Multidisciplinary Messages on Matooke*

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Report on Matooke symposium held on 28-30 September 2021

**Matooke is the local name for cooking banana in Uganda (East-African Highland Banana, Musa spp. AAA-EA). Matooke is a popular staple in Uganda, especially in the western and central region, including urban areas. Matooke is also the name of a dish of steamed cooking banana, the most common way to consume cooking banana in most of Uganda.*

Preface

On 28-30 September, NARO, IITA, the Alliance of Bioversity International and CIAT and the Plant Productions Systems chair group of Wageningen University and Research organised the 'Matooke symposium. The aim was to discuss and share our understanding of the sustainability and productivity of banana-based systems in West and South-West Uganda. This report contains a detailed description of the presentations, discussions and key lessons of the symposium. As scientists, we welcome a healthy and critical debate about research findings and their implications. Some topics were indeed critically debated, and as report authors, we tried to do justice to the presentations and discussions. Given the diversity of scientific disciplines and organizations involved in the symposium, the messages in this report do not necessarily reflect the views of the associated organizations.

Contents

1) Introduction

A rich body of knowledge has been generated on banana-based systems in West and South-West Uganda. Multiple people from various organizations are studying these farming systems from a wide diversity of perspectives. Key players in this research are NARO, IITA, the Alliance of Bioversity International and CIAT and several chair groups at Wageningen University and Research.

The Matooke symposium brought together people and organizations currently working on banana-based systems in West and South-West Uganda.

The interactive and multi-disciplinary symposium aimed to foster collaboration and enable participating researchers to learn from each other's' insights and perspectives, discuss state of the art knowledge and identify the most pressing knowledge gaps. This requires distilling and sharing key lessons from our past and ongoing research, both from a scientific and practical point of view. The main purposes of the symposium were to share research findings, identify knowledge gaps and explore possibilities for collaborative research to improve the sustainability and productivity of banana-based systems in West and South-West Uganda, as learning sites from which generic findings can be adapted and applied in banana agro-ecologies in the wider banana-based cropping systems in the Great Lakes region of Africa. The three objectives and the related questions and outputs are as follows:

Consolidate knowledge on banana-based systems in West and South-West Uganda

What is the state of the art of scientific understanding of banana-based systems in West and South-West Uganda, in terms of:

- Recent developments and land-use change
- Landscape-level perspectives
- Agronomy
- Breeding
- Farm-level perspectives
- Value chains

What practical and strategic knowledge have we generated for policymakers, extension services and farmers to improve the sustainability and productivity of banana-based systems?

Identify knowledge gaps for moving towards sustainable banana-based cropping systems

What are the most critical knowledge gaps for increasing sustainability, productivity and profitability of banana-based cropping systems?

Explore possibilities for collaborative research to address knowledge gaps

How can the various organizations, scientists and key stakeholders collaborate more effectively to address knowledge gaps?

This report contains a detailed description of the symposium's presentations and discussions. In line with the first objective to consolidate knowledge, the key lessons are summarized and presented at the top of each session's description in Chapter 3. In relation to the second objective, the identified knowledge gaps are summarized in Chapter 2. The symposium laid an important foundation for further collaboration through (1) summarizing existing knowledge and identifying knowledge gaps, (2) creating links between the partners, (3) building trust through open discussions, thereby addressing the third objective.

2) Research gaps

This chapter summarizes the knowledge gaps and translates them into opportunities that can contribute to enhanced sustainability and productivity of banana-based systems (Figure 1). Many opportunities cut across scales and scientific disciplines and require involvement from various actors, such as extension agencies, private sector parties and government bodies. Therefore, the first and most straightforward opportunity is to explore strategic partnerships between the various research organizations and to identify or develop tools and approaches for interdisciplinary multicriteria analyses, across spatial and temporal scales. Equally important is the mapping of relevant value chain and societal actors, and their active participation in the design of further research and development plans. Their involvement is also crucial for understanding and improving the institutional context, with the aim to increase productivity and sustainability, especially for resource-poor farmers. Examples mentioned and discussed during the symposium are farmer cooperatives and micro-financing services/facilities tailored to the needs and realities of smallholder farmers.

Opportunities to improve the functionality of the value chain include collective marketing and the exploration of options for value addition. The latter is especially important to tackle problems of production surplus, low farmgate prices during the harvest peak season. The symposium showed that a wide variety of promising management options are available, but these should be tailored to the diversity of farmers and biophysical environments. The (re-)design of management options and farming systems should be done in close collaboration with farmers, taking into account their goals, perspectives, resource endowment, skillsets and constraints. The symposium showcased some promising approaches to achieve this. A main knowledge gap relates to the observation that many poorer farmers still operate at very low levels of productivity, seemingly trapped in unsustainable production. There is an urgent need to identify options for this group to increase the use-efficiency of their land, labour and capital, inside or outside of agriculture.

Another opportunity is the investigation of how resilience to shocks can be improved. Important shocks are droughts, pests such as weevils, and diseases such as black Sigatoka and Banana Xanthomonas Wilt. Options for harnessing agrobiodiversity at the farm to landscape scale to increase resilience should be explored.

In terms of agronomy, the optimal rates between manure and fertilizer should be investigated for different biophysical environments and production objectives. Furthermore, the interaction between plant nutrition and the crop's ability to withstand pests and diseases is not well understood and requires further attention.

Banana breeders have managed to develop hybrid varieties with improved agronomic traits and high farmer acceptance. It is a great opportunity, as well as a huge challenge, to develop a functional seed system to deliver improved varieties to farmers. This requires interdisciplinary research on the characteristics of such a seed system in terms of farmer's needs, effective dissemination, regulation and quality control. Involvement of government bodies and private sector actors is important for respectively quality control and for upscaling the production of starting material.

