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Research Article

Preliminary Survey of Forest Nursery Diseases in Ethiopia

Kumela Regasa Tiki*, Woldesenbet Bezie
Ethiopian Forestry Development, Addis Ababa, Ethiopia

*Email: kumelaregasa71@gmail.com

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ABSTRACT

The availability of a healthy stock of seedlings is fundamental for raising plantations. A survey was conducted from 2023 to 2024 to observe the occurrence of diseases in forest nursery seedlings in different zones of the Oromia and Amhara regions. During the survey, various plant species were examined for disease occurrence. It was found that E. camaldulensis, E. globulus, Acacia decurrens, Cupressus lusitanica, Grevillea robusta, A.indica, Juniperus procera, Pinus patula, and Dovyalis abyssinica were infected by a disease. The assessment recorded seven seedling diseases, with 12 fungal genera of pathogens isolated. The recorded symptoms of disease during the study included powdery mildew, damping-off, leaf spot, leaf blotch, rust, shoot dieback, and wilting. The pathogens identified from the recorded diseases symptoms were B.cinerea, Alternaria ,Pestalotiopsis spp., Podosphaera spp., Fusarium spp., R.solani, Cylindrocladium spp.,Uromycladium spp.,Phoma spp.and Pythium spp. Rhizoctonia solani was frequently isolated from the damping-off symptoms. Field observations indicated that damping-off on C.lusitanica and p.patula, as well as powdery mildew on Eucalyptus species, are becoming serious problems that limit the production of nursery seedlings. The infection of disease is greatly influenced by improper nursery practices during seedling production, location and type. Some the recorded diseases can cause losses in seedling quality and quantity which can affect plantation programs. The surveys reported here provide a foundation for understanding the status of forest nursery diseases in Ethiopia and serve as a useful reference for assessing current and future forest disease developments and management. Further study on inoculum sources and the morphological characteristics of pathogens associated with seedling diseases using molecular tools is also needed.

Keywords: *Forest; Fungal pathogen; Nursery; Seedling; Survey.*

Introduction

In forestry, nurseries and seedlings play a crucial role in afforestation programs by supplying planting stock. In Ethiopia, tree planting is expected to generate economic benefits such as timber, poles and posts, fuelwood, and charcoal, as well as contribute to the rehabilitation of degraded lands and enhanced climate resilience. Various exotic and indigenous tree species are raised in nurseries across Ethiopia for forest plantation purposes [1]. The main species used in industrial plantations are Eucalyptus (59.3%) and Cupressus lusitanica (20.6%), followed by Juniperus procera (5.7%), Pinus spp. (2%), and other species (7%) [2], [3]. The Ethiopian government has implemented afforestation programs at different times to mitigate deforestation. The Climate Resilient Green Economy (CRGE) strategy aims to afforest and reforest 3 million hectares by 2030, with the objective of restoring forests for their economic and ecosystem services, including carbon sequestration [4]. To achieve this target and meet the growing

demand for forest products in Ethiopia, both the government and the private sector have established nurseries for non-native and indigenous tree species, with exotic species such as Eucalyptus, Cupressus lusitanica, and Pinus patula being dominant [5].

However, several biotic and abiotic factors can affect both the quantity and quality of nursery seedlings. Previous reports have indicated that seed-borne pathogens, particularly fungi, can adversely affect seeds by reducing their storage longevity, germination capacity, and vigour, as well as causing seed rot and seedling diseases in nurseries. Nursery environments can also be conducive to disease outbreaks caused by pathogens originating from soil, seeds, or vegetative planting materials introduced into the nursery [6], [7]. In Ethiopia, limited knowledge of forest seedling production, coupled with insufficient information on nursery diseases and their management, often results in partial or complete failure of seedlings and young plants. Inadequate and low-quality seed supplies, poor seedling quality, and improper silvicultural practices have further constrained forest development in the country [8], [9]. Bekele [5], also reported that seedling production in Ethiopia has been suboptimal due to limited knowledge of the genetic background of planting materials, difficulties in species site matching, a high incidence of diseases and insect pests, poor management practices, and related challenges. To date, no comprehensive survey has been conducted to identify the major and minor diseases affecting seedlings in forest nurseries. Although the literature acknowledges that forest nursery seedlings are affected by diseases, there is no documented information on types, symptoms, or distribution of these diseases in Ethiopian nurseries. The study fills this critical knowledge gap by identifying disease types, symptoms, and distribution at the nursery stage, where early infections can severely affect seedling quality, survival, and future plantation productivity. This study provides the first preliminary survey of forest nursery diseases across multiple nursery sites in Ethiopia, addressing this critical knowledge gap by identifying major and minor diseases, describing their symptoms, associated pathogen and their distribution at the nursery stage where early infections can greatly reduce seedling quality and plantation success.

