

**Soil invertebrate pests in the re-establishment of plantations in
South Africa**

by

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CHAPTER 9

General Summary

Insect pests and pathogens cause significant losses to the South African forestry industry, and they pose one of the greatest threats to its long-term sustainability and productivity. South African forestry has previously taken advantage of exotic planting stocks (*Acacia mearnsii*, *Eucalyptus* spp. and *Pinus* spp.) that were initially free from their natural enemies. This situation has changed with the gradual appearance of accidentally introduced and/or invasive indigenous pests. This trend is likely to continue with the increasing movement of people and products around the world and the expansion of commercial forestry into low productivity and old arable sites. Forest entomology services and research in South Africa have become fragmented and depleted to the extent that capacity in this field has declined in recent years. Yet there is a need for research in areas such as biological and other pest control measures, contingency plans against incursions, the biology and bioeconomics of new pests, and insect-pathogen interactions. A concerted effort is, therefore, required to create capacity and revitalise this important field of science in South Africa.

There is a limited availability of land for the expansion of commercial plantations in South Africa, and this has resulted in a shift from extensive to intensive silviculture. Rather than afforest new areas, existing plantation areas are being regenerated. One of the ways to increase productivity in a given area, besides genetic improvement, is to ensure the survival of seedlings during regeneration, thereby increasing the stocking of compartments. The cyclic nature of plantation forestry results in areas being continually regenerated and considerable silvicultural research has been done to ensure the survival of seedlings during regeneration.

Soil invertebrate pests and pathogens constitute some of the important causes of seedling mortality. However, the quantification, impact and the effect of different plantation residue management practices on the incidence of these pests and diseases were, prior to the present work, unclear, and in many instances unknown.

Seedlings that failed to establish during wattle regeneration ranged from 8.95% to 50.84%, and the incidence of damage by soil invertebrate pests ranged from 2.15% to 30.21%. In sites where the plantation residue was windrowed and burnt, the average total incidence of soil invertebrate pests was 20.34%, and the average total failure of wattle seedlings to establish was 34.42%. Whitegrubs were the dominant and most economically important soil invertebrate pests (average incidence of 12.52%), followed by cutworms (average incidence of 3.97%) and grasshoppers (average incidence of 2.12%). Other soil invertebrate pests included termites, tipulid larvae, false wireworms, crickets, millipedes, ants and nematodes. Nematodes were sporadically important (11.58%) in old arable wattle sites.

Little was previously known about the incidence of soil invertebrate pests and diseases in low and high productivity coastal and inland regenerated eucalypt sites. The highest incidence of soil invertebrate pests (average of 15.16% for both *E. grandis* and *E. dunnii* seedlings) was in the low productivity inland site that was in close proximity to wattle and sugarcane plantations. Whitegrubs and cutworms were the dominant pests and their management would be equivalent to that in the regeneration of wattle sites. There was a negligible incidence of soil invertebrate pests in the low productivity inland site (average of 0.75% for both *E. grandis* and *E. macarthurii* seedlings), and coastal site (average of 0.25% for all eucalypt species and clones [*E. grandis*, GCSZ11, GU7, GUSZ17, GCSZ14]). Although the high productivity coastal site had a similar low incidence of soil invertebrate pests (average of 2.57% for all eucalypt species and clones [*E. grandis*, GC747, GU170, TAG53, ZG40]), the incidence of whitegrub damage was sporadically high (7.85%) in clone ZG40. Numerous nursery fungal pathogens, the bacterial wilt (*Ralstonia solanacearum*) and unknown factors were responsible for low establishment of seedlings in the high productivity coastal site. Improving nursery management and screening new clones for pathogen resistance can reduce much of this mortality.

Soil invertebrate pests encountered during the regeneration of pine included whitegrubs, cutworms, the root feeding bark beetle (*Hylastes angustatus*), grasshoppers and termites. They generally caused low damage (up to 9.51%), except when pines were grown in close proximity to wattle plantations, where the incidence of whitegrub damage reached a maximum of 51.25%. The incidence of *H. angustatus* damage ranged from 0.25% to 5.83%, which strongly deviated

from earlier perceptions of its importance because the causes of high mortality in *P. patula* seedlings were ascribed to abiotic factors and site-species matching rather than *H. angustatus* damage. The inferred role of *H. angustatus*, as a vector of fungal pathogens during the regeneration of pine seedlings has further elevated its pest status.

The effect of different plantation residue management practices on the incidence of soil invertebrate pests was previously unknown. During the regeneration of wattle seedlings, a high incidence of cutworm damage was observed in the windrowed-burnt-ripped and fallow sites. There was a greater infestation of soil invertebrate pests on sites where the plantation residue was windrowed-burnt-weeded or 'broadcast' (20.34%) than in the other treatments [windrowed-burnt-ripped or fallow (mowed, manually weeded) 2.36%]. Similarly the burning of pine plantation residue, irrespective of whether it was windrowed or broadcast and completely burnt, resulted in high outbreaks of the root rot pathogen, *Rhizina undulata*, in all species of *Pinus*. Mortality because of *R. undulata* infestation developed only after burning, and ranged from about 16% to 48%. Windrowing and burning of the plantation residue is standard management practice in some pine production areas, and these results warrant a shift to the broadcasting of plantation residue.

