TERMITES IN FORESTRY

Termites have a significant impact on plantation and urban forestry, as well as on agricultural tree crops. Many other insect pest species cause damage to various parts of the tree but often don't cause mortality. Some termite species, however, are able to kill apparently healthy trees and, therefore, have the potential to cause much greater losses. Even where termites do not cause death of the tree, they may cause damage to the bole, for example by consuming the heartwood and, thereby, hollowing the trunk and reducing the value of the tree as a source of timber. The extent to which termites are a problem to trees and the nature of loss they cause are very much related to the geographic region concerned. There are a number of current chemical control methods employed, however, a number of alternative, traditional control methods, largely relating to silvicultural practices or plantation management, are also very important, and should be considered before chemical intervention is attempted. Some of these control strategies are also applicable to urban forestry.

Urban Forestry

In urban forestry, where trees are planted in highly populated areas along streets or in parks, special consideration needs to be given to the types of control strategies that are applicable, because of the environment the trees grow in and the proximity to human dwellings. A number of current chemical control methods are employed, but these have a relatively high environmental impact, and many governments generally refrain from these chemical control methods in urban areas. Some alternative traditional methods of control such as the use of species suitable for a region, use of resistant tree species, reduction of mechanical damage, maintenance of plant vigor and inter-planting may be applicable in some circumstances, depending on the termite pest species in the geographic region concerned. Additionally, some new and potential alternative control methods, such as baiting systems, hold a lot of promise for managing termites in urban plantings.

Termite Pests and Management

Southeast Asia

In Southeast Asia, the termite species responsible for most losses in agricultural tree crops and forestry is the subterranean termite, *Coptotermes curvignathus*, which has the ability to kill healthy trees. Only one other species in the region can attack trees, *Microcerotermes dubius*. The latter species is only very occasionally a problem in forest plantations, because its aerial nests are more readily destroyed than the subterranean nests of the former species. *Coptotermes curvignathus* attacks a wide range of tree species, but some tree species are more resistant to be attacked by termites than others.

In Indo-Pak semi-arid regions like in Punjab, termites such as species of genera Odontotermes (*O. obesus*, *O. guptai*), Microtermes (*M. obesi*, *M. pakistanicus*, *M. mycophagus*), Coptotermes (*C. curvignathus*) and Macrotermes (*M. bellicosus*) are common and important agents of tree mortality in young plantations throughout the tropics. However, in Australia, termites cause most damage by feeding in the heartwood of trees, causing significant losses in wood volume and downgrading potential sawlog into lower value pulpwood.

C. curvignathus usually builds mud and carton sheaths around the bases of trees that it attacks, and undermines the bark beneath with numerous perforations into the living tissue, eventually killing the tree as a result of impaired food transport from the crown above to the root system below. Sometimes it may first penetrate into the heartwood before working outwards to kill the tree in the same manner.

Forest plantation tree species attacked by *C. curvignathus* in Southeast Asia include pines and all other species of conifers, which are particularly susceptible, rubber trees (*Hevea brasiliensis*), sal tree (*Acacia mangium)*, white albizia (*Paraserianthes falcataria)* and white teak or Kashmir tree (*Gmelina arborea)*. Most species of conifers suffer high mortality when attacked by this termite species. *Acacia mangium* is more commonly infested within the heartwood, through pruning wounds, than killed by the termite. Nevertheless, healthy trees can still be killed, although the mortality is much lower than in conifers. Teak (*Tectona grandis*) is relatively resistant, but has problems with the drywood termite, *Neotermes tectonae*. In addition, many species of trees planted in urban areas are also attacked.

Alternative Management Systems of Termites in Forestry

Current chemical control

A number of chemical control methods are currently used to protect trees against attack by termites. These methods have remained largely the same over the years, although the chemicals used have changed to reduce the environmental impact of these treatments. Many, or all, of the organochlorines, which are persistent organic pollutants, are no longer registered for

use in most countries. Current chemical control methods employed are soil treatment, treatment of seedlings before transplanting and baiting techniques.

Soil treatment

Soil treatment to protect trees from attack by termites involves the application of chemicals to the soil surrounding the base of the tree. This may be done at the time of transplanting seedlings from the nurseries into the field, or it can be done to trees already in-ground. In the former, granular formulations of insecticides (e.g. fipronil) are usually used, since they are easy to carry into the field, and they are applied into the planting hole. In the latter, the soil at the base of the tree is removed to form a cavity or trench around the tree, and liquid-based chemicals are poured in and allowed to seep into the ground by gravity and capillary action. The cavity or trench is then filled over with the soil originally excavated from around the tree, and treated as well. Chemicals currently used include chlorpyrifos, imidacloprid and fipronil.

