of bio-ethanol. Cassava mutants could be isolated to produce value added biomass for cost effective production of bio-ethanol. The use of this crop as a source of bio-energy would generate employment, enhance economic status of growers, protect environment, and most likely cut consumption of fossil fuel. It is highly desirable to develop a mutant database of available cassava mutants, which can be characterised with molecular techniques and identify useful genes and determine their functions. This will lead to the functional genomic cassava breeding. Mutants are needed to improve cassava nutrition as well as cooking quality without compromising the total crop yield. We will discuss the use of tissue culture and mutagenesis in cassava improvement programs.

B-02: Somatic embryogenesis and genetic transformation of Brazilian genotypes of cassava

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Cassava is increasing its importance in the economy of most of the Brazilian northeastern states. Besides its traditional use as food and fodder, cassava demand from the poultry and bakery industries is increasing, especially due the high prices of maize and wheat flour. The need to increase production to match this increase in demand, have highlighted the need for more productive genotypes, adapted to the prevailing agro-ecological settings in the northeastern states. Until recently, tissue culture techniques (meristem culture, axillary proliferation or somatic embryogenesis, organogenesis.) and genetic transformation protocols for the cassava genotypes presently used in the Northeast Brazil have not been developed. In order to meet this need, my laboratory has been working towards achieving these goals and succeeded with protocols for the regeneration –both by somatic embryogenesis and organogenesis, of 10 major cassava genotypes. Several of these cultivars showed transient expression of reporter genes. This report gives a summary of the development of regeneration and genetic transformation of cassava genotypes from Northeast Brazil, and the attempts to obtain transgenic cassava cultivars with improved tolerance to drought stress.

B-03: Environmental and genotypic effects on the growth rate of *in vitro* cassava plantlets

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Two cassava cultivars were evaluated *in vitro* in the screen house and culture room using five different media treatments. Each treatment was replicated 12 times and observed for 5 weeks before sub-culturing. There were significant differences in the growth rate of plantlets in different media, which suggests an interaction between treatments and environments. However, F-probability on survival shows that TMS 188/00106 was significantly different from TMS 083/00125 in the culture room than in the screen house. This study confirms that tissue culture can be raised in the screen house but it suggests that plantlet should be allowed to survive in the culture room before transferring to the screen house for further growth.

B-04: Impact of diversification and micro-propagation of cassava clones in a Cuban rural community

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Cassava is an important crop in many rural Cuban communities, not only because of the high consumption habit of our people, but also for animal feeding. There are however many problems with the availability and quality of planting material, which causes farmers to grow a few cassava clones and also limits the planted areas of this crop. With the support of the Cassava Biotechnology Network, we started a capacity building and training project aiming that farmers will be able to apply some sustainable micro-propagation techniques to produce their own high quality planting materials. The results exceeded our expectation and now, farmers have enhanced the number of cassava clones on their farms and even some of them are managing cassava genetic resources, maintaining active collections and spreading cassava clones among their neighbor farmers. We are working on the establishment and functioning of on-farm micro-propagation units, which will be managed by farmers and will supply a high quality planting material to make possible the diversification of clones and the increasing of planted areas of this important crop on target rural areas of the most occidental part of our country.

B-05: Tuberização *in vitro* em genotipos de mandioca

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O presente trabalho teve como objetivo a indução *in vitro* de raízes tuberiformes de dois genótipos de mandioca cultivadas em meio líquido, sob a ação de 6-benzilaminopurina (BAP) e,ou, ácido α-naftalenoacético (ANA), e diferentes concentrações de sacarose. Como explantes foram utilizados segmentos nodais (± 3 cm) excisados de plantas de mandioca das cultivares Mantiqueira e Parazinha, mantidas *in vitro* mediante subcultivos em meio constituído dos sais de MS (Murashige e Skoog, 1962), mio-inositol (100 $mg.L^{-1}$) e sacarose (30 $g.L^{-1}$). O pH dos meios foi corrigido para 5,7 ± 0,1, antes da autoclavagem. Os meios de indução constaram do meio MS com 30 $g.L^{-1}$ de sacarose (T1), MS suplementado com 0,4 µM BAP + 1,6 µM NAA, sob diferentes concentrações de sacarose 30 (T2), 60 (T3), 80 $g.L^{-1}$ (T4), e MS com 5 $mg.L^{-1}$ de BAP também sob diferentes concentrações de sacarose 30 (T5), 60 (T6) e 80 $g.L^{-1}$ (T7). Os experimentos conduzidos sob regime luminoso de 16 horas escuro e 8 horas diárias de luz à temperatura de 27 ± 1ºC e irradiância de 50-60 $\mu mol.m^{-2}.s^{-1}$. Foram avaliados para a indução das raízes tuberiformes o número, comprimento e do padrão de desenvolvimento das raízes. O T1 foi o melhor tratamento para as características comprimento da raiz (CR) e número de raízes (NR), principalmente em 'Mantiqueira', no entanto, não foi constatada microtuberização. Já no T4, o desenvolvimento das raízes tuberiformes foi mais eficiente, apresentando uniformidade tanto no aspecto, como na textura em ambas as cultivares.

B-06: Influence of *in vitro* carbohydrate concentration on cassava rooting *ex vitro*

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Cassava easily grows shoots and develops roots from nodal segments *in vitro* without the need for additional plant growth regulators. However, plant mortality is high following transfer to potting soil and acclimatization due to root deterioration. The objective was to study the influence of sucrose concentration on development of *in vitro* grown cassava and its effect on rooting *ex vitro*. Nodal segments of TMS60444 were grown on Murashige and Skoog basal salt medium with 0 to 10% sucrose gelled medium. Sucrose concentrations in the medium had a significant effect on shoot growth and root development. The higher concentrations of 8% and 10% sucrose caused reduced root and shoot lengths, fewer roots and leaves after four weeks *in vitro*, which may be due to the increased osmotic potential of the medium. Though the growth was reduced at the higher sucrose concentrations, the shoots and roots accumulated more starch. The higher starch accumulation and exposure to stress conditions assisted the harvested shoots for direct rooting *ex vitro*. Growing cassava *in vitro* at increased carbohydrate concentrations can benefit rooting and acclimatization *ex vitro*.

B-07: Tissue culture techniques, a powerful tool for cassava improvement

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Tissue culture techniques can be utilized at various ways in the improvement of cassava. Rapid clonal propagation would be useful for highly heterozygous and low seed set cassava for mass production of planting materials for hybrids, new cultivars, polyploids, and apomictic true clones. In this regard, suitable ex-plants (such as apical meristem, nodal cutting, root, leaf), inducing high proliferation rate (through cytokinin kind and concentration), best medium (kind, phase, supplements) and suitable growth regulators (type, combination and concentration) would be important research subjects. Likewise, tissue culture in cassava allows production of pathogen-free (of virus, bacteria or fungo) planting materials via ex-plant size and thermotherapy. In vitro methods provide a means for storage (incl. cryo-preservation) of cassava hybrids, new clones, and rare genotypes, and their safer germplasm exchange among breeders and countries. Tissue culture can also assist stress physiology research, e.g. for abiotic stress, salinity including sea water use and drought; PEG. The use of in vitro methods may lead to inducing variation (callus, somaclonal variation and mutagens) for useful genetic diversity and producing new variants and cultivars.

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B-08: Cultivo *in vitro* de meristemas de yuca de interés agronómico provenientes de cinco regiones productoras de Venezuela

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La yuca constituye en Venezuela un rubro de interés agrícola con alto valor agregado y mediante técnicas biotecnológicas como el cultivo *in vitro* de meristemas se puede contribuir a la conservación de germoplasma, saneamiento de clones infectados y actualmente es fuente de semilla asexual para el plan nacional de semilla. Se colectaron varas de clones de cinco regiones productoras de Venezuela (Anzoátegui, Monagas, Barinas, Zulia y Aragua) y se cultivaron las estacas en el invernadero del CENIAP-Maracay para utilizar sus brotes como fuente de explante. Los brotes se esterilizaron con hipoclorito de sodio 2.5 % y se aislaron los meristemas en condiciones asépticas. Éstos se cultivaron en MS, 0.02 mg l^{-1}ANA, 0.05 mg l^{-1} BA, 0.05 mg l^{-1}GA, 0.1 g l^{-1} caseína hidrolizada y 6 g l^{-1}agar. Se incubaron en cuarto climático a 27 ± 1ºC y oscuridad durante 15 días, posteriormente en condiciones de foto-período de 16 horas diarias de iluminación. Después de 60 días las plantas arrosetadas se cultivaron en MS, 0.5 mg l^{-1} BA, 0.05 mg l^{-1} GA, 0.02 mg l^{-1} ANA y 6% agar. Se hicieron 2 ciclos de cultivo de meristemas para garantizar mayor calidad fitosanitaria de las plantas. Después de 8 semanas, se obtuvo regeneración de plantas en todos los clones, aunque varió dependiendo del genotipo. En clones provenientes de Anzoátegui la formación de callo fue de 6.9 %, plantas arrosetadas y el porcentaje de regeneración fue el más bajo (21.9%). Los clones del Zulia presentaron los mayores porcentajes de regeneración de plantas (46.6 % en promedio).

B-09: Embriogénesis somática en dos clones de yuca de interés agronómico

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La aplicación de técnicas biotecnológicas en yuca puede contribuir a mejorar la productividad del cultivo y la seguridad alimentaria en las zonas productoras del país. A través de la embriogénesis somática podemos obtener altas tasas de propagación de plantas genéticamente uniformes y sanas de yuca que sirvan como fuente de semilla para los agricultores. Se utilizaron yemas axilares de vitroplantas de 6 semanas de edad de 2 clones (CM6740-7 del CIAT y el clon local 17), cultivadas en un medio MS, 0.1 g l^{-1}caseína hidrolizada, 2,4-D (0, 2, 4, 6 y 8 mg l^{-1}), y 6 g l^{-1}agar. Las yemas se cultivaron en oscuridad por 30 días y luego 16 horas diarias de foto-período, con temperatura de 26ºC. Después de 75 días de cultivo se obtuvieron callos embriogénicos en ambos clones a concentraciones entre 4 y 8 mg l^{-1} de 2,4-D, siendo mayor a 6 mg l^{-1} para CM-6740-7 (70%) y 40% para el clon 17. Aunque a 8 mg l^{-1} de 2,4-D el porcentaje de callos embriogénicos fue menor para CM-6740-7, el número total de embriones somáticos obtenido fue mayor (58). Los embriones somáticos fueron cultivados en un medio MS, 0.5 mg l^{-1} BA y 0.05 mg l^{-1} GA_3 para germinación y crecimiento de las plantas, tanto en medio sólido con 6 g l^{-1} agar, como en biorreactor de inmersión temporal a una frecuencia de 5 min cada 4 horas. El 2,4-D en los medios de cultivo fue determinante para la inducción de la embriogénesis somática en yuca, sin embargo es necesario seguir optimizando el sistema para obtener una alta frecuencia embriogénica y regeneración de plantas.

