Weevil resistant sweetpotato through biotechnology

SASHA
Sweetpotato Action for Security and Health in Africa

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Sweetpotato weevils are responsible for significant losses of up to a third of the annual production in some sub-Saharan African (SSA) countries, threatening their food security. Biotechnology has been applied to introduce synthetic genes that produce proteins with activity against the weevils. A first group of such plants was tested but failed to display insecticidal activity. Quantification of the insecticidal protein in storage roots suggests that its accumulation is too low. More transgenic events are being screened to identify high expresser of the insecticidal protein. Correspondingly, two strategies have been commenced to fully control weevils. First, new synthetic genes are being developed with features reputed to enhance accumulation and functionality of the insecticidal protein. Second, a non-protein-based system is being developed to complement the insecticidal protein strategy in case weevil resistance is not ascertained.

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Damage caused by weevils on sweetpotato roots

What is the problem?

Weevil infestations may reduce plant growth during the first month after planting, and reduce yield after harvest. Larvae and adult feed on leaves, as well as stems and roots underground causing them to turn bitter and thus unfit for human and animal consumption. Weevils can destroy 60% - 100% of sweetpotato crops during periods of pronounced drought. A farmer survey conducted in Uganda revealed that weevils are responsible for 28% of crop losses. As sweetpotato is at times the only food available, this can be quite devastating. The impacts of weevils can affect not only food security, but also sweetpotato production, marketability, and sustainability, especially in areas experiencing longer dry periods.

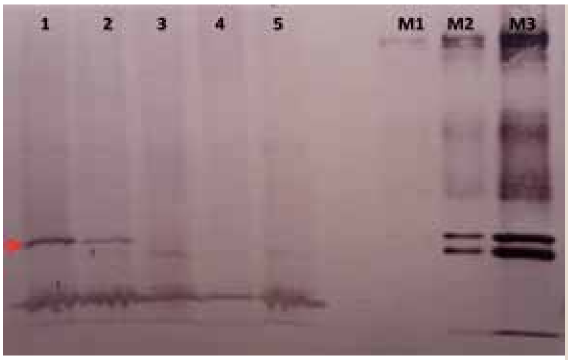
With climate change predictions for Sub-Saharan Africa (SSA) foreseeing an expanding dry season, the threat and impact of weevils may increase further. Adapting conventional integrated pest management practices among smallholder farmers does not seem promising because of the great difficulty associated with controlling field sanitation in small-scale subsistence production systems. In addition, the common practices of in-ground storage, piecemeal harvesting, and strip harvesting mean that sweetpotato crops are exposed to weevils throughout a significant part of the year. Extensive efforts to develop weevil-resistant sweetpotato through conventional breeding methods have failed in spite of considerable investment for decades. As a result, there is currently little farmers can do when weevils infest their fields, other than to quickly try to harvest and salvage what is left of their crop.

What do we want to achieve?

The aim of this project is to develop weevil-resistant sweetpotato varieties through breeding and biotechnology. *Bacillus thuringiensis* (*Bt*) is a soil bacterium that is well-known for its insecticidal activity. Synthetic genes that produce the proteins active against specific insect pests can be developed and introduced into the target plant to confer pest resistance. For example, this so-called *Bt* technology has been used successfully to increase resistance to bollworm in cotton and rootworm or stem borer in maize. The result has been reduced pesticide use and increased yields in

Partners include:

- National Crops Resources Research Institute (NaCRRI) and Kawanda Research Station (KARS) of NARO, [Uganda] for developing and testing resistance to weevils in sweetpotato plants, including a confined field trial
- Biosciences east and central Africa (BecA), Kenyatta University (KU)-[Kenya] for developing and testing resistance to weevils in sweetpotato plants
- University of Puerto Rico Mayagüez, Auburn University-[USA] for testing resistance to weevils in sweetpotato plants including a confined field trial
- Donald Danforth Plant Science Center- [USA] for guidance and oversight in the development of regulatory dossier
- University of Ghent- [Belgium] for capacity building of African scientists and developing communication products