Treatment of seedlings before transplanting

Treating seedlings before transplanting reduces the labor involved in field-based treatments, but provides less protection to the seedlings. The seedlings are usually prepared with granular insecticide mixed into the soil at the time of planting in the nursery.

Baiting techniques

Aggregation and baiting techniques, using the POP (persistent organic pollutant) chemical 'Mirex' as the active ingredient, are used primarily in many countries like Australia, India as a management measure for forest trees' termites infestation.

Alternative control: traditional methods

Many traditional methods of control of termites in forest plantations have a sound basis in the principles of ecology. They are often simple and cost effective means of minimizing termite problems through silvicultural practices that involve thoughtful planning before establishing a plantation and suitable practices following establishment. These, some of which are inter-related, are listed below:

- Selecting Low-Risk Sites
- Use of Species Suitable for a Region
- Resistant Tree Species
- Reduction of Mechanical Damage
- Maintenance of Plant Vigor
- Removal of Nests
- Increasing biodiversity
- Inter-Planting

Selecting low risk sites

Termite pest species have their own native habitats in which they are most abundant. For example, in Southeast Asia, the tree-killing termite species, *C. curvignathus*, is abundant in peat swamps. The abundance of termite species in particular plantation sites is often, therefore, reflective of the history of the site. Plantations established in areas once occupied by peat swamps in Southeast Asia often have a relatively high incidence of attack by *C. curvignathus*. One way of avoiding the problem of termites in forest plantations is not to plant susceptible species of trees on sites known to be high-risk.

Use of species suitable for a region

Tree species-site matching is an important aspect of termite management. Trees grown in regions to which they are not suited may be more stressed and, hence, more prone to attack by termites. *Acacia mangium* for example, which is widely planted in parts of Southeast Asia, does better in a climate with a marked season, such as a wet and dry season. In other areas, it tends to develop a bushy growth form, which requires more pruning and predisposes the trees to attack as a result of mechanical injury to the trees. Terrain, climate and soil properties (physical and chemical) should be suitable for the tree

species chosen; bearing in mind its native habitat and its degree of tolerance outside the conditions in which it naturally grows.

Resistant tree species

Some tree species are naturally resistant to certain termites. However, a tree species that is resistant to one termite species may not be resistant to another. Thus, it is important to identify the termite pest species that is a problem in the geographic area concerned. In Southeast Asia, *C. curvignathus* is the primary species that kills trees in plantations, and it has a wide host range.

Reduction of mechanical damage

Reducing mechanical damage to trees can minimize damage by termites. Such mechanical damage can occur from pruning wounds, or during weed control or thinning operations, especially where heavy machinery is used. Wounds and scars on tree trunks or branches serve as entry points for termites into the heartwood of the tree, sometimes after fungal infections of the wounds. Termite species that kill trees, such as *C. curvignathus* in Southeast Asia, may also preferentially attack trees with wounds, and may locate trees by the exudates that flow from such wounds or dissolve in rainwater. All wounds should be treated with a wound dressing, but minimizing any form of mechanical damage to trees is advisable, as wound dressings do not adequately prevent fungal and termite infestations.

Maintenance of plant vigour

Besides mechanical injury, it is thought that stress also predisposes trees to attack, therefore, maintaining plant vigor is an important means of minimizing damage by termites. Healthy trees are likely to be less readily attacked by termites. Trees under water or nutrient stress, or deprived of sufficient light, due to overly high planting densities or lack of thinning, may be more prone to attack. At the extremes of such conditions, termites that are not normally pests of plantation trees may cause damage or even accelerate death of the trees. But it is also likely that termites that have the ability to kill healthy living trees may preferentially attack stressed trees growing under poor conditions. For similar reasons, reduction of mechanical damage to trees due to silvicultural practices is also important. Selecting trees that are suited to the region in which they are planted is also an integral part of ensuring that plant vigor is maintained.

Removal of nests

Termite nests that are easily visible can be removed manually, thus reducing their population. This has been used in South America to control arboreal nesting species, particularly Nasutitermes, which may occur in high densities on fruit trees. It is also applicable to *Microcerotermes* sp. in Southeast Asia, which may occur very occasionally in forest plantations. Likewise, drywood termites, such as *Neotermes tectonae* on teak, can also be controlled by removal of affected branches.

