NEWS AND VIEWS/NUUS EN MENINGS

Current status and future prospects of forest pathology in South Africa

Michael J. Wingfield

Unlike most countries in the northern hemisphere, South Africa has poor natural resources of timber. The forestry industry in this country is, therefore, dependent on plants of exotic tree species such as pines, eucalypts and wattle. In general, single species of these trees are planted over extensive areas. The manner in which timber is produced is thus not obviously different from the monoculture used in the establishment of agricultural crops.

In view of their susceptibility to disease, monoculture of crops raises considerable concern. Because of the genetic uniformity of the crop, a pathogen to which the host is not resistant can result in devastation. Disease epidemics such as late blight of potato caused by *Phytophthora infestans* (Mont.) de Bary, which was responsible for the Irish potato famine between 1845 and 1847,[1] justify these fears.

The most important difference between monoculture of agricultural and tree crops is that trees, once planted, require many years, even decades, before they realise their growth and economic potential. Plant production and establishment costs are also exceptionally high. Considerable losses can, therefore, be experienced if a disease becomes established in a young plantation.

Although the fact is perhaps not well recognised outside forestry circles, diseases have had a significant impact on forestry in South Africa. For instance, the pathogen *Sphaeropsis sapinea* (Fr.) Dyko & Sutton (= *Diplodia pinea* (Dsm.) Kickx) that infects and kills certain *Pinus* species after hail damage was responsible for restricting the planting of the highly susceptible *P. radiata* D. Don. to areas where hail damage is infrequent.[2–4] Similarly, a leaf disease caused by *Mycosphaerella molleriana* (Thum.) Lindau apparently resulted in an inability to establish *E. globulus* Labill. in this country. More recently, the same pathogen has caused considerable damage to *E. nitens* (Deane & Maiden) Maiden and only certain provenances of this species can be planted today.[5]

Despite the impact that certain diseases have had on forestry in South Africa, the losses have been comparatively small. Our commercial tree species have been isolated geographically from most of their native diseases. Thus, any one of a large number of pathogens that have, as yet, not appeared here could result in devastation. The extensive losses that New Zealand experienced after the accidental introduction of *Dothistroma septospora* (Dorog.) Morelet exemplifies this threat.[6]

The aim of this review is to provide an overall impression of the status of forest pathology in South Africa. Although examples are restricted to pathology, most arguments apply equally to the broader field of forest protection including entomology. The current status of forest pathology in this country is briefly sketched using examples of native and exotic pathogens. This provides a foundation for a discussion of the future prospects for this field of research. This is pertinent in view of increasing population pressures and rapidly diminishing arable land.

Current status

Diseases of commercially planted forest trees were recognised early this century.[7] The two most notable diseases to receive attention were die-back of pines due to *S. sapinea* and root rot caused by *Armillaria*.[8] Subsequently, numerous diseases were recorded by mycologists and plant pathologists but very little attention was given to these disorders. Only in recent years has more detailed research been undertaken on some of the more important diseases.

Diseases of forest trees in South Africa include those caused by introduced as well as native pathogens. Although there are exceptions, introduced pathogens are mostly fungi that infect leaves and stems. In contrast, most root pathogens are probably native to this country.

Introduced pathogens

The best examples of introduced pathogens of pines are *S. sapinea* (mentioned above) and *Rhizina undulata* Fr., a pyrophilous fungus that can cause significant losses to pines after plantation fires.[9] *Dothistroma septospora* has been responsible for extensive losses to *P. radiata* in various parts of Africa and New Zealand.[6] This pathogen has been present in South Africa for many years but has remained restricted to small areas of the eastern Cape.[10]

An interesting group of fungi with a range of pathogenic abilities are associated with pine-infesting bark beetles that were introduced accidentally, with their microbial flora, into the country.[11–14] These include numerous species of *Ophiostoma* H. & P. Sydow and their anamorphs such as *Leptographium* Lagerb. & Melin and *Graphium* Corda. The role of these fungi in the life cycles of their vectors is the subject of considerable debate and represents an exciting and important area of research.

