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Full Length Research Paper

Coconut seedling (*Cocos nucifera*) losses due to termite pest species and possible control measures

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Subterranean termites are major pests of various food and cash crops in tropical and subtropical regions causing serious seedling losses. If control measures are not applied, losses ascribed to termites is estimated at 20%. The aim of this study is to assess coconut seedling (*Cocos nucifera*) losses due to termite pest species and to suggest possible control measures. Assessment of termite damage to coconut seedlings was conducted in established coconut nurseries at four villages (Nyambili, Pagae, Mtawanya and Nambunju) over a period of one year. Hand sorting was carried out from twenty seedlings foraged by termites and to identify termite pest species present in the coconut nurseries. The common pest species were *Microtermes*, *Pseudacanthotermes, Macrotermes* and *Odontotermes*. Infestation from these species was diverse but the most serious parts affected were plant roots, tunneling in root collar, wilting and eventually death of the seedling. Seedlings with physiological stress were uprooted to identify termite species related to the death. Losses caused by *Pseudacanthoermes, Microtermes* and *Macrotermes* ranged from 20-100%. Termite pest species abundance from coconut nurseries was significantly different. This study provided information on termite pest in coconut nurseries that can be used for development of sustainable and socially acceptable termite control measures.

Key words: Foraging, termite pest species, coconut seedlings, dry season, wet season, Rufiji district.

INTRODUCTION

Termite foraging activities are well known to concentrate on dead wood and soil with rich organic content causing serious loss in crop land habitats. Of all known termite species, only 300 species are known as destructive pests in agriculture. Termite families known to occur in tropical forest and grassland savannah areas worldwide include *Mastotermitidae, Kalotermitidae, Hodotermitidae, Termopsidae, Rhinotermitidae, Seritermitidae* and *Termitidae* (Krishna and Weesner, 1970). The most economically important termite genera in agricultural and forest areas are *Macrotermes, Allodontermes, Amitermes, Pseudacanthotermes, Odontotermes, Ancistrotermes, Trinervitermes, Hodotermes* and *Microtermes* (Mitchell, 2002; Kumar and Pardeshi, 2011). The decline of plant species heterogeneity in coconut farms and nurseries is suggested to be related to the decline of termite species richness which is considered to be poor in conservation (Barros et al., 1999).

There has been a growing concern on termite problems in Rufiji district despite their major role in improving the soil fertility. Coconut is a major cash crop in the district, as well as source of vegetable oil and several other by-products. Farmers in Rufiji district, who are mostly subsistence farmers, previously indicated that termite pest problems tended to increase after the forest was opened for food and cash crops. The main crops cultivated by these farmers are food and cash crops which include maize, cassava, rice, cashew and coconut.

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Although some termite species are known to be pests of agricultural crops, forest trees and grasslands (Mitchell, 2002), termites are beneficial to humans, ants birds and the environment (Edwards and Mill, 1986). Termite damage of young tree seedlings is very common in coconut-growing areas since they are often subjected to moisture stress after transplanting (Harris, 1969; Tho, 1974; Johnson et al., 1981; Logan, 1992; Bong et al., 2012). Damage to older coconut trees is not as serious but it may hinder the rate of plant growth. Signs of seedlings attacked by termites are wilting of the central shoot as termites feeding on the nut tunnels up to the collar. Little information is available on the relationship between termite populations, crop damage and factors which influence pest and non-pest species abundance in coconut nurseries and new transplants. The purpose of this study is to present preliminary studies on termite pest abundance and damage to coconut seedlings and to identify termite species response.

MATERIALS AND METHODS

This study was carried out, in selected coconut farms in Rufiji district located 178 km south of Dar Es Salaam and covers an area of about 53,000 km^2. The study area lies between 7° 27´S - 8° 27´S and 37° 52´E - 39°28´ E. The study area was 300 msl and is characterized by hills, plains, varying soil types, and vegetation ground cover.

Despite having a bi annual rainfall, the district is characterized by variable rainfall patterns. Temperatures range between 25 to 35°C and are highly influenced by monsoon winds, which bring rains from March to June followed by short rains in October to December. The district gets an average rainfall of about 1,100 mm per annum.