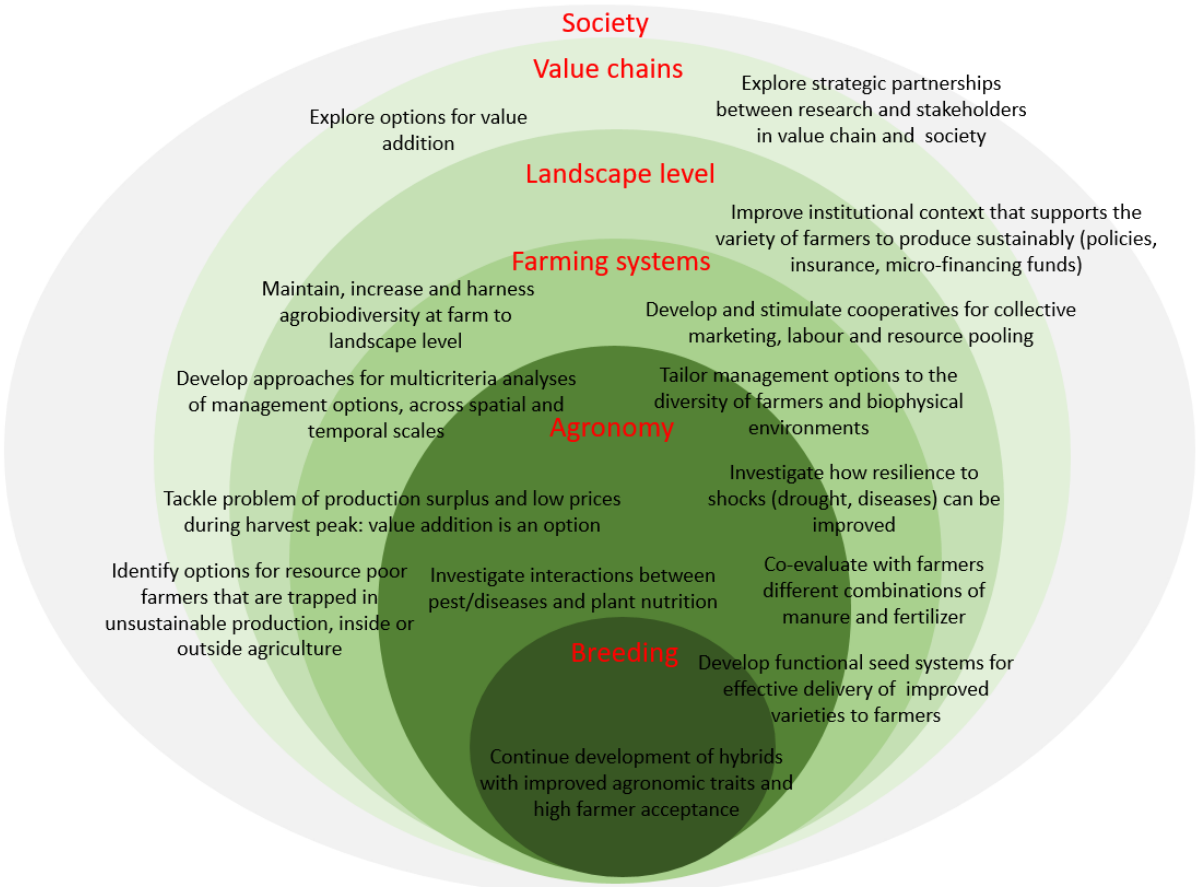

Fig 1. Opportunities for moving towards increased sustainability and productivity of banana-based systems in West and South-West Uganda.

3) Symposium sessions and key lessons

Opening symposium

The symposium was opened by Priver Namanya, Head of the National Banana Research Programme at NARO, who emphasized the key role of Matooke for food and income for a large number of smallholder farmers in Uganda. Hence, improving the sustainability and productivity of banana-based systems is important for food security at a national level. She mentioned that the current agenda should be geared towards commercialization of the banana sector, and that further research should focus on intensification of production, exploring options for value addition, and an improved value chain with more engagement of the private sector. She underlined the need for continued and more intensive collaboration between the participating organisations, and between scientists of various disciplines, and expressed the hope that the symposium would indeed foster this collaboration.

Session 1 Historical perspective and recent developments

Key lessons

- Over the last six decades, a major geographical shift of the Matooke production area has occurred. In the Western region, the Matooke area strongly increased, whereas it strongly decreased in the Eastern region and remained stable in the Central region.
- Expansion of the Matooke area did not necessarily occur in the most suitable areas, with a large expansion in drought-prone areas in the South-West.
- The area under Matooke in South-Western Uganda has increased significantly at the costs of pastures, forests, land under annual crop production and communal lands. At the same time, management practices have intensified: there is increasing specialization in Matooke.
- In South-West Uganda, the increased intensification and specialization has mainly benefitted a relatively small group of wealthy land owners, while the poor struggle for access to resources such as fire-wood, land and manure.
- Increased specialization makes the area more vulnerable to shocks such as droughts
- Resilience to climate change should be included on the research agenda
- Specific attention is needed for resource-poor farmers with small land holdings: what opportunities are there for them both in relation to sustainable production of matooke and other livelihood activities?

