ELSEVIER

Forest Ecology and Management 65 (1994) 11-16

Forest Ecology and Management

Integrated management of forest tree diseases in South Africa

Michael J. Wingfield*, Wijnand J. Swart

Department of Microbiology and Biochemistry and Department of Plant Pathology, University of the Orange Free State, P.O. Box 339, Bloemfontein 9300, South Africa

Abstract

The forestry industry in South Africa depends, almost entirely, on intensively managed plantations of various *Pinus* and *Eucalyptus* species. These exotic trees have largely been separated from insects and diseases that affect them in their areas of origin. Yet, numerous pests and pathogens, often acting in concert, reduce the productivity of plantations. Two of the most important diseases are Sphaeropsis die-back of hail-damaged pines and Rhizina root disease that develops after slash burning. They are used here to exemplify integrated management practices in which insects can play an important role. Losses due to Rhizina root disease are reduced by avoiding slash burning. This can result in a build-up of populations of the root-infesting bark beetle, *Hylastes angustatus* that girdles seedlings after planting. In these instances, chemical control of the insects is necessary. Damage due to Sphaeropsis die-back is often exacerbated through infestation of trees by the weevil *Pissodes nemorensis* (Coleoptera: Curculionidae) and the bark beetle *Orthotomicus erosus* (Coleoptera: Scolytidae). Management of Sphaeropsis die-back is largely achieved by planting resistant species in areas prone to hail damage. Where infection has occurred, insect populations must be reduced by selective felling and associated sanitation practices.

Key words: Integrated forest management; Disease; Root disease; Die-back

1. Introduction

Indigenous species of trees suitable for timber and pulp production are extremely scarce in South Africa. For this reason, plantation forestry has been actively pursued in the country since the early part of this century. Currently, about 1.2 million ha of land has been utilised for forest plantations. It is also probable that this area will have to increase to approximately 2 million ha within the next 20 years to meet projected demands for timber and pulp.

The forestry industry in South Africa depends almost entirely on exotic tree species for its plantations. Most timber plantations comprise species of *Eucalyptus* and *Pinus* and, to a lesser extent, *Acacia mearnsii*. In fact, species of the former genera make up approximately 90% of the plantings. Of these, *Pinus patula*, *Pinus elliottii*, *Eucalyptus grandis* and *Eucalyptus nitens* are the most common, although many other pine and eucalypt species are planted on a smaller scale.

Through exploitation of exotic tree species, the South African forestry industry has separated its primary resource from most of the diseases that occur on these trees in their areas of origin. Despite this fact, numerous tree diseases are encountered in forest plantations (Wingfield, 1987, 1990). These are caused both by native pathogens originating from other hosts and by exotic

*Corresponding author.

0378-1127/94/$07.00
SSDI 0378-1127(93)06062-A

pathogens that have been accidentally introduced into the country. Some of these diseases have caused considerable losses although on a relatively limited scale (Wingfield, 1990). Indeed, when one considers the potential threat of diseases to the highly intensive monoculture being conducted, it is probably fair to say that the South African forestry industry has been relatively fortunate in terms of the losses suffered.

Very little attention has been paid to disease management in South African forest plantations. This is mainly due to the fact that the impact of diseases has been relatively low. Measures to manage losses have, however, been implemented for some of the more important diseases. For the purpose of this paper, we will use two diseases to serve as examples of integrated forest management. These include Sphaeropis die-back caused by *Sphaeropsis sapinea* (Fr.:Fr.) Dyko & Sutton and Rhizina root disease caused by *Rhizina undulata* Fr., both of which occur exclusively on pines. For each disease, we will consider factors associated with losses as well as strategies that are currently being used to reduce these losses.

2. Rhizina root disease

Rhizina undulata is a pyrophilous fungus that requires a heat stimulus for the onset of pathogenicity (Jalaluddin, 1967; Gremmen, 1971). It is exclusively a pathogen of conifers and has a wide distribution including Europe, North America, sub-Saharan Africa and Asia (Gibson, 1979). In Europe, the pathogen is usually associated with older trees and the disease is commonly known as 'group dying of conifers', 'maladie du rond' or 'ringsseuche' (Gremmen, 1971). In such cases, the disease can usually be traced back to camp or cooking fires in conifer plantations (Gibson, 1979).

Rhizina is extremely important in pine plantations in South Africa. Although the causal pathogen has been known in the area since 1944, it is only in relatively recent years that it has caused serious losses (Germishuizen, 1984). In the past, slash burning after clearfelling was a commonly accepted sylvicultural practice. This often resulted in extensive mortality of newly planted seedlings due to infection by *R. undulata*. Seedlings, including those used to replace dead plants will continue to die for at least 3 and often many more months. Where mild fire damage occurs in older pine plantations, trees can also become infected. These trees will often continue to die in groups for many years in the absence of any additional heat stimulus.

