

Diseases of exotic plantation forestry trees in Ethiopia

by

Alemu Gezahgne

M. Phil. (University College of North Wales, Bangor)

Submitted in fulfilment of the requirements for the degree

Doctor of Philosophy

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

March 2003

Promoter

Dr. J. Roux

Co-promoters

Prof. M. J. Wingfield

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Dedicated to my late younger sister, Getenesh Gebre Tsadik.

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ACKNOWLEDGEMENTS

I am very grateful to God for guiding me and for giving me the strength and patience to accomplish this work and for cherishing me in times of joy and sorrow.

I would like to extend my gratitude and sincere appreciation to the following institutions and people who have made significant contributions to the completion of this study. Without your assistance this study would not have been possible.

My sincere thanks go to Dr. Jolanda Roux for her unqualified moral support and technical guidance from the inception to the finalisation of this project. Your guidance, comments and above all your friendship were instrumental to my accomplishment. I have learnt a lot from your wealth of knowledge on forest pathology.

I am also very much indebted to Professor Michael J. Wingfield, not only for accepting me to be part of FABI but also for his guidance, comments and support, as well as for his moral encouragement whenever I needed it.

I thank Professor Brenda D. Wingfield for her assistance in the area of molecular biology and for her constructive comments and suggestions on the content of this study.

The wonderful people in the Forestry and Agricultural Biotechnology Institute (FABI) deserve special thanks for their extended support during my study at the institution. I have learnt a lot from each one of you. I thank you all. I am really proud of being a member of this highly renowned institution.

I would also like to thank Bernard Slippers, Martin Coetzee, Mauricio Marin, Gavin Hunter and Juanita de Wet for their tireless assistance in specific chapters of this thesis.

My wife Yeshi Ketema and my daughter Rekik Alemu deserve special thanks for their understanding and patience in my absence from home. Yeshi, without your

moral support, encouragement, endurance and love, it would have been difficult to accomplish this work. I very much appreciate your determination to bear alone the responsibility of bringing up our daughter in the three years of my absence. I am proud of you and I love you very much.

I do not have enough words to express my gratitude to my mother Shewaye Demessie. Your determination, dedication and all round support have been the corner stone of all my achievements. You are a wonderful mother. I honour you and love you very much.

I also thank my aunt Lackech Demessie for being with me and supporting me in difficult times. I really appreciate this support.

I thank my brothers Getachew Shale, Fitawek Gebre Tsadick, Afework Gebre Tsadick, Lakew Bekele, my sisters Tezeru Ayele, Haregua Zewde as well as Betelihame Girma, Tizita Girma, Eden Girma, Mulumbet Girma, Firegenet Alemu and Etaferu Getachew for their continuous moral support and encouragement as well as for the support you gave to my wife Yeshe and for taking care of my daughter Rekik.

Many, many thanks go to my mother-in-law Desta Wolde Gebrael, my father-in-law Ketma Meshesha as well as my brother-in-law Binyam Ketma and sister-in-law, Jerusalem Ketema for closely attending my family in my absence. It is a blessing to have had you on my side at such a critical time. Mesfin Woje, Belay, and Kedir also deserve special thanks for taking care of my family while I was away.

Dr. Pia Barklund deserves special honour for her all-rounded assistance from the inception up to the completion of this study. I also thank my colleague Dagne Duguma for his unqualified support during the fieldwork and thereafter.

I thank the Agricultural Research and Training Project (ARTP) of the Ethiopian Agricultural Research Organisation (EARO) for the financing of my study. I also thank the Forestry Research Centre and its staff for facilitating and supporting the fieldwork.

Wondo Genet Forestry College, Munesa Shashemene Forest Development and Marketing Enterprise and the Jima Zonal Agricultural Bureau of Oromia region are acknowledged for allowing me to do field work in their forests and for their assistance during the field work.

Lastly, but not least the University of Pretoria, FABI and the Tree Pathology Co-operative Programme are thanked for providing the infrastructure and equipment for the lab work, as well as for funding.

