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CLISMABAN News

LEAP-Agri
A Long term EU-Africa research and innovation Partnership on food and nutrition security and sustainable Agriculture

EUROPEAN UNION

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PHENOTYPING THE BANANA BIODIVERSITY TO IDENTIFY CLIMATE SMART VARIETIES WITH OPTIMAL MARKET POTENTIAL IN AFRICA AND EUROPE

Summary of progress 2020

The CLISMABAN (CLImate SMArt BANanas) project exploits the existing genetic resources and diversity of banana to select, with input from all actors of the banana value chain (consumers, farmers, processors…), the varieties that will be resilient to the constraints that are threatening production because of climate change. To address the increasing demand for food, this project investigates the potential of some microorganisms to be beneficial for the soil and the productivity of the banana plant. The project combines top-notch phenotyping technologies to identify the varieties from the collection that fit the established "cahier des charges". Beneficial microorganisms living in the banana plant are being isolated and characterized for growth enhancement and drought resistance. Laboratory obtained results are brought to the field in different agro-ecological zones of Kenya, Uganda and Canary Islands for evaluation. Producers and researchers are being trained in different cross cutting issues of the banana research to market pipeline for a better utilization of scientific results in the development and adoption of agricultural systems. CLISMABAN has the ambition to help banana growers to meet the increasing demand and provide them the tools to mitigate the challenges of a sustainable use of land and water under a changing climate.

2020 has been an exceptional year in many aspects for everyone on the planet. With the spread of the coronavirus, our resilience has been tested, our creativity and flexibility has been challenged. The LEAP-Agri CLISMABAN project and its partners have been no exception to that. Although on site interactions among partners and field activities have been hindered by the restrictions, each partner of the CLISMABAN project was able to make progress above expectations. As many other partnerships, the CLISMABAN partners have embraced the digital technologies to hold regular update meetings and scientific exchanges.

1. CLISMABAN young scientists in the spotlight

Dr. Fatima Zahra Maghnia is a postdoctoral researcher at Gembloux Agro-Biotech (Liège University). During her PhD in Biology. She studied the "plants-fungi" interactions networks within the scope of Mediterranean cork oak forest. This research was conducted jointly between the mycology laboratory of the Forest Research Center at Rabat, Morocco, and Mediterranean and Tropical Symbiosis Laboratory in Montpellier, France. She received her Master's degree on Microbial Biotechnology from Sciences and Technical Faculty in Fes, Morocco. In general, she is interested in studying and understanding the relationship between plants and microorganisms. She is collaborating on the CLISMABAN, she works on banana's microbiome, especially endophytes that can play essential role to face the drought stress and the climate change that threatens the international production of Banana and food security.

Ms. Alice Wambura Kaguongo is pursuing a Master's Degree in Gender and Development Studies in the School of Humanities and Social Sciences, at Kenyatta University. She is partnering with the CLISMABAN Project to evaluate the uptake, utilization and sharing of gender knowledge among smallholders; men and women farmers in the cooking banana and plantain value chains. This will be through evaluating the efficacy of gender training offered to men and women farmers within three counties in Central Kenya- Murang'a, Kirinyaga and Embu. Under the supervision of Prof. Grace Ngare and Dr. Sheila Mutuma, the study will further seek to understand how gender relations, roles, division of labour and access to and control of productive resources impact uptake of gender knowledge and adoption of new banana varieties. Alice holds a Bachelor of Arts Degree in Sociology, from Kenyatta University.

Ms. Clara Gambart is a PhD student at the laboratory of Tropical Crop Improvement at KU Leuven, Belgium. She obtained in 2019 her master degree in agricultural sciences at the faculty of Bioscience Engineering (KU Leuven, Belgium). During her master thesis she investigated the potential agroecological intensification strategies on the profitability, productivity and sustainability of banana-based systems in Uganda. This project gave her the opportunity to examine local banana farms in-depth and analyze key obstacles smallholder farmers are facing. Triggered by this experience she started a PhD to thoroughly understand the physiological mechanisms behind plant stress/tolerance/quality and aims to map the phenotypic banana diversity in relation to the environment by combining genomics with phenotyping at the plant and cellular level.