The addition of a rip treatment to a depth exceeding 50 cm in the windrowed and burnt regime significantly reduced the infestation of soil invertebrate pests, especially whitegrubs, during wattle regeneration. Seedlings that were planted at a closer spacing in windrowed and burnt sites also had a lower incidence of soil invertebrate pest damage (7.79%). This has important management implications because windrowing and burning are standard plantation residue management practices, in wattle silviculture. Pursuit of sustainable silviculture warrants a move away from the burning of windrows (hot burns) to cool burns or the broadcasting of plantation residue. Planting in wattle and eucalypt sites is facilitated by the use of a tractor operated 'coultter ripper', which consists of a hydraulic cutting wheel and ripping tine on terrain with slopes of up to 40%. Planting in pine sites is facilitated by the use of a chopper roller after the plantation residue has been broadcast. Insecticide application is the alternative option.

The dominant soil invertebrate pest of wattle, eucalypts and pines is whitegrubs. Besides the effect of ripping during the regeneration of wattle, plantation residue management does not appear to affect the incidence of whitegrub damage. Whitegrub larvae are polyphagous and their distribution is related to the presence of host trees (pine, wattle) of the adult. This, therefore, necessitates the prophylactic application of an insecticide at planting in high risk areas. Such examples are where eucalypts are grown in close proximity to wattle, sugarcane and sometimes pine plantations, or when seedlings are regenerated late in the planting season, or during the regeneration of wattle and sometimes pines. Although the prophylactic application of an insecticide at planting is routinely practiced in some pine regions with the objective to control *H. angustatus*, its use is unwarranted. The routine use of insecticides in certified plantations is, furthermore restricted by Forest Stewardship Council (FSC) guidelines. Application for the relaxation of these rules are necessary in the case of whitegrub control in high risk areas until alternative control measures can be developed.

The certification of commercial forestry according to the FSC specifications has successfully occurred in many South African plantations and this trend is set to increase in the future. Various principles and criteria govern the management of insect pests in certified forests, which differ from traditional control measures. Regulations on the use of insecticides, biocontrol agents, monitoring, assessment and management of insect pests have become more specific. World Health Organisation type 1a and 1b, chlorinated hydrocarbons and persistent, toxic and bioaccumulative insecticides are prohibited. Only *Bacillus thuringiensis* is acceptable from the twelve or so insecticides currently used in forestry in South Africa. The use of biological control agents needs to be monitored and documented, but their future use, as a control measure needs to be minimised to avoid unanticipated side-effects. The general flora and fauna, and especially insect pest species must be regularly monitored and the results incorporated into an ongoing management plan. An integrated pest management approach for the control of insect pests is advocated but with restrictions on the use of insecticides and biological control. Although the FSC's management plan for the control of insect pests would certainly contribute to the sustainability of commercial plantations in future, it poses many challenges in the short term. For example, indigenous soil invertebrate pests during seedling regeneration can presently only be controlled with insecticides because of the polyphagous nature of the dominant pest.

South Africa has approximately 1.4 million hectares committed to commercial plantation forestry, which, besides soil invertebrate pests and pathogens, is also attacked by many post establishment pests. Three indigenous lepidopteran pests, (*Imbrasia cytherea cytherea*, *Pachypasa capensis* and *Euproctis terminalis*) regularly defoliate pine trees. All other pine pests are exotic. The pine weevil, *Pissodes nemorensis* damages the root collar region of saplings and causes dieback of the terminal shoots of established trees. The pine woolly aphid, *Pineus boernerii*, stunts tree growth. The exotic bark beetle *Orthotomicus erosus* infests stressed pine trees and is responsible for vectoring blue stain fungus. The pine wood wasp, *Sirex noctilio*, was introduced into the country and rapidly spread within the Mediterranean region, before invading the southern section of the summer rainfall area. Biocontrol using the parasitic nematode (*Deladenus siricidicola*) and hymenopteran parasitoids (*Ibalia leucospoides*, *Megarhyssa nortoni*) on the different life stages of *S. noctilio* is ongoing. Furthermore, monitoring and studies on the associated fungal symbiont (*Amylostereum areolatum*) with *S. noctilio* are areas of active research. Four exotic pests attack *Eucalyptus*. The eucalypt snout beetle, *Gonipterus scutellatus*, a defoliator, is under effective biological control by the egg parasitoid *Anaphes nitens*, but often fails at high altitude sites. The eucalypt tortoise beetle, *Trachymela tincticollis*, another defoliator, is also under effective biological control by an egg parasite (*Enoggera reticulata*). Two longhorn beetles, *Phoracantha semipunctata* and *P. recurva* damage the wood of stressed and recently felled trees. The egg parasitoid, *Avetianella longoi* has been established while several larval parasitoids (*Syngaster lepidus*, *Jarra maculipennis*, *Jarra phoracanthae*) are being evaluated for biological control.