B-10: Evaluación preliminar de clones de yuca propagados *in vitro* y seleccionados en el Campo Experimental INIA-CENIAP

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El cultivo de yuca en Venezuela es de gran importancia socio-económica y con gran demanda en producción de "semilla" de buena calidad. El objetivo de este trabajo fue propagar *in vitro*, en umbráculo y en campo clones de yuca seleccionados por su interés agronómico para ser usados en los Planes Nacionales de Producción de Semilla. Para la propagación *in vitro* se cultivaron micro-estacas de 20 clones provenientes del CIAT, Colombia y un clon local (Clon 21) en el medio de cultivo 4E modificado. Las plantas se sembraron en condiciones de umbráculo en materos con sustrato estéril compuesto de tierra, arena y aserrín de coco en la proporción 1:1:1 y luego en el campo en surcos. Los 20 clones introducidos y el clon local, en el medio de propagación, regeneraron plantas con porcentajes entre 60 y 95%. El mayor porcentaje correspondió al Clon 17. En el umbráculo el porcentaje de sobrevivencia fue superior al 60% y en el campo entre 22 y 100%. El Clon 1 presentó el mayor porcentaje de aclimatación en umbráculo (80,6 %) y en campo, los Clones 11 y 17 (100%). Los rendimientos en campo variaron entre 41 t ha^{-1} para el clon 02 y 16 t ha^{-1} para el clon 10, estos rendimientos superan el rendimiento promedio nacional que es de 12 t ha^{-1}. Otro clon a destacar es el 12, con rendimientos de 29 t ha^{-1} y de excelente calidad culinaria.

B-11: Transgenic approaches to add economic and nutritional values in cassava

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The tropical root crop cassava is a major source of food for approximately one billion people worldwide. Conventional breeding efforts have succeeded to address several constraints to cassava production, but are time consuming. The new tools of biotechnology can change this situation by offering new approaches to the challenges of cassava. These new technologies have the potential to make cassava much more productive, a better source of nutrients, and profitable to grow, hence, greatly contributing on the sustainable development of tropical agriculture. Recently we have developed biotech cassava with value-add traits, including resistance to cassava mosaic virus by RNA-mediated resistance, prolonged leaf life by autoregulatory inhibition of leaf senescence, and insect resistance by expressing Bt-toxin. New strategies are also explored to increase protein content by organelle targeting of essential amino acid rich protein, and to modulate post-harvest physiological deterioration of cassava storage roots. We are currently undertaking pilot studies with two teams of leading scientists and experts for projects to test ACMV-resistant transgenic cassava lines in sub-Saharan Africa and lines with extended leaf retention in Colombia and Hainan (China) under field conditions. The goal of the pilot studies will be the development and coordination of a broader project that produces important and novel scientific results, valuable information on the need and impact of biotechnology at the subsistence farming level, and a sound scientific basis for the development of guidelines for biosafety assessments and release of transgenic organisms into the environment and agricultural production in sub-Saharan African and Latin American countries.

B-12: Two years of transgenic cassava field trials from micro-propagated plants

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Cassava clone TMS 60444 was used to develop amylase free starch plants through particle bombardment at Wageningen University. The amylose free genetically modified cassava was micro-propagated in vitro, directly rooted and acclimatized in pots. The first GM cassava was established in the USDA-APHIS approved biotechnology field at the University of the Virgin Islands on St. Croix in 2003 and a year later in 2004. During 2003, 150 GM-cassava plants were established and 800 plants the following year. The plants were grown with control guard rows for 12 to 14 months prior to harvest. The tuberous roots were harvested, evaluated for amylose free starch via an iodine test and grated to extract the starch. The gene construct for amylase free cassava had remained stable and all the plants were amylose free.

BIOTECHNOLOGY – DNA MARKERS

D-01: Sequencing the cassava genome - a milestone for the Global Cassava Partnership

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The Global Cassava Partnership, which was established in 2003, has listed five major constraints for the genetic improvement of cassava: access to genetic biodiversity, use of micro-propagation, production of double haploids, implementation of genetic transformation, and access to genomic information. Each of these topics is equally important for improving cassava productivity throughout the world by using very different technologies. However, "cassava genomics" is notable because while it is extremely costly, it is the door to the future for modern molecular breeding. Sequencing the cassava genome is the key through which we can benefit from genomic investments made in plant species such as *Arabidopsis* and rice. Cell biology is conserved enough to allow "extrapolation" for gene functions and biosynthetic pathways from one species to another, however its application requires knowledge of exact cassava sequences. Sequencing the cassava genome is therefore the first step in a number of genomic studies necessary to access modern molecular breeding. This first step is now underway at the Joint Genomic Institute in California (funded by the U.S. Department of Energy -DOE). The sequencing will be completed by the end of 2007. Although only a handful of scientists participated in the proposal to DOE, the whole community is invited to participate in the subsequent actions such as annotation of the sequences and evidently the use of these sequences. By contract, all sequences will be deposited in public databases as soon as possible. The immediate benefit of this sequencing will be for the breeders using marker assisted selection, as molecular markers will be designed at wish. Another immediate use will be the possibility to access the huge molecular diversity of the *Manihot* wild species to retrieve genes of interest to improve cassava cultivars. However, this will pose the question of the biological and physical access of this diversity by the cassava community for the benefit of humanity.

D-02: Development of QTL affecting starch content and storage root productivity in two F_1 populations of non-inbred parents in cassava

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Cassava is a perennial vegetatively propagated crop grown throughout the global tropics for its starchy roots. Finding quantitative trait loci (QTL) for important yield and quality traits is an important aid for its genetic improvement. QTL for starch content, and four other traits associated with storage root productivity and resistance to BLS had been mapped by using a population of 213 individuals from the cross SC 6 ×Mianbao grown in two years. An incomplete genetic map including 11 linkage groups with 34 SSR marker loci, with a total length of 644.8 cM and an average marker distance of 18.9 cM was developed. A total of 54 primary QTL were detected by interval mapping. The percentages of the observed phenotypic variance explained by individual QTL ranged from 10 to 71.3%. Six main effective QTL of starch content with PVE accounted for 27.1 to 71.3% of variation, whereas 14 QTL for fresh root yield had phenotypic effects above 20%. There were also 9 QTL for harvest index, 16 QTL for BLS resistance, whose phenotypic effects ranged from 22.0 to 65.3%, respectively. Likewise, leaf retention and branching height were mapped at the terminal of linkage group 11 as qualitative traits. Some of the QTL for starch content and root productivity were mapped to the same or near locations controlling other traits influencing yield. These results will provide an opportunity for marker-assisted selection and improvement of quality and yield potential in cassava. However, the efficiency of molecular-aided selection for high starch yield, and using these markers associated with the identified QTL still needs to be investigated.

D-03: Genetic mapping of QTL for β-carotene in an S_1 population of cassava

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Beta-carotene is the precursor of vitamin A, an essential micronutrient for growth and development in human health. Cassava roots can be a valuable source of vitamin A to about 500 million people that depend on this crop as staple food. Improving β-carotene content of cassava could help alleviate the acute deficiency of vitamin A in the third world where per capita income is low and poverty levels are high. The objective of this study was to identify DNA markers associated with β-carotene content in cassava through quantitative trait loci (QTL) analysis towards the development of improved cassava cultivars with high β-carotene. A Thai cultivar (MTA18) with high yellow root color (often associated with β-carotene) was selfed to generate an S_1 segregating population (AM 320 family) which was used for the construction of a genetic map and QTL analysis. The S_1 population of 230 individuals was genotyped using 140 polymorphic micro-satellites (SSR) markers and phenotyped for β-carotene by evaluating for pulp color. An S_1 genetic map of 26 linkage groups, spanning a length of 1905.9 cM with an average marker interval of 25.44.cM was constructed. QTL analysis results indicate that three QTL on linkage groups 3 and 24 were associated with β-carotene content in the AM320 family. These three markers linked were rSSRY313, rSSRY251, NS109, which account for 40.7%, 37%, and 33.6% of phenotypic variance, respectively. These QTL have increasing effects and additive gene action for β-carotene. Our findings indicate that β-carotene is therefore controlled by few major QTL. The implications of these results suggest that this trait may be amenable to rapid manipulation via marker assisted breeding in the development of high β-carotene content cassava cultivars.

D-04: Amylose content variation of Indonesian cassava genotypes and its correlation with RAPD and AFLP markers for further breeding program

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A total of 20 random decamer primers and 6 primer pairs of random amplified polymorphic DNA (RAPD) and amplified fragment length polymorphism (AFLP), respectively were screened to analyze over 150 accession of cassava, which were mainly collected in various Indonesian locations. Their amylose content ranged between 22.65%-32.53%. Only seven primers (OPE-5, OPE-15, OPF-4, OPF-13, OPH-17, OPE 20, OPB-10) were used for further research, and three of them were used to analyze 60 to 97 genotypes. Five candidate RAPD markers OPE-15H, OPE-15I, OPE-15K, OPE-15L, OPE-15O) of high amylase were identified by correlating the obtained bands with amylose content. Similarly, OPE-15-B, OPE-15F and OPE-15I were associated with high amylopectin. A dendogram, which was constructed based on a combination of three RAPD primers (OPE-15, OPF-4 dan OPF-13), showed no distinct pattern between genotypes possessing low amylose with those of high amylose content, although some genotypes with the same characters were grouped in the same cluster or sub-clusters. These results were also confirmed with other results obtained using AFLP markers. The amylose content variation was also compared with the morphological variation. Effort to obtain genotypes with extreme amylose content is underway through genetic engineering and γ-irradiation with or without hybridization.

D-05: Genetic changes as a result of cassava domestication - a study of genes controlling selected traits important for cassava improvement

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Cassava has been cultivated and domesticated for more than 5000 years. Selection during domestication has resulted in morphological, physiological and biochemical differences between the domesticated cassava and its wild relatives. Many traits and genes, which were not under human selection, were lost during the domestication of cassava and are only preserved in the wild relatives. The wild relatives are therefore the most useful or only genetic sources for the introgression of favourable traits such as resistance to pests and diseases and high protein content into cassava cultivars. By crossing cassava with its wild relatives, it is of course very important to retain the "good" traits, which have been selected upon during domestication such as large tuberous roots and thickened stems with enlarged nodes for vegetative propagation. Accordingly, it is of major interest for future breeding to have knowledge about the genetic basis of quantitative traits controlling the differences between cassava and its wild relatives. The main goal of this project is to study the genetic and phenotypic changes that have occurred during cassava domestication, especially to identify the genes or quantitative trait loci (QTL), and linked molecular markers, that control differences in selected traits between cassava and its wild ancestor *Manihot esculenta* ssp. *flabellifolia* and to compare the genetic diversity in cassava and its wild ancestor. This knowledge is of great importance for the use of wild relatives as genetic sources in breeding programs based on marker-assisted selection.