Experimental plots were established at four villages namely: Nyambili, Pagae, Mtawanya and Nambunju. Fifty local East African Tall (EAT) seed nuts were sown in each plot without fertilizer except regular weeding on monthly interval. In each nursery, two rows with ten seed nuts were used for data collection. Coconut seedlings were sown at spacing of 30 × 20 cm. Source of planting material was obtained from old coconut trees aged more than twenty years at Mtawanya and Nambunju villages.

During data collection, termites were hand sorted randomly to a depth of 10 cm below the soil surface (Silva and Martius, 2000). Only three middle rows were used for data collection. Presence or absence of termite damage on coconut seedlings or foraging underneath mainly cutting the roots, tunnels along the stem filled with soil upwards to the collar followed by wilting was considered as damage symptoms.

Damaged seedlings with physiological stress or non-germinated coconuts were uprooted using a hand hoe after three months to examine number of individuals and species type. Termite soldiers were collected and preserved in 70% alcohol in specimen vials for laboratory identification. Each plot was examined and scored for termite foraging or damage from sowing date to transplanting stage. The incidence of termite attack was recorded at monthly intervals. Termite damage or intensity of activity was rated using a scale of 0-5 whereby: 0 = no damage; 2, 3 and 4 = medium damage; and 5 = high damage).

0 - Healthy seedling with no sign of damage;
1 - One coconut leaf attacked by termites;
2 - Two leaves attacked by termites;
3 - Three leaves attacked by termites;
4 - Four coconut leaves attacked including spear leaf and
5 - Coconut seedling killed by termites.

Coconut seedling damage due to termites was calculated using the following formula:

$$Di = (ni \times 100)/N$$

Where Di = Percentage seedling dead, n = number of coconut seedlings dead, N = Total number of seedlings assessed. One way analysis of variance was used to check termite pest abundance.

Taxonomy

Termites species collected were examined under microscope using identification keys (Bouilon and Mathot, 1965; Pearce et al., 1992). Termites without soldiers were excluded from the analysis.

RESULTS

There was a distinct rainfall pattern, characterized by a wet and dry season in the district whereby the long rainfall season was from the end of February to May. The short rainfall season was from November to December whereas the long rain season was from mid March to end of June. The mean rainfall data were used to assess whether or not there was any correlation between termite abundance and amount of rainfall during the wet season. The district received the highest rainfall (187.1 mm) in March. During the short-rains season in November, the lowest amount of rainfall received was 3.2 mm and the highest was 10.3 mm in December 2011.

As regards infestation during the rainfall season (February to May), there was no infestation recorded (Figure 1). However, there was a rapid increase in the numbers of termite pest species towards the end of the rainy season. Similarly, at lower bottom valley, infestation was not observed at Nyambili coconut nursery even during the dry season unlike in the old coconut farms at Mtawanya and Nambunju where 20% of the coconut seedlings sown in the nurseries were damaged. At Pagae coconut nursery on the other hand, *Microtermes* termite infestation was more severe and losses were up to 100% (Figure 2). Termite pest species abundance from different coconut nurseries were significantly different (P =

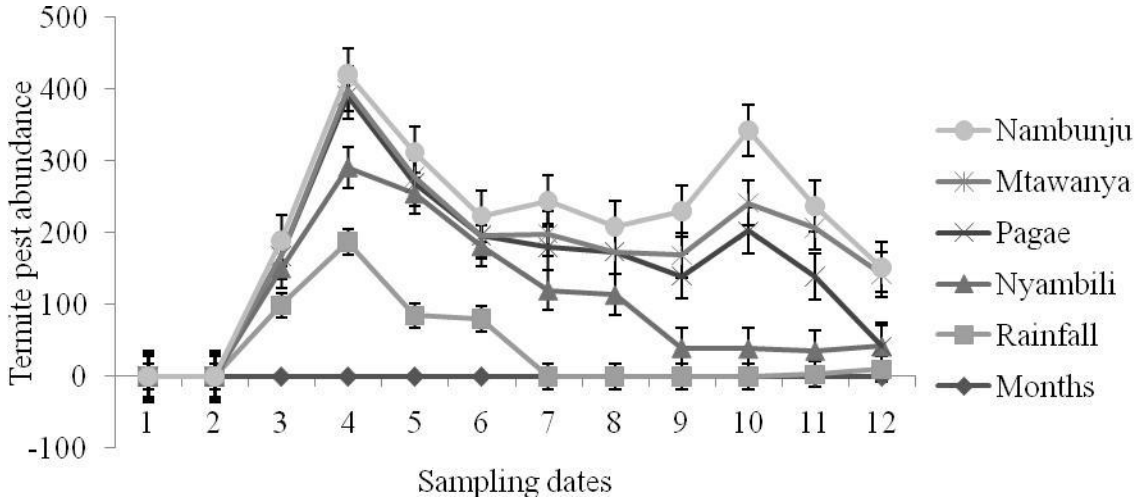

Figure 1. Mean of termites abundance and cumulative rainfall during the study period.

