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*Original Article*

# Incidence of Pests and Diseases in Tree Nurseries and Plantations in Kimondi Forest, Nandi County, Kenya

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## ABSTRACT

Increasing demand for wood is putting pressure on forest resources that are equally under threat from insect pests and diseases. Reported average annual forest loss stands at 0.2% globally, 0.8% in Africa, and 1.6% in Kenya. To meet the increasing demand for forest products in Kenya, the government and private sector have established plantations of non-native tree species dominated by *Eucalyptus species*, *Cupressus lusitanica*, and *Pinus patula*. To ensure successful forest plantation establishment and management schemes, there is a need for sufficient knowledge and understanding of tree growth conditions and threats including pests and diseases. This study aimed at determining the incidence of plantation and tree nurseries in Kimondi Forest, Kenya. Tree plantations were mapped into 2.5 Ha rectangular portion transects parallel to the forest roads. In randomly selected portions, observations were carried out for disease and pest signs and symptoms on various tree parts (leaves, stem, roots, fruits, and twigs). In the tree nurseries, 3 m × 1 m rectangular quadrants were placed on seedling beds and similar observations were made. Collected data indicated a high incidence of nursery seedling pests (5.3 % leaves and 5.1% stems) on *Eucalyptus species* and least on *P. patula* (2.4% leaves and 3% stems). Higher incidence of plantation pests (35.0% leaves of *Eucalyptus sps.*) and least on *P. patula* stems (1.2%) were recorded. On the other hand, twelve (12.0%) of *C. lusitanica* and (1.8%) *Eucalyptus species* plantation twigs were infested by pests. A high incidence of nursery seedling disease (9.8%) was observed on *C. lusitanica* leaves and least on *P. patula* stems (3.6%). Higher incidence of plantation diseases (32 %) on leaves of *Eucalyptus sps.* and least on *C. lusitanica* stem (1.4%) was recorded. In both tree nurseries and plantations, roots and fruits remained free from pests and disease. Major tree

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pests and diseases identified in Kimondi forests include (Human, wildlife, livestock, Cinara cupressi, G*onipterus scutellatus*, *Pinus pini*, and *Leptocybe invasa*) and (damping-off, *Fusarium wilt*, *Botryosphaeria* canker, cypress canker, and Mycosphaerella spp.) respectively. These results suggest a need for regular monitoring and intervention measures to control pest and disease infestation in the Kimondi forest.

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## INTRODUCTION

Increasing demand for wood and wood products has exerted pressure on natural forest resources throughout the world (FAO, 2007). These resources are currently under threat due to other factors including clearing forest land for agricultural production or settlements. According to FAO (2007), the world average annual forest losses stand at 0.2%, while that of Africa is about 0.8%.

The need to accommodate the increasing demand for tree products such as fibre and wood in Africa has therefore led to an increasing establishment of forest plantations using non-native tree species such as *Eucalyptus*, *Cupressus lusitanica* and *Pinus patula* species (Evans, 1992). These plantations have an important economic and social bearing for several countries in Africa providing a source of employment, wealth creation, the production of export capital as well as fuel and construction timber (FAO, 2007). Despite their importance, forest plantations using non-native species (exotic) are fragile and face unique threats mostly from pests and disease (Wingfield *et al.*, 2001; Cock, 2003) due to a limited genetic base (Wingfield *et al.*, 2008). Documented examples of major disease outbreaks in the history of forest plantations include Dothistroma needle blight of *Pinus* species in Chile, New Zealand and Kenya (Gibson, 1975); *Phytophthora pinifolia* in Chile (Durán *et al*., 2008); conifer aphid (*Cinara cuppressivora)* on Cupressus species in Eastern and Central Africa (Murphy, 1998; Day *et al*., 2003); the sirex wood wasp (*Sirex noctilio*) on Pinus species in South Africa (Tribe, 2003; Hurley *et al*., 2007), and the blue gum chalcid (*Leptocybe invasa*) on *Eucalyptus* species in many countries in Africa, Asia, the Middle East and Europe (Mutitu, 2003; Mendel *et al*., 2004; Nyeko, 2005; EPPO, 2006). *Dothistroma septosporum* led to the termination of *P. radiata* planting in many African countries, particularly those in East Africa (Gibson *et al*., 1964; Barnes *et al*., 2004). Similarly, the susceptibility of *Eucalyptus* to the snout beetle, *Gonipterus scutellatus* and *Mycosphaerella* leaf disease led to the partially discontinued planting of