D-06: Genetic divergence in sweet cassava cultivars by using agronomic traits and RAPD molecular markers

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The aim of this research was to assess the genetic divergence among 14 sweet cassava traditional cultivars, by using agronomic traits and RAPD molecular markers. Two environments were considered using the randomized complete blocks with four replicates and twelve morphological traits were evaluated. The generalized Mahalanobis distance was used as dissimilarity measure whereas clustering analysis was utilized as dispersion measures. Generalized Mahalanobis distance indicated that the most dissimilar pairs of traditional cultivars were Pão and Guaíra, Fécula Branca and Pão, Pão and Caipira, whereas the most similar were Fécula Branca and Branca 1, Branca 3 and Branca 1, and Guaíra and Branca 1. By use of clustering analysis through the Tocher method, it was possible to compose six distinguished groups. Group I showed great notability since it was constituted by 42.85% of the evaluated cultivars. The most important trait for the divergence was height of the first ramification, which contributed with 51.59% of the total variation. The divergence analysis by RAPD molecular markers generates a total of 119 amplified bands, where 99 of them were polymorphic, producing 83.19% of polymorphism, which means that they presented a high genetic variability among studied cultivars. Jaccard's coefficient obtained with RAPD molecular markers presented that the most similarly cultivars were Guaíra and Quarenta Quilos (23.37%) while the most dissimilarly were Branca 3 and Amarela da Rama Cinza (58.02%). The results obtained from the agronomic traits were partially in agreement with the ones present by RAPD molecular analysis

D-07: The genetic diversity of cassava cultivars commonly grown in the eastern, southern and Lake Victoria zones of Tanzania

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Cassava is widely grown and ranks among the important crops in Tanzania. Cassava was first introduced in Tanzania in 1600s by Portuguese explorers but to date, there are several grown cultivars in the country. Some of these cultivars are identical or closely related. The research work was done to study the genetic diversity of the commonly grown cassava cultivars and investigate their relationship with the improved cultivars bred by the East Africa Cassava Research Institute at Amani (Tanzania). A total of 135 cultivars including local cultivars collected from the potential cassava growing areas in eastern, southern and Lake Victoria zones and some improved cultivars formerly bred at Amani were characterized using simple sequence repeats (SSR) molecular markers. Results revealed three major clusters; *cluster1* for locals from Lake Zone, *cluster 2* for local cultivars from eastern and southern zones and *cluster 3* for improved cultivars formerly bred at Amani. Some local cultivars –namely Bwana mrefu, Guzo, Tandika, Usilie chumbani and Mreteta, are closely related to improved varieties 5043, 4749, 5535/17, 553/6 and 50298/21, respectively. Gene diversity in locals was higher (0.7091) than the improved cultivars (0.6782) suggesting that local cultivars are a valuable genetic resource for cassava improvement. Higher gene diversity in locals was contributed by the Lake Victoria zone cultivars (0.6049) as compared to eastern and southern cultivars (0.4944). The observed genetic differentiation was very low (0.0344), indicating less variability between local and improved cultivars.

AGRONOMY & PHISIOLOGY

A-01: Toxicity and detoxification of cassava bitter cultivars

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Cassava is an interesting food crop because both the roots and leaves contain cyanogenic glucosides (primarily linamarin) which can yield hydrogen cyanide (HCN), a potent toxin. All cassava cultivars contain cyanogenic glucosides but amounts vary greatly depending on both genotype and the effects of local edaphic conditions. Cultivars with high levels of cyanogens are potentially toxic and commonly referred to as being "bitter." The processing of bitter cassava roots and leaves for food typically reduces, but does not eliminate the presence of cyanogens. The manner in which cassava is processed varies widely. In South America the roots are typically macerated, dewatered and baked as a flat bread, or water soaked, macerated and dry toasted into *farinha (*a coarse meal). In Africa the roots are commonly processed into *gari* –a product similar to *farinha*, or sundried and pounded into a flour. In Africa, but not in South America, health problems, such as acute toxicity, iodine deficiency, konzo (a neurological disorder) and tropical ataxic neuropathy, have been associated with the residual cyanogens in cassava-based foods. In many instances these health problems have been linked to cases of inadequate processing or conditions of nutritional vulnerability such as famines. In addition, dietary exposure to cyanogens has been linked to growth retardation in children because of the preferential use of the sulphur containing amino acids for metabolic detoxification.

A-02: Cyanogenic potential of cassava cultivars grown under varying levels of potassium

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Cassava cultivars NR-44/72, NW-45/72 and OY-44/72 were grown under different levels of potassium in a field experiment at Jimma Agricultural Research Center. The experiment was carried out to determine the effect of potassium nutrition on the level of free cyanide (HCN) in cassava roots. Increasing levels of potassium significantly reduced HCN content in the three cultivars. However, reduction in HCN level was noticed only after high doses of potassium (200 and 250 kg K_2O ha^{-1}) were applied. The lower rates (0, 50, 100, and 150 kg K_2O ha^{-1}) did not significantly reduce the content of HCN. A very clear and significant cultivar difference in HCN content was also observed. The cultivar OY-44/72 had the highest level of HCN (80.59 ppm), while cultivar NR-44/72 contained the lowest level of HCN (71.76 ppm) in its root. Finally, the three cultivars responded differently to potassium application indicating a highly significant cultivar by potassium interaction. Hence, potassium application profoundly affected the level of free HCN content in cultivar NR-44/72, in which the lowest HCN content of 50.65 ppm was found at the highest rate of potassium (250 kg K_2O ha^{-1}).

A-03: Minisett multiplication of micro-propagated cassava – A strategy for quality planting material production

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Research at the Central Tuber Crops Research Institute (Trivandrum, India) yielded conclusive results on the enhanced multiplication ratio in cassava planting material production to the extent of 1:60. However, in order to ensure the production of cassava mosaic disease (CMD)-free cassava planting materials, *in vitro* raised cassava plants were first micro-propagated and were then subjected to hardening. Hardened micro-propagated plants were then transplanted under 35% shade net nursery on beds consisting of sand:soil mixture of 50:50 proportion. Among the spacing adopted in the nursery, 30 x 30 cm was ideal. First cutting from these plants were taken 5 months after planting in the nursery and such stem cuttings were further made in to minisetts of two nodes. A mean of 30 minisetts were obtained from each cutting, and were then planted in a separate nursery under a shade net cover of 35% shade. On attaining one month growth, the minisetts were transplanted to the main field for planting material production. All prescribed agro-techniques required for planting material production was followed and the crop finally harvested on maturity. Quality and CMD free planting materials were obtained apart from the significantly higher tuber yield per hectare.

A-04: Effect of harvesting time and rainfall pattern on some agronomic properties of different improved cassava cultivars

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Cassava is grown and produces acceptable yields on poor soils where other crops yield essentially little or nothing. It can be therefore used to take advantage of marginal lands. The suitability of cassava for industrial use depends on the root yield and quality of starch obtained from it. The objective of this research was to determine the effect of month after planting and rainfall pattern on yield of cassava root, dry matter content, and yield of starch from four new improved varieties namely: *Abasafita*, *Afisiafi*, *Nkabom*, and *Tek Bankye*, which were harvested from 9 to 15 months after planting at different seasons. The quality indices of the cassava roots measured were root yield, dry matter content and starch yield. The rainfall distribution pattern over the entire period of the year 2003 was obtained from the Kumasi Meteorological Station. The root yield and starch yield (dry weight basis) ranged from 7.2 to 60 t ha^{-1}, and 6.22 to 12.21% respectively. The dry matter content of the roots ranged between 26.5 to 49.8%. The effect of rainfall on root yield, dry matter content and starch yield was minimal. About 11 to 14 months after planting recorded appreciably high starch yield, root yield and dry matter content. *Abasafita*, *Nkabom*, and *Tek Bankye* could be selected for production because they had high yields for starch. Dry matter content had an inverse influence on starch yield contrary to the root yield.

A-05: Influence of soil water stress on vegetative growth and yield of cassava genotypes under screen house conditions

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Cassava grown under field conditions is known to adapt to conditions of soil water shortage through various mechanisms such as of leaf shedding, stomata closure, osmotic adjustment, increasing root length and decrease in leaf area. The influence of soil moisture stress on the vegetative growth and yield of nine newly-bred cassava genotypes were studied in the screen house using large polythene bags of 60cm length and circumference of 106cm in a two factor experiment (moisture levels and genotypes) in a completely randomized design with three replicates. Plants were well watered for four weeks after which moisture regimes of 75% (control), 50% and 25% field capacity (FC) were imposed. Plant height and stem girth were measured at 4, 8, 12, 16, 20 and 30 weeks after planting (WAP), whereas yield traits were determined at 16 and 30 WAP. Results showed significant difference ($P < 0.05$) among genotypes and moisture regimes for most traits evaluated. At 16 and 30 WAP, moisture regime of 25% FC led to a mean reduction (% of control) of 12.6% and 21.2% for plant height, 16.3 % and 21.7% for stem girth, 94.5% and 88.7% for root number, 93.3% and 94.9% for root weight, and 59.2% and 50.6% for shoot weight, respectively. As cassava cultivation is expanding into non-traditional semiarid regions of sub-Saharan Africa, breeding cassava for drought tolerance is more than needed with germplasm introductions from Latin America providing unique sources of variability to broaden the genetic base for drought tolerance in cassava.

A-06: An innovative ratooning technique for rapid propagation of cassava in Côte d'Ivoire

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Cassava is cultivated in Côte d'Ivoire on approximately 80 % of its territory. It constitutes the second food crop after yam with a volume of production estimated at 1.5 million tons. It becomes both a subsistence and cash crop for the producers. The low rate of current propagation of cassava limits its extension and on farm diffusion of new cultivars. To overcome that constraint, researchers carried out an experiment during two consecutive years in Côte d'Ivoire. It consisted in taking cuttings at 10 cm, 35 cm and 60 cm from soil on growing plants of three cassava cultivars 7 months after planting. Control was a non-ratoon plant. Plants and tuberous roots were harvested 8 month after ratooning. Results showed that at 35 and 60 cm from soil, the loss in dry matter was significant. However, at 10 cm from soil, the rates of loss in yield and dry matter of tuberous roots were low and were estimated at less than 3.5 %. Moreover, at that level, the quantity of cuttings was the highest. Applying this technique, producers will resolve the problem of planting material on farm.

A-07: Effect of K and Ca fertilization in cooking properties of cassava cultivar IAC 576-70

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The consumption of boiled or fried cassava is a culinary tradition in Latin America. In recent year, culinary consumption increased but with a demand for stable quality. Cassava rots cooked badly in some periods of the year seems to be associated to cellular wall permeability. An experiment was undertaken at 20º 26´ South, 54º 38´ West, 532 m in soil Neossolo Quartzarrenic with the objective evaluating the effect of K and Ca in the cooking quality. Cultivar IAC 576-70 was planted in October 2005. The experimental layout was a complete randomized block with 4 replications for each of the 3 treatments. All treatments had NPK 4:20:20 at planting and thereafter 8 g urea (T1), 22.5 g nitro-calcium (T2), 3 g KCl + 8 g urea (T3). The urea was used to balance the nitrogen in the treatments. Harvests were in March, April and May of 2006. Rainfall was 126, 101 and 56mm m^{-2} in each of the above periods. There were not significant differences for the measured agronomic traits. In March and April the behavior was similar for both cooking traits (deformation and firmness) for sticks cooked for 30 minutes in boiling water. In May T1 showed softer sticks (498.53 g) than both T2 (564.36 g) and T3 (597.46 g), which did not differ statistically to each other. K or Ca can therefore increase the rigidity of the vegetable tissue.

A-08: Crescimento e produção de diferentes variedades de mandioca em sistema agroecológico

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No nordeste, o uso do sistema de cultivo agroecológico com objetivo de melhorar as características químicas e físicas do solo e evitar o uso de produtos químicos, que degradam o ambiente, tem se intensificado nos últimos anos. A cultura da mandioca é muito disseminada entre os produtores nordestinos por apresentar adaptação ao ambiente seco desta região, sendo utilizada tanto para consumo humano, como para os animais. O trabalho foi instalado na comunidade de Morro Alto, município de Acauã (PI), localizada na Serra da Parreira, situada à 620 m de altitude e teve como objetivo avaliar o crescimento e produção da mandioca em cultivo consorciado com guandu, sorgo, caupi, algodão e girassol em sistema agroecológico de produção. A altura, retenção foliar e sobrevivência das plantas de mandioca não apresentaram diferenças significativas considerando os tipos de consórcio. Observou-se diferença apenas entre variedades na sobrevivência das plantas, sendo que a variedade Do Céu (BGM 537) mostrou-se com a maior porcentagem de sobrevivência. As espécies consorciadas mantiveram diferentes teores de umidade do solo, destacando-se o guandu como a cultura que manteve maior teor de umidade do solo (10%), porém o tipo de consórcio não modificou a produtividade de raízes. Observou-se que a produção de raízes por hectare variou de 13 a 26 toneladas, dependendo da variedade utilizada. Esta produtividade, considerada acima da média da região (12 t ha^{-1}), mostra que o cultivo consorciado, principalmente com leguminosas como o feijão caupi e guandu, pode melhorar o rendimento do agricultor e promover melhores características do solo local.