Therefore, the aim of this study was to generate baseline data on seedling diseases, including their types, distribution, and associated fungal pathogens in selected forest nurseries in Ethiopia.

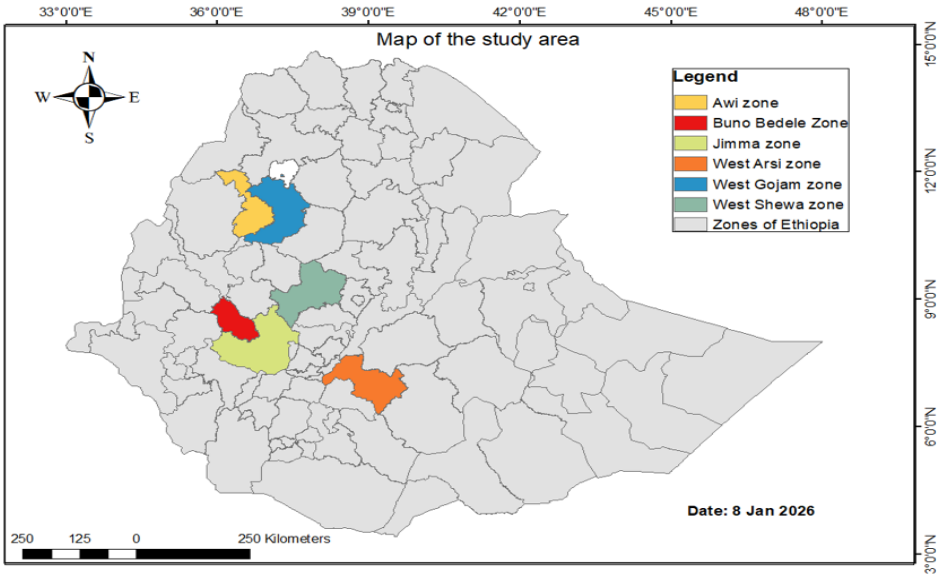

Figure1. Map showing forest nursery diseases survey.

Materials and Methods

Surveyarea and collection of diseased samples

Forest tree nursery disease surveys were carried out in different Zone of Amhara and Oromia regional states in Ethiopia from 2023 to 2024, with a focus on seedling production availability in government and private forest nurseries (Figure 1). The Amhara region has an altitudinal range of 500 to 4,620 meters above sea level, with average annual minimum and maximum temperatures ranging from 15°C to 21°C and an average annual rainfall of 1,194 mm. In the Oromia region, the average annual minimum and maximum temperatures range from 18°C to 39°C, annual rainfall ranges from 450 to 820 mm, and altitude varies between 500 and 4,607 meters above sea level.

Different forest seedling species in selected areas were carefully examined for the presence of diseases. Samples of leaves, roots, and shoots showing diseases symptoms were collected and stored in separate paper bags, then transported to the laboratory for isolation. Diseases incidence data were collected from a 1 m² plot for each species. The percentage incidence of diseases in the nurseries was calculated by dividing the number of diseased seedlings by the total number of seedlings assessed across all plots, using the following formula:

$$\text{Disease Incedence} = \frac{Number\ of\ diseased\ seedlings\ observed}{Totalnumber\ of\ seedlings\ examined} x\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Identification of fungal pathogens

In the laboratory, pathogen isolation was conducted based on seedling species and collection location. Approximately 2 cm of infected leaf and root tissues were excised from the advancing margins of disease symptoms using a sterile razor blade. The tissue samples were surface-sterilized by immersion in a 70% ethanol solution for two minutes, followed by rinsing in three successive changes of sterile distilled water. The sterilized tissues were then placed on potato dextrose agar (PDA) supplemented with 100 ppm streptomycin in Petri dishes to suppress bacterial growth. All plates were incubated at 25°C for one week to promote fungal growth.

