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Editorial

The Global Cassava Partnership for Genetic Improvement

Introduction

The present special issue of Plant Molecular Biology dedicated to cassava is the expression of one type of activity aiming at raising scientific awareness about cassava. Because cassava is a difficult and poorly studied plant, scientists have great difficulty generating data of good scientific quality, but when they succeed, it is a more difficult task to publish this data in very good journals. This special cassava issue is proof that this is possible and we invite the readers to discover cassava through a series of articles representing some of the recent discoveries made on cassava, its biology, its physiology, its genetics and its evolution. We hope that some readers will become interested and will decide to work on cassava, a fascinating biological model that has the great merit of being the source of food for 700 million people!

In August 1988, we had the first meeting centered on cassava biotechnology at the International Center for Tropical Agriculture (CIAT) in Cali, Colombia, and there was a consensus that the members of the cassava community needed to get together regularly and needed to communicate about the use of these new technologies for an orphan crop such as cassava. The attendees present at that meeting decided to organize themselves in a network dedicated to the biotechnology of cassava named: *Cassava Biotechnology Network, or CBN* in short. After the Cali meeting, a steering committee was formed and proposals were generated and sent to international donors. In 1990, DGIS from The Netherlands became interested in CBN and awarded a major grant to CIAT to run CBN for 8 years. CBN became a success right after its creation; in a span of 8 years we organized several scientific meetings and the last one was at CIAT in March 2004. CBN was much more than a meeting every other year; it was a 'family' with one common interest: *Cassava*. The DGIS grant allowed us to launch case studies on several topics and various continents, permitted a large number of small training grants, provided seed money for grant preparation to a number of scientists, and finally it allowed us to collect all the available information about cassava in useful databases and CDs.

However, there were two items that CBN did not cover very well and that was raising public awareness about cassava and cassava biotechnology in particular, and we never raised funds to accomplish larger tasks. In 2001, at CBN-V in St Louis, Missouri, USA, the CBN Steering Committee decided to restructure CBN to make it more proactive, particularly targeting tasks such as cassava genome sequencing, desperately needed for this very important crop, to benefit from the formidable advances of science made all over the world in model plants! To achieve these new goals we felt a reform was needed and at a meeting in Bellagio, Italy, in October 2002, we released the creation of the *Global Cassava Partnership* dedicated to the genetic improvement of cassava (GCP-GI). This new organization was placed under the umbrella of a larger organization: the Global Cassava Development Strategy (GCDS), hosted by FAO, with the proposal that a sister organization, the Global Cassava Partnership for Processing and Marketing (GCP-PM) would be created soon after.

Rationale of GCP-GI

Cassava is a root crop and the third most important source of calories in the tropics, consumed by over 700 million people on a daily basis in Africa, Asia, and Latin America. Cassava is cultivated mainly by poor farmers, often on marginal lands. For them, the crop is vital for both food security and income generation. In Asia and Latin America, cassava serves as livestock feed, an industrial input, and a source of food. In Africa, it serves as the second most important source of calories, an inexpensive and essential food for the poor, and an emerging cash crop (Figure 1).

Despite its importance, investment in research to improve cassava has lagged behind that of other staple crops such as rice, wheat, maize, and potatoes. This under-investment has resulted in only relatively minor increases in cassava's productivity over the past 30 years. In Africa, average yields are only 8.5 tons per hectare compared to potential yields of over 80 tons under ideal conditions. Production constraints include cassava mosaic disease, cassava bacteria blight, arthropod pests, and other biotic and abiotic stresses. Farmers' success in marketing their cassava has also fallen well short of its potential due to problems such as rapid post-harvest deterioration and inadequate starch and protein content in the roots.

Conventional breeding efforts attempting to address many of the constraints to cassava's productivity have had some success, mainly under non-stress conditions in Thailand. Progress has been slow because of the crop's heterozygous genetic makeup, which makes it time consuming to breed efficiently. The new tools of advanced molecular biology and cell biology can change this situation by offering new approaches to the challenges of cassava. These new technologies, used in coordination with conventional plant breeding, can make cassava much more productive, nutritious, and profitable to grow. The Global Cassava Partnership for Genetic Improvement (GCP-GI) was created to develop and use these tools for the benefit of cassava farmers and end-users worldwide. Improved cassava will help alleviate poverty and improve millions of lives.

Goal and objectives

GCP-GI's goal is to enhance global food security, sustainable production, and economic opportunity through the application of advanced molecular technologies for cassava improvement.

GCP-GI's objectives are:

1. To use advanced molecular and genetic technologies to create cassava that is higher-yielding, more resistant to diseases and pests, more

Figure 1. Peeling of cassava roots in Ivory Coast, West Africa (photo J. Pita).

marketable, and more nutritious, for the benefit of the poor.

2. To further develop these new tools and technologies to make them more useful for cassava improvement and freely available as public goods.

