CGIAR SP-IPM
...innovative solutions for crop protection

Technical Innovation Brief
No. 9, January 2011

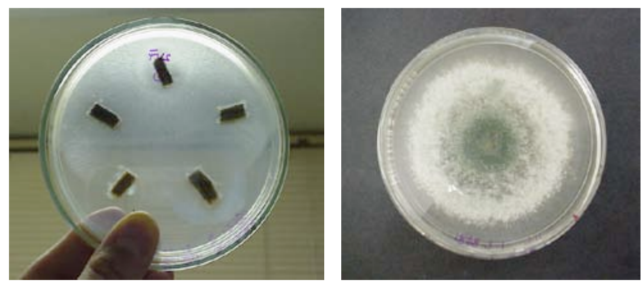
Endophytes: novel weapons in the IPM arsenal

Alexandra zum Felde

What are endophytes?

Endophytes are microorganisms that live in plant tissue for part or all of their lifecycle (Sikora et al. 2007), and can be classified as beneficial, neutral, or detrimental, depending on the nature of their interaction with their host plant. Though not initially identified or recognized as such, many well-known and studied organisms are in fact endophytes: arbuscular mycorrhizal fungi and rhizobia, for example, are beneficial endophytes, whereas the *Fusarium* spp. causing wilt are examples of detrimental endophytes.

Microbial and fungal endophytes have been isolated from a broad range of plants, including grasses, herbs, and trees, and from various plant tissues (Backman & Sikora, 2008). Mutualistc endophytes have been defined as beneficial microorganisms that protect plants from pests and diseases and can enhance plant growth. They are especially interesting for IPM as innovative biological control agents (BCAs).



Endophytes to enhance plant defense and growth: *Fusarium* spp. (left) and *Trichoderma* spp. (right). – A. zum Felde

How do mutualistic endophytes work?

A lot of research has recently focused on exposing the modes of action of mutualistic endophytes. What has become clear from these studies is that some endophytes activate their host plant's existing defense mechanisms, sometimes before pests/pathogens are introduced into the system and sometimes afterwards (Vu et al. 2006; Paparu et al. 2008). Other endophytes seem to directly antagonize pests/pathogens, either by producing metabolites detrimental to the pest/pathogen in question (Hallmann & Sikora 2006), or by competing with it for nutrients (Olivain et al. 2006).

Further research into the subject may identify additional modes of action though it is already known that greater plant protection can be achieved when plants are inoculated with multiple endophytes (zum Felde et al. 2009; Sikora et al. 2010). However, when studied, the effects of inoculating multiple endophytes versus single endophytes were neither synergistic nor additive. This may be due to the inoculated endophytes having similar modes of action. If endophytes with different modes of action were inoculated, control levels would feasibly be additive. For this reason, the search for the perfect combination of endophytes to mimic the natural conditions found in suppressive plants should be a research priority.

Banana seedlings in rooting tray dipped in endophyte spore suspension. – A. zum Felde

Why use endophytes?

A major advantage of endophytes is that their use circumvents many of the problems traditionally associated with inundative inoculations of conventional BCAs on fields. For example, endophytes can be applied solely to seeds (i.e., in seed coating/dressing) or to seedlings (especially tissue culture plants or seedlings in rooting trays). Thereby the need to treat huge quantities of surface soil or large numbers of already established plants in the field is avoided. This requires large amounts of BCA propagules, and exposes the BCA to other

CGIAR Systemwide Program on Integrated Pest Management (SP-IPM) is a global partnership that draws together the diverse IPM research, knowledge and expertise of the international agricultural research centers and their partners to build synergies in research outcomes and impacts, and to respond more effectively to the needs of farmers in developing countries.

SP-IPM Technical Innovation Briefs present, in short, IPM research findings and innovations for the management of pests, diseases and weeds in agricultural production.

This and other IPM Briefs are available from www.spipm.cgiar.org

microorganisms and abiotic stresses (sunlight, heat, dryness, etc.), which decrease their survival chances; also farmers do not need to apply the BCA as this is done by the seed or tissue culture producer. When endophytes are the BCA of choice, and are inoculated into/onto seeds or seedlings, their survival chances are greatly enhanced, as they are protected by the plant tissues from competition and inhospitable abiotic conditions. Mutualistic endophytes isolated from root tissues are of special interest in controlling plant parasitic nematodes and soil-borne diseases, as these endophytes inhabit the same niche as these pests and pathogens (Sikora et al., 2008).