Predictable patterns of unsustainable intensification; Banana farming in SW Uganda
Anne Rietveld: Associate scientist at the Alliance of Bioversity International and CIAT; PhD candidate at Farming Systems Ecology Group at WUR

Anne Rietveld discussed the intensification of Matooke production from a historical perspective, and by placing the developments in the context of multiple domains of sustainability. The changes in Rugaaga sub-county (Isingiro district, South-West Uganda) between 1998 and 2018 were discussed as a case-study. First, a brief history of the sub-county was given. In the beginning of the 20th century the study area was sparsely populated, but before independence in the 40's-50's, the colonial government promoted settlement in this area and migrants could acquire land for free. This policy continued after independence in 1962. A large refugee settlement area was also established in the region. In 1986 -after the civil wars- an improved road network resulted in better connection to urban markets, especially the rapidly growing capital, Kampala. Increasing demand for Matooke drove up prices, while extension services became more active in the region. This resulted in huge expansion of Matooke area in the region, in combination with ongoing intensification. Besides the increasing specialization in Matooke, the other main changes in the study period were: a decrease in communal land such as forests and grazing land, reduced on-farm crop diversity and increased erosion from the hillslopes. In the meantime, the population increased rapidly and living standards generally improved. However, the benefits of Matooke expansion and intensification seem to accrue mainly to a small group of wealthy land owners who can afford to invest in intensive management practices such as weeding, mulching, disease control and manure application. The poorer farmers suffer from decreasing availability of firewood due to reduced area under forests and communal lands, while their dietary diversity reduced as a result of reduced on-farm crop diversity. Due to the specialization in Matooke, the whole production system in the area has

become increasingly vulnerable to droughts, and famines and food shortages have occurred in recent years. The negative changes as a result of increasing specialization and intensification of Matooke production are shown in Figure 2.

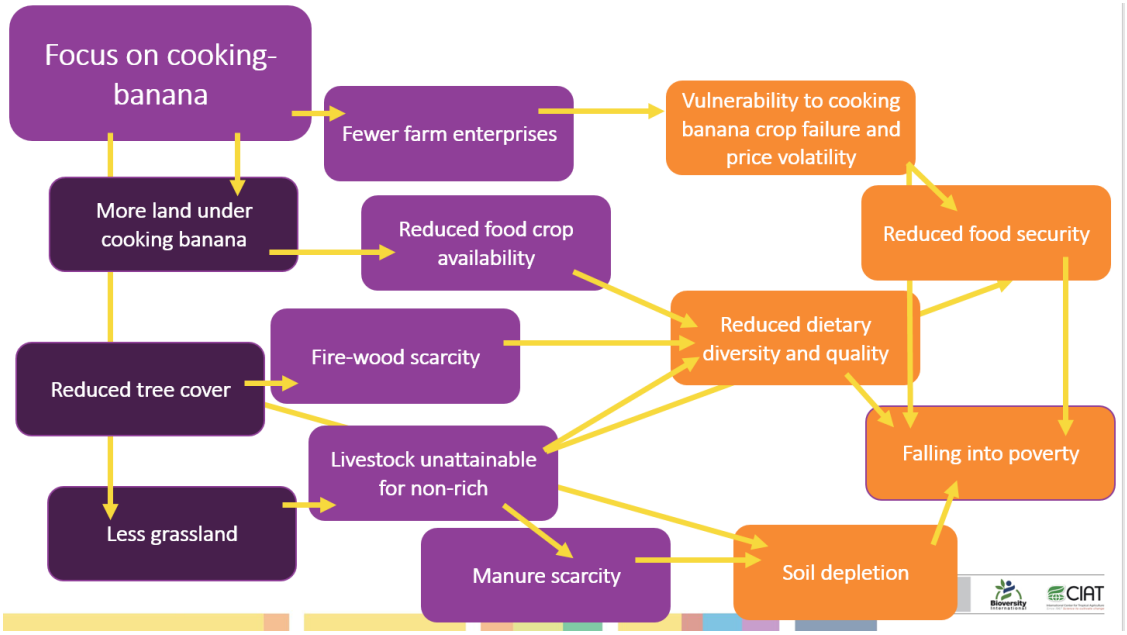

Figure 2: Changes as a result of increasing specialization and intensification of Matooke production. Figure credits: Anne Rietveld.

In terms of social sustainability, there are two main problems arising as a result of the increased intensification. First, the inequality within households has increased because the income of Matooke is controlled by men. Hence, men can invest in new households and polygamy has increased. This results in disempowerment of 'first' wives and fewer resources per HH member available. Second, inequality between households increased with new classes of very rich and very poor, landless farmers. A small group of rich farmers has reaped most benefits from increased specialization and intensification, while the poor struggle for access to resources such as firewood, drinking water during droughts, land and manure. Furthermore, there is increased competition for casual farm work, hence, there are less earning opportunity for women, landless casual workers and refugees. This study was published here: https://www.tandfonline.com/doi/full/10.1080/14735903.2021.1940731

During the discussion after this presentation, it was noted that to counterbalance the negative effects on the poorer farmers, there are several options: smallholders could benefit from input aggregation through cooperatives, but there is also a need to look for alternatives beyond Matooke, for instance diversification through other crops or non-farm enterprises. It was debated to what extent the negative consequences as presented in Figure 2 can indeed be attributed to matooke specialization and intensification, and no consensus was reached regarding this issue. There was however, consensus on the notion that banana production and expansion / intensification in the specific region has also resulted in a lot of benefits for many farmers especially in regards to raising livelihood standards. The study highlighted above is a valuable contribution to this debate, since it shows that benefits and negative consequences from banana intensification and commercialization were not equally distributed.

