Cassava Research Team (www.pb.ethz.ch/research/cassava)

Technology transfer and capacity building:
Making tropical crop technologies available where it can have an impact

The cassava research team at ETH Zürich

The research activities of the cassava research team (Plant Biotechnology Laboratory, ETH Zürich) aim at improving cassava by combining molecular understanding of crop physiology and responses to stresses with the development of molecular markers for conventional breeding as well as genetic engineering. A better understanding of the crop responses to various stresses and the investigation of different biotechnological approaches to improve cassava have been instrumental to generate cassava plants with increased resistance to biotic and abiotic stresses over the last decade (10, 14, 15, 17, 18). The cassava research team has also gained international recognition for its pioneering work on genetic transformation methods since the mid 90's.

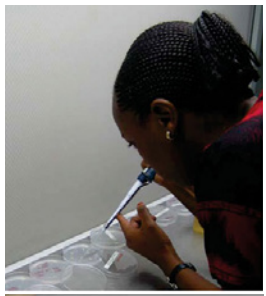
The importance of cassava for tropical agriculture

Widely grown in tropical Africa, Asia and Latin America, cassava is the developing world's fourth most important crop, with production in 2009 estimated at 241 million tones (6). It is the staple food of nearly a billion people in 105 countries, where the root provides as much as a third of daily calories. And it has enormous potential – at present, average cassava yields are barely 20% of those obtained under optimum conditions (5). The difficulty to reach the full potential of the crop is due to multiple factors. Suboptimal agricultural practices and the susceptibility to multiple abiotic and biotic stresses account for poor performance of the crop. Therefore crop improvement has the potential to increase food security, small scale farmer income as well as industry benefits.

ETH PhD student harvesting cassava roots on a drought field trial in Kiboko (Kenya)

Fostering technology transfer to developing countries

In the recent years, the cassava research team has actively worked on the establishment of a reliable and high-throughput transformation platform for the production of transgenic cassava plants. Those activities followed the early establishment of the first cassava transformation protocol at ETH Zürich (8). The improved cassava transformation method recently released in ***Nature Protocols*** (3) has had a major impact in the international cassava research community as attested by numerous requests for technology transfer ***in Africa and Asia***. The cassava transformation technology has for long remained a technique exclusively restricted to "Western" laboratories. As part of the ***BiocassavaPlus (BC+) consortium*** **(13)** funded by the Bill and Melinda Gates Foundation (BMGF), the cassava research team has been requested to actively transfer and implement the cassava transformation method in African laboratories. Transformation technology transfer activities currently include the development of ***transformation protocols for farmer-preferred cultivars and its implementation*** at Mikocheni Agricultural Research Institute (MARI, Dar es Salaam, ***Tanzania***), University of Witwatersrand (Johannesburg, ***South Africa***), Biosciences eastern and central Africa Hub (BecA, Nairobi, ***Kenya***) and LIPI (Bogor, ***Indonesia***). The successful technology transfer is based on two approaches: 1) training of African and Asian scientists at ETH Zürich who contribute to the establishment of the technology in their home institution (Kenya and Indonesia, supported by the BMGF and Swiss Government Scholarship Program) and, 2) training of local scientists and technicians in Africa (Tanzania and South Africa, supported by the BMGF and Swiss National Science Foundation). The transformation technology is now available in several African laboratories (2, 4). Access to this technology will be essential for scientists based in Africa and Asia to develop suitable and locally adapted solutions to sustain cassava production. The capacity building component in public research is essential to maintain and adequately manage novel technologies in developing countries (1) and ascertain that it is used for the benefit of the local population. Involvement of public institutions in developing biotechnology-based products helps transferring the benefit and margins of the technology to farmers (12). With the help of ETH scientists, laboratories in Africa are currently generating farmer-preferred cassava lines with improved traits.