Participants, constituency, and relationship to other initiatives

GCP-GI is a partnership of institutions cooperating to achieve these objectives, including national research organizations in developing countries, international agricultural research centers, and advanced laboratories in Europe and the United States. The work of GCP-GI will strengthen national research organizations in cassava-growing countries and benefit their constituents – cassava farmers, consumers, and industrial users – through the development of improved cassava. Improved planting materials will also benefit farmers' families and farm laborers by making cassava cultivation more profitable.

GCP-GI will operate within the context of the Global Cassava Development Strategy (GCDS). GCDS is a global alliance of R&D partners to promote improvements in production, processing, and marketing of cassava; its secretariat is housed at the Food and Agriculture Organization (FAO) of the United Nations. GCP-GI builds on the earlier work of the global Cassava Biotechnology Network (1991–1998).

Principles of the partnership

Participants in GCP-GI agree to:

- coordinate efforts to develop and use advanced molecular and genetic tools for cassava;
- develop a coherent research program by identifying knowledge gaps and avoiding duplication of efforts;
- make newly developed molecular and genetic tools freely available to all who can use them to improve cassava;
- implement responsible biosafety policies and carefully respect institutional and national biosafety policies as well as international agreements such as the Convention on Biological Diversity;
- incorporate end-users into the design, implementation, and evaluation of their projects;
- include capacity building efforts into projects for national institutions in cassava-growing countries, and
- operate transparently in related initiatives, with maximum information sharing.

Solving problems and adding useful traits to the crop

Members of the GCP-GI are committed to using advanced molecular, cellular and genetic tools to address constraints to cassava production and enhance useful traits in the crop. The partnership will seek to address:

Production constraints

- *Viral diseases* – Viruses cause the cassava mosaic disease that dramatically reduces cassava yields in Africa and South Asia. Infected planting materials and whiteflies spread this disease from plant to plant. New virus-resistant planting materials are needed that retain other qualitative traits valued by farmers and consumers. Advanced molecular technologies can help create these planting materials.
- *Cassava bacterial blight* – The most important worldwide disease of cassava, blight is responsible for severe losses in both Africa and South America. Symptoms include water-soaked leaf spots, blight, leaf wilt, and severe defoliation with yield losses of up to 60% on infected plants. New resistant planting materials are needed and may be produced by transferring genes for resistance from wild to cultivated species of cassava (genus: *Manihot*).
- *Arthropod pests* – Green mites, stem borers, whiteflies, and mealy bugs cause significant production losses. Advanced molecular tools can contribute to both identifying and creating varieties that are resistant to these pests.
- *Drought* – Although cassava is a drought-tolerant crop, and therefore useful as a famine reserve food, yields are negatively affected by this stress. Research involving molecular biology will one day result in cassava with improved resistance to drought and other abiotic stresses.

Added value traits

- *Post-harvest deterioration* – Fresh cassava deteriorates rapidly after harvest, presenting a fundamental constraint for marketing and obtaining full value for the crop. Overcoming this problem will increase cassava's value by making it easier to transport and market. Success in addressing this constraint will have a major impact on the industrial potential of the crop.
- *Protein deficiency* – Cassava roots contain only one to two percent protein. By enhancing protein levels, the consortium can make this crop more nutritious for the millions who consume it as their staple food and also increase its value as animal feed.
- *Biofortification* – Cassava roots are deficient in key micro-nutrients. Biotechnology tools can be used to incorporate zinc, iron and vitamins into the plant, making it more nutritious and valuable as a food crop.
- *Starch content and quality* – Cassava can be processed into starch for use in industry; however, the starch market is highly competitive. Advanced tools of molecular biology can be used to create cassava varieties with higher starch levels and improved qualities to increase the crop's market value.
- *Cyanogenic compounds* – These compounds occur naturally in cassava and can present problems of toxicity in certain varieties if they are incorrectly prepared for consumption. Biotechnology tools offer the potential of modifying cassava to reduce or eliminate this problem.

Development and use of advanced molecular technologies

The partnership will develop and utilize new biotechnological tools and useful genes found in landraces and wild species of cassava to create improved planting materials. The revolution in molecular biology, recombinant DNA technologies and genetic engineering provides new tools that circumvent many of the problems that have persistently hindered cassava improvement. For the first time, the potential exists to efficiently exploit beneficial traits existing within wild and domesticated *Manihot* and transfer these to farmer-preferred cassava cultivars in a predictable and timely manner.