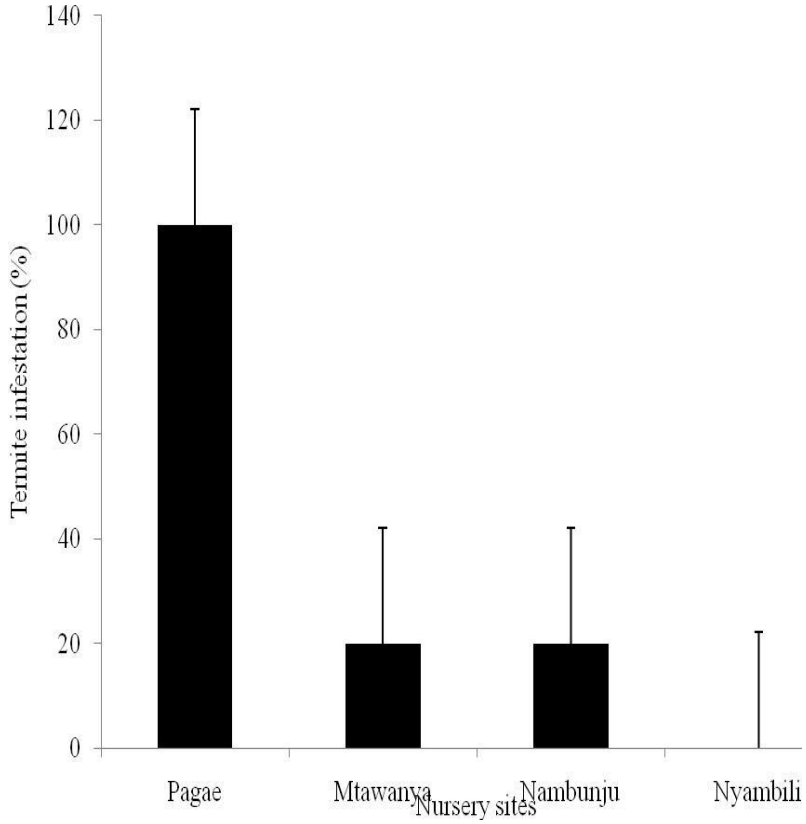

Figure 2. Termite pest species infestation in coconut nurseries in Rufiji district.

0.0001).

The common termite pest species recorded from Nyambili coconut nursery were *Odontotermes, Pseudacanthotermes, Macrotermes* and *Microtermes.* On the other hand, three species were recorded from Pagae namely *Macrotremes*, *Pseudacanthotermes,* and *Microtermes. Microtermes* was more abundant than *Macrotermes* and *Pseudacanthotermes.* Furthermore, at