Tanzanian scientist using the ETH improved transformation protocol (above) and subsequent production of the first transgenic cassava at MARI (Dar es Salaam, Tanzania) (3)

Promoting technology development and capacity building through education and research at ETHZ

A special emphasis has been made in the last years to offer training and education opportunities to ***students from developing countries*** in the cassava research team. The majority of graduate students and trainees of the cassava research team originate from countries where cassava is grown. Current and past graduate students and trainees (research topic / country of origin): Judith Owiti (post-harvest physiological deterioration / Kenya), Isabel Moreno (virus resistance / Columbia), Charles Orek (drought tolerance / Kenya), Kuan-Te Li (biofortification / Taiwan), Ravi Bodampalli (virus resistance / India), Huahong Wang (biotechnology / China), Evans Nyaboga (post-harvest physiological deterioration / Kenya), Ima Zainuddin (biotechnology & post-harvest physiological deterioration / Indonesia). Training and education at ETH cassava research team also offer opportunities to **learn and implement cutting edge technologies** essential for crop improvement. Besides transformation technologies (3), proteomics and transcriptomics techniques to study crop response to biotic and abiotic stresses are being implemented (7, 9, 11). Cutting edge proteomics techniques have been applied to decipher pathways associated with the onset of post-harvest physiological deterioration (PPD), one of the most important constraints to cassava production. Our proteomics study of PPD, performed by Judith Owiti, represents the most extensive cassava proteome characterization reported to date (11). Such studies are particularly essential to understand the complex PPD phenomenon and to develop potential markers for increased shelf life. A method to reliably quantify virus load in cassava accessions has recently been developed by Isabel Moreno (9). Quantification of cassava brown streak viruses (CBSVs) in farmer-preferred cassava accessions and elite lines is a reliable method to uncover virus resistance in the cassava germplasm. Moreover, aforementioned technologies are ***included in the technology transfer*** activities between ETHZ and partner institutions in Kenya and Indonesia through ***joint research projects and PhD programs***.

Capacity building and technology transfer contribute to crop improvement and food security in developing countries

Virus-infected wild type cassava (top) and virus resistant line (bottom) (15)

Molecular techniques are becoming increasingly important for crop improvement through traditional breeding and genetic engineering. Therefore capacity building in cutting edge technologies as well as their transfer to laboratories in developing countries are key tools to improve crop production and food security. As member of the ***BC+ consortium***, the ETH cassava research team has actively participated in the development of improved cassava for the benefit of African farmers. The BC+ consortium has developed several biotechnology-based approaches to improve the nutritional quality of cassava (high vitamins content, high protein content and low cyanide), to prolong shelf life and to generate virus resistant cassava lines (13). Several strategies to improve ***resistance to cassava mosaic disease (CMD)***, the most important cassava disease on the African continent, have been successfully implemented at ETH Zürich (14-17). The CMD resistant cassava lines have been field trialed in Puerto Rico for agronomic performance evaluation. CMD resistant lines are ready for field test that is currently under preparation with partner institutions in Africa. With the emergence of cassava brown streak disease (CBSD) in eastern Africa, two axis of research have been implemented at ETH to develop sustainable ***resistance to CBSD***. In collaboration with cassava breeders in Kenya and Tanzania, farmer-preferred cassava accessions and elite lines from the cassava germplasm have been screened for CBSD resistance under controlled conditions at ETH Zürich. Their performance has been reliably assessed with molecular tools developed at ETH Zürich (9). Several lines displaying high level of CBSD resistance have been selected and transferred to Africa for evaluation in the field in collaboration with IITA-Tanzania. In the other approach, transgenic lines highly resistant to CBSD have been developed. Resistance has been engineered in a traditionally bred farmer-preferred cultivar resistant to CMD but highly susceptible to CBSD (10). The latter approach represents a promising strategy **combining traditional breeding and genetic engineering** to provide farmers with cassava resistant to multiple viral diseases.

By its comprehensive approach combining technology transfer and training of local scientists, the cassava research team has contributed to independent and sustainable research activities in developing countries. It now opens opportunities to develop locally adapted solutions to improve cassava production. ETHZ scientists will continue supporting sustainable solutions for agriculture in developing countries by implementing and transferring novel technologies in collaboration with local scientists.

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