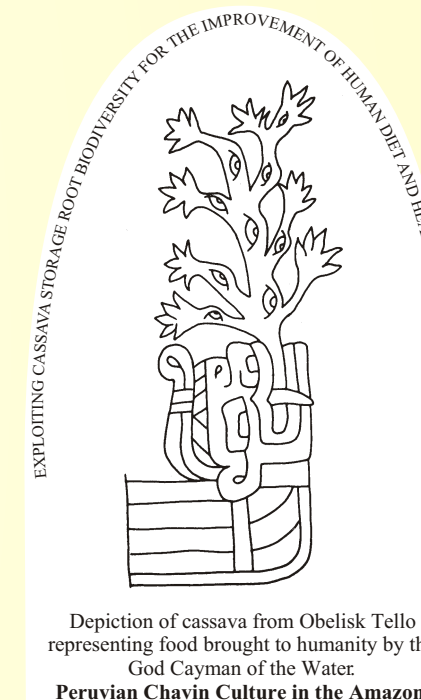


Celebrating diversity in storage root of cassava (*Manihot esculenta* Crantz)¹.



Luiz Joaquim Castelo Branco Carvalho² Claudia Regina Batista de Souza^{2,3}, Julio César de Mattos Cascardo⁴ Marco Antonio Valle Agostini², Barbara Anna Schaal⁵, Carlos Bloch Junior².

Rockefeller Foundation (RF96010#25/RF9707#26), Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq (45 2714-98.2). Programa. Nacional de Pesquisa em Biotecnologia CENARGEN (Project N° 060302058). Cassava Biotechnology Network (CBN-Small Grant to LJCB). ¹EMBRAPA-Genetic Resources and Biotechnology, Brasília-DF, Brazil. ²Current address: Departamento de Genética Universidade Federal do Pará, Belém-PA, Brasil. ³Departamento de Biologia CelularUniversidade Estadual de Santa Cruz, Ilhéus-BA, Brasil. ⁴Department of Biology - Washington University in St Louis (USA). ⁵Author for correspondence: carvalho@cenargen.embrapa.br.