1. Consultation of stakeholders for the selection of cultivars for screen in Uganda.

In Uganda our partners from NARO under the lead of Dr. Priver Bwesigye, a baseline survey has been implemented in three sites; Ntungamo, Sembabule and Isingiro along the cattle corridor. Random sampling procedure were used to select respondents in these sites. Two sub-counties were purposively selected for the survey based on the information given by the District Production /Agricultural officers for each district. Two parishes were randomly selected in each of the sub-county basing on a list of all parishes provided by the Sub-county Agricultural Extension worker, four Villages were randomly selected from the list of all villages in each of the selected parish and six households were randomly sampled for interview. Key information captured among other things include; Farmers perceptions about drought, banana production levels including varieties preferred, banana production constraints, drought effect on banana production and the mitigation measures and membership in farmer organisations, Farmers awareness of new banana hybrids that are drought tolerant and ownership of resources/land by gender. A total 526 farmers were interviewed in all the sites of whom 32% were female.

2. Screening the banana diversity for climatic resilience

Mining the existing genetic diversity for cultivars better adapted to the future agro-environment, will give us solutions to alleviate yield gaps and mitigate the risk of yield loss. Since temperature is rather stable in tropical environments, the long term rate of the crop cycle is heavily influenced by basal temperature and the short term growth is more a function of water supply. Therefore, the team of Prof. Rony Swennen and Dr Sebastien Carpentier developed a pipeline (Figure 1) to assess the growth potential of the banana cultivars in the Musa Germplasm Transit Centre (ITC) of Bioversity International at different temperature and water availability regimes.

Figure 1: Phenotyping pipeline to assess the growth potential of the banana cultivars in the Musa Germplasm Transit Centre at different temperature and water availability regimes.

In a first step, the impact of temperature was evaluated in a highly climate controlled reefer container, the BananaTainer. Therefore, canopy growth of 60 different cultivars was measured and the long term response was modeled. We observed a diverse spectrum diversity with an optimal growth temperature ranging from

24 to 29 °C. Photosynthesis measurements confirm the observed diversity as cultivars with lower optimal growth temperatures also exhibit a lower optimal temperature of photosynthesis. Root growth is less affected by changes in temperatures. To further unravel the underlying physiological processes of the short term responses, greenhouse experiments were established in a second phase. Transpiration, leaf turgor and stomatal conductance responses towards water availability show significant genetic diversity. All promising results, will be validated under more agricultural relevant situations to complete the developed pipeline.

3. Identifying banana endophytes for drought stress mitigation and growth promotion

Banana crops are complex micro-ecosystems in which different niches are filled by a wide variety of microorganisms, including endosymbionts (bacteria, fungi and Arbuscular Mycorrhizal Fungi (AMF)). Those beneficial microorganisms can play a key role as biological control agents in numerous diseases, in the promotion of plant growth, in the bioremediation of polluted areas, and drought stress tolerance. The use of those microorganisms as "eco-friendly" intrants and the introduction of more diverse banana varieties will contribute to sustainable agriculture. For this purpose, the composition of the endophytic microbiota of the corm tissue of banana plants from Uganda has been surveyed. More than 50 strains were isolated by the team of Sébastien Massart, especially by Fatima Maghnia. The screening of those strains, based on several functional traits (the solubilization of inorganic phosphates and potassium, and the production of ammonia, siderophores, indole acetic acid (phytohormone stimulating the plant growth) and ACC deaminase (breakdown of plant produced ethylene under stress condition)) was carried out (Figure 2). This allowed the identification of interesting and potential plant growth promoting bacterial endophytes belonging to Pseudomonas and Pantoea genera and from several fungal genera: Hannaella, Rhodotorula, Cladosporium and Meyerozyma. Identified PGPM will be used for the formulation of microbial consortium that will be applied in in-vitro culture of banana. On the other hand, in vitro mycorrhization of Grand Naine (ITC 0180) and Mbwazirume vitroplants (ITC 1356) by Rhizophagus irregularis (MUCL 41833) was performed using the Mycelium Donor Plant (MDP) (Figure 2). Afterwards, drought stress mitigation properties and plant growth promotion will be assessed by in greenhouse culture test.