PREFACE

In several parts of Africa, exotic tree species are planted mainly in agroforestry development programs, for reduction of soil erosion, run-off control to combat desertification and rehabilitation of degraded land. They also contribute to the production of fuelwood, sawn timber and in some cases for pulp and paper production. In Ethiopia, planting exotic species commenced 110 years ago with the introduction of *Eucalyptus globulus*. Currently, several exotic species including those of *Eucalyptus*, *Pinus*, *Acacia* and *Cupressus* have been planted in Ethiopia. The government, the community and individual small-scale farmers own these plantations. These plantations contribute to the production of round wood for sawn timber, poles and posts and to meet wood requirements for local use, such as for construction material and for wood fuel. *Eucalyptus* spp. are the preferred planting stock, especially for fuel wood owing to their rapid growth and immediate economic return. *Pinus* spp. and *Cupressus* spp. are mostly planted in state owned forest areas.

Plantations of exotic species are successful in most areas where they have been planted. The success of these plantations is ascribed, at least in part, to the separation of the trees from their natural enemies. Despite this, pathogenic fungi, including native and introduced organisms pose serious threats to the development of exotic plantations. In Ethiopia, even though plantations of exotic species commenced over a century ago, little attention has been afforded to diseases of plantation trees. Currently, very little knowledge is available on the status of diseases in these plantations. The aim of studies making up this thesis has, therefore, been to increase the knowledge base pertaining to diseases in Ethiopian plantations.

The studies in this thesis focus mainly on identifying and recording the major diseases found in plantations of *Eucalyptus* and *Pinus* species. The thesis is comprised of seven separate chapters and each should be seen as an independent unit. Except for chapter one, the remaining six chapters were structured based on results of disease surveys conducted in 2000 and 2001. They have been presented as separate manuscripts and, therefore, some redundancy in introduction and methodologies used, could not be avoided.

Chapter one of the thesis presents a review of the impact and importance of diseases recorded on the most commonly planted exotic forestry species in Africa. The review discusses briefly, diseases recorded on *Eucalyptus*, *Pinus*, *Acacia* and *Cupressus* species. Root diseases, stem diseases, foliage diseases and wilt diseases recorded on plantations of exotic species in Africa have been included in the review. Knowledge pertaining to the disease situation on trees in Ethiopia was also evaluated and the lack of information on this aspect of forestry in the country is highlighted.

In order to manage forests and plantations effectively and to obtain maximum returns from them, it is essential to obtain information on the prevalence of diseases and their importance. In 2000 and 2001, disease surveys were conducted in major plantation areas situated in South, South Western and Western Ethiopia. Chapter two of the thesis deals with the results of these disease surveys, focusing on plantations of *Eucalyptus* and *Pinus* spp. This chapter presents the first record of major diseases in Ethiopian plantation forests.

Armillaria root rot was one of the most common diseases found associated with *Pinus* spp. It was, however, also found on some indigenous and exotic species. Although Armillaria root rot had previously been recorded from Ethiopia, there was uncertainty regarding the identity of the fungus found in the country. Chapter three discusses the results of the survey on the distribution and host range of this pathogen in plantations of Ethiopia. Also included is a taxonomic study, identifying the *Armillaria* sp. responsible for the disease in areas that we have considered.

Eucalyptus camaldulensis is one of the most widely planted *Eucalyptus* species in Ethiopia. A serious stem canker was frequently observed on *E. camaldulensis* planted in South and South Western Ethiopia. Preliminary investigations suggested that the disease was Coniothyrium stem canker. Chapter four presents the results of a study aimed at identifying this stem canker pathogen.