As is true in the case of pines, numerous pathogens of eucalypts in South Africa are of exotic origin. Some of the most notable are *Mycosphaerella molleriana*. Other leaf pathogens that occur commonly and have the potential to cause extensive losses are *Aulographina eucalypti* (Cooke & Massee) Von Arx and Muller and *Phaeoseptoria eucalypti* Hansf. *emend.* Walker.[15,16] The most recent pathogen to be discovered on eucalypts in this country is *Cryphonectria cubensis* (Bruner) Hodges.[17] This fungus has caused considerable losses to eucalypt crops in Brazil and elsewhere so its appearance in South Africa is of obvious concern. This is particularly true because one of the more susceptible hosts is *E. grandis* Hill: Maiden,[18] which is the most widely planted *Eucalyptus* species in South Africa. It is currently assumed that the pathogen is of exotic origin. Further studies, particularly including molecular characterization, are necessary to establish the origin and thus evaluate the potential threat of the pathogen to our *Eucalyptus* plantations.

Native pathogens

Pathogens of pines and eucalypts that are probably native to South Africa include the root pathogens, *Phytophthora cinnamomi* Rands, *Armillaria heimii* Pegler and *Pseudophaeolus baudonii* (Pat.) Ryv. As is typical of most root pathogens, these all have wide host ranges and have been found on both pines and eucalypts. Losses due to these fungi in plantations have been sporadic and not significant thus far.[19]

Phytophthora cinnamomi is the best known of the tree pathogens thought to be native to this country. This fungus is a notorious pathogen of woody plants and has a cosmopolitan distribution.[20] There is considerable controversy over its origin and there has been strong evidence to suggest that it originated in Papua New Guinea.[21] Equally convincing evidence supports the notion that the fungus is native in more than one geographic location including Southern Africa,[22–24] a view I share.

The opportunistic stem pathogen *Botryosphaeria ribis* Grossenb. & Dug. is common on many native woody plants including Proteaceae.[25] This fungus has also been found to cause sporadic incidences of extensive die-back of pines and eucalypts. Because of its presence on indigenous

Professor M.J. Wingfield is in the Department of Mirobiology and Biochemistry, University of the Orange Free State, P.O. Box 339, Bloemfontein, 9300 South Africa.

plants, I favour the notion that it is a native pathogen. At this stage we assume that races of the pathogen, virulent on exotic hosts, have developed with time.

The example of *B. ribis* as an apparently native pathogen that can infect and kill exotic tree species has interesting implications for biological control. Where exotic plants have attained the status of a weed in a country, it is possible that native pathogens could move to those plants and even reduce their spread considerably. For example, the invasive weed, *Hakea sericea* Schrad., of Australian origin has become infected with *Colletotrichum gloeosporiodes* (Penz.) Sacc., and the weed population has been significantly reduced.[26] The pathogen in this case is native on indigenous Proteaceae.

Future prospects

The forestry industry in South Africa is expanding and is one of the foremost earners of income from exports.[27] Land for its expansion is, however, limited and optimal productivity on available land will become essential.[28] Our past approach of producing 'more with more' must thus be replaced with a philosophy of producing 'more with less'. Consequently, losses due to disease that were ignored in the past will become progressively less acceptable in the future.

Quarantine

While the premium on available land for forestry will increase, it must also be assumed that the number of diseases affecting forest trees will grow. In the course of time, the movement of people and plant material around the world is likely to result in the appearance of additional exotic pathogens. Every attempt must be made to improve quarantine measures to reduce such accidental introductions.

Some of the most destructive plant diseases are those of trees. Dutch elm disease, caused by *Ophiostoma ulmi* (Buism.) Nannf., has resulted in devastating losses to both European and North American elms,[29] chestnut blight caused by *Cryphonectria parasitica* has decimated the American chestnut, *Castanea dentata* (Marsh.) Borkh.,[30] and more recently, the pine wood nematode, *Bursaphelenchus xylophilus* (Steiner & Buhrer), has been responsible for epidemic losses of native Japanese pines.[31,32] In all these cases, the pathogens have been accidentally introduced into a country where a native tree species has not possessed resistance to the disease.

Epidemics on the scale of Dutch elm disease, chestnut blight and pine wilt disease are perhaps not likely to affect the forestry industry in South Africa. This is primarily because the industry is based on a number of exotic tree species with a reasonable degree of genetic heterogeneity within the species. From experience elsewhere in the world, a plant disease epidemic might be expected to be caused by an introduced pathogen on a native woody host. An extreme example might be the total elimination of a native woody plant such as a species of *Protea* or even the entire genus. The importance of quarantine thus cannot be underestimated.