After seven days of incubation, fungal isolates developing on the Petri dishes were purified through subculturing to obtain pure cultures. Cultural morphology was examined using both simple and compound binocular microscopes. Characteristics such as colony morphology, growth rate, texture, pigmentation, odour, and other diagnostic features were recorded and compared with descriptions in the literature for fungal identification. Powdery mildew disease was identified based on its characteristic morphology, including the presence of mycelia/hyphae and conidia observed directly on the living leaves of tree seedlings.

Results and Discussion

Results

During the study a total of 12 tree seedling species were examined for diseases presence. *E. camaldulensis, E. globulus, A. decurrens, C. lusitanica, G. robusta, A. indica, J. procera, P. patula, and D. abyssinica* were found to be infected by disease (Table 1). No typical diseases were found in indigenous trees such as *Cordia africana, Olea africana,* and *Podocarpus gracilio*, but reduced numbers of germinated seeds were observed in indigenous trees in all surveyed nurseries. Exotic seedlings of *Pinus, Eucalyptus*, and *Cypressus* are raised on a large scale and are affected by most diseases. Various symptoms of foliar and root diseases were observed. Powdery mildew, leaf spot, leaf blotch in Eucalyptus (Figure a-c), damping-off in *C. lusitanica* (Figure f) *and needle blight in pinus* (Figure i), rust Acacia mearnsii (Figure g), and *C. lusitanica* wilting (Figure b) were the disease

symptoms recorded during the survey, with different pathogens associated with each symptom (Table.1). Damping-off was widespread in nearly all forest nurseries examined. Seedlings of Eucalyptus, *J. procera*, *P. patula*, and *C. lusitanica* were the most impacted by this disease compared to others. Symptoms of wilting, discoloration, tip dieback, and seedling death were noted in the nursery of these coniferous mostly in *C. lusitanica* seedlings (Figure d-f). Seedling mortality was also found for the first 2-5 weeks after germination in the Eucalyptus nursery. Five fungal genera belonging to *B. cinerea, Rhizoctonia solani, Cylindrocladium* spp., *Pythium* spp., *and Alternaria* were associated with damping-off disease symptoms in the seedlings (Table 1).

Figure 2. Pathogens damaging forest nurseries seedlings in Ethiopia. (a) *E. globules* powdery mildew; (b-c) eucalyptus leaf spot; (d) *C. lusitanica* damping off; (e) *C. lusitanica* wilting; (g)*Acacia mearnsii; (h) gravlia robosta* damping off; (i) *P. patula* Needle blight.

Table 1. Diseases and pathogen- associated with nursery seedlings in Ethiopia

Location (Zones)	Locality or Nursery	Host	Diseases	Incidence %	Pathogen associated
West Shewa	Sokondo, Holota, Mangash suba	*E. globules*	Leaf spot	22.2	*Pestalotiopsis* spp. *Phoma* spp.
			Powdery mildew	23.4	*Podosphaera* spp.
			Damping-off	9.1	*Rhizoctonia* spp.
		G. robusta	Leaf spot	6	*Cercospora* spp.
		C. lusitanica	Damping-off	5.4	*R. solani.*
West Gojjem	Merawi, wetat Abay	*E. camaldulensis*	Leaf spot,	12.5	*Pestalotiopsi* spp. *Alternaria* spp.
			Damping-off,	9.4	*Fusarium* spp. *Cylindrocladium* spp.
			Powdery mildew	21	*Podosphaera* spp.
Shashemene	Gambo	*D. abyssinica*	Leaf spot	17	*Pestalotiopsis* spp.
		C. lusitanica	Damping-off	11	*R. solani*
		E. globules	Leaf spot	6	*Pestalotiopsis* spp.
Jimma	Shashemane Gibe bosso	*C. lusitanica*	Damping-off, wilting	16.6	*Phoma* spp. *R. solani*
		E. camaldulensis	Damping-off,	12	*Pythium* spp.
			Leaf spot leaf blotch	4.5	*Alternaria* spp.
		A. indica	Powdery mildew	4	*Podosphaera* spp.
Bedelle	Goban	*D. abyssinica*	Leaf spot	21	*Pestalotiopsis* spp.
		C. lusitanica	Damping-off	13.3	*Rhizoctonia*
		P. patula	Needle blight	9	*Phoma, Pestalotiopsis Botrytis cinerea*
			Damping-off	15.7	*Rhizoctonia*
		J. procera	Discoloration	4.3	*Rhizoctoniasolani*
Awi Zone	Fagita, Ankesha	*E. globules*	Powdery mildew	67	*Podosphaera* spp.
			Damping-off	12.9	*Botrytis cinerea,*
		Acacia Mearnsii	Rust	47	*Uromycladium* spp.