A-09: Efeitos de plantas daninhas sobre o desenvolvimento da cultura da mandioca

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Objetivou-se com este trabalho avaliar a interferência das plantas daninhas sobre as características altura de plantas e diâmetro de caule, visando definir épocas para o início do controle. O experimento foi instalado no município de Viçosa-MG e o delineamento experimental adotado foi em blocos casualizados. Os tratamentos foram compostos por diferentes períodos de convivência das plantas daninhas com a cultura da mandioca, que foram assim constituídos: testemunha 1 (cultura sempre mantida no limpo), testemunha 2 (convivência com plantas daninhas até o final do ciclo), CPD 25 DAP (convivência com plantas daninhas 25 dias após o plantio), CPD 50 DAP, CPD 75 DAP, CPD 100 DAP e o tratamento CPD 125 DAP. Adotou-se o espaçamento de 1 x 0.5 m, sendo a área útil da parcela constituída pelas duas linhas centrais, deixando-se 1 m em cada extremidade como bordaduras frontais, totalizando 8 m^2. As avaliações de altura de plantas e diâmetro do caule foram realizadas em doze épocas após o plantio: 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325 e 350 dias. As medições foram realizadas vinte e quatro horas antes das capinas estabelecidas conforme os tratamentos. Concluiu-se que a convivência de plantas daninhas com a cultura de mandioca por intervalo igual ou superior a 50 dias após o plantio provocou drástica redução no diâmetro de caule e na altura das plantas de mandioca. O controle das plantas daninhas na cultura da mandioca deve ser iniciado em torno de 25 dias após o plantio.

A-10: Efeitos da interferencia de plantas daninhas na cultura da mandioca

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Objetivou-se com este trabalho identificar as espécies de plantas daninhas infestantes da cultura da mandioca e o grau de interferência que estas exerceram sobre o cultivo. Dois experimentos foram realizados em áreas adjacentes, no município de Viçosa-MG. O delineamento experimental adotado foi em blocos casualizados, com sete tratamentos e quatro repetições. Os tratamentos do primeiro experimento foram compostos por períodos iniciais de convivência da cultura com as plantas daninhas: 25, 50, 75, 100 e 125 dias após o plantio (DAP) e no segundo experimento as plantas de mandioca inicialmente permaneceram livres das plantas daninhas pelos mesmos períodos. Para ambos experimentos adotou-se o espaçamento de 1 x 0.5 m. As plantas daninhas foram avaliadas aos 25, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325 e 350 dias após o plantio. As características produtividade de raízes, peso da parte aérea, índice de colheita, teor de amido e matéria seca foram avaliadas aos doze meses após o plantio. As espécies de plantas daninhas que predominaram na área experimental foram: *Bidens pilosa, Raphanus raphanistrum* e *Cyperus rotundus*. Os períodos de convivência com as plantas daninhas não interferiram nos índices de colheita, teor de amido e matéria seca das raízes. Todavia considerando produtividade de raízes o final do período anterior à interferência foi próximo dos 25 dias e, o período crítico de prevenção da interferência situou-se entre 25 a 75 DAP. Cultivos realizados após 75 DAP não afetaram as características da cultura da mandioca avaliadas.

A-11: Avaliação de três cultivares de mandioca de mesa submetidas ao controle de plantas daninhas

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Com o objetivo de avaliar o comportamento de três cultivares de mandioca mesa, submetidas a treze tratamentos de controle de plantas daninhas, realizou-se um experimento de fevereiro a outubro de 2004, no Município de Teresina, Piauí, Brasil. Foram avaliadas as cultivares Casca Roxa, Manteiga e Saracura, plantadas em leiras de 6 m de comprimento, com 10 plantas por leira, sendo 1 m entre fileiras e 0.6 m entre plantas. Adotou-se o delineamento experimental blocos casualizados, com quatro repetições, em arranjo fatorial 3 x 13. Utilizaram-se oito das dez plantas das parcelas (parcela útil) para obtenção dos dados relativos à altura de planta aos trinta, cinqüenta e setenta dias após o plantio, produtividade de raízes, produtividade de parte aérea da planta e índice de colheita. A flora infestante foi identificada e acompanhada sua evolução. As espécies *Cyperus Cayennensis* (Lam.) Brit., *Cyperus iria* L. e *Cynodon dactilon* (L.) Pers. foram as plantas daninhas de maior ocorrência na área do experimento durante todo o ciclo da cultura. Aos setenta dias após o plantio, a cultivar Casca Roxa foi superior às cultivares Manteiga e Saracura em altura de planta. Nesta característica a cultivar Manteiga foi superior à cultivar Saracura. As três cultivares estudadas tiveram comportamento semelhante com relação à produtividade de raízes. A cultivar Casca Roxa (21.33 $t.ha^{-1}$) foi igual estatisticamente à cultivar Saracura (18.39 $t.ha^{-1}$) e diferiu da cultivar Manteiga (16.66 $t.ha^{-1}$) em produtividade de parte aérea. A cultivar Saracura igualou-se à cultivar Manteiga em produtividade de parte aérea.

A-12: Competição inter e intra-específica de mandioca consorciada com milho varietal

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O objetivo do trabalho foi determinar o desenvolvimento e o rendimento em arranjos de plantas na cultura de mandioca consorciado com milho varietal. O experimento foi na a UFSM, Santa Maria, RS. A mandioca cv RS 13 foi plantada em 27/09/2005. O milho cv BRS Missões foi semeado em duas épocas: quando 50% das plantas de mandioca estavam emergidas e quando a mandioca apresentava cinco folhas visíveis. Doze tratamentos foram usados caracterizando diferentes arranjos de plantas nas culturas solteira e consorciados. O delineamento experimental foram blocos completos ao acaso com três repetições. As datas dos estágios de desenvolvimento foram registradas em seis plantas/parcela para milho (emergência, pendoamento, embonecamento, florescimento e maturação fisiológica) e para a mandioca (emergência, início da acumulação de amido, 1ª ramificação simpodial e 2ª ramificação simpodial). Foi calculada a soma térmica (Tb=10°C milho;Tb=14°C mandioca) das fases acima. Foram também determinados os componentes de rendimento da mandioca e do milho. Os parâmetros de desenvolvimento na mandioca consorciada com o milho não foram afetados pelo arranjo de plantas tanto em cultivo solteiro como em consórcio, indicando que a competição inter-específica da mandioca com o milho em consórcio não afeta o desenvolvimento das duas espécies. O maior uso eficiente da terra (UET) foi obtido no consórcio de mandioca com milho, com a mandioca em fileiras duplas de 1.6 x 0.5 x 0.6 m e uma fileira de milho a 0.8 x 0.21m ou 2 fileiras de 0.4 x 0.42m entre as fileiras duplas de mandioca com milho semeado logo após a emergência da mandioca.

A-13: Emissao de folhas e inicio de acumulaco de amido en raizes de una variedade de mandioca em varias epocas de plantio no Rio Grande do Sul

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O número de folhas acumulado (NF) na haste principal está associado ao aparecimento de vários estágios de desenvolvimento da cultura da mandioca. O início de acumulação de amido (IAA) nas raízes tuberosas da mandioca marca o início da translocação dos fotoassimilados para um órgão de reserva na planta. A identificação do IAA é difícil e inconveniente, pois exige o arranquio da planta. O objetivo deste trabalho foi estimar o filocrono e identificar um indicador morfológico (NF) para IAA. Um experimento de campo foi conduzido na UFSM, Santa Maria, RS, com quatro épocas de plantio (28/09; 11/10; 16/11 e 27/12/2005) da mandioca, variedade RS 13 em baldes, enterrados no solo e distanciados de 0.8 m entre si. O delineamento experimental foi o inteiramente casualisado com 11 repetições. O IAA foi determinado em uma das plantas de cada balde quando uma raiz atingia um diâmetro de 1 cm. O NF na data do IAA foi determinado. A soma térmica (Tb = 14°C) diária (STd, °C dia) foi calculada a partir da emergência e acumulada por: STa = ∑STd. O número final de folhas (NFF) até o 1° simpódio também foi determinado. O filocrono variou de 20.5 a 29.5 ^{o}C dia folha^{-1} com maiores valores nos dois plantios mais cedo. O NFF variou entre as épocas de plantio, mas não houve diferença estatística entre as mesmas. O NF no IAA foi similar nas quatro épocas de plantio de desenvolvimento, independente da época de plantio e ocorre quando o NF = 20.8 (±1) folhas.

A-14: Competição de 10 variedades de mandioca no Planalto de Conquista, BA

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Com o objetivo de avaliar variedades locais de mandioca, selecionando aquelas mais adaptadas às condições do Planalto de Conquista - BA, foram instalados três experimentos com 10 variedades locais de mandioca. Utilizou-se o delineamento em blocos casualizados, com 10 tratamentos e 3 repetições. Nos experimentos com mandioca o peso de raízes totais, não diferiu significativamente entre as variedades, em cada localidade. Quando se comparou a média dos experimentos verificou-se que o maior valor foi referente ao plantio realizado na região de Cândido Sales. Quando cultivada em Cândido Sales, a variedade Vassoura apresentou melhor produção de raízes (28.162,39 $kg.ha^{-1}$) e na região de Vitória da Conquista, esta mesma variedade está entre as quatro mais produtivas. A variedade Sergipe, mais cultivada na região de Vitória da Conquista, apesar de não ter diferido significativamente das demais, apresentou boa produtividade de raízes tuberosas, destacando-se como o melhor resultado em Vitória da Conquista e segundo melhor resultado Cândido Sales. No Brasil, a média de produtividade da cultura da mandioca é baixa, aproximadamente 12 toneladas de raízes tuberosas por hectare, segundo o IBGE (2003). Segundo Diniz et al. (1992), um dos motivos para esse baixo rendimento pode ser o uso de variedades pouco produtivas. Os resultados obtidos nestes experimentos mostraram que, a média da produtividade das variedades está acima da média nacional. Este resultado é um indicativo que as variedades utilizadas possuem bom potencial produtivo.