Mapping spatial distribution and geographic shifts of East African highland banana (Musa spp.) cropping systems in Uganda
Dennis Ochola: Graduate research fellow at the International Institute of Tropical Agriculture (IITA); PhD candidate at Plant Production Systems Group at WUR

Dennis Ochola shared the insights from a recent study on the drivers of geographical shifts of the Matooke area over the last six decades. Several geostatistical tools were combined for the analysis: 1) a geosurvey; 2) ensemble machine learning; 3) logistic regression; 4) vector overlay analysis and 5) CART analysis. The results show that the central region was the main Matooke production area in 1958, but in 2016 the Western region is the major production area. Between 1958 and 2016, the banana area in the Western region increased by 60%, it remained stable in the Central region and it decreased strongly in the Eastern region. What are the biophysical drivers of these geographic shifts in Matooke production

areas? An increased banana area was associated with relatively low precipitation seasonality, annual mean temperatures below 23 °C, a bulk density above 1396 kg/m^{-3}, and a relatively low soil organic matter pool. It seems that expansion of the Matooke area did not necessarily occur in the most suitable areas. For instance, a 28% expansion of the Matooke area occurred in the South-Western Grass farmlands (i.e. the South-western end of the so-called cattle corridor), which have poor rainfall amount and distribution. These results emphasize the need to include resilience to impacts of climate change in the agenda for sustainable intensification of banana cropping systems, especially in terms of water supply.

Session 2 Landscape perspectives

Key lessons

- Matooke production requires large amounts of potassium, and large amounts of manure are needed to satisfy potassium requirements. Hence, a large number of livestock, and a large rangeland area are needed to supply sufficient manure.
- Potential manure supply was not sufficient to raise yields in the banana-based cropping systems of South-West Uganda.
- Combining the available manure with potassium-based fertilizer is recommendable
- Next steps for research are
    - Investigate farmers' reservations and (perceived) barriers towards the use of mineral fertilizer
    - Co-evaluate with farmers different combinations of manure and fertilizer through on-farm trials
    - Engage with input suppliers to increase the local availability of mineral fertilizer.
- Multicriteria analyses, across spatial scales (field-farm-landscape) are key to design promising management options, to avoid trade-offs and to check whether options are feasible across scales.

Manure matters: Prospects for regional banana-livestock integration for sustainable intensification in South-West Uganda

Harmen den Braber: Research assistant at Plant Production Systems Group at WUR

Banana farmers in South-West Uganda regard manure as the most important determinant of high yields, but is there enough manure for intensification of banana? **Harmen den Braber** addressed this question in his talk, presenting a case study about two sub-counties in South-West Uganda were manure demand is so high that farmers import manure by truck from rangelands up to 50 km away. Hence, crop-livestock integration takes place at regional level. Field-level modelling, farm-level surveys and regional-level spatial analyses were used to investigate the prospects for regional banana-livestock integration for sustainable intensification. At field-level, for median to 90th percentile banana yields (37-52 t FW/ha/year), potassium (the main limiting nutrient in South-West Uganda) requirements ranged from 118 - 228 kg/ha/year. To supply this with manure, 10.5 – 20.5 t DM manure/ha/year would be needed, requiring 47 – 91 tropical livestock units and 27 – 52 ha of rangeland. At farm-level, banana was the most important source of income for the majority of respondents. Farmers preferred to use manure, but on-farm availability of manure was low. Hence, 35% of the respondents in both sub-counties imported manure from the rangelands. At regional level, the potential manure availability from the rangelands was related to the manure requirements of the total banana area in the study sub-counties. The results showed that the potential manure supply was not sufficient to raise yields in the banana-based cropping systems of South-West Uganda. Hence, it was concluded that a more recommendable way towards intensifying banana production is to combine the available manure with K fertilizer. Since mineral fertilizer use is currently very low, next steps that should be taken are: 1) Investigate farmers' reservations and (perceived) barriers towards the use of mineral fertilizer; 2) Co-evaluate with farmers different combinations of manure and fertilizer through on-farm trials, and 3) engage with input suppliers to increase the local availability of mineral fertilizer. This study is published and can be accessed via this link: https://doi.org/10.1080/14735903.2021.1988478.

Session 3 Agronomy

Key lessons

- Yields in farmers' fields can be increased considerably with good management practices.
- Relevant and fitting management practices differ among famers, a stepwise approach towards intensification proved useful. The generalized steps are, in order of increasing management intensity and resource requirement: 1) clean-up (weeding and de-suckering); 2) pest and disease management (+ corm removal and male bud removal); 3) water and soil conservation (+ trenching and mulching); and 4) crop nutrition (+manuring).
- Nutrient applications affect weevil damage, but effects differ: nitrogen in high doses is associated with higher weevil damage, while high doses of potassium and silicon are associated with lower weevil damage.
- Nitrogen should be applied in moderation.
- Appropriate nutrient management is important to reduce yield losses from weevil damage.
- The mechanisms behind interactions between pests and nutrients are still poorly understood

Effect of nitrogen, potassium and silicon on weevil damage in East African Highland Banana
Hannington Bukomeko: Graduate research fellow at the International Institute of Tropical Agriculture (IITA); PhD candidate at Plant Production Systems Group at WUR