The infection incidence of seedlings varied depending on location and seedling type (Table 1). The highest damping-off seedling incidence was observed in *C. lusitanica*, (16.6%) at Jimma, followed by *P. patula* (15.7%) and *Eucalyptus* (12.9%), whereas the lowest was recorded in *J. procera* nursery, with only 4.23% (Table 1). *Azadirachta indica* and Eucalyptus spp. seedlings were found to be infected by

powdery mildew disease with isolated fungal *Podosphaera* spp. The powdery disease was recorded on both *E. camaldulensis and E. globules* (Figure a). In infected nurseries, reduced seedling growth was observed in both tree species. The highest disease incidence (67%) was recorded at Beddelle, followed by West Shewa Zone (23.4%) and West Gojjem (21%) for *Eucalyptus camaldulnesis*. On *A. indica,* its incidence is very low (4%) compared to Eucalyptus. A severe rust disease of *A. mearensii* was observed in Awi Zone causing the death of petioles and leaflets and reduces the growth of young trees.

Leaf diseases were observed in seedlings of *Grevillea robusta*, *Dombeya abyssinica*, and *Eucalyptus* spp. Symptoms on Eucalyptus seedlings included small, circular to irregular leaf spots that were brown to black in colour, whereas large, irregularly shaped lesions were observed on *G. robusta* and *D. abyssinica*. *Pestalotiopsis* spp., *Alternaria* spp., and *Cercospora* spp. were isolated from infected leaves of *G. robusta* and *D. abyssinica*, while Phoma spp. was isolated from leaf spot lesions on *Eucalyptus seedlings*. The highest incidence of leaf spot disease (22.2%) was recorded on Eucalyptus seedlings in West Shewa, followed by *D. abyssinica* in the Jimma Zone (21%). Overall, disease incidence varied according to location and seedling species.

Discussion

Ethiopian forest nurseries play a critical role in supplying seedlings for the country's major tree-planting initiatives including commercial plantations, agroforestry systems, and national reforestation programs. In nurseries, exotic species such as Eucalyptus, pines, *C.lusitanica*, and *G.robusta* are produced large scale plantation, along with indigenous species for small-scale plantations. Yirdaw [10], noted that forest plantations in Ethiopia mainly comprise exotic genera like Eucalyptus, *Cupressus*, *Casuarina*, *Pinus*, and native *Juniperus* species. The survey examined tree seedling species across Ethiopian forest nurseries to assess the presence of diseases and their potential impact on seedling health. The preliminary nursery survey revealed both minor and significant diseases affecting forest seedlings in Ethiopia, with their importance varying by location, and seedling type (Table 1). The variation in incidence highlights the strong influence of environmental conditions, management practices, and host susceptibility on disease development. Diseases that are initially considered minor but important in different seedlings can become a serious problem in terms of survival rates after out-planting, as the plants are exposed to a biotic factors [11], [12].

