Host-endophyte-pest interactions of endophytic *Fusarium oxysporum* antagonistic to *Radopholus similis* in banana (*Musa spp.*)

By

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Submitted in partial fulfilment of the requirements for the degree of
PhD (Plant Pathology)
In the Faculty of Natural and Agricultural Sciences.
University of Pretoria
Pretoria, South Africa

June 2006

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Dedication

To my family
Declaration

I declare that the thesis which I hereby submit at the University of Pretoria for the award of the degree PhD (Plant Pathology) is my work and has not been submitted by me for a degree to any other university or institution of higher education.

.................................................................

Shahasi Yusuf Athman
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Acknowledgements

First of all I would like to thank Almighty Allah for giving me the beautiful gift of life and for being the strongest pillar and source of inner strength and resilience through out my entire life.

The research presented in this thesis was conducted with a scholarship from the International Institute of Tropical Agriculture (IITA) through a grant by the German Ministry for International Cooperation (BMZ). My sincere gratitude to these two institutions for providing the financial support to conduct this research.

I am indebted to my supervisors at IITA namely Drs. Cliff Gold, Thomas Dubois, Bjorne Niere and Danny Coyne for giving me a chance to pursue my PhD studies under their leadership. At the University of Pretoria (UP), Prof. Nico Labuschagne and Dr. Altus Viljoen, for accepting to supervise me and for supporting me through out the study. Thank you all for your outstanding and critical editing skills that helped me articulate the complex issues in this thesis.

At UP, Dr. Thierry Regnier and Mr. Rony Gilfillan, thanks for your help with the phenolics and HPLC analysis respectively. Barbara and Susan, for sharing your knowledge on RFLP and AFLP analyses.

Dr. John Kimenju, (University of Nairobi) for all the support and guidance that you have given me since my undergraduate studies in Kabete and especially for introducing me to the world of the ‘unseen worms’. Thanks for believing in me.
Friends and colleagues at IITA-Uganda (Fred, Jully, Baker, Patrick, Pam, Jolly, Frank, Sinnia, William, Agnes, Hussein, Kagezi, Perez and many others) for your inestimable support and encouragement. I really enjoyed working with you all. Phillip Ragama, for providing help with statistical analysis.

At the Faculty of Veterinary Medicine of Makerere University: William, Maria and Monica for your technical assistance during the histological analysis of phenolic compounds, it was fun working with you guys.

My friends in Pretoria, Doris, Elizabeth, Jessica, Evonne, John and Yusuf for your friendship and prayers.

The Mathenge family in Kampala for the many ways in which you supported me, the weekend getaways to your home gave me a new lease on life every single week.

Lastly and most specially, my deepest appreciation goes to my dear family, mom and dad, for giving the gift of education, instilling confidence and for believing in me. My sisters, Amina, Hidaya, Asha and Kinya and brothers Kaka, Abdi, Sultan and Farid for your motivation and prayers. Especially my small sister Kinya, nieces and nephews for whom unlimited opportunities lie ahead. Your unending support gave me the strength to live my life to the fullest and persevere through the lonely and difficulty times. May Allah bless you all abundantly ‘barakALLAHufika’.
General introduction

Bananas (*Musa* spp.) are among the most important tropical fruits in Sub-saharan Africa, providing the bulk of dietary carbohydrates and daily calorie intake for millions of people. Highland cooking banana (*Musa* spp. group AAA-EA) is the most important staple food crop in the Lake Victoria basin (INIBAP, 1986). Uganda is one of the largest banana producing and consuming countries in the world, and a secondary center of diversity of the highland bananas of the *Musa* AAA group. The primary center of diversity for AAA banana group members is the Malaysian region from where the plants were introduced to the East African Highlands (Simmonds, 1987). The dominant cultivars in Uganda belong to the East African highland cooking bananas, which comprise over 76% of banana production in the country (Karamura, 1993). Banana production is primarily undertaken by semi-subsistent, small-scale households, and most bananas are locally consumed as a starch staple after cooking.