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this species in South Africa (Lundquist et al., 1987). The afforestation examples illustrate how forest pests and diseases raise serious concerns to developers of tropical tree plantation enterprises. Unfortunately, FAO observed that many people working with trees do not pay systematic attention to tree health until trees have died and it is too late for intervention (FAO, 2003).

Outbreaks of serious pests and diseases may still be a major threat to future plantation development in Kenya. Example devastating outbreaks of Psyllid, *Heteropsylla cubana* in plantations of *Leucaena leucocephala* in South East Asia, *conifer aphids* in plantations in East Africa and *eucalyptus* leaf diseases are only recent history (Nair, 2000).

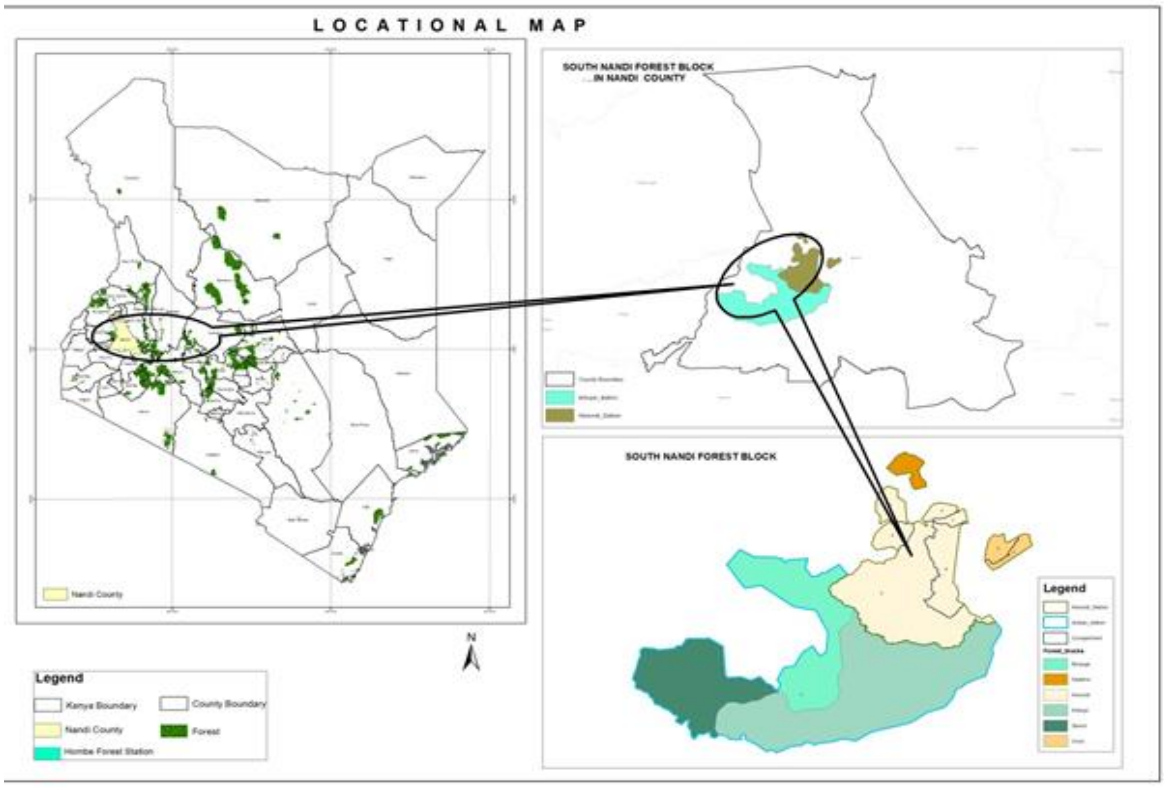
In order to contain pest and pathogen problems, there is a need for knowledge and information regarding the occurrence of nursery and plantation insect pests and diseases. This study aimed at evaluating the incidence of pests and diseases of tree nurseries and plantations of Kimondi Forest, Nandi County, Kenya.

