OPEN FORUM ON AGRICULTURAL BIOTECHNOLOGY IN AFRICA (OFAB HELD AT AbiZARDI, ARUA

Biotechnology Research Approaches in Uganda with Special Focus on Research to Address Cassava Brown Streak Virus Pandemic in Uganda

Key Note Speaker: DR. Titus Alicai, NaCRRI

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1.0 Introduction

The Open Forum on Agricultural Biotechnology in Africa (OFAB) is a platform that brings together stakeholders in biotechnology and enables interactions between scientists, journalists, the civil society, industrialists, lawmakers and policy makers. It is a forum that provides an opportunity for key stakeholders to know one another, share knowledge and experiences, make new contacts and explore new avenues of bringing the benefits of biotechnology to the African agricultural sector. Is a program of the African Agricultural Technology Foundation and is implemented in five different Countries through partners and collaborators. In Uganda, the Uganda National Council for Science and Technology is the host for OFAB and it implements the program through sub-contracts with different stakeholder organisations. These include the following: the Program for Biosafety System (PBS), Science Foundation for Livelihoods and Development (SCIFODE), Uganda Biotechnology and Biosafety Consortium (UBBC). The National Agricultural Research Organisation (NARO) is a key stakeholder in the implementation of OFAB as spearheads most of the agricultural biotechnology research programmes in Uganda.

2.0 Welcome Remarks by the Director, Abi-ZARDI

The Director of Abi-ZARDI welcomed the participants to Abi-ZARDI and thanked them for keeping time. He pointed out that Abi-ZARDI is setting out to be a centre of excellence for guiding agricultural transformation in the region. It will be is helping different farmers to address the challenges of agricultural productivity especially diseases and pests of major crops. He thanked the district and sub-county leadership for being very supportive especially when they are addressing key disease epidemics such as brown streak virus of cassava. Farmers and leaders need to listen to the scientists especially to avoid the spread of diseases and pests. He thanked the organizers of OFAB for recognizing Abi-ZARDI by calling it upon to host the OFAB on Cassava diseases and emphasized that Cassava is West-Nile sub regions' major crops both for commercial and food security purposes. He indicated that a lot of cassava is produced and exported to the neigbouring countries— South Sudan and DR Congo, helping many families to gain some income. He thanked the National Council sfor science and Technology for sending members of the OFAB Programming Committee to participate in Abi-ZARDI OFAB and Science Foundation for Livelihoods and Development (SCIFODE) for coordinating the workshop. He wished the participants fruitful deliberations.

3.0 Remarks by Arthur Makara

Arthur Makara gave a brief overview of OFAB and OFAB Uganda Chapter. He informed the participants that OFAB Uganda chapter was launched in December 2007 in

Kampala and that it runs in several other Countries including Kenya, Tanzania, Ghana, Nigeria and soon it will be launched in Burkina Faso. It is supported by the Bill and Melinda Gates Foundation through the African Agricultural Technology Foundation (AATF). At Country level, OFAB is a programme of the Uganda National Council for Science and Technology which implements it through sub-contracting partners including SCIFODE. He further clarified that OFAB is managed by a programming committee that was represented in the Abi-ZARDI OFAB by two members: Mr. Robert Anguzu and Mr. Henry Richard Kimera. He further clarified that the first phase of OFAB was mainly in Kampala but the current three-year phase targets upcountry stakeholders, and that was the reason they were in Arua.

Mr. Makara raised a question to the participants on whether they have heard about biotechnology and where they have heard it from. A number of participants responded in affirmative. When he asked those who think biotechnology is good for the Country, only four out of over 40 participants in the room at the time raised their hands. On the other hand, when he asked those who thought biotechnology was dangerous, over 20 participants raised their hands. He said that response what not different from other stakeholder groups. He clarified that many people have fears about biotechnology and that is the very reason why OFAB was conceptualized to allay those fears and to put facts right. He assured the participants that by the end of the OFAB meeting, all their fears will be gone, and called upon them to be open and to ask all the questions they have, such that they can be clarified upon.

4.0 Main Presentation: *Biotechnology Research Approaches in Uganda with Special Focus on Research to Address Cassava Brown Streak Virus Pandemic in Uganda* by Dr. Titus Alicai:

Dr. Titus Alicia presented a paper on Biotechnology interventions in Uganda to address virus disease epidemics of cassava with main focus on cassava brown streak virus. He requested the participants to have open minds for this discussion as he would begin with a broad overview of what biotechnology is; the effort by NARO to address several other challenges, and eventually zero on efforts to address cassava virus diseases. A summary of Dr. Titus' presentation is given as Annex 1 of this report.