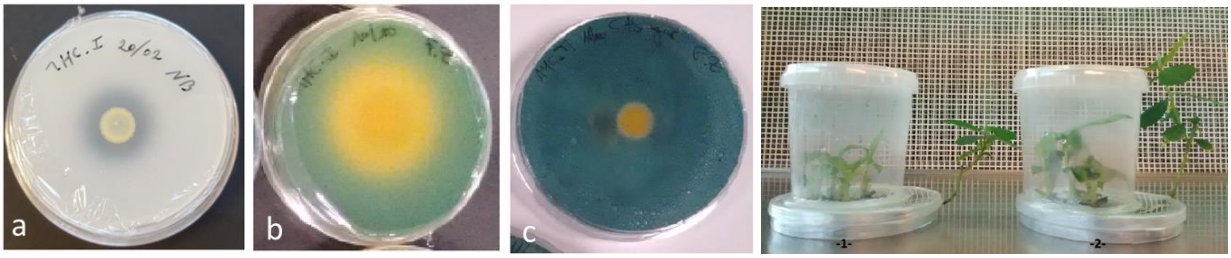

Figure 2 : Solubilization of phosphate (a) and potassium (b) by bacteria "*Pantoea* vagans" on NBRIP medium showing the formation of a halo around the colony and on modified Aleksandrov medium amended with bromophenol blue showing a yellow halo respectively. Production of siderophores by *Pseudomonas rhizosphaerae* on chrome azurol S (CAS) agar plates (c). **right panel :** Banana shoot tips grown in MPD *in vitro* system. 1- Banana shoot tips grown on MSR medium without Arbuscular mycorrhizal fungi (AMF). 2- Banana shoot tips grown on MS medium with Arbuscular mycorrhizal fungi.

4. Testing climate smart banana varieties with good market potential in Africa and Europe

The Canarian Institute of Agricultural Research-ICIA-, under the lead of Dr María José Grajal-Martin and Juan Cabrera-Cabrera participates in the European CLISMABAN project for the identification of climate-smart varieties with good market potential in Africa and Europe. During the period from the beginning of the project to date, cultivars selected for their different behaviors against water stress have been introduced, *in vitro* multiplied, hardened in the greenhouse and planted in the field. These banana cultivars could be potentially interesting for the banana production under the new climatic conditions that are occurring. The cultivars that are being tested in the field are: ITC 1356 Mbwazirume, ITC 0632 Cachaco Enano, ITC 0962 Prata ana and ITC 1180 Nakitengwa, Grand naine and Petite naine Gruesa selection. These last two cultivars belong to the Cavendish subgroup, being the ones cultivated in the Canary Islands. We have two treatments, the usual irrigation in the area and with a reduction to 50%.

Several trials have been carried out to study the behavior of three cultivars with mycorrhization and with three different levels of applied water stress. Dr. Águeda Mª González-Rodríguez evaluates the response by measuring physical variables (length and diameter of leaf and plant (cm), number of leaves, fresh and dry biomass (g) and leaf surface (cm2), microbiological variables (% colonization radical) and chemical variables (content in foliar N, P, K). In addition, the functional response of the plant is being studied using non-modulated light fluorimeters and changes in the content of photosynthetic pigments, antioxidants and proline will be analyzed.

5. Evaluation and adoption of cooking banana hybrid varieties in Kenya

The Kenyan partners, under leadership of Mary Mwangi and Grace Wamue-Ngare have embarked on popularization and evaluation of improved cooking banana (NARITA) and plantain (PITA) hybrids using a participatory, gender-integrated approach. A baseline survey was carried out to establish the status of the cooking banana value chain in 3 selected counties (Murang'a, Kirinyaga and Embu). Stakeholder sensitization, mapping and gender sensitization have been accomplished. The team has also established a tissue culture laboratory and an experimental farm at Kenyatta University to further propagate and maintain in vitro germplasm sourced from the International Banana Transit center in Ibadan, Nigeria. The importation process and research infrastructure have been duly approved by the Kenya Plant Health Inspectorate Services (KEPHIS).