## RESEARCH METHODOLOGY

### Study Area

This study was carried out in the Kimondi forest located in Nandi County, Kenya (*Figure 1*). It lies on latitude $0^0$ 18' and $0^0$ 32' N and longitude $37^0$05' to $37^0$23' E in the North Rift Conservancy. The soils are characterized as very shallow to deep and dark yellowish-brown to very dark brown, respectively. Soil types range from friable sandy loam to sandy clay loam and friable gravelly sandy clay loam to sand clay with 5 – 50% fine to medium iron and manganese concentrations (Otieno *et al.,* 2014)).

**Figure 1: Map of the Study Area**




**Source*:*** Adopted from KFS.

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The Kimondi forest is mainly drained by both Kimondi and Sirua rivers which merge further downstream to form River Yala that finally flows into Lake Victoria (Mitchell, 2004). The forest is the source of water for the recently inaugurated Nzoia cluster II water project (supplies water to Kakamega town and its surroundings) and the Kobujoi water supply project (supplies water to Kobujoi and its surrounding) (Simon *et al.,* 2016). Other rivers that drain water out of the Kimondi forest include Mokong, Orobo, Kundos, Gorgor, Chemogonja and Cheptaburbur. These rivers are perennial and therefore provide water for domestic and industrial use by the adjacent forest communities as well as have waterfalls, which can be harnessed for hydroelectric power generation (District Development Plan, Nandi South 2008-2012, GoK, 2008).

**Target Population**

The study targeted pests and diseases in both tree nursery seedlings and plantation species of *Cupressus lusitanica* (678.3 Ha), *Pinus patula* (147.5 Ha) and *Eucalyptus species* (48.8 Ha).

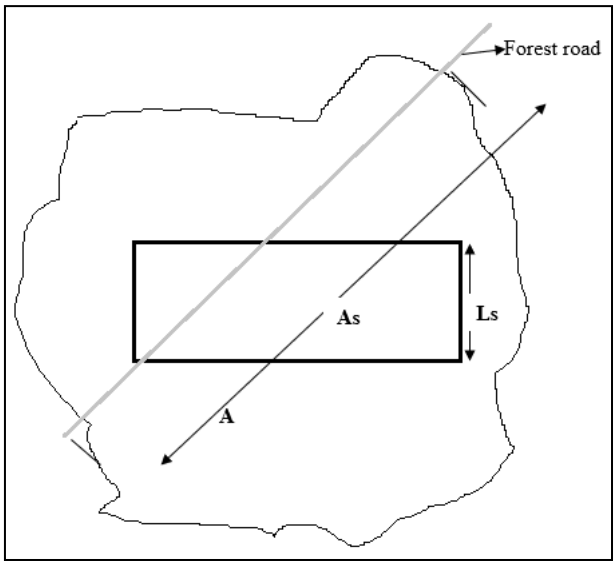
***Sampling in Tree Nurseries***

Tree seedlings within 10 portions of size 3 m × 1 m were sampled for this study according to Sokal and Rohlf (2012) as follows: Nursery beds of the three tree species (*C. lusitanica*, *P. patula*, and *Eucalyptus species*) were separately divided into equal portions of 3 m by 1 m along the nursery lengths. Each portion was numbered; then, 10 portions were randomly selected for the purpose of this study. Incidence of nursery pests and diseases were observed on the roots, leaves and stems of the seedlings within each portion.

***Sampling in the Forest Plantations***

The targeted plantations (*Eucalyptus, C. lusitanica* and *P. patula)* were separately mapped into 2.5 Ha rectangular plots (*Figure 2*). The plots were positioned in such a way that its long axis ran parallel with the planting rows.