Recent advances

Researching the effectiveness of novel BCA is a valuable goal in and of itself; an additional aim of much research is the development of a commercial product, based on the organism studied. Progress towards this goal has recently been made in East Africa. An endophyte, originally isolated from banana tissue, *F. oxysporum* strain V5W2, is being registered as a commercial biological control agent in Kenya, under the leadership of Jomo Kenyatta University of Agriculture and Technology and in cooperation with the International Institute of Tropical Agriculture. Following registration, the Real IPM Company will be licensed to mass-produce the product for use in banana seed systems to control nematodes and weevils. In Uganda, endophyte technology has been embedded directly into commercial tissue culture companies, such as Agro-Genetic Technologies. In Central America, Bioversity International (formerly INIBAP), in cooperation with Fresh Del Monte Produce Inc., has carried out successful field trials testing the effectiveness of locally isolated banana endophytes to control nematodes in commercial plantations.

Engaging in such public-private partnerships facilitates the transition of research results into commercially available products, for use to the benefit of many.

Endophyte treated (right) and untreated (left) banana seedlings of same age. – A. zum Felde

Further reading

Backman, P.A. and Sikora, R.A. (2008). Endophytes: An emerging tool for biological control. Biological Control 46: 1-3.

Hallmann, J. and Sikora, R.A. (1996). Toxicity of fungal endophyte secondary metabolites to plant parasitic nematodes and soil-borne plant pathogenic fungi. European Journal of Plant Pathology 102: 155-162.

Olivain, C., Humbert, C., Nahalkova, J., Fatehi, J., L'Haridon, F., and Alabouvette, C. (2006). Colonization of tomato root by pathogenic and nonpathogenic *Fusarium oxysporum* strains inoculated together and separately into the soil. Applied and Environmental Microbiology 72(2): 1523-1531.

Paparu, P., Dubois, T., Coyne, D., and Viljoen, A. (2008). Defense-related gene expression in susceptible and tolerant bananas (*Musa* spp.) following inoculation with non-pathogenic *Fusarium oxysporum* endophytes and challenge with *Radopholus similis*. Physiological and Molecular Plant Pathology 72: 149-157.

Sikora, R.A, Schäfer, K., and Dababat, A.A. (2007). Modes of action associated with microbially induced *in planta* suppression of plant parasitic nematodes. Australasian Plant Pathology 36: 124-134.

Sikora, R.A., Pocasangre, L., zum Felde, A., Niere, B., Vu, T.T., and Dababat, A.A. (2008). Mutualistic endophytic fungi and *in planta* suppressiveness to plant parasitic nematodes. Biological Control 46: 15-23.

Sikora, R.A., zum Felde, A., Mendoza, A., Menjivar, R., and Pocasangre, L., (2010). *In planta* suppressiveness to nematodes and long-term root health stability through biological enhancement - do we need a cocktail? Acta Horticulturae (ISHS) 879: 553-560.

Vu,T., Hauschild, R., and Sikora, R.A. (2006). *Fusarium oxysporum* endophytes induced systemic resistance against *Radopholus similis* on banana. Nematology 8(6): 847-852.

zum Felde, A., Mendoza, A., Cabrera, J.A., Kurtz, A., Schouten, A., Pocasangre, L., and Sikora, R.A. (2009). The burrowing nematode of bananas: strategies for controlling the uncontrollable. Acta Horticulturae 828: 101-108.

About the author

Alexandra zum Felde studied agriculture and ecology, specializing in plant pathology and nematology in Europe, North and Central America. She received her doctoral degree in 2008, and is presently working at IITA-Ibadan as PostDoc in Banana and Plantain Agronomy for West Africa.

email: A.zumFelde@cgiar.org

This Technical Innovation Brief is published by:
SP-IPM Secretariat
SP-IPM@cgiar.org
www.spipm.cgiar.org