Increasing biodiversity

Taking measures to increase biodiversity may increase competition from non-pest termite species and, thereby, reduce populations of pest termite species. For example, in Southeast Asia established colonies of the pest termite species, *C. curvignathus*, have a competitive edge over other termite species in plantations of susceptible tree species because of its ability to kill trees. However, encouraging a diversity of termite species in forest floor wood litter may reduce nesting opportunities for new founding colonies and, in the long term, reduce the population of the pest termite species. In addition to providing increased competition against termite pest species, increasing biodiversity can also increase natural enemies of termites, such as ants. Measures that can be taken to encourage biodiversity in forest plantations include inter-planting, retaining a litter layer, retaining ground cover, encouraging rapid canopy closure and reducing pesticide usage.

Inter-planting

When tree species susceptible to termite attack are to be used, inter-planting them with resistant species may help reduce the overall incidence of attack in the plantation and, consequently, limit the build-up of the termite pest population. Inter-planting may also help reduce attack on susceptible tree by making it more difficult for the termites to locate them. It also helps increase biodiversity in the plantation, which may help reduce populations of termite pest species.

Alternative control: new and potential methods

A number of novel methods of termite control have been recently introduced, or may be introduced in the future. These are:

- Resistant tree varieties & genetic engineering
- Biological control

- Baiting systems
- Treatment of soil and seedling with new generation insecticides

Resistant Tree Varieties & Genetic Engineering

The development of resistant tree varieties through breeding programs and genetic engineering is still at an early, exploratory stage, and is hampered by the long rotation periods of forest plantation trees in comparison to annual agricultural crops. However, it may become an important means of protection against termites in the future. Genetic engineering for resistance usually involves the introduction of genes from insect pathogens, such as bacteria, into the tree, which then expresses pathogenic characteristics towards insects. The environmental implications of such genetically modified organisms in agriculture and forestry are controversial and still largely unstudied. Some studies indicate that they may carry a set of environmental problems of their own. Use of timber that is naturally resistant to termites such as turpentine tree, teak, white cypress etc. could be effective. But usually no tree species has every individual tree yielding only timbers that are immune to termite damage, so even with well-known termite-resistant timber types, some pieces occasionally will be attacked.

Biological Control

Biological control of termites has largely focused on the use of fungi (e.g., Metarhizium) and nematodes. It is not easily achieved in the field because of the tendency of termite colonies to cut off and avoid infected areas as soon as disease sets in. Nevertheless, such biological control agents can be a substitute for chemicals when they are used to control local infestations. The use of these agents against termites is an area of active research and, in the future, methods may be developed for colony elimination using biological control agents. Trials using the entomopathogenic nematode, *Heterorhabditis* sp., have given encouraging results for the control of many termites in Australia. Also, initial studies indicate that Neotermes colonies attacking Mahogany in the South Pacific Islands can be eliminated by both the fungus *Metarhizium anisopliae* and the nematode *Heterorhabditis* sp.

Baiting Systems

Baiting systems using active ingredients such as moult (chitin synthesis) inhibitors, have become widely used in the control of termites affecting housing. They are effective in eliminating colonies when used consistently over an extended period of time. However, their application against termite pests in agriculture and plantation or urban forestry has not yet been widely developed or specifically tailored for the purpose. They would almost certainly prove to be effective against subterranean pest species from among the lower termites, such as Reticulitermes and Coptotermes. Systems specifically designed for the treatment of termites on trees will probably become available in the future, and will be a low-environmental-risk chemical method of control, because the chemicals can be targeted specifically at pest species of termites in baiting receptacles. Bait systems have already been tested and have shown promising results against *Reticulitermes santonensis* in Paris, where city officials are also co-operating with the Centre National de la Recherche Scientifique (CNRS) in a pilot study to investigate colony and population structure using molecular and chemical markers. Hopefully this knowledge will lead to a better understanding of the pest's invasion strategies and allow development of effective targeted control measures for Paris and other big cities.

Treatment of Soil and Seedlings with New Generation Insecticides

Soil treatment and the treatment of seedlings before transplanting have been used as classical methods of control and prevention of termite attack in forest plantations for many years. These methods of control have a high environmental impact because of the large amounts of insecticides that have to be applied in open areas that are exposed to leaching. In recent years, new generation insecticides that are active at very low doses have become available. These chemicals generally also have a low toxicity to other life forms. When chemical treatment is deemed necessary, such chemicals provide an environmentally preferable alternative to traditional chemicals. Examples of these new generation insecticides are imidacloprid and fipronil. However, before adopting a chemical means of control, alternative, traditional methods of control should be considered.

Arboreal nest

Infestation in living tree trunk

Nest within dead wood-log