5.0 Discussion/ Open Forum

After a detailed presentation by Dr. Titus Alicai, a number of questions were raised by the participants and discussed in plenary thus:

5.1 This is my first time to attend the biotechnology workshop on cassava. How are you communicating our research efforts? A lot seems to have been done and yet people are not aware of this.

Communicating science is not an easy task and also delivering information to large audiences requires resources. Traditionally, we have been waiting till we finish the research, but since biotechnology is not understood and controversial, we feel now we have to come out and inform the public of what we are doing and why. There have been efforts in this direction since the early 2000s but now we are at the stage of intensifying the efforts. OFAB is one such avenue we shall continue to use to reach out to the public. Other avenues are radio programmes, community visits among others.

5.2 Cassava brown streak virus is an emerging epidemic in this region. Our leaders have tried to educate the masses on phytosanitary measures but we need resistant varieties. How long will it take for these genetic engineering efforts to give us resistant varieties?

The research we are working on is making good progress, though none of the products are ready for the market. We anticipate that the first GM cassava varities will be ready for release to the farmers by the year 2017. However, what makes biotech research efforts unpredictable is the delay by Government to enact the National Biotechnology and Biosafety law that would guide our work.

5.3 People have a feeling that GMO's are the dangerous to our health, can you clearly allay these fears that the virus genes incorporated in the cassava will not harm human beings consuming the cassava?

There is no way how the viruses can harm human beings. In any case, most of the cassava we have eaten from time immemorial contains viruses. So, even if you eat raw cassava, there is no worry. The genes for viruses we are using to 'immunise' the cassava are got from the same viruses that naturally infest cassava. Viruses are very specific. Those that affect cassava cannot affect a human being. In any case, before we release these materials to farmers, we test them rigorously and ensure that they are

sure for human consumption.

5.4 You have come at the right time. Can we also have some field trials conducted here in Arua district so that we can see for ourselves how the experimental crop looks like?

The issue of having the field trials conducted at Abi-ZARDI shall be considered in our research protocol. Though I don't want to promise, in one or two years time, we may have some of the experiments running here at Abi so that you can see for yourselves.

5.5 GM Crops have a risk of weedness and the risk of gene flow and allerginicity

There have been many allegations leveled on GM food but I would like to assure you that over almost 20years of GM consumption in some countries such as South Africa

and United States of America, there is no evidence that has shown that these allegations are true. The risk of GM crops becoming weeds is not there at all because, the same crops you are growing are the ones transformed. So, if you put a gene for resistance to brown streak virus, does that make the cassava to change into something strange or weedy plant? The reason all these allegations are raised is the same reason we conduct rigourous experiments before we release the crops to farmers. Thus, there should be nothing to worry about.

5.6 What is the risk of the new genes getting breaking down overtime?

The risk of the introduced genes breaking down and the plants becoming susceptible is real. There are mechanisms of managing such resistance especially in insect resistant varieties. Such include planting boarder rows or refugia but that does not completely eliminate that possibility. New viruses are also expected to emerge. Since evolution of viruses is a natural process, it can not be stopped. We have to continue researching for new solutions.

5.7 What is the effect on soils when the genes express themselves in plants?

There is no any evidence that links genetic escape from plants into the soil and any effect that this may have on the soil. In fact, it is an assumed impossibility.

5.8 There are challenges of political statements—how prepared are the political leaders as far as GMOs are concerned?

As you have stated, politicians make unsubstantiated statements, which affect how the public perceive biotechnology. We have decided to target them directly through different avenues. We invite them to breakfast meetings, OFAB fora and sometimes we organize visits for them to the research stations to see the technology and hear from the scientists themselves. This has empowered some whereas others are still not informed because we cannot reach all of them.

5.9 Will biotechnology be available to all or to some few chosen ones?

Biotechnology crops will be available for all who see their value. It is like any other crop. You choose what you want and go for it.

5.10 As far as TME 204 cassava variety which is the favorite in the West Nile sub-region, how will they identify it from the non-transgenic ones?

Of course it will be hard to tell which one is transgenic and which one is not because they will not look the same. The difference will be that the non-transgenic ones will not succumb to the disease, and if someone deceives you, you can know it when your crop succumbs. The other option is to have certified seed farmers.