Because we plant a number of species representing a wide variety of provenances, I do not expect large-scale epidemics to affect our forestry industry. However, significant and even debilitating losses are possible, as illustrated by the effect that *D. septospora* has had on forestry in various parts of the world where it has been introduced. A high level of quarantine will reduce the risks of introducing pathogens.

Education

Success in reducing the impact of diseases in the future will rest on our ability to detect new pathogens as soon as possible. Once a disease problem has been identified, it would then be possible to manage plantations to reduce the problem. Strategies to ensure that susceptible trees are not planted extensively in high hazard areas can continue to be developed.

Enhanced ability to detect new disease problems early will necessitate improved and continuing surveys of plantations for disease. In my opinion, the key issue in such a programme lies in the improved education of foresters at all levels, in pathology. This must be backed up by research and diagnostic laboratories to deal with observations made by survey teams.

The expertise to provide education in tree pathology at the college and university level is available in South Africa, but inadequately used. Admittedly, only a small number of forest pathologists are available here. However, means by which they could contribute to the education of foresters could easily be developed.

Better use of computer technology could also improve education in pathology and its application in South African forestry. For example, the development of expert systems by means of which foresters could diagnose commonly occurring diseases is possible. This would unquestionably also improve the awareness of disease problems amongst foresters and improve their ability to recognise these problems at an early stage. The ultimate goal of educating forestry personnel in pathology should be to have disease and pest problems taken into consideration well before planting commences, rather than after they appear.

Research

A strong research component should, in my opinion, form the nucleus of the forest pathology programme. It should incorporate studies on priority disease problems, provide the necessary diagnostic services, assist in the education of foresters in pathology and provide tertiary education to future researchers.

Like most research, investigation of a tree disease problem is labour intensive, costly and usually protracted. To make significant headway, considerable investment is required. It is fallacious to believe that one or two people with limited funds will make much impact on the more important diseases that already affect forest trees in this country. If, as I believe, tree diseases pose the single most important threat to South African forestry, funding in this field is utterly disproportionate to the importance of the industry.

It is well-established that a successful research programme requires a critical mass of scientists who are able to interact closely. This ensures a stimulating, positively competitive and productive research environment. Flexibility to absorb a healthy exchange of staff is also guaranteed. The number of laboratories dedicated to basic forest pathology research must depend on the funds available. It is also my belief that fewer laboratories with larger teams would be far preferable to a number of 'one-person shows'.

The trend towards clonal propagation of forest trees in South Africa lends itself to exciting possibilities in forest pathology research. While clones might imply limited genetic variability, the ability to select for disease resistance is significantly enhanced. Perhaps the most important consideration in forestry at present is that all clones be screened for the most important diseases. This programme should be continually adapted to include new diseases that appear. Screening clones of eucalypts and pines for resistance to *C. cubensis* and *S. sapinea*, respectively, are obvious priorities at this stage.

The opportunities to improve and expand the forestry industry through microbiological research are enormous. Modern technology, particularly in the application of recombinant DNA techniques, are almost limitless. Propagation of trees through tissue culture is already receiving considerable attention in this country. Thus, the rapid screening of plants for somaclonal variation[33,34] in disease susceptibility will become relatively simple. The development of DNA probes for desirable characteristics in trees is also possible.

Identification of pathogens at the morphological level is highly subjective in many cases. This can lead to incorrect diagnoses and, subsequently, significant losses. Recombinant DNA technology will significantly enhance our ability to identify tree pathogens and even determine their origin. Knowing where a pathogen has originated will improve our ability to predict the outcome of a disease situation and provide clues to where solutions might be found.

Internationally, perhaps the most exciting aspect of tree pathology today lies in forest products research. The exploitation of microorganisms in biological pulping and bleaching in the paper industry is a case in point.[35,36] Microbial detoxification of effluent from pulp mills also holds great promise for the future. Furthermore, the production of fungi and microorganisms on forest waste for both food and medicinal purposes is the basis of significant industries elsewhere in the world. The opportunities for South Africa in the latter case seem endless. The ultimate goal must be to shift from the resource-rich to the knowledge-rich scenario discussed by Sunter.[37]

Conclusions

The number of diseases affecting forest trees can be expected to increase significantly in the future. More intensive propagation of trees could also result in greater losses due to disease. As available land for the expansion of forestry becomes limited, such losses will become much less tolerable.