ABSTRACT

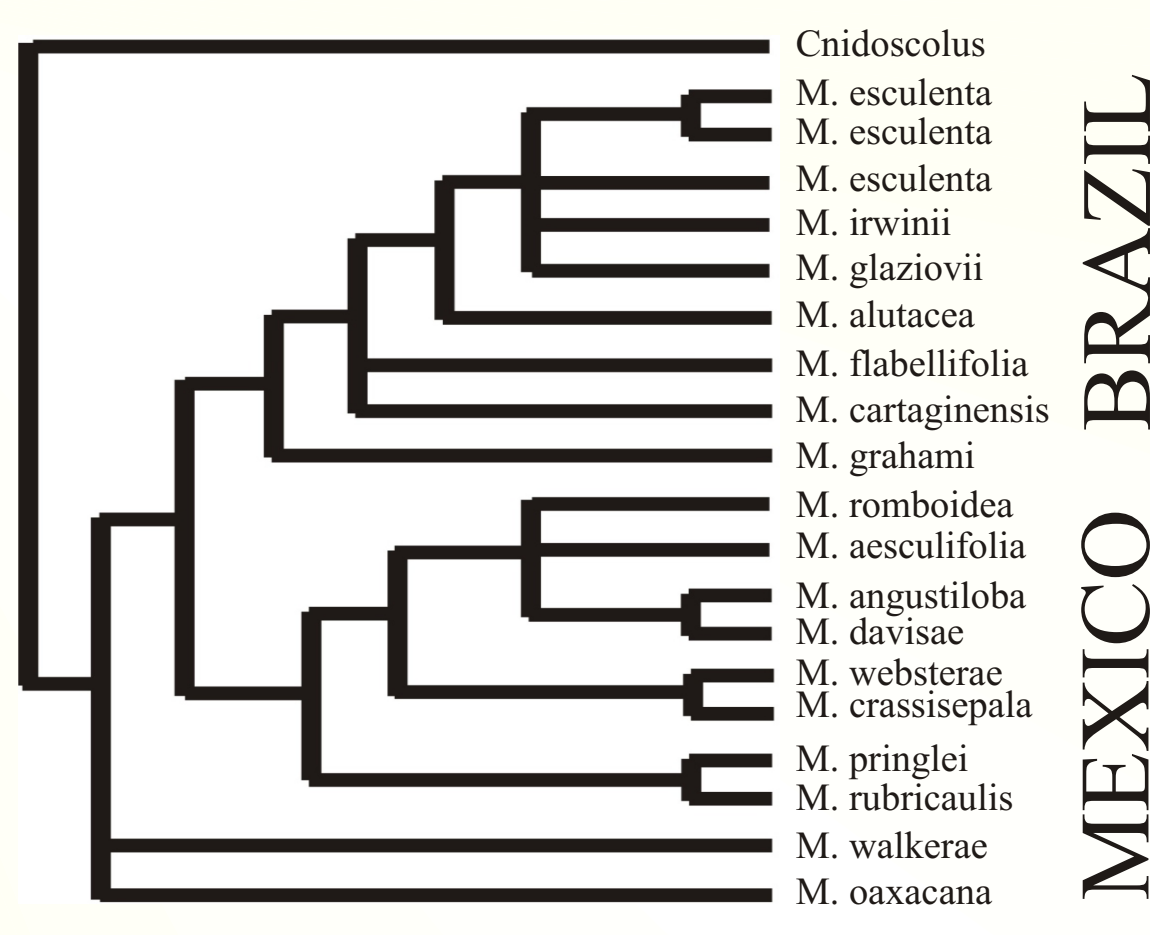
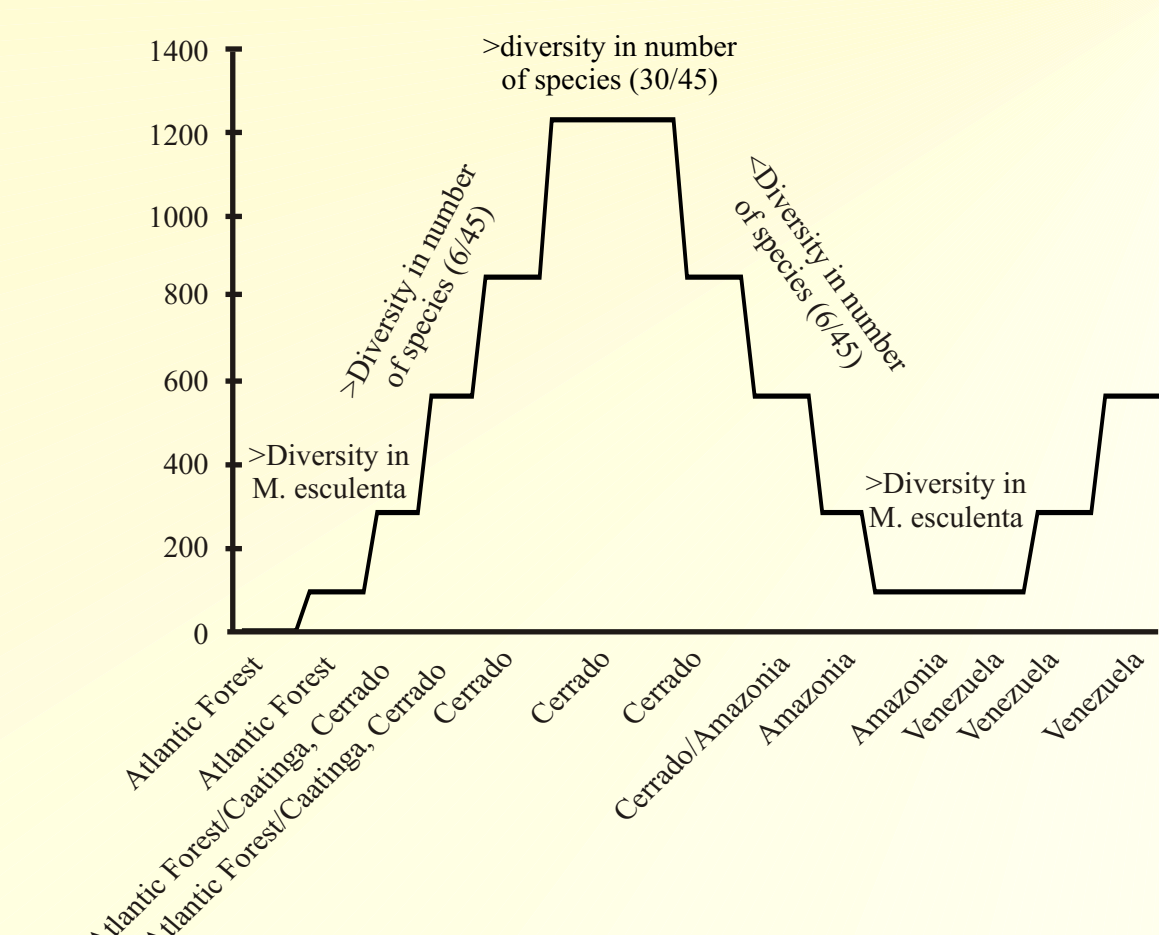
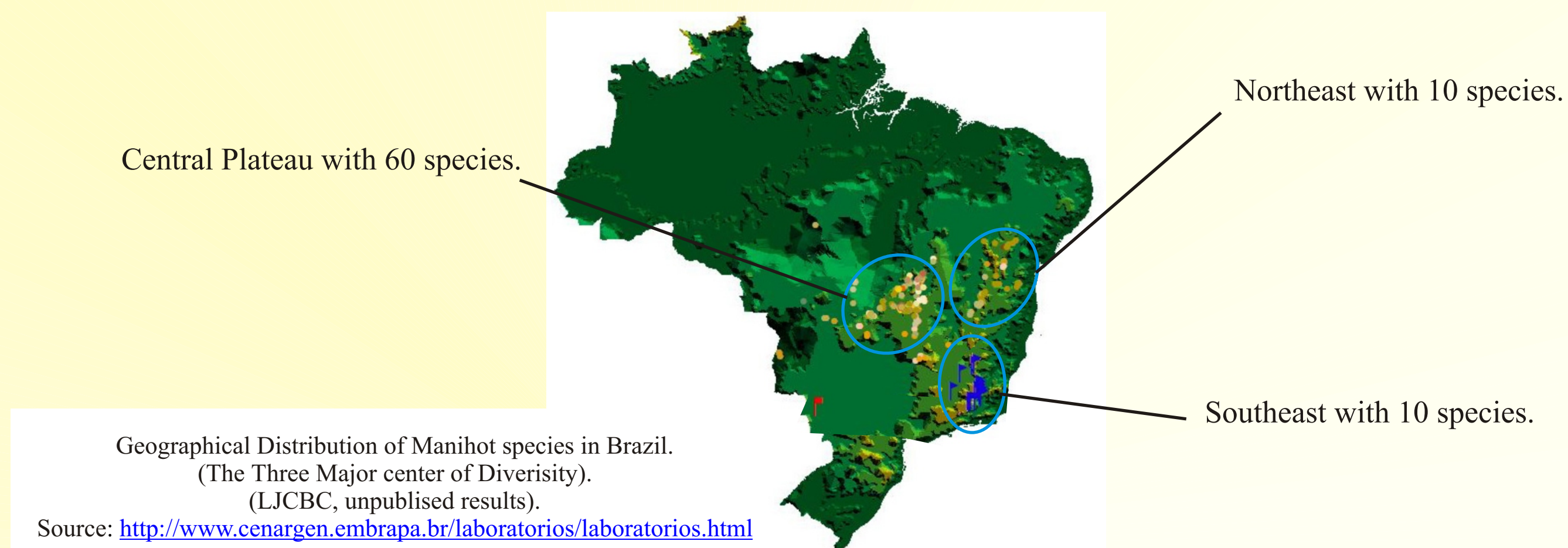
Cassava (*Manihot esculenta* Crantz) belongs to the Euphorbiaceae plant family and is the only cultivated species of the genus. Eighty, out of 98 species of the genus, occurs in Brazil with distribution from the high lands of the central plateau of Brazil down to low lands in Amazon Basis and Northeast cost. This pool of genes from the diversity of the genus and the cultivated species is under intense studies in our laboratory to gain knowledge in the storage root potential for improving storage root quality associated to human health. Herbarium database, field trip expedition, DNA molecular markers technology, organization of a GENEBANK of clones, functional genomics technology, and development of new commercial products from the diversity has been carried out in the past six years. In the present document we are reporting the compiled information generated to illustrate our concept working-model to improve cassava. Results, so far, indicate that: 1. The Central plateau of Brazil presents the largest diversity in terms of number of species of the genus. 2. The low lands of Brazil, mainly Amazon Basis, present the largest diversity within the cultivated species. 3. The largest diversity within the cultivated species occurs in Amazon and Northeast of Brazil. 4. Unusual storage root traits have been identified in traditional clones. 5. Natural mutations have been described for the first time in cassava storage root. 6. Processing technologies have been approached to add value to the new cassava clones. In addition solid collaboration among Brazilian and USA institutions have created. 7. Functional genomics has been