5.11 How can you improve on the landraces that don't have symptoms of CBSD?

Those landraces are not resistant. The fact is that the disease pressure in Arua sub-region is very low but those land races are not resistant as you may assume.

5.12 Do improved varieties decline in productivity at all?

No, they don't decline in productivity at all. If you are improving for disease resistance, then that does not affect yield. But what you have to note is that even GM crops need to be managed very well.

5.13 Uganda Industrial Research institute says that the bitter varieties are better and yet people want to replace the bitter varieties with the sweet ones.

This depends on the usage. UIRI's interest is industrial processing of cassava, thus in that case, they are promoting bitter varieties. But for food security purposes, we need to grow sweet varieties.

5.14 You have said that the Bisoafety bill has not yet come to Parliament. When is the bill coming out? How sure are you that you may generate varieties which may never help us due to absence of this law.

The bill process is a very unpredictable process. In the recent months, a lot of progress has been made in that the bill has been drafted and is now before cabinet. We hope that before the end of this year or at the latest early next year, it will be tabled in Parliament and enacted.

5.15 The rates of adoption is affected by taste and palatability. Are such studies also being conducted?

Yes, we do conduct those studies otherwise; you don't want to waste resources and generate unparatable varieties. We even involve selected farmers and farmers groups in such studies.

6.0 Closing Remarks

The closing remarks were given by two senior district officers viz: Ms. Onyiru Sarah, the Assistant Chief Administrative Officer (CAO) of Arua District and the Vice Chairperson of Arua District Local Government Ms. Ayikoru Sunday. In her remarks, the Assistant CAO thanked SCIFODE, UNCST, sub-county leaders and most importantly the Vice Chairperson of LCV for Arua for attending the workshop.

He further thanked Abi-ZARDI for hosting the workshop and for mobilizing them as leaders of the district to come and hear for themselves from the scientists. He pointed out that crop diseases especially cassava brown disease was a major threat to the food security of the district and he was happy that as leaders, they have received guidance that will help them to manage the disease as scientists strive to get a lasting solution.

She noted that OFAB is a very important forum through which the public fears about biotechnology and GMOs will be allayed. He personally testified that he did not know much and was one of the people that were scared whenever one mentioned GMOs but indicated that now she is better equipped and no one can confuse her.

He thanked the participants for the good quality discussions, and the resource persons for very empowering responses. He promised that in case in future they desire to visit the district again, he would be supportive for such community engagements because without prioritizing agriculture, the Country will not be able to develop.

On her part, the Vice Chairperson of Arua District Local Government Ms. Ayikoru thanked Abi-ZARDI for inviting the district leaders, and for organizing such a well attended workshop. He thanked them for mobilizing the community leaders, opinion leaders and farmers. He acknowledged that they have had excellent working relationship as a district with Abi-ZARDI and this has helped them to contain disease epidemics such as the current threat of Cassava brown streak virus disease. She pointed out that before this workshop, she did not know much about biotechnology and genetic engineering but now she was very well informed, and promised to pass on the knowledge gained to her constituencies. She however called upon Abi-ZARDI and her partners to develop programmes in the local languages to air on radios in order to educate the masses. She pointed out that at least every household in Arua has a radio even if it is a small one and it is through the radio that information can easily trickle to the masses. The radio is helping them to mobilize the masses against the cassava brown streak virus using the strategies given by the scientists at Abi-ZARDI and the

same should be done to explain biotechnology. She however noted that the people would appreciate biotechnology better if the crops were available for them to see them, and realize how better they are. It is bad to lead poor and hungry people and urged them to stick to scientific facts and avoid rumors. Continuous sensitization of communities will lead to change of attitudes.

She thanked the scientists and other organizers of the workshop that worked with Abi-ZARDI, the funders of the workshop and pledged continuous support of the district whenever they are called upon. She wished those who were to travel back to Kampala the next day a safe journey. She declared the workshop officially closed.

Deputy LCV Chairperson, closing the workshop

Annex 1: Main Presentation: *Biotechnology Research Approaches in Uganda with Special Focus on Research to Address Cassava Brown Streak Virus Pandemic in Uganda* by Dr. Titus Alicai

The cassava was originated in Central America and was brought to Africa by the Portuguese and brought it to Africa. Currently, Africa grows more cassava than any other continent in the world. Africa grows 50%, Asia 30% and Latin America was 20%. Though we produce most cassava in the world, our productivity is very low. The biggest problem is viruses we have in on our Continent which is not the case in America.