An expanded research programme on tree diseases will be necessary to protect the forestry industry from losses that are likely to occur. A policy that anticipates pathology problems is advisable. Here, on the basis of research, diseases should be taken into account before planting is begun rather than after problems appear. The education of foresters in the field of pathology must be improved. Adequate feedback from plantation to laboratory and vice versa is essential.

The potential applications of recombinant DNA technology for dealing with disease problems and the improvement of forest trees are many. This type of research is exceptionally expensive but essential if the value of the forestry industry is not only to be maintained but increased. The broader microbiological sciences offer the forestry industry excellent opportunities for improvement and expansion. Enthusiasm and imagination on the part of researchers are prerequisites. This, coupled with realistic financial support, will ensure that the South African forestry industry remains a winning concern.

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1. Large E.C. (1958). *The Advance of the Fungi.* Jonathan Cape, London.
2. Laughton E.M. (1937). The incidence of fungal disease on timber trees in South Africa. *S. Afr. J. Sci.* **33**, 377 – 382.
3. Lückhoff H.A. (1964). Diseases of exotic plantation trees in the Republic of South Africa. *FAO/IUFRO Symposium meeting No. VI.*
4. Swart W.J., Knox-Davies P.S. and Wingfield M.J. (1985). *Sphaeropsis sapinea* with special reference to its occurrence on *Pinus* spp. in South Africa. *S. Afr. For. J.* **13**, 1 – 8.
5. Lundquist J.E. and Purnell R.C. (1987). Effects of Mycosphaerella leaf spot on growth of *Eucalyptus nitens. Plant Dis.* **71**, 1025 – 1027.
6. Gibson I.A.S. (1972). Dothistroma blight of *Pinus radiata. Ann. Rev. Phytopathol.* **10**, 51 – 72.
7. Kotze J.J. (1935). Forest fungi. The position in South Africa. *British Empire Forestry Conference, South Africa.*
8. Wingfield M.J. (1986). Diseases of pines, eucalypts and wattles. In *Forestry Handbook*, 2nd edn, edit. K. von Gadow *et al.*, pp. 153 – 164. South African Forestry Institute, Pretoria.
9. Germishuizen P.J. (1984). *Rhizina undulata*, a pine seedling pathogen in Southern Africa. In *Proc. IUFRO Symposium on Site and Productivity of Fast Growing Plantations*, Pretoria and Pietermaritzburg, vol. 2, pp. 753 – 756.
10. Lundquist J.E. and Roux C. (1984). Dothistroma needle blight of *Pinus patula, P. radiata* and *P. canariensis* in South Africa. *Plant Dis.* **68**, 918.
11. Wingfield M.J. and Marasas W.F.O. (1980). *Verticicladiella alacris* sp. nov. associated with a root disease of pines in South Africa. *Trans. Br. Mycol. Soc.* **75**, 21 – 28.
12. Wingfield M.J. and Marasas W.F.O. (1980). *Ceratocystis ips* associated with *Orthotomicus erosus* (Coleoptera: Scolytidae) in the Cape Province of South Africa. *Phytophylactica* **12**, 65 – 69.
13. Wingfield M.J. and Marasas W.F.O. (1983). Some *Verticicladiella* spp. including *V. truncata* sp. nov. associated with root diseases of pine in New Zealand and South Africa. *Trans. Br. Mycol. Soc.* **80**, 231 – 236.
14. Wingfield M.J., Capretti P. and MacKenzie M. (1988). *Leptographium* spp. as root pathogens of conifers. An international perspective. *Leptographium Root Diseases on Conifers*, edit. T.C. Harrington and F.W. Cobb Jr, pp. 113 – 128. American Phytopathological Society Press, St Paul, Minn.
15. Crous P.W., Knox-Davies P.S. and Wingfield M.J. (1988). *Phaeoseptoria eucalypti* and *Coniothyrium ovatum* on *Eucalyptus* spp. in South Africa. *Phytophylactica* **20**, 337 – 340.
16. Crous P.W., Knox-Davies P.S. and Wingfield M.J. (1989). A summary of fungal leaf pathogens of *Eucalyptus* and the diseases they cause in South Africa. *S. Afr. For. J.* **149**, 9 – 16.