Nutrient management and weevil infestation are key factors determining Matooke productivity, but the interactions between these factors is poorly understood. **Hannington Bukomeko** presented insights from recent experiments to shed light on the effect of nitrogen, potassium and silicon on weevil damage in banana. In two different experiments, different rates of nitrogen, potassium and silicon were applied, and weevil damage was scored as the percentage of the corms' cross-sectional surface area damaged by weevils. In general, yield losses occur when more than 10% of the corm is affected. Weevil damage ranged from roughly 5% to 15% in the different treatments. The results show that increasing nitrogen levels (i.e. 0 – 150 – 400 kg/ha/year) are associated with higher weevil damage. Conversely, high doses of potassium (250 – 600 kg/ha/year) and silicon (300 kg/ha/year) are associated with lower weevil damage. A practical lesson from this work is that nitrogen should be applied in moderation. How do the experimental results link to circumstances in farmer's fields? Farmers rarely apply the high nitrogen doses associated with increased weevil damage, so the danger of excessive nitrogen application is limited. Weevil damage in farmer's fields is likely to be higher than in the experiments, which further underlines the importance of appropriate nutrient management to reduce yield losses from weevil damage. The mechanisms that cause the interactions between nutrients and weevil infestation are still poorly understood. It was postulated that high nitrogen doses make the plant more succulent and hence more attractive for weevils, while it also reduces the production of secondary metabolites, which play an important role in the plant defense against weevil infestation. Potassium, on the other hand, may enhance the production of secondary metabolites, while it is also associated with the translocation of water, nutrients and carbohydrates in plant tissue, which may help in 'repairing' the damaged tissue. Sufficient silicon application may result in stronger cell walls, hence providing more protection against weevil attacks.

Stepwise Intensification Pathway enhances uptake of agronomic packages in smallholder banana cropping systems of East Africa
Daphine Kamusingize: Research assistant at National Agricultural Research Organisation (NARO, Uganda); PhD candidate at Plant Production Systems Group at WUR

Daphine Kamusingize discussed ongoing work on the Step-wise Intensification Pathway (SIP) to enhance the uptake of agronomic management practices. The SIP approach acknowledges the huge diversity in farming systems and between farmers and promotes context-specific management practices in a step-wise manner. The SIP approach was deployed in West and South-West Uganda, in the districts Kabarole and Insingiro, respectively. The generalized steps are: 1) clean-up (weeding and de-suckering); 2) pest and disease management (+ corm removal and male bud removal); 3) water and soil conservation (+ trenching and mulching); and 4) crop nutrition (+manuring). First, farm segments were identified in both districts, based on the current management-level and productivity of the banana plantations owned by the household. Then, based on the identified segments, farmer meetings were organized, and learning sites were established. The rationale was that relevant and fitting management practices are different between the various farmer segments: the 'poor-management segment' needs to

start with step 1 (clean-up), while farmers in the medium and high management segment benefit more from step 4 (improved crop nutrition). This approach was upscaled using a radio-campaign, drama screening series and farmer field days. Monitoring the results from 2017-2020 showed that uptake of the different practices improved considerably over the years, and as a result yields also increased, showing the effectiveness of the approach. However, in Western Uganda, farms in the medium and high management segments showed a downward trend in terms of mulching and manuring over the monitoring period. This may have been caused by increased scarcity of manure and mulch at landscape level, since farmers in the lower segments also started using mulch and manure. Important issues that were raised during the discussion were whether there were enough resources (labour, capital, mulch, manure) available for the intensive management practices that were promoted. It was discussed that labour can be organized more efficiently by farmer cooperatives who work in 'labour rounds' in different farms. Furthermore, the availability of organic resources (mulch, manure) may prove to be problematic if an increasing amount of farmers start applying these practices.

Session 4 Breeding

Key lessons

- Hybrid Matooke varieties with improved traits such as high yield potential, pest tolerance, disease resistance and high farmers acceptance are available.
- Key difficulties in Matooke breeding are: the crop's long life cycle, low fertility of seed, polyploid nature, limited knowledge on the genetics of resistance, and large amounts of space needed for field evaluation.
- The banana seed system is dominantly informal, while the formal seed system is still at its infancy.
- Current efforts to disseminate improved varieties to farmers focus mainly on developing the formal seed system. Minor attention is paid to current, informal seed systems.

Breeding Matooke for Sustainable Production in Uganda
Dr. Ivan Arinaitwe: Banana breeder at National Agricultural Research Organisation (NARO, Uganda)

Ivan Arinaitwe explained banana breeding efforts and goals of NARO and it's partners IITA and the Alliance of Bioversity International and CIAT. Since the 90's, these partners have collaborated with the aim to develop Matooke varieties with the following traits: yields of over 25 t/ha/year, resistant to black Sigatoka, resistant to weevils and nematode damage of up to 20% damage level and scoring at least 4 out of 5 in terms of farmer and consumer acceptability. The release rate of new hybrids has been low, because of the crop's long life cycle, low fertility, polyploid nature, limited knowledge on the genetics of resistance, and large amounts of space needed for field evaluation. At current, there are seven new Matooke hybrids released which match the above-mentioned product-profile.

Breeding for banana pests and diseases
Dr. Valentine Nakato: Postdoctoral fellow in Plant Pathology at International Institute of Tropical Agriculture (IITA)

Valentine Nakato gave an overview of activities in the Breeding Better Bananas project, a collaboration between NARO and IITA. Her talk focused on breeding for pest and disease resistance. The main biotic constrains are in the region are Black sigatoka or Black Leaf streak, Fusarium Wilt, Xanthomonas Wilt, weevils and various plant parasitic nematodes. Known varieties, wild relatives and related species are screened for specific resistances, while mutations and unrelated organisms may also provide the required resistance. The project was successful in bringing the first hybrid Matooke varieties, called NARITA's, on the market. The ultimate goal of the project is to increase the economic returns on investments for farmers, through the development of hybrids that are similar to reference varieties, but with higher yields and improved resistance to major biotic constrains.

Are there efforts to link to formal and informal seed systems in this region? This question was discussed after the presentations. Currently, the banana seed system is dominantly informal, while the formal seed system is still at its infancy. For the formal seed system to improve, quality control and seed health need to be standardized through certification, and the system would need drastic upscaling before it could be effective in reaching large numbers of farmers. Yet, it seems that current breeding work does not (try to) link to the informal seed system in any major way and seems to focus exclusively on developing and linking to the formal seed system. There are ongoing efforts to upscale the production and marketing of banana plantlets from tissue culture, also with the private sector.
Questions were asked regarding other important product traits such as drought tolerance. In the current breeding efforts, this has been given a low priority because of resource constraints.

