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Technical Innovation Brief
No. 10, February 2011

Enhanced protection for tissue cultured banana plants

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Banana

About one-third of the global banana production comes from sub-Saharan Africa, especially the Great Lakes region of East Africa, where millions of subsistence farmers and consumers depend on the crop as a staple food. Dessert banana production is a multi-million dollar industry in Latin America, which produces over 70% of global banana exports.

The world over, banana is traditionally propagated by means of field-obtained suckers or side-shoots, which are often contaminated with soil-borne diseases and pests, such as nematodes (*Radopholus similis, Pratylenchus goodeyi, P. coffeae, Helicotylenchus multicinctus. Meloidogyne* spp.) and banana weevils (*Cosmopolites sordidus*). With the exception of fastidious bacteria and viruses, normally eliminated at the stock nurseries, tissue cultured (TC) plants provide a source of pest- and disease-free planting material. TC plants also have the benefits of uniformity, enabling better planning for markets and more rapid recovery from broad-scale damage, such as that from hurricanes. In Africa, a number of commercial enterprises are now beginning to supply farmers with TC plants, while in Latin America, TC plants are used almost exclusively to renovate aged commercial farms and establish new ones.

Banana corm damaged by tunnelling larvae of the banana weevil (left); toppled banana plants due to nematode infestation (right). – D. Coyne

However, following their transfer to the field, TC plantlets tend to be less robust than suckers and require greater care and attention. As a consequence of their aseptic and sterile production, TC plants are devoid of the beneficial microorganisms present in suckers and have an untested defense mechanism. They are nevertheless regularly planted into fields with high pest and disease burdens and abiotic constraints.

Healthy banana seedlings from commercial tissue culture. – A. zum Felde

Endophytes

Endophyte is a ubiquitous term for microorganisms that naturally occur *in planta* with neutral, positive, or negative impact to the host (Backman & Sikora 2008). Some endophytes have proved beneficial by enhancing plant growth and by providing host protection from pests and diseases (Sikora et al. 2008). The many strains of *Fusarium oxysporum* are the most common endophytes in banana roots. Reintroducing beneficial endophytes during the TC production process, to enhance the plant's natural defense system has proved viable and beneficial (Dubois et al. 2006a; zum Felde et al. 2009).

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Although the endophyte-host-pest association is complex, studies have revealed that certain endophyte strains will activate enzymatic host-plant defense mechanisms following inoculation (Sikora et al. 2007, Paparu et al. 2010). Some enzymes become upregulated only when plants have been further challenged by nematodes, a phenomenon called priming, which is particularly desirable as this enables enhanced plants to conserve energy in the absence of pests.

Depending on field conditions and the endophyte strain inoculated, enhanced TC banana plants have outperformed nematicide-treated TC plants, exhibiting less root damage and with 20-50% lower populations of *R. similis* (zum Felde et al. 2009). Currently, the economic effects of endophyte-enhanced TC banana plants in smallholder farms are being investigated in Uganda, and preliminary results indicate that yields and revenues are greater than those from non-enhanced TC plants.

Fusarium oxysporum-enhanced (left) and conventional (right) tissue culture banana seedlings of same age. – T. Dubois

Banana tissue culture plantlets are drenched in endophyte spore suspension to enhance their defense mechanisms. – A. zum Felde

In banana, TC plants are enhanced with endophytes by drenching the roots of plantlets with a spore suspension; this technique circumvents many of the problems traditionally associated with biological control agents (BCAs) at the farmers' level and can be readily integrated into commercial TC production (Sikora et al. 2008). Research has also been initiated using known BCAs, such as the entomopathogenic fungi *Beauveria bassiana* and *Trichoderma* spp., to act as "artificial endophytes". These fungi have shown high levels of internal colonization of banana tissues with good potential for managing the banana weevil (Akello et al. 2008).

Going commercial

Releasing endophyte-enhanced TC plants to farmers has created an efficient and novel plant protection option and constitutes a much sought-after alternative to pesticide use in commercial production. At present, *F. oxysporum* strain V5w2 is being commercially registered in Kenya, under the leadership of Jomo Kenyatta University of Agriculture and Technology (Dubois et al. 2006b). Following registration, the Real IPM Company will be licensed to mass-produce the product for use in banana seed systems. However, as only low doses per plant are needed, concerns have been voiced over profit margins. In Uganda, endophyte technology has therefore been embedded directly in commercial TC companies, such as Agro-Genetic Technologies.

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This Technical Innovation Brief is published by:
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