Chapter five of this thesis deals with Botryosphaeria stem canker of *Eucalyptus* spp. *Botryosphaeria* spp. are well known as wound and stress related opportunistic pathogens. Symptoms of Botryosphaeria stem canker, including production of brown

SUMMARY

In Ethiopia, the planting of exotic species commenced with the introduction of *Eucalyptus globulus* approximately 110 years ago. Today several different *Eucalyptus*, *Pinus*, *Cupressus* and Australian *Acacia* species are planted to provide wood for fuel/energy and raw material for furniture and construction. In many areas, people are dependent solely on wood to provide for their basic fuel and construction needs. Despite this, little attention has been given to improve the silvicultural and management practices of plantations in Ethiopia. In particular, disease surveillance and management has never received due attention. The aim of the studies that make up this thesis have been to address the issue of diseases of plantation trees in Ethiopia. Studies have thus focused on the prevalence, identity and importance of major diseases of especially *Eucalyptus* and *Pinus* spp.

As a background to this thesis, available information on diseases of exotic tree species in Africa has been reviewed and this is presented in the first chapter. In the review, diseases of the major exotic plantation species including *Eucalyptus*, *Pinus*, *Cupressus* and *Acacia* species have been considered. A section was also devoted to highlight tree diseases reported from Ethiopia. The review shows clearly that there is a great lack of information on diseases of exotic plantation species in most African countries, with the exception of South Africa. This suggests the need for more pathology studies in African plantations. The review also highlights the importance of diseases in plantation forests.

In Ethiopia, little information is available on tree diseases in plantation forests. To partially address this problem, disease surveys were conducted in 2000 and 2001 in *Eucalyptus* and *Pinus* plantations in South and South Western Ethiopia. The results of this survey showed that a number of pathogens, known from other countries, including Armillaria root rot, stem canker and foliage diseases are found in plantations of Ethiopia. The major diseases discovered during the survey are discussed in Chapter two of this thesis and an indication is given of their impact and distribution.

During the disease survey, Armillaria root rot was found to be associated with both exotic and native tree species. Morphological and molecular identification techniques revealed that the *Armillaria* sp. collected in this study is *A. fuscipes*. This is discussed in chapter three, where I also provide preliminary data regarding the host range and distribution of Armillaria root rot in Ethiopia. Prior to this study it was suggested that *A. mellea* is responsible for Armillaria root rot of

hard woods in Ethiopia. The current study, however, showed that at least two *Armillaria* spp., *A. mellea* and *A. fuscipes* are causing Armillaria root rot in the country. Of significance is the fact that *A. fuscipes* was isolated from two indigenous tree species, *A. abyssinica* and *J. excelsa*.

Chapter four of this thesis deals with the identity of the fungus causing stem canker on *Eucalyptus camaldulensis*. Disease symptoms identical to those caused by *Coniothyrium zuluense* were commonly found on *E. camaldulensis* in restricted areas in Western Ethiopia. The causative agent was determined based on DNA sequence analysis of the ITS 1, ITS 2 and 5.8S gene region and β -tubulin genes. According to the phylogenetic tree generated for these sequence data, the Ethiopian *Coniothyrium* isolates seem to be closely related to *C. zuluense*, however, the Ethiopian isolates formed a separate group. This may suggest that *C. zuluense* represents a species complex, but this needs further investigation. Coniothyrium canker is considered to be one of the most serious diseases of *Eucalyptus* spp. especially to the sawn timber and construction industry as it weakens and flaws the timber. Its occurrence in Ethiopia is, therefore, of great importance.

Disease symptoms similar to those of Botryosphaeria canker on *Eucalyptus* were commonly observed in all the areas where surveys were conducted. *Botryosphaeria* spp. are known as opportunistic stress related and endophytic pathogens on a wide range of woody plants, worldwide. In Ethiopia, symptoms similar to those associated with *Botryosphaeria* infection elsewhere, were found in almost all plantations surveyed. The disease was found on several *Eucalyptus* spp. including *E. globulus*, *E. saligna*, *E. grandis* and *E. citriodora*. Both morphological and molecular identification techniques were used to determine the identity of the fungus and the results are presented in chapter five. It was shown that *B. parva* is responsible for Botryosphaeria stem canker of *Eucalyptus* spp. in Ethiopia and the pathogenicity of Ethiopian isolates was also tested. This pathogen can have a serious effect on *Eucalyptus* in Ethiopia, as growing conditions in the country are often harsh and many people rely on coppicing to reproduce their stands. All these factors are conducive to stress and thus to *Botryosphaeria* infection.