The biggest challenge in modern agriculture is to improve food supply in terms of quantity and quality for the 828 million people that leave under the limit of poverty in the tropical world, and its aggravation by the growth rate projection for the next 50 years. Modern biotechnologies have the highest technology innovation capacity to do this job, because all the improvement it allows to be made is incorporated directly into the plant, avoiding high-energy agriculture input and environmental management and manipulation. However, there are two antagonistic situation related to this claim. One is that biotechnology is a very expensive technology, and a high technical experimental demand research activity to do all by itself. This fact intimidates pour country government to make public investment in the agriculture experimentation needed to apply this technology. Therefore, this research investment has to be done by someone else or properly financed to a particular tropical country with appropriate build or building capacity to apply this technology. Here comes the antagonistic point in terms of economics. Since the public sector is restraining from invest, the private companies are indirectly asked to take over. Obviously, the consequence of this trend does not favor the claim for biotechnology being the most useful technology to the poor farm in the tropics, simply because the poor farmer has no money to buy this technology from private companies. On the top of that is that the companies are committed to make improvement in the five major crops (wheat, corn, soybean, cotton and potato), while poor farmers are traditionally using different crops in their environment. It means that for them to get benefit from biotechnology, they have to replace their own traditional crops to adopt high biotechnologically improved crops. But we still have an alternative to benefice small farm in the tropics with biotechnology by exploring natural variation in their local promise crops. Besides this circumstantial advantage, this kind of exploration would allow one to add information to basic plant biology in a completely new perspective as well as to understand the genetic basis of plant biology in its full range from nature to manipulated trait. With this mindset, comes the question where to start? Here comes our novel approach to this problem. Six years ago we took the crop cassava as an example from the tropics to apply molecular biology and molecular genetics as well as plant physiology and biochemistry in a context of crop domestication to improve food quality. We first, looked for the phylogeography and taxonomy of *Manihot* to clarify the questionable species relationship including the cultivated species. Second, we looked to recognize the origin of the cultivated species, their ancestor, and its center of domestication. Finally we returned to this center of origin and domestication to look for diversity in the cultivated species, specifically in relation to traits most close to domestication that was storage root.