2.1. Factors associated with Rhizina root disease

Slash burning

In South Africa, the practice of slash burning on old pine sites prior to replanting has been discontinued due to losses from *R. undulata* (Germishuizen, 1984). However, various problems arise when pine slash is left in stands. Considerable inconvenience results from having to plant amongst slash and physical stacking of this waste material is often necessary. The slash can also act as a refuge for small rodents that feed on newly planted seedlings.

The most serious consequence of the cessation of slash burning is the resultant build-up in populations of the pine root-infesting bark beetle, *Hylastes angustatus* (Herbst). These insects breed in old pine stumps and roots and, after emergence, undergo maturation feeding on the newly planted seedlings (Tribe, 1990). The discontinuation of slash burning has, in many cases, necessitated the implementation of chemical control for *H. angustatus*. This measure is, however, only necessary in the summer rainfall areas of the country where *H. angustatus* is active in spring and summer, the period when seedlings are usually planted.

Accidental fires

The discontinuation of slash burning has significantly reduced losses due to *R. undulata* in South Africa. However, accidental fires still occur in plantations and replanting of these stands remains a problem. It is known that the pathogen eventually loses its ability to infect seedlings. Detailed studies by Germishuizen (1984) in

Swaziland suggested that a delay of up to 6 months might be necessary before replanting after a fire. Unfortunately, in various parts of South Africa, *R. undulata* has maintained its pathogenicity for a considerably longer period.

A currently applied solution to the problem of replanting accidentally burnt sites is for forest managers to establish monitoring plots to gauge the level of infectivity of the pathogen. These monitoring plots usually comprise a small number of trees planted in blocks randomly arranged in the previously burned stand. Seedlings in the monitoring plots are inspected regularly and new plots are established at monthly intervals. This process continues until seedlings in the monitoring plots stop dying. At this stage it is assumed that the pathogen is no longer active and that large-scale plantings can then be undertaken.

Where mild fires have passed through pine plantations, trees are often not sufficiently damaged to result in death. However, in such cases, *R. undulata* is often activated and these secondary infections can result in very substantial losses. These trees can also become severely infested with the European bark beetle, *Orthotomicus erosus* (Wollaston) that contributes to and hastens tree death (Tribe et al., 1985; Baylis et al., 1986). The dead trees in turn, serve as a breeding base for these bark beetles, which in high populations, will also infest healthy trees. The recommended management strategy in this case is to remove dead and dying trees from plantations as soon as possible.

3. Sphaeropsis die-back

Die-back of *Pinus* spp. caused by *S. sapinea* is a well-known disease in many parts of the world (Punithalingam and Waterston, 1970; Gibson, 1979; Swart et al., 1985). The pathogen is opportunistic and is, therefore, also associated with many other disease symptoms (Swart et al., 1985). Extensive mortality of *Pinus* spp. in plantations after hail damage has been known in South Africa since the early part of this century (Laughton, 1937). It is indeed this disease for which the pathogen is best known and it has recently been estimated that losses of R9.5 million (approximately 3.2 million US$) have been incurred per year (Zwolinski et al., 1990). Other losses due to disease are associated with infection of wounds, particularly those associated with pruning operations (Swart and Wingfield, 1991).

Sphaeropsis sapinea has been the subject of a number of recent and extensive review articles (Swart et al., 1979; Swart and Wingfield, 1991). This discussion will thus be limited only to aspects of the biology and ecology of the pathogen that relate to integrated management of pine die-back after hail damage in South Africa.

3.1. Factors associated with Sphaeropsis die-back

A number of factors are known to affect the development of disease associated with *S. sapinea*. Knowledge of these varies from being quite extensive to merely peripheral. However, considerable information concerning these factors has been accumulated in recent years and will be useful in reducing losses due to the disease. The following factors are considered particularly important and could be, or have already been, used in disease management programmes.

Susceptibility of species

During the early years of forestry in South Africa, *S. sapinea* caused extensive losses to plantations of *Pinus radiata* and *Pinus pinaster* after hail damage (Laughton, 1937; Gibson, 1979). This led to the restriction of planting of these highly susceptible species to areas of the country where hail damage is less frequently experienced. *Pinus elliottii* and *Pinus patula* are the most commonly planted species in summer rainfall areas of the country where hail frequently damages trees. Of the latter species, *Pinus patula* has a relatively high level of susceptibility to *S. sapinea* and extensive mortality of this species remains a serious problem after hail.

Recent experimentation using artificial inoculation techniques (Swart et al., 1988) has confirmed field observations on the relative susceptibility of *Pinus* spp. to *S. sapinea*. Of the four most commonly planted *Pinus* spp. in South Africa, *Pinus elliottii* and *Pinus taeda* were shown to be most tolerant to infection by *S. sapinea*, whereas *P. patula* and *P. radiata* were most susceptible to the pathogen.