**Figure 2: Configuration of the 2.5 Ha Sample Plot Within a Plantation**




The ratio of the length of road within the compartment (L) to the compartment area (A) was the same as the length of road (Ls) within the 2.5 Ha sample area (As).

Ground line transect walk was carried out along the road and a take-off point was randomly chosen along the distance abutting each of the 2.5 Ha sample plots per plantation species. Observations were made on 20 consecutive trees for incidences of pests and disease incursion. Across several rows, a further 20 consecutive trees were inspected for damage on the return journey to the road.

**Determination of Diseases and Pests Incidence**

In each sampled portion (nursery beds or plantations) number of diseased and pest-infested roots, leaves, fruits, twigs and stems were recorded separately and expressed as the proportion of total number in each set respectively according to Anonymous (2006) as follows:

$$\text{Leaf incidences}(\%) = \frac{\text{Number of infected leaves}}{\text{Total leaves observed in a portion}} \text{ X } 100 \ldots\ldots\ldots [1]$$

$$\text{Fruit incidence}\ (\%) = \frac{\text{Number of infected fruits}}{\text{Total fruits observed in a portion}} \text{ X } 100 \ldots\ldots\ldots [2]$$

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$$\text{Twigs incidences}(\%) = \frac{\text{Number of infected twigs}}{\text{Total twigs observed in a portion}} \text{ X } 100\text{……..[3]}$$

$$\text{Root incidences}(\%) = \frac{\text{Number of infected leaves}}{\text{Total leaves observed in a portion}} \text{ X } 100\text{……[4]}$$

$$\text{Stem incidences}(\%) = \frac{\text{Number of infected leaves}}{\text{Total leaves observed in a portion}} \text{ X } 100\text{……[5]}$$

Photographs of pest and disease-infested plant parts were taken and used for identification purposes.

## RESULTS AND DISCUSSION

### Incidence of Tree Nursery and Plantation Pests

*Table 1* reports the incidence of nursery pests in Kimondi forest tree nurseries. Five (5.3 %) of Eucalyptus leaves were damaged by pests in comparison with 4.7% in *C. lusitanica* and 2.4 % in *P. patula.* Roots for all the seedlings were free from pests.

**Table 1: Incidence of Tree Nursery Pests**

| Species | (% ) Incidence of Pests | | |
|---|---|---|---|
| | **Leaves** | **Stems** | **Roots** |
| *P. patula* | 2.4 | 3.0 | 0.0 |
| *C. lusitanica* | 4.7 | 5.0 | 0.0 |
| *Eucalyptus* | 5.3 | 5.2 | 0.0 |

*Table 2* reports the incidence of pests in the Kimondi forest plantation. Thirty-Five per cent (35%) of Eucalyptus leaves were damaged by pests in comparison with 11.5% in *C. lusitanica* and 9.6 % in *P. patula.* Twelve per cent (12%) of *C. lusitanica* twigs were damaged by pests in comparison to a lower margin (1.8%) observed in *Eucalyptus* species. Fruits for all the tree species were free from pests.

**Table 2: Incidence of Forest Plantation Pests**

| Species | % Incidence of Pests | | | |
|---|---|---|---|---|
| | **Leaves** | **Stem** | **Twigs** | **Fruits** |
| *P. patula* | 9.6 | 1.2 | 8.1 | 0.0 |
| *C. lusitanica* | 11.5 | 1.3 | 12.0 | 0.0 |
| *Eucalyptus species* | 35.0 | 5.6 | 1.8 | 0.0 |

Minor pest attack on *Eucalyptus* (5.6%), *P. patula* (1.3%) and *C. lusitanica* (1.2%) stems were observed. These results suggest that leaves of both the tree nurseries and plantation species are mainly targeted by pests in comparison to the stems, fruits and roots. Such observation has been reported in other similar studies (Nsolomo & Venn, 1984); Nyeko & Nakabonge, 2008; Wingfield *et al*., 2010).

### Incidence of Tree Nursery and Plantation Diseases

*Table 3* reports the incidence of diseases in Kimondi forest tree nurseries. 9.8% of *C. lusitanica* leaves were damaged by diseases in comparison with 8.0% in *P. patula and* 5.6% in *Eucalyptus* tree species.