Session 5 Farm level perspectives

Key lessons

- Matooke farmers are highly heterogenous and have multiple objectives, it's not only about yield. This should be taken into account when designing options to improve sustainability and productivity.
- Incorporating farmers' perspectives and opinions in options for (re)-design of farming systems is key: promising options are co-learning and participatory visioning and back-casting.
- Seeking common ground between researchers and farmers is essential.
- Resource constraints limit farmers' decision space, hampering opportunities for learning and experimenting. Methods and policies are needed to increase farmer's decision spaces.
- Model explorations show large space for improvement in terms of farm profitability, environmental sustainability and nutritional yield for a variety of farmers in Central and South-West Uganda.
- Diversification of Matooke production systems through leguminous cover crops or hedges, or through intercropping with yams, are promising options.
- Intensive co-learning approach influenced input choices by farmers.
- Specialization in banana was favourable for food self-sufficiency and income, but labour requirements for this specialization are high.
- Current fertilizer recommendations are unbalanced, as they result in N-surpluses and K-deficiencies.
- Interventions in Matooke should take into account that it is regarded a men's crop: women were worried that they would not benefit from increased banana income.
- Important questions for further research are:
    - What are the optimal combinations of manure and fertilizer?
    - Can nutrient advise be tailored to specific regions and/or target yields?

Farm diversity and Agroecological Intensification of Matooke landscapes/ farming systems
Dr. Walter Ocimati: Associate scientist at the Alliance of Bioversity International and CIAT

Walter Ocimati presented work on the impact and opportunities of agro-ecological intensification (AEI) on farm performance in central and South-West Uganda. 4 farm types were identified on basis of location, farm size and TLU ownership. Then representative farms for each farm type were studied in more detail and the input variables for the FarmDESIGN model were collected. The objective of the study was to assess the effect of AEI practices on farm profitability, environmental sustainability (soil N balances and soil erosion levels) and nutritional yield (dietary energy, vitamin A and iron). Findings showed that the number of AEI practices differed widely per farm type, with farms in central Uganda having a much higher crop diversity index than farms in South-West Uganda. For all farm types, the model explorations resulted in new farm configurations that outperformed the original farm configurations in terms of profit, environmental indicators and nutritional diversity. Furthermore, the potential of crop diversification was explored through addition of leguminous species such as *Mucuna pruriens* (covercrop) and *Calliandra calothyrsus* hedges. These species add nitrogen to the soil and also suppress weeds. Intercropping with yams (*Dioscorea esculenta*) was also explored. First model explorations showed that these options could have a positive effect on several production objectives. Discussing these options with farmers further strengthened these conclusions. During the discussion after the session, these conclusions were heavily debated, showing that there is need for larger scale in controlled field trials running for an adequate period of time.
Another discussion topic was that simulated optimal farm configurations seem to contrast with empirical vidence from the farming system, especially in the case of the farms in South-Western Uganda. The main conclusions from Walter's work were that AEI practices have the potential to improve farm performance: model explorations show that Calliandra (hedgerow) and Mucuna cover crop increased on-farm manure/mulch production, sustainability indicators and profitability. Furthermore, typologies proved a useful method to address the heterogeneity of Matooke farmers.

Co-learning for improved advice
Wytze Marinus: PhD-candidate at the Plant Production Systems group at WUR

Wytze Marinus started his presentation by emphasizing that although many yield-improving technologies are 'on the shelf', smallholder farmers often don't use them. Important reasons are resource constraints and a limited decision space, which limit farmers' opportunities for learning and experimenting. Hence, an integrated co-learning approach was developed to explore pathways towards sustainable intensification. In Western and South-Western Uganda, co-learning groups and control

groups were established (n=12 per group). Both groups received an input voucher of US$100 per season. Farmers could spend this voucher on inputs they wanted to buy, (partly) releasing resource constraints and allowing farmers to experiment with new inputs. In addition, workshops were organized with the co-learning groups for 4 growing seasons, seeking common grounds for communication between farmers and researchers. In the workshops, farmers noted that yields were declining, and that manure was too expensive. They were very skeptical about the use of mineral fertilizer and stated it 'poisons the soil' and 'makes the soil lazy'. Common grounds were sought by discussing the concept of balanced plant nutrition using the analogy of a plate of food: different types of local food represented different nutrients (N,P,K), whereas the plate itself represented the Soil Organic Matter. The need for K fertilization for banana was stressed in the workshops. Results showed that workshops topics evolved over the season, and that the co-learning group opted for mineral fertilizer more often than the control group, indicating that the co-learning approach had influenced input choices. Important questions for further research are: 1) What are the optimal combinations of manure and fertilizer? 2) Can nutrient advise be tailored to specific regions and/or target yields?