In recent years, there have been marked changes in the location and intensity of banana production in Uganda. Highland banana production in the country has declined sharply. Karamura (1993) reported a production decline of more than 25% from more than 8 tons/ha in the 1970s to less than 6 tons/ha in the 1990s. The major constraints to banana production in the region are mainly pests and diseases (Gold *et al*., 1993). This has led to the replacement of highland cooking bananas in some traditional growing areas in Central Uganda with more pest and disease tolerant brewing and dessert bananas (Gold, *et al*., 1999). A complex of plant-parasitic nematodes affect banana production: the burrowing nematode *Radopholus similis* (Cobb) Thorne, the spiral nematode *Helicotylenchus multicinctus* (Cobb) Golden, the lesion nematodes *Pratylenchus goodeyi* (Sher and Allen) and *Pratylenchus coffeae* (Goodeyi), and the root-knot nematodes *Meloidogyne* spp. (Goeldi). These nematodes, together with the banana weevil *Cosmopolites sordidus* (Germar) (Coleoptera: Curculionidae), are the primary banana pest constraints in East Africa (Gold *et al*., 1993; Karamura, 1993; Speijer *et al*., 1999a).

Control measures against *R. similis* include the use of (uninfested) planting material such as pared and hot water treated suckers and tissue culture plants (Stanton, 1999; Speijer *et al*., 1999b). Clean planting material may provide adequate control in the first crop cycle, but the problem of re-infestation of plants in the field is a major disavantage (Speijer *et al*., 1995; Speijer *et al*., 2001). Host plant resistance would offer a safe and long-term intervention
strategy against *R. similis*. Resistance to *R. similis* is, however, yet to be identified in East African highland cooking banana cultivars. Thus, research is currently focusing on several alternative ways, including the use of microbial antagonists such as endophytes, for controlling banana pests and diseases (Sikora and Schuster, 1999; Pocasangre, 2000; Niere, 2001).

Endophytes are microorganisms that spend some time in their life cycle living symptomlessly within plant tissues (Petrini, 1991). Although tissue culture plants may provide healthy, nematode-free planting material, the effects may offer only a temporary solution to nematode problems in banana, necessitating the need for affordable, sustainable and environmentally friendly management strategies that complement the benefits of clean planting material. Due to the sterile conditions under which tissue culture plants are produced, the plants lose naturally beneficial microorganisms such as endophytes (Pereira *et al.*, 1999). The artificial introduction of endophytic fungi in these sterile plants at the hardening phase may offer protection against pests and diseases to the young plants in the early growth stages and extend the life of planting material (Sikora and Schuster, 1999). This strategy would form part of an integrated pest management approach consisting of biological control and clean planting material.

Research on the use of endophytes for the biological control of the main banana pests in Uganda was initiated at the International Institute of Tropical Agriculture (IITA) in the late 90s. This led to the isolation of hundreds of endophytic fungal isolates from apparently healthy banana plants growing in nematode and banana weevil infested plantations (Griesbach, 2000; Niere, 2001). These isolates are being preserved at the IITA laboratory in Namulonge, Uganda. Although various fungal endophytes were isolated, *Fusarium* spp. and especially *Fusarium oxysporum* Schlecht.: Fries were the dominant endophytic taxa. Research aimed at identifying fungal isolates with nematode-controlling activities has since focused on *F. oxysporum* isolates against the most economically important nematode species *R. similis*. Preliminary results have shown that some fungal isolates tested against *R. similis* possessed *in vitro* nematicidal activity and also led to a reduction in nematode populations in tissue culture plants under screen house conditions (Niere, 2001).
Problem statement

Preliminary results involving *R. similis* control with endophytic *F. oxysporum* isolates have been very promising (Niere, 2001). The isolates tested have shown the potential to kill *R. similis in vitro* and also reduce *R. similis* populations in endophyte-treated tissue culture plants. Despite these exciting results, information on the interactions between the host plant, the endophyte and the nematode, and the mechanisms involved in nematode suppression, remains limited. Little is known on the effects of the endophyte on host preferences, invasion and root penetration, and population build-up of *R. similis* in banana plants. The role of induced resistance by endophytes against *R. similis* has also been postulated but not confirmed. Knowledge of these interactions is essential in elucidating the mechanisms involved in nematode suppression. Understanding how endophytes control *R. similis* in banana plants would further be useful in designing appropriate nematode control strategies and also in maximizing benefits of endophyte inoculation in plants.

Research objectives

The main objective of this research was to identify endophytic *Fusarium* spp. isolates for use as biological control agents against the major banana nematode *R. similis* and to study the interactions and mechanisms of control involved.

Specific objectives:

- To screen endophytic *Fusarium* spp. for *R. similis* suppression both *in vitro* and *in vivo* in tissue culture banana plants.
- To determine the effect of endophytic *F. oxysporum* isolates on the *R. similis*-banana plant association.
- To determine mechanisms involved in *R. similis* control by endophytic *F. oxysporum* isolates.
References