POST-HARVEST

P-01: Resíduos de campo e da industrialização da mandioca: usos, tratamentos e potencialidades

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O Brasil é um dos países que se destaca no panorama mundial na produção de raízes de mandioca e na sua transformação. O processamento da mandioca gera produtos diversos como os de mercado nacional como a farinha de mandioca, polvilho azedo e o amido, ou mercados regionais ou locais, como a tapioca, farinha de tapioca, carimã, etc. Todos esses processamentos geram resíduos em maior ou menor volume e com diferentes graus de impacto sobre o meio ambiente. As empresas mais competitivas têm analisado seu pátio de processamento em busca de resíduos que possam se transformar em co-produtos e produtos, valorizando matérias-primas que são não são utilizadas. Caso não sejam encontrados usos para esses resíduos eles devem ser tratados antes de serem descartados, o que pode resultar em custos elevados e difíceis de serem assumidos por pequenas e médias empresas. A fiscalização tem estado cada vez mais atuante em defesa do meio ambiente e tem aplicado multas vultuosas ou mesmo fechado empresas processadoras de mandioca. Argumentos de que as empresas são pequenas, importantes do ponto de vista social ou mesmo que não há solução razoável para tal resíduo são cada vez menos aceitos. Com resíduos podem ser considerados os de campo e os de indústria. No campo apenas 20% as ramas produzidas no campo são suficientes para novo plantio da mesma área. As folhas de mandioca apresentam cerca de 30% de proteína em massa seca e em sua maioria são perdidas no campo. Nas industrias são gerados resíduos sólidos e líquidos. Os resíduos sólidos são diferentes para as indústrias de farinha ou de amido. Como resíduos sólidos são citadas as cascas, calcanhar, varredura, carolos, farelo, etc. Entre esses resíduos sólidos o mais problemático, mas com maior potencial de uso é o farelo, que apresenta alto teor residual de amido, mesmo nas empresas com bom índice de extração. O farelo apresenta ainda dificuldades pelo grande volume de massa úmida (cerca de 80%) com elevada viscosidade. Entre os resíduos líquidos destacam-se a água de lavagem das raízes e a água de constituição da mandioca que no Brasil recebe a denominação técnica de manipueira. Dois tipos de manipueira são geradas: a água de prensagem da massa ralada do processamento de farinha de mandioca, em menor volume e maior concentração e a água de extração do amido, mais diluída, mas em maior volume. Um agravante dessas águas residuais é que arrastam os compostos solúveis da mandioca incluindo a linamarina, princípio tóxico da mandioca que é solúvel em água. Esforços têm sido feitos para reduzir o volume desses resíduos. Os resíduos sólidos não chegam a ser um problema para o ambiente ou a indústria, a não ser em situações muito especiais. Resíduos secos ou úmidos podem compor rações ou alimentar diretamente os animais. Os resíduos líquidos são mais problemáticos, principalmente nas indústrias de maior porte, farinheiras ou fecularias. Existem resultados de pesquisas que mostram que o tratamento anaeróbio com separação de fases é o mais adequado para os resíduos líquidos, podendo gerar gás combustível (metano) e biofertilizante líquido estabilizado. Embora ainda

faltem resultados de pesquisa em áreas de sacrifício sobre dosagem e formas de aplicação, o maior limitante ainda é o preço dos reatores. Mesmo que seja esperado retorno em uso de gás na indústria o custo de implantação ainda é elevado e na maior parte dos casos, proibitivo. As novas diretrizes geradas do Pacto de Kyoto que incluem impostos especiais para proteção do meio ambiente e comercialização de cotas de carbono em mercado internacional, ainda que tímidas, poderão mudar drasticamente esse contexto. Outra forma de contornar os problemas causados pelos resíduos gerados do cultivo e processamento da mandioca é seu uso como co-produto. O farelo contém fibra de boa qualidade nutricional e a manipueira já esta sendo investigada como meio de cultivo para microrganismos e sofisticados produtos de metabolismo intermediário, como surfactantes, enzimas, compostos de aroma, ácidos orgânicos, vitaminas, etc. Pesquisa recente mostra que mesmo a linamarina poderá ter aplicação valorizada na área de saúde humana. Para que esses usos sejam implementadas há necessidade de quantificar e caracterizar essas matérias.

P-02: **Production of sugar syrup from cassava flour using a combination of rice malt and amyloglucosidase**

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The use of cassava for the production of sugars is a promising industry in sub-Saharan Africa. Hydrolysis of cassava flour by the combination of rice-malt extract (RME) and amyloglucosidase (AMG) on yield and type of sugars were investigated. RME was prepared by malting paddy rice for 10 days at 28°C and diastatic power determined. Effect of rice-malt enzyme concentration on rate of liquefaction and AMG concentration on rate of saccharification were studied. The combined effect of RME and AMG on yield of sugars was investigated. Simultaneous consideration of temperature, pH, and time was studied using response surface methodology. Types of sugars present in syrups were identified and quantified by HPLC. Results indicated that the RME had a diastatic power of 91.46-degree Lintner. The highest RME concentration that could liquefy 10% w/v of cassava flour was 8% w/v within an hour. The combination of 8% w/v of RME with 300-units/ml AMG or 10% w/v of RME with 200-units/ml AMG resulted in the highest yield of sugars. Simultaneous consideration of temperature, pH, and time indicated that the highest yield of sugars occurred at 60°C, pH 4.5 in 4.5 hours of liquefaction and saccharification. HPLC analysis on sugar syrup produced by RME, identified glucose, maltose and other sugars; but the combination of RME and AMG produced glucose and maltose. The combination of rice-malt extract with amyloglucosidase under the specified conditions of temperature, pH and time could increase yields of sugars to DE 80 from cassava flour.

P-03: Effects of cultivars, and peeling plus retting sequence on cassava root processing

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Congo

Eight cassava cultivars grown in Congo, were compared for their processing into "chikwangue" and "foufou". The duration of peeling the roots before or after retting, and matter balance during processes were determined, and the organoletic characteristics of "chikwangue" and "foufou" obtained from roots peeled before or after retting were compared. For most cultivats, peeling before retting had an positive effect, which was more accentuated for "foufou" than "chikwangue", on organoleptic qualities of processed products. The duration of peeling, the processing output and the quality of finish products therefore varied as function of cultivars, and order in which peeling and retting was done. Moreover, certain processing methods were more or less adapted to the cultivar according to the order in which peeling and retting were done.A strict collaboration between the cassava breeders who selects new genotypes, and multiplies cultivars, and food technologists capable to define their ability to undergo technological treatments is therefore indispensable.

P-04: Development of a mix starter culture for cassava root bioconversion

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Two drawbacks limit the utilisation of cassava roots as human food: its low protein content and potential cyanide toxicity. Traditional processing methods used by people in the rural areas to reduce these bottlenecks, always include a typical step of fermentation witch occurs spontaneously. This natural fermentation is plagued with many problems related to high levels of residual cyanide (100 to 170 ppm), long softening time (4 to 5 days), non-reproducible quality and non-hygienic products. To solve these problems, about 100 micro-organisms were isolated from dried fermented cassava tuberous roots, on the basis of their ability to produce β-glucosidase, α-amylase, pectin hydrolase and polygalacturonase. These enzymes are involved in biochemical and physicochemical phenomena, which occur in cassava natural fermentation and are responsible for the degradation of cyanide compounds and tuber softening by degrading pectin, which constitutes the major part of cassava cell wall. Among these isolates 60% were identified as α-amylase producers, 46% as β-glucosidase producers, and 36% pectinase producers. The ability of these selected micro-organisms to produce enzymes was screened. Among the isolates, two micro-organisms were particularly interesting: lactic acid bacteria identified as *Lactobacillus plantarum,* showing α-amylase activity of 17,000 ± 100 UE/ml, and ß-glucosidase activity of 2,000 ± 300 µmol CN^-/mn; a mould identified as *Rhizopus oryzae* with an α-amylase activity of 20,000 ± 500 UE/ml, and pectinhydrolase activity of 2.3 ± 0.2 µmol COO^-/mn/mg. These strains were selected and used as starter culture for cassava fermentation. The use of these strains as a mix starter culture (10^6 fuc/g fresh cassava tubers of *Lactobacillus plantarum* and 10^3 spores/g fresh cassava tubers of *Rhizopus oryzae*) for cassava retting rapidly softened the roots (12 ± 3mm/5s after 48 hours of retting), and induced a rapid decrease in pH (3.5 after 24 hours of fermentation). Natural fermentation was found however to reduce more cyanide than starter fermentation. The rapid acidification observed with starter fermentation was found to be responsible of this low cyanide degrading activity by starter strains as low pH stops the reaction at the cyanohydrins step. Research on the effect of environment on starter strains shows that *Lactobacillus plantarum's* optimal growth temperature was 40 ± 5°C for an optimal pH of 6, while *Rhizopus oryzae* show an optimal growth temperature of 30 ± 7°C for an optimal pH of 5. These strains also showed a good growth rate on Law *et al.,* cassava medium (CTM). With the aim of large-scale utilization of this starter culture, the micro-organisms were tested for their ability to withstand drying conditions. Survival of *Lactobacillus plantarum* and *Rhizopus oryzae* after drying was determined under various support conditions. The support constituting starch and glycerol as protectants was found to be the best with more than 75 ± 5% survivors after drying at 35°C under a hot air flow of 10 m^3/h. The use of the dried mix starter for cassava retting permit the reduction of the total cyanide content by about 95 ± 4%, as NaOH were added after 24 hours of fermentation to enable a drop in the pH level to 5. This approach allowed us to solve the bad effect of low pH on cyanide reduction observed by the fermentation of tubers using mixed starter cultures.

P-05: Evaluation of rural processing techniques for the reduction of cyanides in cassava cultivars grown in Zambia

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This research aimed to determine the effect of different processing methods on the reduction of cyanogenic glucocides (HCN) in major cassava cultivars grown in Zambia. The sensory evaluation of the raw and processed cassava for bitterness and acceptability was conducted to determine the acceptability of the processed products after the different treatments the cassava was subjected too. The nutrient content of the cultivars was also quantified, including the cassava peel due to its potential for the feed industry. The cultivars Bangweulu, Chila, Kapumba and Manyopola were subjected to five treatments namely soaking, mashing and drying (1), soaking and drying (whole root) (2), grating and drying (3), chipping and drying (4), and grating, fermenting and roasting or "gari" processing (5). Chemical analysis, which gave information on glycoside concentration in cassava, pH and acid levels during fermentation were performed. Proximate analysis for ash, moisture, protein, crude fiber, fat and energy levels were conducted. Microbial analysis was undertaken on fermented products. Sensory evaluation for bitterness and acceptability was done all the four cultivars. Chila had a higher concentration of glucocides and consequently more bitter followed by Bangweulu and Kapumba. Manyopola was the least bitter: it tasted sweet as it had lower levels of glucocides. The concentration of the HCN in the four cultivars was reducing logarithmically with processing, which gave negative slopes but the rate of reduction varied among cultivars and treatments. With soaking all cultivars lost HCN to acceptable levels of 10mg kg^{-1}. There was no significant difference in the rate of reduction of HCN concentration between the soaking treatments (1 and 2) and between those that involved drying (3 and 4). Soaking treatments alone reduced the HCN concentration to 10 mg kg^{-1}, which was achieved even before drying the samples. A higher growth of lactic acid bacteria was observed at 30^{o}C (optimum temperature) than at 35^{o}C during fermentation and this led to the production of organic acids like lactic and acetic acid, which lowered the pH and increased the percent titratable acid. "Gari" from Manyopola had HCN reduced to 10mg kg^{-1} with fermentation of 24 hours whereas "gari" from Chila and Bangweulu still retained HCN when fermented for 24 hours, which was lost after 72 hours of fermentation. During sensory evaluation Chila was ranked as the most bitter followed by Bangweulu, Kapumba and Manyopola. All the soaked products were liked for lack of bitterness. The products from Manyopola had a higher overall acceptability on flavor, aroma, color and taste than those from Chila. Cassava peels were found to be rich in ash protein carbohydrates and energy content though the HCN concentrations were still above 10mg kg^{-1} after oven drying at 30^{o}C to 10% moisture content.

P-06: Fungal enrichment of cassava peels protein

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About 60% of the cassava produced all over the world is used for human consumption. These peels waste were found to contain 42.6% carbohydrate, 1.6% protein, 12.1% ether extract, 5% total ash and 22.5% crude fiber. With the advent of biotechnology approaches, there are opportunities for economic utilization of agro-industrial residues such as cassava peels waste. The micro-organisms isolated from the fermenting cassava waste were *Aspergillus niger*, *A. flavus*, and *A. fumigatus*. These fungi and *Trichoderma* sp. from soil were studied for their ability to increase the protein content of cassava peels waste.