Among the recorded diseases, powdery mildew in Eucalyptus and damping-off in conifer nurseries are the most significant nursery disease symptoms. Powdery mildew caused by *podosphera* spp. affecting Eucalyptus *camaldulensis* and *E.globulus*, shows that eucalyptus species share susceptibility. The vibration in incidence among trees suggests higher natural resistance or environmental conditions not favoring infection. The recorded diseases were observed in both bare root and polythene seedlings, affecting quality and number. Damping-off caused more loss in exotic seedlings compared to indigenous nursery seedlings. Severe infection was recorded in *P.pastula* and *C.lusitanica* nurseries compared to other seedlings. Highest incidence in *Cupressus lusitanica* (16.6% jimma**)** and *P.pastula* suggests that this species is highly susceptible to soil-borne pathogens. In nurseries infected with damping-off, reduced growth, and in some places reduced numbers of seedlings were observed. This indicates fungal diseases cause seedling mortality in nurseries that threaten future seedling production for forest regeneration. Several reports indicate that damping-off diseases have

become the most significant diseases affecting conifers seedlings worldwide and have had a severe impact on nursery production [13], [14], [15]. The study conducted by Lazreg *et al*. [16] further strengthens this idea, highlighting the devastating effects of soil-borne and seed-borne fungal pathogens on young seedlings in *pinus* nurseries.

Pathogens such as *Botrytis cinerea*, *Phoma* spp, *Rhizoctonia solani*, *Pestalotiopsis* spp., *Cylindrocladium* spp., *Alternaria* spp., and *Pythium* spp. are associated with disease symptoms in different seedlings (Table1). Previously, these pathogenic fungi were reported to harm both indigenous and exotic trees, causing leaf spots, root rot, and damping-off disease symptoms in forest nurseries worldwide [17], [18], [19]. According to Ezekiel *et al*. [20], seed fungal pathogens that affecting forest seed include *Aspergillus*, *Penicillium*, *Curvularias*, *Alternaria* species, and *Phoma* species. This indicates that if there is no appropriate fungal pathogen management system for seeds during storage and for seedlings at the nursery level, these pathogens can cause diseases at both the nursery and plantation sites. Among the identified pathogens, *Rhizoctonia solani* was isolated from multiple seedling species during the study [Table1]. Globally, this pathogen is a predominant cause of damping-off in forest nurseries, infecting a wide range of hosts [21], [22]. While this fungus can disseminate through seeds or airborne spores, it primarily transmits via infected soil, where it survives the winter as sclerotia [19], [23].

Foliar diseases, such as leaf spot and leaf blotch caused by fungi, were common in eucalyptus-growing areas. Pathogens such as *Phoma* spp., *Pestalotiopsis* spp., and *Alternaria* spp. were identified as the causes of leaf spot diseases in Eucalyptus spp. in the nursery. Tang *et al*. [24], reported that several genera of fungi, notably *Pestalotiopsis*, *Diplodia*, *Alternaria*, and *Phoma*, are responsible for causing leaf spot infections in a wide range of agricultural and forestry species. These fungal species have also been found in Ethiopian plantations as fungal pathogens affecting the eucalyptus tree [25]. The close spacing of plants, regular watering, and dark shade in nurseries can contribute to the development of disease epidemics in nurseries, which are not typically destructive in forests or plantations. This suggests that forest tree species, like many other crops, are affected by numerous biotic and a biotic factors that impact the overall productivity of plantations and natural stands [26], [27].

Conclusion

The survey has revealed that there are various fungal diseases affecting forest seedlings in Ethiopia to varying degrees, depending on the location, and seedling types. Different root and leaf disease symptoms were observed in nurseries surveyed, mainly in exotic rather than indigenous tree species. During the study, seven seedling diseases were identified, with 12 fungal genus pathogens isolated from these diseases. Disease incidences in all forest nurseries depend on improper nursery practices followed during seedling production, seedling type, and location. The information generated from this study can assist nursery managers, forestry practitioners, and policymakers in designing effective disease management strategies and strengthening seedling certification and quality control systems. Strengthening capacity building and awareness among nursery operators, combined with continuous surveillance of nursery diseases, will be crucial for sustaining forest plantation programs in Ethiopia under changing climatic conditions. Extensive study on inoculums sources are also needed to develop management strategies for producing high-quality seedlings in Ethiopia. Additionally, molecular tools are needed to identify pathogens associated with seedling diseases at the species level.

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Conflict of interest

The authors declare that no conflict of interest in this study.

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