Participatory exploration of transformative pathways for banana-based farming systems in Uganda
Dr. Esther Ronner: Postdoctoral researcher at the Plant Production Systems group at WUR; visiting scientist at the International Institute of Tropical Agriculture (IITA), Kampala, Uganda

What is a sustainable and desirable future for banana-based farming systems in Uganda? **Esther Ronner** and her team explored transformative pathways in a participatory way in the STEP-UP project. Major challenges for the Matooke sector in terms of production are soil fertility decline, increased vulnerability to droughts , and increased inequality between producers. In the meantime, there is little cooperation in the Matooke value chain as many producers do individual marketing, and limited value is added to the raw product. In Western and South-Western Uganda, participatory visioning and back-casting were used to develop a shared vision for a sustainable and desirable future, and steps towards this future were identified. As interventions, Integrated Soil Fertility Management (training, demonstrations and linkages to private sector input producers) and value addition through banana beverages were selected. Qualitative ex-ante results from workshops showed that farmers expected better yields and incomes, and improved knowledge on soil fertility management as a result of the interventions. The overuse of mineral fertilizer was perceived as a negative outcome, whereas women were worried that they would not benefit from increased banana income, as banana is considered a men's crop. Qualitative ex-post assessments showed that mineral fertilizer purchases increased and that the trainings improved farmers knowledge. However, the majority still resented the use of mineral fertilizer and women still had little money and decision power to put the newly acquired knowledge into practice. On basis of these ex-ante and ex-post assessments, the project developed tailored nutrient recommendations, gender sessions embedded were in the trainings, linkages to micro-finance funds were made and an interactive radio show on ISFM will soon be broadcasted. Several plausible future scenarios were developed and the impact of these scenarios on sustainability indicators was investigated through a quantitative ex-ante assessment. Main findings were that specialization in banana was favourable for food self-sufficiency and income, but labour requirements for this specialization are high. Furthermore, current fertilizer recommendations were found to be unbalanced, as they result in N-surpluses and K-deficiencies. The participatory approach proofed valuable because it facilitated in-depth understanding (e.g. income sharing from banana between men and women) and this enabled the revisioning of interventions.

Session 6 Value chains

Key lessons

- During the harvest peak season there is surplus production, resulting in low farmgate prices and high competition between farmers to sell their produce. Farmers with small landholdings struggle to sell during this season.
- During harvest peak season, traders have more bargaining power, in the off-peak season, farmers have more bargaining power.
- Credit arrangements play an important role in the Matooke value chain.
- Membership of cooperatives among farmers is low, collective marketing should be stimulated.
- Traders rely on casual workers, farm management labour is mostly performed by household members.
- Labourers in the value chain consider their employment not decent.
- Options for value addition should be explored, mostly targeting the surplus production during the harvest peak seasons.

Employment and competitiveness in the cooking banana value chain in Uganda
Dr. Enoch Kikulwe: Scientist at alliance of Bioversity International and CIAT

Enoch Kikulwe shared insights regarding employment and competition in the Matooke value chain. A quantitative study was done in West and South-West Uganda, conducting key informant interviews and Focus Group Discussion with the different actors in the Matooke value chain, such as wholesalers, retailers, processors, transporters and cooperatives, casual laborers and farmers (Figure 4). The results showed that competition and bargaining power is heavily influenced by the season. As a farmer put it "*During the peak period it is the farmer who tries to please the traders and during the off peak it is the trader who tries to please the farmer".* During the peak harvest season, the quality of the harvested products is high but the banana bunch prices are low, because competition between farmers is very high and their bargaining power is low. In this time, to be able to sell some bananas farmers often have to sell on credit. In the off-season, this pattern is reversed, and traders sometimes pre-finance the harvest or give presents to farmers to ensure that farmers keep the harvest for them. This shows that credit relations play an important role in the value chain. Cooperation membership was very limited among farmers, and collective marketing was not common. In terms of employment, farmers used mostly household labour, hired labour was mainly used for strenuous activities. Along the value chain, permanent employment is rare, and in general, casual laborers didn't consider their employment decent. An important recommendation was that collective marketing, for instance through cooperatives, needs to be promoted, because this could increase farmer's bargaining power. Furthermore, options for value addition should be explored, mostly targeting the surplus production during the peak seasons.

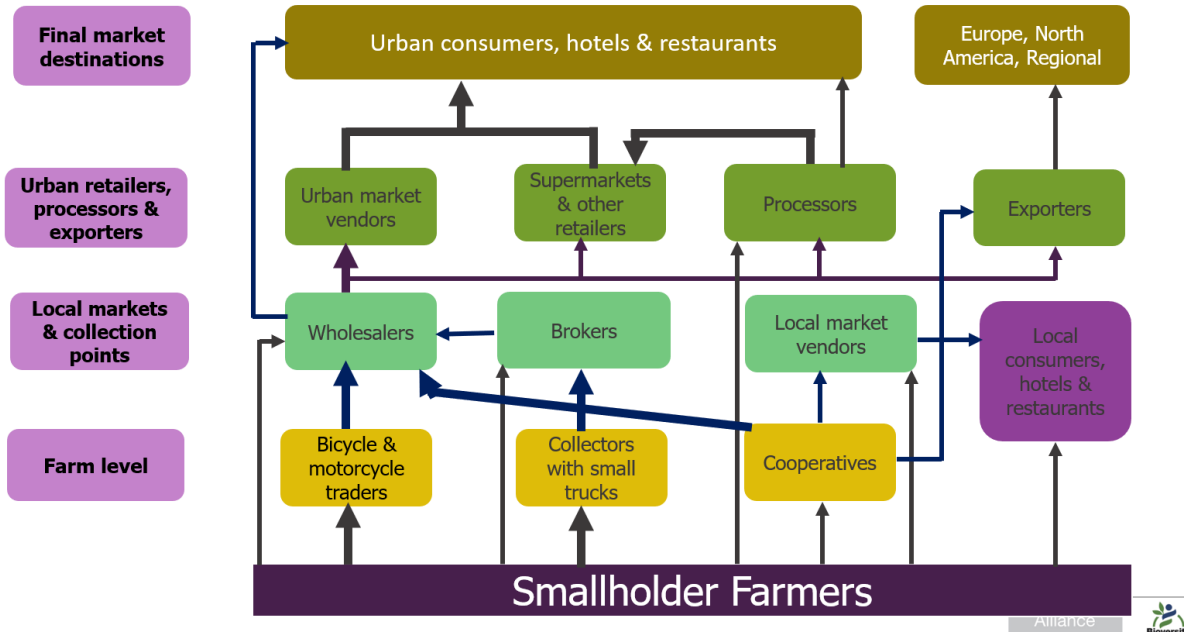

Figure 4. Structure of the Matooke value chain. Figure credits: Enoch Kikulwe.