We all know about cassava, especially this zone – Arua region where cassava is number one food security crop as well as a source of income. Other than that, cassava is known for reducing hunger. Besides, cassava has been designated as a strategic prority crop for East and Central Africa thus it is a:

- Major source of food, improved nutrition and income for Africans,
- 2nd most important food crop in Africa after maize,
- NEPAD priority crop as a "poverty fighter which will spur industrial development in Africa".
- One of the strategic crops identified by CAADP to address Pillar number 3 (increasing food supply, reducing hunger and improving responses to food emergency crises)

In broad terms, it has been shown that the biggest impact on poverty reduction in East and Central Africa will come from concentrating on staple crops and cassava ranks high among these staples.

Cassava was introduced in Uganda in the 1850s and very important staple food crop. It also provides food and income security of most rural farmers. This may also ranks 2nd in area planted and per capita consumption after bananas. It is grown by 75% of all farm households to areas under cassava 500,000 ha and current production 5.4m Mt.

Industrial Applications of cassava

One farmer in Fort portal by names of Amooti has harvested millions of money from cassava. Government is also promising to set up factories for production of start and other industrial products. High quality cassava starch can be used in pharmaceuticals, brewing and bakery industries.

NATIONAL NEWS

Cassava growing to be compulsory

By Mary Karugaba and Rashidah Tebajukira

EVERY household at sub-county level will be required to grow two crops such as cassava and potatoes when the current laws on food production are reviewed.

Agriculture minister Hope Mwesigye told MPs that the ministry has set up a team to review the laws to ensure that every household grows enough food for consumption and storage. Mwesigye said some districts in western Uganda had already passed by-laws making cassava growing mandatory.

"Nwoya's sub-county has passed a bylaw that requires all farmers to grow at least 100 cassava plants every season. We are looking at the possibility of adopting the same by-

community service."

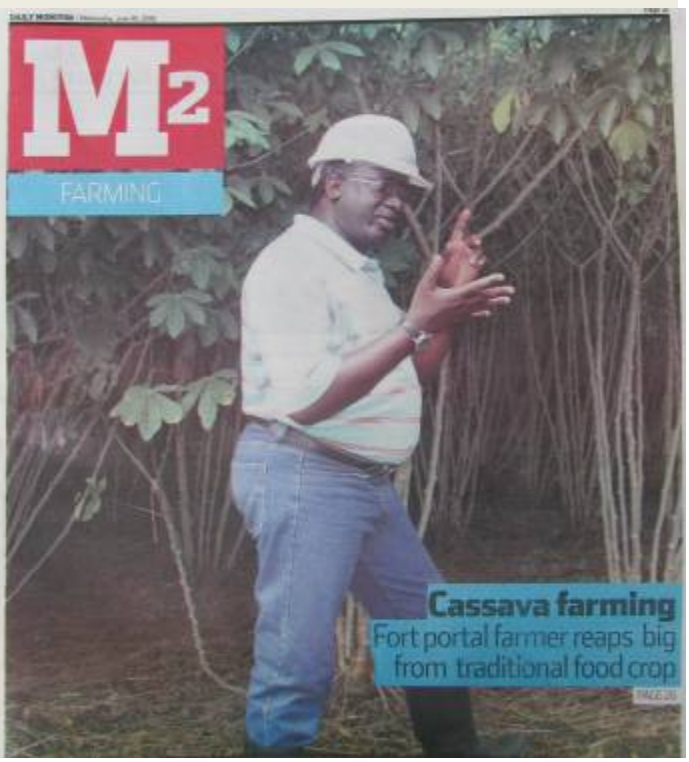
He revealed that research has established that most of the money sent to districts to support farmers to grow more food crops has been diverted.

"We now want this money centrally managed. If the districts had used it for food growing, famine would not be so intense as it is today," Mwesigye said.

Northern districts in the north east north-eastern Uganda are experiencing famine. The worst hit districts include Amuria, Kitgum, Kaberamaido, Bukedea, Kumi, Soroti, Bukwo and Adjumani. Others are Arua, Koboko, Moyo, Yumbe, Maracha, Kotido, Kaabong, Nakapiripirit and Abim.

Mwesigye urged MPs to encourage farmers to grow and store more food.