P-07: Bio-potential of cassava bagasse- the concept of bio-refinery

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Cassava bagasse, which is a fibrous material, is the by-product of the cassava-processing industry. It contains about 30 to 50% starch on dry weight basis. Due to its rich organic nature and low ash content, it can serve as an ideal substrate for microbial processes for the production of value-added products. Attempts have been made to produce several products such as organic acids, flavor and aroma compounds, and mushrooms from cassava bagasse. Solid-state fermentation has been mostly employed for bioconversion processes. Cassava bagasse could be an attractive raw material to work on the principle of bio-refinery to utilize each of its components in order to increase economy of cassava industry. Bio-refinery integrates biomass conversion processes and equipment to produce chemicals, fuels, and power from biomass. The bio-refinery concept came analogous to today's petroleum refineries. Bio-refineries have been identified as the most promising route to the creation of a bio-based industry. Bio-refinery development focuses on integrating the production of biomass-derived chemicals, fuels and other products in a single facility. The emphasis is on using improved processes to derive products such as ethanol, lactic acid, succinic acid, 3-hydroxypropionic acid, 1,3-propandiol, and xylitol. Biomass is made up of cellulose, hemi-cellulose, and lignin. The agriculture crop residues, tree and forest thinning, and other wastes may be utilized for bio-refining.

P-08: Cassava as a feed source for the industry in Ghana

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Developing better breeding practices and higher yielding and disease resistant cassava cultivars forms the corner stone of the cassava industry and for domestic use in the Sub-Sahara Africa and many other developing countries including Ghana. The dual uses and the multipurpose roles which cassava is use for has resulted in cassava becoming a household and the most cheapest and most accessible to homes in Ghana, Sub-Sahara Africa and many developing countries. Presently in Ghana, bigger industries and factories are producing cassava in a much larger proportion on commercial scale for the production of starch for scale to the local economy, for export to other countries in the sub region and elsewhere. The Ayensu starch factory. which has been set up by a presidential special initiative (PSI). The PSI is a statutory drive by the Government of Ghana to create jobs through agriculture and to add the needed value to some selected staple crops, which has yielded grate positive results. The poultry industry in Ghana heavily rely on the Ayensu processing factory for cassava left over that they use as key component and ingredient in the feeds that is produced to feed poultry and is also used as key component of feed for other farm animals. Cassava as the back bone of the animal farming industry in Ghana and many other African countries also heavily rely on by the farmers as the number one source of feed for animals in both large scale and small to medium scale farming all rely on cassava and its leaves as the main source of feed to feeding these animals for commercial and subsistence purposes. Ghanaian and African research scientists based in Ghana are working in collaboration with development partners to develop a disease resistant and high yielding cultivar that will be sought after by industry and also for animal farming industry as feeds. Among the countries that rely on Ghanaian cassava as feed for their animals include feeding the animals brought to the northern part of Ghana by pastoralists from Burkina Faso, Mali and Guinea and it has been identified this is also a good source of income for the local Ghanaian farmers.

P-09: Eco-friendly approach to manage aphids in vegetable crops by using biopesticide prepared from cassava seeds

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Large number of fruits produced by certain edible cassava (*Manihot esculenta*) cultivars has not been exploited for any commercial purposes. In the present investigation, the biopesticide extracted from cassava seeds in organic solvents was proved to be a potent eco-friendly insecticide to manage certain major insect pests of vegetable crops. Laboratory study showed that the biopesticide is highly toxic to *Aphis craccivora* (pea aphid), a noxious pest of pea in the field. Mortality of the aphid at a dose of 1% was 79.3% on 1 day after treatment (DAT) and it increased to 90.5 and 96.7% on 3 and 5 DAT respectively. But mortality recorded from the control batch was only 22.1%. Field experiments revealed that the biopesticide at a dose of 2% when sprayed killed 87.8% aphids whereas no mortality was recorded in the untreated plot. The yield was also increased significantly in the treated plots, and the average quantity of yield per plant was 131.6 and 46 g respectively from the treated and untreated plots. Colonies of aphids on the leaves and fruits of *Coccinia indica,* (ivy gourd), another important vegetable crop, were completely cleared by the biopesticide at a dose of 2%. The study proved that cassava fruits estimated to be over 10,000 fruits per hectare could be exploited to prepare eco-friendly insecticide against certain field pests. Bulk quantity of the biopesticide can be extracted from cassava seeds, as its extractability is very high (30%). Successful adoption of this technique will ensure additional revenue to the farmers from the bio-waste.

P-10: Monitoring of malnutrition weaning tribal infants by introducing cassava made indigenous semisolid diet

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Early marriages of girls, inadequate breast feeding to new born and then shifting babies directly on plane solid diet are the regular traditional practices in tribal inhabited in western part of India which force early trigger of grade IV malnutrition and mortality of the infants. The effect of cassava made semisolid indigenous diet was studied in weaning tribal babies before shifting them on solid diet. This research was conducted between May 2004 and Dec 2004 in two hamlets located in the interior, inaccessible tribal belt where there was alarming rate of grade III and IV malnutrition. Two group of weaning subjects constituting control and experimental between the age groups of two and six months were selected. The pre-weaning weight and malnutrition status of each baby was recorded. On the onset of weaning process the indigenous cassava based semisolid diet providing 1800 calories daily was given to each baby thrice in a day under perfect hygienic conditions for six months until babies were shifted on normal traditional cereal based solid diet. The health of babies was monitored regularly. The introduction of cassava based weaning food had decreased the malnutrition and infectious diseases significantly compare to the control where all the babies were found malnourished with diarrhea infections. The introduction of cassava based weaning food first time in this belt has helped to reduce malnutrition linked mortality in tribal infants where this concept was totally missing and every year thousands of malnourished tribal infants becomes true victims of diarrhea. The weaning baby food prepared from cassava appears to be very promising source of nutrition to the children to eradicate the root cause of malnutrition. The results of this experiment were observed and confirmed by many lactating tribal mothers on experimental site it self. Large-scale cultivation of genetically improved cassava cultivars is recommended in this nutritionally affected belt to have a permanent solution to eradicate child malnutrition.

P-11: Production of cassava bread using indigenous micro-flora and improved cassava cultivars

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In sub-Saharan Africa, bread is an important staple food, the consumption of which is steady and increasing. It is however, relatively expensive, being made from imported wheat that is not cultivated in most Nigerian locations due to climatic reasons. In choosing the appropriate flour type for non-wheat baking practices, it is important to give full consideration to the realities of the local agricultural resources prevalent in the area in question. Most important crops grown in Nigeria are maize, sorghum, millet, cassava, sweet potato and yam, as well as legumes as soybean, cowpea and groundnut that can be used as protein quality improvers. Many nations all over the world have for instance developed their own bread specialties based on their available agricultural resources. The use of cassava flour for bread making will reduce this large dependence on imported wheat and increase the production of cassava in the country. About 33 million t of cassava, which is basically a carbohydrate food, is produced in Nigeria annually. An important part of developing and strengthening commitment to eliminate hunger and malnutrition is developing methods of utilizing local agricultural resources to design new food products. Many African foods are fermented before consumption and a variety of microorganisms are widely used as starter organisms in these food fermentations because they convert sugars into organic acids, ethanol, aldehydes, ketones, and diacetyl among others, thus improving the organoleptic and rheological properties of the products. It is known that fermentation may enrich foods in protein by removing part of the fermentable carbohydrate as documented in fermented foods made from cassava such as gari and foofoo. Our research focus includes production of a bread specialty from 100% cassava flour using starter cultures selected from dominant epiphytic micro-flora isolated from spontaneously fermented cassava flour; genetic modification of cassava to produce low cyanide, high flour yielding and quality protein cassava cultivars for bread-making in Nigeria.

P-12: Small scale cassava processing and vertical integration into the sub-sector in Uganda

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Cassava plays an increasingly important food security role and demand for food consumption and industrial use is growing in Uganda. Traditionally cassava is processed into chips, flour and gin but these traditional methods give low yields of poor quality products. Developing the income generating potential of cassava can improve the livelihoods of rural farmers and processors. To achieve this small holder farmer groups were provided with simple cassava processing technologies to transform highly perishable fresh cassava into stable market-grade intermediate products like chips or flour for the industry. The farmers and processors were trained in processing high quality cassava chips, group dynamics and business skills. They were linked to the private sector (feed millers, equipment fabricators, traders) and to, research institutes working on cassava (vertical integration). A pilot site managed by the farmer group leaders was set up and this serves as a one stop centre for buyers who have an agreement with the farmers to buy specified quality and quantity of cassava at an agreed price. Because of the improved quality of the cassava chips obtained by using appropriate market-oriented cassava processing technologies (e.g. the chipper and raised drying racks), the farmer groups are receiving a better price than the traditional cassava chips.

P-13: Further processing of cassava: sub-Saharan African way

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Cassava products have over the years been a staple food of many sub-Sahara African people. Cultivation of cassava was known to be the main food crop of one the tribes of Nigeria and Benin called Yoruba. According to the historians of the tribe, the number of acres of cassava plantation is a measure of community social power during slave trade era. The slaves sold out to the Americas were those that were energetic and work well in cassava farms. They also brought with them the skills of cultivation and processing of cassava into products. However the advent of foreign cultures in the countries of destination of the African slaves, as well as mass production with much emphasis on profits and little attention on eating quality diluted the original cassava further processing skills. The products in northeast of Brazil are different from those in sub-Saharan African. Products such as "farinha de mandioca" and "karuma" have resemblance to "gaari" and "fufu" of West Africa respectively but they are not the same. The differences are in their taste, texture and the behavior of the products when processed into food. The cassava products in Brasil cannot be adjudged the best until those from the sub-Saharan African are tried and tasted. The processing of cassava in the region is the factor. At *Vision Foods*, we understand the processing factors that contribute to the eating quality of cassava products. Hence our products are made base on this knowledge.

P-14: Laboratory analyses as a tool for assessing landraces grown by small Brazilian cassava producers. I. Physical-chemical composition

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The center of origin and domestication for cassava is Brazil, where a great genetic variation occurs for this crop. Cassava domestication was the result of its utilization as food crop. A landrace cassava collection was assessed through laboratory analyses (AACC, 1995) to determine the efficiency of traditional selection and search for other potential uses. The landraces were collected in the North of Brazil as described by Martins (1994): 30 from Rio Negro's Basin (AM), of which 2 were recommended for food use and the others for Brazilian flour, and 16 from Rio Solimões's Basin (AM), being all selected for flour manufacturing. In the South border of SP State 9 landraces were collected: 2 for flour and 7 for food use. Harvest was about 10 to 12 months after planting the landraces in SP State (22º 48´ South, 48º 07´ West, 469 m altitude). The content of potential of cyanide was analyzed independently in leaves, stalks and roots. The leaves had high nitrogen content and the stalks showed significant total carbohydrates content. Domestication was able to select cassava landraces with high starch and dry matter contents. Starch yield was 2.05 kg/plant in a SP –landrace, and the minimum was 0.10 kg/plant in an AM-landrace but both were suitable for flour manufacturing. The Anta landrace with yellow pulp (PA) had the lowest starch and dry matter contents after extracting the cassava juice (*tucupy*), which can be used as sauce in local cuisine.