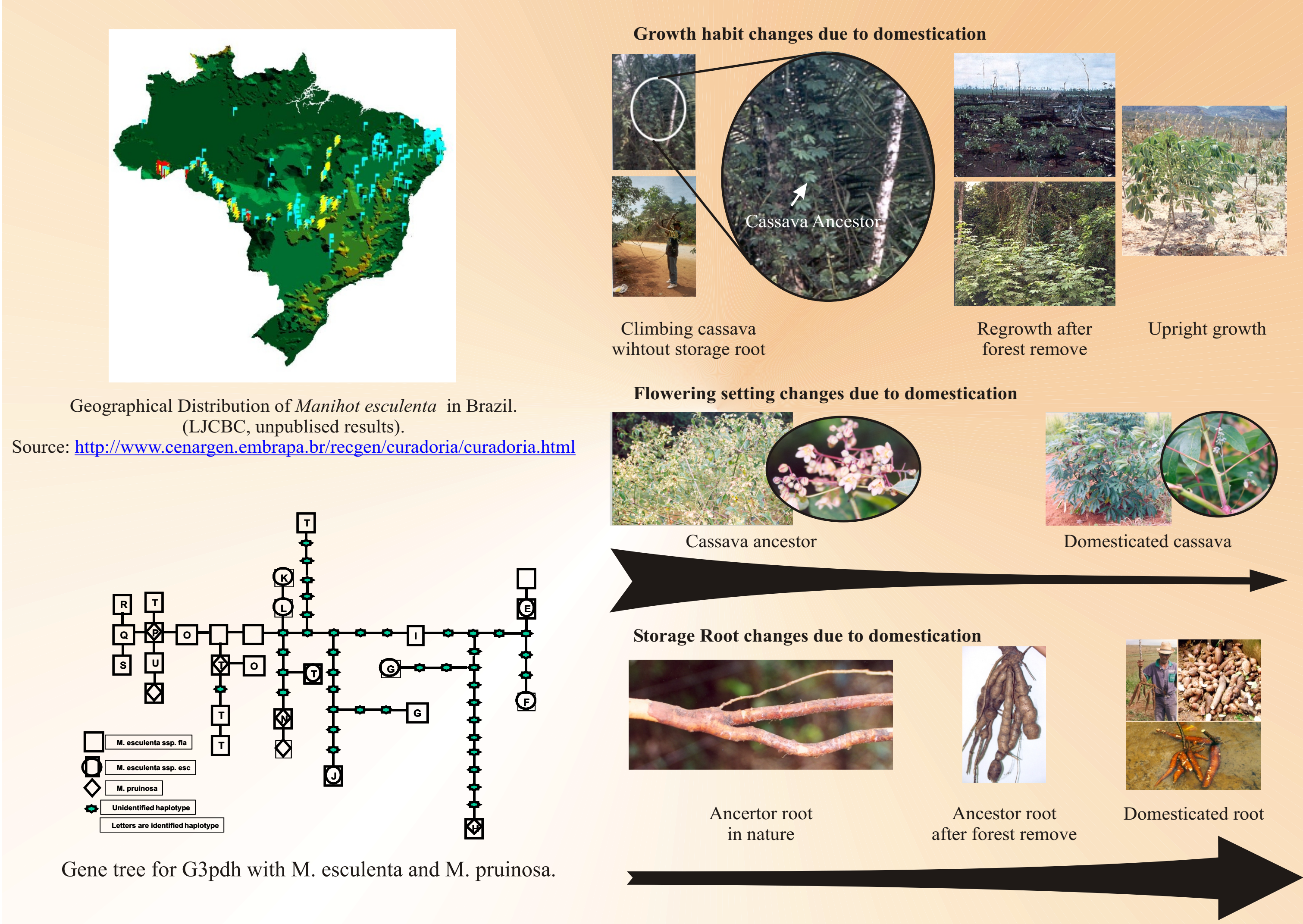
This document shows the use of concepts on biodiversity and biotechnology to add value to cassava crop and beneficie the small farmers. Values from the domestication events affecting flowering setting habit in the modern cultivars with strong effect on conventional breeding to scientific knowledge by isolating natural mutations in storage root and novel food products are brought together to **CELEBRATE DIVERSITY** in the storage root. Potential diversity to efficient application of functional genomics in isolating new gene directly from the diversity is shown. Potential to diversify the utilization of cassava traditional products derived from carbohydrate, high carotenoid clones associated with high protein content in the storage root are also showed. Finally, potential commercial values are added to products already processed in local rural communities are initialized to help small farm in Amazon. An accompany VHS video press document complementing with the social cultural value of this celebration of the diversity of cassava storage root is also showed.