Detection of the *Bt* protein in tuberous roots of two of the five transgenic sweetpotato plants (M1-3: purified protein as control).

those crops. In addition, there is now well-documented evidence that the *Bt* crops have even benefited the non-*Bt* crop growers by reducing pest populations. Farmers, including small-scale producers, have been the primary beneficiaries of growing *Bt* crops. In the case of *Bt* sweetpotato, farmers will be able to harvest only what is needed while the rest of the crop will remain stored in the soil and protected from weevil devastation. In addition, health benefits may be expected because farmers will not consume partially damaged roots containing toxic compounds as they do currently under severe food shortage.

Where are we working?

Research on the identification of insecticidal proteins from *Bt* (Cry proteins) has taken place in the US University of Auburn and at NaCRRI in Uganda. The development of synthetic genes and genetic transformation of sweetpotato took place mainly at the CIP biotech lab ABL in Peru and later at the University of Makerere, KARS and NaCRRI in Uganda, and BecA and Kenyatta University in Kenya. Activity of Cry proteins against the weevils is tested at NaCRRI in Uganda and at the University of Puerto Rico Mayaguez in the US. The characterization of the interaction between the active Cry proteins and the weevils is being investigated at the University of Valencia in Spain. Finally, biosafety research and capacity building are led by the Donald Danforth Plant Science Center in US and the University of Gent in Belgium. The project is targeting primarily sweetpotato production in Uganda and possibly Kenya where weevils are devastating pests and where enabling regulatory frameworks are in place.

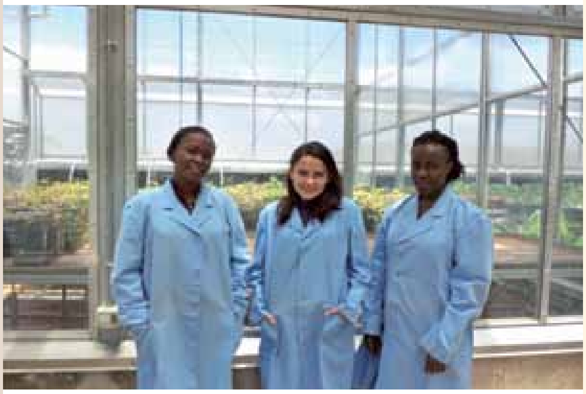
How are we going to make it happen?

In 2004, with Rockefeller Foundation funding, CIP facilitated the foundation of the development of weevil-resistant varieties for SSA countries based on the *Bt* technology. Capacity strengthening focused from the very beginning on developing facilities for undertaking biotechnology on sweetpotato at the National Agricultural Research Organization of Uganda with three African students pursuing their doctoral degrees at Makerere University. With Auburn University in the USA, in 2007, we identified three distinct Cry proteins exhibiting weevil toxicity at levels similar to proteins expressed in commercial *Bt* crops. Soon after, weevil-resistant genes were developed using genetic information from the sweetpotato crop itself in order to make 3 sweetpotato-like weevil resistance (WR) genes. This step was co-funded by Rockefeller foundation and USAID. These are now being introduced into susceptible varieties and tested against weevils under the sponsorship of the Bill & Melinda Gates Foundation and USAID.

What have we learned so far?

We have identified insecticidal proteins against the two African weevil pests. Genes have been developed to confer resistance to these pests and introduced into sweetpotato varieties. The first two initially selected African sweetpotato varieties had very low transformation efficiency, but four were subsequently found to give better results, and have now generated transgenic events ready to be tested. Hence, transformation of sweetpotato is genotype-dependent and has to be the first criteria before selecting the recipient variety.

The testing of resistance to weevils has been slow due to inappropriate growth conditions under the biosafety greenhouse in ABL in Peru. The development of the transgenic events in Uganda and Kenya will speed up this testing activity which is essential to move forward towards the identification of weevil-resistant events.



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