P-15: Laboratory analyses as instrument for assessing landraces grown by small Brazilian cassava producers. II. Cyanide

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Brazil is the center of origin for cassava, and through vegetative propagation its great genetic variation spreads. The whole cassava plant contains linamarin, a glycoside potentially generator of cyanide by the action of autochthonous enzyme. The Brazilian culture values the plant of low cyanide content (sweet) for food use and high (bitter) for processing (flour or starch). Cyanogenic contents (free and total), expressed as mg CN^-/kg in dry basis, were used to assess landraces for any potential users. Cyanide was determined in the whole cassava roots and inner peel and pulp separately as Essers, (1994). Landrace collections included 30 from Rio Negro's Basin (AM), of which 2 are of food use and the others for flour manufacturing; 16 from Rio Solimões's Basin (AM), being all selected for cassava flour, and 9 from south of SP State border: 2 for flour and 7 for food use. The landraces were grown in SP State (22º 48´ South, 48º 07´ West, 469 meters) for a cropping cycle of 10 to 12 months. Free and total cyanide showed low correlation with agronomic descriptors, confirming the difficulty in identifying plants by morphologic characteristics. There was not relationship between the cyanogenic potential and traditional use. The landraces had on average roots with 126.7 mg/kg db, and the range varying from a maximum of 340.65 to a minimum of 45.68 mg/kg db. Pulps presented lower contents. If expressed as fresh pulp all the landraces could be considered innocuous in spite of the recommendation for flour production. The results show the danger of just considering the views of the traditional growers without doing an analysis that confirm the user needs.

P-16: Cyanide-free cassava analysis using KCN or acetone-cyanydrin

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Brazil

In the free and total cyanide determination by colorimetric reaction linamarin is used as pattern in an enzymatic reaction or ny chemical hydrolysis. The enzyme linamarase is extracted from cassava. The commercial linamarin is very expensive and obtained by synthesis. Linamarin has not been recently offered in the chemicals catalog. Acetone cyanidrin is the product of the linamarin hydrolyzes by linamarase as intermediary phase for CN liberation. If used as pattern presents advantages in relation to linamarin by not demanding the enzyme linamarase. The potassium cyanide can also be used as pattern due to low cost and readiness in the Brazilian trade. The proposed method was based on the colorimetric reaction using picric acid as reagent. It was compared as pattern both acetone cyanidrin and potassium cyanide diluted in sulfuric acid 0.1M solution (pH 2.5) readings in 535 nm by a spectrophotometer. Times of reaction of 15, 20, 25 and 30 minutes ware compared for color development. The minimum time selected to obtain stable readings was 15 minutes. The calibration curve had a coefficient of determination (R^2) of 0.97 for both patterns, showing that both have a good sensibility. Cyanide-free analyses in cassava liquor using KCN as pattern for 14 samples of cassava liquor had on average 193.53 µg $CN^-.L^{-1}$ with the lowest contents (193.07 µg $CN^-.L^{-1}$) for laboratory samples and the highest in a commercial sample (199.52 µg $CN^-.L^{-1}$). The method will be tested for analyses of cassava landraces for culinary and industrial use.

P-17: Use of native cassava starches for processed foods in stress conditions

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Starch is the largest source of carbohydrates after cellulose. Cassavais the second raw material most used in the world after maize. The materials included in this research were cassava landraces Dg 100, Dg132, Dg135, Dg163, Dg272 and Dg387 from the ESALq (Escola Superior de Agricultura Luiz de Queiroz), Piracicaba, Brazil along with commercial native cassava (*Branca de Santa Catarina*), maize starches, and 2 modified maize starches. The starch analyses allowed to assess stress functional properties, which were determined through water retention, viscosity and consistency of the gels after passing through a simulation of a food processing (stress). The evaluated stresses were freezing [-18ºC], sterilization [121°C, with pressure of 1 kgf/cm² during 2 h], resistance to acidity [pH of 3.5, with citric acid] and storage in fridge temperature [+ 4 ºC]. Cassava has cultivars suitable for each kind of stress with the exception of freezing. There are thousands of cassava cultivars in Brazil whose starch have not been assessed and with potential for commercial uses.

P-18: Cassava cooking time

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Cassava roots are used at home mainly cooked, or fried after cooked. It is therefore important to have a trustful and simple way to estimate this cooking time for cassava roots. We built an instrument, based on that of Matheson, which was developed to measure peas cooking time. It consists of two aluminum supports and 15 stalks (90g) each with a needle on its end. We worked with six different cultivars grown for two consecutive years. The roots were harvested 8 to 20 months after planting. We analyzed 3 plants for each cultivar, using the middle part of each root, which was cut for having 80 g. They were then cooked with de-ionized water. Cooking time was settled when 8 needles completely entered the root. The variation coefficient varied from 2 to 7 %, and cooking time varied from 19 to 35 minutes. It was possible to statistically discriminate the different cultivars with different ages. This interesting instrument can therefore help cassava breeding for home uses.

P-19: Physical properties of cassava starch films containing glycerol

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The aim of this work was to investigate some physical properties of cassava starch films containing glycerol. Films were prepared from film-forming solutions with 2g cassava starch per 100g water plus 0, 15, 30 and 45g glycerol per 100g starch, and analyzed to determine its mechanical properties by tensile tests; the glass transition temperature (Tg) by differential scanning calorimetry; the crystallinity by X-ray diffraction and moisture content by a new, fast and non-destructive microwave methods. The infrared spectra of the films were also recorded. The resistance values of the films decreased while those of the elasticity increased with the increase of the glycerol concentration, due to plasticizer effect of glycerol, which was also observed in DSC curves. The Tg of the films prepared decreased with the glycerol content. However, for samples with 30 and 45g glycerol per 100 g starch, two Tg curves were observed, probably due to a phase separation phenomenon. According to the XRD diffractograms, films with 0 and 15g glycerol per 100 g starch presented an amorphous character, but some tendency to show crystalline peaks was observed for films with 30 and 45 g glycerol per 100 g starch. The results obtained with FTIR corroborated these observations. Microwave measurements were sensitive to the moisture on films.

[2]

P-20: Effect of month of harvest on yield and quality of gari from four elite cassava cultivars

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Four elite cassava cultivars, two of which (*Afisiafi* and *Tekbankye*) were planted in July 2000 and the other two (*Abasafitaa* and *Gblemoduade*) in August 2000, were harvested each month from April to September, the following year and processed into *gari*, (roasted, fermented cassava mash). Selected physicochemical properties of the *gari* were determined and these include moisture, ash, pH, total titratable acidity, crude fibre and swelling capacity. Moisture content ranged between 9.54% and 11.57% whereas ash was between 0.88% and 1.39%. Values for both properties were below the maximum standards set by Codex Alimentarius Commission. Titratable acidity was between 0.85% and 1.62% while pH ranged between 3.58 and 4.21. Swelling capacity was below 3, indicating that *gari* from all four cultivars could not swell to three times their initial volume. *Afisiafi*, *Tekbankye* and *Abasafitaa* had optimum *gari* yields in August while that of *Gblemoduade* was in September of the same year. The cultivars significantly differed ($P < 0.05$) from each other with respect to pH while month of harvest significantly affected ($P < 0.05$) moisture, bulk density and yield of the *gari* from the fresh roots.

P-21: Harvesting time effect on yield and selected physico-chemical properties of flour from four elite cassava cultivars

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Four elite cassava cultivars (*Afisiafi, Tekbankye, Abasafitaa* and *Gblemoduade*) were harvested each month from 9 months to 15 months after planting and processed into flour. The yield and some of its physicochemical properties were studied to determine how they are affected by age at harvest. The properties of flour studied were moisture, ash, pH, crude fibre, crude protein, amylose, starch, swelling power and solubility. *Afisiafi* and *Tekbankye* had optimum flour yields at 13 months after planting while *Abasafitaa* and *Gblemoduade* had optimum flour yields when harvested at 12 months after planting. *Afisiafi* and *Tekbankye* had flour yields increasing uniformly from 11 to 13 months after planting after which they fell while *Abasafitaa* and *Gblemoduade* had their flour yields increasing from 9 to 12 months after planting after which they fell. Flour pH ranged between 5.1 and 6.7 while starch content was between 53.6% and 76% and solubility between 7.8% and 18.8%. Age at harvest significantly affected ($P < 0.05$) flour yield, crude protein and ash. The cultivars significantly differed ($P < 0.05$) from each other with respect to solubility and flour yield.

P-22: Starchy properties of selected cassava roots and commercial stiffening agent

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This research was undertaken to compare the clarity and textural properties of series of starch gels from selected cassava cultivars with those from a commercial cassava based product used to starch textile. The transmittance was measured at 650 nm using spectrophotometer to determine the clarity of gels. Back-extrusion with TA-XT2i was performed to measure gel viscosity. The starch gels of selected cassava cultivars 98/0002 and Yavo were clearer and more viscous than that of the commercial product. The selected cassava cultivars showed a positive correlation between the gel concentration and the clarity property, while commercial product presented a opposite effect. This research showed therefore the non-food applications of new and native cassava starches as stiffener agent in textile.

MISCELLANEOUS

M-01: Improving cassava for enhancing yield, minimizing pest losses and creating wealth in sub-Saharan Africa

Rodomiro Ortiz
Perú

Cassava was brought to Africa by the Portuguese at the end of the 16th Century and today should be regarded among the two top staples of the continent. However the crop faces many challenges because it may be affected by biotic stresses and end-user demands. Cassava can be a source of income by adding-value through domestic agro-processing or as raw material for the local industry. This article provides an overview of cassava improvement through crop breeding, especially for cassava mosaic disease and bacterial blight, and biological control of pests such as cassava mealybug and green mite. The achievements in the genetic enhancement of the crop or its eco-friendly plant health management result from using genetic resources of the crop or biological control agents brought from the South American center of origin of cassava. Without these research-for-development successes brought cassava output cassava production would be 50% or less in Africa, i.e., over 13 million t $year^{-1}$ of dry cassava, enough to meet the calorie requirements of 65 million people in sub-Saharan Africa. In recent years, cassava changed rural landscapes, and this poor farmer's crop became a pacesetter of African rural development. Cassava post-harvest processing may be a major vehicle for job creation and poverty reduction in rural areas. The accomplishments of cassava research-for-development in, and for Africa ensued from a strategy that considers producing locally, minimizing risks and creating wealth.

M-02: Uncovering local understanding of cassava varietal selection at Koudandeng – Obala, Cameroon

Ntumngia Regina Nchang
Cameroon

This research uses data at the individual level to assess the diversity of cassava cultivars among male and female cassava producers, and documents the link between their decision-making frameworks and their practices in the selection of cassava genetic diversity using the case of male and female cassava farmers of Koudandeng village in the Obala administrative sub-division of Cameroon. The free-listing and ethnographic data, which formed the basis of the analysis, were collected in 2005 from a stratified sample of 39 male and female cassava producers, each per household. Free-listing analysis was done to identify the genetic diversity of cassava among male and female farmers and while the index of salience was used to highlight the important cassava cultivars and the gender differentiation in the degree of importance of each cultivar. The pivot table analysis was used to cluster the characteristics of each cultivar across informants, reasons for their cassava varietal selection and how these local evaluation and classification of the different cassava cultivars, which constitute their knowledge, is translated into male and female farmers' everyday strategies and practices. The findings question the extent to which government policies that promote major shifts in traditional production systems to more intensive production systems for the market where high yielding cassava cultivars are bred and disseminated affect cassava genetic diversity in the light of increased commoditisation of cassava. They highlight that high yielding cassava cultivar introduction does not necessarily lead to cassava genetic diversity loss but to an increase or maintenance and suggests that the link between farmers' (especially women as custodian of cassava genetic diversity) local evaluation and classification frameworks of the different cassava cultivars they grow and their varietal selection strategies and actions should be clearly understood by looking at intra-species level variation in the characteristics of the different cassava cultivars in agricultural policies and research. The results given are a fist step towards an in-depth analysis of farmers' knowledge in the management of cassava genetic diversity and are therefore intended to stimulate further discussion.