Diplodia pinea is a fungus that commonly resides in the cones of *Pinus* spp. and it tends to move from these sites to infect stems, when trees are under stress. Therefore, isolations were made from *Pinus patula* cones to determine whether *D. pinea* was present in these structures in Ethiopia. Chapter 6 of the thesis provides results of this study. It was expected that *D. pinea* would be the most common inhabitant of the cones. Contrary to this, a *Fusicoccum* sp. was found more

frequently than *D. pinea*. The results presented in this chapter show clearly that the A morphotype of *D. pinea* is found in cones of *P. patula* in Ethiopia. The *Fusicoccum* sp. found associated with *P. patula* cones is most closely related to *B. parva*. Results of greenhouse inoculation studies showed that both these fungi are pathogenic to *Pinus tadea*, with *D. pinea* being the more pathogenic.

Serious leaf spot and shoot die-back symptoms were observed on leaves of *E. globulus* at several localities. The leaf blotch symptoms closely resemble those caused by *Mycosphaerella* spp. Even though 30 different *Mycosphaerella* spp. are known to be associated with *Eucalyptus* species world-wide, the cause of *Mycosphaerella* leaf blotch on *E. globulus* in Ethiopia is not known. Morphological and DNA based comparisons were used to determine the identity of the species found in Ethiopia and the results are provided in chapter seven. I was thus able to show that three *Mycosphaerella* spp. namely, *M. marksii*, *M. grandis* and *M. nubilosa* are involved in causing *Mycosphaerella* leaf disease of *E. globulus* in Ethiopia. This is the first report of these species from Ethiopia and the first report of *M. grandis* from a country other than Australia.

The results presented in the various chapters making up this thesis provide the first detailed studies on diseases of plantation trees in Ethiopia. Most tree diseases discussed in the thesis are first reports for the country. The thesis provides information on the identity of the pathogens and their significance in plantation development in Ethiopia. It also highlights the need for adequate management and silvicultural practices, as well as the need for selecting disease tolerant provenances and/or individuals. The information presented in the thesis also expands the host range and geographic distribution of all the pathogens included in the study, giving the study international significance.

exudate as well as stem cracking, were commonly found on several *Eucalyptus* spp. in all areas surveyed. This chapter discusses the results of the morphological and DNA based comparisons conducted to determine the identity of the *Botryosphaeria* spp. in Ethiopia.

Chapter six investigates the occurrence of species of *Botryosphaeria sensu lato* in *Pinus patula* cones in Ethiopia. *Diplodia pinea* is a common endophyte and stress related pathogen in *Pinus* spp. Interestingly, the most common inhabitant of *P. patula* cones in Ethiopia proved to not be *D. pinea*. In this chapter I discuss these findings, the identification of the two *Botryosphaeria* type fungi present, as well as their relative pathogenicity to *Pinus patula*.

Serious leaf spotting and shoot die-back typical of *Mycosphaerella* leaf blotch disease was observed on *E. globulus*, widely planted in cooler areas of Ethiopia. The last chapter of the thesis deals with the identification of the causal agents of MLD in Ethiopia. Ascospore germination patterns, cultural morphology and DNA sequence data were used to determine the identity of the fungus.

The research presented in this thesis represents the first comprehensive series of studies on diseases of plantation trees in Ethiopia. From an Ethiopian point of view, the information contained in this thesis will hopefully create due awareness among forest managers regarding the importance of diseases in plantation development. I also hope that they will form a foundation and pave the way for further studies on these and other tree diseases in Ethiopia in the future.