

**Diseases associated with plantation forestry in  
Uganda**

**By**

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B. Sc. Hons (Makerere University)

A Thesis submitted in fulfilment of the requirements for the  
degree

**Magister Scientiae**

In the Faculty of Natural and Agricultural Sciences, Department  
of Microbiology and Plant Pathology, University of Pretoria,  
Pretoria, South Africa.

December 2002

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*I dedicate this thesis to my dear friends and parents*

## ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to the following people and institutions:

To the Norwegian Agency for International Development (NORAD), Strengthening of the Ugandan Forestry Department and the Faculty of Forestry and Nature Conservation, Makerere University for financial assistance provided.

My gratitude to Dr. J. R. S. Kaboggoza, your encouragement, the strength you gave me to persevere, your support and guidance, without which the completion of this study would not have been possible.

To Dr. Jolanda Roux for introducing me to the field of forest pathology, your guidance throughout this study, the knowledge you provided, being there during the times I needed your help and for the long hours you spent editing my scripts.

Prof. M. J. Wingfield who gave me an opportunity to join FABI, all the support and guidance you provided is highly appreciated.

Prof. T. A. Coutinho, for the guidance and training you offered me especially when you offered me work in the diagnostic clinic.

Uncle Kibira and Rev Fr Kennedy Lubega for all the support and encouragement, which have made me what I am today.

To my parents for being understanding during the time I haven't been there for you.

Mr. Hudson Andrua and Mr. Denis Mujuni who assisted me during fieldwork.

To the University of Pretoria and the Forestry and Agricultural Biotechnology Institute for the facilities and equipment to undertake this study.

To the fabulous FABI family and colleagues for sharing knowledge, and to my dear friends who have always given me courage especially during difficult times.

To Mr Bernard Slippers for translating the general summary to Afrikaans and help you provided with the *Botryosphaeria* chapter.



## PREFACE

The growing demand for wood and wood products has increased worldwide dependency on plantation forestry. This has also resulted from the over exploitation of natural forests, especially in tropical countries. In Uganda, plantation forestry is of great importance. However, its success depends on appropriate management practices. During recent disease surveys, a number of serious plantation diseases have been reported in the southern part of the country. These diseases are known in other countries, where they have been shown to seriously reduce the productivity of exotic plantation forests. Of these diseases, *Botryosphaeria* canker, bacterial wilt and blight, as well as *Ceratocystis* wilt of *Eucalyptus grandis* and *Acacia mearnsii* have been identified as the most common diseases in Uganda. These diseases are responsible for the death of trees and they greatly reduce the growth, yield and quality of timber and poles.

In Chapter one of this thesis I present a general review of the development and status of plantation forestry in Uganda. This review gives a broad history of exotic plantation trees in the country, development of the forestry industry, importance and impact of the industry, its current status and it provides a perspective of the future of forestry in the country. Past and present plantation forestry problems are also considered. Special reference is made to the diseases that have been reported in *Eucalyptus*, *Pinus* and *A. mearnsii* plantations. The review emphasises the lack of general knowledge on the importance of diseases in plantation forestry. It, furthermore, attempts to highlight the impact these diseases may have on the developing industry and the measures that will need to be taken to avoid losses.

*Botryosphaeria* canker caused by *Botryosphaeria* spp. is the most widely spread disease of *Eucalyptus* spp. in Uganda. These pathogens are known to be endophytic and opportunistic on woody hosts, causing disease on stressed trees. Several *Botryosphaeria* spp. have been reported from *Eucalyptus* spp. worldwide, but the species causing disease in Uganda are not known. The results of a survey of *Botryosphaeria* stem canker in Southern Uganda are discussed, specifically focusing on the identification of the *Botryosphaeria* spp. in Uganda. Use is made of both morphological and molecular techniques, as morphology is known to provide variable results for this group of fungi.

Effective disease management relies fundamentally on understanding the population biology and phylogeny of a pathogen. Rapid adaptation to disease management practices by a pathogen depends on the diversity of the pathogen and also its ability to recombine. Knowledge of the population diversity, structure and reproductive mode of pathogens, thus provides clues to their origin and makes it possible to trace their movement, globally. Pathogen populations with low diversities are considered to be recently introduced and vice versa. Polymorphic Simple Sequence Repeats (SSR) are currently widely used to answer these questions, due to their high levels of polymorphism, and abundance throughout the genome. In chapter three, SSR DNA markers are used to determine the population diversity and structure of *Ceratocystis albobundus*, an important pathogen of *A. mearnsii*. Until recently, *C. albobundus* was known only from South Africa. With its discovery in Uganda in 2000, it was possible to determine the population structure and diversity of a Ugandan population. Results are further compared to those for a South African population in order to better understand the biology and origin of *C. albobundus*.