**Table 3: Incidence of Tree Nursery Diseases**

| ***Species*** | **(%) Incidence of Diseases** | | |
|---|---|---|---|
| | **Leaves** | **Stems** | **Roots** |
| *P. patula* | 8.0 | 5.1 | 0.0 |
| *C. lusitanica* | 9.8 | 3.6 | 0.0 |
| *Eucalyptus species* | 5.6 | 7.7 | 0.0 |

Based on *Table 3,* 7.7% of *Eucalyptus species* stems were damaged by diseases in comparison to 3.6% observed in *C. lusitanica* and 5.1% in *P. patula*. Roots of all tree seedling species remained free from

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diseases. Such observations have been reported in other similar studies (Gichora *et al.,* 2017).

*Table 4* reports the incidence of diseases in the Kimondi forest plantation. Thirty-Five (32%) of Eucalyptus leaves were damaged by pests in comparison with 12% in *C. lusitanica* and 21 % in *P. patula*. Fourteen (14.6%) of *C. lusitanica* twigs were damaged by pests in comparison to a higher margin (17%) observed in *Eucalyptus* species. Fruits for all the tree species were free from pests, while minimal damage on stems (8.5%) on Eucalyptus species, (1.4%) on *C. lusitanica* and 3.2% on *P. patula* was observed.

**Table 4: Incidence of Forest Plantation Diseases**

| **Species** | **(%) Incidences of Diseases** | | | |
|---|---|---|---|---|
| | **Leaves** | **Stem** | **Twigs** | **Fruits** |
| *P. patula* | 21.3 | 3.2 | 7.8 | 0.0 |
| *C. lusitanica* | 12.0 | 1.4 | 17.7 | 0.0 |
| *Eucalyptus species* | 32.0 | 8.5 | 14.6 | 0.0 |

**Major Pests and Diseases in Kimondi Forest**

*Table 5* reports the major pests identified in the Kimondi forest. *Leptocybe invasa* was observed on young seedlings of *Eucalyptus species* in the nursery (*Plate 1a & b*) as small circular galls on the midribs of the leaves. *Leptocybe invasa* lays eggs on the bark of shoots or the midribs of leaves; eggs develop into the minute, white, legless larvae within the host plant.

**Table 5: Major Pests Identified in Kimondi Forest**

| **Pest** | **Observed Symptoms** | **Affected Tree Species** |
|---|---|---|
| *Leptocybe invasa* | Pinhole on leaves, galls on mid-ribs and petioles | *Eucalyptus l*eaves |
| Termites | Nearby termite mounds, stems debarked at the base of the plant | All species |
| Livestock/wildlife | De-budding, cut stems and branches, debarking, browsings on leaves | All species |
| *Pinus pini* | Defoliation, dieback, needle shading, dead trunks | *Pinus patula* |
| *Gonipterus scutellatus* | Leaf defoliation, scalloped leaf edges, dieback of shoot tips | *Eucalyptus* |
| *Cinera cupressi* | Galls | *Cupressus lusitanica* |
| Human | Logging, debarking, cuttings, uprooting | *All species* |

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**Plate 1: a)Galls of *Leptocybe invasa* on Eucalyptus Leaves; b) Debarked *P. Patula* Stem**

**a**

**b**

Damage to trees is caused when the developing larvae of *Leptocybe invasa* produce galls on the leaf midribs, petioles and twigs. The galls cause the twigs to split, destroying the cambium. Small circular holes indicating exit points of adults from pupae are common on the galls. Repeated attacks lead to loss of growth and vigour in susceptible trees. Severely attacked seedlings show gnarled appearance, stunted growth, lodging, dieback and eventually die (Mendel *et al*., 2004; Nyeko & Nakabonge, 2008; Jhala, Patel & Vaghela, 2010; Petro, 2015; de Souza *et al*., (2014).