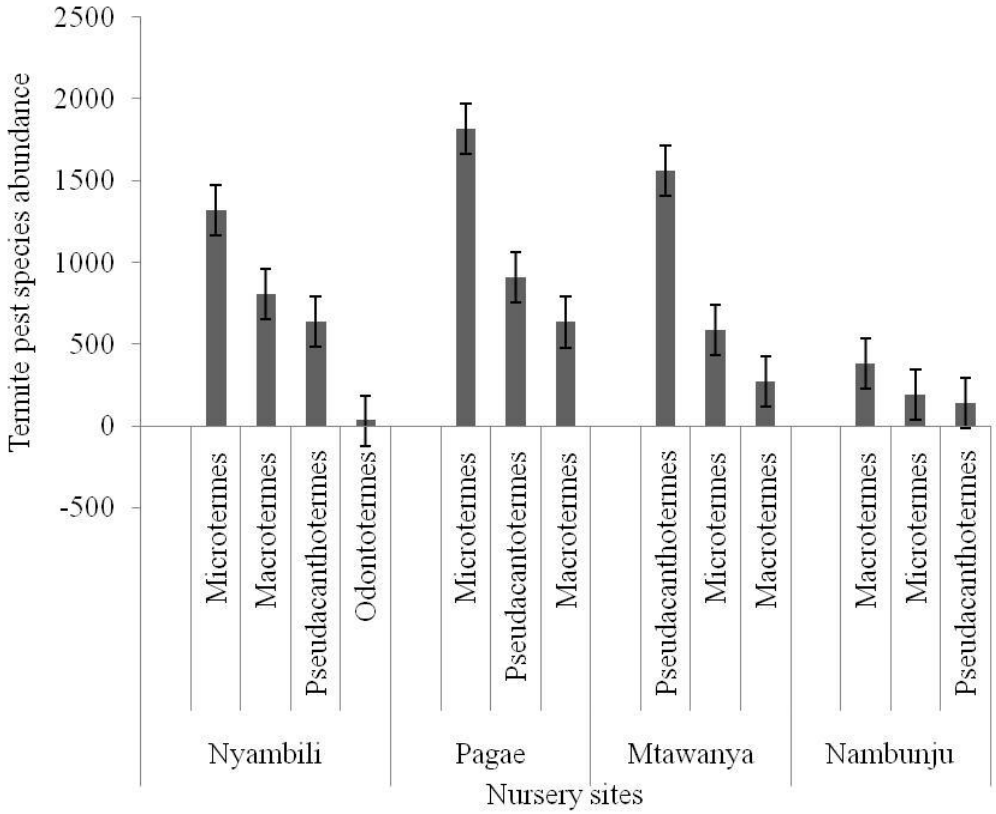

Figure 3. Common termite pest species recorded from different coconut nurseries established in Rufiji district.

Table 1. Termite pest species recorded from coconut nurseries and their mode of infestation.

Termite species	Roots	Collar	Wilted seedling	Dried seedling
Microtermes alluaudanus	+++	+++	+++	+++
Pseudacanthotrmes militaris	+++	+++	+++	+++
Macrotermes bellicosus	++	++	++	++
Odontotermes amanicus	+	=	=	=

Damage level: - = low or nothing; + = medium; +++ = high.

Mtawanya, *Pseudacanthotermes* was more abundant than *Macrotermes* and *Microtermes*. Results from Nambunju coconut nursery revealed that *Macrotermes* was more abundant than *Microtermes* and *Pseudacanthotermes* (Figure 3).

Mode of infestation

Termite pest species infestation was observed to vary from each other depending on the season. During wet season, the presence of termite pests were recorded but with no severe damage on coconut seedlings. Mode of infestation were categorised into three levels as low, medium and high (Table 1).

DISCUSSION

Incidence of termite attack to coconut seedlings

Both sown seed nuts and germinated seedlings of the local coconut variety were susceptible to termite infestation depending on availability of soil moisture. Termite infestation of coconut seedlings was highest during the dry season particularly between August and

September when the moisture stress was highest. Termites attacked coconut seedlings only after they had shown signs of wilting during the dry season. Moisture stimulates growth of vegetation ground cover which attracts termite foraging activities (El Bakri, 1986). During the short rain season between November and December, there was plenty of food for termites provided by crop residues like dead cassava stems or cuttings, maize straws, dead coconut leaves, dead tree brunches and stumps, fallen wooden logs.

Termite foraging activity was highest between February and May when their abundance increased due to excess rainfall which provided good vegetation. During this time, there was no incidence of termite attack on coconut seedlings because termites fed on alternative food types. Seedlings in the nursery site located at the valley bottom with high soil moisture content throughout the growing season were able to escape termite infestation. Adequate soil moisture supported not only healthy growth of coconut seedlings but of other vegetation type preferred by termites. This suggested that during wet seasons, termites do not cause severe damage or losses to endemic crops including coconut and that is why farmers ignore damage related to these species in their farms during the wet season. Seedlings grown in drier habitats are likely to be more prone to high termite incidence and attack. Damage by termites was therefore greater during dry seasons or droughts than during periods of regular rainfall at Pagae.

Ugandan and Kenyan farmers also consider termite damage to be more severe in the dry months compared with the wet months (Sileshi et al., 2005). Ground foraging galleries or viable termite mounds were indicators of termite presence.