Bacterial blight of *Eucalyptus* spp. is a relatively newly recognised disease, caused by *Pantoea ananatis*. The disease was first discovered in South Africa on young *E. grandis* and *E. nitens* hybrids. During a survey conducted in Uganda, a disease causing similar symptoms was reported from *E. grandis*. Chapter four of this thesis deals with the characterization of the causal agent of bacterial blight in Uganda. Use was made of biochemical and sequence data comparisons of the 16S rRNA gene, to prove whether the pathogen is similar or different from that reported in South Africa.

Studies making up this thesis were aimed at expanding knowledge obtained from recent disease surveys in Uganda. It represents the first detailed study of plantation forestry diseases in this country. It also adds knowledge pertaining to the pathogens, to international forestry and the scientific community. Through this series of studies, a possible new species of *Botryosphaeria* has been discovered, several first reports of pathogens are made from Uganda and the geographic distribution of important pathogens is expanded. It has also provided information to the Ugandan Forestry Department on future strategies, which can be used to reduce the impact of plantation diseases in Uganda.



## SUMMARY

Plantation forestry is important to Uganda as it represents a future resource of timber for fuel and structural purposes. Diseases, however, pose a serious threat to the productivity and sustainability of this emerging industry. A number of serious diseases have already been reported from surveys recently conducted in Uganda. The aim of the present study was to expand on the current knowledge of some of the diseases and to gain additional information regarding their causal agents.

The first chapter of this thesis reviewed the literature pertaining to diseases of plantation trees in Uganda. The observation is made that diseases were recognised as problematic, as early as the 1950's and trials were conducted at that time to select disease resistant planting stock. Due to political unrest, these initiatives ceased and a reliance on natural forests for the supply of wood and wood products persisted. Over exploitation of natural forests has now resulted in awareness that this resource is threatened and plantation forestry is widely recognised as the only alternative for the supply of wood and wood products. The Uganda Forestry Department is now actively promoting the establishment of plantations to reduce destruction of natural forests. This initiative has included surveys to identify the diseases affecting forest plantations in Uganda. These surveys have shown that diseases pose a serious threat to the establishment of plantation forests in the country.

Botryosphaeria canker is the most common disease of plantation *Eucalyptus* in Uganda. In chapter two of this thesis, I have shown that *B. parva*, *L. theobromae* and an undescribed species are associated with Botryosphaeria canker of *Eucalyptus* spp. in Uganda. Pathogenicity trials revealed statistically significant differences in virulence between different species, with *L. theobromae* being the least pathogenic and the undescribed species the most pathogenic. Further investigations are now needed to evaluate the pathogenicity of these fungi in the field and to consider their biology and relative importance.

*Ceratocystis albofundus* is an important pathogen of *Acacia mearnsii* and *A. decurrens* in South Africa. In 1999, *C. albofundus* was reported for the first time in south western Uganda. The results obtained in the current study indicate that the Ugandan population has high gene diversity similar to that of a South African

population. The results further show that the fungus reproduces clonally in both countries, with very little gene flow occurring between them. The high gene diversity values obtained in this study indicate that *C. albofundus* is native to Africa and not only South Africa, as previously hypothesized. The high gene diversity of *C. albofundus* revealed within the two populations gives a clear indication that management of Ceratocystis wilt should focus on breeding for resistance. Selection of resistant varieties is in progress in South Africa and in future, it will be useful in management of the disease.

Most *Eucalyptus* diseases are caused by fungi, but bacterial pathogens are increasing in importance. In the fourth chapter of this thesis, a bacterium known as *Pantoea ananatis* was identified as the causal agent of blight and dieback on *Eucalyptus* spp. in Uganda. This is the first report of the disease outside South Africa. The disease primarily damages young trees and it is thus of great concern in terms of plantation establishment. It will now be necessary to establish trials to select bacterial blight-tolerant planting stock. The bacterium has also been reported to infect agricultural crops which is especially important in the Ugandan situation, where trees are grown in close proximity to agricultural crops.

The results obtained in this thesis will help to manage diseases affecting plantation forest species in Uganda. The study will hopefully also provide farmers and foresters with an elevated understanding of the importance of diseases in plantation forestry. This should impact strongly on the capacity of Ugandans to deal with diseases, not only those caused by the pathogens identified in the study, but also other diseases, particularly of forest and fruit crops.