Termites attack on both *Eucalyptus species* and *C. lusitanica* seedlings was associated with debarked shoots slightly above and below the base level and the presence of anti-hills around the tree nursery. Petro (2015) previously observed termites as a major pest of nursery seedlings and young plantation of *Eucalyptus species* below age five. Termites debark the stems below and slightly above ground level, thus affecting the functioning of the physiological process of plant structures, thus leading to the death of seedlings in the nursery (Nyeko & Nakabonge, 2008). Other pests included humans, sap sacking C*inera cupressi* and leaf defoliation caused by *Pinus pini*. These results are in agreement with the findings of Nyeko and Nakabonge (2008) and Gichora *et al.* (2017).

Major diseases in the Kimondi forest were identified by observing disease signs and symptoms. Results are presented in *Table 6*.

**Table 6: Major Diseases Identified in Kimondi Forest**

| Disease | Observed Symptoms | Affected Tree Species |
|---|---|---|
| Damping-off | Wilting, rotting stems, toppling or drying of stems | Young seedlings of all species |
| *Fusarium wilt* | Chloris of terminal needles wilted flaccid needles | *Pinus patula* |
| *Botryosphaeria canker* | Kino cracks, resin exudation, dieback on tips, coppice failure, fruiting bodies | *Eucalyptus* |
| *Cypress canker* | Fruiting bodies, yellowing of needles, dieback, oozing resin, stem lesion | *Cupressus lusitanica* |
| *Mycosphaerella sps* | Pale brown leaf margins | *Eucalyptus* |

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Damping-off disease associated with wilting and rotting stems was prevalent in young seedlings (*Plate 2b*). However, sometimes the yellowing and wilting of pine seedlings in some nurseries are associated with delayed pricking out, overstaying in the nursery or use of insufficient mycorrhizal soil (Drenth & Sendall, 2001), but this was never the case. *Eucalyptus* seedlings in the nursery as well as in the plantation displayed dieback and stem canker symptoms associated with *Botryosphaeria* infection (*Plate 2a*).

**Plate 2: a) Cracks, Kino and Resin Exudation on Eucalyptus Stem; b) Wilting of *C. lusitanica* Seedlings due to Damping Off Disease**

**a**

**b**

*Botryosphaeria* infection was characterized by dieback of the growing tips, coppice failure and stem cankers. Old trees showed extensive kino accumulation, wood rot and fruiting bodies of *Botryosphaeria* spp. *Cypress canker* characterized by fruiting bodies on infected trees, yellowing of needles, and dieback of branches, oozing resin, stem lesion and trunks were observed on *C. lusitanica* plantation. *Mycosphaerella sps* characterized by irregular pale, brown colouration on leaves with distinct red-brown leaf margin was observed (*Plate 3b*).

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**Plate 3: a) Stem Canker of C .lusitanica; b) Mycosphaerella Sps on Eucalyptus Leaves**

**a**

**b**

## CONCLUSION

A high incidence of nursery seedling pests (5.3% leaves and 5.1% stems) was observed on *Eucalyptus species* and least on *P. patula* (2.4% leaves and 3% stems). Higher incidence of plantation pests (35.0% leaves of *Eucalyptus sps.*) and least on *P. patula* stems (1.2%) were recorded. On the other hand, twelve (12.0%) of *C. lusitanica* and (1.8%) *Eucalyptus species* plantation twigs were infested by pests. A high incidence of nursery seedling disease (9.8%) was observed on *C. lusitanica* leaves and least on *P. patula* stems (3.6%). Higher incidence of plantation diseases (32 %) leaves of *Eucalyptus sps.* and least on *C. lusitanica* stem (1.4%) was recorded. In both tree nurseries and plantations, roots and fruits remained free from pests and disease, respectively. Major tree pests and diseases identified in Kimondi forests include (Human, wildlife, livestock, *Cinera cupressi*, G*onipterus scutellatus*, P*inus pini* and *Leptocybe invasa*) and damping off, *Fusarium wilt*, *Botryosphaeria* canker, cypress canker and *Mycospherella sps*.) respectively. These results suggest a need for intervention measures to control pest and disease infestation in the Kimondi forest.

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