Disease avoidance through planting tolerant species has already been of considerable value in reducing losses due to *S. sapinea* in South Africa. Plantations, particularly of *P. patula* and *P. radiata* are, however, occasionally affected by the pathogen following hail damage. It is hoped that these losses might be further reduced by selection of disease tolerant provenances within otherwise susceptible species.

Microclimate

A recent case study of *S. sapinea* infection after severe hail storm damage to a plantation of *P. radiata* has provided important new data concerning the pathogen (Zwolinski et al., 1990). Of particular interest in this study was the conclusion that most severe damage due to *S. sapinea* occurs on trees in enclosed valley sites. This is presumed to be due to conditions such as reduced air movement and higher humidities that would favour infection.

Disease due to *S. sapinea* could, therefore, possibly be reduced by planting less susceptible species in areas such as enclosed valleys that apparently favour infection (Zwolinski et al., 1990). It might also be possible to reduce the impact of disease on these sites through the adoption of thinning and other planting regimes that increase air movement and reduce humidity. There are certainly good indications that the association of microclimate and *S. sapinea* infections deserve further study and could lead to a reduction of losses due to this pathogen.

Insect damage

Insect damage is known to provide infection courts for *S. sapinea* (Haddow and Newman, 1942; Wingfield and Palmer, 1983). Infections associated with such damage is usually of a limited scale and not particularly important. A recent study (unpublished) has, however, shown that the pine weevil (*Pissodes nemorensis* Germar) will infest healthy wood adjacent to tissue discoloured by *S. sapinea*. There are also good indications that infestations by this insect will contribute to the spread of *S. sapinea*.

After hail damage and subsequent *S. sapinea* infection, populations of *P. nemorensis* will increase dramatically in dead timber. Such a population build-up can be reduced through efficient removal of dead trees or tree parts. We believe that this strategy will contribute to a reduction in the impact of die-back associated with *S. sapinea* after hail.

Seasonal susceptibility

Pinus spp. in South Africa are most susceptible to *S. sapinea* during spring and early summer (Swart and Wingfield, 1991). This period also coincides with peaks in conidial production that are closely linked to ambient temperatures (Swart et al., 1987). These data are particularly useful when silvicultural strategies such as pruning are considered. They have thus led to the recommendation that pruning is restricted to the winter months (Swart et al., 1987). This is irrespective of the fact that, in certain regions of South Africa, rainfall occurs predominantly in winter and that conidia of *S. sapinea* depend on moisture for dispersal.

4. Conclusions

Rhizina root disease and Sphaeropsis die-back are serious diseases of *Pinus* spp. in South Africa. As is true of most tree diseases, they depend on many factors associated with the pathogens, their hosts and the environment. Other contributing factors such as associated insect infestations are also important and exacerbate these problems.

An integrated approach to the management of Rhizina root disease in South Africa has been relatively successful. Strategies to reduce losses have included the cessation of slash burning on old pine sites, the use of delayed planting after accidental fires, chemical control of *H. angustatus*, and sanitation to reduce populations of *O. erosus* in older stands. These strategies are, however, based on relatively limited biological information. For example, almost nothing is known about the survival of the pathogen in the soil. It is evidently widespread throughout the country but only occurs on old pine sites and never occurs when native forests or grasslands are burned prior to establishment of plantations. Presumably some factor associated with a previous pine rotation is important in the biology of *R. undulata*. Such information might be useful in developing additional strategies to reduce losses due to Rhizina root disease.

There have been indications that Rhizina root disease tends to occur predominantly on acidic soils (Jalaluddin, 1967). This interesting observation has not been extensively tested under field conditions. Yet it might be the basis of an outstanding strategy to prevent seedling death after accidental fires.

Considerably more information is available pertaining to Sphaeropsis die-back than for Rhizina root disease. This is due to the fact that *S. sapinea* has been known in the country for considerably longer than *R. undulata*. *Sphaeropsis sapinea* is easily grown in culture and, unlike *R. undulata*, lends itself to artificial experimentation.

Research on *S. sapinea* in South Africa and its association with die-back of pines after hail has added considerably to the information base necessary to manage this important disease. It has, for instance, been possible to plant the most susceptible species of pines in parts of the country where hail damage is least common. When susceptible species are damaged by hail, selective felling of the most seriously affected trees is possible. Here it is important to prevent a build-up in the populations of insects such as *O. erosus* and *P. nemorensis* that can exacerbate damage due to *S. sapinea*. In this way, trees that will recover after the damage are not lost due to indiscriminate felling.