## OPSOMMING

Plantasiebosbou is belangrik in Uganda, omdat dit 'n toekomstige bron van hout vir energie en strukturele behoeftes bied. Siektes is egter 'n ernstige bedreiging vir die produktiwiteit en volhoubaarheid van hierdie opkomende industrie. 'n Aantal ernstige siektes is alreeds aangemeld tydens vorige opnames wat in Uganda gedoen is. Die doelwit van die huidige studie is om die kennis oor sommige van hierdie siektes te verbreed en om verdere inligting oor siekteveroorsoekende agente te verkry.

Die eerste hoofstuk van hierdie verhandeling gee 'n oorsig van die literatuur i.v.m. die siektes van plantasiespesies in Uganda. Dit word uitgewys dat siektes as problematies beskou is van so vroeg as die 1950's en dat proewe gedoen is om siekteweerstandbiedende plantmateriaal te selekteer. As gevolg van politieke oproer is hierdie inisiatiewe gestaak en het die land afhanklik gebly van natuurlike woude vir die verskaffing van hout en houtprodukte. Huidiglik is daar 'n bewuswording dat oorbenutting die voortbestaan van natuurlike woude bedrieg, en dat plantasiebosbou die enigste alternatief bied vir die verskaffing van hout en houtprodukte. Die Uganda Bosbou Departement promoveer nou aktief die vestiging van plantasies om die vernietiging van natuurlike woude te verminder. Hierdie inisiatiewe sluit in pogings om die siektes wat bosbouplantasies in Uganda beïnvloed, te identifiseer. Vroër het ondersoekers getoon dat siektes 'n ernstige bedreiging inhou vir die vestiging van plantasiebosbou in die land.

*Botryosphaeria* kanker is die mees algemene siekte van *Eucalyptus* spp. in Uganda. In hoofstuk twee van die verhandeling, wys ek dat *B. parva*, *L. theobromae* en 'n onbekende *Botryosphaeria* sp. geassosieer word met *Botryosphaeria* kanker van *Eucalyptus* in Uganda. Patogenisiteitstoetse het gewys dat daar statisties betekenisvolle verskille in die virulensie van die genoemde spesies is. *Lasiodiplodia theobromae* was die mins virulente spesie, terwyl die onbekende spesie die mees virulent was. Verdere ondersoek is nodig om die virulensie van hierdie swamme in die veld te toets en om hulle biologie en relatiewe belang te bepaal.

*Ceratocystis albofundus* is 'n belangrike patogeen van *Acacia mearnsii* en *A. decurrens* in Suid-Afrika. In 1999, is *C. albofundus* die eerste keer geïdentifiseer in die suid weste van Uganda. Die resultate in die huidige studie wys daarop dat die



Ugandese populasie hoë geendiversiteit het, wat vergelykbaar is met die Suid-Afrikaanse populasie van die swam. Die resultate wys verder dat die swam klonaal voortplant in beide bg. lande, met baie min genetiese vloei tussen hulle. Die hoë geendiversiteits-waardes wat in hierdie studie verkry is, wys dat *C. albofundus* inheems is aan Afrika en nie Suid-Afrika soos 'n vroeëre hipotese voorstel nie. Die hoë geendiversiteit van *C. albofundus* in die twee populasies, wys daarop dat daar gefokus moet word op die kweek van weerstandbiedende variëteite as 'n beheerstrategie. Die seleksie van weerstandbiedende variëteite is reeds aan die gang in Suid-Afrika en sal baie bruikbaar wees vir beheer van die siekte in die toekoms.

Meeste siektes op *Eucalyptus* word veroorsaak deur swamme, maar bakteriese patogene word al meer belangrik. In die vierde hoofstuk van die verhandeling word die bakterium, *Pantoea ananatis*, geïdentifiseer as die oorsaak van skroeisiekte en terugsterwing van *Eucalyptus* spesies in Uganda. Dit is die eerste aanmelding van die siekte buite Suid-Afrika. Die siekte affekteer hoofsaaklik jong boompies en is daarom 'n bron van ernstige kommer vir die vestiging van plantasies. Dit is nou nodig om proewe op te stel om plantmateriaal te selekteer wat weerstandbiedend is teen bakteriese skroeisiekte. Die bakterium infekteer ook ander landbou-gewasse. Laasgenoemde is belangrik in Uganda, aangesien bome dikwels naby aan ander landbou gewasse geplant word.

Die resultate van hierdie verhandeling sal help met die beheer van siektes van bosbouplantasies in Uganda. Die studie sal hopelik ook dien as hulpmiddel om land- en bosbouers 'n beter begrip te gee van die belang van siektes in bosbouplantasies. Dit sal ook 'n wesenlike impak hê op die kapasiteit van die mense van Uganda om plantasiesiektes te hanteer, nie net die wat veroorsaak word deur die patogene wat in hierdie verhandeling geïdentifiseer is nie, maar ook ander siektes in die bosbou- en vrugtebedrywe.