HAADS executive director Nahdy Stiro, animal husbandry state minister Bright Rwamirama and Erute County MP Charles Angiro Gubomei at Parliament yesterday



Challenges to cassava production

Though growing of cassava is a good enterprise, there are a number of diseases and pests which are a major threat to cassava production in the Country. Some of the problems include Cassava Mosaic Disease (CMD), Cassava Brown Streak Disease (CBSD), CBB, whiteflies, mites etc.

Nutritional quality such as protein, micronutrients (iron, zinc and vitamin A) contents, trace minerals may not be got once the cassava is affected with the viruses.

Post-harvest physiological deterioration – others take long like one year before we get a new size.

Cassava Virus Disease Constraints

The cassava mosaic disease has been the most important disease of cassava in Africa. most important in Africa and the most important disease of cassava in Africa. The disease was first seen in Tanzania in 1894. The disease is transmitted by the whitefly and causes damage to the leaves causing leaf chlorosis (loss of leaf color), mosaic, Africa losses an average 30-40% (15-24 million tones; $6-25 billion/year) due to cassava mosaic disease.

CMD affected plants (left), white flies underneath cassava leaves (right)

Cassava Brown Steak Virus Disease

After struggling with the CMD and generating disease resistant varieties, a new virus emerged recently and that the Cassava Brown Streak virus.

Cassava Brown Streak Disease (CBSD), caused by 2 viruses namely; Cassava Brown Streak Viruses (CBSV) and Ugandan Cassava Brown Streak Viruses (UCBSV). CBSD was first reported in Dar-salaam, Mozambique till recently when reported in Uganda. The epidemic was thus first and for many years restricted to the East African coast (<1000 m asl). It was reported in Uganda in mid 1990s and currently it is a big pandemic that has spread in the entire great lakes region and towards the Congolese cost. It causes Up to 100% crop losses. The affected roots are unfit for consumption. It is also now known to be whitefly transmitted. Whereas in Uganda, it started in in Mukono, the disease now has spread all over the country and has received international 'recognition' as shown below.

Necrotic Rot of Roots Cassava

Cassava Brown Streak Disease(CBSD) and Cassava Mosaic Disease (CMD) incidence 2011

- Cassava Mosaic Disease (CMD) present in all cassava growing districts
- Cassava Brown Streak Disease(CBSD) reported in at least 38 districts

District	CBSD		CMD	
	Incidence	Severity	Incidence	Severity
Adjumani	8	2.4	4	2.9
Moyo	23	2.0	0.8	2.5
Yumbe	11.5	2.1	2.6	0.8
Koboko	0	1.0	11.3	2.9
Arua	18.5	2.0	2.8	9.3
Nebbi	14.5	2.0	12.3	2.7

The above table shows the 38 districts reported on Cassava Brown Streak Disease (CBSD). Specifically, Ugandan Brown Streak Disease (UBSD) and it is how is it a problem. In 2006, 0-10%, last year 11 – 30% and after 2 years i.e. its spreading worst in areas like Luwero, Wakiso and currently CBV is more deadly than any other crop disease in history of the Country.

In this situation, Arua sub-region has been very bold taking handling this problem through the following ways:

- Increase awareness about Ugandan Brown Streak Disease (UBSD)
- Institute management measures
- Monitor introduction, spread and establishment in new areas
- Routine virus diagnostics
- Basic studies to clearly understand virus biology, transmission and spread
- Develop and disseminate Ugandan Brown Streak Disease (UBSD) resistant varieties

- Inspection and selection of planting materials

Summaries of all diseases / challenges to management of the two diseases

- Continuous presence of the virus and the vector throughout the year
- Attachment of farmers to particular cultivars which are susceptible to the disease
- Lack of resistant / tolerant genotypes preferred by farmers

Cassava breeding

One way we do that is through cassava breeding. In the case of plants, we cross the male flower parts with the female flower parts to produce seeds which we pant to get young ones (young plants). The same way you need to raise a cow, you get a cow and a bull and produce the an offspring (calf). Breeding is therefore the art and science of changing plants through crossing pollinating them, to produce the off-springs of the desired characteristics such as disease resistance. It is a very lengthy and tedious process whereby you have to keep producing seeds, replanting them, selecting them, testing them against the disease and repeating the exercise year in and year out until you get what you want. It is also a very unpredictable exercise because you can take all that time and fail to get a new variety.

For example, because cassava takes at least a year to mature, its breeding programme can take a minimum of 8 years before you generate a new variety.

What is Biotechnology?