M-03: Exploring cassava as a viable alternative to food crisis in Zambia

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Zambia

Zambia is one of the Southern African countries that experienced drought between 2001 and 2003. As a result, the country had low levels of maize harvest, which is the country's main staple food. The Zambian population depends on maize for both household food security and cash. Cassava is a major staple food crop of North-Western, Northern and Luapula provinces making up 30% of the population. In terms of scale and productivity gains, 300.000 small–scale farmers grow cassava with an average plot size of 5 ha. Furthermore, 20% of cassava area grows bred-cultivars and this area continues growing rapidly. These provinces have surplus of cassava and are constantly selling it to Democratic Republic of Congo and Angola. The crop is considered as success in the sense that mealybug biological control averts famine in cassava –dominant zones, new disease resistant cassava cultivates are high yielding, and cassava is a less labor-intensive crop viz. a viz. maize and other food crops. It is however, important to note that funding for cassava research plus marketing and processing technology are key to the expansion of cassava. The government should recommended farmers to grow cassava as a viable food security alternative especially in Southern province which is prone to drought.

M-04: Konzo and cassava toxicity – a study of associated nutritional factors in the Popobaka district of the Democratic Republic of Congo

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Konzo is a neurological disorder characterized by sudden onset of paralysis of the legs. This disorder has been attributed to the high dietary cyanide exposure from insufficiently processed roots of bitter cassava. Cassava contains cyanogenic glycosides, mainly linamarin that after enzymatic conversion to cyanohydrins, may release spontaneously or enzymatically the toxic hydrogen cyanide (HCN). This research was initiated with the objective of identifying associated nutritional factors involved in konzo, which still occurs in Popokabaka district with an incidence rate of 1.3 ‰ in 2002. The diet was largely dominated by cassava and almost all households consumed at least once a day luku, the stiff porridge from the cassava flour. Cassava and cowpeas leaves, which are of poor quality in protein –especially for sulphur-containing amino acids, were the major food items consumed as side-dishes to the staple food. Cassava leaves cannot compensate for the dietary deficiency in sulphur-containing amino acids in the staple food in konzo affected areas. Furthermore, cassava leaves could be an additional source of dietary cyanogen in the region because the leaves require prolonged cooking and with the unavailability of electricity or gas and scarcity of firewood, they are consumed after a short cooking time. The urine samples from half of the participants contained more than 300 μmol l^{-1} of thiocyanate, which suggested a high cyanide overload. The low concentration of taurine suggested that more sulphur is directed to the detoxification of cyanide by formation of thiocyanate. The populations of Popokabaka are still highly exposed to cyanogen dietary cassava and perhaps to environmental cyanogens. The increased risk of konzo in this region where the paralytic disease is still occurring requires a more efficient post-harvest processing, and a better balanced diet –particularly richer in methionine.

M-05: Alianza pública-privada aplicada al mejoramiento de la yuca y al rescate del conocimiento tradicional

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En el marco del Proyecto" Promoción del uso de la yuca en la industria de producción animal y de alimentos balanceados para animales de América Latina y el Caribe: Un enfoque de mercado para mejorar la competitividad", auspiciado por el Consorcio Latinoamericano de la Yuca-CLAYUCA y el Fondo Común de los Productos Básicos (CFC), se diseño un programa de capacitación y transferencia tecnológica para un grupo de 65 productores de yuca, pertenecientes a las comunidades El Guamo (estado Monagas) y Mucura (estado Anzoátegui), ubicadas en la región oriental Venezolana. La metodología empleada contempló actividades de evaluación participativa, talleres vivenciales y establecimiento de bancos de germoplasma comunitarios. El objetivo principal de estas actividades fueron propiciar el rescate del conocimiento tradicional de cada comunidad y armonizarlos con una nueva visión científica y tecnológica, valorando al ser humano, al ambiente como medida de sostenibilidad del proceso productivo y la necesidad de establecimiento de una actividad económica rentable y adaptada a los requerimientos de seguridad y soberanía alimentaría del país. Resultados preliminares han permitido la identificación y valoración de los clones adecuados a cada localidad e iniciar un programa de incremento de material vegetativo de calidad, identificar los criterios empleados por los agricultores para la evaluación del germoplasma, conocimiento e internalización de las herramientas tecnológicas adecuadas para el manejo rentable del cultivo y como valor agregado adicional, ha servido de punto de concurrencia entre funcionarios de la empresa privada y pública, en un área tan importante y de interés común.

M-06: Manioc and fish consumption in riverine Caboclo households in two Amazonian ecosystems: a comparative analysis

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The objective of this study was to compare preliminary data on household food intake with especial emphasis on manioc consumption of two caboclo populations settled in different riverine ecosystems in the lower Amazon: a terra firme (upper-land forest) environment in the Caxiuanã National Forest and a floodplain environment on Ituqui Island. Data on household food consumption were collected using 24-hour food recall in 1995/1996 on Ituqui Island and in 2004/2005 in Caxiuanã. Structured interviews were undertaken in 12 households in Ituqui and 17 in Caxiuanã, during 7 consecutive days, in both rainy and dry seasons. Caloric and protein values were calculated using the major Brazilian food composition tables. The data was statistically anayzed through ANOVA at $P < 0.05$. Manioc products and fish are the staples in both Caxiuanã and Ituqui populations. Manioc products count for 44% and 30% of the total calories ingested in these populations, respectively, whereas fish counts for 62% and 54% of the total protein consumed, respectively. Caxiuanã shows significantly higher values of caloric and protein intakes originated in manioc ($P_{calorie}= 0.000$, $P_{protein}= 0.001$) than in Ituqui. However, when caloric intakes originated in fish are compared, Ituqui shows values significantly higher than those obtained for Caxiuanã ($P_{calorie} = 0.003$). The differences observed between the two populations are most likely related to higher resource diversity in the terra firme environment, land availability for cultivation, and seasonal environmental extremes observed in the flood-stressed environment of Ituqui.

M-07: Cassava in Assentamento 72 from Ladário city – MS, Brazil.

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Brazil

Cassava is a subsistence crop and important for food security. The locations were the agrarian reform was made in Brazil are called Assentamento. In the Assentamento the farmers are their own manager and work is divided by the family. The study analyzed the Assentamento 72 located at Ladário city, Mato Grosso do Sul (MS) between 19°03 ' and 19°07 ' South and 57°36 ' West. The total area is 2,351.55 hectare divided in 85 lots with 18.5 hectare on average. A questionnaire was given to 85 families to verify if and for what cassava is grown by farmers. About 50 forms were returned (59% of the total). The great majority originated from regions but about 8% came from other cities of MS State and 6% from other states. About 76% of the interviewees came from urban areas and only 24% from rural zones. The main activity is milk production (96%) and only 4% works in agriculture. Cassava crop was a family tradition for 90% of those farmers but 24% of the interviewees does not grow cassava. About 42% of farmers grow cassava for as staple food, and 34% for feed. The largest difficulties identified for cassava crop were 38% “non appropriate soils” and 24% drought. Only 4% answers told that lack of stalk to plant was an issue. Cassava is therefore cropped for food security.

M-08: Cassava brown streak disease in coastal Kenya

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A cassava brown streak disease (CBSD) survey was carried out in Kilifi, Kwale and Malindi Districts of coastal Kenya. The objectives of the survey were to update information on the status of CBSD distribution and severity and identify farmers' perceptions about CBSD. Data was collected by administering a questionnaire and field observations. Incidence of plants with CBSD leaf symptoms and percent leaf chlorosis, stem lesions and root necrosis of each cassava landraces within farms were recorded. Cassava brown streak disease was widely distributed found in 98%of the farms surveyed. The overall mean incidence of CBSD based on above ground symptoms was 54% and varied among landraces from 0% to 100%. Symptoms of CBSD were observed on cassava roots, stems and leaves and included brown necrotic tissues, radial constrictions and pits on the roots, corky cortex, brown lesions on the stem and chlorotic patches on the lamina. Results showed high incidence of leaf chlorosis. Incidence of root necrosis and constrictions were low but where they occurred the damage was severe. Farmers' perceptions on causes and management of CBSD were also recorded. Most farmers were not aware of CBSD presence in their farms and suggested wrong causes and management strategies. Implications for short and long term management strategies are discussed.

M-09: The potentials and prospects of cassava as food security crop in Ethiopia

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Cassava was introduced to Ethiopia in the 19th century. The ones identified as the bitter cultivars by locals had been introduced first, and then followed by the sweet cultivars, which show high and low cyanide contents, respectively. Although, it is difficult to make a clear distinction between sweet and bitter cultivars, because, it is affected by environmental factors. Cassava is known by a variety of local names in the southern parts of Ethiopia, where it is dominantly grown and utilized. It is known as *Mita Boye, Yenchet Boye, Furno Tree and Mogo***.** It is primarily grown and used as food crop for about a century in different parts of Ethiopia. A survey conducted in different parts of southern and south-western Ethiopia showed that farmers use stem cuttings (30-100 cm length) as planting materials and leave the cassava to grow for a number of years, harvesting the tuberous roots as they need it. The local experience indicated that bitter cultivars take 15 months to mature whereas the sweet cultivars mature within 8 to 10 months. The sweet cultivars yield about 2.7 kg $plant^{-1}$ with up to 5 roots. Cassava grows between 480 to 1800 m within 15 to 30^{o}C and 692 to 1470 mm annual rainfall. In southern Ethiopia, in a particular place known as Amarokelo, cassava is used as a staple food. In another place known as Wolita cassava roots are widely consumed after washing and boiling or in the form of bread and *enjera* (a local thin pancake like bread) after mixing its flour with that of cereal crops, such as teff, maize, and sorghum. It is also used to make local alcoholic drinks known as *areke* and *tela*. In Konso fresh roots and flours are also sold in the local markets. The major factor that limits the use of cassava as food is the toxicity of hydrogen cyanide, which occurs as a result of the hydrolysis of cyano-genic glucosides. The total cyanide, which comprises both bound and free cyanide, indicates the potential of the cyano-genic glucosides in the roots or leaves. The cyano-genic glucoside concentration is higher under the peel and around the fiber in the middle part of the root. The concentration may be influenced by several factors, including soil types, soil moisture and time of maturity. Several post-harvest practices, mainly the storage and cooking methods considerably affect the cyanide content. The importance of cassava as a major source of carbohydrate for several million people in developing countries in general, and Ethiopia in particular is immense; nevertheless, quite limited research has been conducted on this important crop in Ethiopia. Agronomic research and post harvest studies are absolutely essential to fully exploit and utilize cassava for the wellbeing of Ethiopian farming communities. It is important to take the advantage of what has been achieved by IITA in Nigeria: high yielding cultivars that are adapted to highlands and lowlands of sub-Saharan Africa, with a yield capacity of 20 to 30 t ha^{-1}, and mature within 12 months, which are constantly transferred to African research institutions. Their adoption has been gradual, first on a farmer to farmer basis in Nigeria and in other countries. In most of the sub-Saharan African countries there is an assurance of a new wave of cassava production that will go a long way to alleviate the food situation in the continent. The early realization of this feat will depend largely of course, on the individual Government's positive approach towards assisting farmers in procuring improved planting materials and educating farmers on the new processing techniques to

eliminate or minimize loss. Ethiopian Government and farmers are open to innovative and new ideas that may result into useful outcome for the concerned community.

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