In many cases it is necessary to plant pine species, susceptible to *S. sapinea*, in areas where hail damage is occasionally experienced. Thinning to increase spacing, particularly in enclosed valley sites, might significantly reduce damage due to the pathogen. This information has, as yet, not been applied under field conditions but shows considerable promise in the management of Sphaeropsis die-back.

Diseases pose one of the greatest threats to exotic plantation forestry in South Africa. All indications are, however, that it will be possible to develop integrated management strategies to reduce such losses. To capitalise on these strategies, it is necessary to have an extensive knowledge of the pathogens concerned. This knowledge should include information on the biology of the pathogen, host susceptibility, climatic and site factors associated with disease development and the influence of associated pests and pathogens. The success of forest tree disease management will depend on cooperative research involving many disciplines such as pathology, entomology, silviculture, genetics and soil science.

References

Baylis, N.T., de Ronde, C. and James, D.B., 1986. Observation of damage of a secondary nature following a wild fire at Otterford State Forest. S. Afr. For. J., 137: 36–37.

Germishuizen, P.J., 1984. *Rhizina undulata*—A pine seedling pathogen in Southern Africa. In: D.C. Grey, A.P.G. Schonau, C.J. Schutz and A. van Laar (Editors), IUFRO Symposium of Site and Productivity of Fast Growing Plantations, May 1984, Pretoria, Vol. 2. South African Forest Research Institute, Pretoria, 968 pp.

Gibson, I.A.S., 1979. Diseases of forest trees widely planted as exotics in the tropics and southern hemisphere. Part II. The genus *Pinus*. Commonwealth Mycological Institute, Kew and Commonwealth Forestry Institute, University of Oxford, 135 pp.

Gremmen, J., 1971. *Rhizina undulata*. A review of research in the Netherlands. Eur. J. For. Pathol., 1: 1–6.

Haddow, W.R. and Newman, F.S., 1942. A disease of the Scots pine (*Pinus sylvestris* L.) caused by the fungus *Diplodia pinea* Kickx associated with the pine spittlebug (*Aphrophora paralella* Say.). Trans. R. Can. Inst., 24: 1–18.

Jalaluddin, M., 1967. Studies on *Rhizina inflata*. I. Mycelial growth and ascospore germination. Trans. Br. Mycol. Soc., 50: 449–459.

Laughton, E.M., 1937. The incidence of fungal disease on timber trees in South Africa. S. Afr. J. Sci., 33: 377–382.

Punithalingam, E. and Waterston, J.M., 1970. *Diplodia pinea*. Descriptions of Pathogenic Fungi and Bacteria 273. Commonwealth Mycological Institute, Egham, UK, 2 pp.

Swart, W.J. and Wingfield, M.J., 1991. The biology and control of *Sphaeropsis sapinea* in South Africa. Plant Dis., 75: 761–766.

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., 35: 1–8.

Swart, W.J., Wingfield, M.J. and Knox-Davies, P.S., 1987. Conidial dispersal of *Sphaeropsis sapinea* in three climatic regions of South Africa. Plant Dis., 71: 1038–1040.

Swart, W.J., Wingfield, M.J. and Knox-Davies, P.S., 1988. Relative susceptibilities to *Sphaeropsis sapinea* of six *Pinus* spp. cultivated in South Africa. Eur. J. For. Pathol., 18: 184–189.

Tribe, G.D., 1990. Phenology of *Pinus radiata* log colonization by the pine bark beetle *Hylastes angustatus* (Herbst) (Coleoptera: Scolytidae) in the south western Cape Province. J. Entomol. Soc. S. Afr., 53: 93–100.

Tribe, G.D., Wingfield, M.J. and Cillie, J.J., 1985. Interaction of fire, *Rhizina undulata* and *Orthotomicus erosus*. For. News 3/85, Department of Environment Affairs, South Africa, 19 pp.

Wingfield, M.J., 1987. Diseases in South African forest plantations in South African Forestry Handbook. In: K. von Gadow, D.W. van der Zel, A. van Laar, A.P.G. Schonau, H.W. Kassier, P.W. Warkotsch, H.F. Vermaas, D.L. Owen and J.V. Jordan (Editors), Southern African Institute of Forestry, Pretoria, pp. 153–163.

Wingfield, M.J., 1990. The current status and future prospects of forest pathology in South Africa. S. Afr. J. Sci., 86: 60–62.

Wingfield, M.J. and Palmer, M.A., 1983. *Diplodia pinea* associated with insect damage on pines in Minnesota and Wisconsin. In: Fourth Int. Congress of Plant Pathology, August 1983, Melbourne, Australia, p. 249. (Abstract.)

Zwolinski, J.B., Swart, W.J. and Wingfield, M.J., 1990. Intensity of dieback induced by *Sphaeropsis sapinea* in relation to site conditions. Eur. J. For. Pathol., 20: 167–174.