So far, 25 accessions of NARITAs have been successfully multiplied, acclimatized and planted in the Kenyatta University Research farm. Data collection on agronomic performance is ongoing in the laboratory, greenhouse and the farm. This information will guide the selection of the most promising accessions for further multiplication. The next step is to embark on participatory varietal selection whereby gender-integrated farmers will work closely with the researchers to identify the most desirable varieties based on agronomic and sensory evaluations. The team will generate data to support variety release using the laid-out procedures. In addition, a tissue culture technician has been trained on the job. A graduate student has also been enrolled to study for an MA in Gender and Development studies. She will be examining the utilization of gender acquired knowledge through training in enhancing production within the cooking bananas and plantains value chains. She has completed course work and is currently developing the research proposal.

Figure 5. Mary Mwangi active in the newly established banana tissue culture laboratory with support of Kenyatta University and the CLISMABAN project

Figure 6. The NARITA hybrid banana plants after multiplication for evaluation in the field

6. CLISMABAN in the spotlight

http://research.ku.ac.ke/images/2021/rio_newsletter_dec_2020.pdf

CLISMABAN Project Pioneers keen on establishing Centre for improved cooking bananas and plantain hybrids at KU

Prof. Grace Wamue-Ngare and Ms. Mary Mwangi (in orange t-shirt) pose with participants during a gender training brainstorming workshop

The CLISMABAN project is a being implemented by a consortium of researchers from Kenya, Uganda, Spain and Belgium and is funded by the LEAP-Agri: EU-Africa Research and Innovation grant. The project is aimed at exploiting the existing genetic resources and diversity of bananas to select varieties resilient to climate change-induced constraints, using a participatory gender responsive and all-inclusive approach in the banana and plantains value chains. CLISMABAN has a strong capacity building strategy targeting both producers and researchers, training them in different aspects of the banana research- to- market pipeline, with the aim being to stimulate better utilization of scientific results.

The Kenyan team which comprises of Prof. Grace Wamue -Ngare of the department of Sociology, Gender & Development studies and Mary Mwangi of Biochemistry, Microbiology and Biotechnology have embarked on popularization and evaluation of improved cooking banana (NARITA) and plantain (PITA) hybrids using a participatory, gender-integrated approach.

Prof. Ngare offers the gender strategy for the entire project team, the participating famers and other players in the banana and plantain value chains. In this, she advises on affirmative action, where applicable, especially in all training and knowledge transfer activities while Ms. Mwangi works closely with other scientists in the team to identify the most promising accessions for evaluation in Kenya. This culminated in the importation of in vitro cultures of certified germplasm from the International Banana transit centre in Ibadan Nigeria. Further, Prof. Rony Swennen a consortium members and a lead scientist in the development of the hybrids facilitated the importation of the germplasm to Kenya for the first time. As per the KEPHIS requirements, Kenyatta University has supported the establishment of a tissue culture laboratory to specifically propagate the new varieties. So far, 25 accessions of NARITAs have been successfully multiplied, acclimatized and planted in the Kenyatta University Research farm. Data collection on agronomic performance is ongoing in the laboratory, greenhouse and the farm. This information will guide the selection of the most promising accessions.

The next step is to embark on participatory varietal selection whereby gender-integrated farmers will work closely with the researchers to identify the most desirable varieties based on agronomic and sensory evaluations. The sustainability plan is one, to utilize the laboratory for training and commercial propagation. The team is looking into the possibility of establishing an in vitro cooking banana and plantain germplasm conservation centre at KU, as well as extending the demonstration and research farm for the climate resilient varieties at the KU, Kitui campus.

Ms. Mary Mwangi in the lab