There are many definitions about Biotechnology. However, some of the good examples are how yeast is used to make bread and wine. Though there are other definitions on Biotechnology as stated;

- Any technique that uses living organisms, or parts of these organisms to make useful products
- Examples – agriculture, medicine, industry
- Traditional Biotechnologies – e.g. Use of yeast to make bread and wine
- Pioneer knowledge on principles of heredity (Gregor Mendel) in the late 19th Century gave farmers new tools for selecting individuals with beneficial characteristics
- Modern biotechnology – based on advances made in molecular biology in the 1970s and 1980s
    - Cell culture
    - Monoclonal antibodies
    - DNA technology
    - Genetic engineering

What is Genetic Engineering?

In Genetic Engineering based on DNA—that element of life that makes living things look the way they look through sets of instructions We are all made of DNA and the set of components of DNA in all living organisms are the same. It is the sets of instruction given to the cell that differ, making us appear different. Genetic engineering is therefore our capacity as scientists now to work in the lab at the level of the DNA where we can move it from one organism to another to produce desired varieties. We can remove a one or a few DNA components from carrot to make vitamin A and introduce it in Cassava to make vitamin A also. In case of the work we are doing in Cassava for virus resistance, we have got a set of DNA components from the virus, deactivated them antroced them in the Cassava itself, so that it is immune from virus attack—the same way humans are immunised by injecting attenuated viruses, to prepare our bodies for virus attack where we then become resistant. The method we are using is known as

gene silencing technique. It is very handy and will help us deliver resistant varieties in a much shorter time compared to conventional plant breeding.

We therefore now operate at cell level and then regenerate the cells into whole plants. By this method, it is possible to introduce a new gene or a few genes that may allow the plant to grow better, defend itself better against pests and diseases, make new compounds in its seeds and other storage organs, become better adapted to stresses.

Through the use of genetic engineering, the following have been achieved:

- Increasing crop and animal productivity; yields
- Improving human and animal health,
- Industrialisation
- Improving quality of the environment; reducing pesticide use (estimated 356 million kg reduction of ai from 1996 to 2008 – Brooks &Barfoot, 2010)
    - No till through herbicide tolerance reduces soil erosion
- Improving food and nutrition security, poverty eradication and national development.
- Biotechnology will drive future economic growth
- Uganda's rich biodiversity is ideal for the development of biotechnology-based enterprises

Virus Resistant Cassava for Africa Project

Using the same technology of genetic engineering, at Namulonge, we are now working on improving cassava to resist brown streak and cassava mosaic viruses.

The goal of the cassava genetic engineering project is to deliver transgenic virus-resistant varieties of farmer-preferred cultivars to Ugandan farmers

- Sofar, we have been able to produce these varieties and we have tested them in 4 confined field trials at Namulonge.
- We have evaluation 12 lines for resistance to cassava mosaic disease for 2 seasons (2 seasons)

- We also conducted durability experiments to see whether the plants will remain resistant when we plant stems over several seasons. This has been done in two lines.
- We have also evaluated 14 lines for resistance to cassava brown streak disease
- During collection of data, we record the following: disease severity, disease
    - disease incidence, yield per hectare, viral load, among others.

Best test line; No rotting of the storage roots

Control line without the gene; severe rotting of roots

Transfer into farmer preferred cultivars

We have demonstrated that biotechnology can work for cassava. Therefore, we are at the stage of developing what to give to farmers – transfer into farmers preferred cultivars. Through genetic elements used in this approach (siRNA/gene silencing) we were able to effectively control the targeted viruses, translating in better growth and higher yields

Summary

- We are using 2 approaches in biotechnology to fix some of the problems in plants
- In Uganda we are advancing very fast, talk about virus resistance breeding using biotechnology and we are a model for the rest of the world.
- Apart from breeding for virus resistance, there are several ways that plant biotechnology can be beneficial to farmers since a wide range of useful traits can be put into plants
- The benefits of GM crops are such that the technology has been taken up very quickly the world over, and Uganda will not be left behind.
- We have to balance the potential benefits with potential risks and assess release on a case by case basis, of course following approved national biosafety laws and regulation.
- Research in GM Crops in Uganda is advancing fast
- GM crops developed by NARO scientists are expected soon; Virus Resistant Cassava, Drought Tolerant Maize, Bacterial resistant banana, pest resistant cotton among many others.
- A relevant law is required for wide scale testing and commercial deployment of the GM crop products

Annex 2: List of Participants

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