Pseudacanthotermes, Microtermes and *Macrotermes* were considered as pest in coconut nurseries (Figure 3). In fact, of all known 2600 termite species, only a few of them are considered pests of economical importance with regard to agricultural crops in the world (Harris, 1971; Cowie and Wood, 1989). Sustainable termite management can be achieved by integrating ethno-ecological and scientific knowledge of termites. Farmers' knowledge, for example can be enhanced to control termites in maize production in semi arid tropical areas (Wood et al., 1980; Reddy et al., 1994). Farmers can apply their knowledge in pest management (Sekamatte et al., 2003, Sileshi et al., 2005). Such knowledge was applied to control termites in Kenya (Malaret and Ngoru, 1989). Cultural practices like regular weeding, early planting of coconut seed-nuts and transplanting is essential to allow good establishment of the seedlings before the dry season. Studies carried out in south-eastern Nigeria have shown that termite damage to yams and cassava can be effectively controlled by cultural methods, for example by reducing competition with weeds and maintaining plant vigor concurring with other studies (Atu, 1993).

Seasonal termite seedling damage and rainfall patterns

Losses of coconut seedlings varied from one location to another. Losses ranged from 20% and rose to as high as 100% during the same period. Among the identified termite pest species, were found in patches infesting coconut seedlings therefore management strategies should be focused on the infested areas. Blanket recommendation on termite control in cropland and forest areas should be discouraged because of poor occurrence of termite pest species in cropland habitats which makes such recommendations uneconomical. Furthermore, not all termite species are considered as pests in agricultural production. Disturbance of any sort may increase predation especially for *Macrotermes, Microtermes* and *Pseudacanthotermes* not only in cropland but also in the grassland and forest habitat. Disturbance is also known to increase competition for food particularly among wood feeding termite species (Filho, 2005).

Effect of regular weeding in coconut nurseries on termite pest

Hand hoe tillage operations in the coconut nurseries change soil conditions as they involve breaking galleries connecting to food sources and expose termites to the soil surface. The thick coconut and citrus tree canopy in cropland habitats probably encourages predation but also increased termite food resources and hence reduced their infestation of coconut seedlings. Furthermore, leaving crop residues as mulching can maintain soil moisture and at the same time can be used as alternative termite food. The presence of mulch layer together with other plant materials has been shown to influence the soil characteristics and termite species composition (Brusaard and Jumas, 1996; Black and Okwakol, 1997). Studies carried out in Mbalmayo Forest Reserve, Southern Cameroon, showed that termites differ in abundance and biomass under different levels of disturbance (Eggleton, 1996).

Mulching or leaving crop residues in coconut nurseries and other common crops, for example results into higher soil organic matter and increased termite activity. Regular mulching is important in improving soil moisture content and also maintains plant health (Bhanot, 1994). Leaving crop residues and uprooted weeds as mulch in a maize crop intercropped with coconut leads to increase in the abundance of termite pest species, that is, *Macrotermes, Microtermes, Odontotermes* and *Pseudacanthotermes.* In Sudan, the availability of good moisture or rain stimulates different vegetation ground cover on termites forage (El Bakri, 1986). Studies on association of termites with fungi showed that the association enables termites to digest the low quality fodder materials including crop residues (Tian et al., 1993) and influences species turn over which is the change of species composition reflecting the

changes in natural habitat to agricultural activities (Gilbert, 1980).

Minimizing tillage operations through intercropping of coconut with other tree crops is a common approach used by farmers to maximize land use and at the same time to reduce risk of crop failures. Furthermore, intercropping coconut with other crops increases plant species diversity which influences termite species abundance and reduces crop infestation as well as the cost of production. In eastern Zambia, some legume trees in agro forestry reduced termite damage to maize than on mono cropping in nitrogen limited soils (Sileshi et al., 2005). Studies carried out in Uganda and Zambia on application of the ethno-knowledge showed that cultural control measures are effective in the control of soil pests including termites (Sekamatte, 2003; Sileshi et al., 2005).

Conclusion

During the study period, it was concluded that *Macrotermes, Microtermeres, Odontotermes* and *Pseudacanthotermes* species were observed to be attacking both live and dead plants from the selected study areas. Infestation due to *Macrotermes* spp to young coconut seedlings was from the sowing period in contrast with other studies reported by Wood et al. (1980). In all coconut nurseries, the degree of damage from termite pest species was higher during the dry season from June to September. Infestation of coconut seedlings was higher due to moisture stress in contrast with Collins (1984).

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