Session 7 Key lessons and prospects

Panel discussion

Moderator:
Dr. Godfrey Taulya: Associate Scientist at the International Institute of Tropical Agriculture (IITA)

Panelists:
Dr. Katrien Descheemaeker: Associate professor in the Plant Production Systems group of Wageningen University and Research
Dr. Beatrice Ekesa: Associate Scientist at the Alliance of Bioversity International and CIAT
Dr. Jerome Kubiriba: Senior Scientist at the National Agricultural Research Organisation (NARO, Uganda)

Key lessons

- A wide variety of promising opportunities and tools are available to analyze and enhance sustainability and productivity of Matooke and the farming systems in West and South-West Uganda.
- Matooke is part of a farm system and as such should be considered as one of the options in a range of enterprises.
- Several matooke production constraints still remain or are emerging threats (e.g. drought stress and pests). These need knowledge-based solutions, while existing technologies need to be optimized to suit different socioeconomic and biophysical contexts. Participatory design, testing and evaluation of these technologies and solutions is key.
- Opportunities for enhancing agro-biodiversity at various scales of integration should be explored, especially to meet food and nutritional demands of the local population.
- The functionality of the matooke value chain needs to be improved and options for value addition should be explored. The private sector should be more engaged. It is necessary to develop concrete examples on how the private sector could benefit from value addition.
- Many poorer farmers still operate at very low levels of productivity, seemingly trapped in unsustainable production. There is an urgent need to identify options for this group to increase the use-efficiency of their land, labour and capital, inside or outside of agriculture.
- Multicriteria analysis of management options or policies and the identification of trade-offs and synergies across domains and scales is urgent.
- Future research projects should be interdisciplinary and foster a system perspective. They should seek strategic engagements with key stakeholders, including the private sector.

The symposium ended with a panel discussion with **Katrien Descheemaeker**, **Beatrice Ekesa** and **Jerome Kubiriba**, moderated by **Godfrey Taulya.** They reflected on the main insights from the symposium, the main research gaps and the way forward to addressing these gaps.

Main insights

Panel members agreed that although there are many interrelated threats to the sustainability of the broad Matooke production system, this symposium showed that there is a wide variety of promising opportunities and tools available. Some threats also pose opportunities that should be harnessed, for instance, population growth also provides a growing labour force and a growing market. The panel members underlined the complexity of the matooke production systems, and noted that this diversity should be taken into account designing options to improve sustainability and productivity. Several production constraints still remain or are emerging threats (e.g. drought stress and pests, nutrient deficiencies) to the banana farming system. These need knowledge-based solutions, and existing technologies need to be optimized to suit the diversity of socioeconomic/biophysical contexts. It is therefore important to work directly with farmers and other stakeholders, and to understand their visions and perspectives. Some promising examples were discussed during the symposium, such as co-learning approaches and participatory visioning. It was also noted that agrobiodiversity is still present in the banana-based systems and that maintaining crop diversity is important to meet livelihoods needs such as income and healthy nutrition. Furthermore, the symposium made clear that there is scope for harnessing agrobiodiversity in banana cropping systems at farm to landscape level for long term system resilience and ecosystem services.

Main gaps identified

Innovation and improving sustainability in the Matooke productions systems requires a holistic and interdisciplinary approach which also takes into account social and environmental considerations next to economic and productivity related issues. But how can the various tools and approaches be integrated? Furthermore, the functionality of the value chain needs to be improved and the private sector needs to be more engaged. In particular, it was stressed that scientists and other stakeholders should work together to develop concrete examples of how the private sector could benefit from value addition from Matooke. What products do we need to develop? What profits could be made?
Another set of important research questions relates to the involvement of various actors: how do we effectively engage with different stakeholders? How do we translate research findings into meaningful

messages for farmers? Examples from the symposium showed that seeking common grounds and participatory visioning exercises are useful tools. A last important research gap is the integration of the different sustainability domains, with special attention to the social domain. Multicriteria analysis of management options or policies and the identification of trade-offs and synergies across domains is urgent.
Lastly, a main gap relates to the observation that many poorer farmers still operate at low levels of productivity, seemingly trapped in unsustainable production. What options are there for them? Matooke is part of a farm system and as such should be considered as one of the options in a range of enterprises. When looking for opportunities inside agriculture at various nodes of the value-chain, a key knowledge gap is the type of institutional context that would be needed to improve sustainability and productivity for this group of farmers. Examples are farmer cooperatives, policies and micro-financing funds.

Discussion with the audience
In the discussion with the audience, the need for value addition and private sector engagement was underlined a few more times and many participants considered that this is an important way forward. However, it was also noted that many value addition initiatives have been piloted in the past, but processed products from banana have always remained a niche, and it may be expected that the main market will always be the selling of fresh produce. No consensus was raised regarding this point. Another relevant point raised during the discussion was that the resilience of the system has not been addressed a lot in the various presentations. The increased specialization and intensification might render cropping systems less resilient to shocks or changing conditions such as likely to be induced by climate change. The audience was convinced that further research projects should be more inter-disciplinary and that strategic engagements with key stakeholders, including the private sector are crucial.