17. Wingfield M.J., Swart W.J. and Abear B.J. (1989). First record of *Cryphonectria* canker of *Eucalyptus* in South Africa. *Phytophylactica* **21**, 311 – 313.
18. Sinclair W.A., Lyon H.H. and Johnson W.T. (1987). *Diseases of Trees and Shrubs.* Cornell University Press, Ithaca.
19. Wingfield M.J., Swart W.J. and Von Broembsen S.L. (1988). Root diseases of pines and eucalypts in South Africa. In *Proc. Seventh International Conference on Root and Butt Rots of trees*, edit. D.J. Morrison, pp. 563 – 569. Vernon, British Columbia.
20. Zentmeyer G.A. (1983). The world of *Phytophthora*. In *Phytophthora. Its biology, taxonomy, ecology and pathology,* edit. D.C. Erwin, S. Bartnicki-Garcia and P.H. Tsao, pp. 1 – 7. The American Phytopathological Society Press, St Paul, Minn.
21. Zentmeyer G.A. (1988). Origin and distribution of four species of *Phytophthora. Trans. Br. Mycol. Soc.* **91**, 367 – 378.
22. Von Broembsen S.L. (1979). *Phytophthora cinnamomi*—a threat to western Cape flora? *Veld & Flora* **65**, 53 – 55.
23. Von Broembsen S.L. (1984). Occurrence of *Phytophthora cinnamomi* on indigenous and exotic hosts in South Africa, with special reference to the south-western Cape Province. *Phytophylactica* **16**, 221 – 225.
24. Von Broembsen S.L. and Kruger F.J. (1985). *Phytophthora cinnamomi* associated with mortality in native vegetation in South Africa. *Plant Dis.* **69**, 715 – 717.
25. Knox-Davies P.S., Van Wyk P.S. and Marasas W.F.O. (1986). Diseases of Proteas and their control in the South-Western Cape. *Acta hort.* **185**, 189 – 200.
26. Morris M.J. (1983). Evaluation of field trials with *Colletotrichum gloeosporiodes* for the biological control of *Hakea sericea. Phytophylactica* **15**, 13 – 16.
27. Van As E. (1988). Opening address. In *Forestry Management and Research. Partners into the 21st Century,* edit. Shonau, pp. 3 – 4. South African Institute of Forestry, Pietermaritzburg.
28. Huntley B., Siegfried R. and Sunter C. (1989). *South African Environments into the 21st Century.* Human and Rousseau, Tafelberg, Cape Town.
29. Gibbs J.N. (1978). Intercontinental epidemiology of Dutch elm disease. *Annu. Rev. Phytopathol.* **16**, 287 – 307.
30. Griffin G.J. and Elkins J.R. (1986). Chestnut blight. In *Chestnut Blight, Other Endothia Diseases and the Genus Endothia,* edit M.K. Roane, G.J. Griffin, and J.R. Elkins, pp. 1 – 26. American Phytopathological Society Press, St Paul, Minn.
31. Mamiya Y. (1983). Pathology of pine wilt disease caused by *Bursaphelenchus xylophilus. Annu. Rev. Phytopathol.* **21**, 201 – 220.
32. Wingfield M.J., Blanchette R.A. and Nicholls T.H. (1984). Is the pine wood nematode an important pathogen in the United States? *J. For.* **82**, 232 – 235.
33. Meins F., Jr (1983). Heritable variation in plant cell culture. *Annu. Rev. Physiol.* **34**, 327 – 346.
34. Ostry M.E. and Skilling D.D. (1988). Somatic variation in resistance of *Populus* to *Septoria musiva. Plant Dis.* **72**, 724 – 727.
35. Erikson K.-E. and Kirk T.K. (1985). Biopulping, biobleaching and treatment of kraft bleaching effluents with white-rot fungi. In *Comprehensive Biotechnology,* edit. C.L. Cooney and A.E. Humphrey, pp. 271 – 294. Pergamon, Toronto.
36. Kirk T.K., Jeffries T.W. and Leatham G.F. (1983). Biotechnology: Applications and implications for the pulp and paper industry. *TAPPI J.* **66**, 45 – 51.
37. Sunter C. (1988). *The World and South Africa in the 1990's.* Human and Rousseau, Tafelberg. Cape Town.

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● **Dr Michael Witcomb,** Director of the Wits University Electron Microscope Unit, has been elected President of the Electron Microscopy Society of Southern Africa.