PRESENTATION

Manihot species diversity and phylogeny: Three major centers of species diversities are recognized in Brazil being the Central Plateau for the larger number of *Manihot* species together with northeast and southeast as well as the Amazon as the center of diversity of the cultivated species and its ancestor. Preliminary phylogeny reconstruction of *Manihot* species points out to Brazil with the largest number of *Manihot* species closely related to the cultivated species.

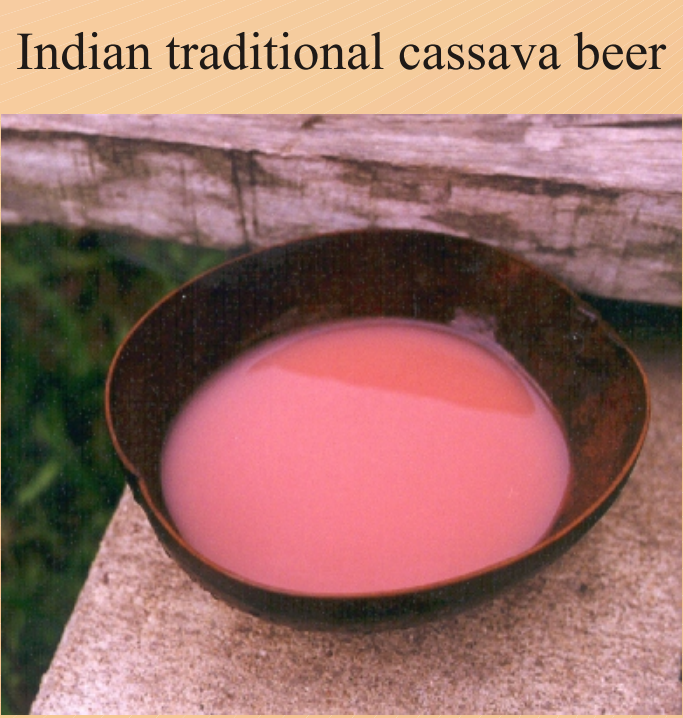


Manihot esculenta domestication center and diversity: Geographical distribution of cassava and its ancestor shows that the southern border of Amazon region has the largest diversity within *M. esculenta* species, and probable one of the center of domestication of this species. It also indicates that a more exhaustive collecting expedition is urgent needed deep in the Amazon River valley to explore the diversity of cassava. The three most important domestication changes in the cassava ancestor to modern commercial cassava was observed as growth habit of ancestor,



Innovating technology with biodiversity (sugary cassava): Glucose syrup and glycogen from the sugary cassava, discovered in Amazon as well as documentation of traditional beer processed in rural community in Amazon. Both, glucose and glycogen are natural products extracted directly from the sugary cassava storage root.

Glucose syrup processing from sugary cassava



Glycogen from sugary cassava



Innovating technology with biodiversity (pigmented cassava): Three products of commercial values from pigmented cassava were developed. Two of them corroborate for direct use by small farmer community, being the Pickles and the TUCUPI powder. A third one directed to high technology demand market.



AKNOWLEDGEMENTS

Special acknowledgements are extended for the financial support provided by the Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq (grant number 680.410/01-1 for LJCB) of the Minister of Science and Technology of Brazil as well as to National Biotechnology Program of EMBRAPA (grant number 060302058 for LJCB), the Small Grant program of Cassava Biotechnology Network (CBN) and The Rockefeller Foundation (RF96010#25/RF9707#26). Our special thanks to Tiago Oberda Carneiro Marques for the great help in the arts of the posters in the last moment is appreciated

LITERATURE

Cassava germplasm collection source: <http://www.cenargen.embrapa.br/recgen/curadoria/curadoria.html>
Cassava geographical distribution source: <http://www.cenargen.embrapa.br/recgen/curadoria/mapa-bags.html>
Manihot herbarium documentation source: <http://www.cenargen.embrapa.br/laboratorios/laboratorios.html>
Allen A.C. 1994. The origin of *Manihot esculenta* Crantz (Euphorbiaceae). Genetic Resources and Crop Evolution 41:133-150.
Carvalho LJCB, Cabral GB, and Campos L. 2000a. Raiz de reserva de mandioca: Um sistema biológico de múltiplas utilidade. EMBRAPA-Recursos Genéticos e Biotecnologia. Serie Documentos #44, p16. Brasília,DF, Brazil.

Carvalho LJCB, Boiteux MENF, and Rocha TL. 2000b. Carotenoid synthesis and accumulation in cassava storage root. Plant Biology (ASPB-USA), Abs. 397.
Carvalho LJCB, and Schaal BA. 2001 Assessing genetic diversity in cassava (*Manihot esculenta* Grantz) germplasm collection in Brazil using PCR-based markers. EUPHYTICA 120:133-142
Carvalho LJCB, de Souza CRB, Cascardo JCM, Junior CB. 2004. Identification and characterization of a novel cassava (*Manihot esculenta* Crantz) clone with high free sugar content and novel starch. Plant Molecular Biology. (In press).
Daito ER. 2000. Biosintese de amido durante o crescimento secundario da raiz de reserva da mandioca. MSc. Dissertation, Universidade Estadual de São Paulo, Botucatu-SP, Brazil.
de Souza CRB. 2001. Isolamento e caracterizacao molecular de genes e proteínas de raiz de reserva de mandioca (*Manihot esculenta* Crantz). Ph.D. Dissertation, Universidade de Brasília, Brazil.
Fukuda MGW, Costa IRS, Vilarinhos AD, de Oliveira RP. 1996. Banco de germoplasma de mandioca: Manejo, Conservação e Caracterização. Documentos CNPMF N° 68, p103, Cruz das Almas, BA, Brasil.
Olsen K and Schaal BA. 1999. Evidence on the origin of cassava: phylogeography of *Manihot esculenta*. Proc Natl. Acad. U.S.A. 96:55865591.
Schaal BA, Carvalho LJCB, Prinzie T, Olsen K, Hernandez M, Cabral G, and Mueller D. 1997. Phylogenetic relationships and genetic diversity in *Manihot* species. African Journal of Root and Tuber Crop. 2:147-149.