- *Micropropagation* – This relatively simple biotechnology allows for planting materials to be produced through tissue culture. The technique is useful for producing 'clean', disease-free and pest-free planting materials. A low-cost micropropagation system can make large quantities of clean planting materials available to farmers who need them. Micropropagation can produce millions of plantlets of improved varieties and new genotypes, facilitating their deployment and dissemination to farmers. New diagnostic techniques can ensure the quality of tissue culture operations.
- *Double haploid breeding* – Cassava is a highly heterozygous crop subject to severe inbreeding depression. Breeding is difficult. The production of doubled haploids offers the advantages of allowing for: the production of better performing hybrids; the identification of commercially useful recessive traits; a consolidated and consistent genetic progress through time; and an end to the isolation in which cassava breeding projects operate due to restrictions in germplasm exchange.
- *Genetic resources* – Over 98 species of wild cassava have been identified in the Amazon Basin and meso-America. These species likely contain genes for desirable traits – such as pest resistance and improved nutrition – that can be identified and transferred into cultivated lines of cassava by breeders and biotechnologists. The GCP-GI seeks to evaluate and conserve this biodiversity and make use of it to develop improved planting materials for the benefit of farmers worldwide.
- *Genomics* – Development of a high-density map of cassava will facilitate marker-assisted breeding, adding accuracy and speed to the development of improved varieties. More advanced genomics work – such as induced mutation, the development of high saturation BAC libraries, high saturation ESTs, and complete sequencing – will allow researchers to identify genes of interest in cultivated and wild cassava and then introgress them into cultivars through genetic engineering.
- *Transformation and biosafety* – Genetic engineering allows the introduction of genes of interest – from both related and unrelated spe-

Figure 2. Virus-free Ugandan landrace cassava plant in Uganda (photo J. Legg).

cies – into the cassava genome. Its development and use under the GCP-GI will allow the varieties that farmers prefer to be enhanced with the disease resistant and qualitative traits needed to improve production and value. The partnership will use transformation only in conjunction with strict adherence to institutional and national biosafety policies (Figure 2).

Operations and governance

Membership in the GCP-GI will be voluntary and open to all institutions in developing or developed countries dedicated to the goal and objectives of the partnership. The founding institutions expect membership to expand significantly over the next few years.

The Global Cassava Partnership for Genetic Improvement will be managed by a Steering Committee headed by two co-chairpersons. There will be a total of seven members, elected to reflect the global nature of the partnership. The Steering Committee will:

- facilitate information sharing and coordination between participants;
- raise awareness about GCP-GI, its objectives, the importance of improving cassava, and the role of biotechnology in this process;
- organize meetings of the GCP-GI;
- work to mobilize resources and support the proposal development and fund raising efforts of the Technology Leaders;
- develop proposals for a limited number of activities at the level of the entire partnership, e.g., meetings, special events, training programs.

Members of the present GCP-GO Steering Committee

Co-Chair: C.M. Fauquet
Co-Chair: J. Tohme
Chair of GCDS: A. Dixon
Representative of India: T. Edison
Representative of Africa: O. Omaliko
Representative from South America: A. Alvez
Representative from developed Countries: W. Gruissem

The GCP-GI will designate Technology Leaders for selected biotechnology tools and trait development efforts. Each Technology Leader will:

- serve as the leader and point-person for efforts to develop the technology;
- organize meetings as necessary to develop approaches to technology development;
- raise awareness of the potential of the new technology to improve cassava and improve livelihoods;
- develop or assist in the development of proposals to donors for projects relating to the technology;
- implement or assist in the implementation of funded projects through participating institutions;
- keep the Steering Committee informed to facilitate coordination.

The GCP-GI membership will also designate National Leaders to serve as point-persons for issues concerning the partnership and fulfilling its mission. Each participating country will have a designated National Leader who will be responsible to:

- Interact with the GCP-GI at the level of the Steering Committee, Technology Leaders, or individual project development efforts.
- Initiate project or activity ideas to be coordinated with other partners and governance bodies.
- Raise awareness in their countries about the GCP-GI and its objectives and the importance

in general of cassava for food security, income generation, and industrial uses.

Conclusion

The Global Cassava Partnership for Genetic Improvement will mobilize the tools of advanced molecular biology to improve dramatically the productivity of cassava for the benefit of the poor throughout the developing world. The resulting tools and improved planting materials will positively change the lives of millions of cassava growers and users all over the globe.

Founding organizations

Food and Agriculture Organization (FAO)
International Center for Tropical Agriculture (CIAT), Colombia
International Institute of Tropical Agriculture (IITA), Nigeria
Brazilian Agricultural Research Corporation (Embrapa), Brazil
Donald Danforth Plant Science Center (ILTAB), USA
Central Tuber Crops Research Institute (CTCRI), India
FAO/International Atomic Energy Agency Joint Division, Austria
National Agricultural Research Organization (NARO), Uganda
National Biotechnology Development Agency (NABDA), Nigeria
Research Institute for Legumes and Tuber Crops (RILTC), Indonesia
Root and Tuber Improvement Programme (RTIP), Ghana
Swiss Federal Institute of Technology (ETH), Switzerland
University of Bath, Bath, United Kingdom
South China Institute of Botany, Chinese Academy of Sciences, China
Institute for Biosystems Biology, Seattle, USA

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